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City of Inglewood, California

Voluntary Seismic Improvement of Civic Center: Library Building

Based on Nonlinear Analysis Procedures

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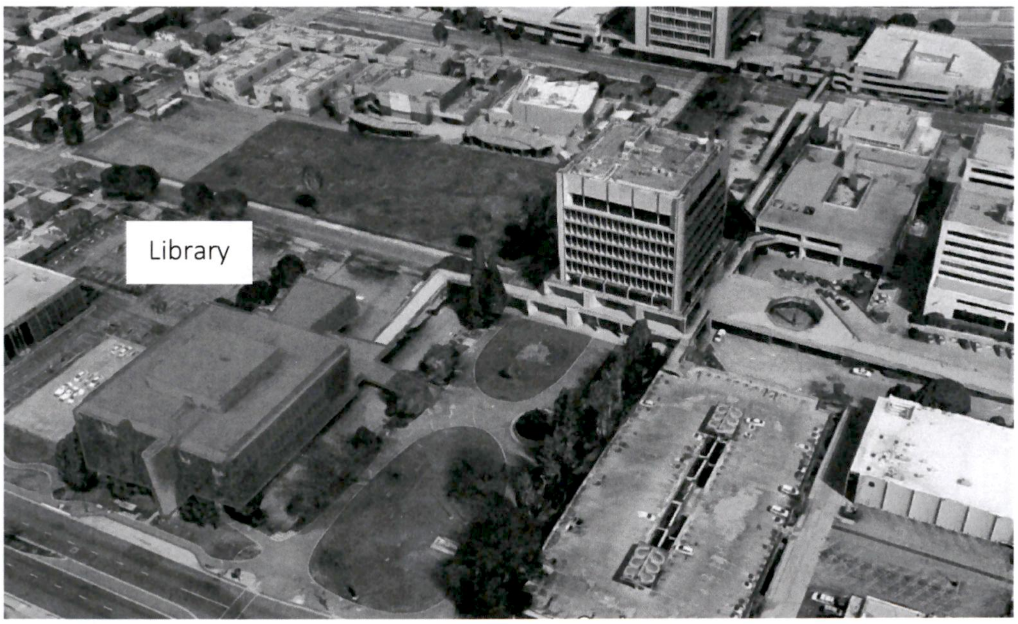
Structural Calculations



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THESE PLANS AND DETAILS ARE
REVIEWED FOR CODE COMPLIANCE
THESE PLANS SHALL NOT BE CONSTRUED TO BE A PERMIT FOR ANY VIOLATION OF ANY CODE OR ORDINANCE.
By Jenne Ku
Date 2/23/2023
THESE PLANS SHALL BE ON THE JOB FOR ALL REQUESTED INSPECTIONS

KPFF JOB # 10012000362
February 28, 2022

DEPARTMENT OF BUILDING & SAFETY
CITY OF INGLEWOOD
APPROVED
By Ali Pouraghabagher
Date 04/13/2023
This set of plans & specifications MUST be kept on the job at all times and it is unlawful to make any changes or alterations on same without written permission from the Div. of Building & Safety, City of Inglewood. The stamping of this plan and specifications SHALL NOT be held to permit or to be an approval of the violation of any provisions of any City Ordinance, State or Federal Law.

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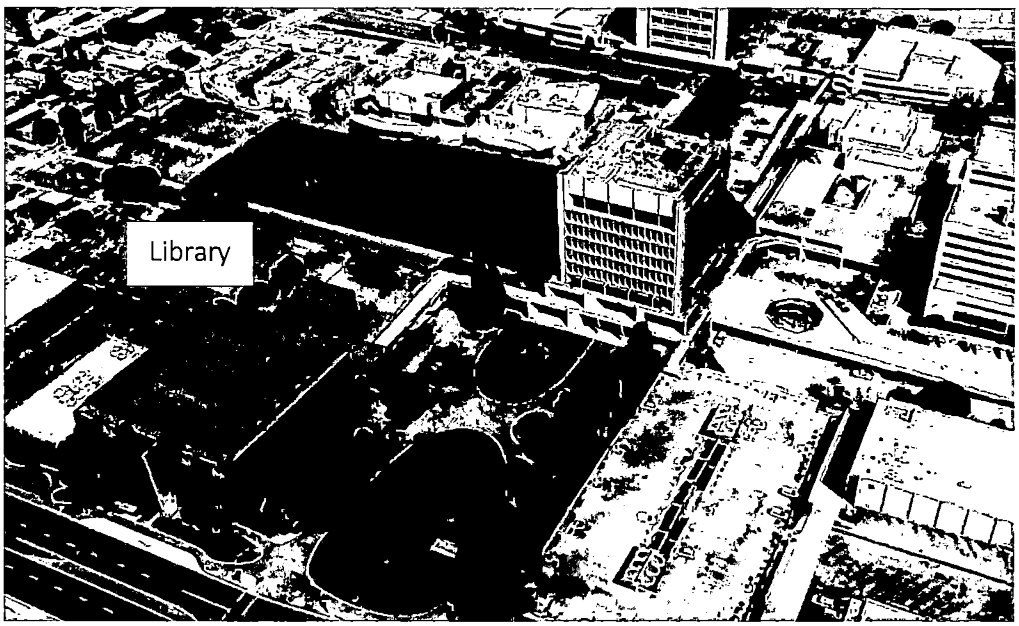
City of Inglewood, California

Voluntary Seismic Improvement of Civic Center: Library Building

Based on Nonlinear Analysis Procedures

Structural Calculations
Volume 1 (Back Check #1)



KPFF JOB # 10012000362

June 25, 2021

~~April 9, 2021~~

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Table of Contents

Appendix

1 - Loading Criteria

1.1 - Gravity Loading Criteria

Executive Summary

This section includes the superimposed dead load and live load criteria of the building. These loads are applied as surface area loads in the ETABS model, which are then imported into PERFORM-3D as nodal point loads at column locations and distributed loads on beams.

KPFF Consulting Engineers
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(213) 310 8579

Project : COI Library
Job no. : 2000362
Date : 3/9/2021
By : JL

LOADING CRITERIA

LOAD TYPE: A - 1st Floor Library

Slab

5" LWC Slab (120pcf)	50	psf
Floor Finishes	1	
Ceiling and Lights	4	
MEP, Piping, Sprinklers	5	
Misc	3	
Slab Total:	**63**	**psf**

Beam

Girders - explicitly modeled	0	psf
Secondary Beams	20.3	psf
Beam Total:	**83.3**	**psf**

Columns

Columns - explicitly modeled	0	psf
Column Total:	**83.3**	**psf**

Seismic Dead Load

Partitions	5	psf
LFRS - explicitly modeled	0	
Seismic Total:	**88.3**	**psf**

Subtract out in ETABS for Beam-slab and Beam-wall overlaps	10.9	psf

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LOADING CRITERIA

LOAD TYPE: B - 2nd & 3rd Floor

Slab

	5" LWC Slab (120pcf)	50 psf
	Floor Finishes	1
	Ceiling and Lights	4
	MEP, Piping, Sprinklers	5
	Misc	3
	Slab Total:	**63 psf**

Beam

	Girders - explicitly modeled	0 psf
	Secondary Beams	14.4 psf
	Beam Total:	**77.4 psf**

Columns

	Columns - explicitly modeled	0 psf
	Column Total:	**77.4 psf**

Seismic Dead Load

	Partitions	10 psf
	LFRS - explicitly modeled	0
	Seismic Total:	**87.4 psf**
	Subtract out in ETABS for Beam-slab and Beam-wall overlaps	9.6 psf

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Job no. : 2000362
Date : 3/9/2021
By : JL

LOADING CRITERIA

LOAD TYPE: **C - Typ Roof**

Slab		
	5" LWC Slab (120pcf)	50 psf
	Roofing	10
	Ceiling and Lights	4
	MEP, Piping, Sprinklers	5
	Misc	3
	Slab Total:	**72 psf**
Beam		
	Girders - explicitly modeled	0 psf
	Secondary Beams	14.4 psf
	Beam Total:	**86.4 psf**
Columns		
	Columns - explicitly modeled	0 psf
	Column Total:	**86.4 psf**
Seismic Dead Load		
	Partitions	5 psf
	LFRS - explicitly modeled	0
	Seismic Total:	**91.4 psf**
	Subtract out in ETABS for Beam-slab and Beam-wall overlaps	9.7 psf

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Job no. : 2000362
Date : 3/9/2021
By : JL

LOADING CRITERIA

LOAD TYPE: D - Mechanical Roof

Slab

	5" LWC Slab (120pcf)	50 psf
	Roofing	10
	Ceiling and Lights	4
	MEP, Piping, Sprinklers	5
	Misc	3
	Slab Total:	**72 psf**

Beam

	Girders - explicitly modeled	0 psf
	Secondary Beams	14.4 psf
	Beam Total:	**86.4 psf**

Columns

	Columns - explicitly modeled	0 psf
	Column Total:	**86.4 psf**

Seismic Dead Load

	Partitions	5 psf
	Permanent Equip (25% LL)	32
	LFRS - explicitly modeled	0
	Seismic Total:	**123.4 psf**

Subtract out in ETABS for Beam-slab and Beam-wall overlaps 9.7 psf

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Job no. : 2000362
Date : 3/9/2021
By : JL

LOADING CRITERIA

LOAD TYPE: E - Penthouse Roof

Slab		
	1 1/2" deck + 2.25" LWC fill	45.25 psf
	1" Cement Plaster	8
	Ceiling and Lights	4
	MEP, Piping, Sprinklers	5
	Misc	1
	Slab Total:	**63.25 psf**
Beam		
	Steel Joists (14B22) @ 8'-0" OC	1.1 psf
	Beam Total:	**64.35 psf**
Columns		
	5" DIA STD Pipe (14.5' Tall)	1 psf
	Column Total:	**65.35 psf**
Ext Walls		
	4" Precast Panels (14.5' Tall)	40.28 psf
	Wall Total:	**105.63 psf**
Seismic Dead Load		
	Partitions	0 psf
	Seismic Total:	**105.6 psf**

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Project : COI Library
Job no. : 2000362
Date : 3/9/2021
By : JL

LOADING CRITERIA

LOAD TYPE: **G - 1st Floor - Lecture Hall**

Slab		
	5" NWC Slab	62.5 psf
	Floor Finishes	1
	Ceiling and Lights	4
	MEP, Piping, Sprinklers	5
	Misc	3
	Slab Total:	**75.5 psf**
Beam		
	Girders - explicitly modeled	0 psf
	Beam Total:	**75.5 psf**
Columns		
	Columns - explicitly modeled	0 psf
	Column Total:	**75.5 psf**
Seismic Dead Load		
	Partitions	0 psf
	LFRS - explicitly modeled	0
	Seismic Total:	**75.5 psf**
	Subtract out in ETABS for Beam-slab and Beam-wall overlaps	10.9 psf

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Project : COI Library
Job no. : 2000362
Date : 3/9/2021
By : JL

LOADING CRITERIA

LOAD TYPE: F - Lecture Hall Roof

Slab		
	5" NWC Slab	62.5 psf
	Floor Finishes	1
	Ceiling and Lights	4
	MEP, Piping, Sprinklers	5
	Misc	3
	Slab Total:	**75.5 psf**
Beam		
	Beams	74.3 psf
	Beam Total:	**149.8 psf**
Columns		
	Columns - explicitly modeled	0 psf
	Column Total:	**149.8 psf**
Seismic Dead Load		
	Partitions	0 psf
	LFRS - explicitly modeled	0
	Seismic Total:	**149.8 psf**

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Project : COI Library
Job no. : 2000362
Date : 3/9/2021
By : JL

EXTERIOR WALL WEIGHT

LOAD TYPE:

Precast Conc Ext Panels - 1st Floor	1706.54 plf
Precast Conc Ext Panels - 2nd & 3rd Floor (Excluding Grid 5)	1996.18 plf
Precast Conc Ext Panels - 2nd & 3rd Floor (Grid 5 Only)	1117.2 plf
Precast Conc Ext Panels - Roof (Excluding Grid 5 and 1 bay of Grid A between Grids 5 and 4)	1296.18 plf
Precast Conc Ext Panels - Roof (Grid 5 and 1 bay of Grid A between Grids 5 and 4 Only)	973.29 plf
Precast Conc Roof Parapet (6" THK x 3'-6" Tall)	262.5 plf
8" Partially Grouted CMU Wall - 1st Floor Half Height (from Ground Floor Below) (Lightweight Block, grouted at 16" OC, 60psf)	390 plf
12" Partially Grouted CMU Wall - 1st Floor Half Height (from Ground Floor Below) (Lightweight Block, grouted at 16" OC, 88psf)	572 plf
12" Conc Parapet - 1st Floor (3'-10" Tall)	575 plf
12" Conc Parapet - Lecture Hall Roof (8 1/2" Tall)	106.25 plf
4" Precast Conc Panel - Penthouse (14.5' Tall)	725 plf
Glass/Curtain Wall Main Entrance - 1st Floor & Roof	315 plf
12"x18'x30' Conc Ramp - Grid A, 1st Floor Half Ramp only (NWC Conc)	4500 plf

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Project : COI Library
Job no. : 2000362
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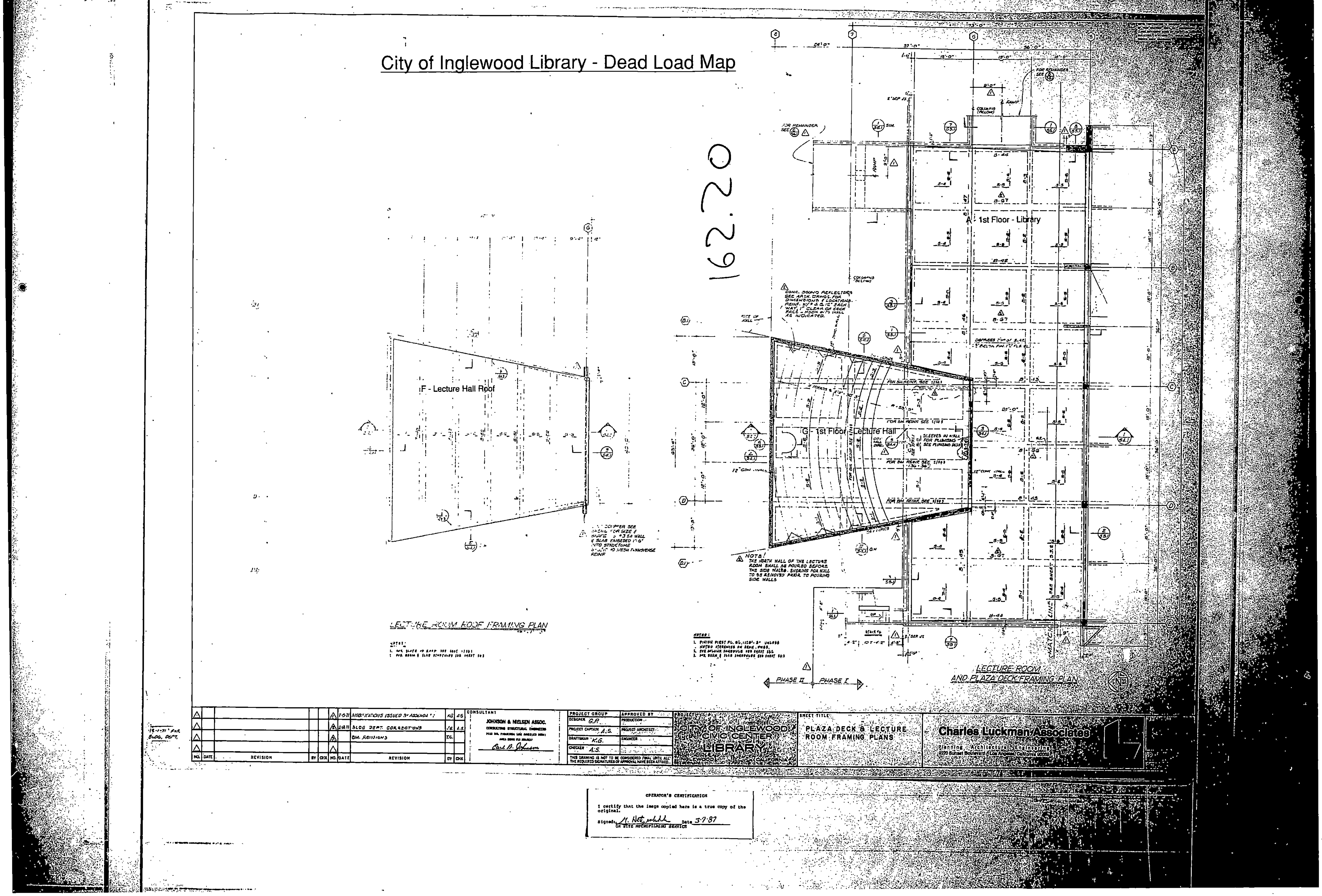
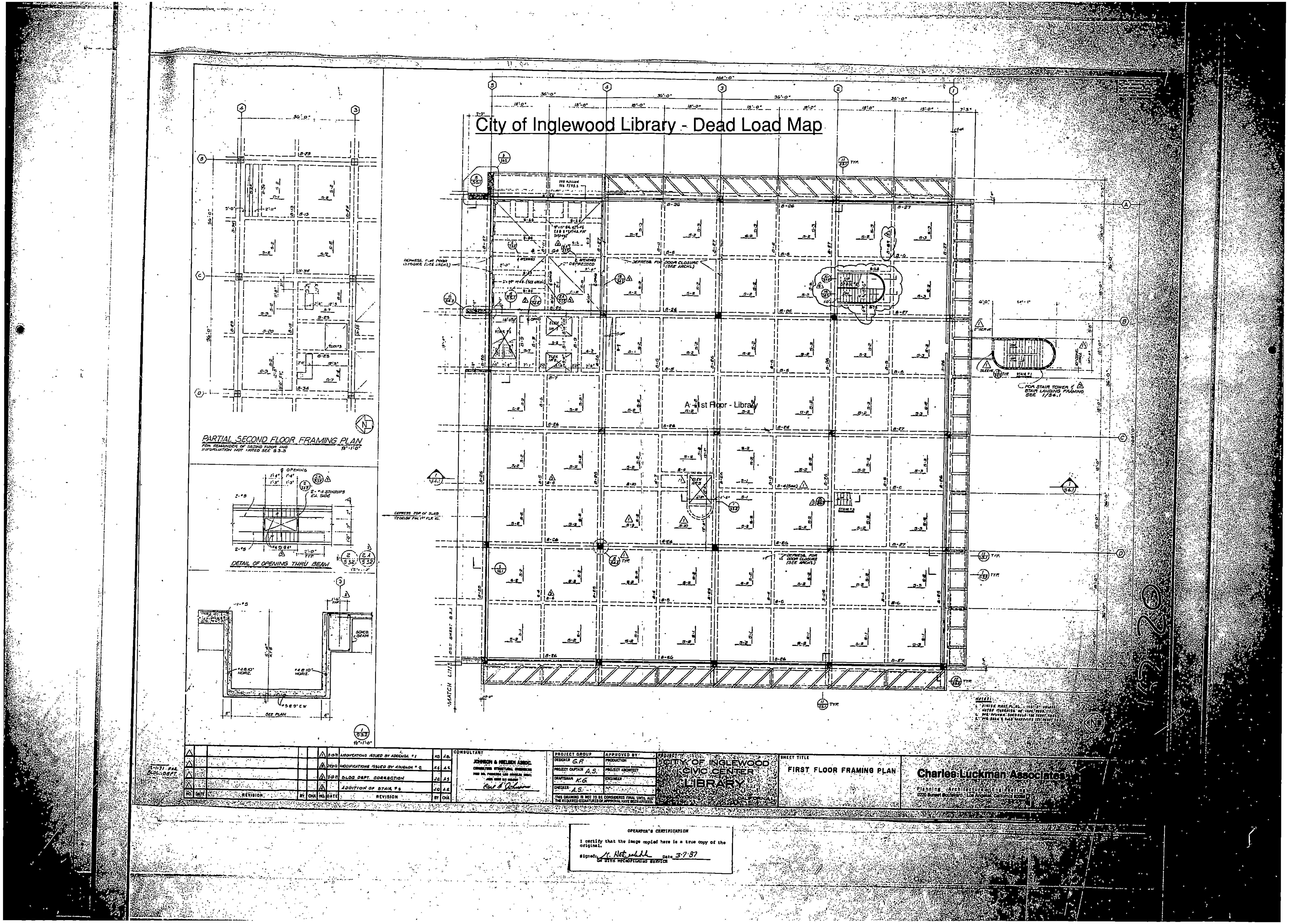
By : JL

LIVE LOAD SUMMARY

Area Type	Loading
Lobby	100 psf (non-reducible)
Lecture Hall (Assembly Area - Fixed Se(	60 psf (non-reducible)
Reading Rooms	60 psf (reducible)
Stack Rooms	150 psf (non-reducible)
Partitions	20 psf (non-reducible)
Roof (unoccupied)	20 psf (reducible)
Mechanical Equipment Areas	125 psf (non-reducible)
Weighted Avg Typ Floor	90 psf

City of Inglewood Library - Dead Load Map




City of Inglewood Library - Dead Load Map
A -1st Floor - Library
PARTIAL SECOND FLOOR FRAMING PLAN
DETAIL OF OPENING THRU BEAM
MODIFICATIONS ISSUED BY ADDENDA #1
MODIFICATIONS ISSUED BY ADDENDA #2
BLDG DEPT. CORRECTION
ADDITION OF STAIR #3
REVISION
CONSULTANT
JOHNSON & NIELSEN ASSOC.
PROJECT GROUP
APPROVED BY
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SHEET TITLE
FIRST FLOOR FRAMING PLAN
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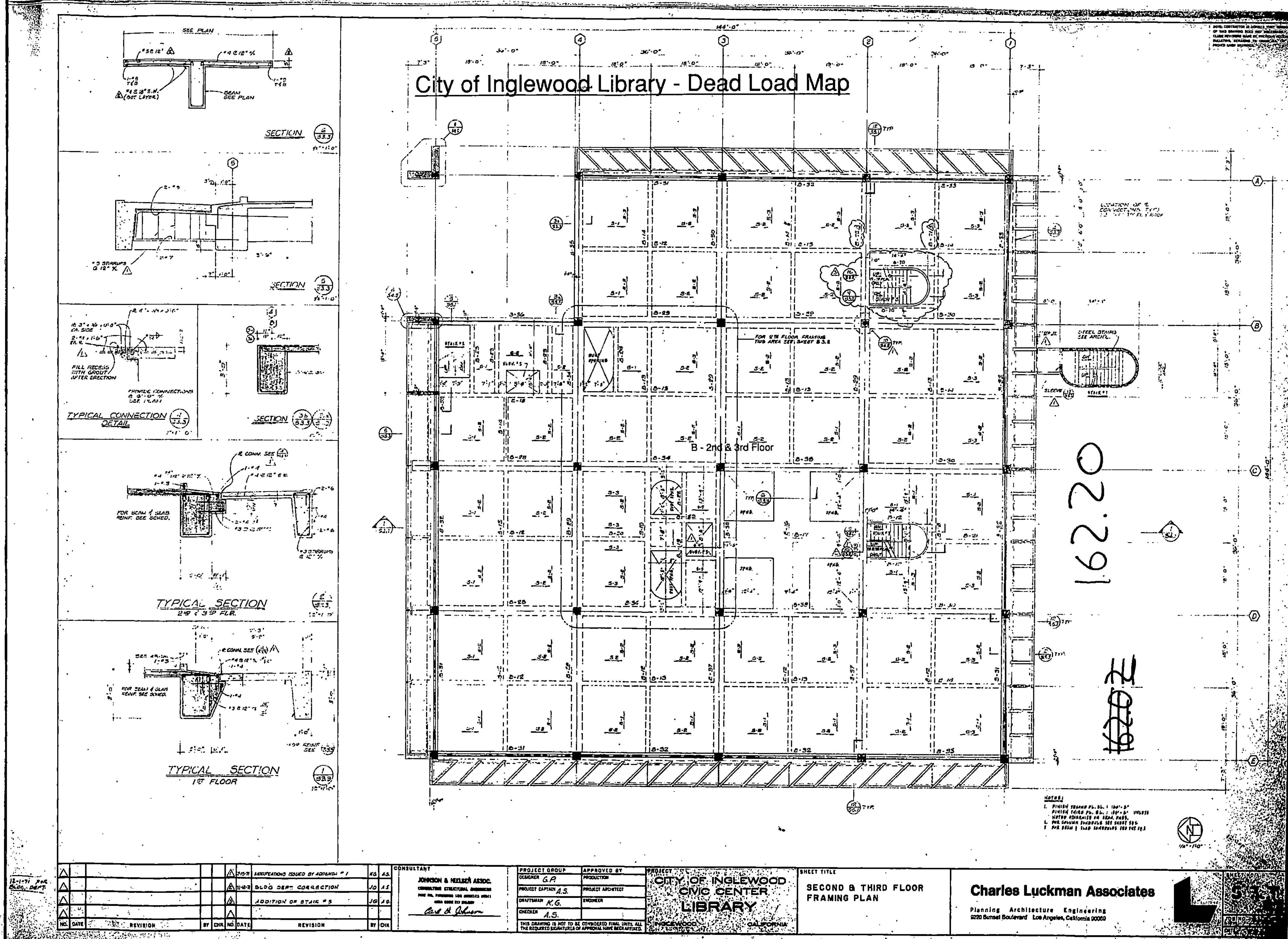

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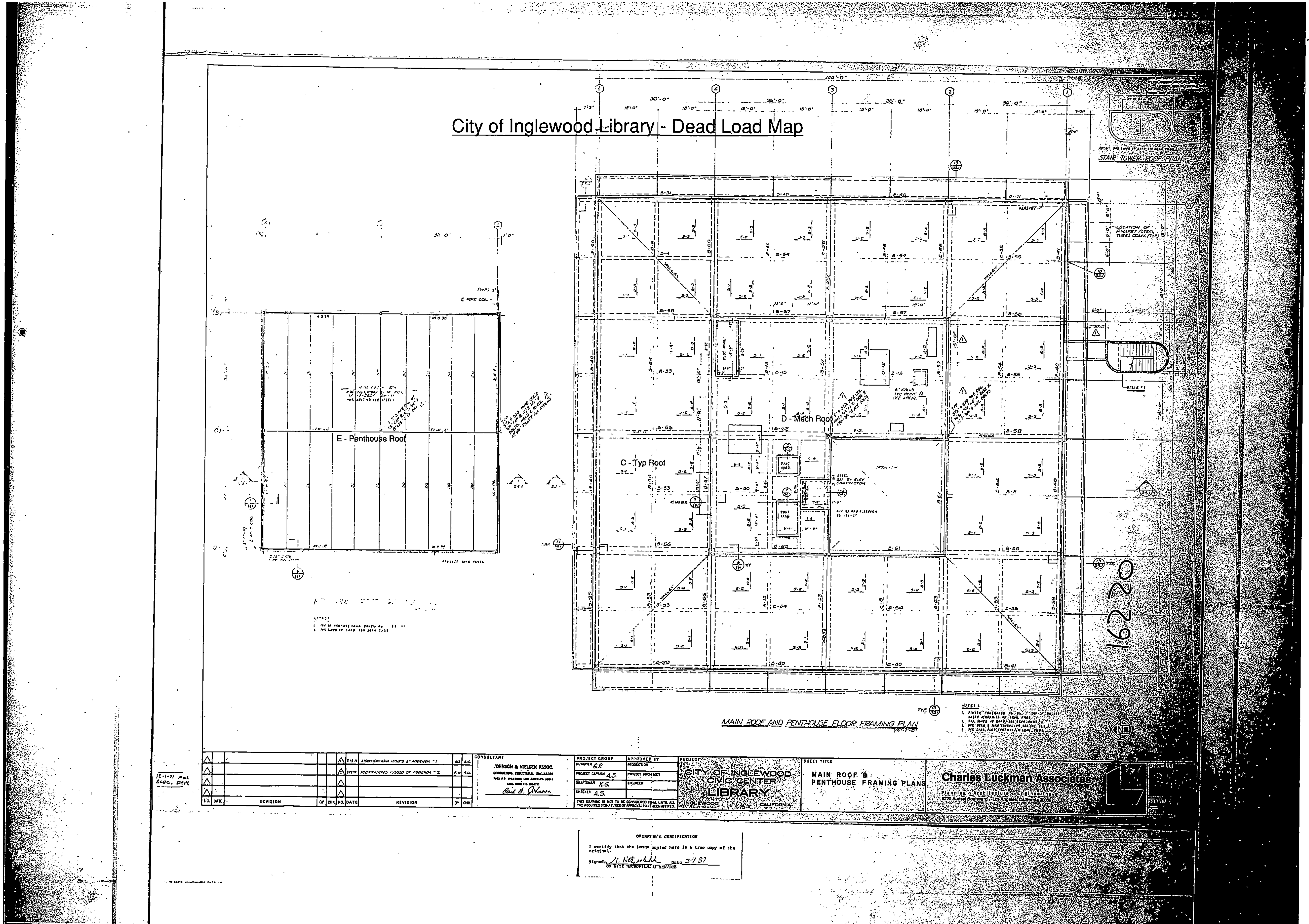
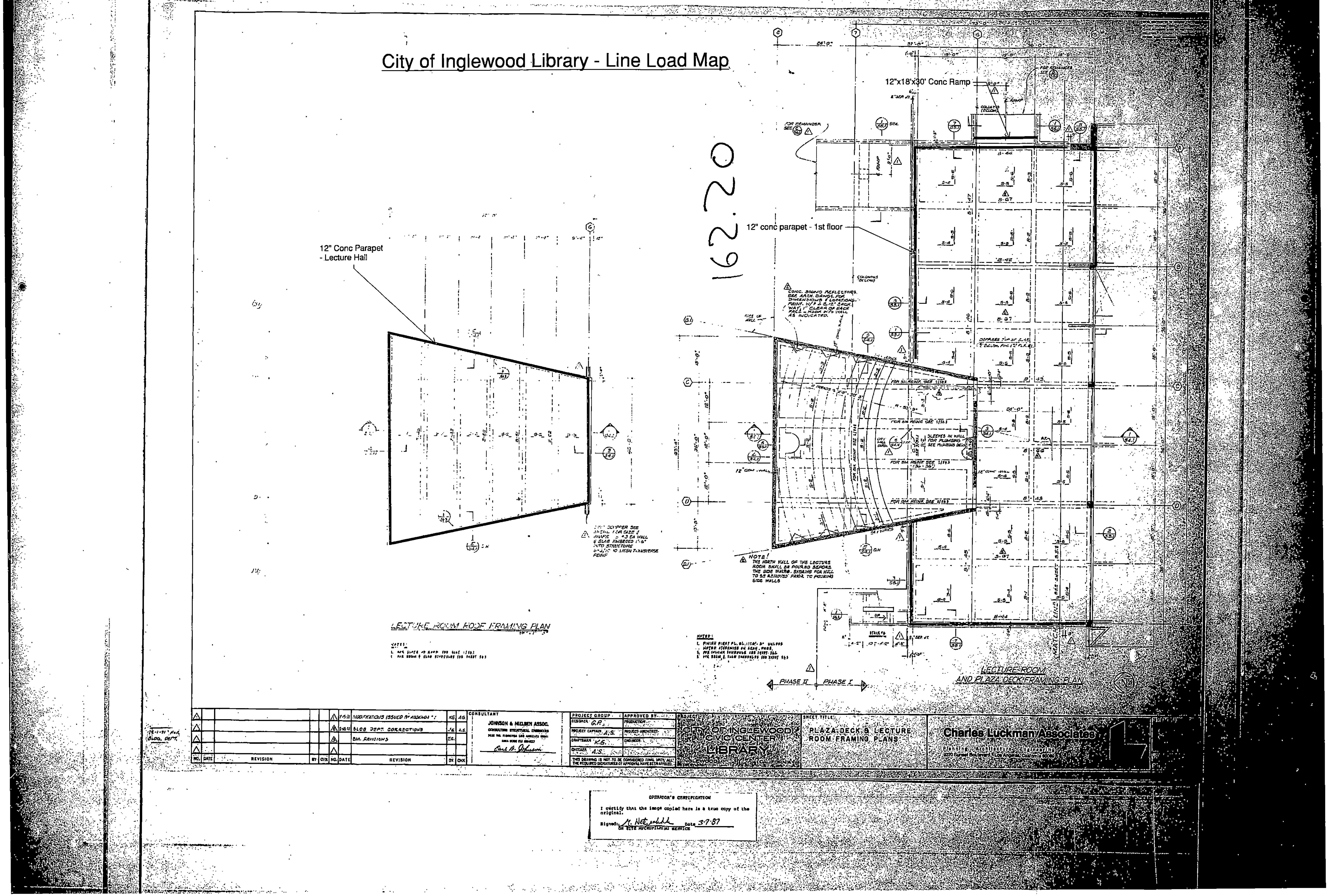
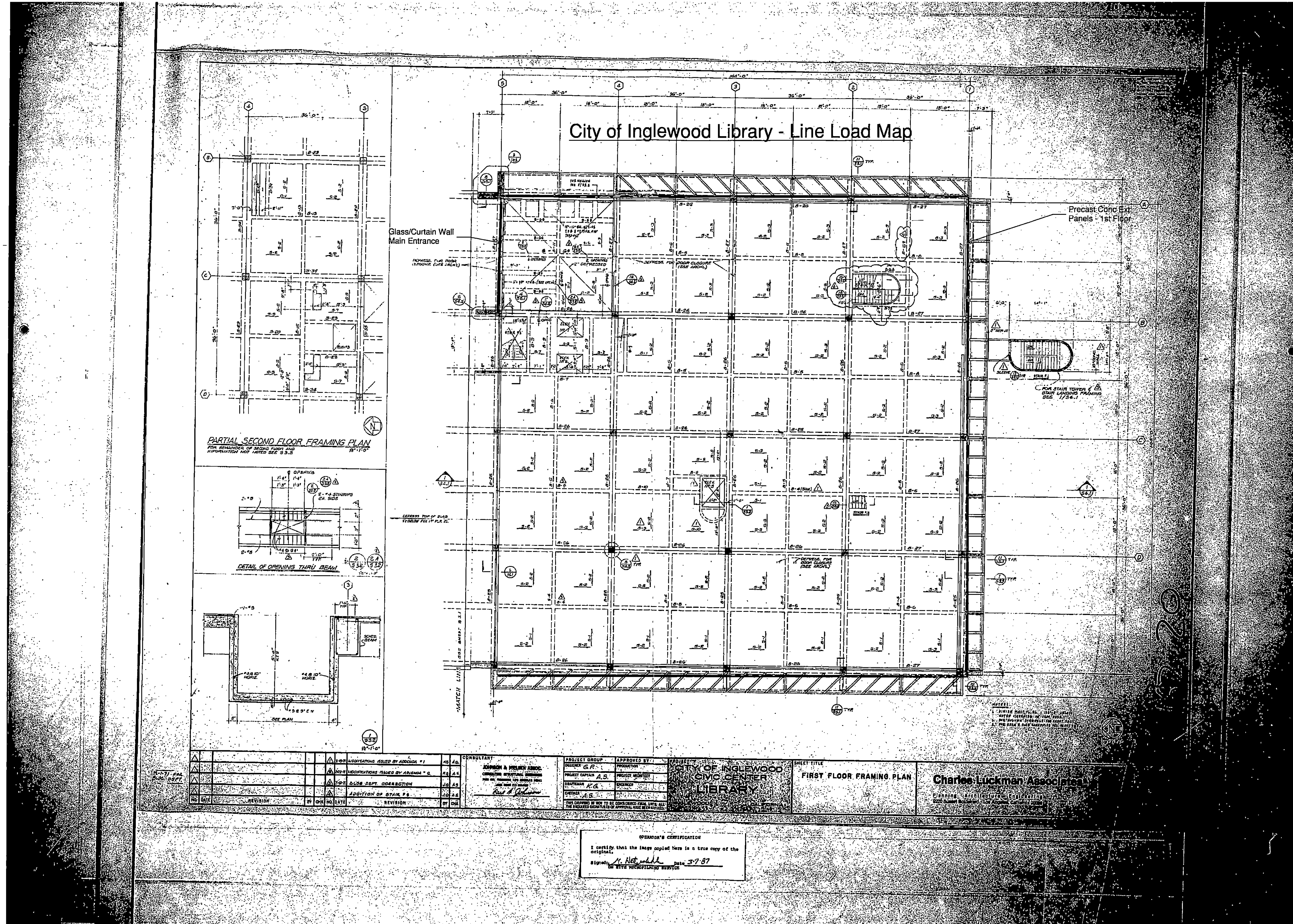
City of Inglewood Library - Dead Load Map



City of Inglewood Library - Line Load Map




City of Inglewood Library - Line Load Map
Glass/Curtain Wall
Main Entrance
Precast Conc Ext
Panels - 1st Floor
PARTIAL SECOND FLOOR FRAMING PLAN
DETAIL OF OPENING THRU BEAM
MATCH LINE
FIRST FLOOR FRAMING PLAN
CITY OF INGLEWOOD
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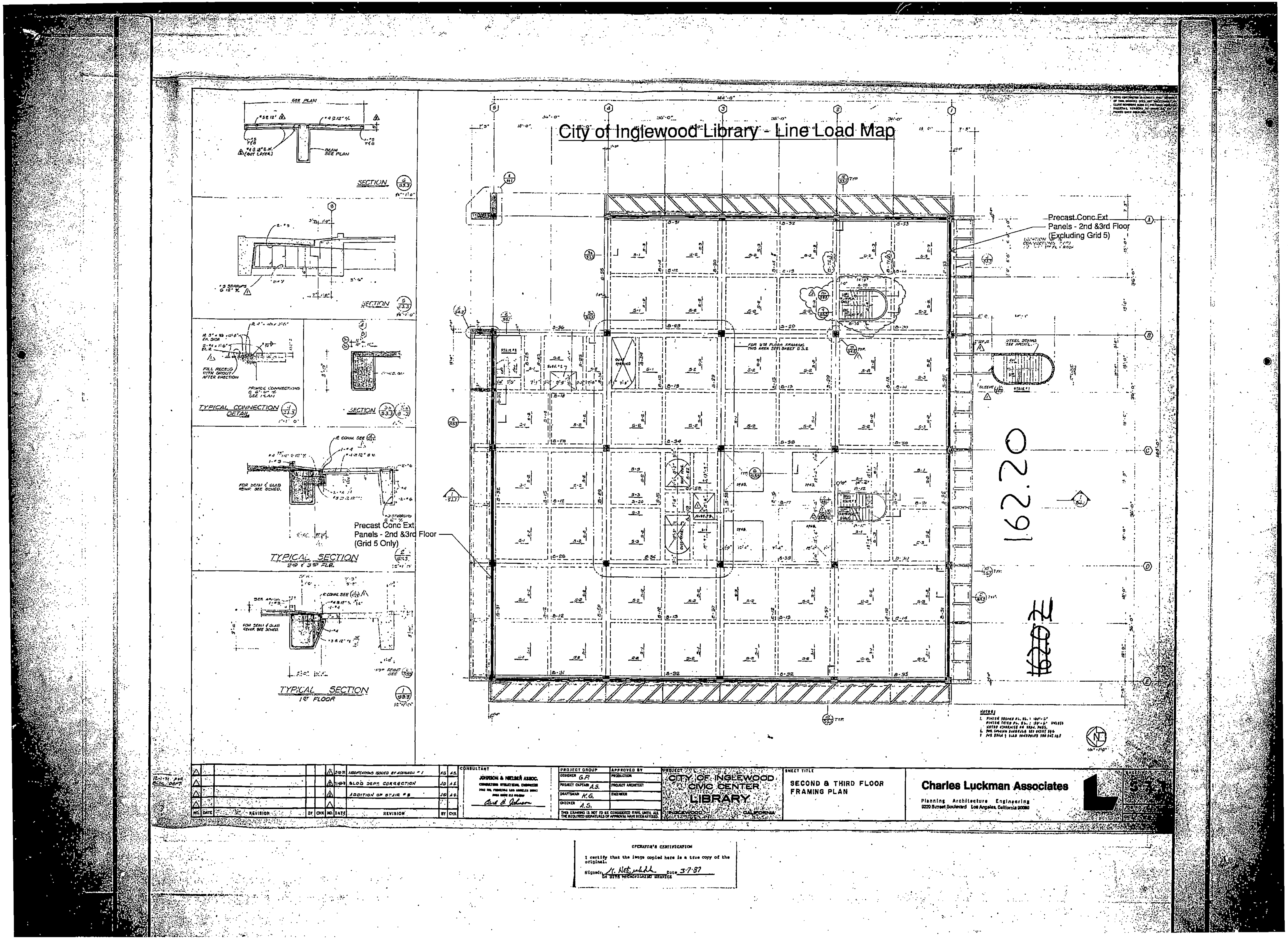

City of Inglewood Library - Line Load Map
Precast Conc Ext Panels - 2nd &3rd Floor (Excluding Grid 5)
Precast Conc Ext Panels - 2nd &3rd Floor (Grid 5 Only)
162.20
SECTION
TYPICAL CONNECTION DETAIL
TYPICAL SECTION
2ND & 3RD FLR.
TYPICAL SECTION
1ST FLOOR
ADDITION OF STAIR #5
BLDG DEPT. CORRECTION
MODIFICATIONS ISSUED BY ADDENDA #1
REVISION
CONSULTANT
JOHNSON & NIELSEN ASSOC.
CONSULTING STRUCTURAL ENGINEERS
PROJECT GROUP
DESIGNER G.P.
PROJECT CAPTAIN A.S.
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CHECKER A.S.
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SHEET TITLE
SECOND & THIRD FLOOR FRAMING PLAN
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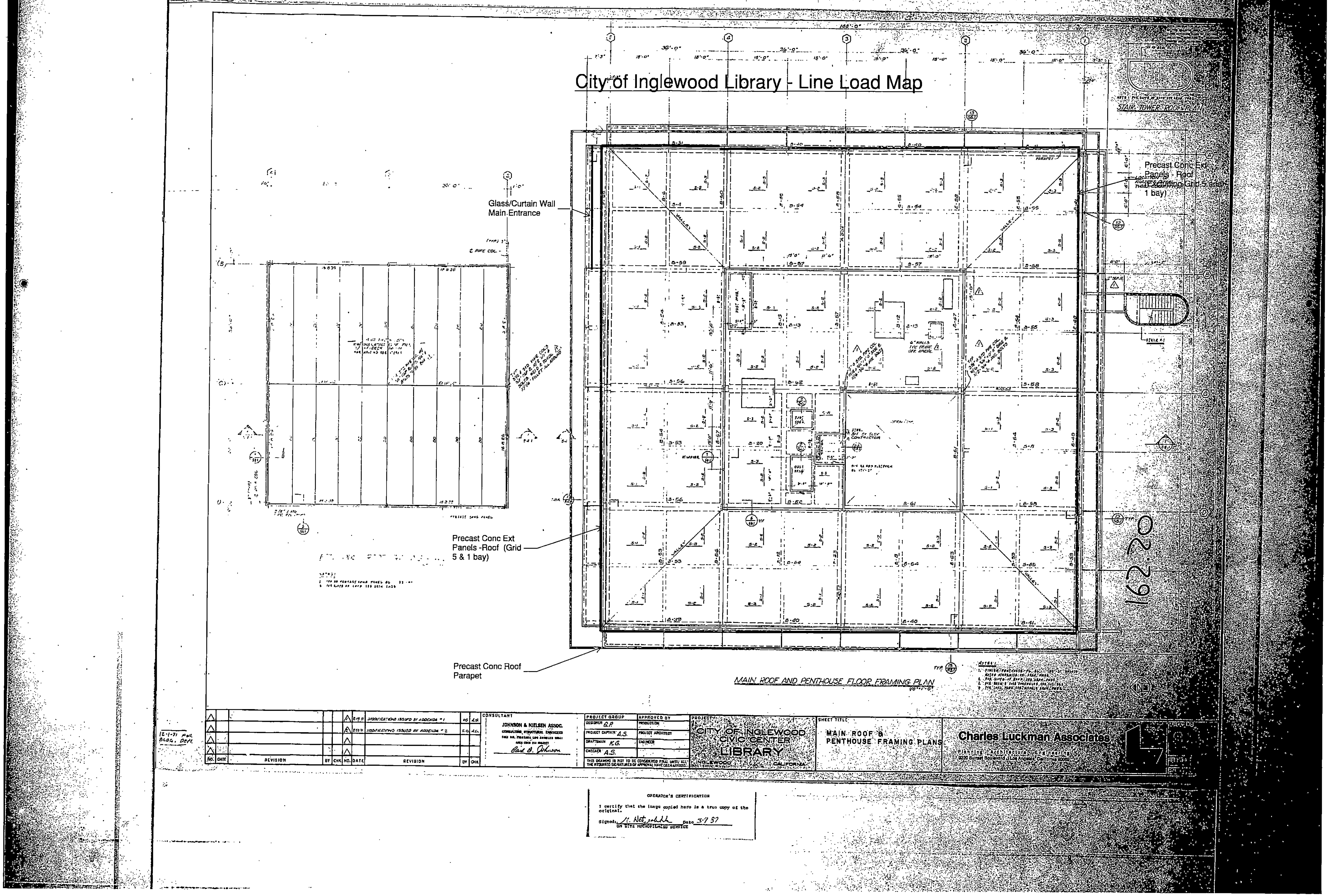
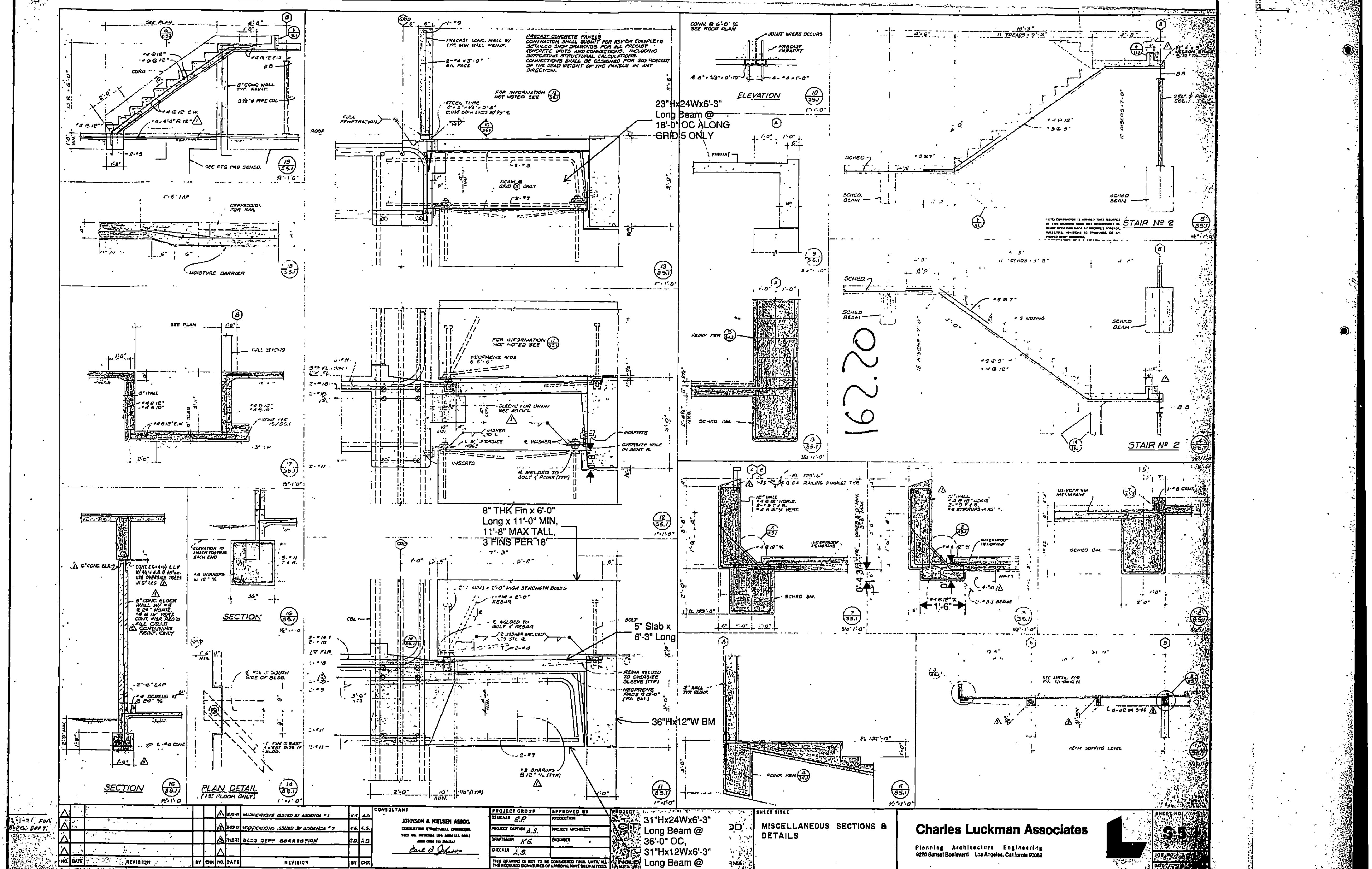
City of Inglewood Library - Line Load Map





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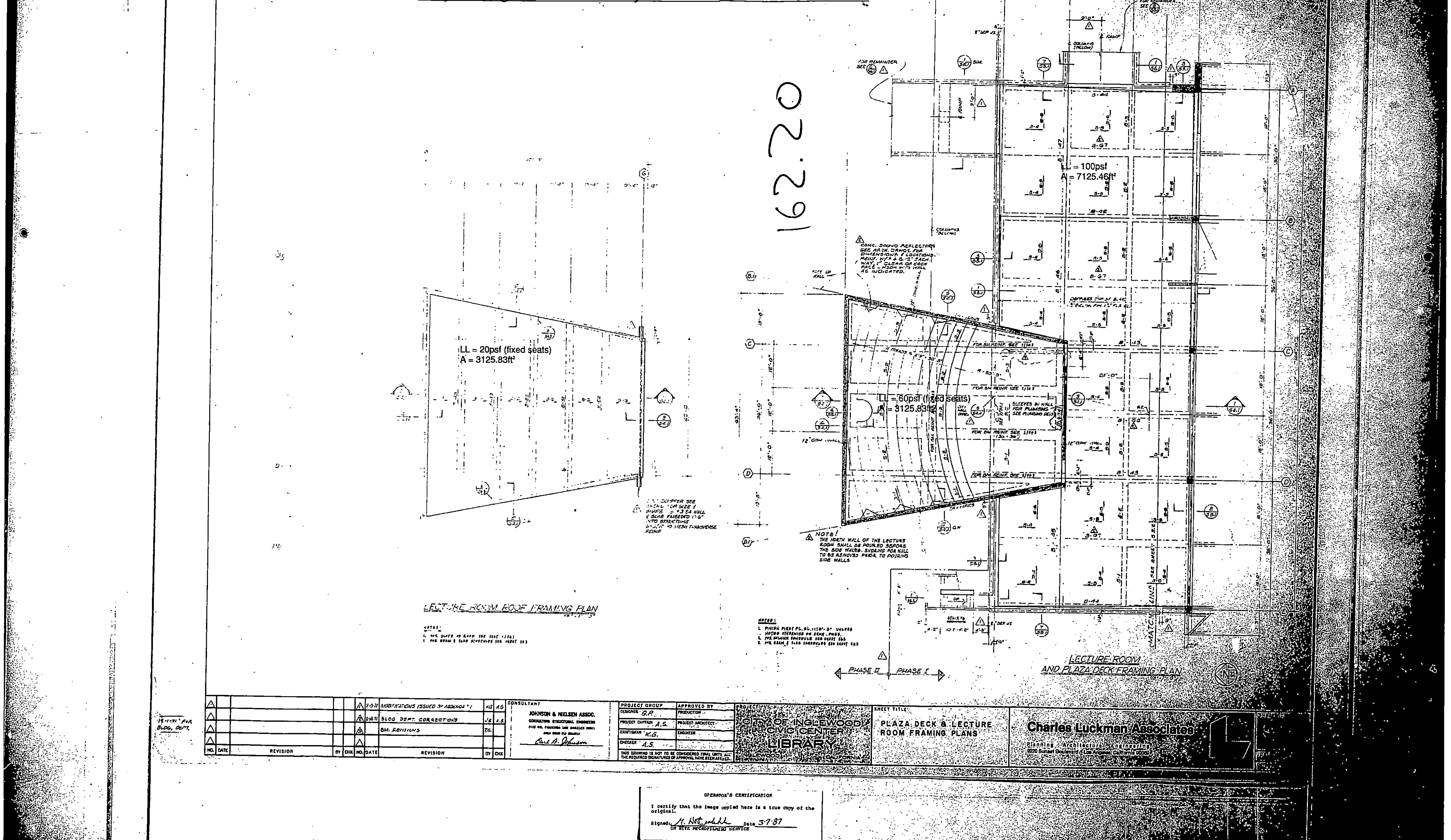
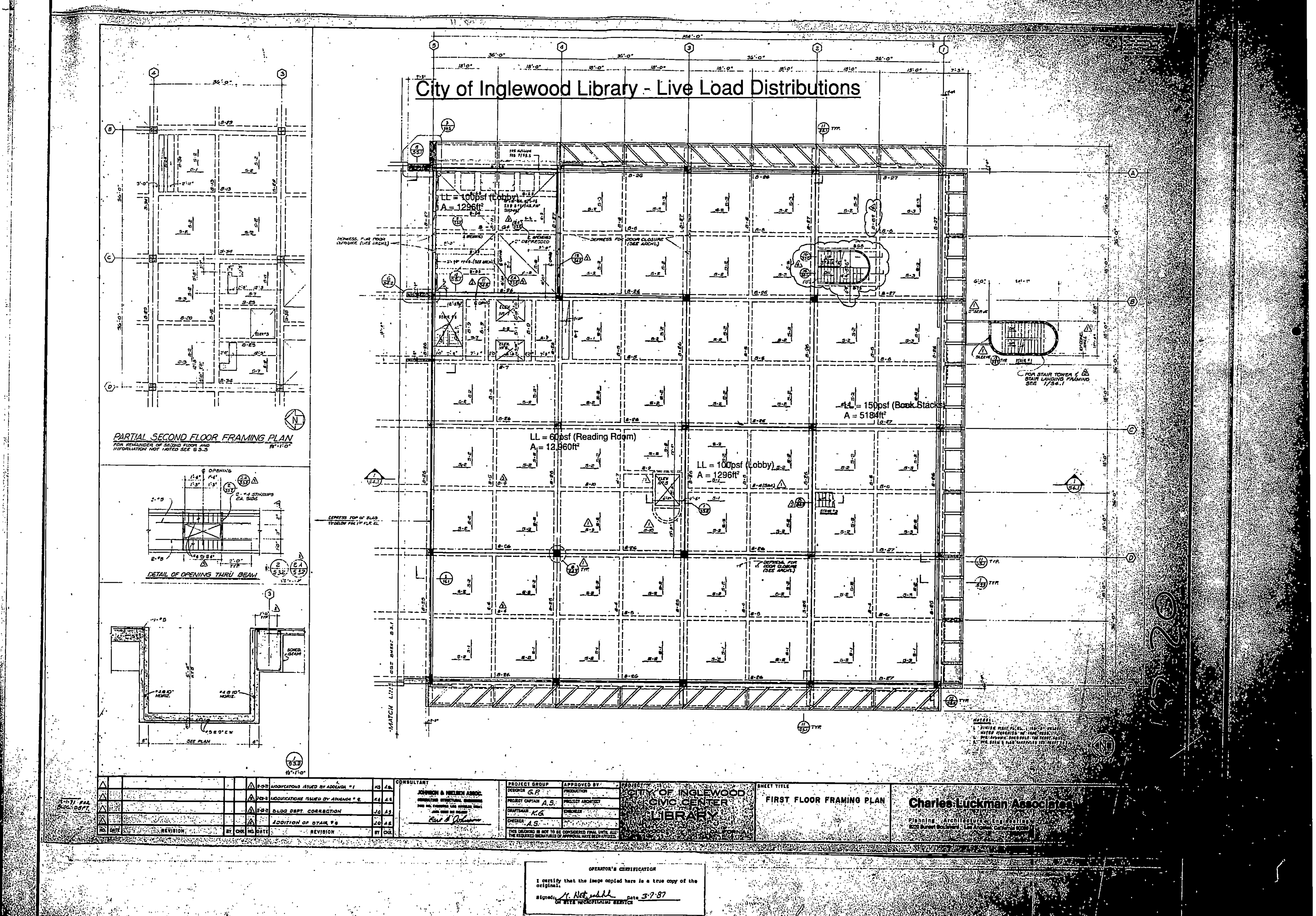
ON SITE MICROFILMING SERVICE

City of Inglewood Library - Live Load Distributions




City of Inglewood Library - Live Load Distributions
LL = 100psf (Lobby)
A = 1296ft²
LL = 60psf (Reading Room)
A = 12,960ft²
LL = 100psf (Lobby)
A = 1296ft²
LL = 150psf (Book Stacks)
A = 5184ft²
PARTIAL SECOND FLOOR FRAMING PLAN
DETAIL OF OPENING THRU BEAM
CITY OF INGLEWOOD
CIVIC CENTER
LIBRARY
FIRST FLOOR FRAMING PLAN
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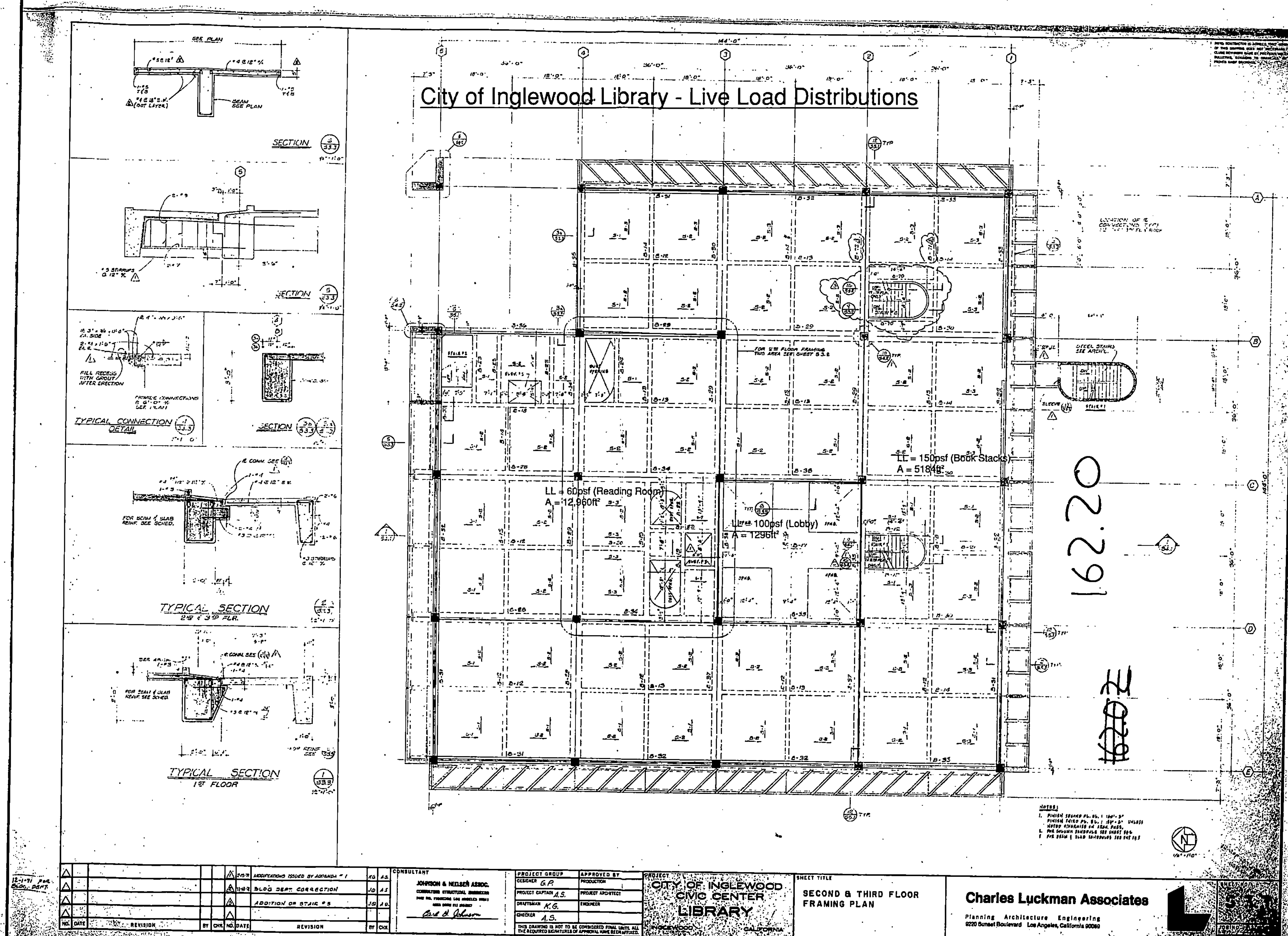

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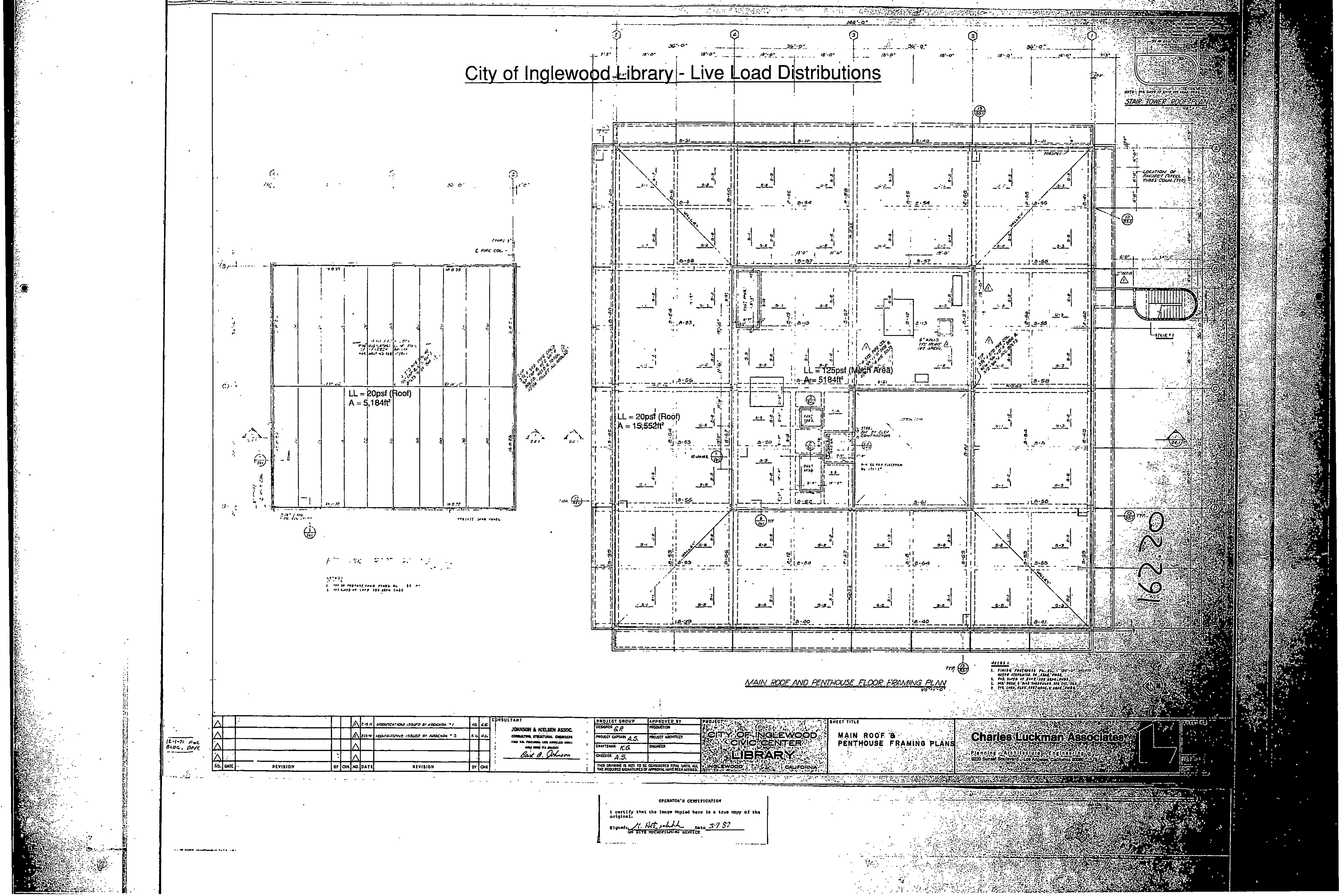
City of Inglewood Library - Live Load Distributions



1.2 - Seismic Loading Criteria

kpff 700 South Flower Street, Suite 2100 Los Angeles, CA 90017 (213) 418-0201	project City of Inglewood - Library	by JL	sheet no. 1.2-2
	location Inglewood, CA	date 3/9/21	
	client	job no. 2000362	
	Seismic Loading Criteria		

The Library building model has been subjected to 11 ground motion pairs. The ground motion pairs were developed by Group Delta. Ground motions were rotated to align with the N-S and E-W directions of the buildings. Ground motion development, scaling and rotation is per Appendix C of the Geotechnical Report prepared by Group Delta. See the Basis of Design Appendix C for the Geotechnical Report prepared by Group Delta.

2 - Material Properties

Material Properties

Expected and lower bound material properties for the structural elements in the Library building have been calculated based on the material testing results shown in the Basis of Design Appendix B. A summary of expected and lower bound material properties can be seen in the Basis of Design Section 5.1.2.

3 - Seismic Mass Calculation

Executive Summary

This section includes an overview of the seismic mass used for the analysis. The superimposed dead loads and line loads per Section 1.1 are applied as superimposed surface loads and line loads in the ETABS model. These superimposed loads, along with the self weight of the elements, are included in the mass definition of the ETABS model. The mass, lumped at each story, is exported to PERFORM-3D along with the diaphragm mass moment of inertia.

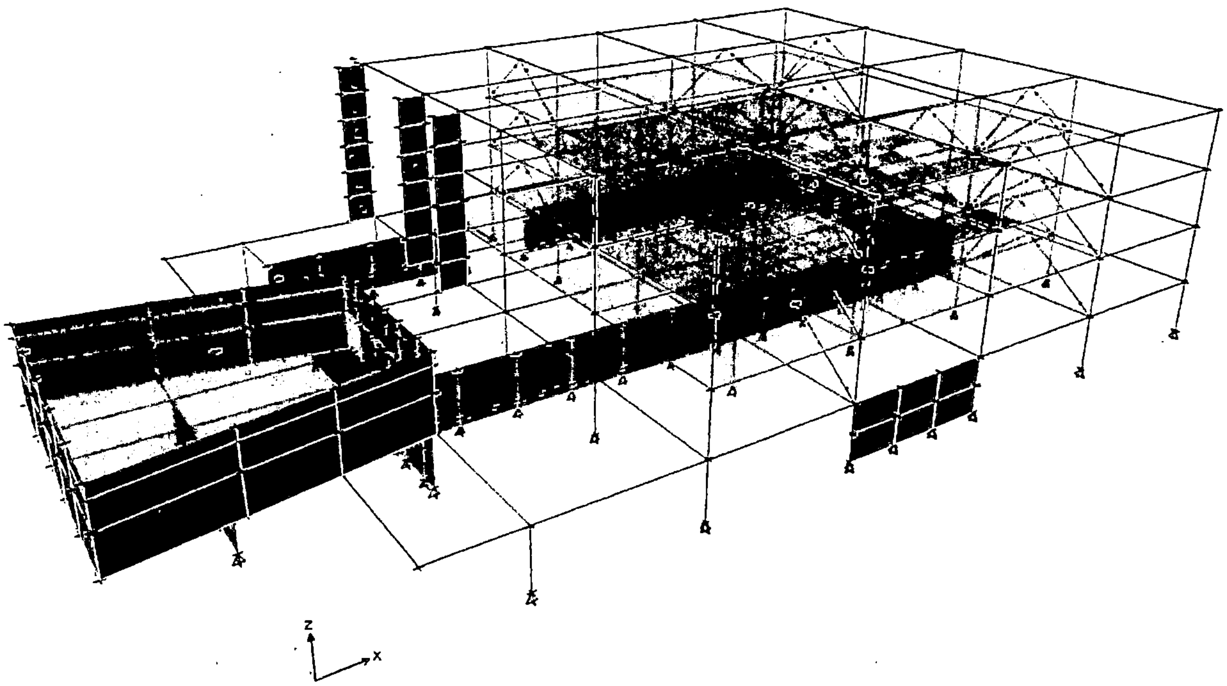


Figure 3-1 Overall 3D view of the ETABS Model

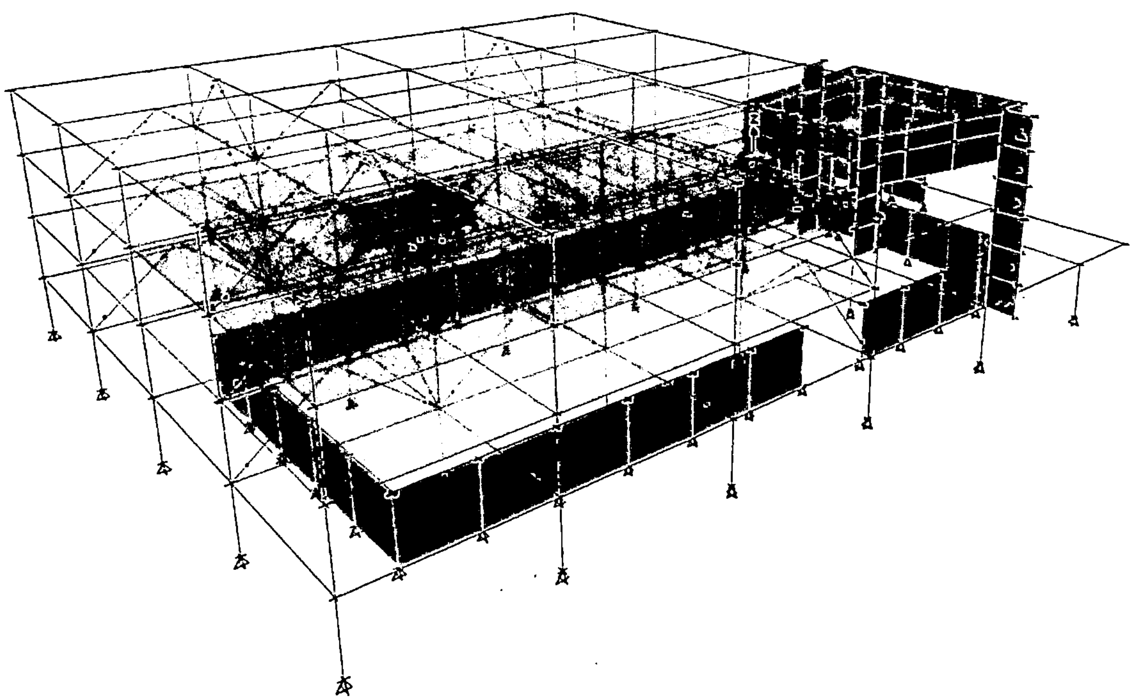


Figure 3-2 Overall 3D view of the ETABS Model

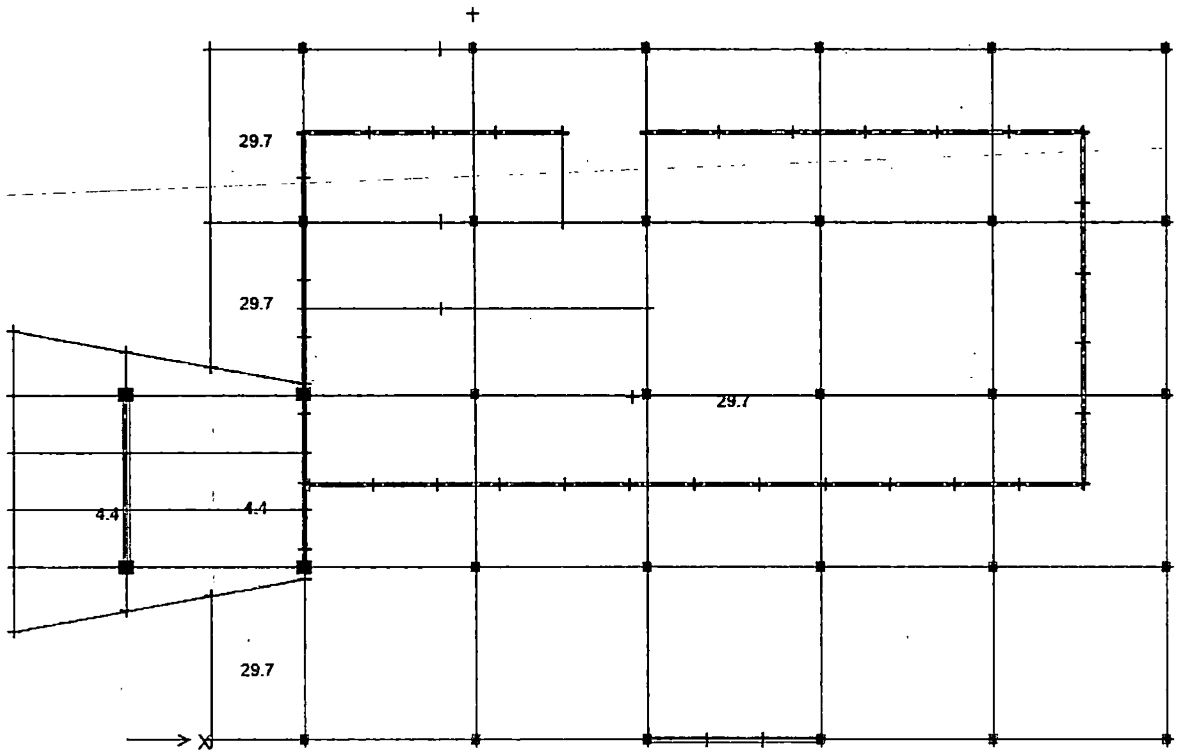


Figure 3-3 1st Floor with Superimposed Dead Loads (psf)

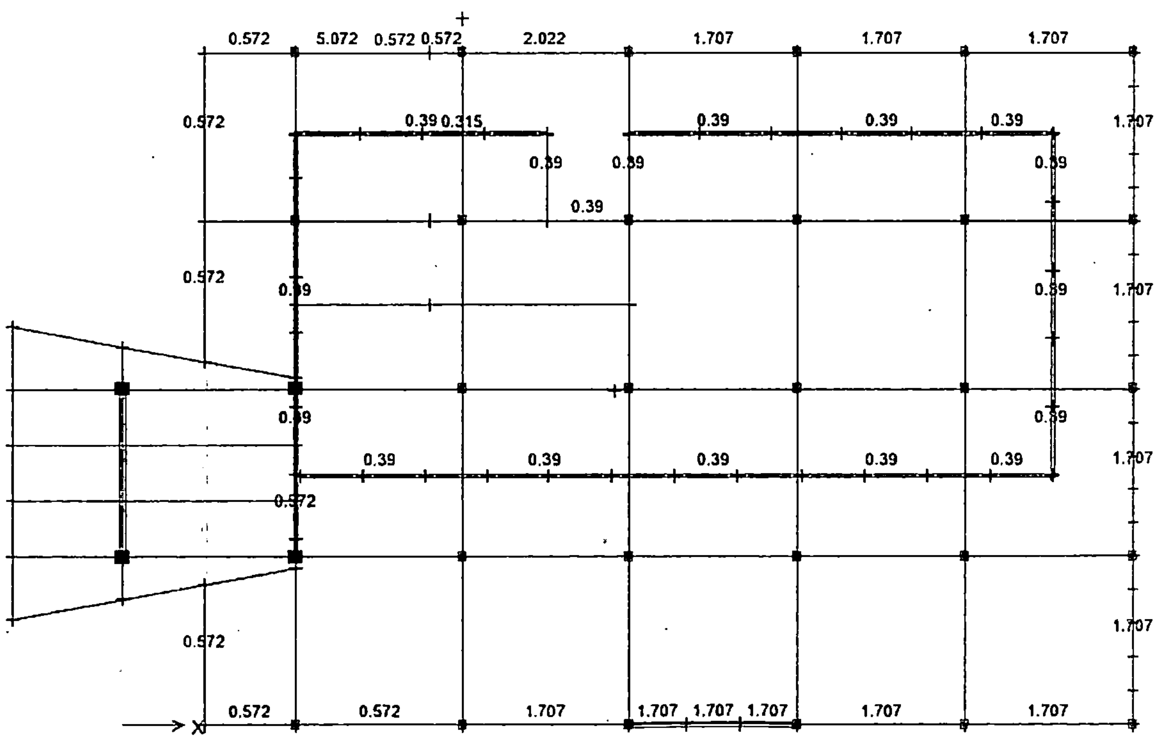


Figure 3-4 1st Floor with Line Loads (klf)

kpff 700 South Flower Street, Suite 2100 Los Angeles, CA 90017 (213) 418-0201	project City of Inglewood - Library location Inglewood, CA client ETABS Seismic Mass	by JL date 6/17/21 job no. 2000362	sheet no. 3-5

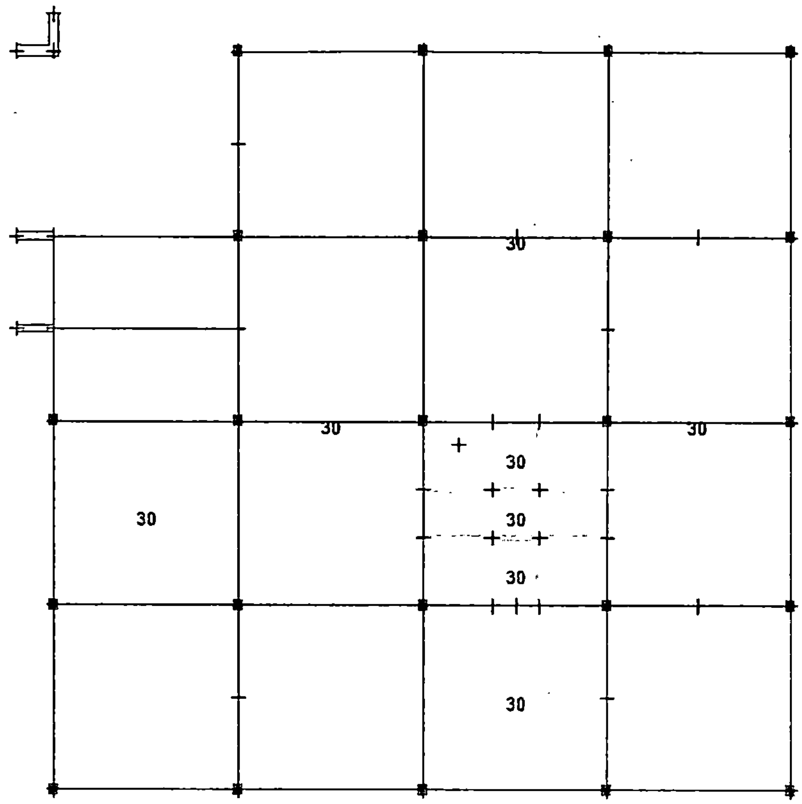


Figure 3-5 2nd/3rd Floor with Superimposed Dead Loads (psf)

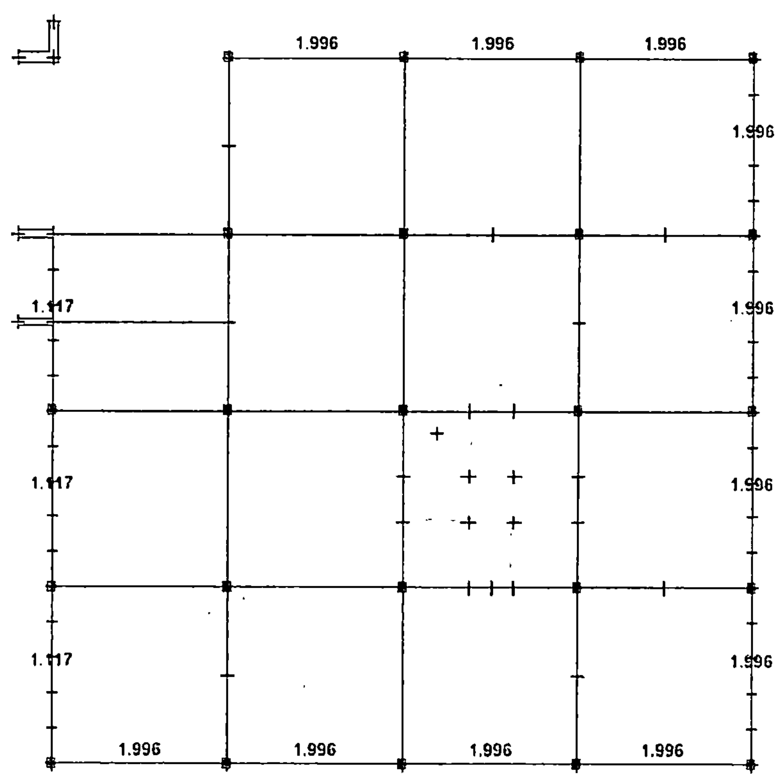


Figure 3-6 2nd/3rd Floor with Line Loads (klf)

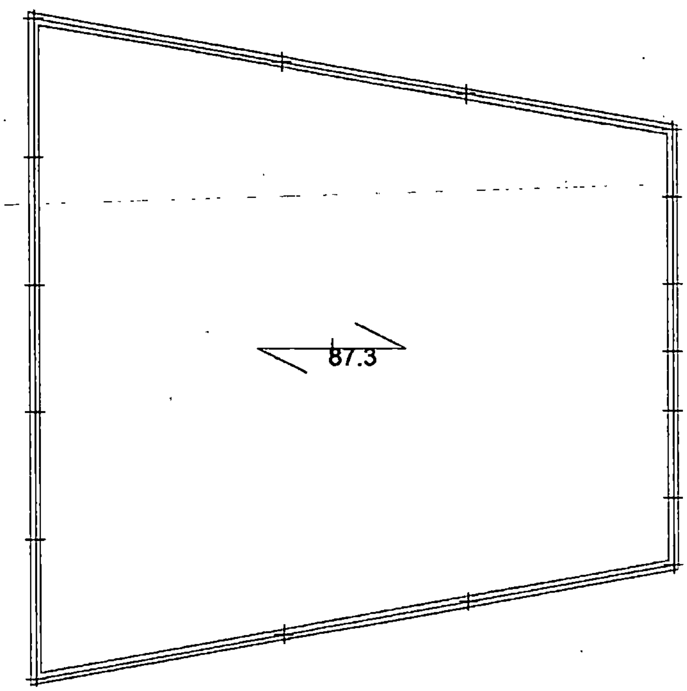


Figure 3-7 Lecture Hall Roof with Superimposed Dead Loads (psf)

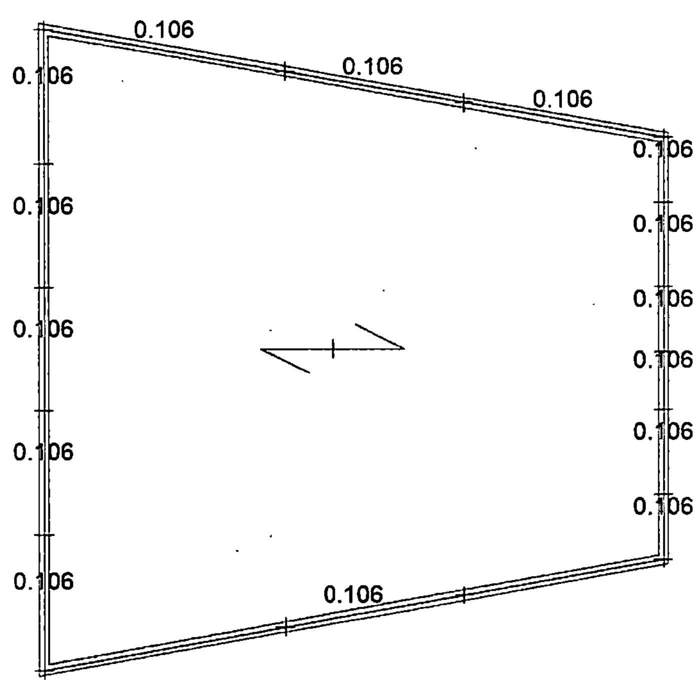


Figure 3-8 Lecture Hall Roof with Line Loads (klf)

kpff	project City of Inglewood - Library	by JL	sheet no. 3-7
700 South Flower Street, Suite 2100 Los Angeles, CA 90017 (213) 418-0201	location Inglewood, CA	date 6/17/21	
	client	job no. 2000362	
	ETABS Seismic Mass		

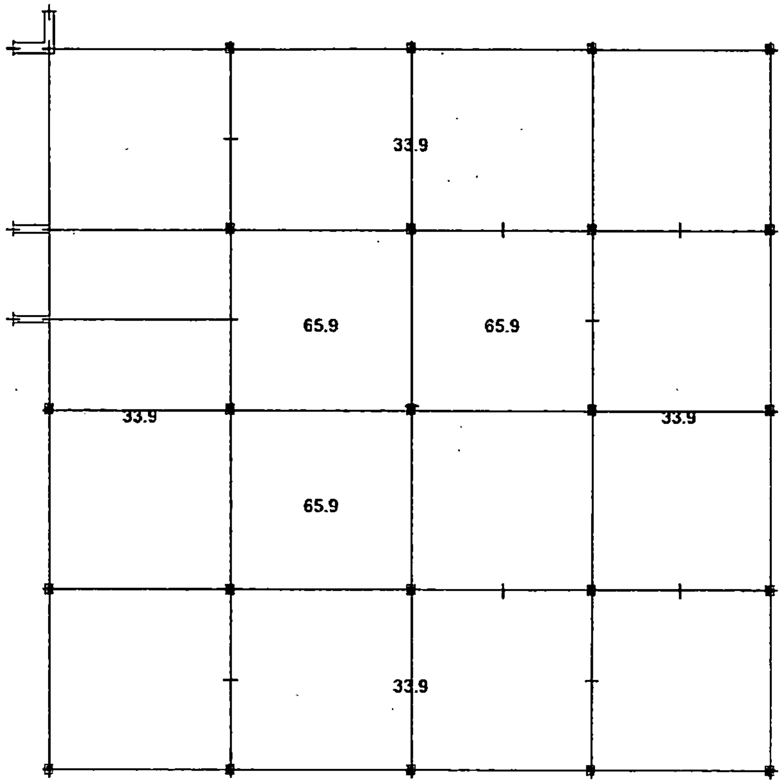


Figure 3-9 Library Roof with Superimposed Dead Loads (psf)

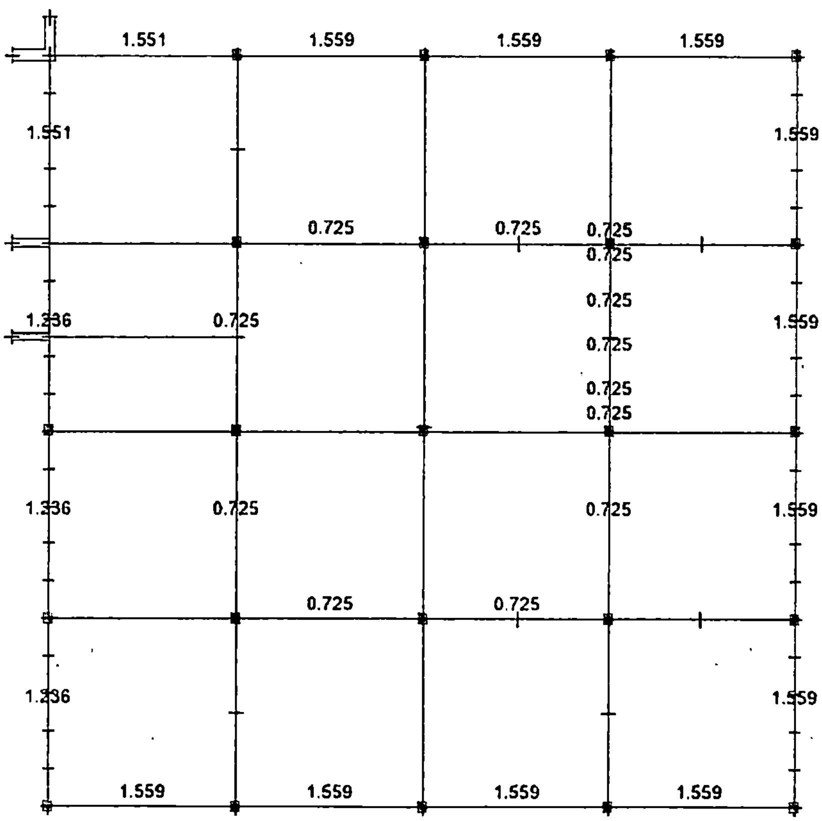


Figure 3-10 Library Roof with Line Loads (klf)

Damper Mass/Weight Calculation

330 k damper:

Weight: 675 lbs
Length: 3'-7.5"

Extender Brace:

HSS9.625x.375
Weight: 37.08 plf

Total Length of damper assembly: 21.36'

Total weight of Each Damper assembly:
675 + 37.08*(21.36' - 3.625') = **1332.6 lbs**
1332.6/21.36 = **62.4 plf**

The weights were distributed evenly between the 2 end nodes of the dampers in Perform3D. They were applied as point loads.

Mass per floor:
1332.6*16 = **21.32 kips**

This additional mass was captured by updating the Etabs model and importing new masses into Perform3D. Pipe sections were modeled in place of dampers with an equivalent unit weight.

ETABS Seismic Mass

Mass Summary Calculated by ETABS

Story	Diaphragm	Mass X	Mass Y	Mass Moment of Inertia	X Mass Center	Y Mass Center
		k	k	kip-in^2	in	in
Story4	D1	4234.6	4234.6	2579920294	1739.4	873.9
Story3	D1	3548.4	3548.4	2334768928	1823.4	809.7
Story3	D2 - Lecture Hall Roof	479.6	479.6	37703783.33	57.9	648.0
Story2	D1	3548.4	3548.4	2334768928	1823.4	809.7
Story1	D1	5851.1	5851.1	6100962953	1269.1	858.9

Mass Summary of values used in PERFORM

Story	Mass X	Mass Y	Mass Moment of Inertia	X Mass Center	Y Mass Center
	k	k	kip-in^2	in	in
Roof	4234.6	4234.6	2579920294	1739.4	873.9
Level 3	3548.4	3548.4	2334768928	1823.4	809.7
Lecture Hall Roof	479.6	479.6	37703783.33	57.9	648.0
Level 2	3548.4	3548.4	2334768928	1823.4	809.7
Level 1	5851.1	5851.1	6100962953	1269.1	858.9

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location	date 6/18/21	
client	job no. 200362	

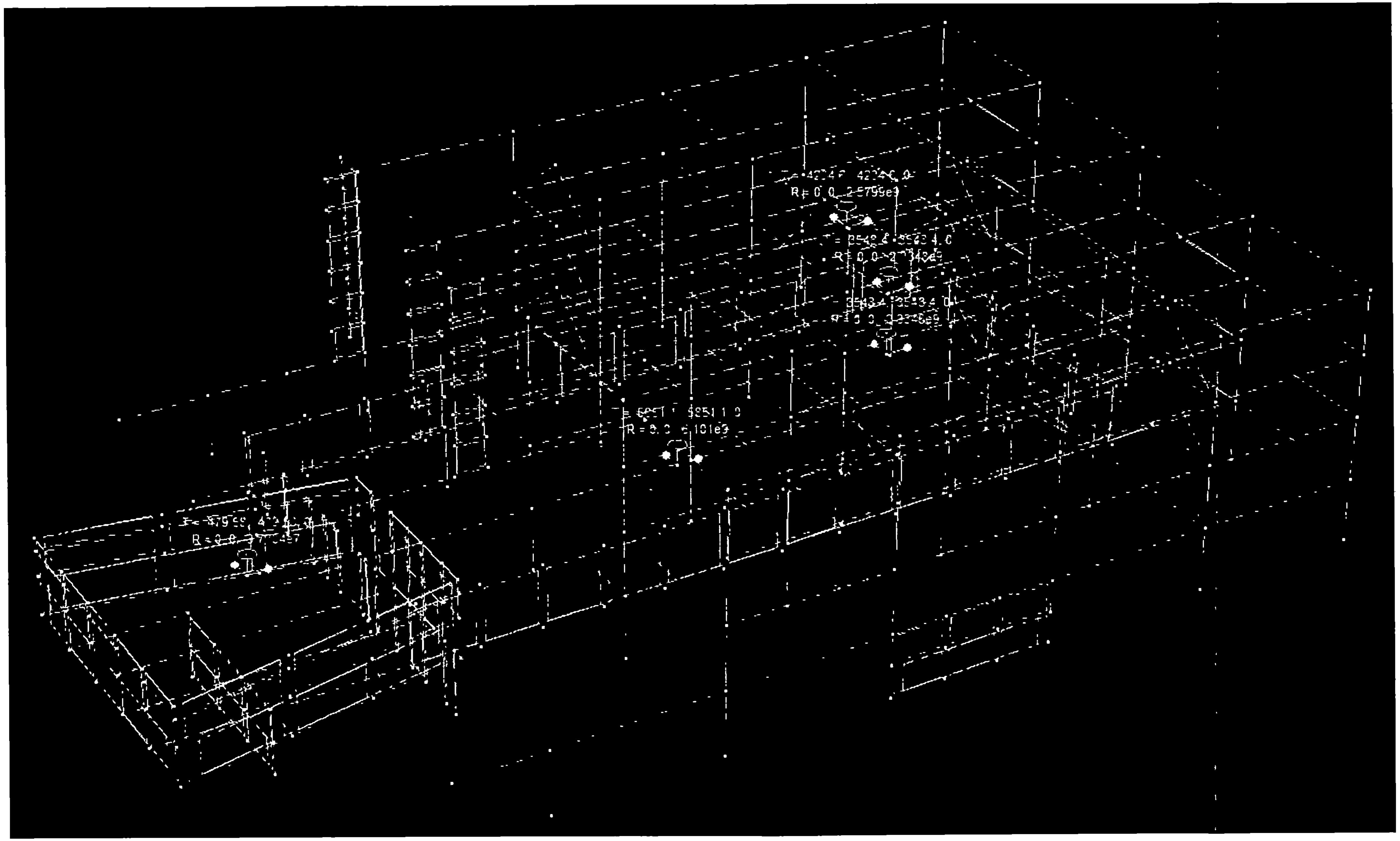

Figure 3-11 Overall 3D view of PERFORM-3D Model with H_1, H_2, V_{rot} masses (kip, kip-in^2)

4 - Gravity Load Patterns

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	client		job no.	2000362	

Executive Summary

This section provide an overview of the calculations done to generate gravity and seismic loads resisted by the beams at every floor. To do so, tributary areas were calculated for each beam. Being a two-way slab, the tributary area results in a triangular loading applied to the beam. To implement this loading in perform-3D, an equivalent distributed load was calculated that resulted with the same moment reactions and magnified shear loads at the ends of the beams. Therefore, positive shear loads are calculated and applied at each end of the beam to account for this discrepancy.

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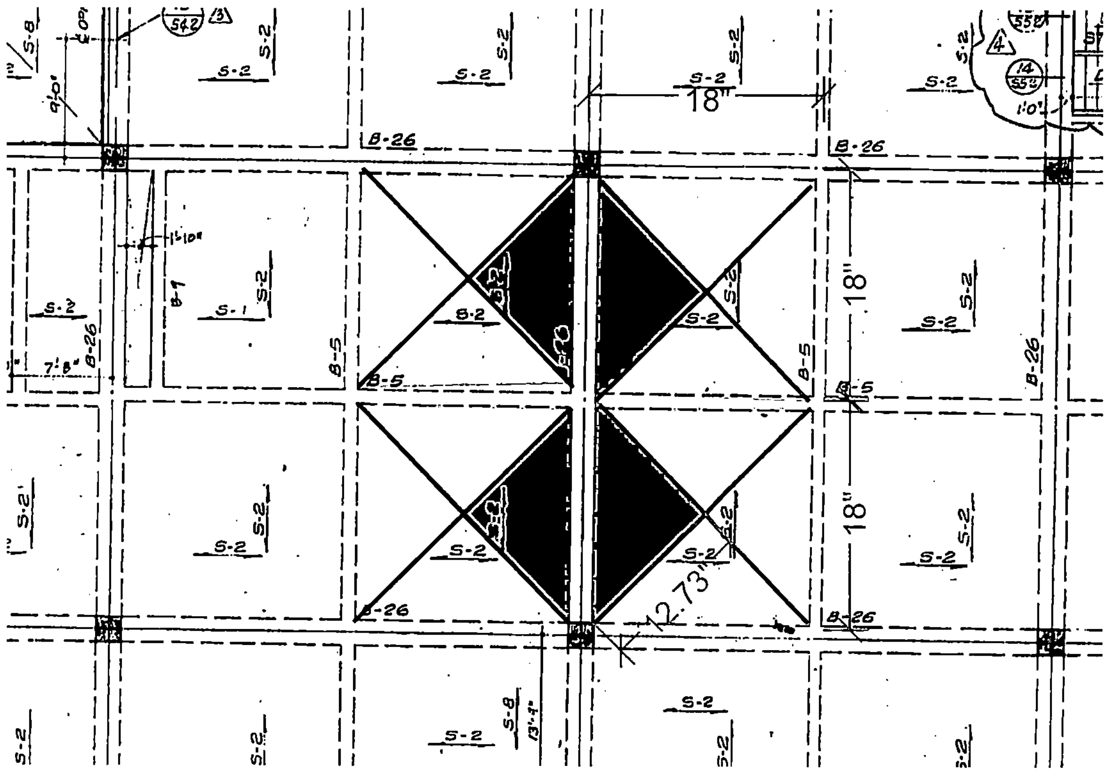
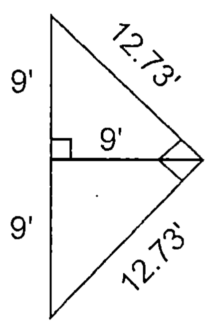
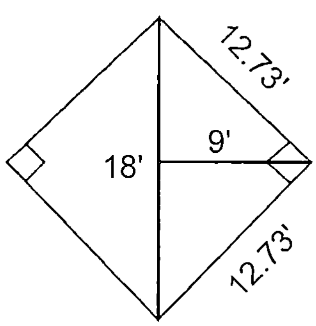
1st Floor - Typical Interior Beam



Typical Triangle Dimensions

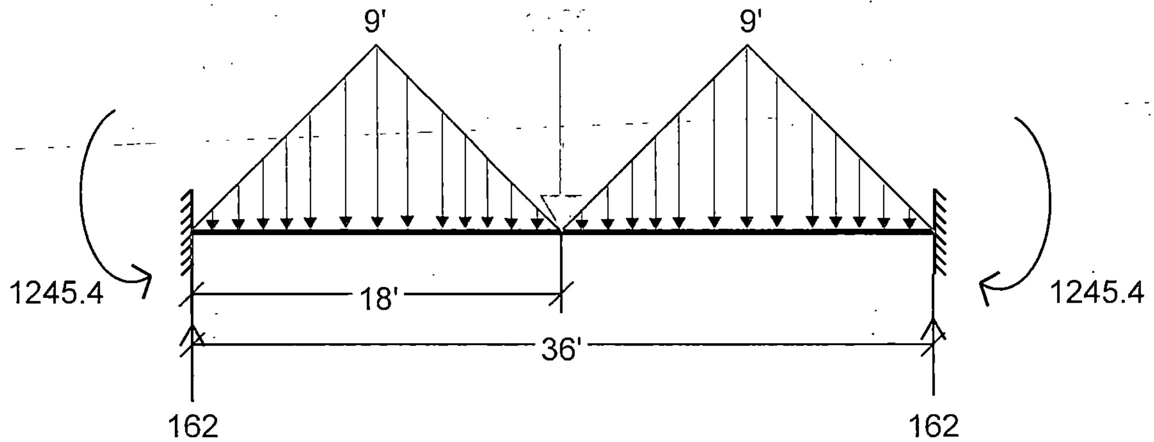


Area of the triangle is calculated as follows:
$A = (12.73)^2/2 = 81.03\ ft^2$

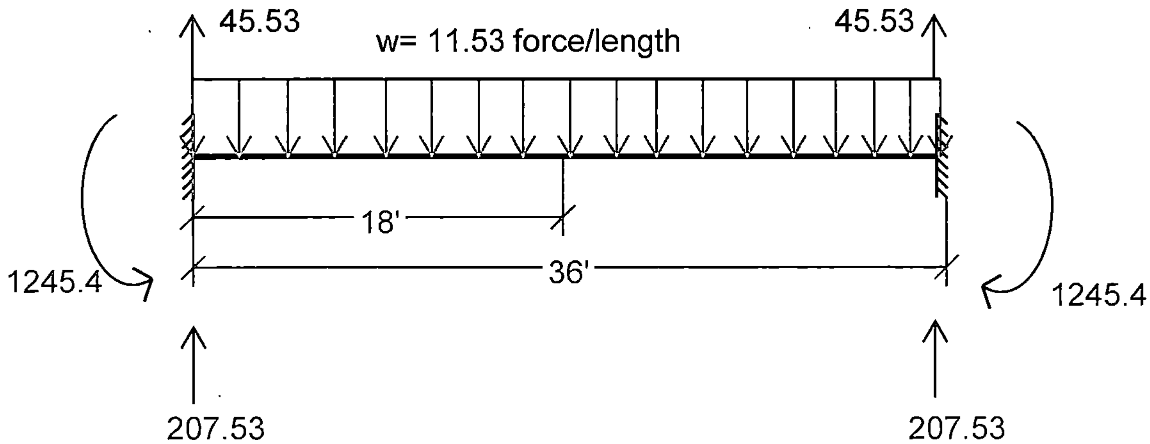


Every two triangles form a square of Area
$A = (12.73)^2 = 162\ ft^2$

TYPICAL TRIBUTARY AREA ASSOCIATED WITH EACH SIDE OF THE BEAM



TYPICAL TRIBUTARY EQUIVALENT LOAD ASSOCIATED WITH EACH SIDE OF THE BEAM



By using Enercal SEL (see next sheet) the reactions are calculated to be
M_{end} = 1245.375 force-length units
V_{end} = 162 force units

The equivalent distributed load that would generate the same moment reactions is calculated as follows:

$M_{end} = wl^2/12 \rightarrow w = M_{end} \times 12 / l^2 = 1245.375 \times 12 / 36^2 = 11.53$ force/length units
$V_{end} = wl/2 = 11.52 \times 36 / 2 = 207.53$ force units

To account for the added shear load, a vertical shear force must be applied at EA end of Bean

$V_{applied} = 207.53 - 162 = 45.53$ force units

MOMENT AND SHEAR REACTIONS DUE TO THE TRIANGULAR LOADING

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General Beam

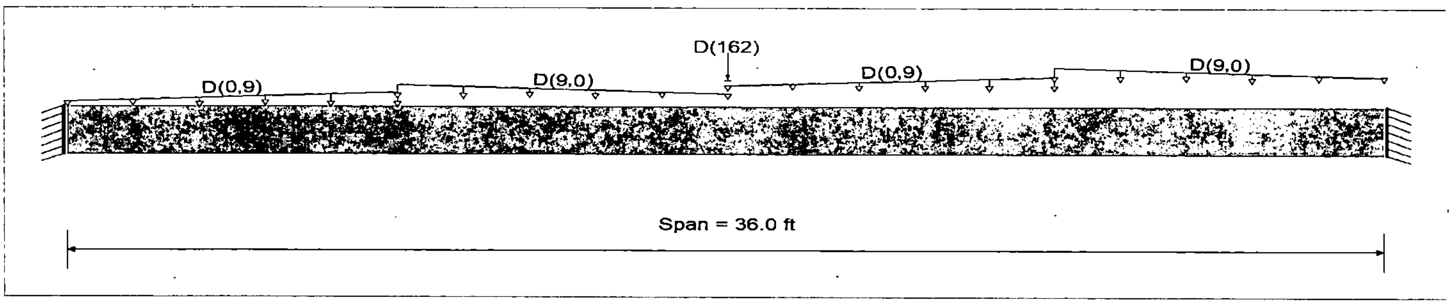
File: Beam Equivalent Trib Area.ec6
Software copyright ENERCALC, INC. 1983-2020, Build:12.20.8.17

Lic. # : KW-06008320 KPFF

DESCRIPTION: Trianglular Loading and Point Load Based on Trib Area

General Beam Properties

Elastic Modulus	29,000.0 ksi					
Span #1	Span Length =	36.0 ft	Area =	10.0 in^2	Moment of Inertia =	100.0 in^4



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Load for Span Number 1

Varying Uniform Load : D= 0.0->9.0 k/ft, Extent = 0.0 -->> 9.0 ft, Trib Width = 1.0 ft, (Area Load 1)

Varying Uniform Load : D= 9.0->0.0 k/ft, Extent = 9.0 -->> 18.0 ft, Trib Width = 1.0 ft, (Area Load 2)

Varying Uniform Load : D= 0.0->9.0 k/ft, Extent = 18.0 -->> 27.0 ft, Trib Width = 1.0 ft, (Area Load 3)

Varying Uniform Load : D= 9.0->0.0 k/ft, Extent = 27.0 -->> 36.0 ft, Trib Width = 1.0 ft, (Area Load 3)

Point Load : D = 162.0 k @ 18.0 ft, (Point Load)

END MOMENT REACTION

END SHEAR REACTION

DESIGN SUMMARY

Maximum Bending =	$\boxed{1,245.375 \text{ k-ft}}$	Maximum Shear =	$\boxed{162.0 \text{ k}}$
Load Combination	D Only	Load Combination	D Only
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1
Location of maximum on span	36.000 ft	Location of maximum on span	0.000 ft

Maximum Deflection

Max Downward Transient Deflection	0.000 in	0
Max Upward Transient Deflection	0.000 in	0
Max Downward Total Deflection	35.183 in	12
Max Upward Total Deflection	0.003 in	154234

Maximum Forces & Stresses for Load Combinations

Load Combination / Segment Length	Span #	Max Stress Ratios M	V	Summary of Moment Values (k-ft) Mmax +	Mmax -	Ma - Max	Mnx	Mnx/Omega	Cb	Rm	Shear Values (k) Va Max	Vnx	Vnx/Omega
Overall MAXimum Envelope													
Dsgn. L = 36.00 ft	1			941.63	-1,245.37	1,245.37					162.00		
D Only													
Dsgn. L = 36.00 ft	1			941.63	-1,245.37	1,245.37					162.00		

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
D Only	1	35.1827	18.180		0.0000	0.000

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	162.000	162.000
Overall MINimum		
D Only	162.000	162.000
+0.60D	97.200	97.200

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File: Beam Equivalent Trib Area.ec6
Software copyright ENERCALC, INC. 1983-2020, Build:12.20.8.17

General Beam

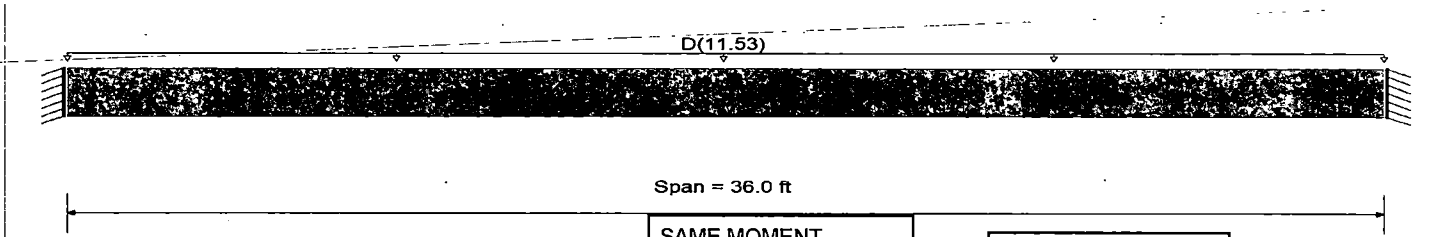
Lic. # : KW-06008320 KPFF

DESCRIPTION: Equivalent Distributed Load

General Beam Properties

Elastic Modulus 29,000.0 ksi

Span #1 Span Length = 36.0 ft Area = 10.0 in^2 Moment of Inertia = 100.0 in^4



SAME MOMENT REACTION AS TRIANGULAR LOADING

SHEAR REACTION IS DIFFERENT.

Applied Loads

entere[illegible]plied for calculations.

Uniform Load : D = 11.530 k/ft, Tributary Width = 1.0 ft, (Dist Load)

DESIGN SUMMARY

Maximum Bending =	$\boxed{1,245.240 \text{ k-ft}}$	Maximum Shear =	$\boxed{207.540 \text{ k}}$
Load Combination	D Only	Load Combination	D Only
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1
Location of maximum on span	36.000 ft	Location of maximum on span	36.000 ft

Maximum Deflection

Max Downward Transient Deflection	0.000 in	0
Max Upward Transient Deflection	0.000 in	0
Max Downward Total Deflection	30.051 in	14
Max Upward Total Deflection	0.007 in	60198

Maximum Forces & Stresses for Load Combinations

Load Combination		Max Stress Ratios		Summary of Moment Values (k-ft)							Shear Values (k)		
Segment Length	Span #	M	V	Mmax +	Mmax -	Ma - Max	Mnx	Mnx/Omega	Cb	Rm	Va Max	Vnx	Vnx/Omega
Overall MAXimum Envelope													
Dsgn. L = 36.00 ft	1			622.62	-1,245.24	1,245.24					207.54		
D Only													
Dsgn. L = 36.00 ft	1			622.62	-1,245.24	1,245.24					207.54		

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
D Only	1	30.0507	18.180		0.0000	0.000

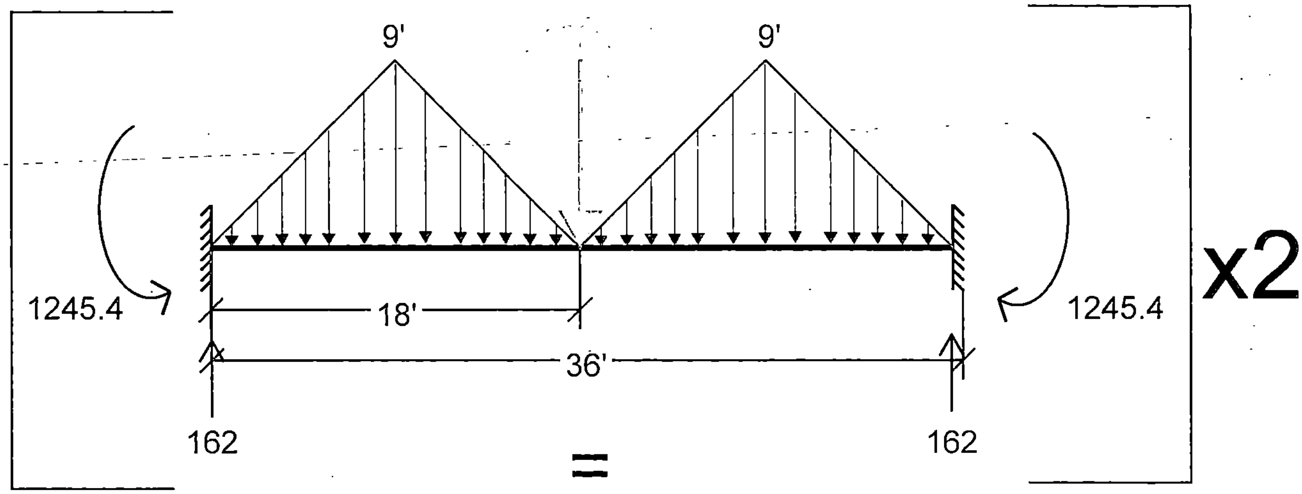
Vertical Reactions

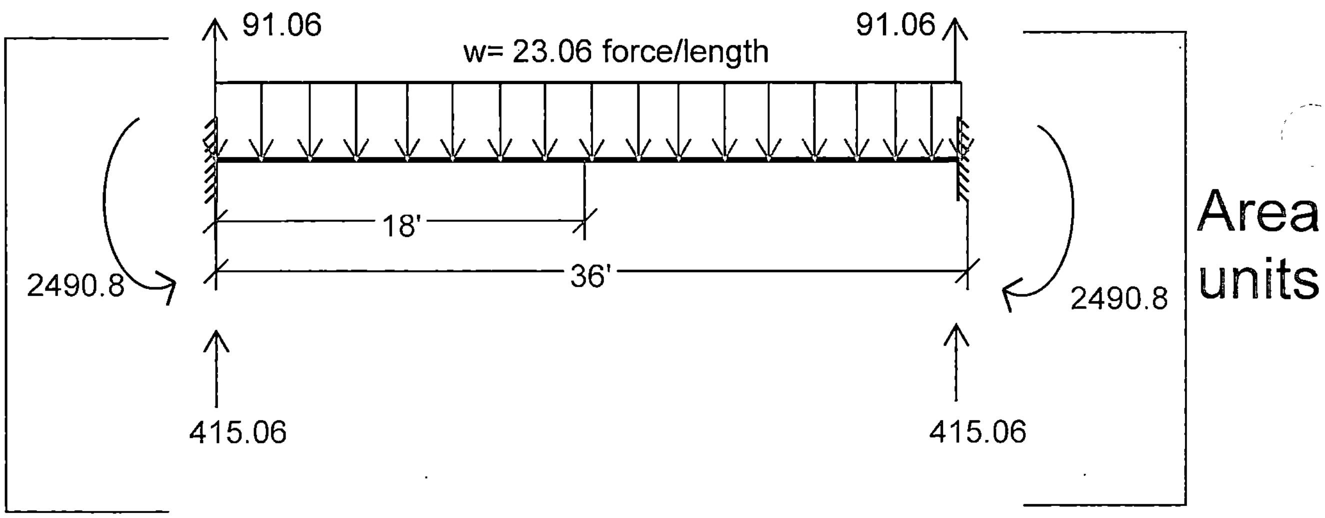
Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	207.540	207.540
Overall MINimum		
D Only	207.540	207.540
+0.60D	124.524	124.524

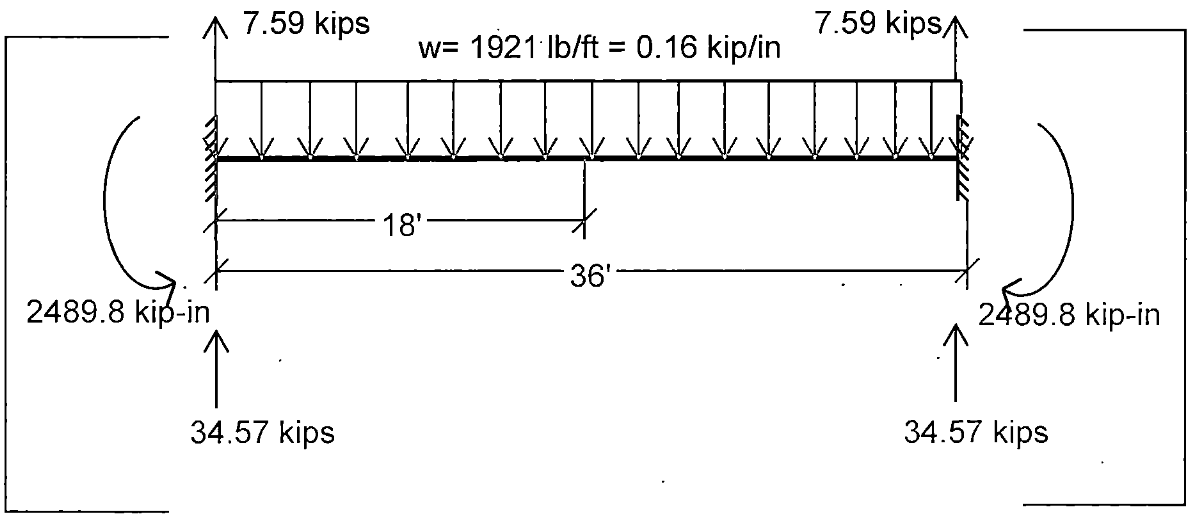
Typical Beams

TYPICAL TRIBUTARY AREA FOR INTERIOR BEAMS





1st floor dead load is = 83.3 psf -> Multiply by 83.3psf



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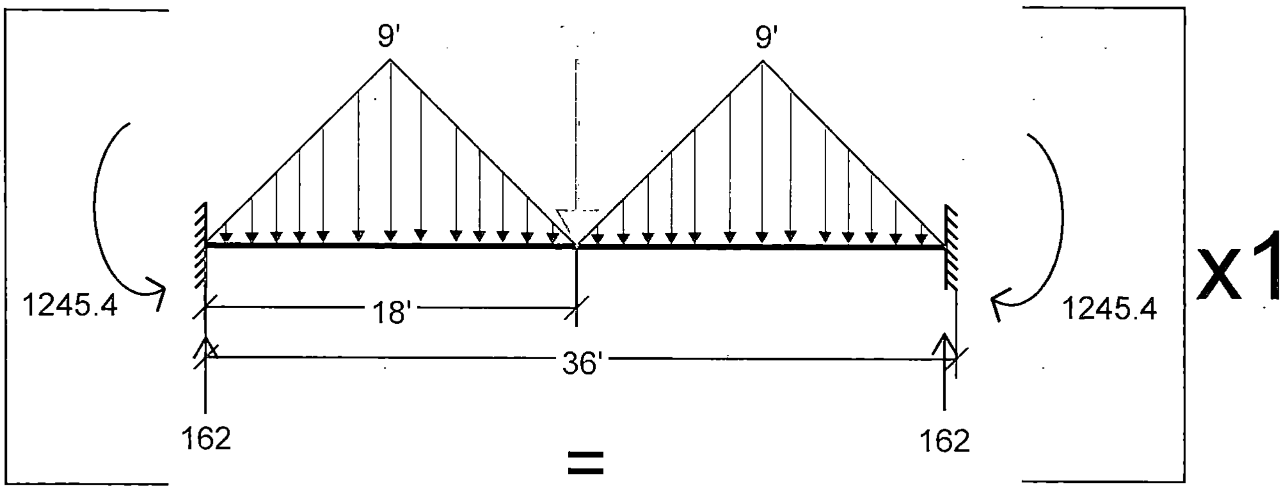
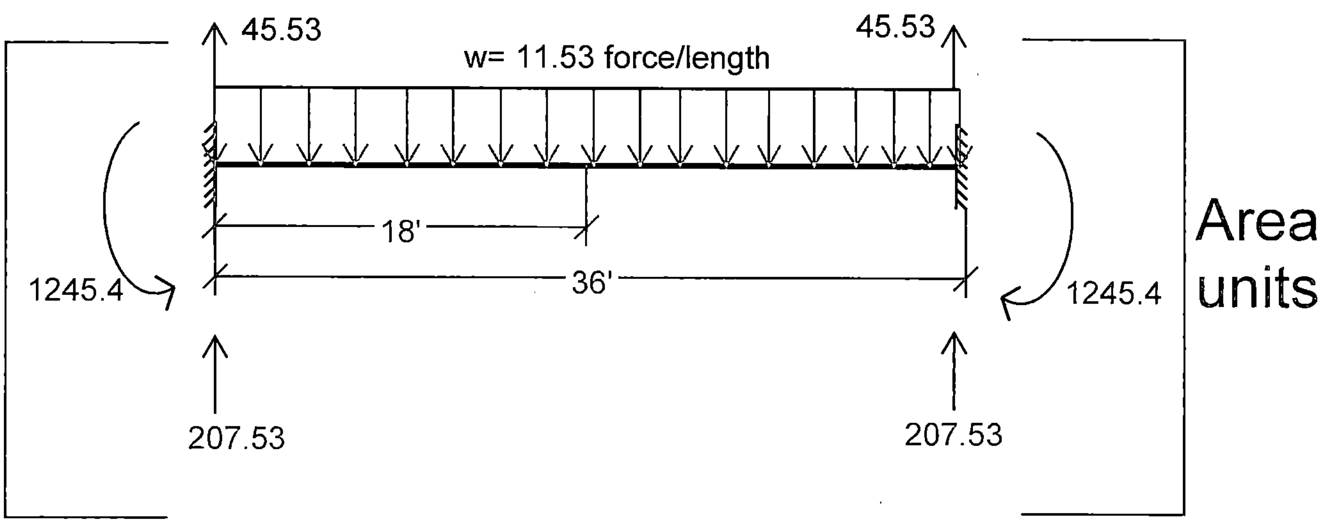
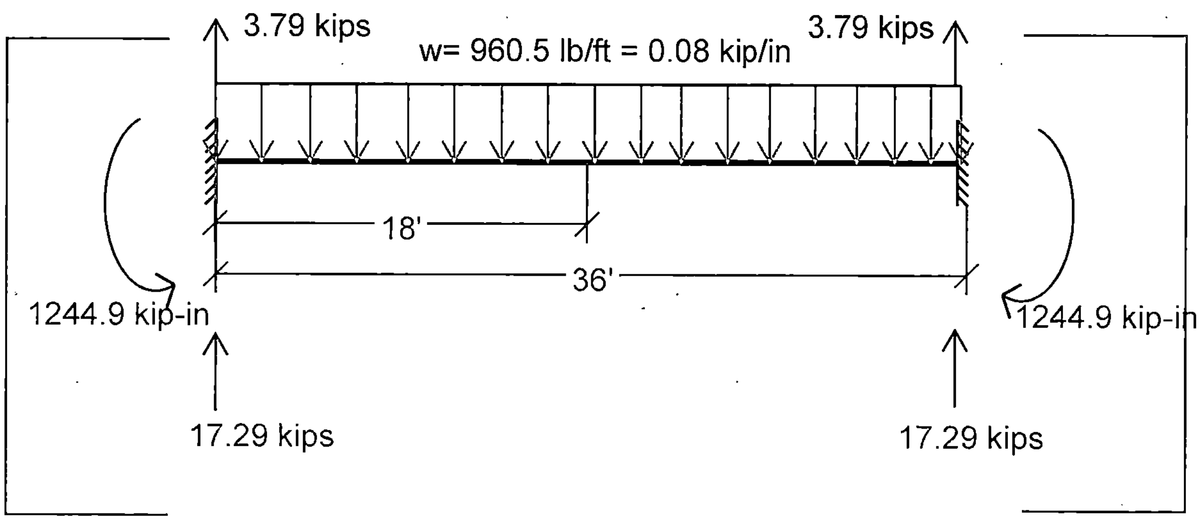
	client	job no. 2000362	
	Perimeter Beams		

TYPICAL TRIBUTARY AREA FOR EXTERIOR BEAMS





1st floor dead load is = 83.3 psf -> Multiply by 83.3psf



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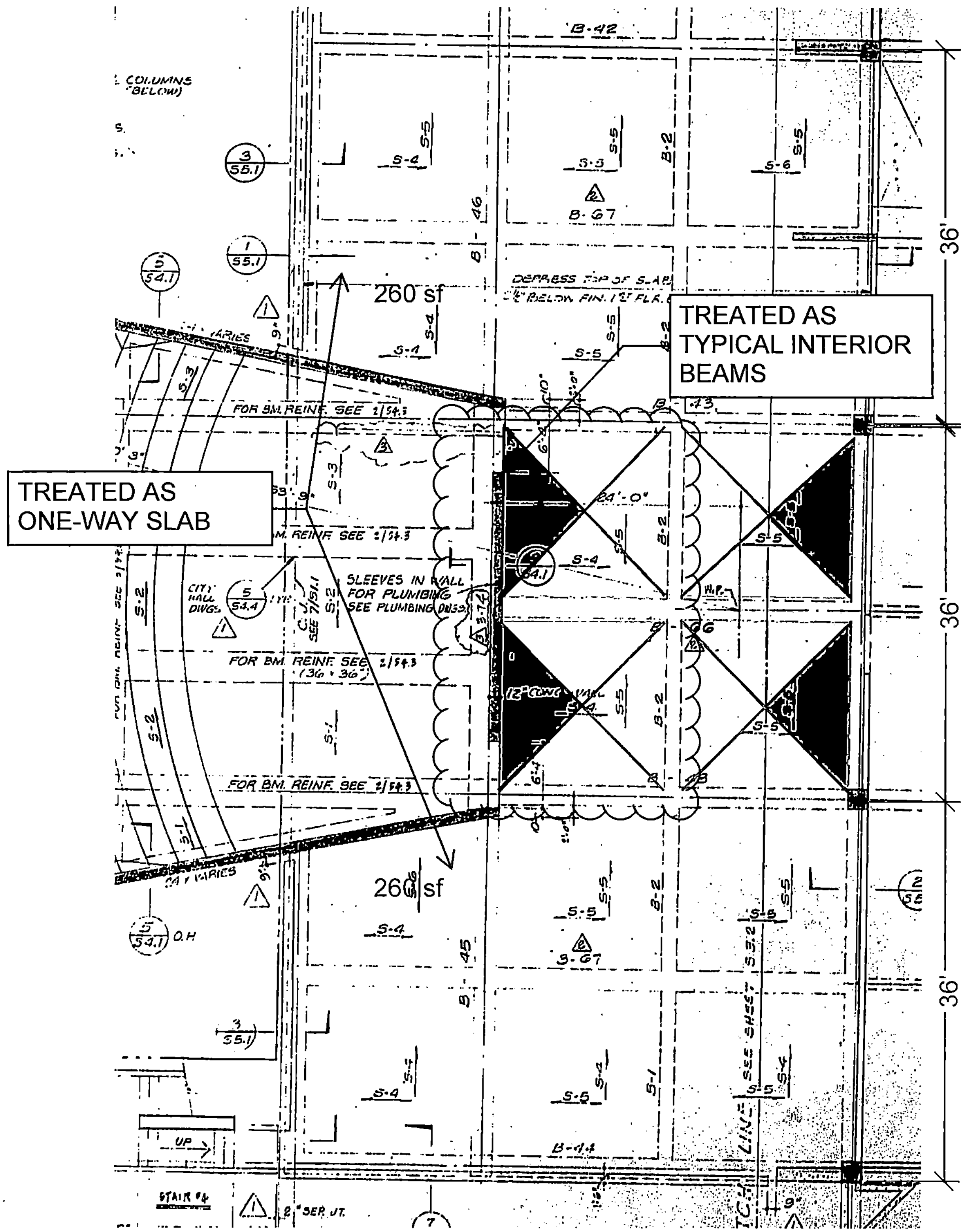

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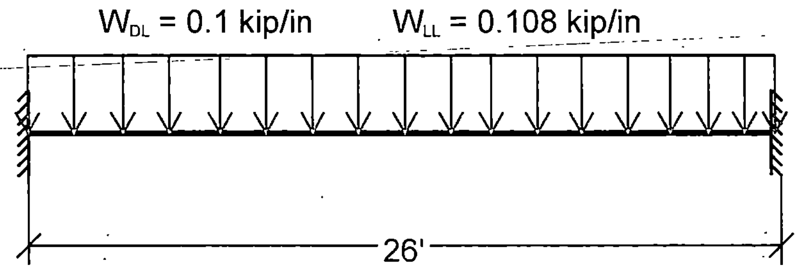
project	City of Inglewood - Library Bldg	by JB	sheet no. 4-12
location	Inglewood, CA	date 11-24-2020	
client		job no. 2000362	

DIAGONAL BEAMS OF LECTURE HALL



TRIBUTARY AREA = 260 ft^2 (measured using Bleabeam)
DL = 83.3 lb/ft^2
LL = 90 lb/ft^2
W_{DL} = (83.3lb/ft^2)x260'/18' = 1203.22 lb/ft = 0.1 kip/in
W_{LL} = (90lb/ft2)x260'/18' = 1300 lb/ft = 0.108 kip/in

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Los Angeles, CA 90017	client	job no. *1900802*	
(213) 418-0201	1st Floor Beams		

Typical Interior Beam

	Trib Area	DL (psf)	DL in Perform	LL (psf)	LL in Perform	Multiplier	2
Dist Load (kip/in)	11.53	83.3	0.1601	90	0.1730		
Added Shear (kips)	45.53	83.3	7.5853	90	8.1954		
Shear React (kips)	207.53	83.3	34.57	90	37.36		
M. react (kip-in)	1245.4	83.3	2489.80	90	2690.06		

Typical Exterior Beam

	Trib Area	DL (psf)	DL in Perform	LL (psf)	LL in Perform	Multiplier	1
Dist Load (kip/in)	11.53	83.3	0.0800	90	0.0865		
Added Shear (kips)	45.53	83.3	3.7926	90	4.0977		
Shear React (kips)	207.53	83.3	17.29	90	18.68		
M. react (kip-in)	1245.4	83.3	1244.90	90	1345.03		

Note: Additional line load is to be applied to account for the exterior walls

Lecture Hall Beams

Diagonal Beams - Treated as one way Slabs

	Tri Area (ft^2)	DL (psf)	DL in Perform	LL (psf)	LL in Perform	Length (ft)	18
Dist Load (kip/in)	260	83.3	0.1003	90	0.1083		

Vertical Beam

	Trib Area	DL (psf)	DL in Perform	LL (psf)	LL in Perform	Multiplier	1
Dist Load (kip/in)	11.53	83.3	0.0800	90	0.0865		
Added Shear (kips)	45.53	83.3	3.7926	90	4.0977		
Shear React (kips)	207.53	83.3		90			
M. react (kip-in)	1245.4	83.3		90			

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client		job no.	1900802
	2nd & 3rd Floor Beams	sheet no	

Typical Interior Beam

	Trib Area	DL (psf)	DL in Perform	LL (psf)	LL in Perform	Multiplier	2
Dist Load (kip/in)	11.53	77.4	0.1487	90	0.1730		
Added Shear (kips)	45.53	77.4	7.0480	90	8.1954		
Shear React (kips)	207.53	77.4	32.13	90	37.36		
M. react (kip-in)	1245.4	77.4	2313.46	90	2690.06		

Typical Exterior Beam

	Trib Area	DL (psf)	DL in Perform	LL (psf)	LL in Perform	Multiplier	1
Dist Load (kip/in)	11.53	77.4	0.0744	90	0.0865		
Added Shear (kips)	45.53	77.4	3.5240	90	4.0977		
Shear React (kips)	207.53	77.4	16.06	90	18.68		
M. react (kip-in)	1245.4	77.4	1156.73	90	1345.03		

Note: Additional line load is to be applied to account for the exterior walls

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location	Inglewood, CA	date	11/30/2020
client		job no.	1900802
Roof Floor Beams		sheet no	

Typical Interior Beam

	Trib Area	DL (psf)	DL in Perform	LL (psf)	LL in Perform	Multiplier	2
Dist Load (kip/in)	11.53	86.4	0.1660	20	0.0384		
Added Shear (kips)	45.53	86.4	7.8676	20	1.8212		
Shear React (kips)	207.53	86.4	35.86	20	8.30		
M. react (kip-in)	1245.4	86.4	2582.46	20	597.79		

Typical Exterior Beam

	Trib Area	DL (psf)	DL in Perform	LL (psf)	LL in Perform	Multiplier	1
Dist Load (kip/in)	11.53	86.4	0.0830	20	0.0192		
Added Shear (kips)	45.53	86.4	3.9338	20	0.9106		
Shear React (kips)	207.53	86.4	17.93	20	4.15		
M. react (kip-in)	1245.4	86.4	1291.23	20	298.90		

Note: Additional line load is to be applied to account for the exterior walls

Interior Mechanical Area Beam

	Trib Area	DL (psf)	DL in Perform	LL (psf)	LL in Perform	Multiplier	2
Dist Load (kip/in)	11.53	86.4	0.1660	125	0.2402		
Added Shear (kips)	45.53	86.4	7.8676	125	11.3825		
Shear React (kips)	207.53	86.4	35.86	125	51.88		
M. react (kip-in)	1245.4	86.4	2582.46	125	3736.20		

Exterior Mechanical Area Beam

	DL in Perform	LL in Perform
Dist Load (kip/in)	0.1660	0.1393
Added Shear (kips)	7.8676	6.6019
Shear React (kips)	35.86	30.09
M. react (kip-in)	2582.46	2167.00

Exterior Mechanical Area Beam **ONLY**

	DL in Perform	LL in Perform
Dist Load (kip/in)	0.0830	0.1201
Added Shear (kips)	3.9338	5.6913
Shear React (kips)	1299.10	1094.88
M. react (kip-in)	35.86	51.88

5 - PERFORM-3D Model Overview

Executive Summary

This section includes the overview of the PERFORM-3D model. In the PERFORM-3D analysis model, nonlinear elements include concrete shear walls, concrete moment frame beams and columns, and fluid viscous dampers. Gravity supporting beams and columns are included to capture P-delta effects and weight only. The model has been modeled as pinned at the foundation level per Section 6.1.2 of the Basis of Design.

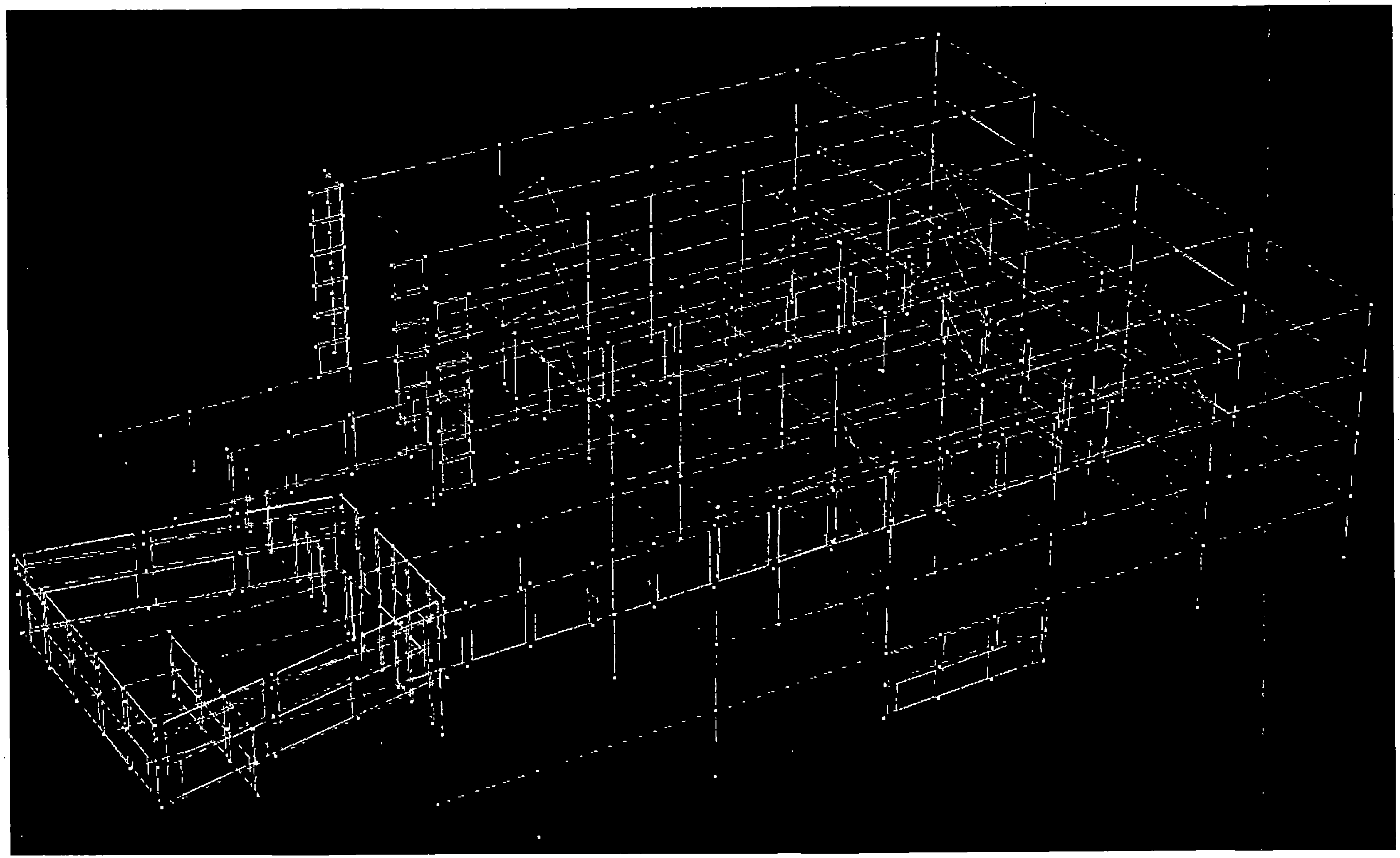

Figure 5-1 PERFORM-3D Model, Isometric View

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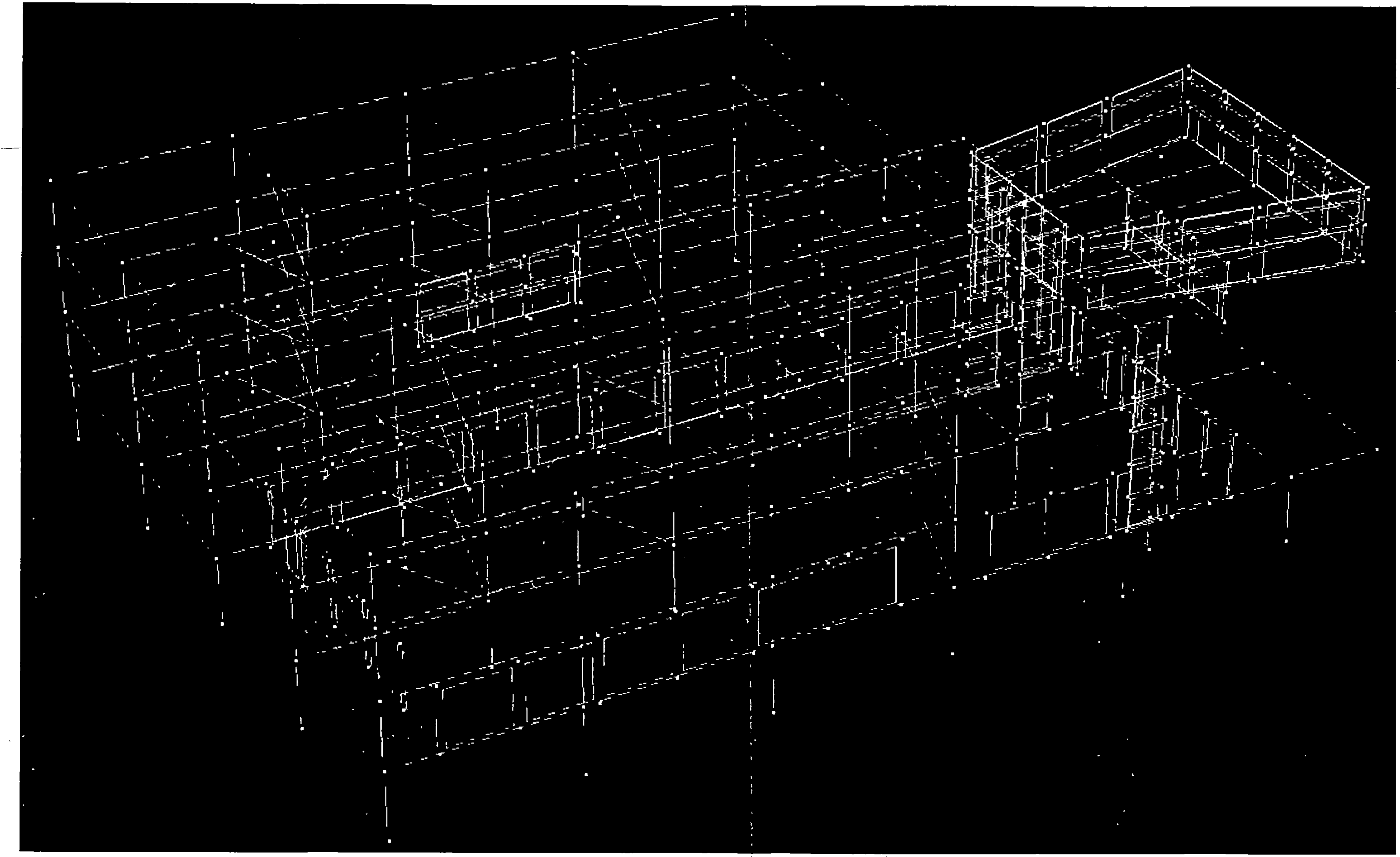

Figure 5-2 PERFORM-3D Model, Isometric View

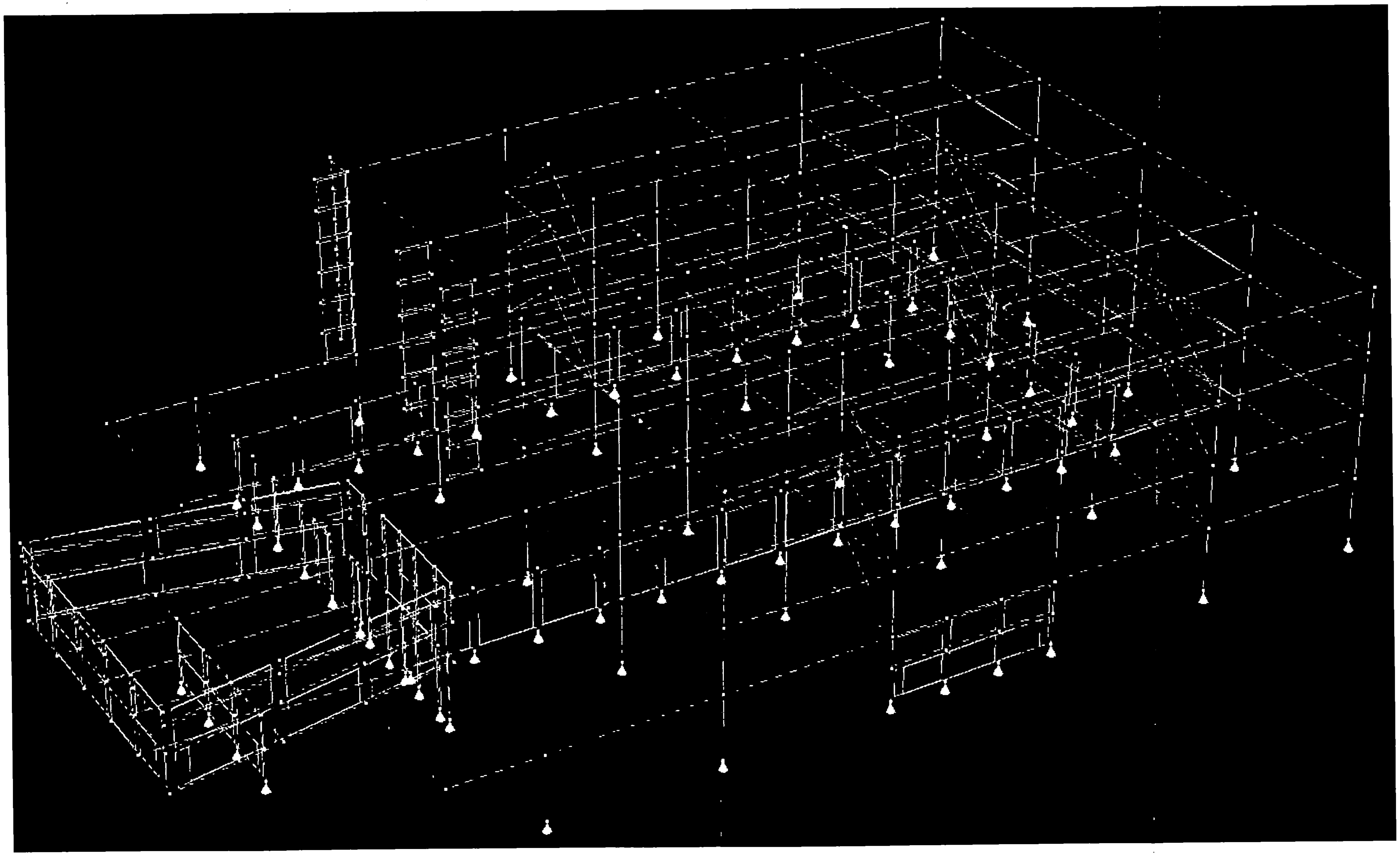

Figure 5-3 PERFORM-3D Model, Isometric View with Nodal Restraints (pinned at the base)

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client	job no. 2000362	

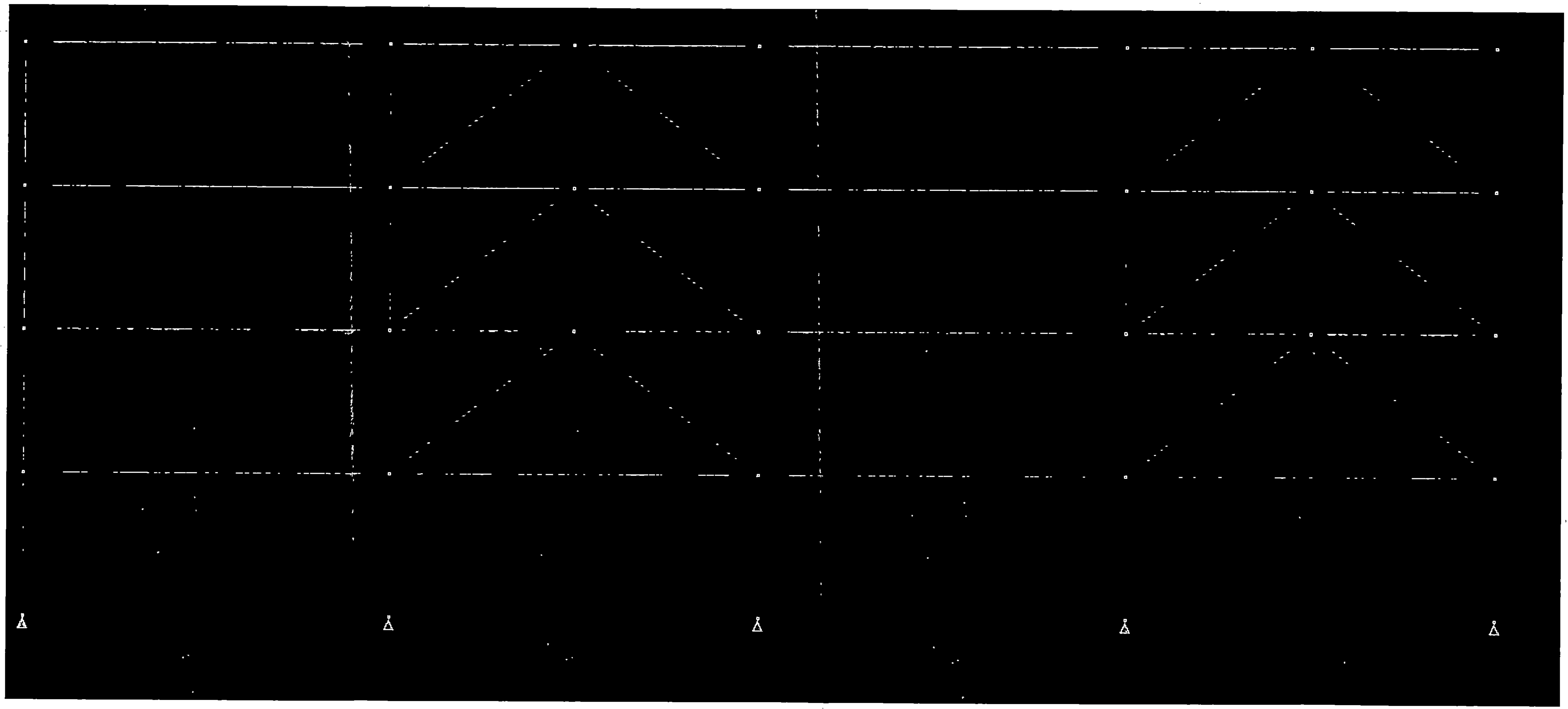

Figure 5-4 PERFORM-3D Model, Elevation at Gridline 2

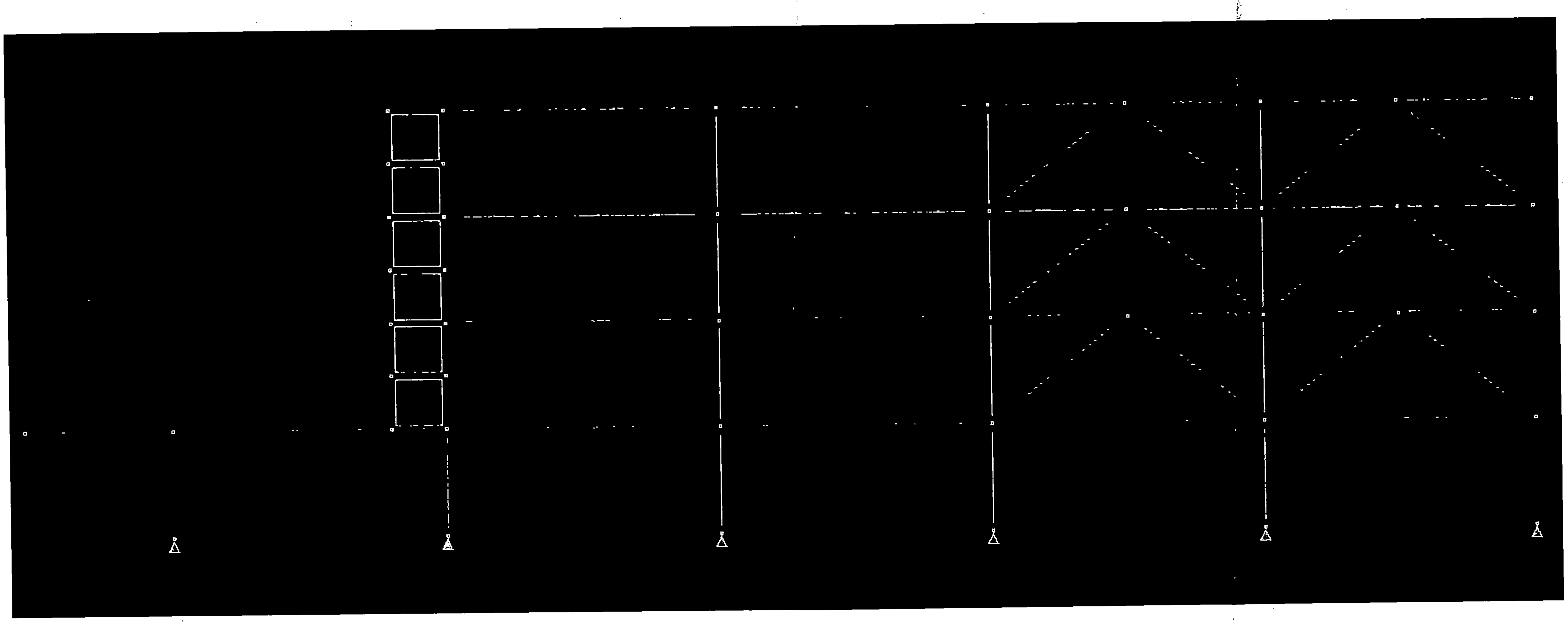

Figure 5-5 PERFORM-3D Model, Elevation at Gridline B

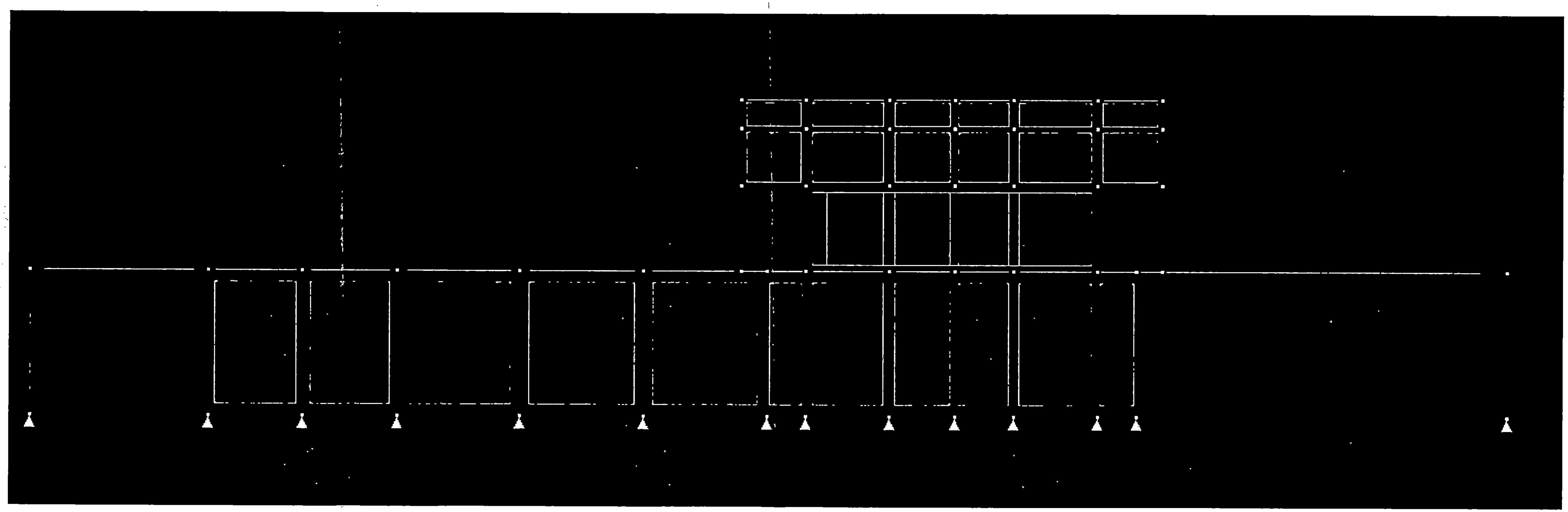

Figure 5-6 PERFORM-3D Model, Elevation at Gridline 6

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project City of Inglewood - Library	by JL	sheet no. 5-9
location	date 6/18/21	
client	job no. 2000362	

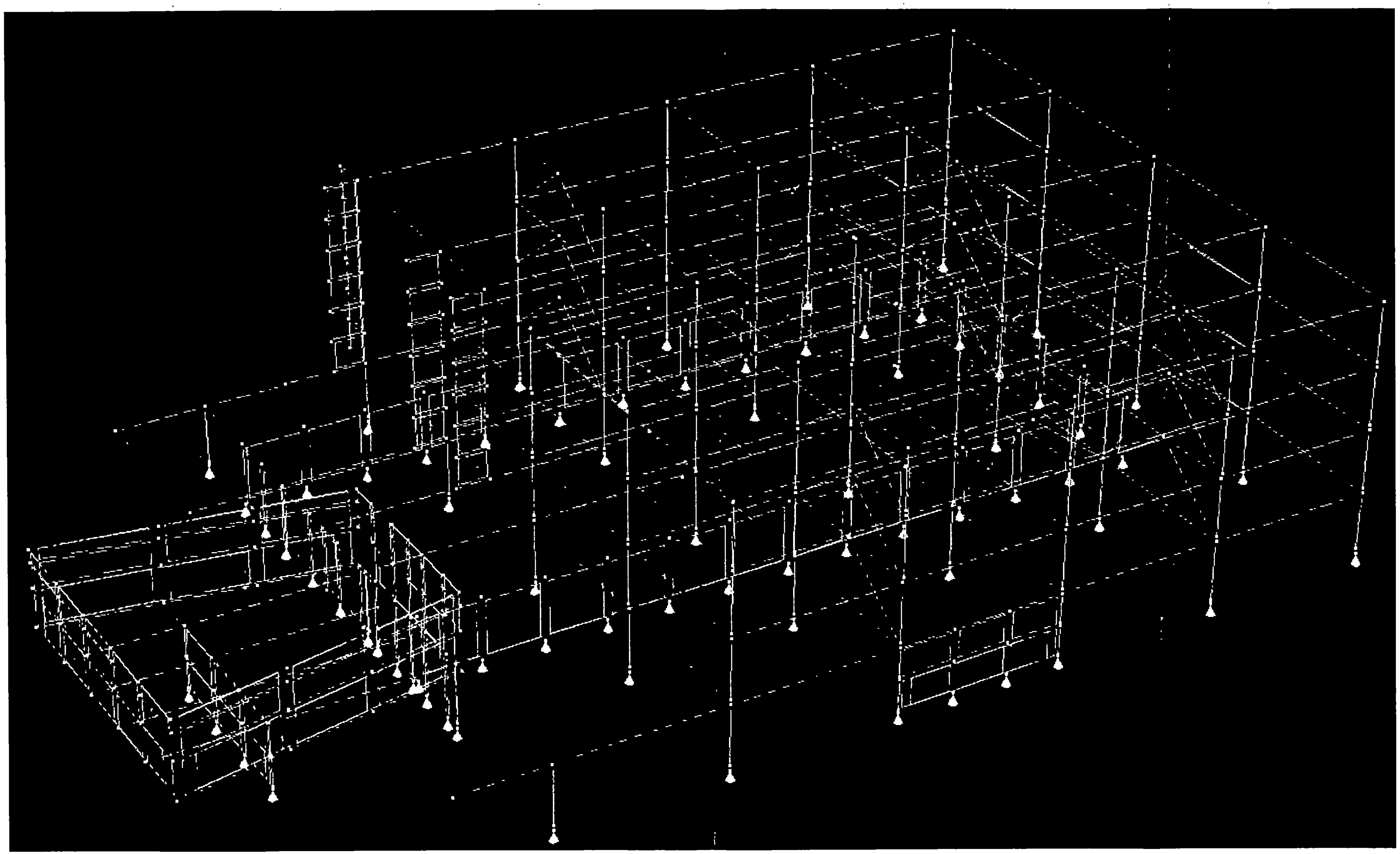

Figure 5-7 PERFORM-3D Model, Nonlinear Column Elements highlighted in blue

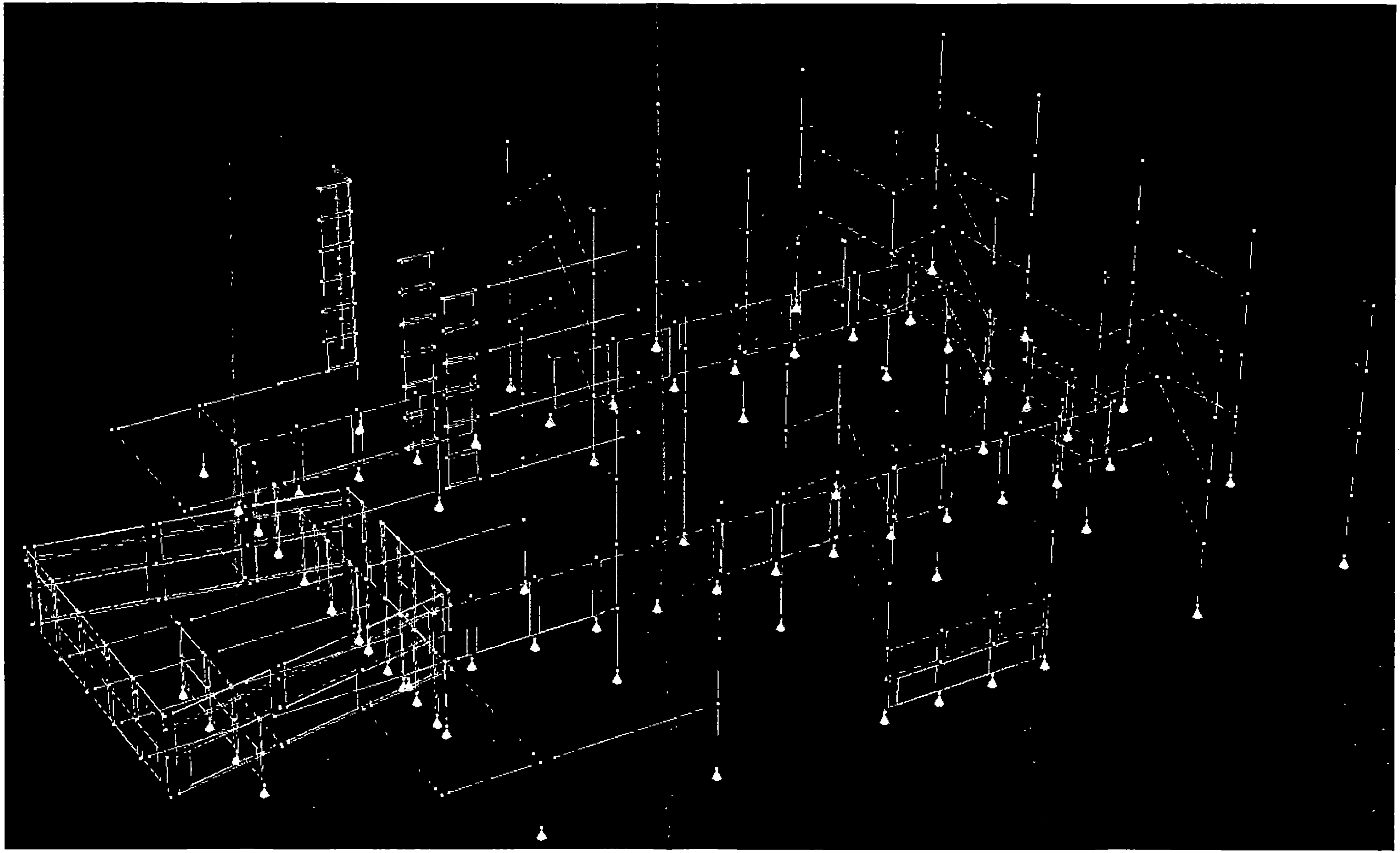

Figure 5-8 PERFORM-3D Model, Elastic Beam Elements highlighted in blue, Nonlinear Beam Elements highlighted in red

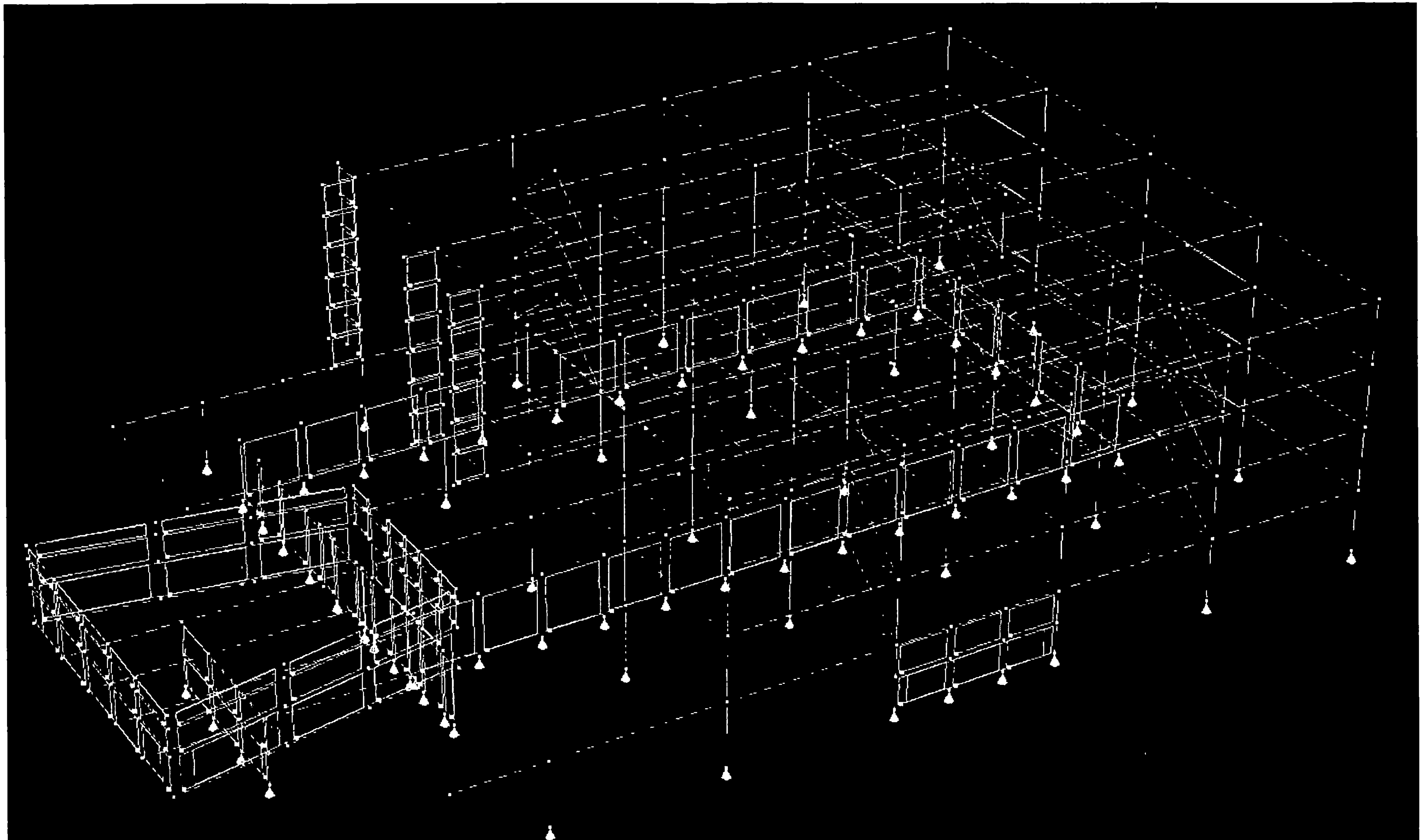

Figure 5-9 PERFORM-3D Model, Shear wall elements highlighted in blue

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location	date 6/18/21	
client	job no. 2000362	

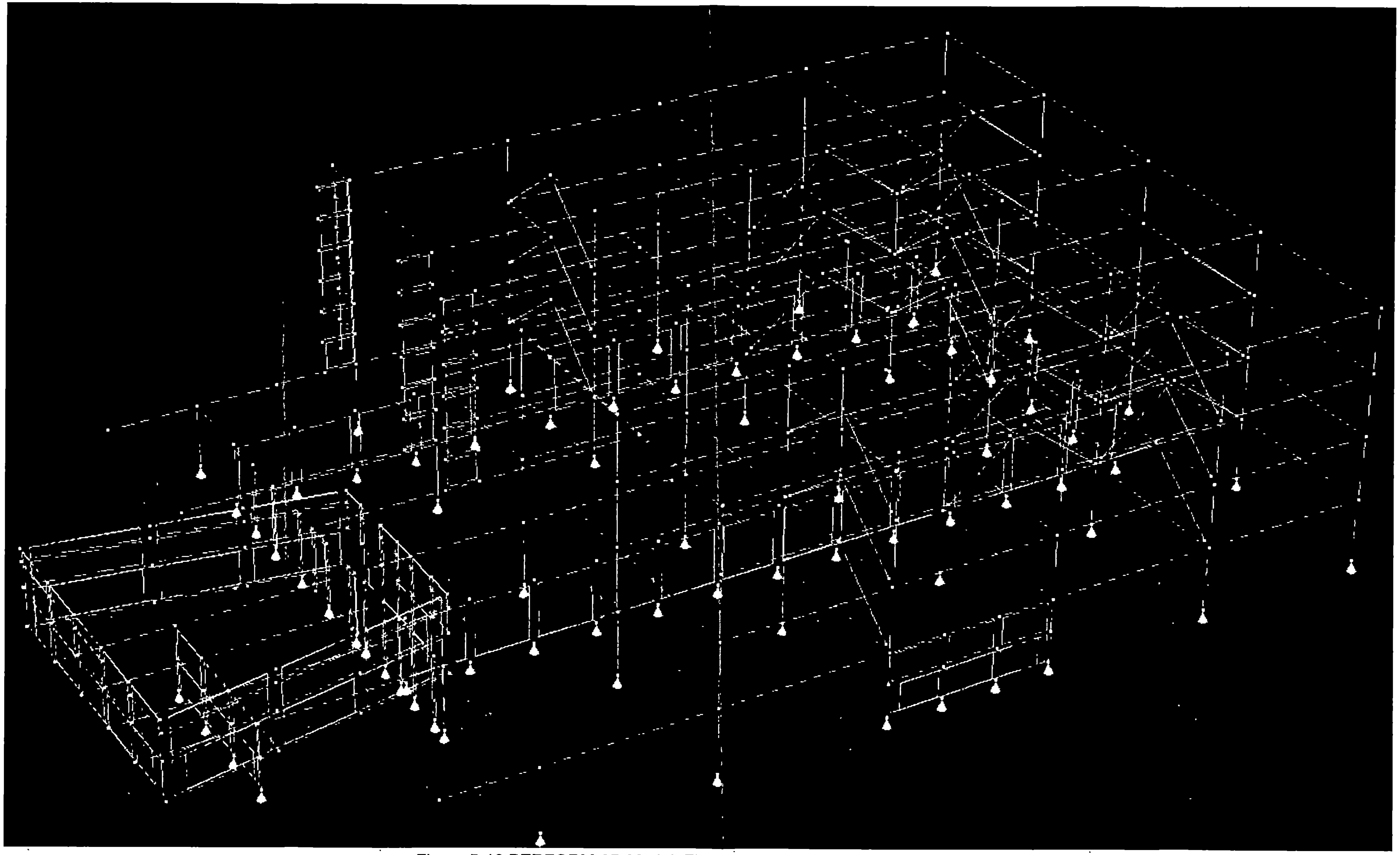
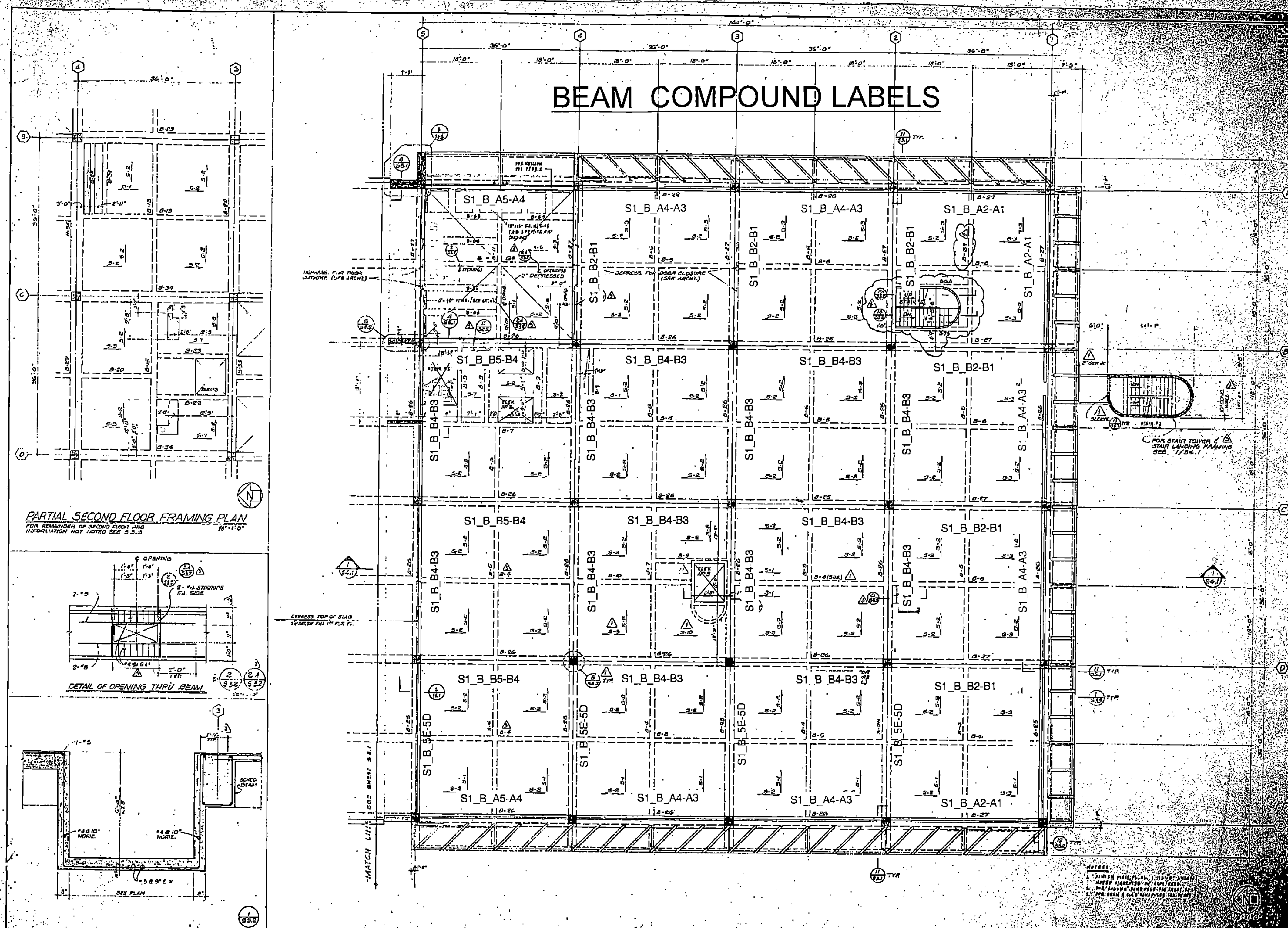


Figure 5-10 PERFORM-3D Model, Fluid Viscous Damper Elements highlighted in blue



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△					△	3-9-71	BLDG. DEPT. CORRECTION	JG	AS
△					△		ADDITION OF STAIR #6	JG	JG
NO.	DATE	REVISION	BY	CHK	NO.	DATE	REVISION	BY	CHK

CONSULTANT: JOHNSON & NIELSEN ASSOC. CONSULTING STRUCTURAL ENGINEERS

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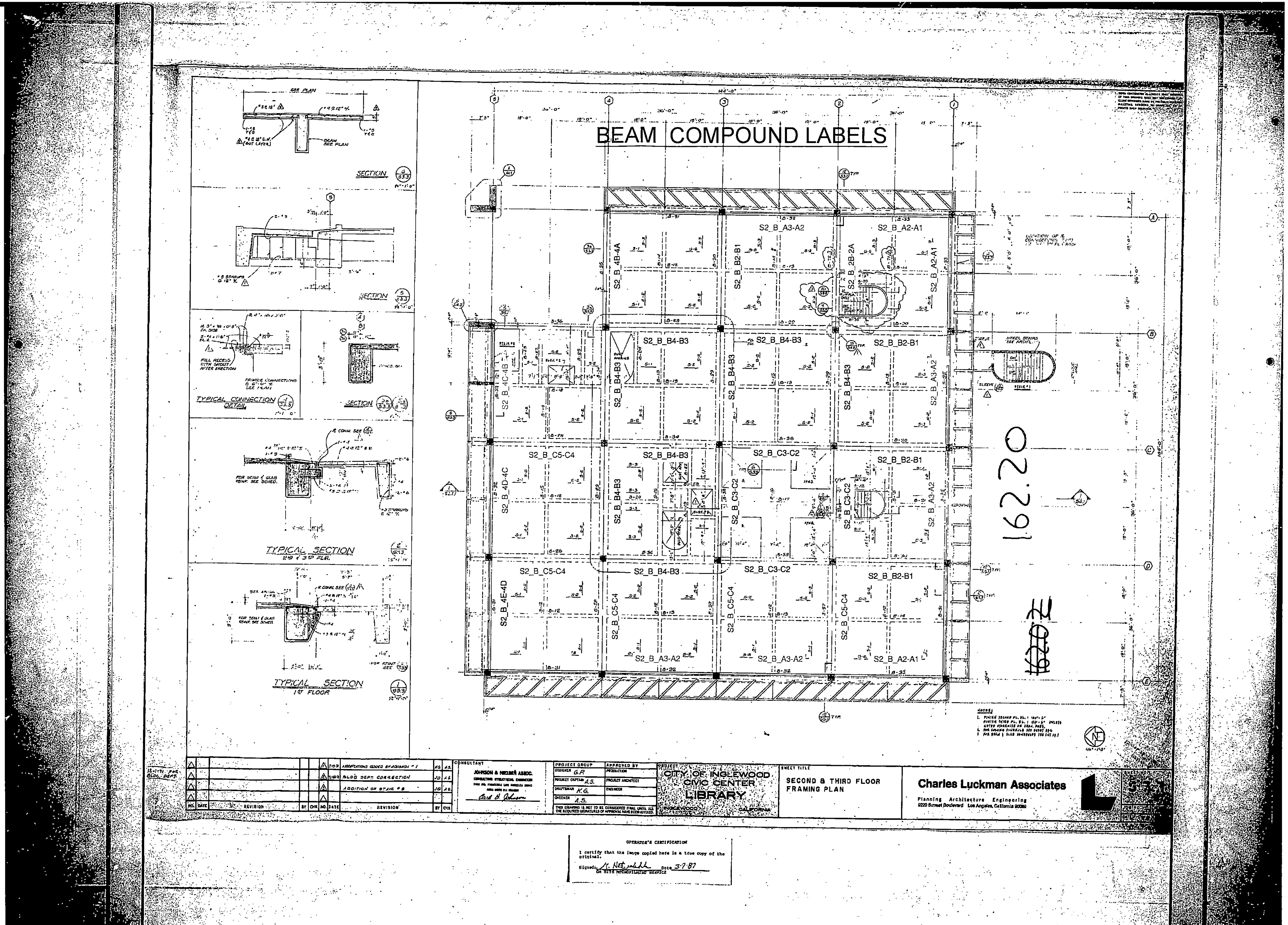

BEAM COMPOUND LABELS
S2_B_A3-A2
S2_B_A2-A1
S2_B_4B-4A
S2_B_B2-B1
S2_B_2B-2A
S2_B_A2-A1
S2_B_4C-4B
S2_B_B4-B3
S2_B_B4-B3
S2_B_B4-B3
S2_B_B4-B3
S2_B_B2-B1
S2_B_B4-B3
S2_B_A3-A2
S2_B_C5-C4
S2_B_B4-B3
S2_B_C3-C2
S2_B_B2-B1
S2_B_4D-4C
S2_B_B4-B3
S2_B_C3-C2
S2_B_C3-C2
S2_B_A3-A2
S2_B_C5-C4
S2_B_B4-B3
S2_B_C3-C2
S2_B_B2-B1
S2_B_4E-4D
S2_B_C5-C4
S2_B_C5-C4
S2_B_C5-C4
S2_B_A3-A2
S2_B_A3-A2
S2_B_A2-A1
162.20
SECTION
SECTION
TYPICAL CONNECTION DETAIL
SECTION
TYPICAL SECTION
2ND & 3RD FLR.
TYPICAL SECTION
1ST FLOOR
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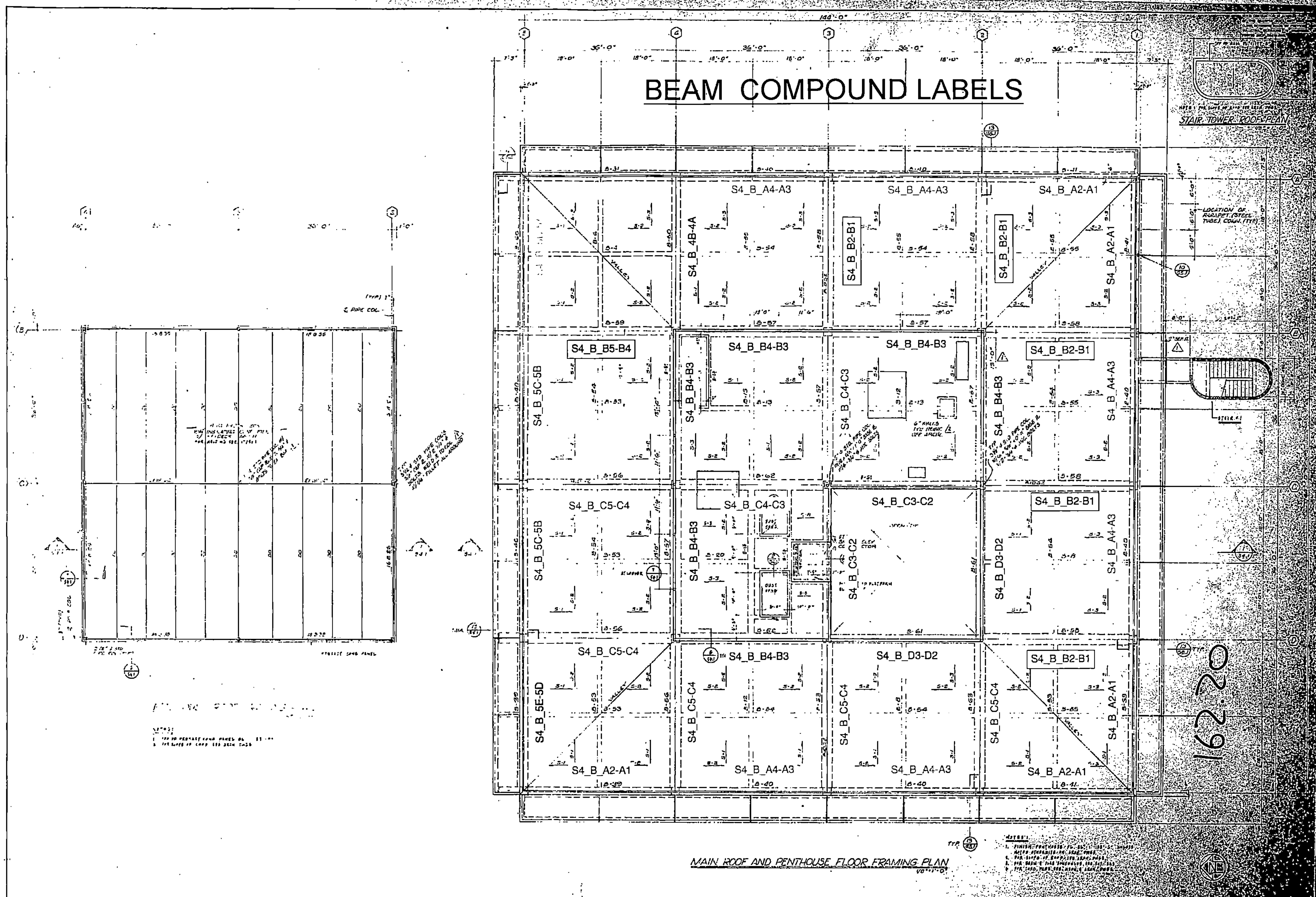

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Beam Hinge Inputs

											I Side of Beam						J Side of Beam					
											Bottom Reinforcement			Top Reinforcement			Bottom Reinforcement			Top Reinforcement		
Beam ID	Level	b (in)	h (in)	L_n (ft)	$f'c_L$ (ksi)	$f'c_E$ (ksi)	fy_L (ksi)	fy_E (ksi)	fy_{tL} (ksi)	fy_{tE} (ksi)	# of Bars B-I	Bar Size B-I	Bot Embed prov. (in) B-I	# of Bars T-I	Bar Size T-I	Splice Length Provided (in) T-I	# of Bars B-J	Bar Size B-J	Bot Embed prov. (in) B-J	# of Bars T-J	Bar Size T-J	Splice Length Provided (in) T-J
S1_B_A5-A4	2	24	36	34	5.042	5.436	65	73	40	50	2	11	36	2	7	18	2	11	48	2	7	18
S1_B_A4-A3	2	24	36	34	5.042	5.436	65	73	40	50	2	11	48	2	7	18	2	11	48	2	7	18
S1_B_A2-A1	2	24	36	34	5.042	5.436	65	73	40	50	2	11	48	2	7	18	2	11	18	2	7	18
S1_B_B5-B4	2	24	36	34	5.042	5.436	65	73	40	50	2	11	36	2	7	18	2	11	48	2	7	18
S1_B_B4-B3	2	24	36	34	5.042	5.436	65	73	40	50	2	11	48	2	7	18	2	11	48	2	7	18
S1_B_B2-B1	2	24	36	34	5.042	5.436	65	73	40	50	2	11	48	2	7	18	2	11	18	2	7	18
S1_B_5B-5A	2	24	36	34	5.042	5.436	65	73	40	50	2	11	48	2	7	18	2	11	18	2	7	18
S1_B_5E-5D	2	24	36	34	5.042	5.436	65	73	40	50	2	11	18	2	7	18	2	11	48	2	7	18
S1_B_1E-1D	2	24	36	34	5.042	5.436	65	73	40	50	2	11	18	2	7	18	2	11	48	2	7	18
S2_B_A4-A3	3	24	36	34	5.042	5.436	65	73	40	50	2	11	18	2	7	18	2	11	48	2	7	18
S2_B_A3-A2	3	24	36	34	5.042	5.436	65	73	40	50	2	11	48	2	7	18	2	11	48	2	7	18
S2_B_A2-A1	3	24	36	34	5.042	5.436	65	73	40	50	2	11	48	2	7	18	2	11	18	2	7	18
S2_B_B5-B4	3	23	36	34	5.042	5.436	65	73	40	50	2	11	18	2	7	18	2	11	36	2	7	18
S2_B_B4-B3	3	28	30	34	5.042	5.436	65	73	40	50	2	14	36	2	7	18	2	14	36	2	7	18
S2_B_B2-B1	3	28	30	34	5.042	5.436	65	73	40	50	2	14	36	2	7	18	2	14	18	2	7	18
S2_B_C5-C4	3	28	30	34	5.042	5.436	65	73	40	50	2	14	18	2	7	18	2	14	36	2	7	18
S2_B_C3-C2	3	24	36	34	5.042	5.436	65	73	40	50	2	11	36	2	7	18	2	11	36	2	7	18
S2_B_4C-4B	3	24	36	34	5.042	5.436	65	73	40	50	2	11	48	2	7	18	2	11	18	2	7	18
S2_B_4D-4C	3	24	36	34	5.042	5.436	65	73	40	50	2	11	48	2	7	18	2	11	48	2	7	18
S2_B_4E-4D	3	24	36	34	5.042	5.436	65	73	40	50	2	11	18	2	7	18	2	11	48	2	7	18
S4_B_A5-A4	5	24	36	34	5.042	5.436	65	73	40	50	2	11	18	2	7	18	2	11	18	2	7	18
S4_B_A4-A3	5	24	34	34	5.042	5.436	65	73	40	50	2	10	18	2	7	18	2	10	18	2	7	18
S4_B_A2-A1	5	24	34	34	5.042	5.436	65	73	40	50	2	11	18	2	7	18	2	11	18	2	7	18
S4_B_B5-B4	5	24	36	34	5.042	5.436	65	73	40	50	2	11	22	2	7	18	2	11	18	2	7	18
S4_B_B4-B3	5	28	30	34	5.042	5.436	65	73	40	50	2	10	18	2	7	18	2	10	18	2	7	18
S4_B_B2-B1	5	28	30	34	5.042	5.436	65	73	40	50	2	11	18	2	7	18	2	11	22	2	7	18
S4_B_C5-C4	5	28	30	34	5.042	5.436	65	73	40	50	2	11	22	2	7	18	2	11	18	2	7	18
S4_B_C4-C3	5	28	30	34	5.042	5.436	65	73	40	50	2	10	18	2	7	18	2	10	18	2	7	18
S4_B_C3-C2	5	24	36	34	5.042	5.436	65	73	40	50	2	10	18	2	7	18	2	10	18	2	7	18
S4_B_D3-D2	5	24	36	34	5.042	5.436	65	73	40	50	2	10	18	2	7	18	2	10	18	2	7	18
S4_B_5B-5A	5	24	36	34	5.042	5.436	65	73	40	50	2	11	18	2	7	18	2	11	22	2	7	18
S4_B_5C-5B	5	24	34	34	5.042	5.436	65	73	40	50	2	10	18	2	7	18	2	10	18	2	7	18
S4_B_5E-5D	5	24	34	34	5.042	5.436	65	73	40	50	2	11	18	2	7	18	2	11	18	2	7	18
S4_B_4B-4A	5	24	36	34	5.042	5.436	65	73	40	50	2	11	18	2	7	18	2	11	22	2	7	18
S2_B_2B-2A	2	24	30	34	5.042	5.436	65	73	40	50	2	14	48	2	7	18	2	14	18	2	7	18
S2_B_4B-4A	2	24	36	34	5.042	5.436	65	73	40	50	2	11	36	2	7	18	2	11	18	2	7	18

			Transverse Reinforcement																
	Cover		At End				At Mid				Gravity Loading				T Shaped Scale Factors				
Beam ID			-E	# of Vert Legs T-E	Spacing (in) T-E	Closed Ties? T-E	Tie Size T-M	# of Vert Legs T-M	Spacing (in) T-M	Closed Ties? T-M	DL (psf)	LL (psf)	Trib Width (ft)	$V_{g,user}$ (k)	Positive SF	Negative SF	Shear/Flexure Controlled	$Vn_{L,end}$ (k)	$Vn_{L,mid}$ (k)
S1_B_A5-A4	2	1.5	4	2	4	Yes	4	2	10	No	178.108	90	18	0	1.51	1.64	Flexure	218.29046	138.38246
S1_B_A4-A3	2	1.5	4	2	4	Yes	4	2	10	No	178.108	90	18	0	1.51	1.64	Flexure	218.29046	138.38246
S1_B_A2-A1	2	1.5	4	2	4	Yes	4	2	10	No	178.108	90	18	0	1.51	1.64	Flexure	218.29046	138.38246
S1_B_B5-B4	2	1.5	4	2	4	Yes	4	2	10	No	83.3	90	36	0	1.63	1.64	Flexure	218.29046	138.38246
S1_B_B4-B3	2	1.5	4	2	4	Yes	4	2	10	No	83.3	90	36	0	1.63	1.64	Flexure	218.29046	138.38246
S1_B_B2-B1	2	1.5	4	2	4	Yes	4	2	10	No	83.3	90	36	0	1.63	1.64	Flexure	218.29046	138.38246
S1_B_5B-5A	2	1.5	4	2	4	Yes	4	2	10	No	92.05	90	36	0	1.63	1.64	Flexure	218.29046	138.38246
S1_B_5E-5D	2	1.5	4	2	4	Yes	4	2	10	No	83.3	90	36	0	1.63	1.64	Flexure	218.29046	138.38246
S1_B_1E-1D	2	1.5	4	2	4	Yes	4	2	10	No	178.108	90	18	0	1.51	1.64	Flexure	218.29046	138.38246
S2_B_A4-A3	2	1.5	4	2	4	Yes	4	2	8	No	188.299	90	18	0	1.07	1.64	Flexure	218.29046	151.70046
S2_B_A3-A2	2	1.5	4	2	4	Yes	4	2	8	No	188.299	90	18	0	1.07	1.64	Flexure	218.29046	151.70046
S2_B_A2-A1	2	1.5	4	2	4	Yes	4	2	8	No	188.299	90	18	0	1.07	1.64	Flexure	218.29046	151.70046
S2_B_B5-B4	2	1.5	4	2	4	Yes	4	2	8	No	77.4	90	18	0	1.07	1.64	Flexure	214.74419	148.15419
S2_B_B4-B3	2	1.5	4	2	4	Yes	4	2	8	No	77.4	90	36	0	1.18	1.64	Flexure	189.59377	135.28677
S2_B_B2-B1	2	1.5	4	2	4	Yes	4	2	8	No	77.4	90	36	0	1.18	1.64	Flexure	189.59377	135.28677
S2_B_C5-C4	2	1.5	4	2	4	Yes	4	2	8	No	77.4	90	36	0	1.18	1.64	Flexure	189.59377	135.28677
S2_B_C3-C2	2	1.5	4	2	4	Yes	4	2	8	No	77.4	90	36	0	1.18	1.64	Flexure	218.29046	151.70046
S2_B_4C-4B	2	1.5	4	2	4	Yes	4	2	8	No	139.467	90	18	0	1.07	1.64	Flexure	218.29046	151.70046
S2_B_4D-4C	2	1.5	4	2	4	Yes	4	2	8	No	139.467	90	18	0	1.07	1.64	Flexure	218.29046	151.70046
S2_B_4E-4D	2	1.5	4	2	4	Yes	4	2	8	No	139.467	90	18	0	1.07	1.64	Flexure	218.29046	151.70046
S4_B_A5-A4	2	1.5	4	2	4	Yes	4	2	8	No	155.055	20	18	0	1.07	1.64	Flexure	218.29046	151.70046
S4_B_A4-A3	2	1.5	4	2	4	Yes	4	2	18	No	172.993	20	18	0	1.07	1.64	Flexure	205.63689	108.05689
S4_B_A2-A1	2	1.5	4	2	4	Yes	4	2	18	No	172.993	20	18	0	1.07	1.64	Flexure	205.17795	107.81573
S4_B_B5-B4	2	1.5	4	2	4	Yes	4	2	18	No	86.4	20	36	0	1.18	1.64	Flexure	218.29046	114.70602
S4_B_B4-B3	2	1.5	4	2	4	Yes	4	2	18	No	86.4	72.5	36	0	1.18	1.64	Flexure	191.07052	105.93497
S4_B_B2-B1	2	1.5	4	2	4	Yes	4	2	18	No	86.4	20	36	0	1.18	1.64	Flexure	190.58176	105.66398
S4_B_C5-C4	2	1.5	4	2	4	Yes	4	2	18	No	86.4	20	36	0	1.18	1.64	Flexure	190.58176	105.66398
S4_B_C4-C3	2	1.5	4	2	4	Yes	4	2	18	No	86.4	125	36	0	1.18	1.64	Flexure	191.07052	105.93497
S4_B_C3-C2	2	1.5	4	2	4	Yes	4	2	18	No	86.4	125	18	0	1.07	1.64	Flexure	218.7494	114.94718
S4_B_D3-D2	2	1.5	4	2	4	Yes	4	2	18	No	86.4	20	18	0	1.07	1.64	Flexure	218.7494	114.94718
S4_B_5B-5A	2	1.5	4	2	4	Yes	4	2	18	No	172.555	20	18	0	1.07	1.64	Flexure	218.29046	114.70602
S4_B_5C-5B	2	1.5	4	2	4	Yes	4	2	18	No	155.055	20	18	0	1.07	1.64	Flexure	205.63689	108.05689
S4_B_5E-5D	2	1.5	4	2	4	Yes	4	2	18	No	155.055	20	18	0	1.07	1.64	Flexure	205.17795	107.81573
S4_B_4B-4A	2	1.5	4	2	4	Yes	4	2	18	No	86.4	20	36	0	1.18	1.64	Flexure	218.29046	114.70602
S2_B_2B-2A	2	1.5	4	2	4	Yes	4	2	8	No	77.4	90	36	0	1.18	1.64	Flexure	178.02523	123.71823
S2_B_4B-4A	2	1.5	4	2	4	Yes	4	2	8	No	77.4	90	18	0	1.07	1.64	Flexure	218.29046	151.70046

6 - Concrete Moment Frames - Modeling Parameters

6.1 - Concrete Beam Calculations

Executive Summary

This section includes a sample calculation of nonlinear beam hinges. The calculation of the beam hinges follows the procedure established in Appendix E of the Basis of Design. Detailed calculations of all beam hinges are located in Appendix C.

Plastic hinge properties are based on properties per ASCE 41-23.

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Beam Hinge Summary

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							Positive Flexural Rotation Parameters						Negative Flexural Rotation Parameters					
							Modeling Parameters			Acceptance Criteria			Modeling Parameters			Acceptance Criteria		
Beam ID	Mn_E^+ (k-in)	Mn_E^- (k-in)	$V_{pr,end}$ (k)	$V_{pr,mid}$ (k)	$Vn_{L,end}$ (k)	$Vn_{L,mid}$ (k)	a	b	c	IO	LS	CP	a	b	c	IO	LS	CP
S1_B_A5-A4-i	9742.28	9949.77	112.97	51.59	218.29	138.38	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0000	0.0264	0.2000	0.0000	0.0132	0.0184
S1_B_A5-A4-j	11097.56	9272.13	112.97	51.59	218.29	138.38	0.0286	0.0499	0.2000	0.0033	0.0250	0.0349	0.0000	0.0264	0.2000	0.0000	0.0132	0.0184
S1_B_A4-A3-i	11097.56	9949.77	112.97	51.59	218.29	138.38	0.0286	0.0499	0.2000	0.0033	0.0250	0.0349	0.0000	0.0264	0.2000	0.0000	0.0132	0.0184
S1_B_A4-A3-j	11097.56	9949.77	112.97	51.59	218.29	138.38	0.0286	0.0499	0.2000	0.0033	0.0250	0.0349	0.0000	0.0264	0.2000	0.0000	0.0132	0.0184
S1_B_A2-A1-i	11097.56	6870.31	112.97	51.59	218.29	138.38	0.0286	0.0499	0.2000	0.0033	0.0250	0.0349	0.0000	0.0264	0.2000	0.0000	0.0132	0.0184
S1_B_A2-A1-j	4938.65	9949.77	112.97	51.59	218.29	138.38	0.0100	0.0200	0.2000	0.0023	0.0133	0.0200	0.0000	0.0264	0.2000	0.0000	0.0132	0.0184
S1_B_B5-B4-i	10516.51	10390.73	119.58	54.83	218.29	138.38	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0000	0.0260	0.2000	0.0000	0.0130	0.0182
S1_B_B5-B4-j	11979.48	9659.24	119.58	54.83	218.29	138.38	0.0289	0.0503	0.2000	0.0033	0.0251	0.0352	0.0000	0.0260	0.2000	0.0000	0.0130	0.0182
S1_B_B4-B3-i	11979.48	10390.73	119.58	54.83	218.29	138.38	0.0289	0.0503	0.2000	0.0033	0.0251	0.0352	0.0000	0.0260	0.2000	0.0000	0.0130	0.0182
S1_B_B4-B3-j	11979.48	10390.73	119.58	54.83	218.29	138.38	0.0289	0.0503	0.2000	0.0033	0.0251	0.0352	0.0000	0.0260	0.2000	0.0000	0.0130	0.0182
S1_B_B2-B1-i	11979.48	7066.55	119.58	54.83	218.29	138.38	0.0289	0.0503	0.2000	0.0033	0.0251	0.0352	0.0000	0.0260	0.2000	0.0000	0.0130	0.0182
S1_B_B2-B1-j	5331.12	10390.73	119.58	54.83	218.29	138.38	0.0100	0.0200	0.2000	0.0023	0.0133	0.0200	0.0000	0.0260	0.2000	0.0000	0.0130	0.0182
S1_B_5B-5A-i	11979.48	7066.55	124.93	54.83	218.29	138.38	0.0289	0.0503	0.2000	0.0033	0.0251	0.0352	0.0000	0.0260	0.2000	0.0000	0.0130	0.0182
S1_B_5B-5A-j	5331.12	10390.73	124.93	54.83	218.29	138.38	0.0100	0.0200	0.2000	0.0023	0.0133	0.0200	0.0000	0.0260	0.2000	0.0000	0.0130	0.0182
S1_B_5E-5D-i	5331.12	10390.73	119.58	54.83	218.29	138.38	0.0100	0.0200	0.2000	0.0023	0.0133	0.0200	0.0000	0.0260	0.2000	0.0000	0.0130	0.0182
S1_B_5E-5D-j	11979.48	7066.55	119.58	54.83	218.29	138.38	0.0289	0.0503	0.2000	0.0033	0.0251	0.0352	0.0000	0.0260	0.2000	0.0000	0.0130	0.0182
S1_B_1E-1D-i	4938.65	9949.77	112.97	51.59	218.29	138.38	0.0100	0.0200	0.2000	0.0023	0.0133	0.0200	0.0000	0.0264	0.2000	0.0000	0.0132	0.0184
S1_B_1E-1D-j	11097.56	6870.31	112.97	51.59	218.29	138.38	0.0286	0.0499	0.2000	0.0033	0.0250	0.0349	0.0000	0.0264	0.2000	0.0000	0.0132	0.0184
S2_B_A4-A3-i	3499.57	8332.91	104.20	39.70	218.29	151.70	0.0100	0.0200	0.2000	0.0022	0.0133	0.0200	0.0079	0.0292	0.2000	0.0000	0.0146	0.0205
S2_B_A4-A3-j	7863.83	6150.77	104.20	39.70	218.29	151.70	0.0267	0.0480	0.2000	0.0033	0.0240	0.0336	0.0079	0.0292	0.2000	0.0000	0.0146	0.0205
S2_B_A3-A2-i	7863.83	8332.91	104.20	39.70	218.29	151.70	0.0267	0.0480	0.2000	0.0033	0.0240	0.0336	0.0079	0.0292	0.2000	0.0000	0.0146	0.0205
S2_B_A3-A2-j	7863.83	8332.91	104.20	39.70	218.29	151.70	0.0267	0.0480	0.2000	0.0033	0.0240	0.0336	0.0079	0.0292	0.2000	0.0000	0.0146	0.0205
S2_B_A2-A1-i	7863.83	6150.77	104.20	39.70	218.29	151.70	0.0267	0.0480	0.2000	0.0033	0.0240	0.0336	0.0079	0.0292	0.2000	0.0000	0.0146	0.0205
S2_B_A2-A1-j	3499.57	8332.91	104.20	39.70	218.29	151.70	0.0100	0.0200	0.2000	0.0022	0.0133	0.0200	0.0079	0.0292	0.2000	0.0000	0.0146	0.0205
S2_B_B5-B4-i	3497.49	7847.22	66.70	36.13	214.74	148.15	0.0100	0.0200	0.2000	0.0024	0.0133	0.0200	0.0089	0.0303	0.2000	0.0000	0.0151	0.0212
S2_B_B5-B4-j	6895.15	6148.39	66.70	36.13	214.74	148.15	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0089	0.0303	0.2000	0.0000	0.0151	0.0212
S2_B_B4-B3-i	7403.92	7326.70	97.24	36.10	189.59	135.29	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0081	0.0294	0.2000	0.0000	0.0147	0.0206
S2_B_B4-B3-j	7403.92	7326.70	97.24	36.10	189.59	135.29	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0081	0.0294	0.2000	0.0000	0.0147	0.0206
S2_B_B2-B1-i	7403.92	5508.34	97.24	36.10	189.59	135.29	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0081	0.0294	0.2000	0.0000	0.0147	0.0206
S2_B_B2-B1-j	3767.20	7326.70	97.24	36.10	189.59	135.29	0.0100	0.0200	0.2000	0.0026	0.0133	0.0200	0.0081	0.0294	0.2000	0.0000	0.0147	0.0206
S2_B_C5-C4-i	3767.20	7326.70	97.24	36.10	189.59	135.29	0.0100	0.0200	0.2000	0.0026	0.0133	0.0200	0.0081	0.0294	0.2000	0.0000	0.0147	0.0206
S2_B_C5-C4-j	7403.92	5508.34	97.24	36.10	189.59	135.29	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0081	0.0294	0.2000	0.0000	0.0147	0.0206
S2_B_C3-C2-i	7613.18	8207.58	99.92	38.78	218.29	151.70	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0081	0.0294	0.2000	0.0000	0.0147	0.0206
S2_B_C3-C2-j	7613.18	8207.58	99.92	38.78	218.29	151.70	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0081	0.0294	0.2000	0.0000	0.0147	0.0206
S2_B_4C-4B-i	7863.83	6150.77	89.26	39.70	218.29	151.70	0.0267	0.0480	0.2000	0.0033	0.0240	0.0336	0.0079	0.0292	0.2000	0.0000	0.0146	0.0205
S2_B_4C-4B-j	3499.57	8332.91	89.26	39.70	218.29	151.70	0.0100	0.0200	0.2000	0.0022	0.0133	0.0200	0.0079	0.0292	0.2000	0.0000	0.0146	0.0205
S2_B_4D-4C-i	7863.83	8332.91	89.26	39.70	218.29	151.70	0.0267	0.0480	0.2000	0.0033	0.0240	0.0336	0.0079	0.0292	0.2000	0.0000	0.0146	0.0205
S2_B_4D-4C-j	7863.83	8332.91	89.26	39.70	218.29	151.70	0.0267	0.0480	0.2000	0.0033	0.0240	0.0336	0.0079	0.0292	0.2000	0.0000	0.0146	0.0205
S2_B_4E-4D-i	3499.57	8332.91	89.26	39.70	218.29	151.70	0.0100	0.0200	0.2000	0.0022	0.0133	0.0200	0.0079	0.0292	0.2000	0.0000	0.0146	0.0205
S2_B_4E-4D-j	7863.83	6150.77	89.26	39.70	218.29	151.70	0.0267	0.0480	0.2000	0.0033	0.0240	0.0336	0.0079	0.0292	0.2000	0.0000	0.0146	0.0205
S4_B_A5-A4-i	3499.57	6150.77	72.63	23.65	218.29	151.70	0.0100	0.0200	0.2000	0.0032	0.0133	0.0200	0.0134	0.0348	0.2000	0.0000	0.0174	0.0243
S4_B_A5-A4-j	3499.57	6150.77	72.63	23.65	218.29	151.70	0.0100	0.0200	0.2000	0.0032	0.0133	0.0200	0.0134	0.0348	0.2000	0.0000	0.0174	0.0243
S4_B_A4-A3-i	2981.37	5631.45	75.58	21.11	205.64	108.06	0.0100	0.0200	0.2000	0.0032	0.0133	0.0200	0.0000	0.0304	0.1833	0.0000	0.0152	0.0213
S4_B_A4-A3-j	2981.37	5631.45	75.58	21.11	205.64	108.06	0.0100	0.0200	0.2000	0.0032	0.0133	0.0200	0.0000	0.0304	0.1833	0.0000	0.0152	0.0213
S4_B_A2-A1-i	3286.48	5784.00	76.70	22.23	205.18	107.82	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0000	0.0296	0.1833	0.0000	0.0148	0.0207
S4_B_A2-A1-j	3286.48	5784.00	76.70	22.23	205.18	107.82	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0000	0.0296	0.1833	0.0000	0.0148	0.0207
S4_B_B5-B4-i	4702.64	6330.66	84.01	28.08	218.29	114.71	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0000	0.0280	0.1833	0.0000	0.0140	0.0196
S4_B_B5-B4-j	3859.34	6752.31	84.01	28.08	218.29	114.71	0.0100	0.0200	0.2000	0.0030	0.0133	0.0200	0.0000	0.0280	0.1833	0.0000	0.0140	0.0196
S4_B_B4-B3-i	2869.22	5059.35	83.40	19.43	191.07	105.93	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0000	0.0279	0.1786	0.0000	0.0139	0.0195
S4_B_B4-B3-j	2869.22	5059.35	83.40	19.43	191.07	105.93	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0000	0.0279	0.1786	0.0000	0.0139	0.0195
S4_B_B2-B1-i	3161.89	5550.86	78.98	23.05	190.58	105.66	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0000	0.0252	0.1786	0.0000	0.0126	0.0177
S4_B_B2-B1-j	3852.25	5205.68	78.98	23.05	190.58	105.66	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0000	0.0252	0.1786	0.0000	0.0126	0.0177
S4_B_C5-C4-i	3852.25	5205.68	78.98	23.05	190.58	105.66	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0000	0.0252	0.1786	0.0000	0.0126	0.0177
S4_B_C5-C4-j	3161.89	5550.86	78.98	23.05	190.58	105.66	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0000	0.0252	0.1786	0.0000	0.0126	0.0177
S4_B_C4-C3-i	2869.22	5059.35	91.43	19.43	191.07	105.93	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0000	0.0279	0.1786	0.0000	0.0139	0.0195
S4_B_C4-C3-j	2869.22	5059.35	91.43	19.43	191.07	105.93	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0000	0.0279	0.1786	0.0000	0.0139	0.0195
S4_B_C3-C2-i	3173.97	5987.97	58.46	22.46	218.75	114.95	0.0100	0.0200	0.2000	0.0031	0.0133	0.0200	0.0000	0.0309	0.1833	0.0000	0.0155	0.0217
S4_B_C3-C2-j	3173.97	5987.97	58.46	22.46	218.75	114.95	0.0100	0.0200	0.2000	0.0031	0.0133	0.0200	0.0000	0.0309	0.1833	0.0000	0.0155	0.0217
S4_B_D3-D2-i	3173.97	5987.97	50.42	22.46	218.75	114.95	0.0100	0.0200	0.2000	0.0031	0.0133	0.0200	0.0000	0.0309	0.1833	0.0000	0.0155	0.0217
S4_B_D3-D2-j	3173.97	5987.97	50.42	22.46	218.75	114.95	0.0100	0.0200	0.2000	0.0031	0.0133	0.0200	0.0000	0.0309	0.1833	0.0000	0.0155	0.0217
S4_B_5B-5A-i	3499.57	6533.12	80.80	26.46	218.29	114.71	0.0100	0.0200	0.2000	0.0029	0.0133	0.0200	0.0000	0.0287	0.1833	0.0000	0.0144	0.0201
S4_B_5B-5A-j	4264.26	6150.77	80.80	26.46	218.29	114.71	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0000	0.0287	0.1833	0.0000	0.0144	0.0201
S4_B_5C-5B-i	2981.37	5631.45	70.09	21.11	205.64	108.06	0.0100	0.0200	0.2000	0.0032	0.0133	0.0200	0.0000	0.0304	0.1833	0.0000	0.0152	0.0213
S4_B_5C-5B-j	2981.37	5631.45	70.09	21.11	205.64	108.06	0.0100	0.0200	0.2000	0.0032	0.0133	0.0200	0.0000	0.0304	0.1833	0.0000	0.0152	0.0213
S4_B_5E-5D-i	3286.48	5784.00	71.21	22.23	205.18	107.82	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0000	0.0296	0.1833	0.0000	0.0148	0.0207
S4_B_5E-5D-j	3286.48	5784.00	71.21	22.23	205.18	107.82	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0000	0.0296	0.1833	0.0000	0.0148	0.0207
S4_B_4B-4A-i	3859.34	6752.31	84.01	28.08	218.29	114.71	0.0100	0.0200	0.2000	0.0030	0.0133	0.0200	0.0000	0.0280	0.1833	0.0000	0.0140	0.0196
S4_B_4B-4A-j	4702.64	6330.66	84.01	28.08	218.29	114.71	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0000	0.0280	0.1833	0.0000	0.0140	0.0196
S2_B_2B-2A-i	9678.58	5498.47	105.60	44.46	178.03	123.72	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0071	0.0284	0.2000	0.0000	0.0142	0.0199
S2_B_2B-2A-j	3756.33	8459.59	105.60	44.46	178.03	123.72	0.0100	0.0200	0.2000	0.0024	0.0133	0.0200	0.0071	0.0284	0.2000	0.0000	0.0142	0.0199
S2_B_4B-4A-i	6903.47	6150.77	66.74	36.17	218.29	151.70	0.0100	0.0200	0.2000	0.0033	0.0133	0.0200	0.0087	0.0300	0.2000	0.0000	0.0150	0.0210
S2_B_4B-4A-j	3499.57	7852.73	66.74	36.17	218.29	151.70	0.0100	0.0200	0.2000	0.0023	0.0133	0.0200	0.0087	0.0300	0.2000	0.0000	0.0150	0.0210

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Beam Hinge Summary Continued

Beam ID	POSITIVE PERFORM INPUT									NEGATIVE PERFORM INPUT								
	STRENGTH (K)		DEFORMATION (in)			DEFORMATION CAPACITIES				STRENGTH (K)		DEFORMATION (in)			DEFORMATION CAPACITIES			
	FU	FR/FU	DL	DR	DX	Level 1 (yield)	Level 2 (IO)	Level 3 (LS)	Level 4 (CP)	FU	FR/FU	DL	DR	DX	Level 1 (yield)	Level 2 (IO)	Level 3 (LS)	Level 4 (CP)
S1_B_A5-A4-i	9742.2840	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	9949.7687	0.2000	0.0010	0.0011	0.0264	0.0001	0.0001	0.0132	0.0184
S1_B_A5-A4-j	11097.5596	0.2000	0.0286	0.0314	0.0499	0.0001	0.0033	0.0250	0.0349	9272.1309	0.2000	0.0010	0.0011	0.0264	0.0001	0.0001	0.0132	0.0184
S1_B_A4-A3-i	11097.5596	0.2000	0.0286	0.0314	0.0499	0.0001	0.0033	0.0250	0.0349	9949.7687	0.2000	0.0010	0.0011	0.0264	0.0001	0.0001	0.0132	0.0184
S1_B_A4-A3-j	11097.5596	0.2000	0.0286	0.0314	0.0499	0.0001	0.0033	0.0250	0.0349	9949.7687	0.2000	0.0010	0.0011	0.0264	0.0001	0.0001	0.0132	0.0184
S1_B_A2-A1-i	11097.5596	0.2000	0.0286	0.0314	0.0499	0.0001	0.0033	0.0250	0.0349	6870.3122	0.2000	0.0010	0.0011	0.0264	0.0001	0.0001	0.0132	0.0184
S1_B_A2-A1-j	4938.6466	0.2000	0.0100	0.0110	0.0200	0.0001	0.0023	0.0133	0.0200	9949.7687	0.2000	0.0010	0.0011	0.0264	0.0001	0.0001	0.0132	0.0184
S1_B_B5-B4-i	10516.5053	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	10390.7313	0.2000	0.0010	0.0011	0.0260	0.0001	0.0001	0.0130	0.0182
S1_B_B5-B4-j	11979.4849	0.2000	0.0289	0.0318	0.0503	0.0001	0.0033	0.0251	0.0352	9659.2415	0.2000	0.0010	0.0011	0.0260	0.0001	0.0001	0.0130	0.0182
S1_B_B4-B3-i	11979.4849	0.2000	0.0289	0.0318	0.0503	0.0001	0.0033	0.0251	0.0352	10390.7313	0.2000	0.0010	0.0011	0.0260	0.0001	0.0001	0.0130	0.0182
S1_B_B4-B3-j	11979.4849	0.2000	0.0289	0.0318	0.0503	0.0001	0.0033	0.0251	0.0352	10390.7313	0.2000	0.0010	0.0011	0.0260	0.0001	0.0001	0.0130	0.0182
S1_B_B2-B1-i	11979.4849	0.2000	0.0289	0.0318	0.0503	0.0001	0.0033	0.0251	0.0352	7066.5498	0.2000	0.0010	0.0011	0.0260	0.0001	0.0001	0.0130	0.0182
S1_B_B2-B1-j	5331.1218	0.2000	0.0100	0.0110	0.0200	0.0001	0.0023	0.0133	0.0200	10390.7313	0.2000	0.0010	0.0011	0.0260	0.0001	0.0001	0.0130	0.0182
S1_B_5B-5A-i	11979.4849	0.2000	0.0289	0.0318	0.0503	0.0001	0.0033	0.0251	0.0352	7066.5498	0.2000	0.0010	0.0011	0.0260	0.0001	0.0001	0.0130	0.0182
S1_B_5B-5A-j	5331.1218	0.2000	0.0100	0.0110	0.0200	0.0001	0.0023	0.0133	0.0200	10390.7313	0.2000	0.0010	0.0011	0.0260	0.0001	0.0001	0.0130	0.0182
S1_B_5E-5D-i	5331.1218	0.2000	0.0100	0.0110	0.0200	0.0001	0.0023	0.0133	0.0200	10390.7313	0.2000	0.0010	0.0011	0.0260	0.0001	0.0001	0.0130	0.0182
S1_B_5E-5D-j	11979.4849	0.2000	0.0289	0.0318	0.0503	0.0001	0.0033	0.0251	0.0352	7066.5498	0.2000	0.0010	0.0011	0.0260	0.0001	0.0001	0.0130	0.0182
S1_B_1E-1D-i	4938.6466	0.2000	0.0100	0.0110	0.0200	0.0001	0.0023	0.0133	0.0200	9949.7687	0.2000	0.0010	0.0011	0.0264	0.0001	0.0001	0.0132	0.0184
S1_B_1E-1D-j	11097.5596	0.2000	0.0286	0.0314	0.0499	0.0001	0.0033	0.0250	0.0349	6870.3122	0.2000	0.0010	0.0011	0.0264	0.0001	0.0001	0.0132	0.0184
S2_B_A4-A3-i	3499.5708	0.2000	0.0100	0.0110	0.0200	0.0001	0.0022	0.0133	0.0200	8332.9057	0.2000	0.0079	0.0087	0.0292	0.0001	0.0001	0.0146	0.0205
S2_B_A4-A3-j	7863.8336	0.2000	0.0267	0.0294	0.0480	0.0001	0.0033	0.0240	0.0336	6150.7743	0.2000	0.0079	0.0087	0.0292	0.0001	0.0001	0.0146	0.0205
S2_B_A3-A2-i	7863.8336	0.2000	0.0267	0.0294	0.0480	0.0001	0.0033	0.0240	0.0336	8332.9057	0.2000	0.0079	0.0087	0.0292	0.0001	0.0001	0.0146	0.0205
S2_B_A3-A2-j	7863.8336	0.2000	0.0267	0.0294	0.0480	0.0001	0.0033	0.0240	0.0336	8332.9057	0.2000	0.0079	0.0087	0.0292	0.0001	0.0001	0.0146	0.0205
S2_B_A2-A1-i	7863.8336	0.2000	0.0267	0.0294	0.0480	0.0001	0.0033	0.0240	0.0336	6150.7743	0.2000	0.0079	0.0087	0.0292	0.0001	0.0001	0.0146	0.0205
S2_B_A2-A1-j	3499.5708	0.2000	0.0100	0.0110	0.0200	0.0001	0.0022	0.0133	0.0200	8332.9057	0.2000	0.0079	0.0087	0.0292	0.0001	0.0001	0.0146	0.0205
S2_B_B5-B4-i	3497.4910	0.2000	0.0100	0.0110	0.0200	0.0001	0.0024	0.0133	0.0200	7847.2167	0.2000	0.0089	0.0098	0.0303	0.0001	0.0001	0.0151	0.0212
S2_B_B5-B4-j	6895.1538	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	6148.3853	0.2000	0.0089	0.0098	0.0303	0.0001	0.0001	0.0151	0.0212
S2_B_B4-B3-i	7403.9186	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	7326.6952	0.2000	0.0081	0.0089	0.0294	0.0001	0.0001	0.0147	0.0206
S2_B_B4-B3-j	7403.9186	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	7326.6952	0.2000	0.0081	0.0089	0.0294	0.0001	0.0001	0.0147	0.0206
S2_B_B2-B1-i	7403.9186	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	5508.3369	0.2000	0.0081	0.0089	0.0294	0.0001	0.0001	0.0147	0.0206
S2_B_B2-B1-j	3767.2020	0.2000	0.0100	0.0110	0.0200	0.0001	0.0026	0.0133	0.0200	7326.6952	0.2000	0.0081	0.0089	0.0294	0.0001	0.0001	0.0147	0.0206
S2_B_C5-C4-i	3767.2020	0.2000	0.0100	0.0110	0.0200	0.0001	0.0026	0.0133	0.0200	7326.6952	0.2000	0.0081	0.0089	0.0294	0.0001	0.0001	0.0147	0.0206
S2_B_C5-C4-j	7403.9186	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	5508.3369	0.2000	0.0081	0.0089	0.0294	0.0001	0.0001	0.0147	0.0206
S2_B_C3-C2-i	7613.1756	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	8207.5767	0.2000	0.0081	0.0089	0.0294	0.0001	0.0001	0.0147	0.0206
S2_B_C3-C2-j	7613.1756	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	8207.5767	0.2000	0.0081	0.0089	0.0294	0.0001	0.0001	0.0147	0.0206
S2_B_4C-4B-i	7863.8336	0.2000	0.0267	0.0294	0.0480	0.0001	0.0033	0.0240	0.0336	6150.7743	0.2000	0.0079	0.0087	0.0292	0.0001	0.0001	0.0146	0.0205
S2_B_4C-4B-j	3499.5708	0.2000	0.0100	0.0110	0.0200	0.0001	0.0022	0.0133	0.0200	8332.9057	0.2000	0.0079	0.0087	0.0292	0.0001	0.0001	0.0146	0.0205
S2_B_4D-4C-i	7863.8336	0.2000	0.0267	0.0294	0.0480	0.0001	0.0033	0.0240	0.0336	8332.9057	0.2000	0.0079	0.0087	0.0292	0.0001	0.0001	0.0146	0.0205
S2_B_4D-4C-j	7863.8336	0.2000	0.0267	0.0294	0.0480	0.0001	0.0033	0.0240	0.0336	8332.9057	0.2000	0.0079	0.0087	0.0292	0.0001	0.0001	0.0146	0.0205
S2_B_4E-4D-i	3499.5708	0.2000	0.0100	0.0110	0.0200	0.0001	0.0022	0.0133	0.0200	8332.9057	0.2000	0.0079	0.0087	0.0292	0.0001	0.0001	0.0146	0.0205
S2_B_4E-4D-j	7863.8336	0.2000	0.0267	0.0294	0.0480	0.0001	0.0033	0.0240	0.0336	6150.7743	0.2000	0.0079	0.0087	0.0292	0.0001	0.0001	0.0146	0.0205
S4_B_A5-A4-i	3499.5708	0.2000	0.0100	0.0110	0.0200	0.0001	0.0032	0.0133	0.0200	6150.7743	0.2000	0.0134	0.0148	0.0348	0.0001	0.0001	0.0174	0.0243
S4_B_A5-A4-j	3499.5708	0.2000	0.0100	0.0110	0.0200	0.0001	0.0032	0.0133	0.0200	6150.7743	0.2000	0.0134	0.0148	0.0348	0.0001	0.0001	0.0174	0.0243
S4_B_A4-A3-i	2981.3718	0.2000	0.0100	0.0110	0.0200	0.0001	0.0032	0.0133	0.0200	5631.4462	0.1833	0.0010	0.0011	0.0304	0.0001	0.0001	0.0152	0.0213
S4_B_A4-A3-j	2981.3718	0.2000	0.0100	0.0110	0.0200	0.0001	0.0032	0.0133	0.0200	5631.4462	0.1833	0.0010	0.0011	0.0304	0.0001	0.0001	0.0152	0.0213
S4_B_A2-A1-i	3286.4814	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	5784.0010	0.1833	0.0010	0.0011	0.0296	0.0001	0.0001	0.0148	0.0207
S4_B_A2-A1-j	3286.4814	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	5784.0010	0.1833	0.0010	0.0011	0.0296	0.0001	0.0001	0.0148	0.0207
S4_B_B5-B4-i	4702.6431	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	6330.6587	0.1833	0.0010	0.0011	0.0280	0.0001	0.0001	0.0140	0.0196
S4_B_B5-B4-j	3859.3397	0.2000	0.0100	0.0110	0.0200	0.0001	0.0030	0.0133	0.0200	6752.3104	0.1833	0.0010	0.0011	0.0280	0.0001	0.0001	0.0140	0.0196
S4_B_B4-B3-i	2869.2244	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	5059.3481	0.1786	0.0010	0.0011	0.0279	0.0001	0.0001	0.0139	0.0195
S4_B_B4-B3-j	2869.2244	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	5059.3481	0.1786	0.0010	0.0011	0.0279	0.0001	0.0001	0.0139	0.0195
S4_B_B2-B1-i	3161.8885	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	5550.8606	0.1786	0.0010	0.0011	0.0252	0.0001	0.0001	0.0126	0.0177
S4_B_B2-B1-j	3852.2495	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	5205.6801	0.1786	0.0010	0.0011	0.0252	0.0001	0.0001	0.0126	0.0177
S4_B_C5-C4-i	3852.2495	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	5205.6801	0.1786	0.0010	0.0011	0.0252	0.0001	0.0001	0.0126	0.0177
S4_B_C5-C4-j	3161.8885	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	5550.8606	0.1786	0.0010	0.0011	0.0252	0.0001	0.0001	0.0126	0.0177
S4_B_C4-C3-i	2869.2244	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	5059.3481	0.1786	0.0010	0.0011	0.0279	0.0001	0.0001	0.0139	0.0195
S4_B_C4-C3-j	2869.2244	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	5059.3481	0.1786	0.0010	0.0011	0.0279	0.0001	0.0001	0.0139	0.0195
S4_B_C3-C2-i	3173.9718	0.2000	0.0100	0.0110	0.0200	0.0001	0.0031	0.0133	0.0200	5987.9748	0.1833	0.0010	0.0011	0.0309	0.0001	0.0001	0.0155	0.0217
S4_B_C3-C2-j	3173.9718	0.2000	0.0100	0.0110	0.0200	0.0001	0.0031	0.0133	0.0200	5987.9748	0.1833	0.0010	0.0011	0.0309	0.0001	0.0001	0.0155	0.0217
S4_B_D3-D2-i	3173.9718	0.2000	0.0100	0.0110	0.0200	0.0001	0.0031	0.0133	0.0200	5987.9748	0.1833	0.0010	0.0011	0.0309	0.0001	0.0001	0.0155	0.0217
S4_B_D3-D2-j	3173.9718	0.2000	0.0100	0.0110	0.0200	0.0001	0.0031	0.0133	0.0200	5987.9748	0.1833	0.0010	0.0011	0.0309	0.0001	0.0001	0.0155	0.0217
S4_B_5B-5A-i	3499.5708	0.2000	0.0100	0.0110	0.0200	0.0001	0.0029	0.0133	0.0200	6533.1194	0.1833	0.0010	0.0011	0.0287	0.0001	0.0001	0.0144	0.0201
S4_B_5B-5A-j	4264.2611	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	6150.7743	0.1833	0.0010	0.0011	0.0287	0.0001	0.0001	0.0144	0.0201
S4_B_5C-5B-i	2981.3718	0.2000	0.0100	0.0110	0.0200	0.0001	0.0032	0.0133	0.0200	5631.4462	0.1833	0.0010	0.0011	0.0304	0.0001	0.0001	0.0152	0.0213
S4_B_5C-5B-j	2981.3718	0.2000	0.0100	0.0110	0.0200	0.0001	0.0032	0.0133	0.0200	5631.4462	0.1833	0.0010	0.0011	0.0304	0.0001	0.0001	0.0152	0.0213
S4_B_5E-5D-i	3286.4814	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	5784.0010	0.1833	0.0010	0.0011	0.0296	0.0001	0.0001	0.0148	0.0207
S4_B_5E-5D-j	3286.4814	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	5784.0010	0.1833	0.0010	0.0011	0.0296	0.0001	0.0001	0.0148	0.0207
S4_B_4B-4A-i	3859.3397	0.2000	0.0100	0.0110	0.0200	0.0001	0.0030	0.0133	0.0200	6752.3104	0.1833	0.0010	0.0011	0.0280	0.0001	0.0001	0.0140	0.0196
S4_B_4B-4A-j	4702.6431	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	6330.6587	0.1833	0.0010	0.0011	0.0280	0.0001	0.0001	0.0140	0.0196
S2_B_2B-2A-i	9678.5799	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	5498.4672	0.2000	0.0071	0.0078	0.0284	0.0001	0.0001	0.0142	0.0199
S2_B_2B-2A-j	3756.3282	0.2000	0.0100	0.0110	0.0200	0.0001	0.0024	0.0133	0.0200	8459.5930	0.2000	0.0071	0.0078	0.0284	0.0001	0.0001	0.0142	0.0199
S2_B_4B-4A-i	6903.4728	0.2000	0.0100	0.0110	0.0200	0.0001	0.0033	0.0133	0.0200	6150.7743	0.2000	0.0087	0.0096	0.0300	0.0001	0.0001	0.0150	0.0210
S2_B_4B-4A-j	3499.5708	0.2000	0.0100	0.0110	0.0200	0.0001	0.0023	0.0133	0.0200	7852.7253	0.2000	0.0087	0.0096	0.0300	0.0001	0.0001	0.0150	0.0210

Concrete Beam Sample Calculation

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Project : COI City Hall
Job no. : 2000362
Date : 6/18/2021
By :

MF Beam ID & Story **S1_B_1E-1D at 2**

Step 1: Summarize Moment Frame Beam Properties, Other Inputs

f'_{cL} =	5.042 ksi	width, b_w =	24 in	DL =	178.1077778 psf
f'_{cE} =	5.436 ksi	height, h =	36 in	LL =	90 psf
f_{yL} =	65 ksi	$A_{cv} = b_w{*}h$ =	864 in^2	Trib width, t_w =	18 ft
f_{yE} =	73 ksi	L_n =	34.00 ft	$V_{g,user}$ =	0 k
f_{ytL} =	40 ksi				
f_{ytE} =	50 ksi				
$\sqrt{f'_{cL}}$ =	71.0 psi				
$\sqrt{f'_{cE}}$ =	73.7 psi				
λ =	0.75				
Ψ_e	1				

	Number	Size	Embed/Splice
Bottom Reinf, i-End:	(2)	#11's	18 in
Top Reinf, i-3rd:	(2)	#7's	18 in
Bottom Reinf, j-End:	(2)	#11's	48 in
Top Reinf, j-3rd:	(2)	#7's	18 in

Clear Cover Bot, $c_{c,Bot}$ =	2.00 in		
Clear Cover Top, $c_{c,Top}$ =	1.50 in		
Transverse Reinf, End:	(2) Legs of	#4 Ties	@ 4 IN OC
Transverse Reinf, 3rd:	(2) Legs of	#4 Ties	@ 10 IN OC
Closed Ties, End:	Yes		
Closed Ties, 3rd:	No		

T-Shaped Scale Factor Positive = 1.51
T-Shaped Scale Factor Negative = 1.64

Factors calculated to factor up moment capacity calculated for a rectangular beam assuming no compression or slab reinforcement. See T-Beam scale factor calculations.

Step 2: Calculate Required Development Length for Top and Bottom Bars

Step 2a: Calculate f_s for Bot i-End Bars per ASCE 41 eq 10-2

$f_{s\,bot\text{-}i} = (2500/d_b){*}l_e$ = 31.91 ksi   per ASCE 41-17 Eq. 10-2

Step 2b: Calculate Top i-3rd Development length required per ACI Section 25.4.2.3

d_b = 0.875 in
Ψ_s = 1.0
Ψ_t = 1.3

c_b = 2.44 in   Assumes c_b is always governed by distance to edge of concrete
A_{tr} = 0.40 in^2
s = 10 in
n = 2

$$K_{tr} = \frac{40A_{tr}}{sn} \quad (25.4.2.3b)$$

K_{tr} = 0.80

$$l_d = \left(\frac{3}{40}\frac{f_y}{\lambda\sqrt{f'_c}}\frac{\psi_t\psi_e\psi_s}{\left(\frac{c_b+K_{tr}}{d_b}\right)}\right)d_b \quad (25.4.2.3a)$$

l_d = 45.05 in

Step 2c: Calculate f_s for Top i-3rd Bars per ASCE 41 eq 10-1a

l_b = 18.00 in
$d = h - c_b$ = 33.56 in

$$f_s = 1.25\left(\frac{l_b}{l_d}\right)^{2/3} f_{yL} \le f_{yL/E} \quad (10\text{-}1a)$$

$f_{s,\,top\text{-}i}$ = 44.08 ksi

Step 2d: Calculate f_s for Bot j-End Bars per ASCE 41 eq 10-2

$f_{s\,bot\text{-}j} = (2500/d_b){*}l_e$ = 73.00 ksi   per ASCE 41-17 Eq. 10-2

Step 2e: Calculate Top j-3rd Development length required per ACI Section 25.4.2.3

$d_b =$	0.875	in	
$\Psi_s =$	1.0		
$\Psi_t =$	1.3		
$c_b =$	2.44	in	Assumes c_b is always governed by distance to edge of concrete
$A_{tr} =$	0.40	in^2	
$s =$	10	in	
$n =$	2		

$$K_{tr} = \frac{40A_{tr}}{sn} \quad (25.4.2.3b)$$

$K_{tr} =$ 0.80

$$l_d = \left(\frac{3}{40}\frac{f_y}{\lambda\sqrt{f'_c}}\frac{\Psi_t\Psi_e\Psi_s}{\left(\frac{c_b+K_{tr}}{d_b}\right)}\right)d_b \quad (25.4.2.3a)$$

$l_d =$ 45.05 in

Step 2f: Calculate f_s for Top j-3rd Bars per ASCE 41 eq 10-1a

$l_b =$	18.00	in
$d = h\text{-}c_b =$	33.56	in

$$f_s = 1.25\left(\frac{l_b}{l_d}\right)^{2/3} f_{yL} \le f_{yL/E} \quad (10\text{-}1a)$$

$f_{s,\,top\text{-}j} =$ 44.08 ksi

Step 2g: Summary of f_s Values

$f_{s,bot\text{-}i} =$	31.91	ksi
$f_{s,top\text{-}i} =$	44.08	ksi
$f_{s,bot\text{-}j} =$	73.00	ksi
$f_{s,top\text{-}j} =$	44.08	ksi

Step 3: Calculate Expected Beam Positive Moment Capacity at Beam Ends, φM_{nE} per ACI 318-14 Section 22.2 & 22.3

Step 3a: Determine Reinforcement Properties (i-Side of Beam)

$d_{b,Bot\text{-}i} =$	1.41	in	
$d = h\text{-}c_{c,Bot}\text{-}d_{b,Bot\text{-}i}/2 =$	33.30	in	Depth to centroid of extreme tensile fiber
$A_{s,Bot\text{-}i} =$	3.12	in^2	
$\rho = A_s/(b_w d) =$	0.0039		
$A_s' = A_{s,Top\text{-}i} =$	1.20	in^2	Area of Compression Reinf to be used in Step X
$\rho' = A_s'/(b_w d) =$	0.0015		Reinforcement ratio of compression reinf to be used in Step X
$\rho_{bal} = (0.85\beta_1 f'_{cE}/(f_{s,bot\text{-}i}))*(\varepsilon_u/(\varepsilon_u+\varepsilon_y)) =$	0.0824		reinforcement ratio to achieve concrete crushing and steel yielding at the same time, to be used in step X

Step 3b: Determine Moment Capacity (i-Side of Beam)

Step 3b.i: Determine Depth of Neutral Axis

$\beta_1 =$	0.7782		ACI 318-14 Section 22.2.2.4.3 and Table 22.2.2.4.3
Assume tension steel yields			
$a = (A_s f_{s,bot\text{-}i})/(0.85 f'_{cE} b_w) =$	0.898	in	
$c = a/\beta_1 =$	1.154	in	Per ACI 318-14 EQ. 22.2.2.4.1

Step 3b.ii: Determine Net Tensile Strain in Steel

$\varepsilon_t = \varepsilon_u((d-c)/c) =$ 0.0836

If ε_t >=0.005	→	Tension Controlled
If 0.002 < ε_t < 0.005	→	Transition
If 0.002 > ε_t	→	Compression Controlled
Therefore		**Tension Controlled**

Step 3b.iii: Calculate Moment Capacity

$M_{nE} = A_s f_{s,bot\text{-}i}(d\text{-}a/2)$ =	3270.63	kip-in	
T Section SF = SF_T	1.51		
$SF_T M_{nE\text{-}i}^{+}$ =	**4938.65**	**kip-in**	Moment capacities scaled up to account for T-Beam capacity. See calculation for T-Beam scale factors.

Step 3c: Determine Reinforcement Properties (j-Side of Beam)

$d_{b,Bot\text{-}j}$ =	1.41	in	
$d = h\text{-}c_{c,Bot}\text{-}d_{b,Bot\text{-}j}/2$ =	33.30	in	Depth to centroid of extreme tensile fiber
$A_{s,Bot\text{-}j}$ =	3.12	in^2	
$\rho = A_s/(b_w d)$ =	0.0039		
$A_s' = A_{s,Top\text{-}j}$ =	1.20	in^2	Area of Compression Reinf to be used in Step X
$\rho' = A_s'/(b_w d)$ =	0.0015		Reinforcement ratio of compression reinf to be used in Step X
$\rho_{bal} = (0.85\beta_1 f'_{cE}/(f_{s,bot\text{-}j}))^*(\varepsilon_u/(\varepsilon_u+\varepsilon_y))$ =	0.0268		reinforcement ratio to achieve concrete crushing and steel yielding at the same time, to be used in step X

Step 3d: Determine Moment Capacity (j-Side of Beam)

Step 3d.i: Determine Depth of Neutral Axis

β_1 =	0.7782		ACI 318-14 Section 22.2.2.4.3 and Table 22.2.2.4.3
Assume tension steel yields			
$a = (A_s f_{s,bot\text{-}j})/(0.85 f'_{cE} b_w)$ =	2.054	in	
$c = a/\beta_1$ =	2.639	in	Per ACI 318-14 EQ. 22.2.2.4.1

Step 3d.ii: Determine Net Tensile Strain in Steel

$\varepsilon_t = \varepsilon_u((d\text{-}c)/c)$ = 0.0348

If ε_t >=0.005	→	Tension Controlled
If 0.002 < ε_t < 0.005	→	Transition
If 0.002 > ε_t	→	Compression Controlled
Therefore		**Tension Controlled**

Step 3d.iii: Calculate Moment Capacity

$M_{nE} = A_s f_{s,bot\text{-}j}(d\text{-}a/2)$ =	7349.38	kip-in	
T Section SF = SF_T	1.51		
$SF_T M_{nE\text{-}j}^{+}$ =	**11097.56**	**kip-in**	Moment capacities scaled up to account for T-Beam capacity. See calculation for T-Beam scale factors.

Step 4: Calculate Expected Beam Negative Moment Capacity at 3rd Points, φM_{nE} per ACI 318-14 Section 22.2 & 22.3

Step 4a: Determine Reinforcement Properties (i-side of Beam)

$d_{b,Top\text{-}i}$ =	0.875	in	
$d = h\text{-}c_{c,Top}\text{-}d_{b,Top\text{-}i}/2$ =	34.0625	in	Depth to centroid of extreme tensile fiber
$A_{s,Top\text{-}i}$ =	1.20	in^2	
$\rho = A_s/(b_w d)$ =	0.0015		

Step 4b: Determine Moment Capacity (i-Side of Beam)

Step 4b.i: Determine Depth of Neutral Axis

β_1 =	0.7782		ACI 318-14 Section 22.2.2.4.3 and Table 22.2.2.4.3
Assume tension steel yields			
$a = (A_s f_{s,top\text{-}i})/(0.85 f'_{cE} b_w)$ =	0.477	in	
$c = a/\beta_1$ =	0.613	in	Per ACI 318-14 EQ. 22.2.2.4.1

Step 4b.ii: Determine Net Tensile Strain in Steel

$\varepsilon_t = \varepsilon_u((d\text{-}c)/c)$ = 0.1637

If ε_t >=0.005	→	Tension Controlled
If 0.002 < ε_t < 0.005	→	Transition
If 0.002 > ε_t	→	Compression Controlled
Therefore		**Tension Controlled**

Step 4b.iii: Calculate Moment Capacity

$M_{nE} = A_s f_{s,top\text{-}i}(d\text{-}a/2)$ =	1789.02	kip-in	
T Section SF = SF_T	1.64		
$SF_T M_{nE\text{-}i}^{-}$ =	**2933.99**	**kip-in**	Moment capacities scaled up to account for T-Beam capacity. See calculation for T-Beam scale factors.

Step 4b.iv: Scale up Moment Capacity for 2 Hinge Simplification

SF_{2h} =	3.39	kip-in	$SF_{2h} = 0.5{*}M_{end}^{+}/M_{mid}^{-} + 1.5$	See BOD Appendix E
$SF_{2h}SF_TM_{nE\text{-}i}^{-}$ =	**9949.77**	**kip-in**		

Step 4c: Determine Reinforcement Properties (j-Side of Beam)

$d_{b,Top\text{-}j}$ =	0.875	in	
$d = h - c_{c,Top} - d_{b,Top\text{-}j}/2$ =	34.0625	in	Depth to centroid of extreme tensile fiber
$A_{s,Top\text{-}j}$ =	1.20	in^2	
$\rho = A_s/(b_w d)$ =	0.0015		

Step 4d: Determine Moment Capacity (j-Side of Beam)

Step 4d.i: Determine Depth of Neutral Axis

β_1 =	0.7782		ACI 318-14 Section 22.2.2.4.3 and Table 22.2.2.4.3
Assume tension steel yields			
$a = (A_s f_{s,top\text{-}j})/(0.85 f'_{cE} b_w)$ =	0.477	in	
$c = a/\beta_1$ =	0.613	in	Per ACI 318-14 EQ. 22.2.2.4.1

Step 4d.ii: Determine Net Tensile Strain in Steel

$\varepsilon_t = \varepsilon_u((d-c)/c)$ = 0.1637

If $\varepsilon_t >= 0.005$	→	Tension Controlled
If $0.002 < \varepsilon_t < 0.005$	→	Transition
If $0.002 > \varepsilon_t$	→	Compression Controlled
Therefore		**Tension Controlled**

Step 4d.iii: Calculate Moment Capacity

$M_{nE} = A_s f_{s,top\text{-}j}(d - a/2)$ =	1789.02	kip-in
T Section SF = SF_T	1.64	
$SF_TM_{nE\text{-}j}^{-}$ =	**2933.99**	**kip-in**

Moment capacities scaled up to account for T-Beam capacity. See calculation for T-Beam scale factors.

Step 4d.iv: Scale up Moment Capacity for 2 Hinge Simplification

SF_{2h} =	2.34	kip-in	$SF_{2h} = 0.5{*}M_{end}^{+}/M_{mid}^{-} + 1.5$	See BOD Appendix E
$SF_{2h}SF_TM_{nE\text{-}j}^{-}$ =	**6870.31**	**kip-in**		

Step 5: Obtain Maximum Probable Shear per ACI 318-14 Section 18.6.5.1

Step 5a: Determine Gravity Contribution to V_{pr}

Per ASCE 41-17 Section 7.2.2 Eq. 7-3: $Q_G = Q_D + 0.25Q_L$

$w_u = DL{*}t_w + 0.25LL{*}t_w$ =	3.61	klf
$V_g = ((w_u L_n)/2$, or $V_{g,user})$ =	**61.39**	**kips**

Step 5b: Determine Seismic Contribution to V_{pr}

$V_{E1} = (M_{nE\text{-}i}^{+} + SF_{2h}M_{nE\text{-}j}^{-})/L_n$ =	28.94	kips	Maximum Probable Shear when frame sways to the right
$V_{E2} = (M_{nE\text{-}j}^{+} + SF_{2h}M_{nE\text{-}i}^{-})/L_n$ =	51.59	kips	Maximum Probable Shear when frame sways to the left
$V_E = Max(V_{E1}, V_{E2})$ =	**51.59**	**kips**	

Step 5c:Calculate V_{pr}

$V_{pr,end} = V_E + V_g$ =	**112.97**	**kips**
$V_{pr,mid} = V_E$ =	**51.59**	**kips**

Step 6: Lower Bound Beam Shear Capacity, φV_n per ACI 318-14 Section 22.5.5.1 & 22.5.10.5.3

Step 6a: Calculate V_c per ACI 318-14 Section 22.5.5.1

$V_{cLB} = 2\lambda(f'_c)^{1/2}b_w d$ = **85.11** **kip**

Step 6b: Calculate V_s per ACI 318-14 Section 22.5.10.5.3

Step 6b.i: Calculate V_s at end

Shear Reinforcement =	(2) Legs of	#4 Ties	@ 4 IN OC
A_v =		0.40	in^2
s =		4.00	in
$V_{sLB,end} = (A_v f_{yt} d)/s$ =		**133.18**	**kip**

Step 6b.ii: Calculate V_s at mid

Shear Reinforcement =	(2) Legs of	#4 Ties	@ 10 IN OC
A_v =		0.40	in^2
s =		10.00	in
$V_{sLB,mid} = (A_v f_{yt} d)/s$ =		**53.27**	**kip**

Step 6c: Calculate V_{nLB} per ACI 318-14 Section 22.5.1.1

Step 6c.i: Calculate V_{nLB} at end

$V_{nLB,end} = V_s + V_c$ =	**218.29**	**kip**
φ =	1.00	
φV_{nLB} =	**218.29**	**kip**

Step 6c.ii: Calculate V_{nLB} at mid

$V_{nLB,mid} = V_s + V_c$ =	**138.38**	**kip**
φ =	1.00	
φV_{nLB} =	**138.38**	**kip**

Step 6d: Check if Beam is Shear controlled or Flexure Controlled

if $V_{nLB} < V_{pr}$	→	Shear	
if $V_{nLB} > V_{pr}$	→	Flexure	
Therefore Beam is		**Flexure**	**Controlled**

Step 7: Obtain Plastic Hinge Rotation Backbone Parameters per ASCE 41-23 Ballot Table 4.2.2.2a for i-Side Flexural Rotations

Step 7a: Positive Bending Backbone Parameters

Step 7a.i: Determine which Conditions apply from Table 4.2.2.2a

No development issues	Applicable	Must be checked regardless
Inadequate Splicing	Not Applicable	Bottom bars are continuous
Inadequate Embed	Applicable	Bars not adequately embedded per procedures of Appendix D of BOD

Step 7a.ii: Calculate Reinforcement Ratios

ρ_t =	0.004167	in
ρ_l =	0.005000	in

Step 7a.iii: Calculate V_{BeamOE} as the Shear Capacity per ACI 318

$V_{BeamOE} = V_s + V_c$

$V_c = 2\lambda(f_c')^{1/2} b_w d$ =		**88.37**	**kip**
Shear Reinforcement =	(2) Legs of	#4 Ties	@ 4 IN OC
A_v =		0.40	in^2
s =		4.00	in
$V_s = (A_v f_y d)/s$ =		**243.05**	**kip**
V_{BeamOE} =		**331.43**	kips
V_{BeamOE}/V_{MCyDE} =		**6.42**	

$V_{MCyDE} = V_E$

Step 7a.iv: Calculate beam backbone parameters a, b, and c and Acceptance Criteria if no development issues

$k_{sc} = 1 \geq 2 * V_{BeamOE}/V_{yE} - 1 \geq 0$ = 1.00

$a_{nl} = k_{sc}*(0.0055*M_{yE}/V_{MCyDE}d + 0.4*\rho_t*f_{ytE}/f'_{cE}) - \theta_{yE} \geq 0$ θ_{yE} = 0.008

a_{nl} = **0.0231** **rad**

If $s \leq d/2$ → $k_{sp} = 1$
If $s > d/2$ → $k_{sp} = 2 * (1-s/d) \geq 0$
Therefore k_{sp} = 1

$b_{nl1} = (0.5 / (5+(1/8)*(\rho_t*f_{ytE}/f'_{cE})^{-1})) - \theta_{yE} \geq a$

b_{nl1} = 0.0525 rad

If $V_{BeamOE}/V_{yE} \leq 1$ → $b_{nl} = b_{nl1}$
If $V_{BeamOE}/V_{yE} > 1$ → $b_{nl} = a_{nl} + 4*\theta_{yE}*k_{sp} \geq b_{nl1}$
b_{nl} = 0.0551 rad

If $V_{BeamOE}/V_{yE} \leq 1$ → $c_{nl} = 0.0$
If $V_{BeamOE}/V_{yE} > 1$ → $c_{nl} = 0.2$
c_{nl} = 0.2 rad

IO = 0.15a ≤ 0.005 0.0035 rad

LS = 0.5b = 0.0276 rad

CP = 0.7b = 0.0386 rad

Step 7a.v: Obtain beam backbone parameters and acceptance criteria for beam with inadequate embedment

a_{nl} = 0.015 rad

b_{nl} = 0.030 rad

c_{nl} = 0.2 rad

IO = 0.01 rad

LS = 0.02 rad

CP = 0.03 rad

Step 7a.vi: Obtain Controlling Hinge Rotation Backbone Parameters as Least Value From Applicable Conditions

			Acceptance Criteria		
Backbone Parameters			Performance Level (rad)		
a (rad)	b (rad)	c	IO	LS	CP
0.0150	0.0300	0.2000	0.0035	0.0200	0.0300

Values are calculated using the proposed changes to ASCE 41 Table 10-7 in ASCE 41-23.

Step 7a.vii: Scale Down Rotation Parameters for 2 Hinge Simplification (BOD Appendix E)

			Acceptance Criteria		
Backbone Parameters			Performance Level (rad)		
a (rad)	b (rad)	c	IO	LS	CP
0.0100	0.0200	0.2000	0.0023	0.0133	0.0200

Step 7b: Negative Bending Backbone Parameters

Step 7b.i: Determine which Conditions apply from Table 4.2.2.2a

No development issues Applicable Must be checked regardless

Inadequate Splicing Applicable Bars not adequately spliced per procedures of Appendix D of BOD

Inadequate Embed Not Applicable Hinge forms away from beam-column joint

Step 7b.ii: Calculate Reinforcement Ratios

ρ_t = 0.001667 in
ρ_l = 0.005000 in

Step 7b.iii: Calculate V_{BeamOE} as the Shear Capacity per ACI 318

$V_{BeamOE} = V_s + V_c$

$V_c = 2\lambda(f_c')^{1/2}b_w d =$ **88.37** kip

Shear Reinforcement = (2) Legs of #4 Ties @ 10 IN OC

$A_v =$ 0.40 in^2

$s =$ 10.00 in

$V_s = (A_v f_y d)/s =$ **97.22** kip

$V_{BeamOE} =$ **185.59** kips

$V_{BeamOE}/V_{MCyDE} =$ **3.60**

$V_{MCyDE} = V_E$

Step 7b.iv: Calculate beam backbone parameters a, b, and c and Acceptance Criteria if no development issues

$k_{sc} = 1 \geq 2 * V_{BeamOE}/V_{yE} - 1 \geq 0 =$ 1.00

$a_{nl} = k_{sc}*(0.0055*M_{yE}/V_{MCyDE}d + 0.4*\rho_t*f_{ytE}/f'_{cE}) - \theta_{yE} \geq 0$

$\theta_{yE} = 0.008$

$a_{nl} =$ **0.0075** rad

If $s \leq d/2$ → $k_{sp} = 1$

If $s > d/2$ → $k_{sp} = 2 * (1-s/d) \geq 0$

Therefore $k_{sp} =$ 1.00

$b_{nl1} = (0.5 / (5+(1/8)*(\rho_t*f_{ytE}/f'_{cE})^{-1})) - \theta_{yE} \geq a$

$b_{nl1} =$ 0.0300 rad

If $V_{BeamOE}/V_{yE} \leq 1$ → $b_{nl} = b_{nl1}$

If $V_{BeamOE}/V_{yE} > 1$ → $b_{nl} = a_{nl} + 4*\theta_{yE}*k_{sp} \geq b_{nl1}$.

$b_{nl} =$ **0.0395** rad

If $V_{BeamOE}/V_{yE} \leq 1$ → $c_{nl} = 0.0$

If $V_{BeamOE}/V_{yE} > 1$ → $c_{nl} = 0.2$

$c_{nl} =$ **0.2** rad

IO = 0.15a ≤ 0.005 **0.0011** rad

LS = 0.5b = **0.0198** rad

CP = 0.7b = **0.0277** rad

Step 7b.iii: Calculate Backbone Parameters per ASCE 41-23 Proposed Changes

a = (1/8)(pt*fytE)/(pl*fylE) ≤0.025

a = **0.0000** rad

Footnote Condition where a=0 if less than 2 ties cross a splice

b = **0.060** rad

c = 0.15 + 36*pt ≤ 0.02

c = **0.200** rad

Step 7b.iv: Obtain Controlling Hinge Rotation Backbone Parameters as Least Tabulated Value From Applicable Conditions

Backbone Parameters			Acceptance Criteria Performance Level (rad)		
a (rad)	**b (rad)**	**c**	**IO**	**LS**	**CP**
0.0000	0.0395	0.2000	0.0000	0.0198	0.0277

Values are calculated using the proposed changes to ASCE 41 Table 10-7 in ASCE 41-23.

Step 7b.v: Scale Down Rotation Parameters for 2 Hinge Simplification (BOD Appendix E)

Backbone Parameters			Acceptance Criteria Performance Level (rad)		
a (rad)	**b (rad)**	**c**	**IO**	**LS**	**CP**
0.0000	0.0264	0.2000	0.0000	0.0132	0.0184

Step 8: Summary of PERFORM Inputs i-Side

Step 8a: Positive Bending PERFORM Inputs

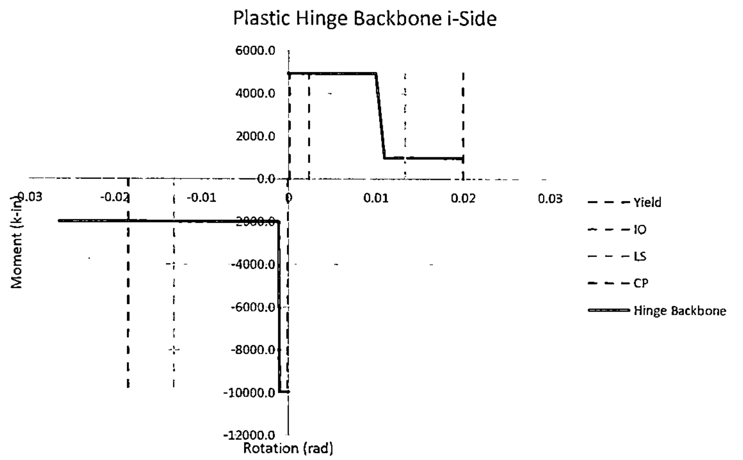
PERFORM INPUT								
STRENGTH (K)		DEFORMATION (in)			DEFORMATION CAPACITIES			
FU	FR/FU	DL	DR	DX	Level 1 (yield)	Level 2 (IO)	Level 3 (LS)	Level 4 (CP)
4938.6	0.200	0.0100	0.0110	0.0200	0.0001	0.0023	0.0133	0.0200

Step 8b: Negative Bending PERFORM Inputs

PERFORM INPUT								
STRENGTH (K)		DEFORMATION (in)			DEFORMATION CAPACITIES			
FU	FR/FU	DL	DR	DX	Level 1 (yield)	Level 2 (IO)	Level 3 (LS)	Level 4 (CP)
9949.8	0.200	0.0010	0.0011	0.0264	0.0001	0.0001	0.0132	0.0184

$FU = M_{nE\text{-}i}^{+}/M_{nE\text{-}i}^{-}$
FR/FU = c

DL = a
DR = 1.1*a
DX = b
Yield Deformation = 0.0001 to represent initial yield



Step 9: Obtain Plastic Hinge Rotation Backbone Parameters per ASCE 41-23 Ballot Table 4.2.2.2a for i-Side Flexural Rotations

Step 9a: Positive Bending Backbone Parameters

Step 9a.i: Determine which Conditions apply from Table 4.2.2.2a

No development issues	Applicable	Must be checked regardless
Inadequate Splicing	Not Applicable	Bottom bars are continuous
Inadequate Embed	Not Applicable	Bars are adequately embedded into joint

Step 9a.ii: Calculate Reinforcement Ratios

$\rho_t =$ 0.004167 in
$\rho_l =$ 0.005000 in

Step 9a.iii: Calculate V_{BeamOE} as the Shear Capacity per ACI 318

$V_{BeamOE} = V_s + V_c$

$V_c = 2\lambda(f_c')^{1/2}b_wd =$ **88.37** kip

Shear Reinforcement = (2) Legs of #4 Ties @ 4 IN OC
$A_v =$ 0.40 in^2
s = 4.00 in

$V_s = (A_vf_yd)/s =$ **243.05** kip

V_{BeamOE} = 331.43 kips

V_{BeamOE}/V_{MCyDE} = 6.42 $V_{MCyDE} = V_E$

Step 9a.iv: Calculate beam backbone parameters a, b, and c and Acceptance Criteria if no development issues

$k_{sc} = 1 \geq 2 * V_{BeamOE}/V_{yE} - 1 \geq 0 =$ 1.00

$a_{nl} = k_{sc}*(0.0055*M_{yE}/V_{MCyDE}d + 0.4*\rho_t*f_{ytE}/f'_{cE}) - \theta_{yE} \geq 0$ θ_{yE}= 0.008

a_{nl} = 0.0429 rad

If s ≤ d/2 → $k_{sp} = 1$
If s > d/2 → $k_{sp} = 2 * (1\text{-}s/d) \geq 0$
Therefore k_{sp} = 1

$b_{nl1} = (0.5 / (5+(1/8)*(\rho_t*f_{ytE}/f'_{cE})^{-1})) - \theta_{yE} \geq a$

b_{nl1} = 0.0525 rad

If $V_{BeamOE}/V_{yE} \leq 1$ → $b_{nl} = b_{nl1}$
If $V_{BeamOE}/V_{yE} > 1$ → $b_{nl} = a_{nl} + 4*\theta_{yE}*k_{sp} \geq b_{nl1}$
b_{nl} = 0.0749 rad

If $V_{BeamOE}/V_{yE} \leq 1$ → $c_{nl} = 0.0$
If $V_{BeamOE}/V_{yE} > 1$ → $c_{nl} = 0.2$
c_{nl} = 0.2 rad

IO = 0.15a ≤ 0.005 0.0050 rad

LS = 0.5b = 0.0374 rad

CP = 0.7b = 0.0524 rad

Step 9a.v: Obtain beam backbone parameters and acceptance criteria for beam with inadequate embedment

a_{nl} = 0.015 rad

b_{nl} = 0.030 rad

c_{nl} = 0.2 rad

IO = 0.01 rad

LS = 0.02 rad

CP = 0.03 rad

Step 9a.vi: Obtain Controlling Hinge Rotation Backbone Parameters as Least Value From Applicable Conditions

			Acceptance Criteria		
Backbone Parameters			Performance Level (rad)		
a (rad)	b (rad)	c	IO	LS	CP
0.0429	0.0749	0.2000	0.0050	0.0374	0.0524

Values are calculated using the proposed changes to ASCE 41 Table 10-7 in ASCE 41-23.

Step 9a.vii: Scale Down Rotation Parameters for 2 Hinge Simplification (BOD Appendix E)

			Acceptance Criteria		
Backbone Parameters			Performance Level (rad)		
a (rad)	b (rad)	c	IO	LS	CP
0.0286	0.0499	0.2000	0.0033	0.0250	0.0349

Step 9b: Negative Bending Backbone Parameters

Step 9b.i: Determine which Conditions apply from Table 4.2.2.2a

No development issues	Applicable	Must be checked regardless
Inadequate Splicing	Applicable	Bars not adequately spliced per procedures of Appendix D of BOD
Inadequate Embed	Not Applicable	Hinge forms away from beam-column joint

Step 9b.ii: Calculate Reinforcement Ratios

ρ_t = 0.001667 in
ρ_l = 0.005000 in

Step 9b.iii: Calculate V_{BeamOE} as the Shear Capacity per ACI 318

$V_{BeamOE} = V_s + V_c$

$V_c = 2\lambda(f_c')^{1/2}b_wd$ = 88.37 kip

Shear Reinforcement = (2) Legs of #4 Ties @ 10 IN OC
A_v = 0.40 in^2
s = 10.00 in

$V_s = (A_vf_yd)/s$ = 97.22 kip

V_{BeamOE} = **185.59** kips
V_{BeamOE}/V_{MCyDE} = **3.60**

$V_{MCyDE} = V_E$

Step 9b.iv: Calculate beam backbone parameters a, b, and c and Acceptance Criteria if no development issues

$k_{sc} = 1 \geq 2 * V_{BeamOE}/V_{yE} - 1 \geq 0$ = 1.00

$a_{nl} = k_{sc}*(0.0055*M_{yE}/V_{MCyDE}d + 0.4*\rho_t*f_{ytE}/f'_{cE}) - \theta_{yE} \geq 0$

θ_{yE}= 0.008

a_{nl} = **0.0075 rad**

If $s \leq d/2$ → $k_{sp} = 1$
If $s > d/2$ → $k_{sp} = 2 * (1-s/d) \geq 0$
Therefore k_{sp} = 1.00

$b_{nl1} = (0.5 / (5+(1/8)*(\rho_t*f_{ytE}/f'_{cE})^{-1})) - \theta_{yE} \geq a$

b_{nl1} = 0.0300 rad

If $V_{BeamOE}/V_{yE} \leq 1$ → $b_{nl} = b_{nl1}$
If $V_{BeamOE}/V_{yE} > 1$ → $b_{nl} = a_{nl} + 4*\theta_{yE}*k_{sp} \geq b_{nl1}$
b_{nl} = **0.0395 rad**

If $V_{BeamOE}/V_{yE} \leq 1$ → $c_{nl} = 0.0$
If $V_{BeamOE}/V_{yE} > 1$ → $c_{nl} = 0.2$
c_{nl} = **0.2 rad**

IO = 0.15a ≤ 0.005 0.0011 rad

LS = 0.5b = 0.0198 rad

CP = 0.7b = 0.0277 rad

Step 9b.iii: Calculate Backbone Parameters per ASCE 41-23 Proposed Changes

a = (1/8)(pt*fytE)/(pl*fylE) ≤0.025
a = **0.0000 rad**

Footnote Condition where a=0 if less than 2 ties cross a splice

b = **0.060 rad**

c = 0.15 + 36*pt ≤ 0.02
c = **0.200 rad**

Step 9b.iv: Obtain Controlling Hinge Rotation Backbone Parameters as Least Tabulated Value From Applicable Conditions

Backbone Parameters			Acceptance Criteria Performance Level (rad)		
a (rad)	b (rad)	c	IO	LS	CP
0.0000	0.0395	0.2000	0.0000	0.0198	0.0277

Values are calculated using the proposed changes to ASCE 41 Table 10-7 in ASCE 41-23.

Step 9b.v: Scale Down Rotation Parameters for 2 Hinge Simplification (BOD Appendix E)

Backbone Parameters			Acceptance Criteria Performance Level (rad)		
a (rad)	b (rad)	c	IO	LS	CP
0.0000	0.0264	0.2000	0.0000	0.0132	0.0184

Step 10: Summary of PERFORM Inputs i-Side

Step 10a: Positive Bending PERFORM Inputs

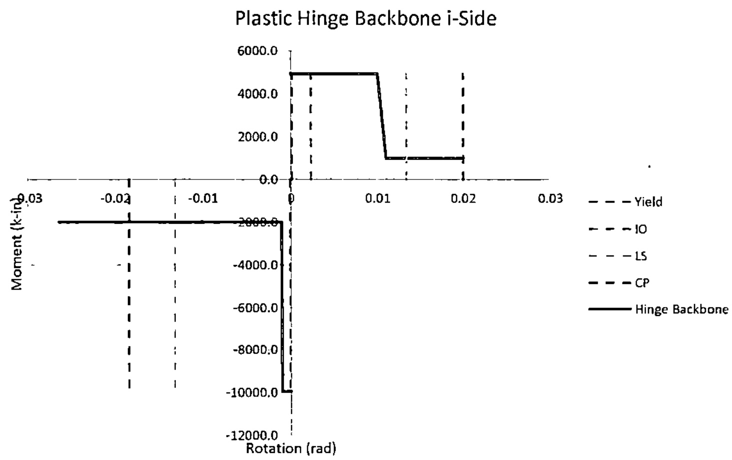
PERFORM INPUT								
STRENGTH (K)		DEFORMATION (in)			DEFORMATION CAPACITIES			
FU	FR/FU	DL	DR	DX	Level 1 (yield)	Level 2 (IO)	Level 3 (LS)	Level 4 (CP)
11097.6	0.200	0.0286	0.0314	0.0499	0.0001	0.0033	0.0250	0.0349

Step 10b: Negative Bending PERFORM Inputs

PERFORM INPUT								
STRENGTH (K)		DEFORMATION (in)			DEFORMATION CAPACITIES			
FU	FR/FU	DL	DR	DX	Level 1 (yield)	Level 2 (IO)	Level 3 (LS)	Level 4 (CP)
6870.3	0.200	0.0010	0.0011	0.0264	0.0001	0.0001	0.0132	0.0184

$FU = M_{nE\text{-}i}^{+}/M_{nE\text{-}i}^{-}$
FR/FU = c

DL = a
DR = 1.1*a
DX = b
Yield Deformation = 0.0001 to represent initial yield



Step 11: Expected Beam Shear Capacity, φV_{nE} per ACI 318-14 Section 22.5.5.1 & 22.5.10.5.3

Step 11a: Calculate V_c per ACI 318-14 Section 22.5.5.1

$V_c = 2\lambda(f_c')^{1/2}b_wd =$ **88.37** **kip**

Step 11b: Calculate $V_{s,end}$ per ACI 318-14 Section 22.5.10.5.3

$V_s = (A_vf_{yt}d)/s =$ **166.48** **kip**

Step 11c: Calculate $V_{s,mid}$ per ACI 318-14 Section 22.5.10.5.3

$V_s = (A_vf_{yt}d)/s =$ **66.59** **kip**

Step 11d: Calculate $V_{nE,end}$ per ACI 318-14 Section 22.5.1.1

$V_{nE} = V_s + V_c =$ **254.85** **kip**
$\varphi =$ 1.00
$\varphi V_{nE} =$ **254.85** **kip**

Step 11e: Calculate $V_{nE,mid}$ per ACI 318-14 Section 22.5.1.1

$V_{nE} = V_s + V_c =$ **154.96** **kip**
$\varphi =$ 1.00
$\varphi V_{nE} =$ **154.96** **kip**

T-Beam Capacity Scale Factor Calculations

Calculation of T-Beam capacities was done for a couple of representative cases. A scale factor was calculated that compared the capacity of the T-Beam to the same rectangular beam assuming no compression or slab reinforcement. These scale factors are then used to scale up moment capacities for all beams. See previous sample calculation of beam capacities for application of the scale factor or the detailed calculations for each beam in Appendix C.

Summary of final T-Beam Scale Factors		
Beam Condition	Floor	Scale Factor
Bot Bar @ Column Face; Interior Beam	1	1.63
Bot Bar @ Column Face; Exterior Beam	1	1.51
Bot Bar @ Column Face; Interior Beam	2, 3, Roof	1.18
Bot Bar @ Column Face; Exterior Beam	2, 3, Roof	1.07
Top Bar @ Third Point; Interior Beam	1, 2, 3, Roof	1.64
Top Bar @ Third Point; Exterior Beam	1, 2, 3, Roof	1.64

See the following page for a summary of individual conditions used to calculate scale factors.

Summary of T Beam Scale Factor Results

Interior Beam Conditions			
Bot Bar Strength Comparisons @ Column Face			
Condition #	$\phi M_{n,spCol}^{+}$ (k-ft)	$\phi M_{n,hand\ calcs}^{+}$ (k-ft)	SF = $\phi M_{n,spCol}^{+}/\phi M_{n,hand\ calcs}^{+}$
1	999.91	612.45	**1.63**
2	858.08	708.57	1.21
3	475.60	411.76	1.16

Avg of Conditions 2-3 = **1.18**

Exterior Beam Conditions			
Bot Bar Strength Comparisons @ Column Face			
Condition #	$\phi M_{n,spCol}^{+}$ (k-ft)	$\phi M_{n,hand\ calcs}^{+}$ (k-ft)	SF = $\phi M_{n,spCol}^{+}/\phi M_{n,hand\ calcs}^{+}$
1	923.19	612.45	**1.51**
2	653.67	612.45	1.07
3	509.99	471.72	1.08

Avg of Conditions 2-3 = 1.07

Interior Beam Conditions			
Top Bar Strength Comparisons @ Third Points			
Condition #	$\phi M_{n,spCol}^{-}$ (k-ft)	$\phi M_{n,hand\ calcs}^{-}$ (k-ft)	SF = $\phi M_{n,spCol}^{-}/\phi M_{n,hand\ calcs}^{-}$
1	402.39	245.77	1.64
2	336.09	202.39	1.66
3	331.88	202.39	1.64

Exterior Beam Conditions			
Top Bar Strength Comparisons @ Third Points			
Condition #	$\phi M_{n,spCol}^{-}$ (k-ft)	$\phi M_{n,hand\ calcs}^{-}$ (k-ft)	SF = $\phi M_{n,spCol}^{-}/\phi M_{n,hand\ calcs}^{-}$
1	402.06	245.77	1.64
2	402.16	245.77	1.64
3	376.67	231.17	1.63

Avg of All Top Bar Conditions = **1.64**

Note:
1. Bottom bar scale factors for Level 1(interior and exterior) are not taken as an average due to the bottom bar conditions being very different to all other floors.
2. Bottom bar scale factors for levels 2, 3 and the roof are based on the average of conditions 2 and 3 only.
3. Phi Mn, hand calcs is based on hand calculations that assume the beam is rectangular and ignore compression steel and slab bars.
4. See the follow page for description of each condition and rebar used. See Appendix C for spCol output of each condition.

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project City of Inglewood - Library	by JL	sheet no. 6.1-24
location Inglewood, CA	date 4/6/21	
client	job no. 2000362	
Concrete Beams		

T Beam Conditions Used

Interior Beam Conditions					
Bottom Bar Conditions					
Condition #	Beam H (in)	Beam W (in)	@ Column Face	Location	slab bars
1	36	24	(4) #18's Top (2) rows, (2) #11's Bot	1st Floor	#5's @12" oc top, #4's @28" oc bot
2	30	28	(4) #18's Top, (2) #14's Bot	2nd/3rd	#4's @10" oc top, #4's @28" oc bot
3	30	28	(4) #11's Top, (2) #10's Bot	Roof	#4's @10" oc top, #4's @28" oc bot

Interior Beam Conditions					
Top Bar Conditions to model in spCol					
Condition #	Beam H (in)	Beam W (in)	@ Column Face	Location	slab bars
1	36	24	(2) #7's Top, (4) #11's Bot	1st Floor	#4's @28" oc bot
2	30	28	(2) #7's Top, (4) #14's Bot	2nd/3rd	#4's @28" oc bot
3	30	28	(2) #7's Top, (3) #10's Bot	Roof	#4's @28" oc bot

Exterior Beam Conditions					
Bot Bar Conditions					
Condition #	Beam H (in)	Beam W (in)	@ Column Face	Location	slab bars
1	36	24	(4) #18's Top (2) rows, (2) #11's Bot	1st Floor	#4's @14" oc bot
2	36	24	(6) #11's Top, (2) #11's Bot	2nd/3rd	#4's @14" oc bot
3	34	24	(4) #11's Top, (2) #10's Bot	Roof	#4's @14" oc bot

Exterior Beam Conditions					
Top Bar Conditions					
Condition #	Beam H (in)	Beam W (in)	@ Column Face	Location	slab bars
1	36	24	(2) #7's Top, (2) #11's + (2) #10's Bot	1st Floor	#4's @14" oc bot
2	36	24	(2) #7's Top, (4) #11's Bot	2nd/3rd	#4's @14" oc bot
3	34	24	(2) #7's Top, (3) #10's Bot	Roof	#4's @14" oc bot

6.2 - Concrete Column Calculations

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	location Inglewood, CA	date 4/3/21	
	client	job no. 2000362	
	Concrete Columns		

Executive Summary

This section includes a sample calculation of nonlinear column hinges. The calculation of each hinge follows the procedure established in Appendix F of the Basis of Design. Detailed calculations of all column hinges are located in Appendix D.

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Concrete Columns

Column Grouping & Axial Load Levels					
Column Group ID	Columns in Group	Stories Represented	N_{UG} (xf'cAg)	Stiffness Modifier	N_{UD} (xf'cAg)
C-36_1	C-6, D-6, C-7, D-7	1	0.15	0.35	0.25
C_24_1	A-2, A-3, A-4, B-5, C-1, C-3, C-4, C-5, D-5, E-3, E-4	1, 2	0.24	0.44	0.3
C_24_3	A-2, A-3, A-4, C-1, C-3, C-4, C-5, D-5, E-3, E-4, B-1, B-2, B-3, B-4, C-2, D-1, D-2, D-3, D-4, E-2	3, 4	0.14	0.34	0.2
C_24.1_1	B-1, B-2, B-3, B-4, C-2, D-1, D-2, D-3, D-4, E-2	1, 2	0.24	0.44	0.36
C_24.2_1	A-1, A-5, E-1, E-5	1, 2	0.14	0.34	0.22
C_24.2_3	A-1, A-5, E-1, E-5	3, 4	0.07	0.3	0.1
C_24.3_1	A-6, B-6, E-6	1	0.05	0.3	0.1

Taken from ETABS model as maximum axial load in column group

Assumed Axial load including seismic. Values are checked in PERFORM through an axial strength section.

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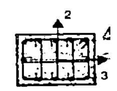
Column Hinge Summary

Development Length Parameters		
Ψe	1	Epoxy Factor
λ	1	Lightweight Factor



Clear Run

Column ID	Level	b (in)	h (in)	L_n (ft)	L_n/h	$f'c_L$ (ksi)	$f'c_E$ (ksi)	fy_L (ksi)	fy_E (ksi)	$fy_{L,t}$	$fy_{E,t}$	Longitudinal Reinf: Bar Size	Total Number Bars	Clear Cover (in)	Dev Len Provided (in)
C_36_1	1	36	36	11	3.67	4.543	5.99	65	73	40	50	14	12	1.5	1000
C_24_1	1	24	24	11	5.50	4.543	5.99	65	73	40	50	18	8	1.5	1000
C_24_3	3	24	24	11.5	5.75	4.543	5.99	65	73	40	50	11	8	1.5	42.3
C_24.1_1	1	24	24	11	5.50	4.543	5.99	65	73	40	50	18	8	1.5	1000
C_24.2_1	1	24	24	11	5.50	4.543	5.99	65	73	40	50	14	8	1.5	1000
C_24.2_3	3	24	24	11.5	5.75	4.543	5.99	65	73	40	50	10	8	1.5	38.1
C_24.3_1	1	24	24	11	5.50	4.543	5.99	65	73	40	50	11	4	1.5	42.3

Column ID	Transverse Reinforcement 2-2 Axis: Tie Size	# of Legs	s (in)	Transverse Reinforcement 3-3 Axis: Tie Size	# of Legs	s (in)	V_{ColOE} Parameters: k_{nl}	N_{UG} (k)	N_{UD} (k)	$M_{pr,2-2}$ (k-ft)	$M_{pr,3-3}$ (k-ft)	P-M Interaction Inputs: P_C (k)	P_T (k)	$P_{B,2-2}$ (k)	$M_{B,2-2}$ (k-ft)	$P_{B,3-3}$ (k)	$M_{B,3-3}$ (k-ft)	$M_{0,2-2}$ (k-ft)	$M_{0,3-3}$ (k-ft)
C_36_1	4	3.00	4	4	6.00	4	1.0	1165	1941	4505.38	3624.11	8644	2198.8	2411.537	4723.995	2428.46	3715.235	2828.23	2593.04
C_24_1	4	3.41	4	4	3.41	4	1.0	828	1035.07	1785	1785	5105.78	2336	819.9592	1832.927	819.959	1832.927	1596.74	1596.74
C_24_3	4	3.41	4	4	3.41	4	1.0	483.03	690.048	1072	1072	3780.2	911.04	998.6122	1165.274	998.612	1165.274	739.95	739.95
C_24.1_1	4	3.41	4	4	3.41	4	1.0	828	1242	1738.58	1738.58	5105.78	2336.0	819.9592	1832.927	819.959	1832.927	1596.74	1596.74
C_24.2_1	4	3.41	4	4	3.41	4	1.0	483	759	1308.6	1308.6	4155.06	1314.0	952.0706	1362.179	952.071	1362.179	1029.88	1029.88
C_24.2_3	4	3.41	4	4	3.41	4	1.0	242	345	845.31	845.31	3622.65	741.7	1016.87	1080.285	1016.87	1080.285	613.43	613.43
C_24.3_1	4	2.00	4	4	2.00	4	1.0	138	345	672.73999	672.73999	3356.45	455.5	1073.868	1046.393	1073.87	1046.393	397.92	397.92

Column ID	$V_{pr,3-3}$ (k)	$V_{ColOE,3-3}$ (k)	$V_{ColE,3-3}$ (k)	$V_{pr,2-2}$ (k)	$V_{ColOE,2-2}$ (k)	$V_{ColE,2-2}$ (k)	Hinge Rotation Parameters - 2-2 Axis (Strong): Modeling Parameters a	b	c	Acceptance Criteria IO	LS	CP	Hinge Rotation Parameters - 3-3 Axis (Weak): Modeling Parameters a	b	c	Acceptance Criteria IO	LS	CP
C_36_1	819.16	909.71	774.15	658.929	661.06	575.23	0.0163	0.0539	0.1400	0.0024	0.0270	0.0378	0.0112	0.0370	0.1400	0.0017	0.0185	0.0259
C_24_1	324.55	315.10	268.29	324.545	315.10	268.29	0.0105	0.0469	0.1200	0.0016	0.0235	0.0328	0.0105	0.0469	0.1200	0.0016	0.0235	0.0328
C_24_3	186.43	292.39	246.24	186.435	292.39	246.24	0.0250	0.0600	0.4000	0.0000	0.0300	0.0420	0.0250	0.0600	0.4000	0.0000	0.0300	0.0420
C_24.1_1	316.11	315.10	268.29	316.105	315.10	268.29	0.0086	0.0424	0.0960	0.0013	0.0212	0.0297	0.0086	0.0424	0.0960	0.0013	0.0212	0.0297
C_24.2_1	237.93	295.44	249.16	237.927	295.44	249.16	0.0191	0.0543	0.1520	0.0029	0.0272	0.0380	0.0191	0.0543	0.1520	0.0029	0.0272	0.0380
C_24.2_3	147.01	273.76	228.24	147.01	273.76	228.24	0.0250	0.0600	0.4000	0.0000	0.0300	0.0420	0.0250	0.0600	0.4000	0.0000	0.0300	0.0420
C_24.3_1	122.32	191.48	161.06	122.316	191.48	161.06	0.0250	0.0600	0.3214	0.0000	0.0300	0.0420	0.0250	0.0600	0.3214	0.0000	0.0300	0.0420

Taken as moment capacity evaluated under expected material properties at the Nud Axial Load

Values taken from spColumn to define P-M interaction Diagram

PERFORM INPUT

AXIAL STRENGTH (K) - COMPRESSION: FU	FR/FU	DEF. (IN): DX	AXIAL STRENGTH (K) - TENSION: FU	FR/FU	DEF. (IN): DX	BENDING STRENGTH (K-in) - 2-2 Axis (Strong): FU	FR/FU	$M_{B,2-2}$	$M_{0,2-2}$	$M_{B,2-2}/M_{0,2-2}$	$P_{B,2-2}/P_C$
8644	0.1400	1	2198.8	0.1400	1	56687.94	0.1400	56687.94	33938.76	0.5987	0.2790
5105.776	0.1200	1	2336	0.1200	1	21995.12	0.1200	21995.12	19160.88	0.8711	0.1606
3780.202	0.4000	1	911.04	0.4000	1	13983.29	0.4000	13983.29	8879.35	0.6350	0.2642
5105.776	0.0960	1	2336	0.0960	1	21995.12	0.0960	21995.12	19160.88	0.8711	0.1606
4155.057	0.1520	1	1314	0.1520	1	16346.15	0.1520	16346.15	12358.61	0.7561	0.2291
3622.654	0.4000	1	741.68	0.4000	1	12963.42	0.4000	12963.42	7361.13	0.5678	0.2807
3356.453	0.3214	1	455.52	0.3214	1	12556.72	0.3214	12556.72	4775.03	0.3803	0.3199

BENDING DEFORMATION (rad) - 2-2 Axis (Strong): DL	DR	DX	DR/DL	BENDING DEFORMATION CAPACITIES - 2-2 AXIS: Level 1 (yield)	Level 2 (IO)	Level 3 (LS)	Level 4 (CP)	BENDING STRENGTH (K-in) - 3-3 Axis (Weak): FU	FR/FU	$M_{B,3-3}$	$M_{0,3-3}$	$M_{B,3-3}/M_{0,3-3}$	$P_{B,2-2}/P_C$
0.0163	0.0171	0.0539	1.05	0.0001	0.0024	0.0270	0.0378	44582.82	0.1400	44582.82	31116.48	0.6979	0.2809
0.0105	0.0111	0.0469	1.05	0.0001	0.0016	0.0235	0.0328	21995.12	0.1200	21995.12	19160.88	0.8711	0.1606
0.0250	0.0263	0.0600	1.05	0.0001	0.0001	0.0300	0.0420	13983.29	0.4000	13983.29	8879.35	0.6350	0.2642
0.0086	0.0090	0.0424	1.05	0.0001	0.0013	0.0212	0.0297	21995.12	0.0960	21995.12	19160.88	0.8711	0.1606
0.0191	0.0201	0.0543	1.05	0.0001	0.0029	0.0272	0.0380	16346.15	0.1520	16346.15	12358.61	0.7561	0.2291
0.0250	0.0263	0.0600	1.05	0.0001	0.0001	0.0300	0.0420	12963.42	0.4000	12963.42	7361.13	0.5678	0.2807
0.0250	0.0263	0.0600	1.05	0.0001	0.0001	0.0300	0.0420	12556.72	0.3214	12556.72	4775.03	0.3803	0.3199

BENDING DEFORMATION (rad) - 3-3 Axis (Weak): DL	DR	DX	DR/DL	DEFORMATION CAPACITIES - 3-3 AXIS: Level 1 (yield)	Level 2 (IO)	Level 3 (LS)	Level 4 (CP)	Axis 2-2/Axis 3-3	CHECKS: Controlled by Inadequate Development Yes/No?	fs-deg
0.0112	0.0117	0.0370	1.05	0.0001	0.0017	0.0185	0.0259	1.4582	No	73
0.0105	0.0111	0.0469	1.05	0.0001	0.0016	0.0235	0.0328	1.0000	No	73
0.0250	0.0263	0.0600	1.05	0.0001	0.0001	0.0300	0.0420	1.0000	Yes	73
0.0086	0.0090	0.0424	1.05	0.0001	0.0013	0.0212	0.0297	1.0000	No	73
0.0191	0.0201	0.0543	1.05	0.0001	0.0029	0.0272	0.0380	1.0000	No	73
0.0250	0.0263	0.0600	1.05	0.0001	0.0001	0.0300	0.0420	1.0000	Yes	73
0.0250	0.0263	0.0600	1.05	0.0001	0.0001	0.0300	0.0420	1.0000	Yes	73

Concrete Column Sample Calculation

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Project :
Job no. :
Date :
By :

Column ID & Story **C_36_1 at 1**

Step 1: Summarize Column Properties, Other Inputs

f'_{cL} =	5	ksi	width, b =	36	in	Longitudinal Reinf:	(12)	#14's
f'_{cE} =	6.0	ksi	height, h =	36	in	Dev len provided, l_b =	1000.00	in
f_{yL} =	65	ksi	A_g = b*h =	1,296	in^2	Transverse Reinf - 2-2:	(3) Legs of	#4 Ties @ 4 IN OC
f_{yE} =	73	ksi	L_n =	11.00	ft	Transverse Reinf - 3-3:	(6) Legs of	#4 Ties @ 4 IN OC
$f_{yL,t}$ =	40	ksi				Clear Cover, c_c =	1.50	in
$f_{yE,t}$ =	50	ksi	k_{nl} =	1				
$\sqrt{f'_{cL}}$ =	67.4	psi				P_C =	8644	k
$\sqrt{f'_{cE}}$ =	77.4	psi	N_{UG} =	1164.5	k	P_T =	2198.8	k
λ =	1		N_{UD} =	1940.76	k	$P_{B,2-2}$ =	2411.537	k
φ_v =	1		$M_{pr,2-2}$ =	4505.38	k-ft	$M_{B,2-2}$ =	4723.995	k-ft
			$M_{pr,3-3}$ =	3624.11	k-ft	$P_{B,3-3}$ =	2428.46	k
Ψ_e	1					$M_{B,3-3}$ =	3715.235	k-ft
Ψ_t	1					$M_{0,2-2}$ =	2828.23	k-ft
						$M_{0,3-3}$ =	2593.04	k-ft

Step 2: Determine if columns are controlled by inadequate development per ASCE 41 Section 10.3.5

Step 2a: Calculate Development length required per ACI Section 25.4.2.3

d_b = 1.69 in
Ψ_s = 1

c_b = 2.85 in — Assumes c_b is always governed by distance to edge of concrete
A_{tr} = 0.60 in^2
s = 4 in
n = 12

$$K_{tr} = \frac{40A_{tr}}{sn} \qquad (25.4.2.3b)$$

K_{tr} = 0.50

$$l_d = \left(\frac{3}{40}\frac{f_y}{\lambda\sqrt{f'_c}}\frac{\Psi_t\Psi_e\Psi_s}{\left(\frac{c_b+K_{tr}}{d_b}\right)}\right)d_b \qquad (25.4.2.3a)$$

l_d = 60.59 in

Step 2b: Calculate f_s and $f_{s\text{-}deg}$ per ASCE 41 eq 10-1b

l_b = 1000.00 in
d = max(h-c_b,b-c_b) = 33.15 in

$l_{b\text{-}deg}$ = l_b - (2/3)d = 977.90 in

$$f_s = 1.25\left(\frac{l_b}{l_d}\right)^{2/3} f_{yL} \le f_{yL/E} \qquad (10\text{-}1a)$$

f_s = 73.00 ksi

$$f_{s\text{-}deg} = 1.25\left(\frac{l_{b\text{-}deg}}{l_d}\right)^{2/3} f_{ytL} \le f_{ytL/E} \qquad (10\text{-}1b)$$

$f_{s\text{-}deg}$ = 73.00 ksi

Step 2c: Check if Column is Controlled by Inadequate Development

if $l_b \geq l_d$ or $f_{s\text{-}deg} = f_{yE}$ → Not Controlled by Inadequate Development
if $f_{s\text{-}deg} < f_{yE}$ → Controlled by Inadequate Development
Therefore Column is Not Controlled by Inadequate Development

Step 3: Calculate Expected Shear Capacity V_{ColOE} for Axis 3-3 (Strong Axis Bending) per ASCE 41-17 Section 10.4.2.3.1

Step 3a: Determine Transverse Reinforcement Properties

A_v =	1.20	in^2
s =	4.00	in
b_c =	33	in

$\rho_t = A_s/(sb_c)$ = 0.0091

ASSUMES TIES ARE ADEQUATELY ANCHORED TO CORE
Cant be greater than 0.0175 with properly anchored ties into core
Cant be greater than 0.0075 if not properly anchored

If pt is < 0.0005 → NG
If pt is ≥ 0.0005 → OK
Therefore Transverse Reinf is OK

$d = h\text{-}c_b$ = 33.2 in

h is oriented to be the strong axis direction and runs parallel to the 3-3 direction

s/d = 0.1207
if s/d ≤ 0.75 → $\alpha_{Col} = 1$
if s/d ≥ 1.0 → $\alpha_{Col} = 0.0$
if 1.0 > s/d > 0.75 → α_{Col} = varies linearly
Therfore α_{Col} = 1

Step 3b: Determine V_{ColOE}

$M_{UD}/V_{UD}d$ = 1.990740043
If $M_{UD}/V_{UD}d \geq 4$ → 4
If $M_{UD}/V_{UD}d \leq 2$ → 2
If $4 > M_{UD}/V_{UD}d > 2$ → $M_{UD}/V_{UD}d$
Therefore $M_{UD}/V_{UD}d$ = 2

$$V_{Col} = k_{nl}\, V_{Col0} = k_{nl}\left[\alpha_{Col}\left(\frac{A_v f_{ytL/E}\, d}{s}\right) + \lambda\left(\frac{6\sqrt{f'_{cL/E}}}{M_{UD}/V_{UD}\, d}\sqrt{1+\frac{N_{UG}}{6A_g\sqrt{f'_{cL/E}}}}\right)0.8\,A_g\right] \text{ (lb/in.}^2\text{ units)}$$

V_{ColOE} assumes all material properties are expected properties

V_{ColOE} = 909.71 k

Step 4: Calculate Plastic Hinge Properties per ASCE 41-17 Table 10-8 about 2-2 Axis (Strong Axis Bending):

Step 4a: Calculate V_{yE}

It is assumed that V_{yE} is equivalent to the maximum probable shear V_{pr}.

$Vy_E = V_{pr,2\text{-}2} = 2M_{pr,2\text{-}2}/L_n$ = 819.16 k

Step 4b: Calculate hinge properties a, b, c and Acceptance criteria IO, LS, CP

$N_{UD}/(A_g f'_{cE})$ =	0.25
ρ_t =	0.0091
ρ_l =	0.0217

a = (0.042-0.043*(NUD/(Agf'cE))+0.63pt-0.023(VyE/VColOE)) ≥ 0.0
a = 0.0163 rad

For NUD/(Agf'cE) ≤ 0.5 → b = (0.5/(5+((NUD/(0.8Agf'cE))(1/pt)(f'cE/fytE))))-0.01≥a
For NUD/(Agf'cE) = 0.7 → b =0 ≥a
For 0.5<NUD/(Agf'cE) < 0.7 → linearly interpolate b ≥a

b @ NUD/(Agf'cE) = 0.5→	0.0370	rad
b @ NUD/(Agf'cE) = 0.1→	0.0716	rad

b = 0.0539 rad

check b ≥ a

if b < a → b = a

if b ≥ a → b = b

Therefore b = 0.0539 rad

c = (0.24-0.4*(NUD/(Agf'cE))) ≥ 0.0

c = 0.140 rad

IO = 0.15a ≤ 0.005 → 0.0024 rad

LS = 0.5b = 0.0270 rad *b calculated with NUD/Agf'c >= 0.1

CP = 0.7b = 0.0378 rad *b calculated with NUD/Agf'c >= 0.1

Backbone Parameters			Acceptance Criteria Performance Level (in)		
a (rad)	b (rad)	c	IO	LS	CP
0.0163	0.0539	0.140	0.0024	0.0270	0.0378

Step 5: Summary of Perform Inputs, about Axis 2-2 (Strong Axis Bending)

BENDING STRENGTH (K-in) - 2-2 Axis (Strong)					
FU	FR/FU	$M_{B,2-2}$	$M_{0,2-2}$	$M_{0,2-2}/M_{B,2-2}$	$P_{B,2-2}/P_C$
56687.94	0.140	56687.94	33938.76	0.599	0.279

BENDING DEFORMATION (rad) - 2-2 Axis (Strong)				BENDING DEFORMATION CAPACITIES - 2-2 AXIS			
DL	DR	DX	DR/DL	Level 1 (yield)	Level 2 (IO)	Level 3 (LS)	Level 4 (CP)
0.0163	0.0171	0.0539	1.05	0.0001	0.0024	0.0270	0.0378

FU = $M_{B,2-2}$ = Moment at the balance point

FR/FU = c

DL = a

DR = 1.05*a

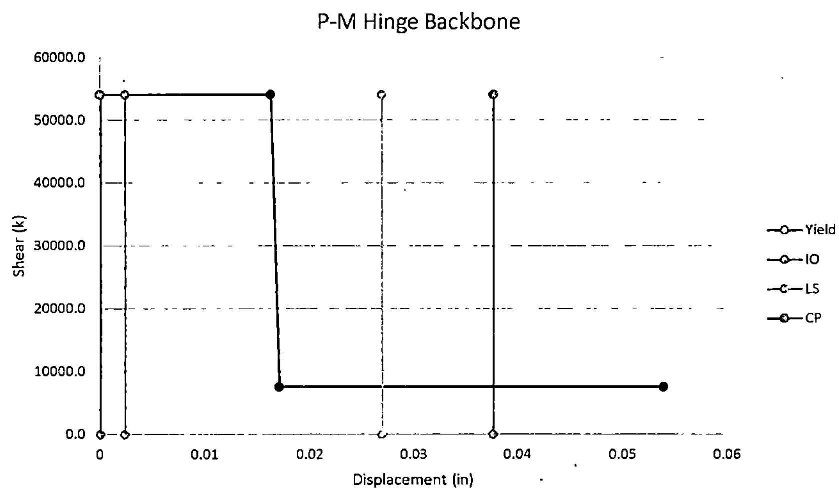
DX = b

Yield Deformation = 0.0001 to represent initial yield

$M_{0,2-2}$ = Moment where axial load is 0

$P_{B,2-2}$ = Axial Load at the balance point

P_C = Maximum Axial Load capacity in the column with 0 moment demand



Step 6: Calculate Expected Shear Capacity V_{ColOE} for Axis 2-2 (Weak Axis Bending) per ASCE 41-17 Section 10.4.2.3.1

Step 6a: Determine Transverse Reinforcement Properties

A_v =	0.60	in^2
s =	4.00	in
b_c =	33	in

$\rho_t = A_s/(sb_c)$ = 0.004545455

If pt is < 0.0005	→	NG
If pt is ≥ 0.0005	→	OK
Therefore Transverse Reinf is		OK

$d = b - c_b$ = 33.2 in — assumes b is oriented to be the weak axis direction and runs parallel to the 2-2 direction

s/d =		0.1207
if s/d ≤ 0.75	→	α_{Col} = 0.75
if s/d ≥ 1.0	→	α_{Col} = 0.0
if 1.0 > s/d > 0.75	→	α_{Col} = varies linearly
Therfore α_{Col} =		**1**

Step 6b: Determine V_{ColOE}

$M_{UD}/V_{UD}d$ =		1.990740043
If $M_{UD}/V_{UD}d \geq 4$	→	4
If $M_{UD}/V_{UD}d \leq 2$	→	2
If $4 > M_{UD}/V_{UD}d > 2$	→	$M_{UD}/V_{UD}d$
Therefore $M_{UD}/V_{UD}d$ =		**2**

$$V_{Col} = k_{nl} V_{ColO} = k_{nl}\left[\alpha_{Col}\left(\frac{A_v f_{ytL/E} d}{s}\right) + \lambda\left(\frac{6\sqrt{f'_{cL/E}}}{M_{UD}/V_{UD}\, d}\sqrt{1+\frac{N_{UG}}{6A_g\sqrt{f'_{cL/E}}}}\right)0.8A_g\right] \text{ (lb/in.}^2\text{ units)}$$

V_{ColOE} assumes all material properties are expected properties

V_{ColOE} = **661.06** k

Step 4: Calculate Plastic Hinge Properties per ASCE 41-17 Table 10-8 about 3-3 Axis (Weak Axis Bending):

Step 4a: Calculate V_{yE}

It is assumed that V_{yE} is equivalent to the maximum probable shear V_{pr}.

$Vy_E = V_{pr,3\text{-}3} = 2M_{pr,3\text{-}3}/L_n$ = 658.93 k

Step 4b: Calculate hinge properties a, b, c and Acceptance criteria IO, LS, CP

$N_{UD}/(A_g f'_{cE})$ =	0.25
ρ_t =	0.0045
ρ_l =	0.0217

a = (0.042-0.043*(NUD/(Agf'cE))+0.63pt-0.023(VyE/VColOE)) ≥ 0.0

a = **0.0112** **rad**

For NUD/(Agf'cE) ≤ 0.5 → b = (0.5/(5+((NUD/(0.8Agf'cE))(1/pt)(f'cE/fytE))))-0.01≥a
For NUD/(Agf'cE) = 0.7 → b =0 ≥a
For 0.5<NUD/(Agf'cE) < 0.7 → linearly interpolate b ≥a

b @ NUD/(Agf'cE) = 0.5→	0.0207	rad
b @ NUD/(Agf'cE) = 0.1→	0.0589	rad

b = 0.0370 rad

check b ≥ a		
if b < a	→	b = a
if b ≥ a	→	b = b
Therefore b =		**0.0370** rad

c = (0.24-0.4*(NUD/(Agf'cE))) ≥ 0.0
c = 0.140

IO = 0.15a ≤ 0.005 → 0.0017 rad

LS = 0.5b = 0.0185 rad *b calculated with NUD/Agf'c >= 0.1

CP = 0.7b = 0.0259 rad *b calculated with NUD/Agf'c >= 0.1

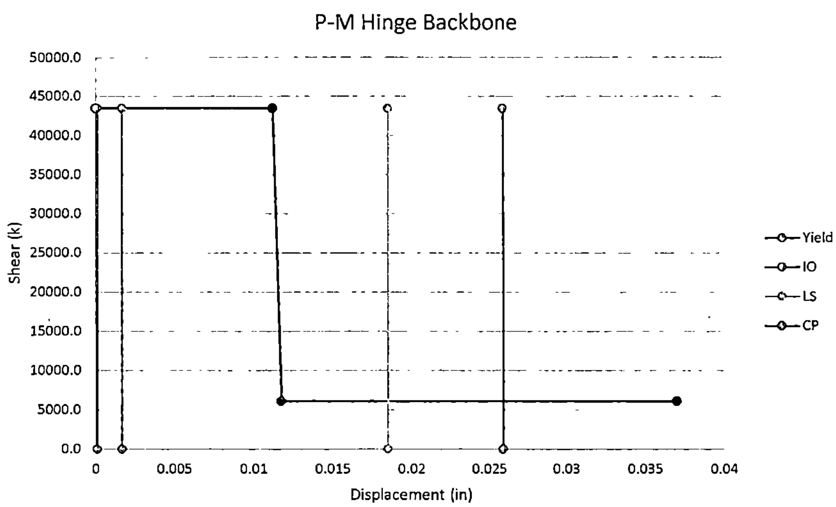
Backbone Parameters			Acceptance Criteria Performance Level (in)		
a (rad)	b (rad)	c	IO	LS	CP
0.0112	0.0370	0.140	0.0017	0.0185	0.0259

Step 8: Summary of Perform Inputs, about Axis 3-3 (Weak Axis Bending)

BENDING STRENGTH (K-in) - 3-3 Axis (Weak)					
FU	FR/FU	$M_{B,3-3}$	$M_{0,3-3}$	$M_{0,3-3}/M_{B,3-3}$	$P_{B,3-3}/P_C$
44582.82	0.140	44582.82	31116.48	0.698	0.281

BENDING DEFORMATION (rad) - 3-3 Axis (Weak)				BENDING DEFORMATION CAPACITIES - 3-3 AXIS			
DL	DR	DX	DR/DL	Level 1 (yield)	Level 2 (IO)	Level 3 (LS)	Level 4 (CP)
0.0112	0.0117	0.0370	1.05	0.0001	0.0017	0.0185	0.0259

FU = $M_{B,3-3}$ = Moment at the balance point
FR/FU = c
DL = a
DR = 1.05*a
DX = b
Yield Deformation = 0.0001 to represent initial yield
$M_{0,3-3}$ = Moment where axial load is 0
$P_{B,3-3}$ = Axial Load at the balance point
P_C = Maximum Axial Load capacity in the column with 0 moment demand



Step 9: Summary of Perform Inputs, Axial Capacities

Compression			Tension		
AXIAL STRENGTH (K)		DEF. (IN)	AXIAL STRENGTH (K)		DEF. (IN)
FU	FR/FU	DX	FU	FR/FU	DX
8644	0.140	1	2198.8	0.140	1

Step 10: Determine V_{ColLB} for Axis 3-3 (Strong Axis Bending) per ASCE 41-17 Section 10.4.2.3.1

$M_{UD}/V_{UD}d$ =		1.990740043
If $M_{UD}/V_{UD}d \geq 4$	→	4
If $M_{UD}/V_{UD}d \leq 2$	→	2
If $4 > M_{UD}/V_{UD}d > 2$	→	$M_{UD}/V_{UD}d$
Therefore $M_{UD}/V_{UD}d$ =		**2**

V_{ColLB} assumes all material properties are lower bound properties

$$V_{Col} = k_{nl}\, V_{Col0} = k_{nl}\left[\alpha_{Col}\left(\frac{A_v f_{ytL/E}\, d}{s}\right) + \lambda\left(\frac{6\sqrt{f'_{cL/E}}}{M_{UD}/V_{UD}\, d}\sqrt{1+\frac{N_{UG}}{6A_g\sqrt{f'_{cL/E}}}}\right)0.8\,A_g\right] \text{ (lb/in.}^2\text{ units)}$$

V_{ColOE} = **774.15** k

Step 11: Determine V_{ColLB} for Axis 2-2 (Weak Axis Bending) per ASCE 41-17 Section 10.4.2.3.1

$M_{UD}/V_{UD}d$ =		1.990740043
If $M_{UD}/V_{UD}d \geq 4$	→	4
If $M_{UD}/V_{UD}d \leq 2$	→	2
If $4 > M_{UD}/V_{UD}d > 2$	→	$M_{UD}/V_{UD}d$
Therefore $M_{UD}/V_{UD}d$ =		**2**

V_{ColLB} assumes all material properties are lower bound properties

$$V_{Col} = k_{nl}\, V_{Col0} = k_{nl}\left[\alpha_{Col}\left(\frac{A_v f_{ytL/E}\, d}{s}\right) + \lambda\left(\frac{6\sqrt{f'_{cL/E}}}{M_{UD}/V_{UD}\, d}\sqrt{1+\frac{N_{UG}}{6A_g\sqrt{f'_{cL/E}}}}\right)0.8\,A_g\right] \text{ (lb/in.}^2\text{ units)}$$

V_{ColOE} = **575.23** k

7 - Concrete Shear Walls - Modeling Parameters and Acceptance Criteria

Executive Summary

This section includes a sample calculation of nonlinear concrete shear wall properties. The calculation of each hinge follows hte procedure established in Appendix G of the Basis of Design. Detailed calculations of all concrete shear walls are located in Appendix E.

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project	City of Inglewood - Library	by	JL
location	Inglewood, CA	date	4/6/2021
client		job no.	2000362
	Concrete Material Properties		

Unconfined Concrete Material Properties

Existing Wall Concrete

E_c modifier 1 for PERFORM

Material Variables

Cf'_c = 6718 psi
E_c = 4671914.2 psi
ε_{c0} = 0.002 ; strain at maximum stress
ε_{sp} = 0.003 ; maximum strain
E_c = 4671914.2 psi 4671.914 ksi

f_{sp} = $7.5f'_c{}^{0.5}$
= 615 psi
$\varepsilon_{sp,T}$ = f_{sp}/E_c
= 0.000132

PERFORM Parameters, Compression			*PERFORM Parameters, Tension*		
FY =	4702.6	psi	FY =	534.8112272	psi
FU =	6718	psi	FU =	615	psi
FR/FU =	0.1		FR/FU =	0.01	
DU =	0.0017		DU =	0.000147	
DL =	0.0022		DL =	0.00015	
DR =	0.005		DR =	0.0015	
DX =	0.012		DX =	0.005	
KH/KO Pos =	0.622		KH/KO Neg =	0.622	

Calculations

Compressive Stress; Mander Equation

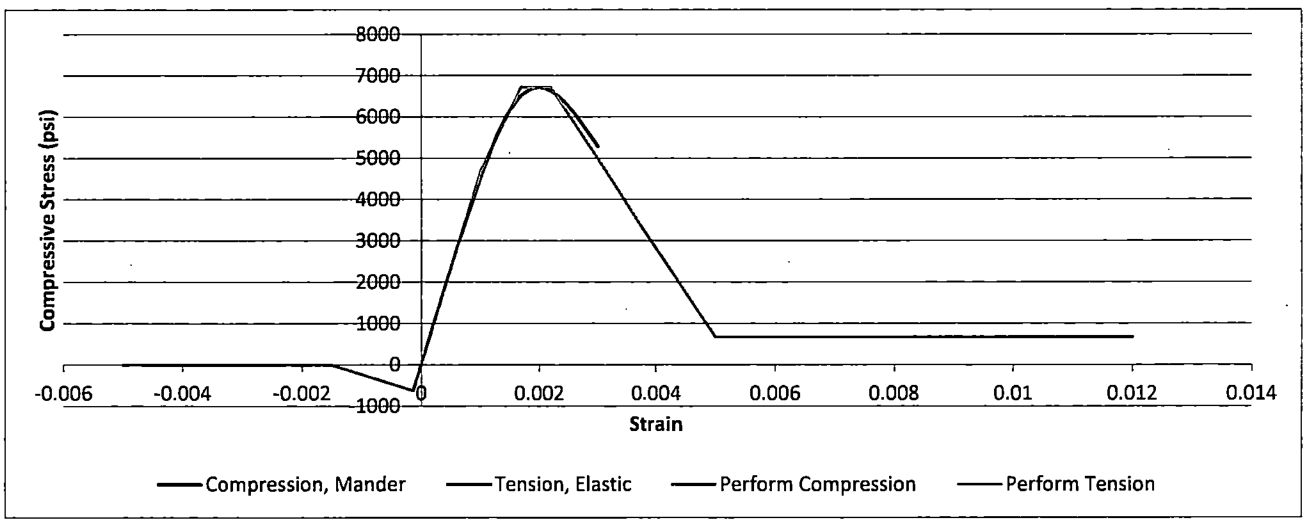
$r = E_c/(E_c - Cf'_c/\varepsilon_{c0})$
= 3.558
$x = \varepsilon_c/\varepsilon_{c0}$
$\sigma = Cf'_c xr/(r-1+x^r)$

Tensile Stress

$\sigma = E_c\varepsilon$

PERFORM

KO^+ = 4671914 psi
KO^- = 4512037 psi



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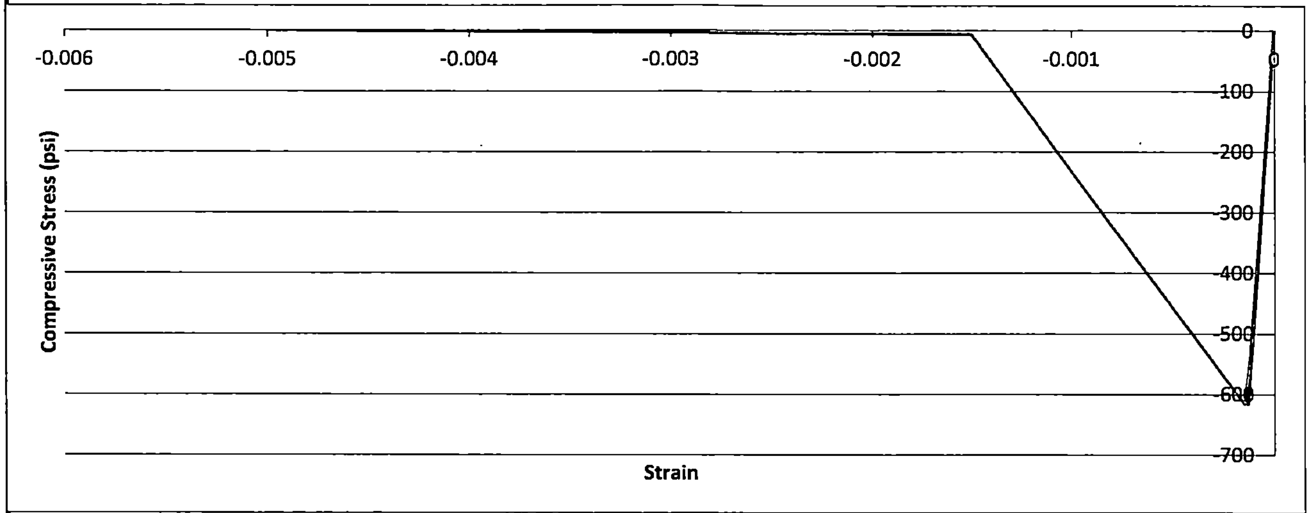
(213) 418-0201		*Concrete Material Properties*		



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project	City of Inglewood - Library	by	JL
location	Inglewood, CA	date	4/6/2021
client		job no.	2000362
	Concrete Material Properties		

Unconfined Concrete Material Properties

New Wall Concrete

E_c modifier 1 for PERFORM

Material Variables

Cf'_c =	5200	psi		f_{sp} =	$7.5f'_c{}^{0.5}$
E_c =	4110328.5	psi		=	541 psi
ε_{c0} =	0.002	; strain at maximum stress		$\varepsilon_{sp,T}$ =	f_{sp}/E_c
ε_{sp} =	0.003	; maximum strain		=	0.000132
E_c =	4110328.5	psi	4110.328 ksi		

PERFORM Parameters, Compression			*PERFORM Parameters, Tension*		
FY =	3640.0	psi	FY =	470.5244414	psi
FU =	5200	psi	FU =	541	psi
FR/FU =	0.1		FR/FU =	0.01	
DU =	0.0018		DU =	0.000147	
DL =	0.0022		DL =	0.00015	
DR =	0.006		DR =	0.0015	
DX =	0.012		DX =	0.005	
KH/KO Pos =	0.415		KH/KO Neg =	0.415	

Calculations

Compressive Stress; Mander Equation

$r = E_c/(E_c - Cf'_c/\varepsilon_{c0})$

$= 2.721$

$x = \varepsilon_c/\varepsilon_{c0}$

$\sigma = Cf'_c x r/(r-1+x^r)$

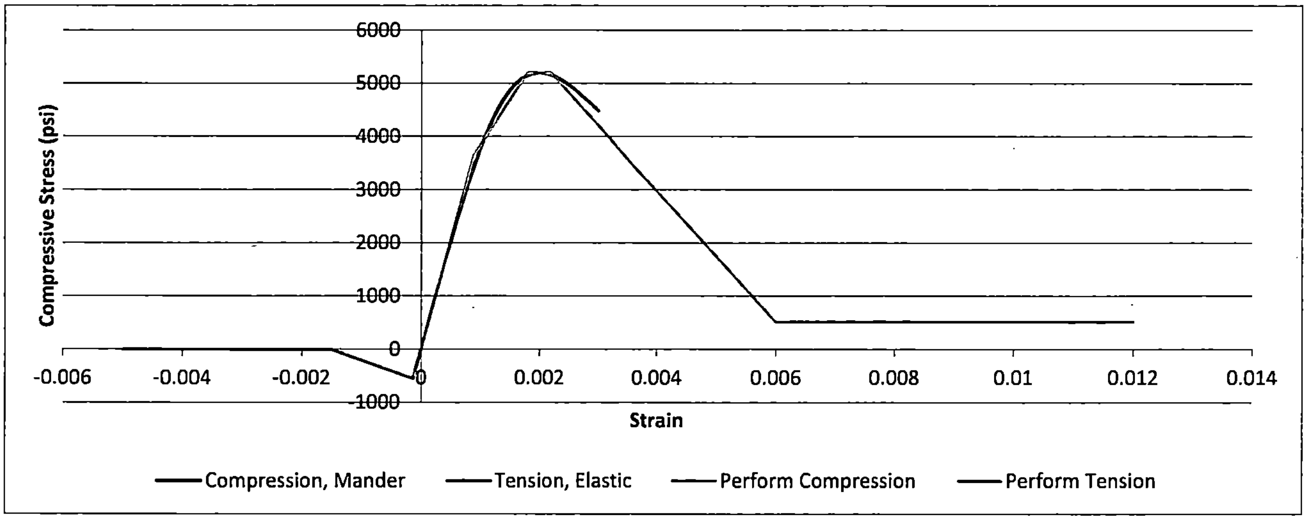
Tensile Stress

$\sigma = E_c\varepsilon$

PERFORM

KO^+ = 4110328 psi

KO^- = 4353210 psi



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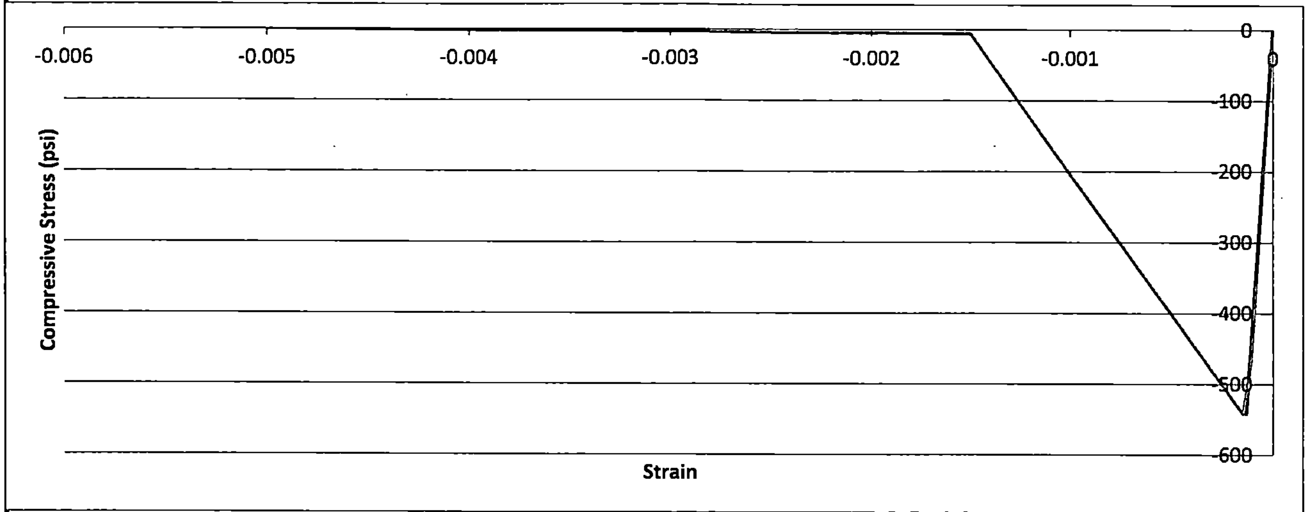
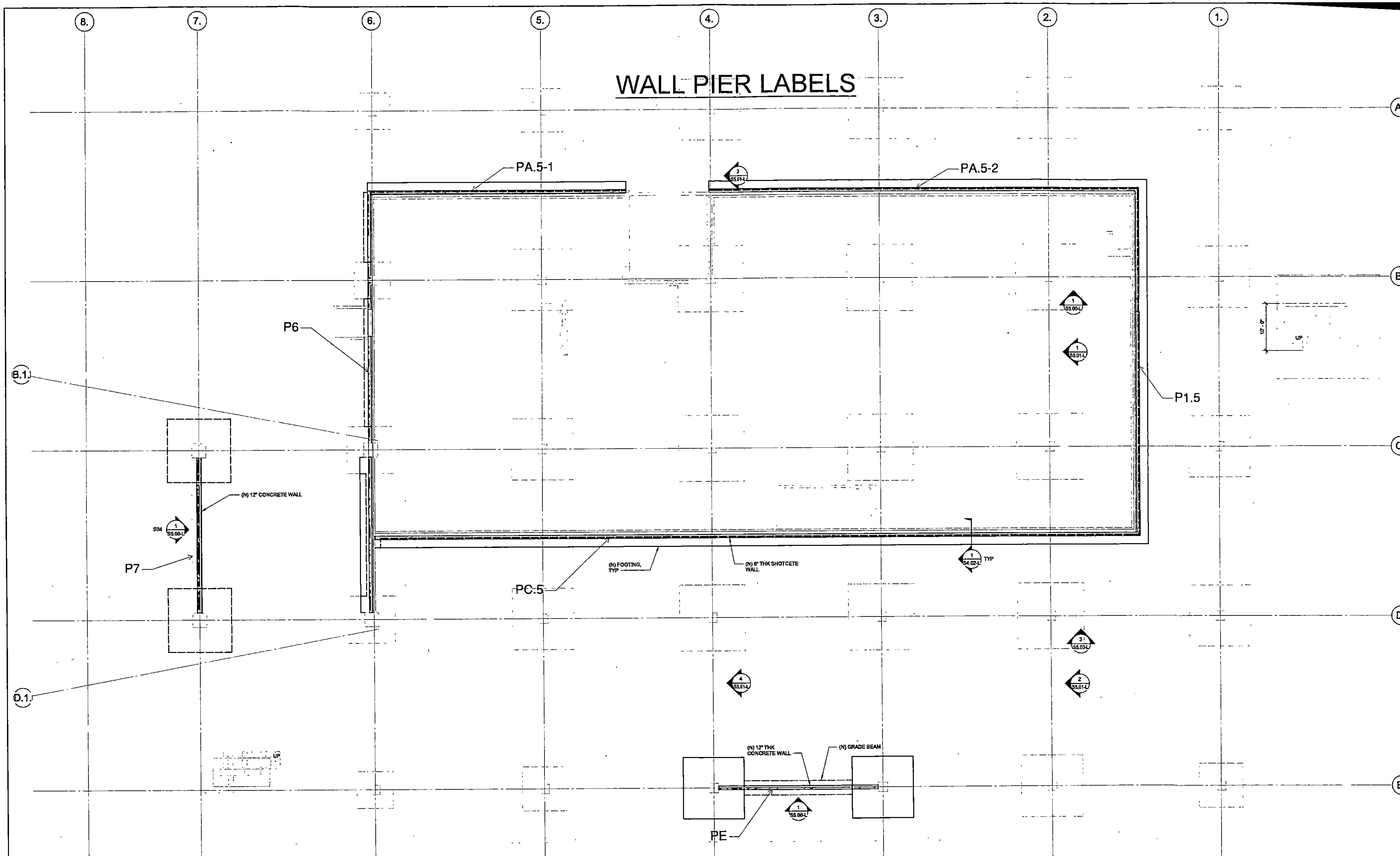
700 S Flower St, Suite 2100	location	Inglewood, CA	date	4/6/2021	
Los Angeles, CA 90017	client		job no.	*2000362*	
(213) 418-0201		*Concrete Material Properties*			





1 GROUND FLOOR - L
SCALE : 1/8" = 1'-0"

PLAN NOTES:

1. SEE SHEET S0.02 FOR GENERAL NOTES.
2. SEE SHEET S2.01 THROUGH S2.08 FOR VISCOUS DAMPER FRAME ELEVATIONS.
3. SEE ARCH DRAWINGS FOR DIMENSIONS NOT SHOWN.
4. CONTRACTOR TO VERIFY ALL EXISTING CONDITIONS, DIMENSIONS AND ELEVATIONS PRIOR TO FABRICATION AND ERECTION AND NOTIFY ARCHITECT OF ANY SIGNIFICANT DISCREPANCIES FROM THAT SHOWN ON THE DRAWINGS.
5. CONTRACTOR TO SHORE ALL EXISTING FRAMING AS REQUIRED FOR DEMOLITION AND REFRAMING WORK.

LEGEND:

XXX'-XXX"	INDICATES TOP OF (E) CONCRETE SLAB ELEVATION.
(E)	INDICATES EXISTING.
	INDICATES EXISTING STRUCTURE.
(N)	INDICATES NEW.
	INDICATES NEW CONSTRUCTION.
	INDICATES PORTION OF BUILDING TO BE DEMOLISHED.
STEEL CONNECTOR PLATE BELOW BEAM	INDICATES DAMPER ASSEMBLY ABOVE FLOOR LEVEL PER ELEVATIONS S5.00 THRU S5.01.
	INDICATES DAMPER ASSEMBLY BELOW FLOOR LEVEL PER ELEVATIONS S5.00 THRU S5.01.
#	INDICATES U-WRAP FRP OF BEAM PER DETAIL 1/S8.01 OR 2/S8.01 # INDICATES NUMBER OF FRP LAYERS
	INDICATES FRP STRENGTHENING BELOW THE SLAB.

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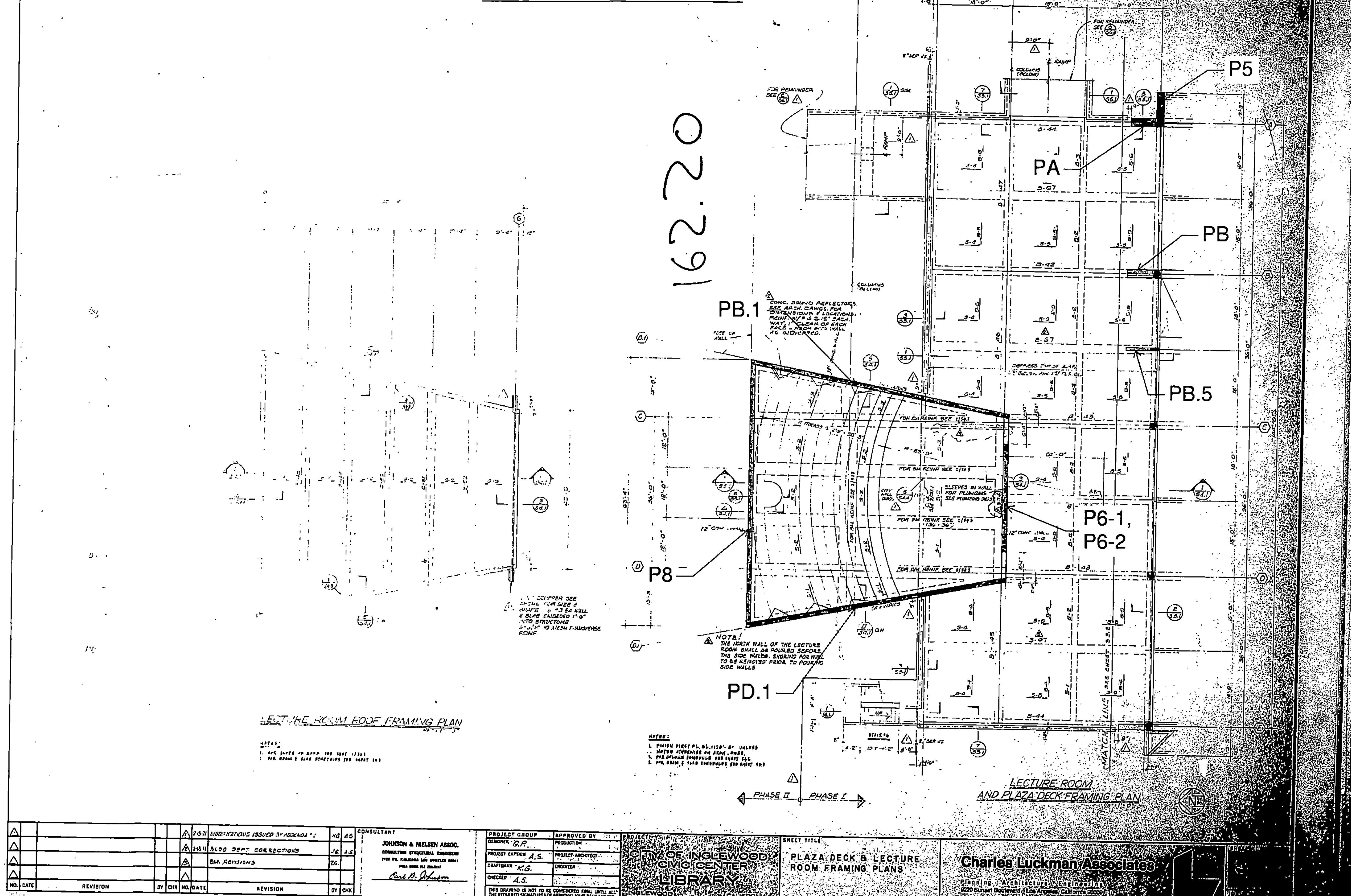
CITY OF INGLEWOOD CIVIC CENTER - LIBRARY VOLUNTARY SEISMIC IMPROVEMENTS

SCHEMATIC DESIGN
KPFF PROJECT # 10012000362
MARCH 31, 2021

LIBRARY - FOUNDATION PLAN

Drawn By:	Author
Designed By:	Designer
Project No:	2000362
Date:	03/31/2021
Scale:	As Indicated
Drawing No:	S2.00-L

WALL PIER LABELS



OPERATOR'S CERTIFICATION

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Signed: M. Netzahuld Date: 3-7-87

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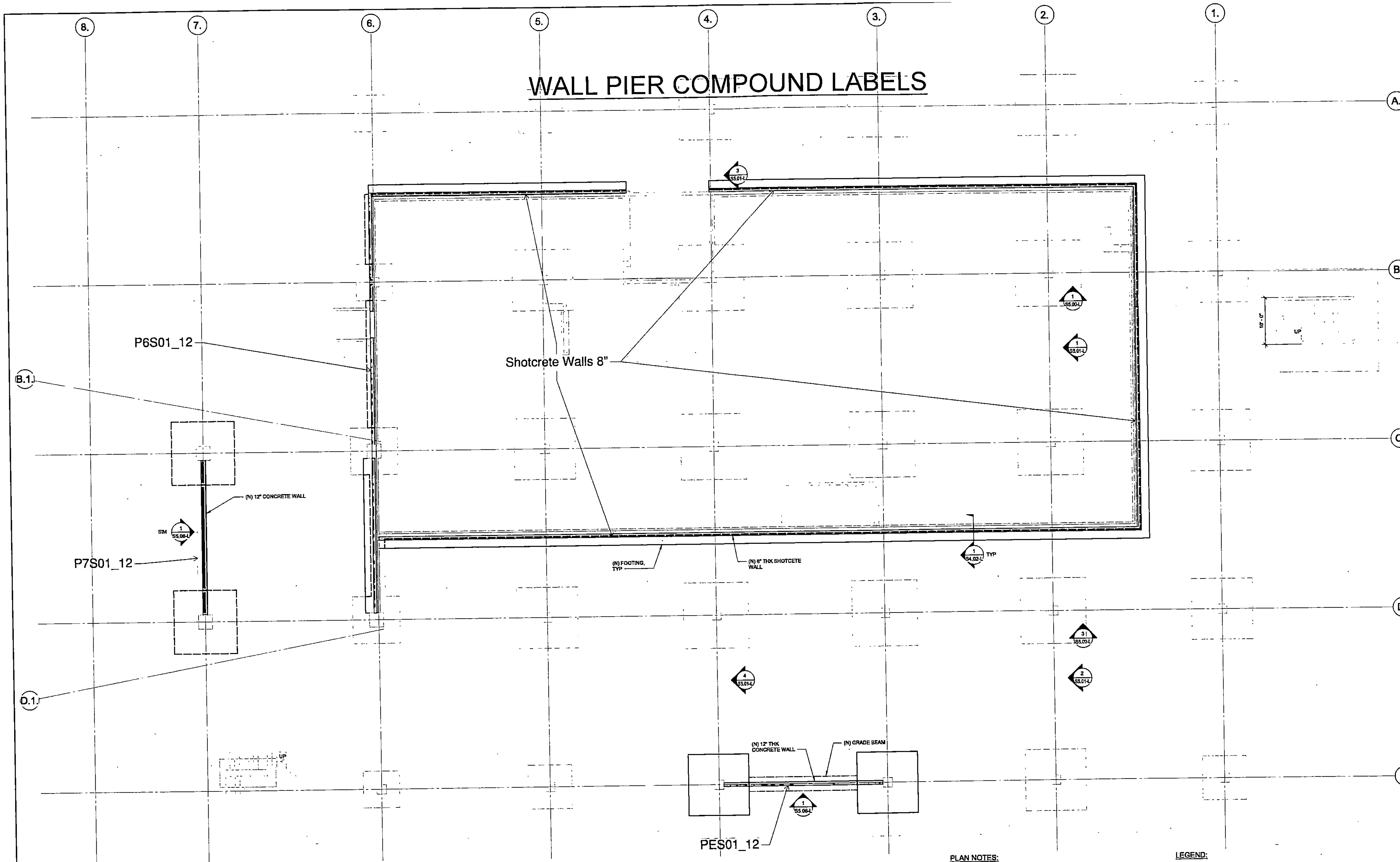
WALL PIER COMPOUND LABELS



1 GROUND FLOOR - L

SCALE : 1/8" = 1'-0"

PLAN NOTES:

1. SEE SHEET S0.02 FOR GENERAL NOTES.
2. SEE SHEET S2.01 THROUGH S2.08 FOR VISCOUS DAMPER FRAME ELEVATIONS.
3. SEE ARCH DRAWINGS FOR DIMENSIONS NOT SHOWN.
4. CONTRACTOR TO VERIFY ALL EXISTING CONDITIONS, DIMENSIONS AND ELEVATIONS PRIOR TO FABRICATION AND ERECTION AND NOTIFY ARCHITECT OF ANY SIGNIFICANT DISCREPANCIES FROM THAT SHOWN ON THE DRAWINGS.
5. CONTRACTOR TO SHORE ALL EXISTING FRAMING AS REQUIRED FOR DEMOLITION AND REFRAMING WORK.

LEGEND:

XXX'-XXX"	INDICATES TOP OF (E) CONCRETE SLAB ELEVATION.
(E)	INDICATES EXISTING.
	INDICATES EXISTING STRUCTURE.
(N)	INDICATES NEW.
	INDICATES NEW CONSTRUCTION.
	INDICATES PORTION OF BUILDING TO BE DEMOLISHED.
	INDICATES DAMPER ASSEMBLY ABOVE FLOOR LEVEL PER ELEVATIONS S5.00 THRU S5.01.
STEEL CONNECTOR PLATE BELOW BEAM	INDICATES DAMPER ASSEMBLY BELOW FLOOR LEVEL PER ELEVATIONS S5.00 THRU S5.01.
#	INDICATES U-WRAP FRP OF BEAM PER DETAIL 1/S8.01 OR 2/S8.01 # INDICATES NUMBER OF FRP LAYERS
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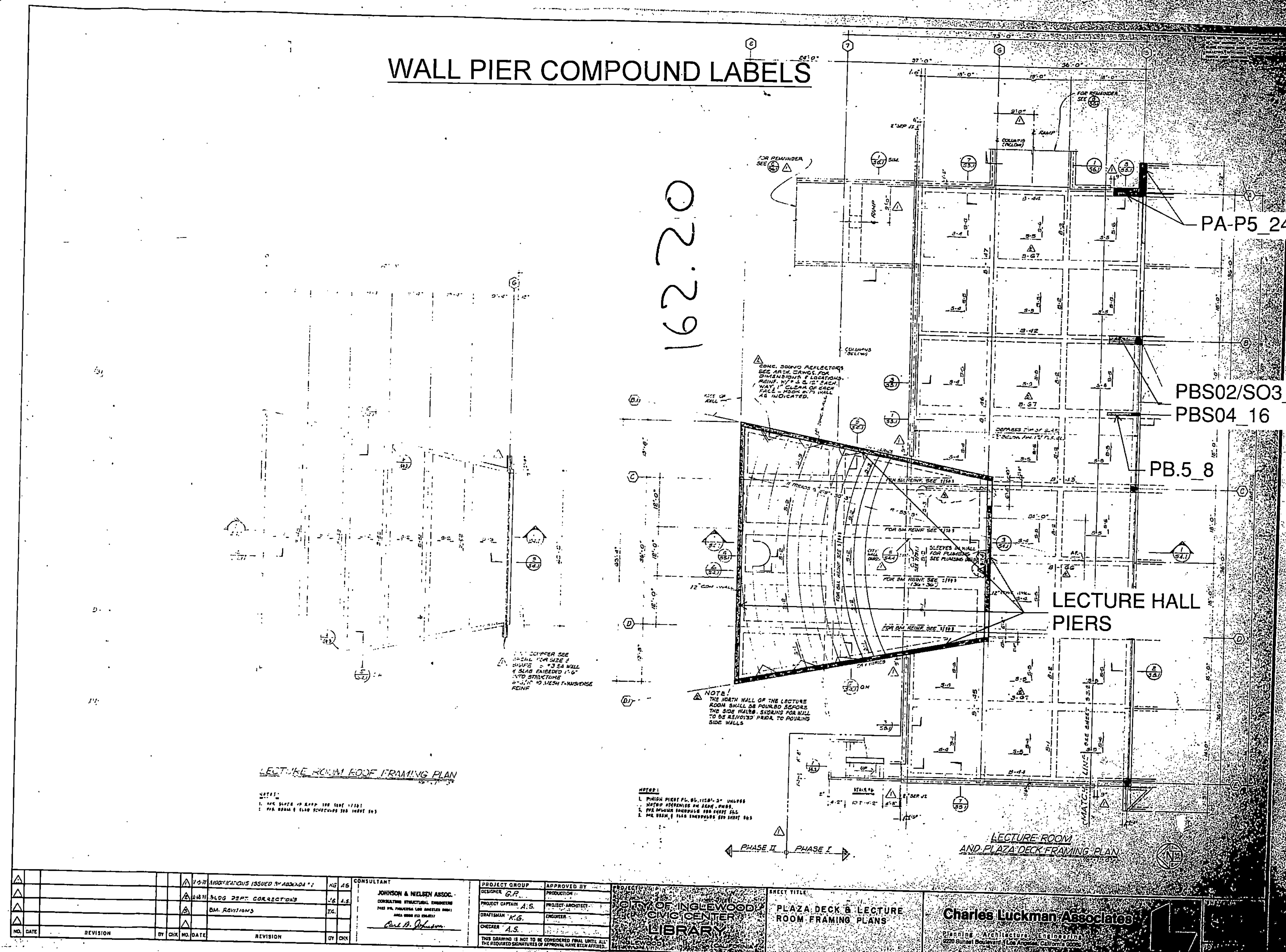
SCHEMATIC DESIGN
KPFF PROJECT # 10012000382
MARCH 31, 2021

LIBRARY - FOUNDATION PLAN

Drawn By:	Author
Designed By:	Designer
Project No:	2000382
Date:	03/31/2021
Scale:	As Indicated

Drawing No:
S2.00-L

WALL PIER COMPOUND LABELS



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Concrete Shear Wall Summary

Longitudinal rebar used to obtain the average of the asymmetric moment strength at the expected axial demand. See additional calculations in Appendix E (Starting page E-362 for PBS02, Starting page E-414 for PBS04/S03)

Shear Wall Modeling Parameters Summary

Inputs																		
Name	**λ**	**$f'_{c,expected}$**	**$f'_{y,expected}$**	**$f'_{yt,expected}$**	**t_w**	**L_w**	**h_u**	**Transverse Bars**			**Longitudinal Bar 1**		**Longitudinal Bar 2**		**P_{CP}**	**V_{CP}**	**α**	**single or double curvature?**
		psi	ksi	ksi	in	in	in		Size	Spacing	Size	Spacing	Size	Spacing	k	k		
PAS04_24	1.00	6718	73	73	24.0	87.0	168.0	(2)	#5 @	10 in OC	#4 @	10 in OC	#4 @	10 in OC	81	96	2	single
PBS04_16	1.00	6718	73	73	16.0	87.0	168.0	(2)	#5 @	10 in OC	#8 @	7 in OC	#8 @	7 in OC	200	366	2	single
P5S04_24	1.00	6718	73	73	24.0	87.0	168.0	(2)	#5 @	10 in OC	#4 @	10 in OC	#4 @	10 in OC	248	97	2	single
PAS03_24	1.00	6718	73	73	24.0	87.0	168.0	(2)	#5 @	10 in OC	#4 @	10 in OC	#4 @	10 in OC	105	219	2	double
PBS03_16	1.00	6718	73	73	16.0	87.0	168.0	(2)	#5 @	10 in OC	#8 @	7 in OC	#8 @	7 in OC	336	622	2	double
P5S03_24	1.00	6718	73	73	24.0	87.0	168.0	(2)	#5 @	10 in OC	#4 @	10 in OC	#4 @	10 in OC	235	231	2	double
PAS02_24	1.00	6718	73	73	24.0	87.0	168.0	(2)	#5 @	10 in OC	#4 @	10 in OC	#4 @	10 in OC	215	249	2	double
PBS02_16	1.00	6718	73	73	16.0	87.0	168.0	(2)	#5 @	10 in OC	#14 @	9 in OC	#14 @	9 in OC	492	622	2	double
P5S02_24	1.00	6718	73	73	24.0	87.0	168.0	(2)	#5 @	10 in OC	#4 @	10 in OC	#4 @	10 in OC	316	257	2	double
PB.1S02_12	1.00	6718	73	73	12.0	737.2	201.0	(2)	#4 @	12 in OC	#4 @	16 in OC	#4 @	16 in OC	280	3695	3	single
PD.1S02_12	1.00	6718	73	73	12.0	737.2	201.0	(2)	#4 @	12 in OC	#4 @	16 in OC	#4 @	16 in OC	224	3637	3	single
P8S02_12	1.00	6718	73	73	12.0	748.0	201.0	(2)	#4 @	12 in OC	#4 @	16 in OC	#4 @	16 in OC	-42	3260	3	single
P6-1S02_12	1.00	6718	73	73	12.0	492.0	100.5	(2)	#4 @	12 in OC	#4 @	16 in OC	#4 @	16 in OC	171	2649	3	single
P6-2S02_12	1.00	6718	73	73	12.0	340.0	100.5	(2)	#4 @	12 in OC	#4 @	16 in OC	#4 @	16 in OC	261	1831	3	double
P7S01_12	1.00	5200	75	75	12.0	394.0	168.0	(2)	#4 @	12 in OC	#4 @	12 in OC	#4 @	12 in OC	418	717	3	single
PES01_12	1.00	5200	75	75	12.0	406.0	168.0	(2)	#4 @	12 in OC	#4 @	12 in OC	#4 @	12 in OC	1104	1831	3	single
P6S01_8	1.00	5200	75	75	8.0	1088.0	168.0	(2)	#4 @	15 in OC	#4 @	15 in OC	#4 @	15 in OC	695	3991	3	single
PA.5-1S01_8	1.00	5200	75	75	8.0	652.0	168.0	(2)	#4 @	15 in OC	#4 @	15 in OC	#4 @	15 in OC	171	2392	3	single
PA.5-2S01_8	1.00	5200	75	75	8.0	1088.0	168.0	(2)	#4 @	15 in OC	#4 @	15 in OC	#4 @	15 in OC	262	1578	3	single
P1.5S01_8	1.00	5200	75	75	8.0	880.0	168.0	(2)	#4 @	15 in OC	#4 @	15 in OC	#4 @	15 in OC	197	3228	3	single
PC.5S01_8	1.00	5200	75	75	8.0	1940.0	168.0	(2)	#4 @	15 in OC	#4 @	15 in OC	#4 @	15 in OC	331	7117	3	single
PB.5S04_8	1.00	6718	73	73	8.0	87.0	168.0	(2)	#4 @	20 in OC	#4 @	24 in OC	#4 @	24 in OC	32	241	2	single
PB.5S03_8	1.00	6718	73	73	8.0	87.0	168.0	(2)	#4 @	20 in OC	#4 @	24 in OC	#4 @	24 in OC	63	241	2	double
PB.5S02_8	1.00	6718	73	73	8.0	87.0	168.0	(2)	#4 @	20 in OC	#4 @	24 in OC	#4 @	24 in OC	93	241	2	double

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Concrete Shear Wall Summary Continued

Name	Controlling	G	KH/KO+	FY	FU	DU	DX	DL	DR	FR/FU	IO	LS	CP
		Shear Output											
		Conventional Shear Material											
PAS04_24	Flexure	1889.061	0.019197972	0.211506	0.35251	0.004	0.02	0.01	0.015	0.2	0.004	0.015	0.02
PBS04_16	Flexure	1889.061	0.024522057	0.268081	0.446802	0.004	0.01	0.0075	0.0095	0.01	0.004	0.0075	0.01
P5S04_24	Flexure	1889.061	0.019197972	0.211506	0.35251	0.004	0.02	0.01	0.015	0.2	0.004	0.015	0.02
PAS03_24	Flexure	1889.061	0.019197972	0.211506	0.35251	0.004	0.02	0.01	0.015	0.2	0.004	0.015	0.02
PBS03_16	Shear	1889.061	0.024522057	0.268081	0.446802	0.004	0.01	0.0075	0.0095	0.01	0.004	0.0075	0.01
P5S03_24	Flexure	1889.061	0.019197972	0.211506	0.35251	0.004	0.02	0.01	0.015	0.2	0.004	0.015	0.02
PAS02_24	Flexure	1889.061	0.019197972	0.211506	0.35251	0.004	0.02	0.01	0.015	0.2	0.004	0.015	0.02
PBS02_16	Shear	1889.061	0.024522057	0.268081	0.446802	0.004	0.01	0.0075	0.0095	0.01	0.004	0.0075	0.01
P5S02_24	Flexure	1889.061	0.019197972	0.211506	0.35251	0.004	0.02	0.01	0.015	0.2	0.004	0.015	0.02
PB.1S02_12	Flexure	1889.061	0.024628263	0.269201	0.448668	0.004	0.02	0.01	0.015	0.2	0.004	0.015	0.02
PD.1S02_12	Flexure	1889.061	0.024628263	0.269201	0.448668	0.004	0.02	0.01	0.015	0.2	0.004	0.015	0.02
P8S02_12	Flexure	1889.061	0.024628263	0.269201	0.448668	0.004	0.02	0.01	0.015	0.2	0.004	0.015	0.02
P6-1S02_12	Shear	1889.061	0.024628263	0.269201	0.448668	0.004	0.02	0.01	0.015	0.2	0.004	0.015	0.02
P6-2S02_12	Shear	1889.061	0.024628263	0.269201	0.448668	0.004	0.02	0.01	0.015	0.2	0.004	0.015	0.02
P7S01_12	Flexure	1661.987	0.026570098	0.2548	0.424666	0.004	0.01	0.0075	0.0095	0.01	0.004	0.0075	0.01
PES01_12	Shear	1661.987	0.026570098	0.2548	0.424666	0.004	0.01	0.0075	0.0095	0.01	0.004	0.0075	0.01
P6S01_8	Shear	1661.987	0.028783656	0.275149	0.458581	0.004	0.01	0.0075	0.0095	0.01	0.004	0.0075	0.01
PA.5-1S01_8	Shear	1661.987	0.028783656	0.275149	0.458581	0.004	0.02	0.01	0.015	0.2	0.004	0.015	0.02
PA.5-2S01_8	Shear	1661.987	0.028783656	0.275149	0.458581	0.004	0.02	0.01	0.015	0.2	0.004	0.015	0.02
P1.5S01_8	Shear	1661.987	0.028783656	0.275149	0.458581	0.004	0.02	0.01	0.015	0.2	0.004	0.015	0.02
PC.5S01_8	Shear	1661.987	0.028783656	0.275149	0.458581	0.004	0.02	0.01	0.015	0.2	0.004	0.015	0.02
PB.5S04_8	Flexure	1889.061	0.018857298	0.207856	0.346427	0.004	0.02	0.01	0.015	0.2	0.004	0.015	0.02
PB.5S03_8	Flexure	1889.061	0.018857298	0.207856	0.346427	0.004	0.02	0.01	0.015	0.2	0.004	0.015	0.02
PB.5S02_8	Flexure	1889.061	0.018857298	0.207856	0.346427	0.004	0.02	0.01	0.015	0.2	0.004	0.015	0.02

Concrete Shear Wall Summary Continued

	Flexural Output																				
Name	Cross Section Normal to Axis 2											Cross Section Normal to Axis 3									
	$t_{w, concrete}$	# Fibers	$t_{w, steel}$	# Fibers	Percent	Conc Fiber	Steel Fiber	$t_{bending}$	$t_{torsion}$	E	Poisson Ratio	$t_{w, concrete}$	# Fibers	Percent	# Fibers	# Conc Fibers	# Steel Fibers	$t_{bending}$	$t_{torsion}$	E	Poisson Ratio
PAS04_24	24	4	24	4	0.166667	2	2	24	24	1180.663	0.2	24	4	0.258333	4	2	2	24	24	1180.663	0.2
PBS04_16	16	4	16	4	1.410714	2	2	16	16	1180.663	0.2	16	4	0.3875	4	2	2	16	16	1180.663	0.2
P5S04_24	24	4	24	4	0.166667	2	2	24	24	1180.663	0.2	24	4	0.258333	4	2	2	24	24	1180.663	0.2
PAS03_24	24	4	24	4	0.166667	2	2	24	24	1180.663	0.2	24	4	0.258333	4	2	2	24	24	1180.663	0.2
PBS03_16	16	4	16	4	1.410714	2	2	16	16	1180.663	0.2	16	4	0.3875	4	2	2	16	16	1180.663	0.2
P5S03_24	24	4	24	4	0.166667	2	2	24	24	1180.663	0.2	24	4	0.258333	4	2	2	24	24	1180.663	0.2
PAS02_24	24	4	24	4	0.166667	2	2	24	24	1180.663	0.2	24	4	0.258333	4	2	2	24	24	1180.663	0.2
PBS02_16	16	4	16	4	3.125	2	2	16	16	1180.663	0.2	16	4	0.3875	4	2	2	16	16	1180.663	0.2
P5S02_24	24	4	24	4	0.166667	2	2	24	24	1180.663	0.2	24	4	0.258333	4	2	2	24	24	1180.663	0.2
PB.1S02_12	12	4	12	4	0.208333	2	2	12	12	1180.663	0.2	12	4	0.277778	4	2	2	12	12	1180.663	0.2
PD.1S02_12	12	4	12	4	0.208333	2	2	12	12	1180.663	0.2	12	4	0.277778	4	2	2	12	12	1180.663	0.2
P8S02_12	12	4	12	4	0.208333	2	2	12	12	1180.663	0.2	12	4	0.277778	4	2	2	12	12	1180.663	0.2
P6-1S02_12	12	4	12	4	0.208333	2	2	12	12	1180.663	0.2	12	4	0.277778	4	2	2	12	12	1180.663	0.2
P6-2S02_12	12	4	12	4	0.208333	2	2	12	12	1180.663	0.2	12	4	0.277778	4	2	2	12	12	1180.663	0.2
P7S01_12	12	4	12	4	0.277778	2	2	12	12	1038.742	0.2	12	4	0.277778	4	2	2	12	12	1038.742	0.2
PES01_12	12	4	12	4	0.277778	2	2	12	12	1038.742	0.2	12	4	0.277778	4	2	2	12	12	1038.742	0.2
P6S01_8	8	4	8	4	0.322997	2	2	8	8	1038.742	0.2	8	4	0.322997	4	2	2	8	8	1038.742	0.2
PA.5-1S01_8	8	4	8	4	0.322997	2	2	8	8	1038.742	0.2	8	4	0.322997	4	2	2	8	8	1038.742	0.2
PA.5-2S01_8	8	4	8	4	0.322997	2	2	8	8	1038.742	0.2	8	4	0.322997	4	2	2	8	8	1038.742	0.2
P1.5S01_8	8	4	8	4	0.322997	2	2	8	8	1038.742	0.2	8	4	0.322997	4	2	2	8	8	1038.742	0.2
PC.5S01_8	8	4	8	4	0.322997	2	2	8	8	1038.742	0.2	8	4	0.322997	4	2	2	8	8	1038.742	0.2
PB.5S04_8	8	4	8	4	0.208333	2	2	8	8	1180.663	0.2	8	4	0.25	4	2	2	8	8	1180.663	0.2
PB.5S03_8	8	4	8	4	0.208333	2	2	8	8	1180.663	0.2	8	4	0.25	4	2	2	8	8	1180.663	0.2
PB.5S02_8	8	4	8	4	0.208333	2	2	8	8	1180.663	0.2	8	4	0.25	4	2	2	8	8	1180.663	0.2

Concrete Shear Wall Summary Continued

Name	Compound Component			Rotation Gage										
	$t_{w, shear}$	$t_{w, self\text{-}weight}$	Weight Density	IO	LS	CP	E_c	I_x	Θ_{yE} /eff	M_{ye} (kip-in)	M_{pr} (kip-in)	a	b	c
PAS04_24	24	24	8.48E-05	0.002	0.008	0.015	4722.652	1317006	9.93E-05	14195	16807	0.008	0.015	0.6
PBS04_16	16	16	8.75E-05	0.001702	0.006511	0.012021	4722.652	878004	0.000572	54511	63291	0.006511	0.012021	0.495748
P5S04_24	24	24	8.48E-05	0.002	0.008	0.015	4722.652	1317006	0.000147	21011	23565	0.008	0.015	0.6
PAS03_24	24	24	8.48E-05	0.002	0.008	0.015	4722.652	1317006	0.000106	15182	17779	0.008	0.015	0.6
PBS03_16	16	16	8.75E-05	0.001687	0.005211	0.00915	4722.652	878004	0.000614	58537	66839	0.005211	0.00915	0.329531
P5S03_24	24	24	8.48E-05	0.002	0.008	0.015	4722.652	1317006	0.000143	20499	23057	0.008	0.015	0.6
PAS02_24	24	24	8.48E-05	0.002	0.008	0.015	4722.652	1317006	0.000138	19669	22220	0.008	0.015	0.6
PBS02_16	16	16	9.09E-05	0.001	0.002274	0.004274	4722.652	878004	0.001214	115760	129732	0.002274	0.004274	0.213719
P5S02_24	24	24	8.48E-05	0.002	0.008	0.015	4722.652	1317006	0.000166	23698	26226	0.008	0.015	0.6
PB.1S02_12	12	12	8.49E-05	0.002	0.006904	0.012261	4722.652	4.01E+08	0.000111	571632	684838	0.006904	0.012261	0.435665
PD.1S02_12	12	12	8.49E-05	0.002	0.006984	0.01246	4722.652	4.01E+08	0.000108	552352	665951	0.006984	0.01246	0.447577
P8S02_12	12	12	8.49E-05	0.002	0.007568	0.01392	4722.652	4.19E+08	9.09E-05	480192	599692	0.007568	0.01392	0.535229
P6-1S02_12	12	12	8.49E-05	0.002	0.006526	0.011315	4722.652	1.19E+08	0.000111	253547	304580	0.006526	0.011315	0.378899
P6-2S02_12	12	12	8.49E-05	0.002	0.006526	0.011315	4722.652	39304000	0.000127	138697	161589	0.006526	0.011315	0.378899
P7S01_12	12	12	8.5E-05	0.002	0.008	0.015	4154.967	61162984	0.0002	257556	298482	0.008	0.015	0.6
PES01_12	12	12	8.5E-05	0.002	0.006789	0.011973	4154.967	66923416	0.000284	389145	429364	0.006789	0.011973	0.418389
P6S01_8	8	8	8.52E-05	0.002	0.006	0.01	4154.967	8.59E+08	0.000214	1403191	1639961	0.006	0.01	0.3
PA.5-1S01_8	8	8	8.52E-05	0.002	0.006	0.01	4154.967	1.85E+08	0.000184	432313	519186	0.006	0.01	0.3
PA.5-2S01_8	8	8	8.52E-05	0.002	0.008	0.015	4154.967	8.59E+08	0.000183	1197323	1440878	0.008	0.015	0.6
P1.5S01_8	8	8	8.52E-05	0.002	0.006	0.01	4154.967	4.54E+08	0.000183	784654	946455	0.006	0.01	0.3
PC.5S01_8	8	8	8.52E-05	0.002	0.006	0.01	4154.967	4.87E+09	0.00018	3762361	4568112	0.006	0.01	0.3
PB.5S04_8	8	8	8.48E-05	0.002	0.007773	0.014433	4722.652	439002	0.000119	5658.58083	6705.652759	0.007773	0.014433	0.566009
PB.5S03_8	8	8	8.48E-05	0.002	0.007773	0.014433	4722.652	439002	0.000145	6896.494369	7928.32688	0.007773	0.014433	0.566009
PB.5S02_8	8	8	8.48E-05	0.002	0.007773	0.014433	4722.652	439002	0.00017	8116.870978	9130.565385	0.007773	0.014433	0.566009

Concrete Shear Wall Sample Calculation

Shear Wall Modeling Parameters Calculations

ASCE 41-17 § 10.7.2

PC.5S01_8

Geometric Properties

t_w = 8 in; thickness of wall
L_w = 1940 in; length of wall
f_{shape} = 1.00 ; shape factor for shear stiffness
h_u = 168 in; story clear height
Single or Double Curvature? single
Type = Shear wall or Wall segment
Diagonal reinforcement No ; NA for wall segments

Rebar Properties

Number Transverse Bars in each Layer = 2
Transverse Bar Size = #4
Transverse Bar Spacing = 15.48 in
Longitudinal Bar Size 1 = #4
Longitudinal Bar Spacing 1 = 15.48 in
Longitudinal Bar Size 2 = #4
Longitudinal Bar Spacing 2 = 15.48 in

Material Properties

$f'_{c,\ expected}$ = 5200 psi
λ = 1
ρ_c = 145 pcf
$f_{y,\ expected}$ = 75 ksi; including overstrength and hardening
$f_{yt,\ expected}$ = 75 ksi
E_c = 4155 ksi
E_s = 29000 ksi

Analysis

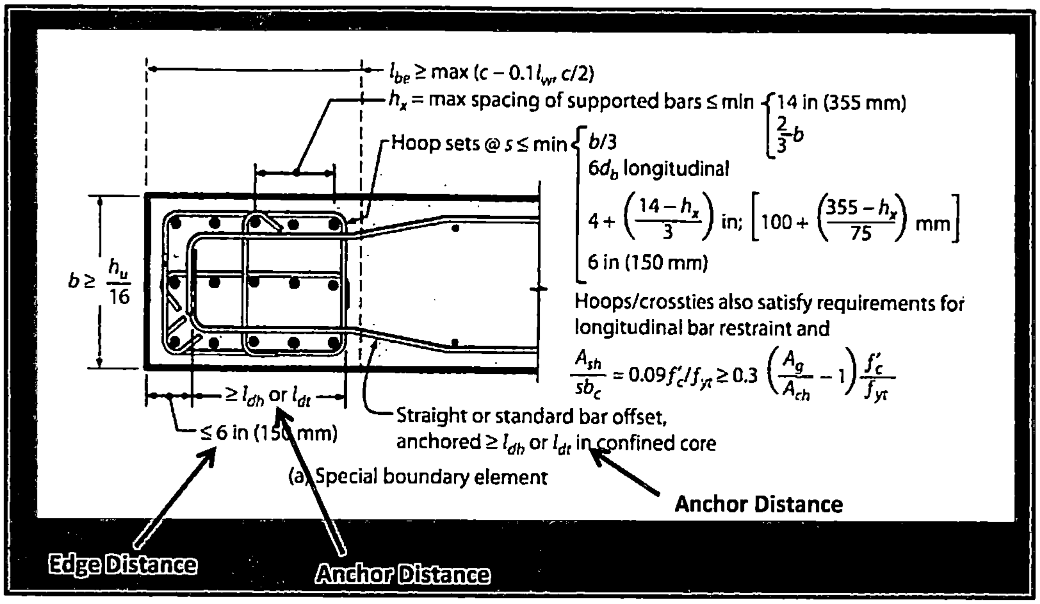
P = 330.8849 k
V = 7117.179 k

Longitudinal Bar Development Length Variables

ψ_ε = 1
ψ_τ = 1.3
Spacing and cover conditions satisfied? Yes

Hook Development Length Variables

ψ_ε: 1
ψ_c: 1
ψ_r: 1



Boundary Element

l_{be} =	NA	in; length of boundary element
Cover to Edge =	NA	in
Cover to Side =	NA	in
h_x =	NA	in
Hoop Size =	NA	
Hoop Spacing =	NA	in
Edge Distance =	NA	in
Anchor Size =	NA	
Anchor Distance =	NA	in
Anchor developed with	NA	
Bar Size (Longitudinal) In Boundary =	NA	
Boundary element on compression side?	No	
Boundary element on tension side?	No	
h_w =	NA	in; total wall height

d_b =	NA	in; anchor in boundary element
L_{dt} =	NA	in; anchor in tension
L_{dh} =	NA	in; anchor in tension in standard hook
L_{dh} or L_{dt} =	NA	

$A_g = t_w (L_{be}$ - Cover); Gross area of boundary element

= NA in^2

$A_{ch} = (L_{be}$-2*Cover)*(t_w-2*Cover); Area of boundary element

= NA in^2

kpff **Consulting Engineers**	project City of Inglewood Civic Center	by	sheet no **7-18**
700 S Flower St, Suite 2100	location	date	
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Boundary Element Detailing Requirements

c = 128.48 in; calculated at Pu and Mn

Special boundary element requirements		Applicable?	
$l_{be} \geq \max\left(c - 0.1 l_w, \frac{c}{2}\right)$	No	Yes	; ACI 318-14 § 18.10.6.4a
$h_x \leq \min\left(14\,in, \frac{2}{3} t_w\right)$	No	Yes	
$s \leq \min\left(\frac{t_w}{3}, 6d_b, 4 + \left(\frac{14 - h_x}{3}\right), 6\,in\right)$	No	Yes	
$t_w \geq \frac{h_u}{16}$	No	Yes	; ACI 318-14 § 18.10.6.4b
$Edge\ Distance \leq 6\,in$	No	Yes	
$\frac{A_{sh}}{sb_c} = 0.09\frac{f'_c}{f_{yt}} \geq 0.3\left(\frac{A_g}{A_{ch}} - 1\right)\frac{f'_c}{f_{yt}}$	No	Yes	
$Anchor\ Distance \geq l_{dh}\ or\ l_{dt}$	No	Yes	

Percentage of Requirements Satisfied = 0.0%

Ordinary boundary element requirements		Applicable?
$l_{be} \geq \max\left(c - 0.1 l_w, \frac{c}{2}\right)$	No	Yes
$h_x \leq \min\left(14\,in, \frac{2}{3} t_w\right)$	No	Yes
$s \leq \min\left(\frac{t_w}{3}, 6d_b, 4 + \left(\frac{14 - h_x}{3}\right), 6\,in\right)$	No	Yes

Percentage of Requirements Satisfied = 0.0%

s_v/d_b = 30.96

The boundary is not confined

* see ASCE 41-17 Table 10-19, note b

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Strength

M_{yE} = 313530 k-ft; nominal strength per ASCE 41-17 § 10.7.2.3. Uses all rebar
M_{pr} = 380676 k-ft; nominal strength per ASCE 41-17 § 10.7.2.3. Uses $1.25f_{yl}$
V_p = MyE/hu
= 27191.1 k

A_{cv} = t_wL_w ; ACI 318-14 § 18.10.4
= 15520 in^2
d = $0.8L_w$ (Not Used)
= 1552.0 in; ACI 318-14 § 11.5.4.2
$\rho_t = A_v/s_vt_w$
= 0.0032
h_w/L_w = NA
α_c = 3.00 ; ACI 318-14 § 18.10.4.1

$V_c = \alpha_cA_{cv}\lambda f'_c{}^{0.5}$
= 3357 k
$V_s = A_{cv}\rho_tf_{yt}$
= 3760 k

$V_n = V_c + V_s$
= 7117 k; ACI 318-14 § 11.5.4

Controling Demand = Flexure; $V_n \geq V_p$
Shear; $V_n < V_p$
Shear

ASCE 41-17 Modeling Parameters, Tables 10-19, 10-20

ASCE 41-17 Tables 10-19, 10-20 Parameters:

A_s' = 3.60 in^2; calculated at P_u and M_n
A_s = 50.4 in^2

$[(A_s-A_s')f_y + P]/(t_wL_wf'_c)$ = 0.05

$V/(t_wL_wf'_c{}^{0.5})$ = 6.36
Shear force "V" used for this claculation are shear demands of analysis
Condition = i

The boundary is not confined

Tranverse reinforcement checked per ASCE 41-17 Tables 10-19 and 10-20, footnote d. Not applicable to shear walls and wall segments.

$V_s \geq {}^3/_4V_n$: No
$s_v <= {}^1/_3L_w$: Yes
Conforming? NA

Per ASCE 41-17 § 10.7.1.1, walls or wall segments cannot withstand more than $0.35P_0$ when considered to resist seismic forces.

P_o = 57693 k
P/P_o = 0.01 OK

If controlled by flexure:

IO =	0.002
LS =	0.006
CP =	0.010

*Note: The wall flexural plastic hinge is explicitly captured by the PERFORM-3D fiber model and not modeled per ASCE 41-17 table 10-19. Table 10-19 will be utilized for the calibration of the moment-rotation relations and calculation of acceptable plastic hinge rotations at the performance levels under consideration.

If controlled by shear:

d =	1.000
e =	2.000
g =	0.400
c =	0.200
f =	0.600
IO =	0.400
LS =	1.500
CP =	2.000

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WALL CONTROLLED BY FLEXURE

Conditions			a	b	c	IO	LS	CP
A_s-A_s')f_y+P]/$t_wL_wf'_c$ 0.05	$V/t_wL_wf'_c{}^{0.5}$ = 6.4							
Condition i		Confined?						
≤ 0.10	≤ 4.0	Yes	0.015	0.02	0.75	0.005	0.015	0.020
≤ 0.10	≥ 6.0	Yes	0.01	0.015	0.4	0.004	0.01	0.015
≥ 0.25	≤ 4.0	Yes	0.009	0.012	0.6	0.003	0.009	0.012
≥ 0.25	≥ 6.0	Yes	0.005	0.01	0.3	0.0015	0.005	0.010
≤ 0.10	≤ 4.0	No	0.008	0.015	0.6	0.002	0.008	0.015
≤ 0.10	≥ 6.0	No	0.006	0.01	0.3	0.002	0.006	0.010
≥ 0.25	≤ 4.0	No	0.003	0.005	0.25	0.001	0.003	0.005
≥ 0.25	≥ 6.0	No	0.002	0.004	0.2	0.001	0.002	0.004
Condition ii								
Conventional longitudinal reinforcement with conforming transverse reinforcement	≤ 3.0		0.025	0.05	0.75	0.01	0.025	0.050
	≥ 6.0		0.02	0.04	0.5	0.005	0.02	0.040
Conventional longitudinal reinforcement with nonconforming transverse reinforcement	≤ 3.0		0.02	0.035	0.5	0.006	0.02	0.035
	≥ 6.0		0.01	0.025	0.25	0.005	0.01	0.025
Diagonal reinforcement	NA		0.03	0.05	0.8	0.006	0.03	0.050

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Los Angeles, CA 90017	client	job no. 2000362	
(213) 418-0201	*Shear Wall Modeling Parameters*		

WALL CONTROLLED BY FLEXURE

Interpolation Multipliers (multiply by corresponding values of table 10-19)

Conditions			a	b	c	IO	LS	CP
$A_s-A_s')f_y+P]/t_wL_wf'_c$ 0.05	$V/t_wL_wf'_c{}^{0.5}$ = 6.4							
Condition i		Confined?						
≤ 0.10	≤ 4.0	Yes	0.0000	0.0000	0.0000	0.0000	0.0000	0.000
≤ 0.10	≥ 6.0	Yes	0.0000	0.0000	0.0000	0.0000	0.0000	0.000
≥ 0.25	≤ 4.0	Yes	0.0000	0.0000	0.0000	0.0000	0.0000	0.000
≥ 0.25	≥ 6.0	Yes	0.0000	0.0000	0.0000	0.0000	0.0000	0.000
≤ 0.10	≤ 4.0	No	0.0000	0.0000	0.0000	0.0000	0.0000	0.000
≤ 0.10	≥ 6.0	No	1.0000	1.0000	1.0000	1.0000	1.0000	1.000
≥ 0.25	≤ 4.0	No	0.0000	0.0000	0.0000	0.0000	0.0000	0.000
≥ 0.25	≥ 6.0	No	0.0000	0.0000	0.0000	0.0000	0.0000	0.000
Condition ii								
Conventional longitudinal reinforcement with conforming transverse reinforcement	≤ 3.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.000
	≥ 6.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.000
Conventional longitudinal reinforcement with nonconforming transverse reinforcement	≤ 3.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.000
	≥ 6.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.000
Diagonal reinforcement	NA		0.000	0.000	0.000	0.000	0.000	0.000

	a	b	c	IO	LS	CP
Final Values =	0.006	0.01	0.3	0.002	0.006	0.01

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WALL CONTROLLED BY SHEAR

		d	e	g	c	f	IO	LS	CP
Conditions									
A_s-A_s')f_y+P]/$t_w L_w f'_c$	0.048								
Condition i									
≤ 0.05		1	2	0.4	0.2	0.6	0.4	1.5	2.0
> 0.05		0.75	1	0.4	0	0.6	0.4	0.75	1.0
Condition ii									
$V/t_w L_w f'^{0.5}_c$ =	6.36								
Conventional longitudinal rei	≤ 3.0	0.02	0.03		0.6		0.006	0.02	0.030
	≥ 6.0	0.016	0.024		0.3		0.005	0.016	0.024
Conventional longitudinal rei	≤ 3.0	0.012	0.025		0.4		0.006	0.01	0.020
	≥ 6.0	0.008	0.014		0.2		0.004	0.007	0.012

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WALL CONTROLLED BY SHEAR

Interpolation Multipliers (multiply by corresponding values of table 10-20)

		d	e	g	c	f	IO	LS	CP
Conditions									
A_s-A_s')f_y+P]/$t_w L_w f'_c$	0.048								
Condition i									
≤ 0.05		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0
> 0.05		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
Condition ii									
$V/t_w L_w f'_c{}^{0.5}$ =	6.36								
Conventional longitudinal rei	≤ 3.0	0.0000	0.0000		0.0000		0.0000	0.0000	0.000
	≥ 6.0	0.0000	0.0000		0.0000		0.0000	0.0000	0.000
Conventional longitudinal rei	≤ 3.0	0.0000	0.0000		0.0000		0.0000	0.0000	0.000
	≥ 6.0	0.0000	0.0000		0.0000		0.0000	0.0000	0.000

	d	e	g	c	f	IO	LS	CP
Final Values =	1	2	0.4	0.2	0.6	0.4	1.5	2

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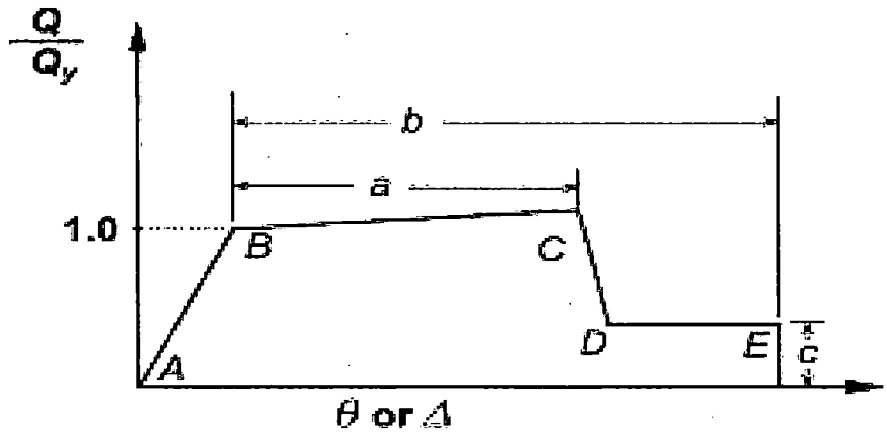
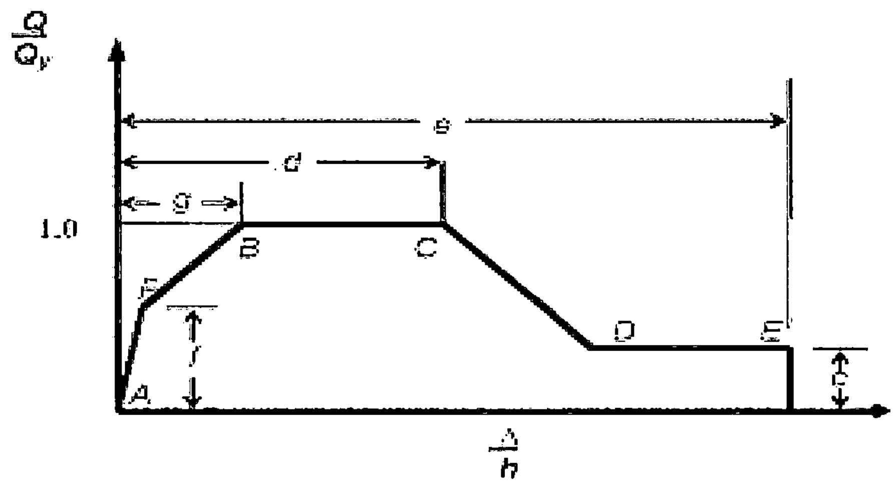
700 S Flower St, Suite 2100	location	date	
Los Angeles, CA 90017	client	job no. 2000362	
(213) 418-0201	Shear Wall Modeling Parameters		

PERFORM Modeling Parameters

Reproduced from ASCE 41-17 Figure 10-1:





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700 S Flower St, Suite 2100	location	date	
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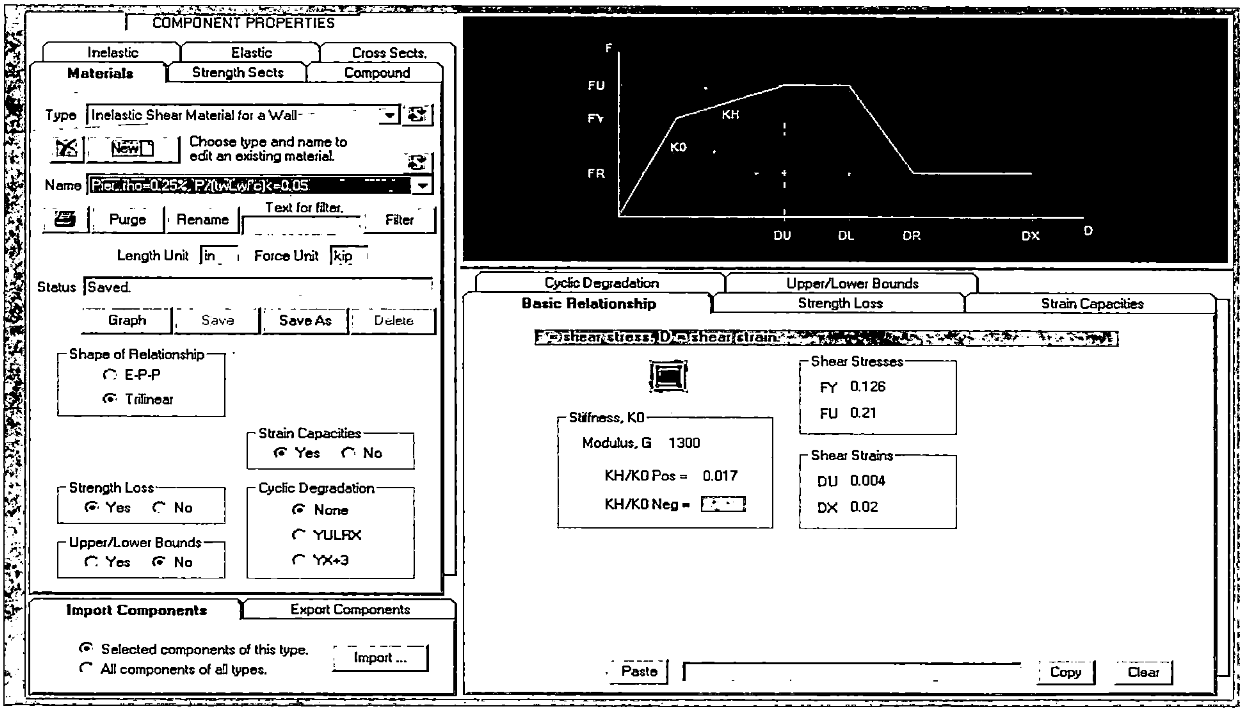
(213) 418-0201	*Shear Wall Modeling Parameters*		

Conventional Shear Material



Modulus, $G = 0.4E_c$

$= 1662$ ksi

KH/KO Pos $= ^{(1-f)} / _{[(KO)g - f]}$

$= 0.0288$

$FY = f\,FU$

$= 0.2751$

$FU = V_n/A_{cv}$

$= 0.4586$ ksi

$DU = g$

$= 0.0040$ rad

$DX = e$

$= 0.0200$ rad

Shear Stiffness $K_v = V/\Delta$

$= GA_{cv}/f_{shape}h$

$KO = (V/V_n)/\Theta$; shear rotational stiffness normalized by the shear strength

$= K_vh/V_n$

$= GA_{cv}/f_{shape}V_n$

$= G/f_{shape}FU$

$= 3624$ rad^{-1}

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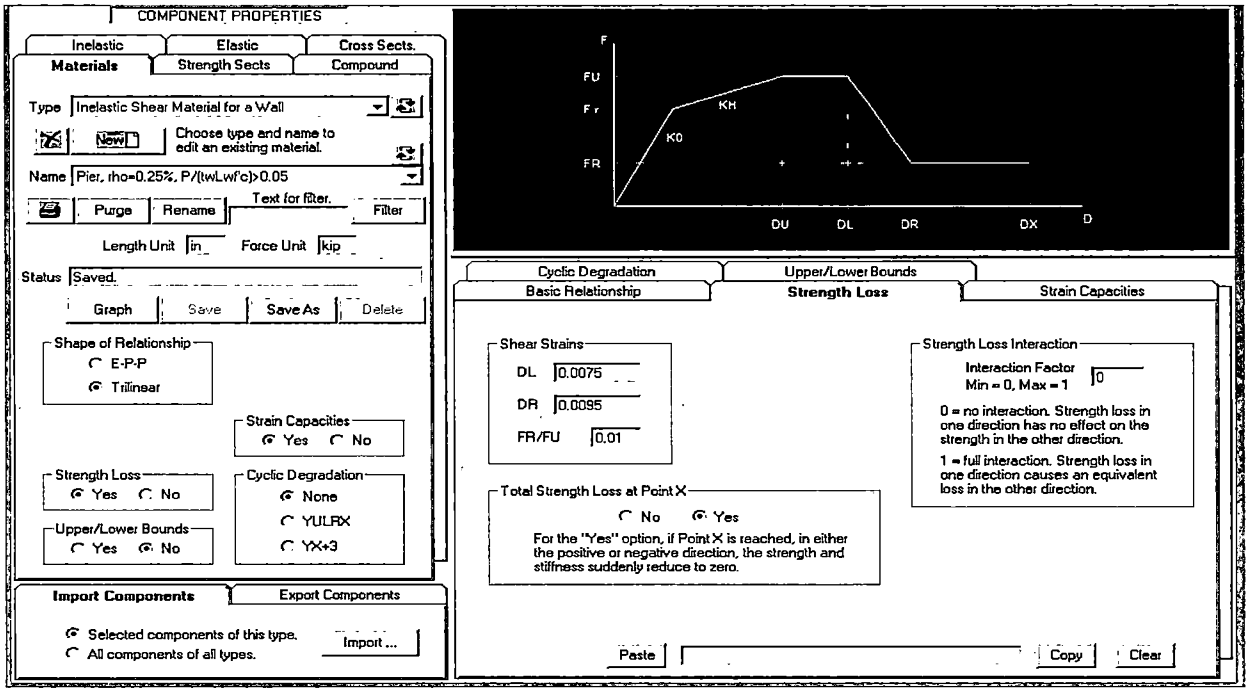


DL = d

= 0.0100 rad

DR = $^1/_2$(DL+DX); c > 0

= 0.95DX ; c = 0

= 0.0150 rad

FR/FU = c

= 0.2000

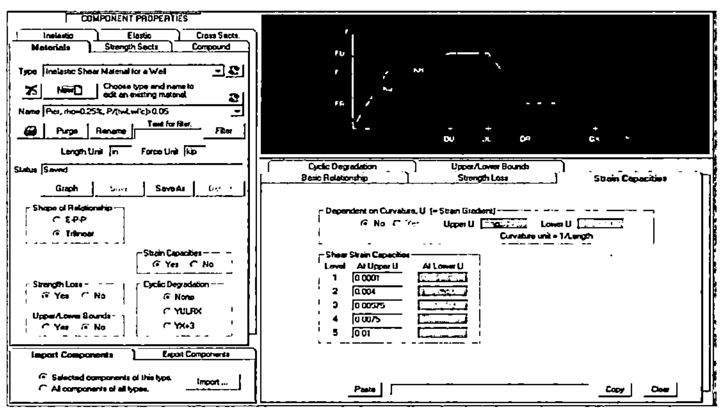
Interaction Factor = 0 ; not calculated

Deformation Capacities:

IO = 0.0040 rad

LS = 0.0150 rad

CP = 0.0200 rad



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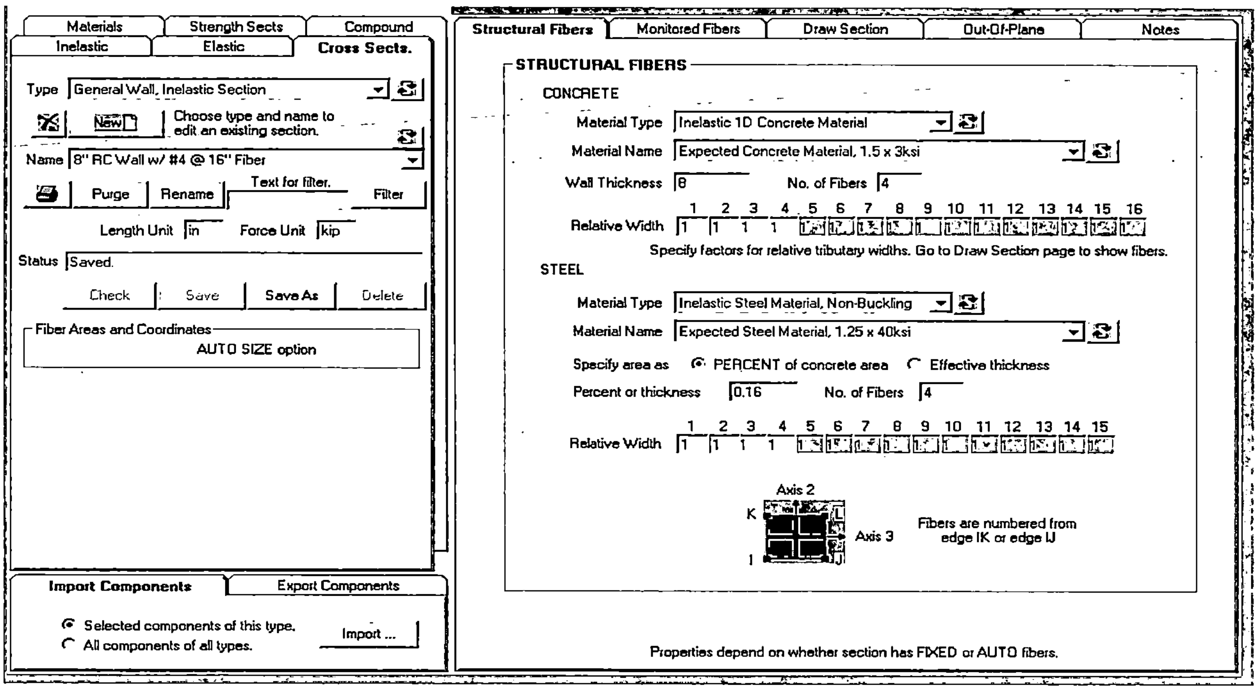
Los Angeles, CA 90017	client	job no. 2000362	
(213) 418-0201	Shear Wall Modeling Parameters		

General Wall, Inelastic Section, Cross Section Normal to Axis 2 (a horizontal section, for vertical axial/bending)



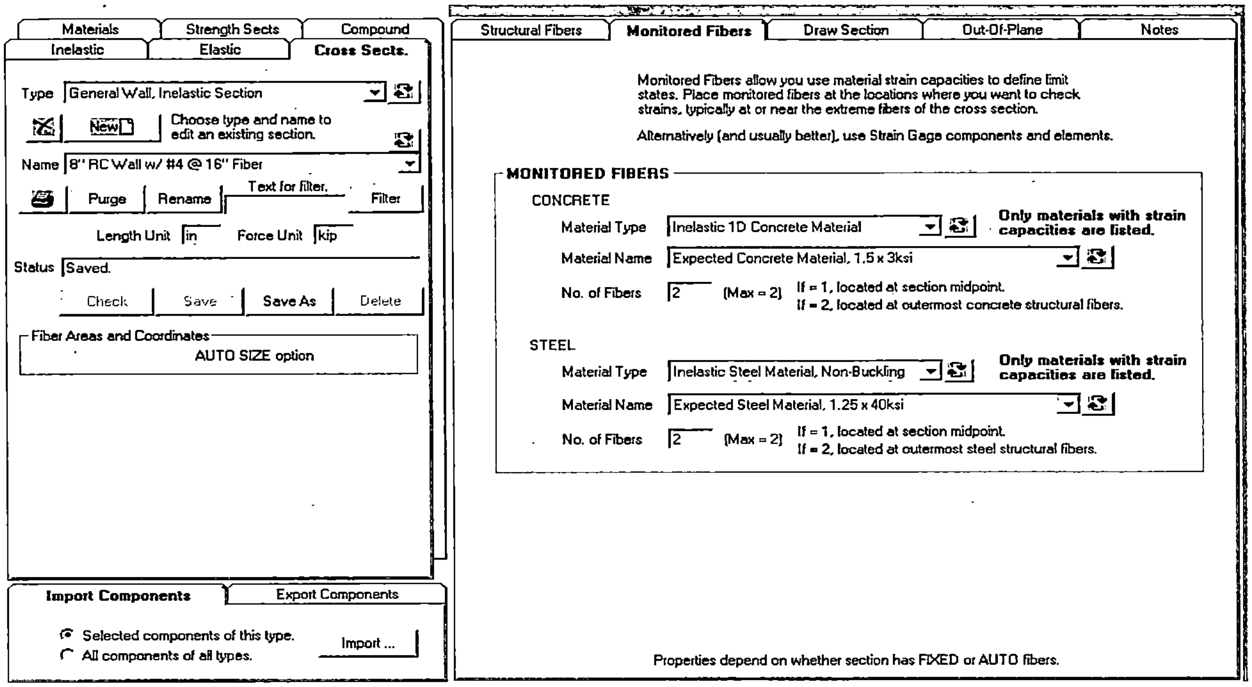
Concrete

Wall Thickness = 8 in No of Fibers = 4 ; not calculated

Steel

Wall Thickness = 8 in No of Fibers = 4 ; not calculated

Percent = 0.3230



Concrete

No of Fibers = 2 ; not calculated

Steel

No of Fibers = 2 ; not calculated

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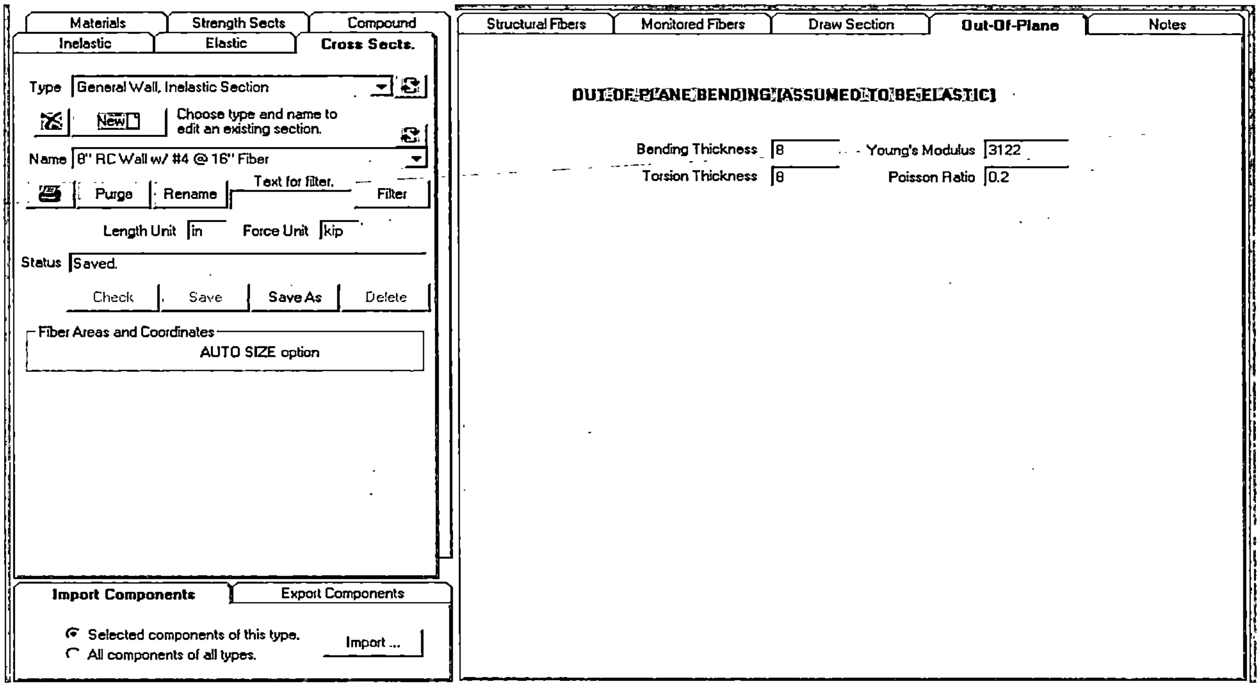

Bending Thickness =	8	in	Young's Modulus =	1039	ksi; use 0.25 multiplier
Torsion Thickness =	8	in	Poisson Ratio =	0.2	; not calculated

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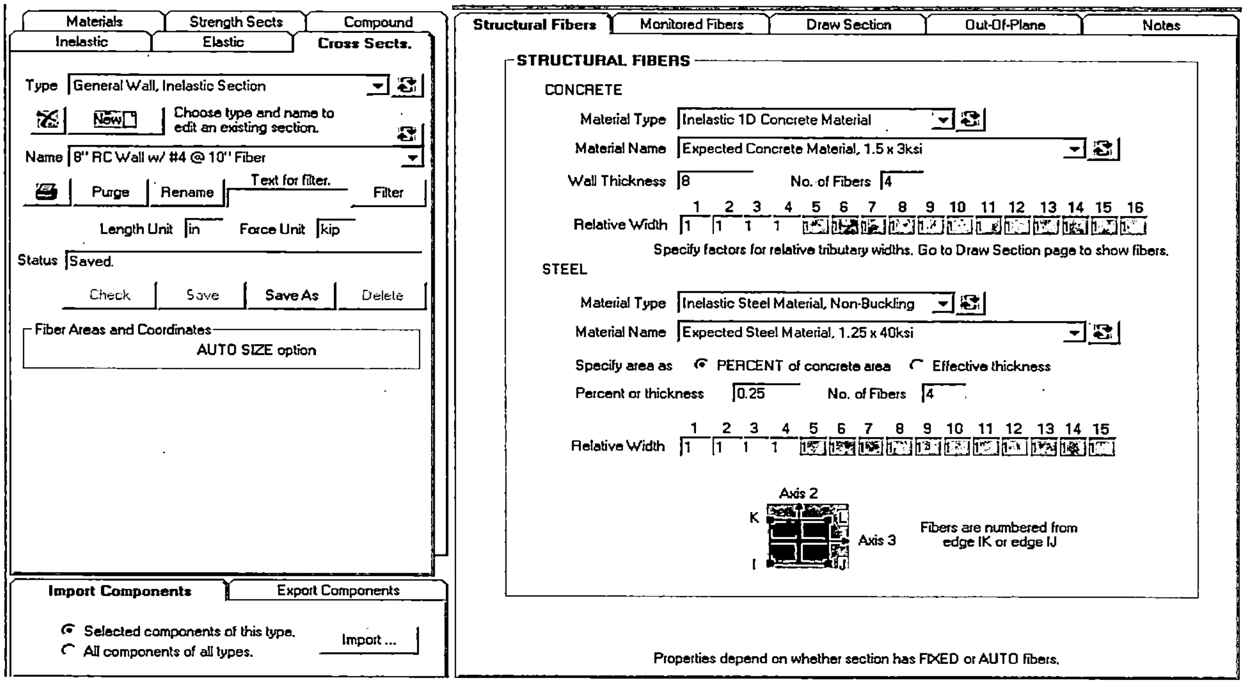
General Wall, Inelastic Section, Cross Section Normal to Axis 3 (a vertical section, for horizontal axial/bending)



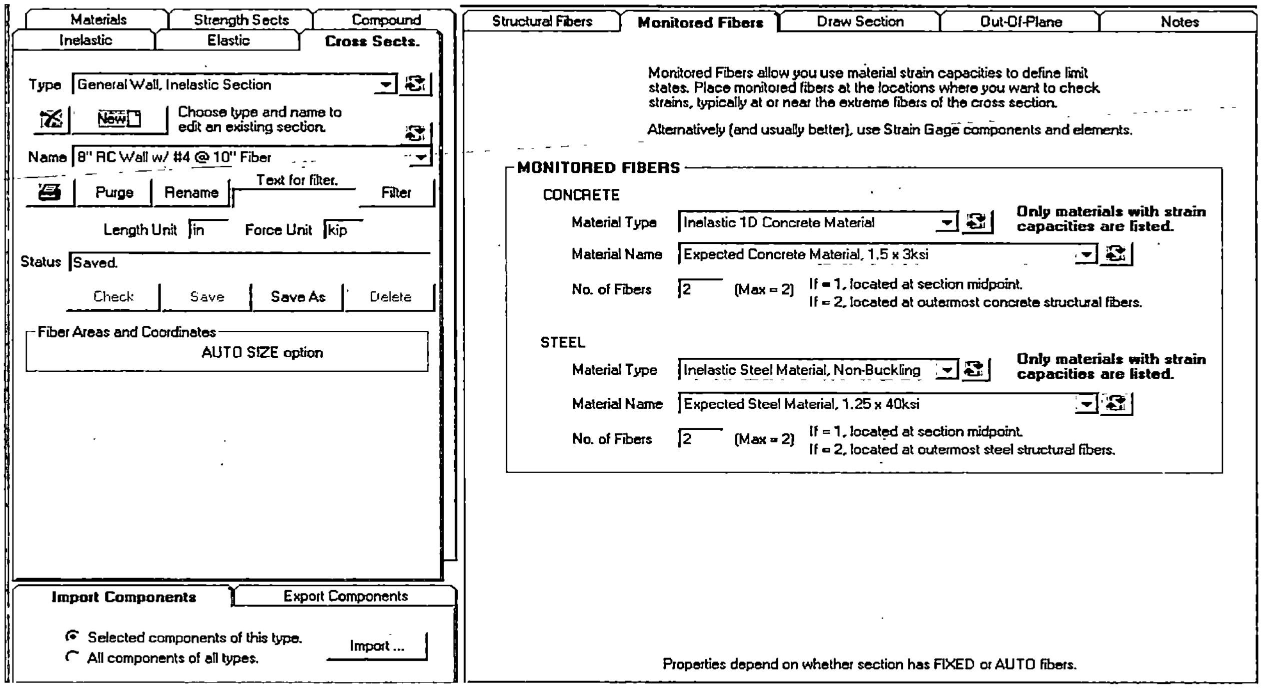
Concrete

Wall Thickness = 8 in No of Fibers = 4 ; not calculated

Steel

Wall Thickness = 8 in No of Fibers = 4 ; not calculated

Percent = 0.3230



Concrete

No of Fibers = 2 ; not calculated

Steel

No of Fibers = 2 ; not calculated

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700 S Flower St, Suite 2100	location		date	
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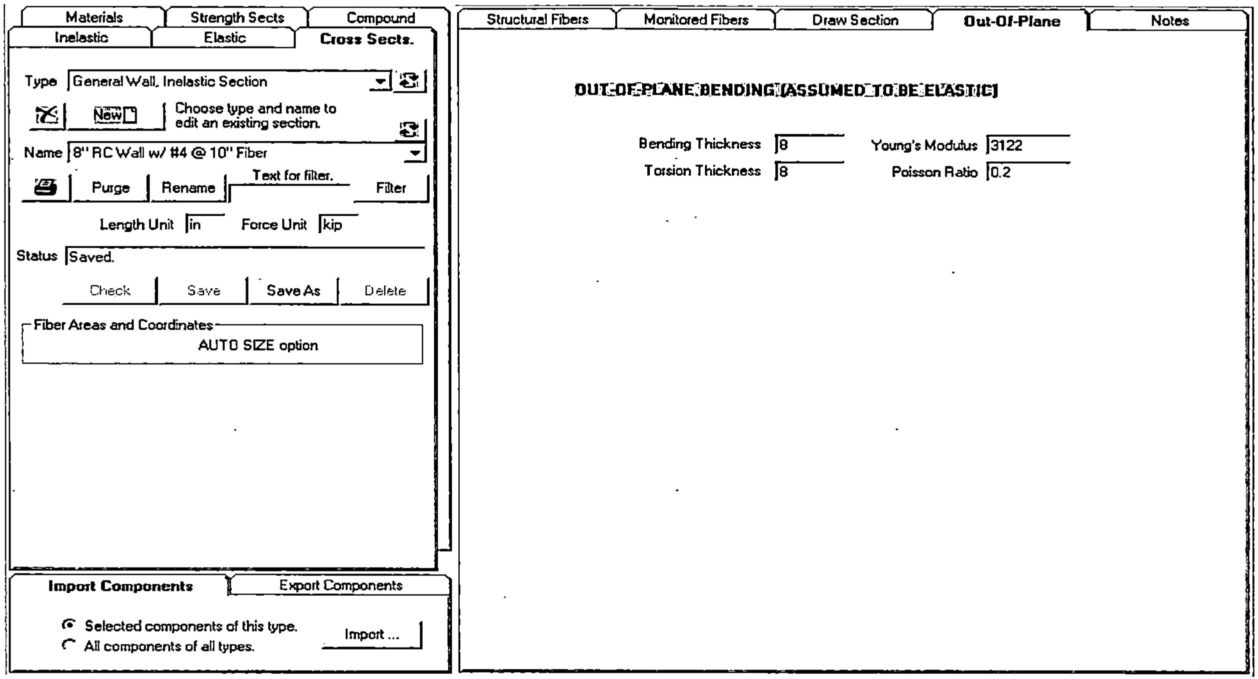

Bending Thickness =	8	in	Young's Modulus =	1039	ksi; use 0.25 multiplier
Torsion Thickness =	8	in	Poisson Ratio =	0.2	; not calculated

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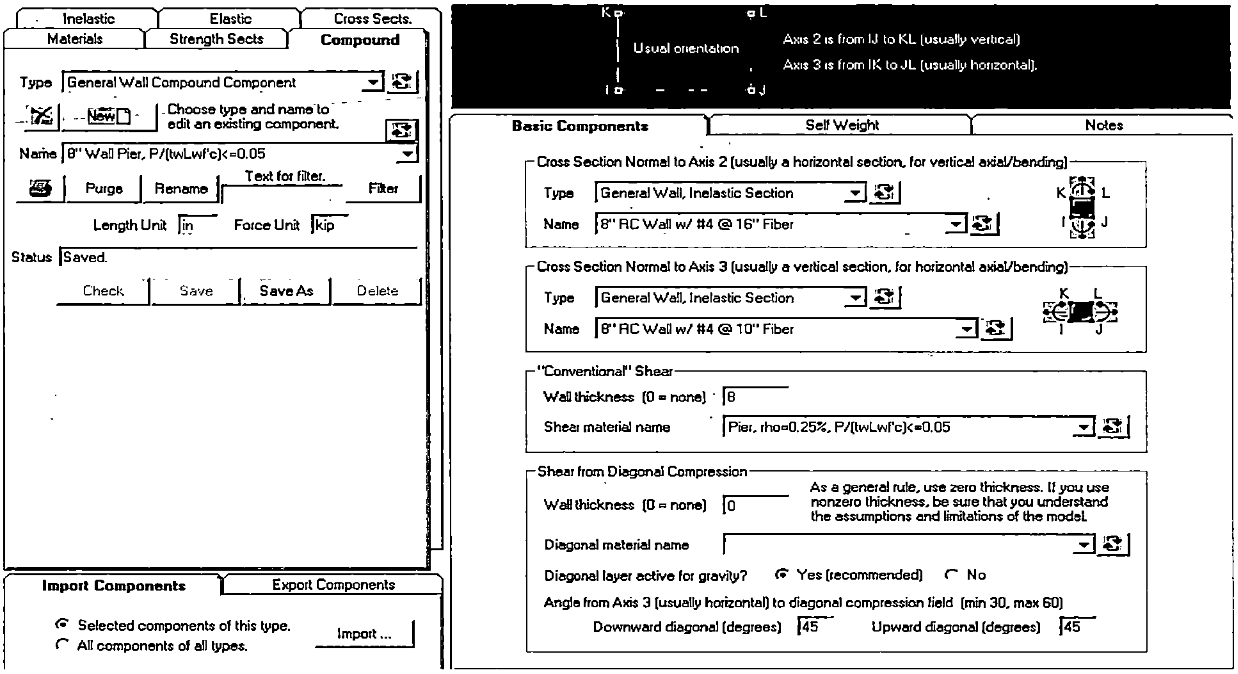
(213) 418-0201	*Shear Wall Modeling Parameters*		

PERFORM Compound Component



Conventional Shear

Wall Thickness = 8 in

Self Weight

Thickness for self weight calculation = 8 in

Weight density of wall material = 8.520E-05 k/in^3

Steel Density w_s = 490 pcf

Concrete Density w_c = 145 pcf

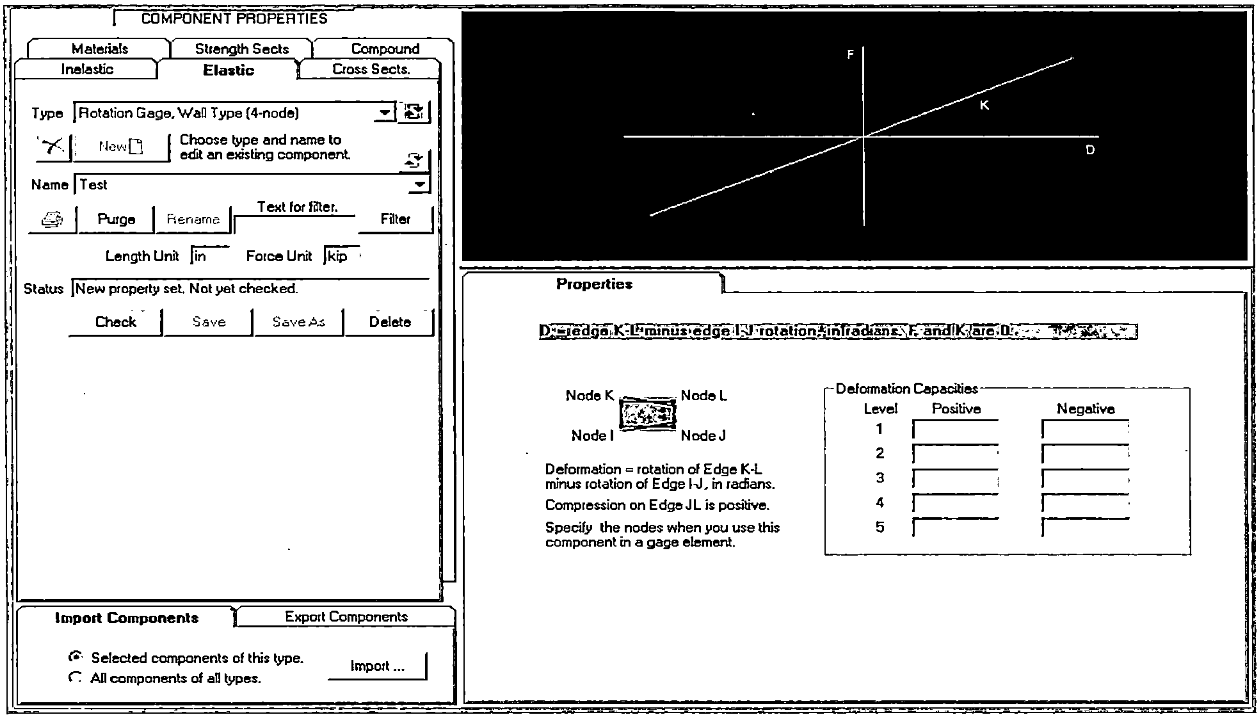
ρ_l = 0.0032 ; Longitudinal reinforcement ratio

ρ_v = 0.0032 ; Transverse reinforcement ratio

Weight density = $(\rho_l + \rho_v)(w_s - w_c) + w_c$

= 147.2 pcf

Rotation Gage



IO = 0.002

LS = 0.006

CP = 0.01

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8 - Fluid Viscous Damper Properties

kpff	project City of Inglewood - Library Bldg	by JL	sheet no. 8-2
	location Inglewood, CA	date 4/7/21	
700 South Flower Street, Suite 2100 Los Angeles, CA 90017 (213) 418-0201	client	job no. 2000362	

Fluid Viscous dampers are modeled using expected properties in PERFORM-3D. The following table shows the properties used to model the viscous dampers within PERFORM-3D and the resulting design values for axial load and stroke obtained from the PERFORM-3D model. Damper properties are preliminary and will be further refined as design of the retrofit progresses, along with accounting for upper and lower bound viscous damper properties. Calculation of the upper and lower bound property modifiers can be seen in the following pages.

COI Library Damper Properties Both Directions										
Floor Level	Damping Coefficient	Number of Dampers	Velocity Exponent	Damper Angle	BSE-2E Damper Demands					
	C (kip-sec/in)	n	α	θ (rad)	Max Avg. Damper Force (k)	Max Damper Design Force (k)[1]	Max Avg. Damper Stroke (+/-) (in)	Max Damper Design Stroke (in)[2]	Max Avg. Damper Velocity (in/sec)	Max Design Force Based on Velocity (k)[3]
4	60	16	0.4	0.66	143.48	183.26	1.65	2.53	9.01	184.67
3	91	16	0.4	0.66	225.45	287.96	1.72	2.63	9.95	291.34
2	120	16	0.4	0.66	287.22	366.85	1.49	2.28	9.11	370.93

Notes:

1. $P = P_{Perform} * 1.15 * 1.3^{0.4}$
2. $S = (S_{Perform}/0.85) * 1.3$
3. $P = 1.15 * C * (1.3 * V_{Perform})^{0.4}$

Per ASCE 41-17 15.3.1 damper properties must be modified by λ factors determined by 15.3.2 to obtain upper and lower bound damper properties.

$\lambda_{max} = \lambda_{test\ max} * \lambda_{spec\ max}\ (1 + SPAF(\lambda_{ae\ max} - 1)) \geq 1.2$ per ASCE 41 17 Eq. 15-1

$\lambda_{min} = \lambda_{test\ min} * \lambda_{spec\ min}\ (1 + SPAF(1 - \lambda_{ae\ min})) \leq 0.85$ per ASCE 41-17 Eq. 15-2

λ_{test} = Lambda factor obtained from testing = +/- 10% per recommendations from Taylor Devices ($\lambda_{test\ max}$ = 1.1, $\lambda_{test\ min}$ = 0.9)

λ_{spec} = Variation on the average of the manufacturing production test values from the nominal design value = +/- 5% per recommendations from Taylor Devices ($\lambda_{spec\ max}$ = 1.05, $\lambda_{spec\ min}$ = 0.95)

λ_{ae} = Property Variation factor caused by the individual aging and environmental effects = 1.0 per recommendations from Taylor Devices

SPAF = System Property adjustment factor = 0.67 for all Performance Objectives

λ_{max} = 1.1 * 1.05 (1 + 0.67(1.0 - 1)) = 1.16, round to 1.15 per Taylor Devices recommendations.
Therefore: λ_{max} = 1.15

λ_{min} =0.9 * 0.95 (1 + 0.67(1 - 1)) = 0.86, round to 0.85 per Taylor Devices recommendations.
Therefore: λ_{min} = 0.85

Maximum Design Property = Nominal Design Property * λ_{max} per ASCE 41 17 Eq. 15-3

Minimum Design Property = Nominal Design Property * λ_{min} per ASCE 41-17 Eq. 15-4

716.694.0800
90 Taylor Drive
North Tonawanda, NY 14120
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FOR REFERENCE

Viscous Damper Specifications Guide

This document provides a standard for specifying the requirements of viscous dampers for seismic applications. The standard provided should be used to communicate the project specific requirements of viscous dampers on structural drawings, to Taylor Devices for production, and to any third-party reviewer.

1. VISCOUS DAMPER PROPERTY MODIFICATION FACTORS - (λ_{max} & λ_{min})

To capture variability in viscous damper properties due to environmental and manufacturing factors, ASCE 7 and ASCE 41 require that both an upper and lower bound property modification factor on the Damper Constant, C, be considered, λ_{max} and λ_{min}. Note that there is no requirement to modify the Velocity Exponent, α.

In general, when the upper bound damper constant, $\lambda_{max}C$, is considered in the analysis, the results will show larger damper forces and therefore control damping system demands. When the lower bound damper constant, $\lambda_{min}C$, is considered, the results will show larger global displacements and will control any drift requirements, deformation-controlled elements, and damper stroke requirements.

For Taylor dampers, engineers may use λ_{max} = 1.15 and λ_{min} = 0.85 as modifiers on the Damper Constant, C, to capture viscous damper behavior upper and lower bound analysis.

Taylor Devices may provide an upper bound property modification factor of 1.15 (less than the 1.2 limit shown in Equation 1 below) due to Taylor Devices' extensive testing history and product performance under the exemption in the Standards if approved by the design professional and the design reviewer. In conjunction with Taylor Devices' Testing Submittal document, previous prototype testing reports may be provided which demonstrate the performance of Taylor viscous dampers within the appropriate bounds.

The definition of these bounds in ASCE 41 and ASCE 7 is shown in the following:

$$\lambda_{max} = \lambda_{test\ max} * \lambda_{spec\ max} * (1 + SPAF(\lambda_{ae\ max}-1)) \geq 1.2 \qquad \text{(Eqn. 1)}$$

$$\lambda_{min} = \lambda_{test\ min} * \lambda_{spec\ min} * (1 - SPAF(\lambda_{ae\ min}-1)) \leq 0.85 \qquad \text{(Eqn. 2)}$$

Where,

λ_{test} = account for variations observed during prototype testing, including effects due to temperature change in the fluid through multiple stroke cycles (fade or regen) and ambient temperature of the device = ±10% ($\lambda_{test\ max}$ = 1.1, $\lambda_{test\ min}$ = 0.90)
λ_{spec} = account for manufacturing variations = ±5% ($\lambda_{spec\ max}$ = 1.05, $\lambda_{spec\ min}$ = 0.95)
λ_{ae} = account for aging and environmental effects, which are not relevant to this type of device, therefore $\lambda_{ae\ max}$ = $\lambda_{ae\ min}$ = 1.0
SPAF = System property adjustment factor = 0.67 for all Performance Objectives

Prototype testing conducted by Taylor Devices captures both elements of λ_{test} (cycle variation and ambient temp.) and manufacturing variations (λ_{spec}) to be within the ± 15% captured by the upper and lower bound property modification factors. Production testing conducted by Taylor Devices does not vary the ambient temperature but does capture variations due to cycle variation and the manufacturing process. For this reason, in applications where significant temperature ranges are expected, targeting ± 10% variation (5% from fade effects and 5% for manufacturing variability) should be used as bounds for production testing, or the upper and lower bounds can be adjusted to $\lambda_{max} = 1.2$ and $\lambda_{min} = 0.80$. Readers are directed to MCEER Technical Report 01-0012 for more information on the derivation and use of the lambda factors.

2. MAXIMUM DESIGN LOAD AND REQUIRED STROKE

In addition to the upper and lower bound property modification factors on the Damper Constant, C, both ASCE 7 and ASCE 41 have provisions for amplification of calculated viscous damper demands based upon the design of force-controlled elements of the damping system, damper layout redundancy and, in the case of ASCE 41-17, performance objectives.

ASCE 41-17

Maximum Design Load:

ASCE 41-17 Section 15.2.2.4 provides a force-controlled element amplifier based upon damper layout redundancy. When considering a Basic Performance Objective (BPOE), a 130% amplifier on the BSE-2X displacement and velocity shall be considered when determining the maximum design load, F_{max}, if there are at least four dampers on a given story in either principal direction with two on either side of the center of stiffness:

$$F_{max} = \lambda_{max} C^*(1.3V_{BSE2\text{-}2X})^{\alpha} \quad \text{(Eqn. 3)}$$

otherwise, if fewer than four dampers are provided, BSE-2X level displacements and velocities are amplified by 200%.

$$F_{max} = \lambda_{max} C^*(2.0V_{BSE\text{-}2X})^{\alpha} \quad \text{(Eqn. 4)}$$

When only the BSE-1X event is considered for a Limited Performance Objective (LPO), then there shall be a minimum of four dampers on a given story in either principal direction, two on either side of the center of stiffness, and the BSE-1X displacement and velocities are amplified by 200%.

$$F_{max} = \lambda_{max} C^*(2.0V_{BSE\text{-}1X})^{\alpha} \quad \text{(Eqn. 5)}$$

Figure 1 shows the theoretical mean damper performance (blue line) captured by the equation $F = CV^{\alpha}$ as well as the upper and lower bounds (red dashed lines). Nominal (BSE-2X) and maximum design loads and velocities corresponding to Equation 3 are shown as well.

9 - Secondary Framing & P-Delta Effects

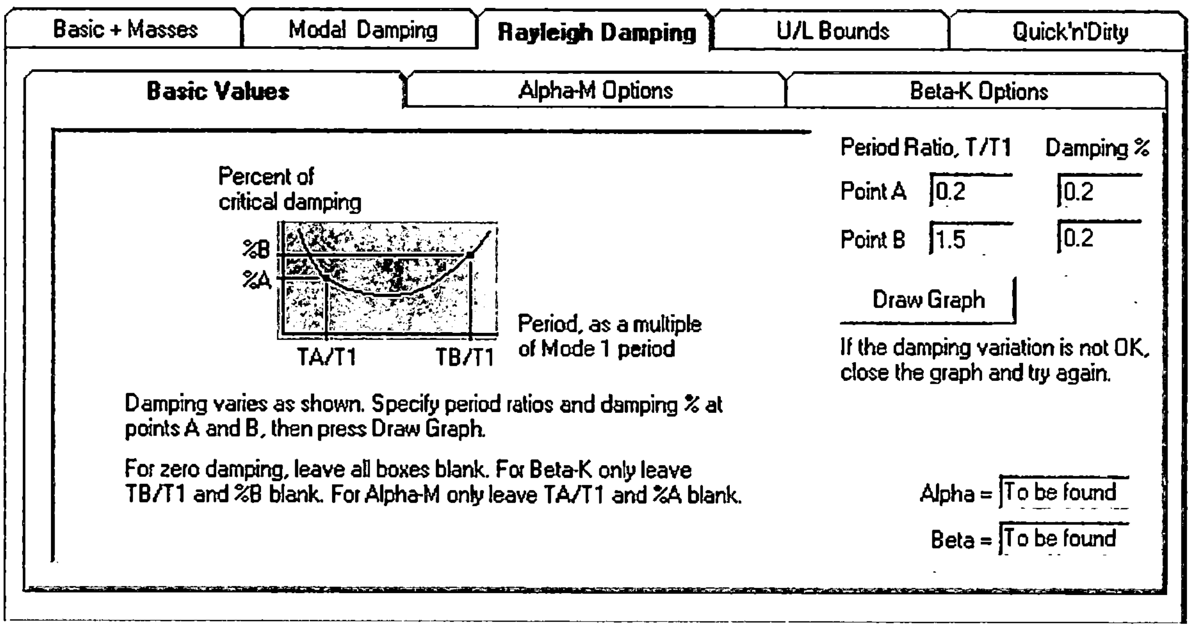
P-Delta Effects have been included in the model. All secondary beams at the 1st floor lecture hall have been modeled. Modeled secondary beams have been modeled as elastic. Modeled secondary beams will be checked for drift and strength demands from demands within PERFORM see Appendix F for calculations of moment and shear capacities. All other secondary gravity beams in the library and lecture hall roof have not been modeled and will be checked for deformation compatibility.

10 - Damping

kpff	project City of Inglewood - Library	by JL	sheet no. 10-2
700 South Flower Street, Suite 2100 Los Angeles, CA 90017 (213) 418-0201	location Inglewood, CA	date 6/18/21	
	client	job no. 2000362	
	Damping		

Damping in the PERFORM-3D model will be applied per Section 4.3.3.7 of the Basis of Design. 2.8% damping will be be applied as modal damping while 0.2% will be applied as β-K Rayleigh damping.

β-K Rayleigh damping will be applied at 0.2T and 1.5T as shown in the screenshot below.



11 - Diaphragms

Executive Summary

Diaphragms are modeled as rigid per Section 4.2.8.1 of the Basis of the Design. The diaphragm is modeled implicitly in PERFORM-3D using nodal constraints at each story level.

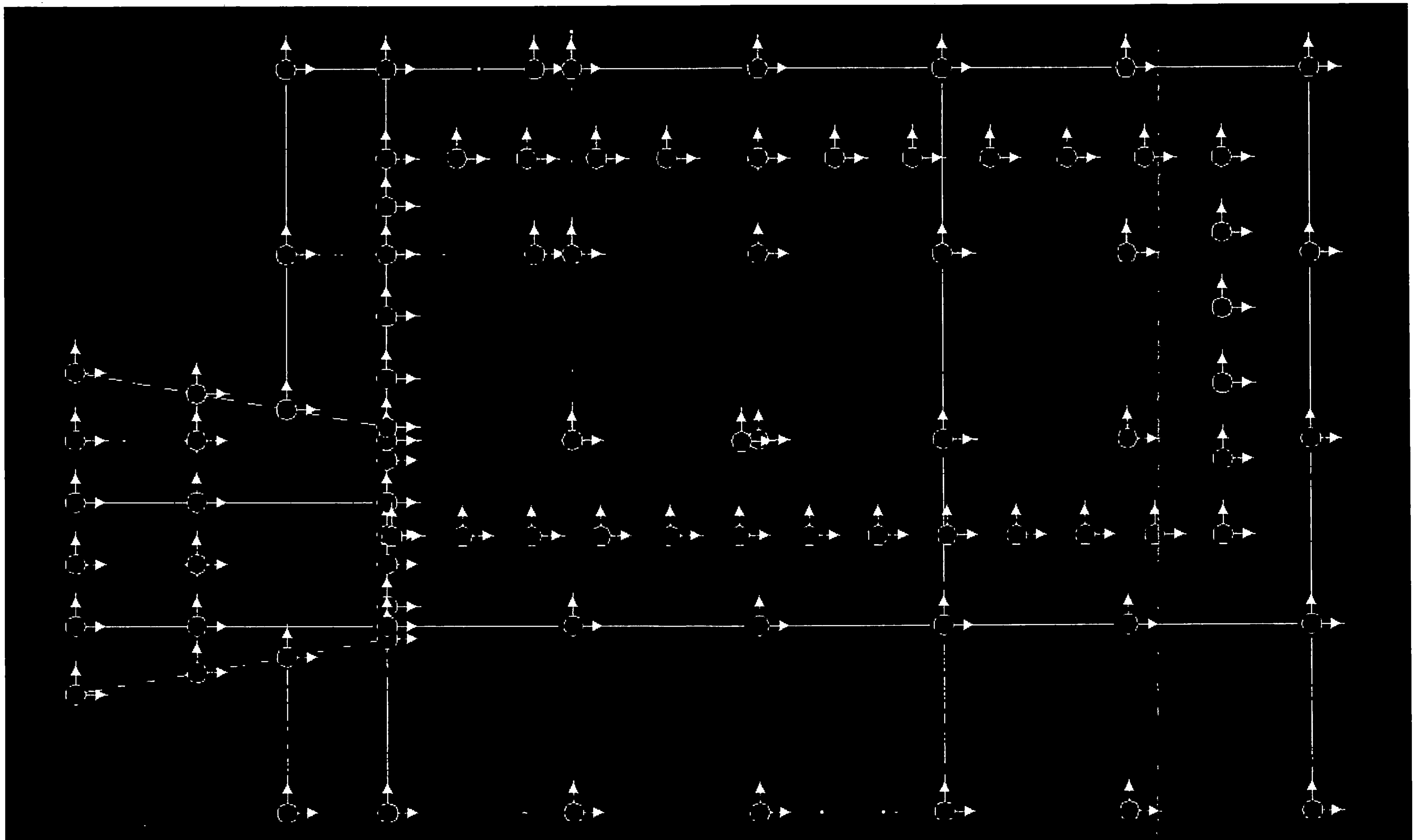


Figure 11-1 PERFORM-3D Model 1st Floor Plan View, Diaphragm Definition (H1, H2, RV Constraints)

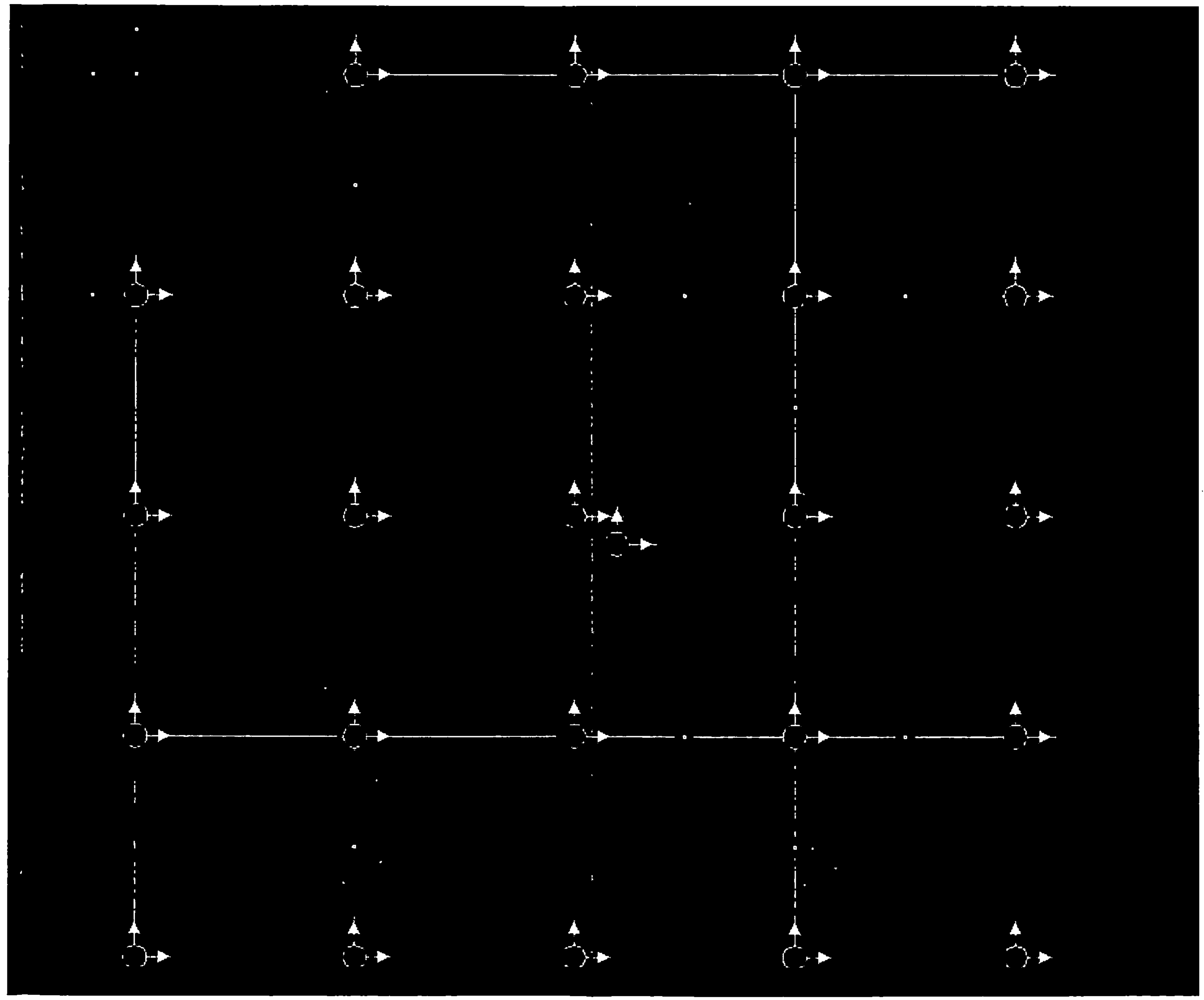


Figure 11-2 PERFORM-3D Model 2nd/3rd Floor Plan View, Diaphragm Definition (H1, H2, RV Constraints)

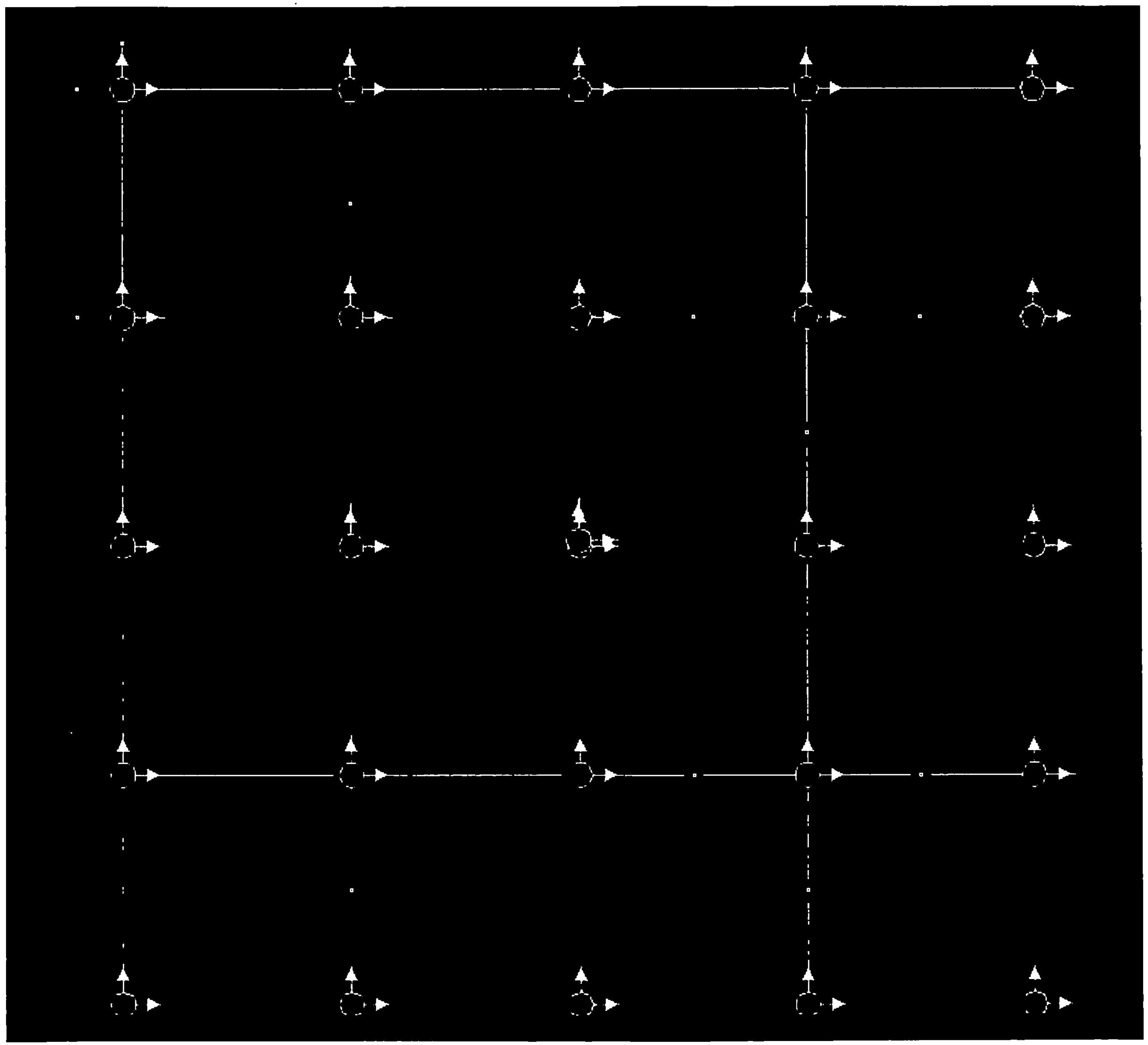


Figure 11-3 PERFORM-3D Model Roof Plan View, Diaphragm Definition (H1, H2, RV Constraints)

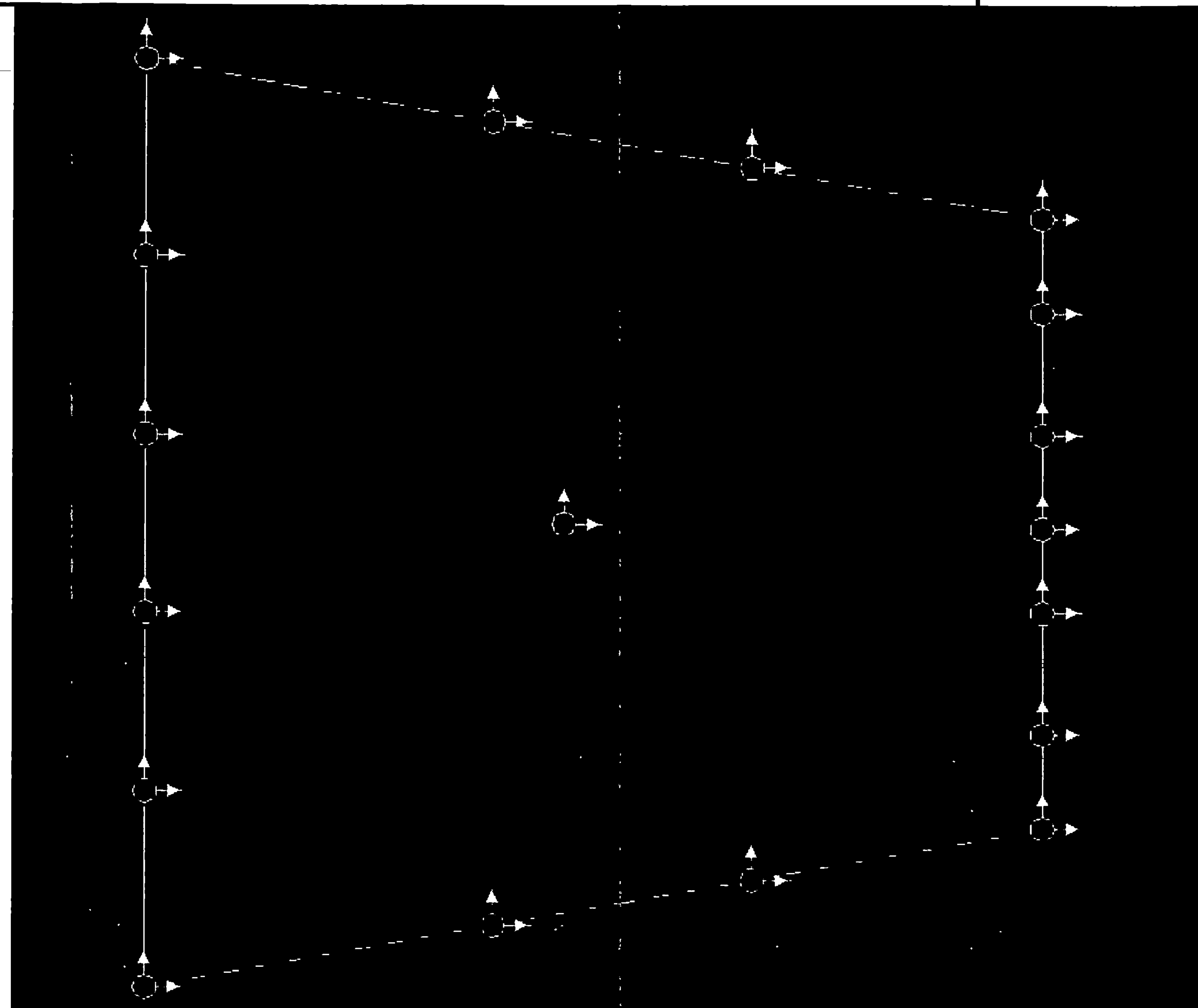


Figure 11-4 PERFORM-3D Model Lecture Hall Roof Plan View, Diaphragm Definition (H1, H2, RV Constraints)

12 - Drift Definitions

Executive Summary

Drift definitions are defined at the center of mass for each story. An additional drift definition at the center of mass from the base to the roof is defined.

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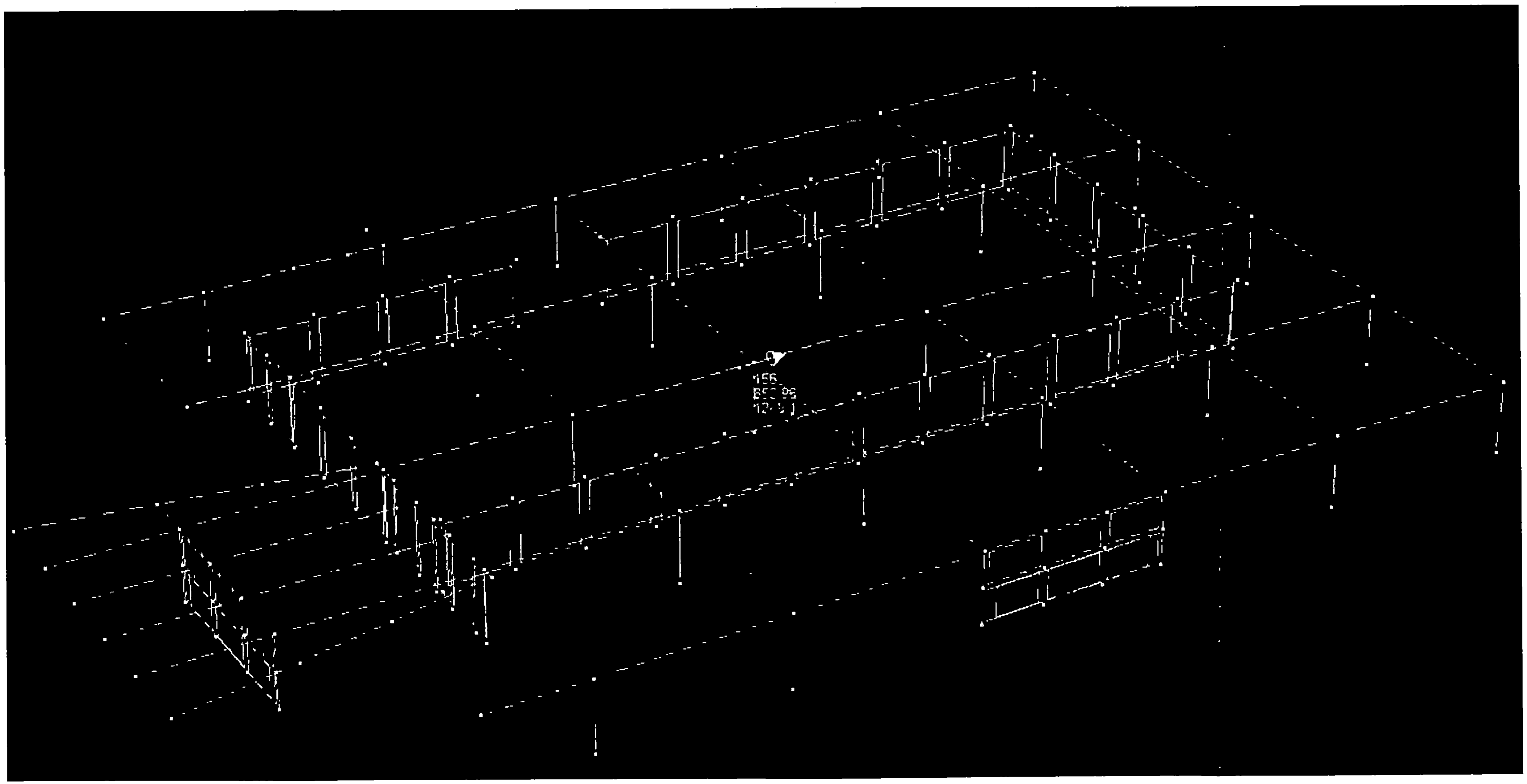
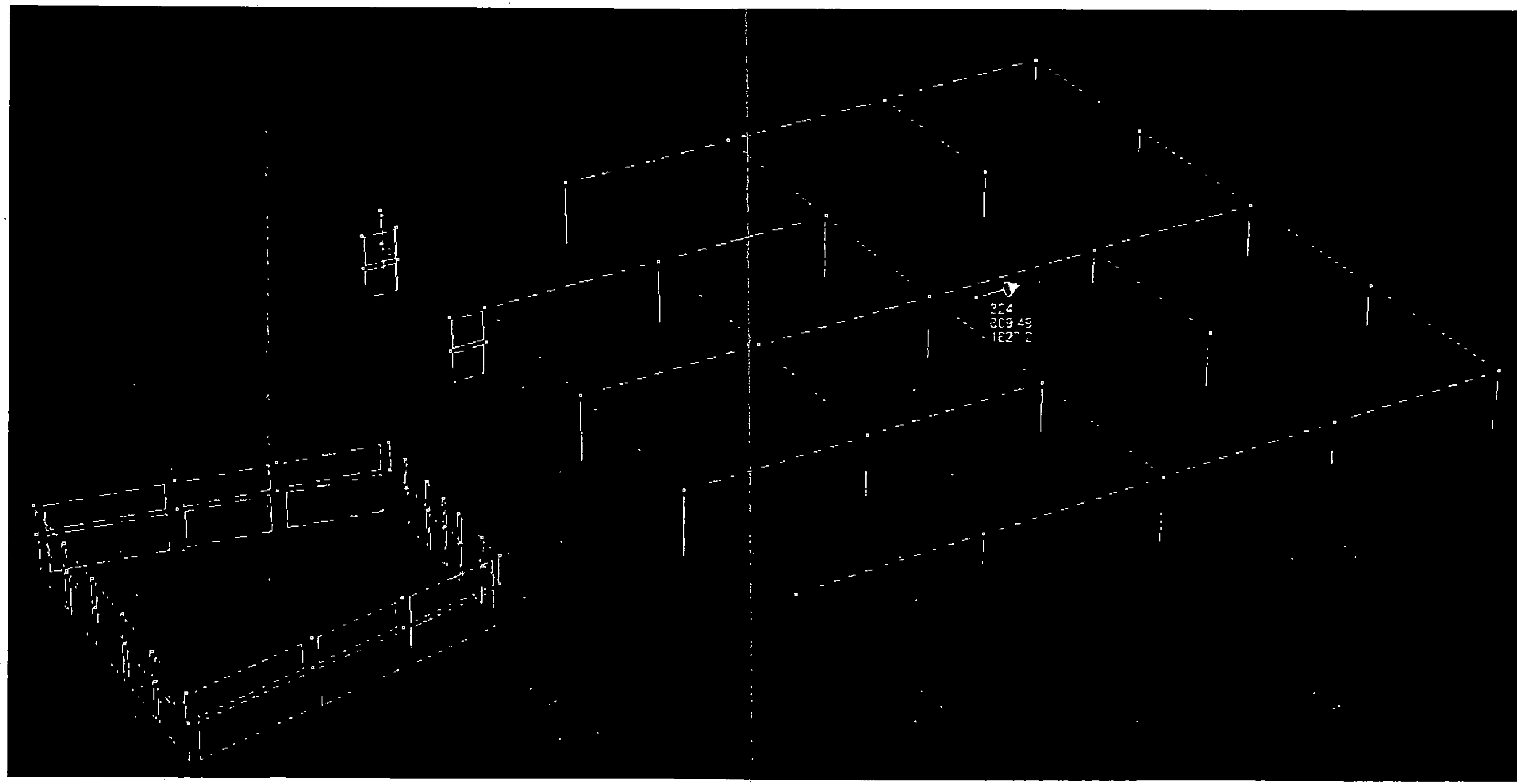
project City of Inglewood - Library	by JL	sheet no. 12-3
location	date 4/3/21	
client	job no. 2000362	



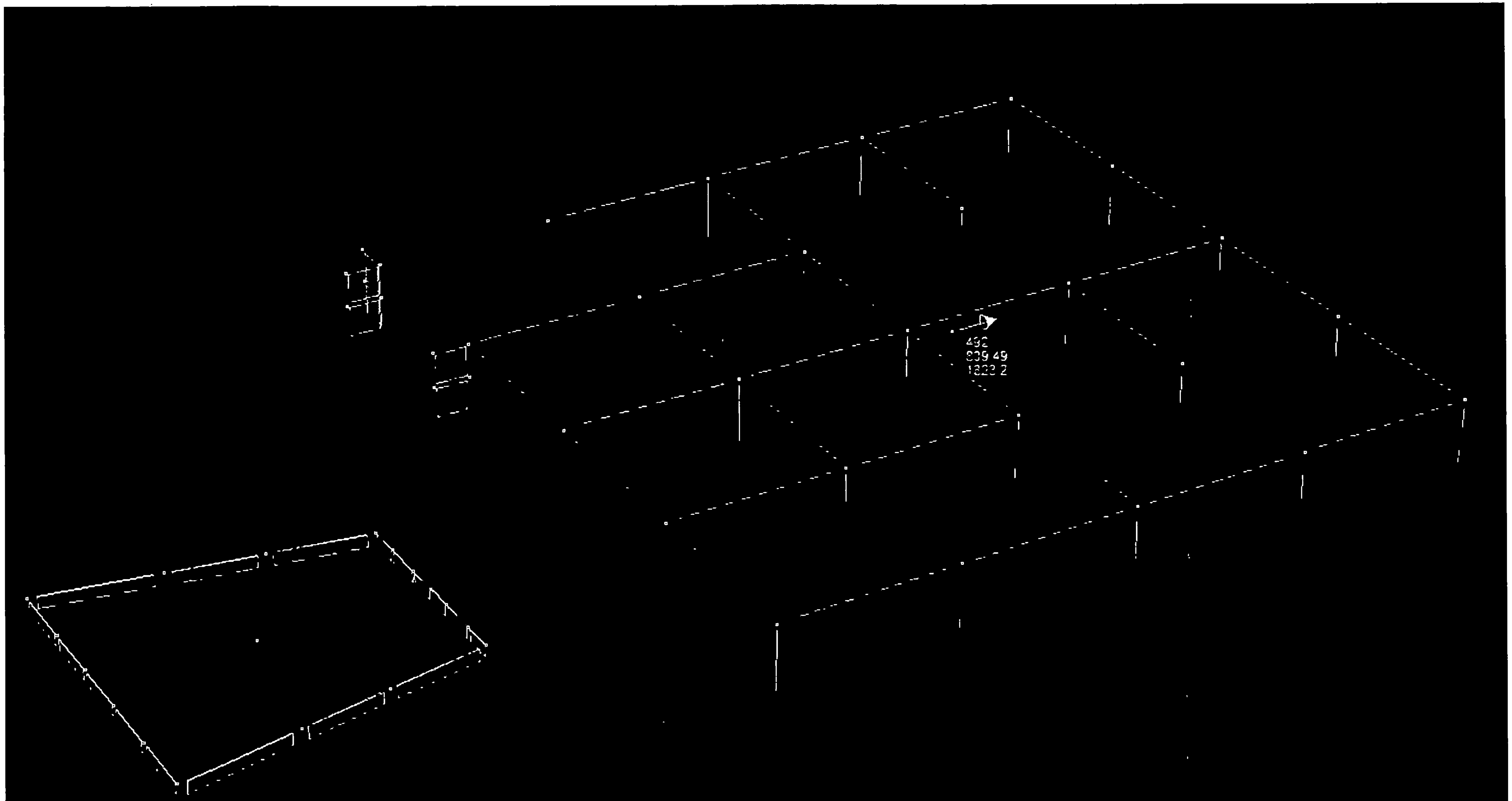
*Drift definitions shown in H1 directions, H2 drifts are defined at the same locations

Figure 12-1 PERFORM-3D 1st Story Isometric View, Drift Definitions



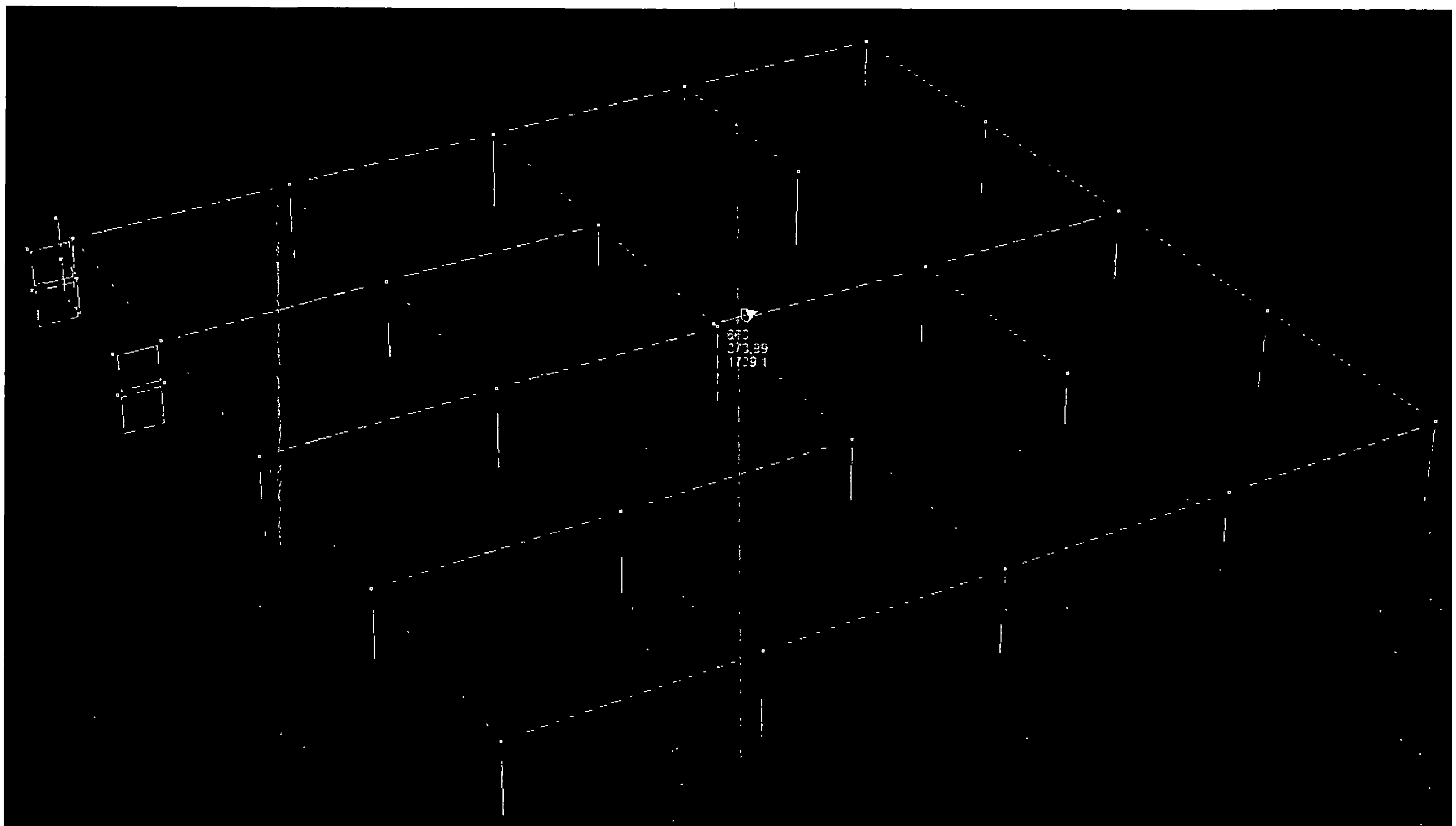
*Drift definitions shown in H1 directions, H2 drifts are defined at the same locations

Figure 12-2 PERFORM-3D 2nd Story Isometric View, Drift Definitions



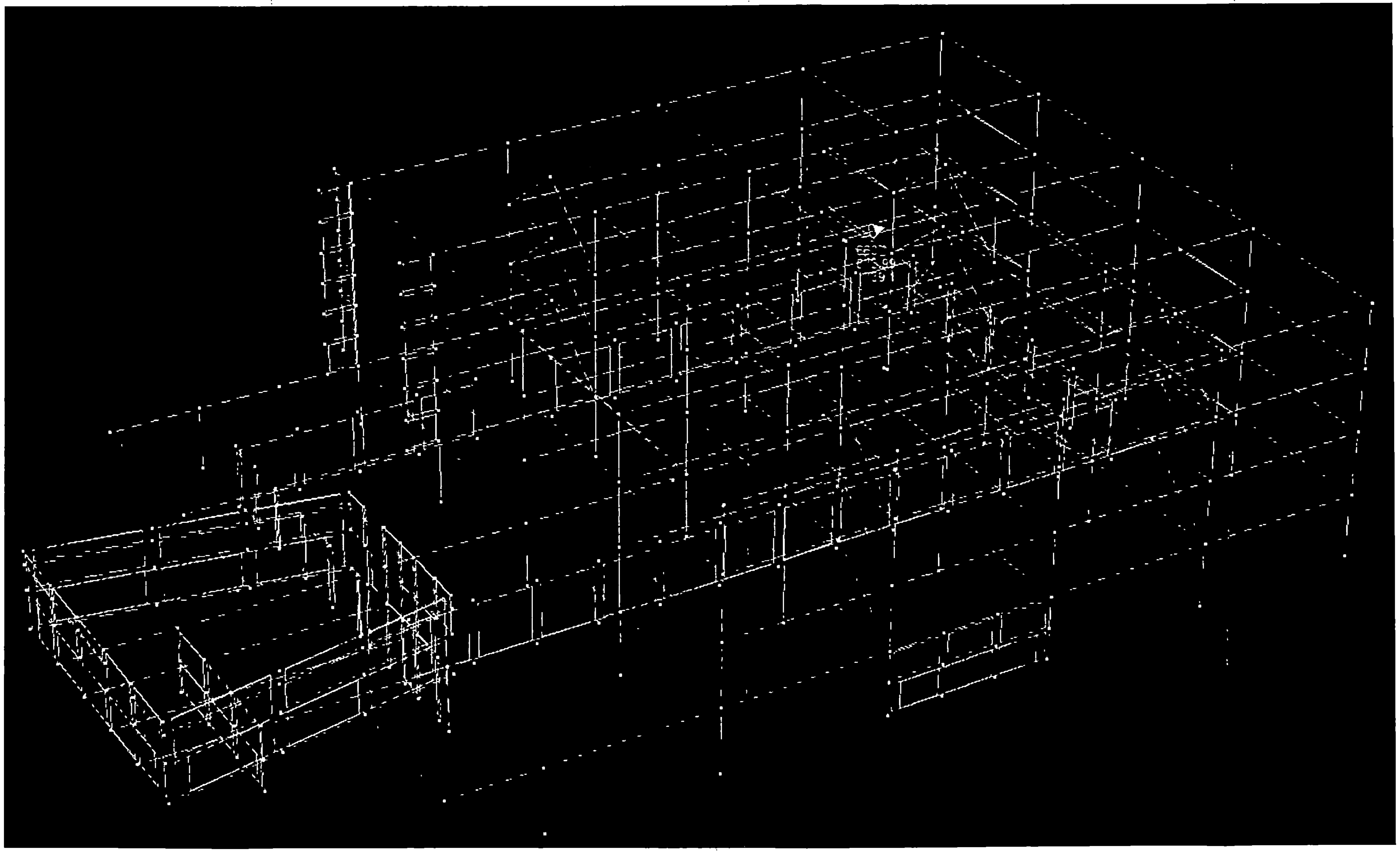
*Drift definitions shown in H1 directions, H2 drifts are defined at the same locations

Figure 12-3 PERFORM-3D 3rd Story Isometric View, Drift Definitions



*Drift definitions shown in H1 directions, H2 drifts are defined at the same locations

Figure 12-4 PERFORM-3D 4th Story Isometric View, Drift Definitions



*Drift definitions shown in H1 directions, H2 drifts are defined at the same locations

Figure 12-5 PERFORM-3D Isometric View, CM Drift Definition

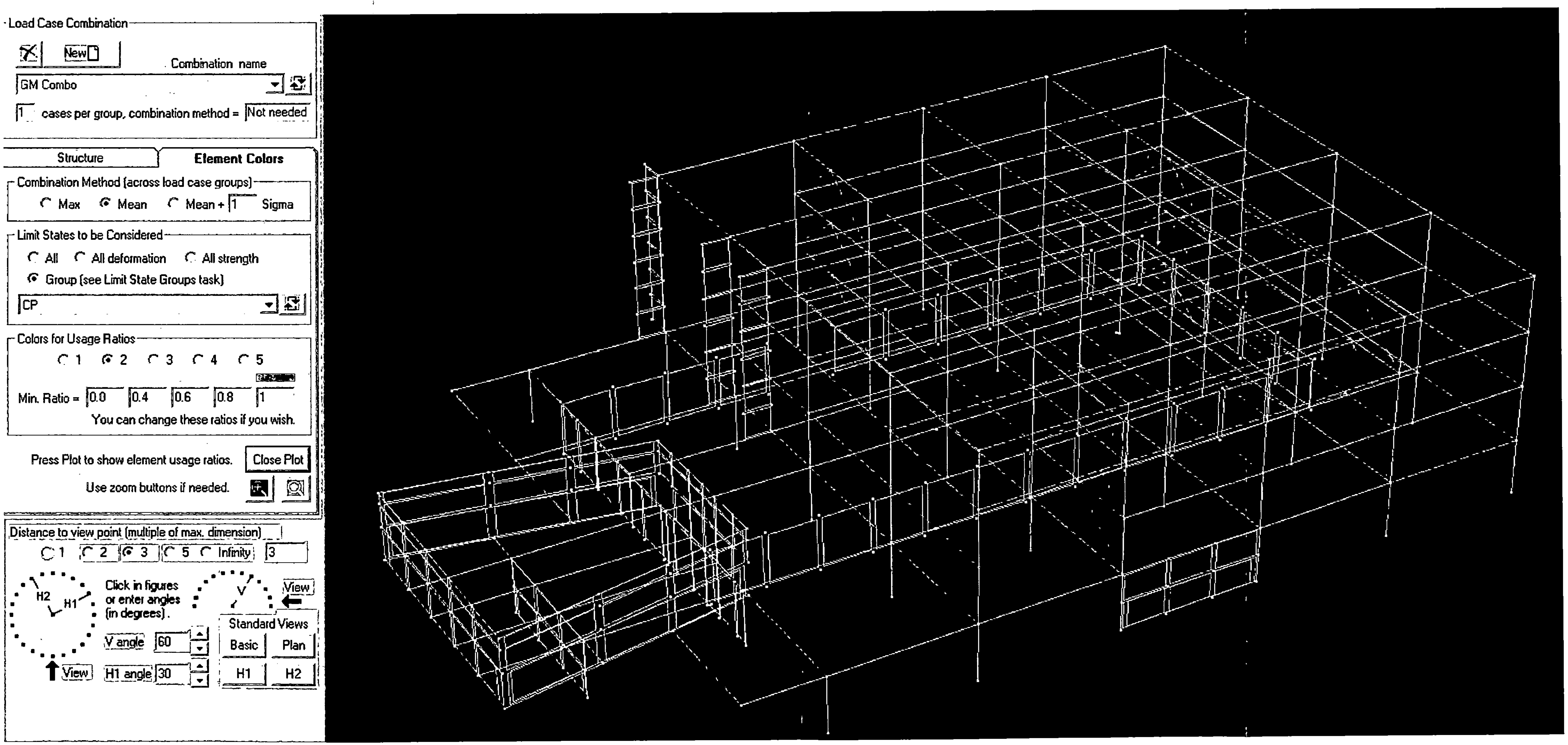


Figure 14-7 Average of 11 Ground Motions, BSE-2E, Collapse Prevention, Deformation Limits

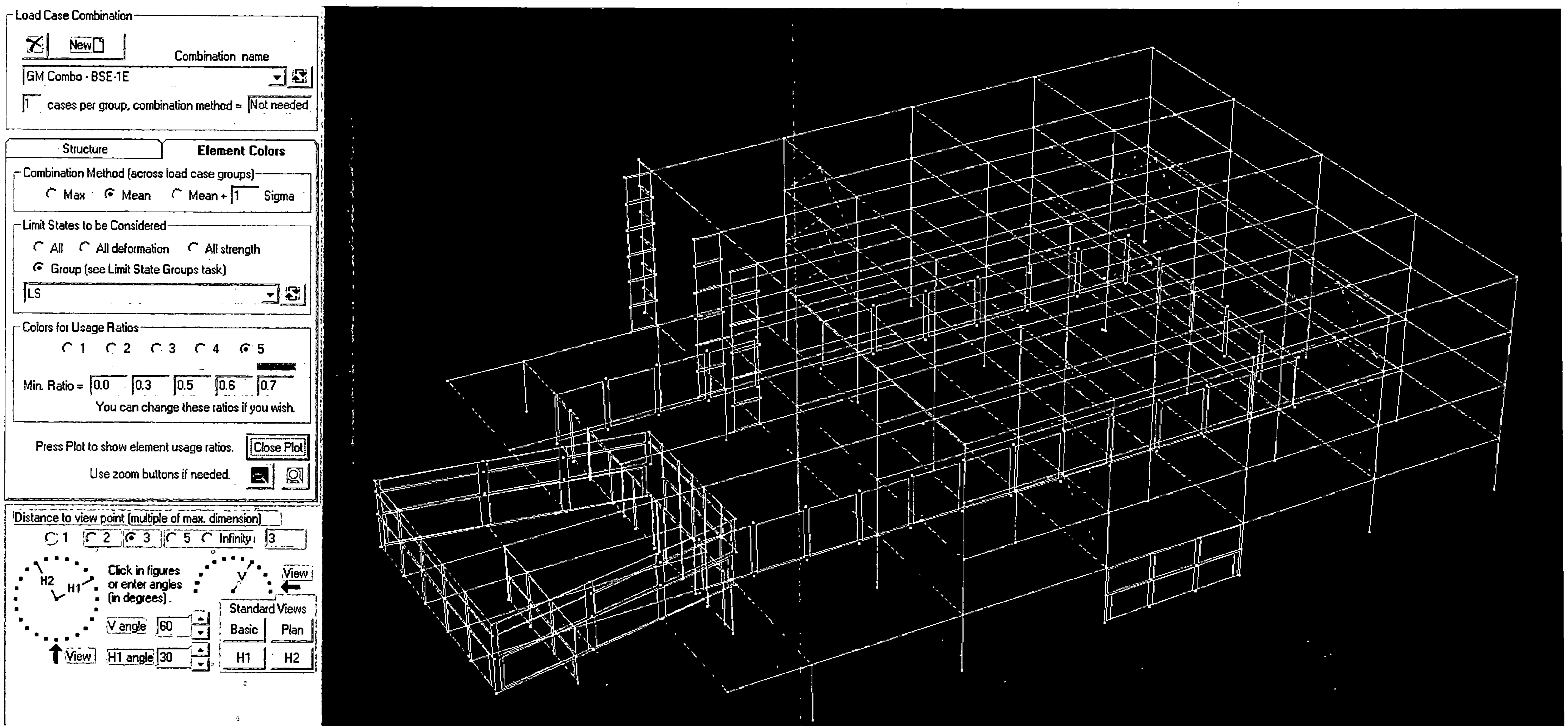


Figure 14-18 Average of 11 Ground Motions, BSE-1E, Life Safety, Deformation Limits

13 - Drift Definitions

Executive Summary

Limit states defined in PERFORM-3D are established for beam, column, and wall elements. Where elements are not explicitly modeled with nonlinear properties, strength sections using lower bound material properties are used to confirm that elements remain elastic.

Figure 13-1 Life Safety Limit States

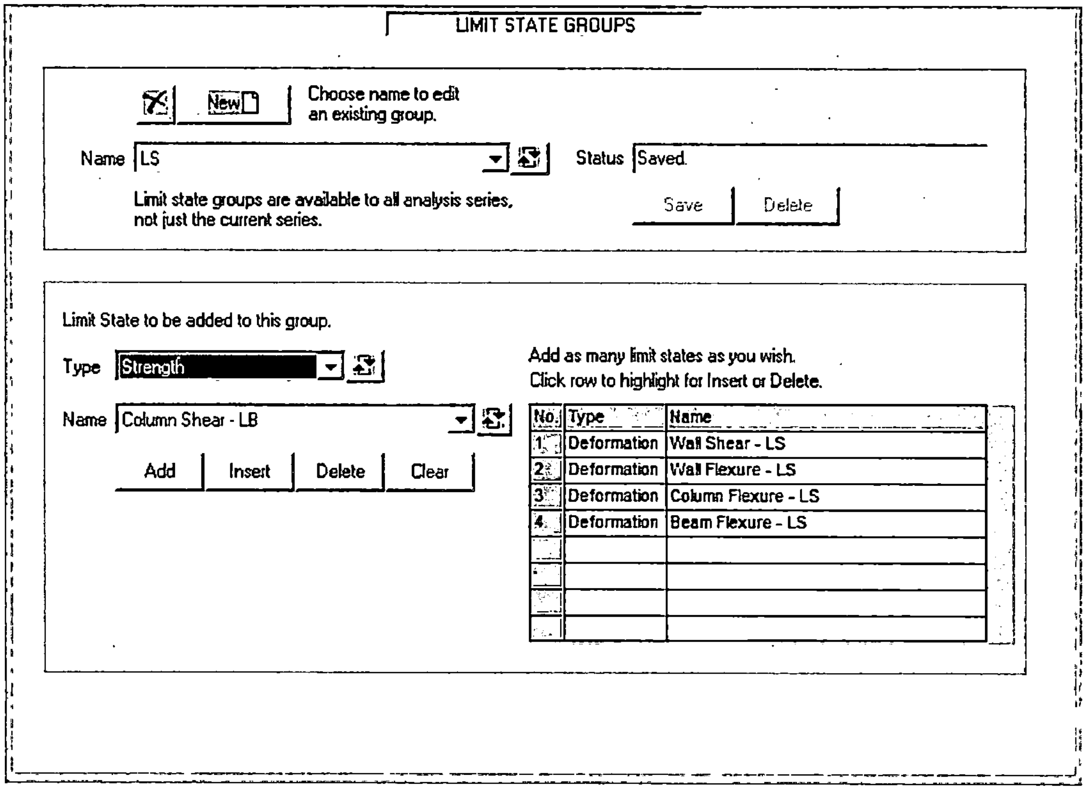
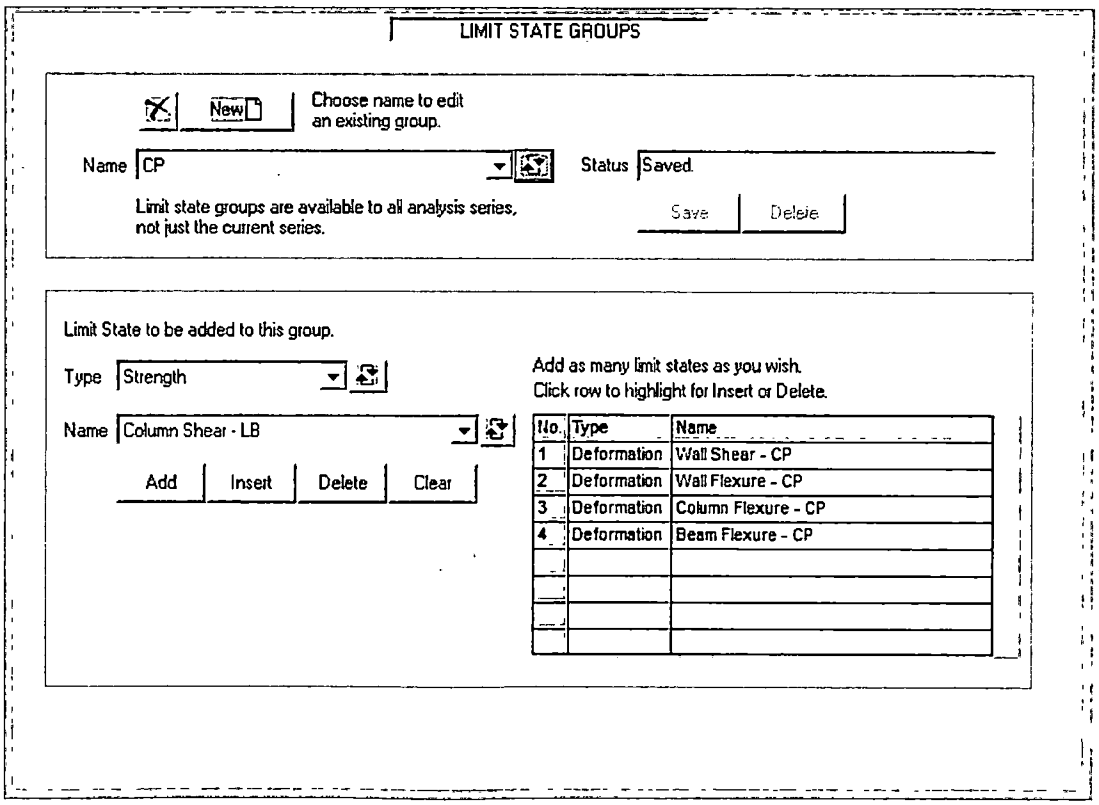


Figure 13-2 Collapse Prevention Limit States



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14 - Preliminary Global Results

Executive Summary

This section includes global results for both hazard levels, and preliminary element level results. All results are the average of 11 ground motions.

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	location Inglewood, CA	date 6/24/21	
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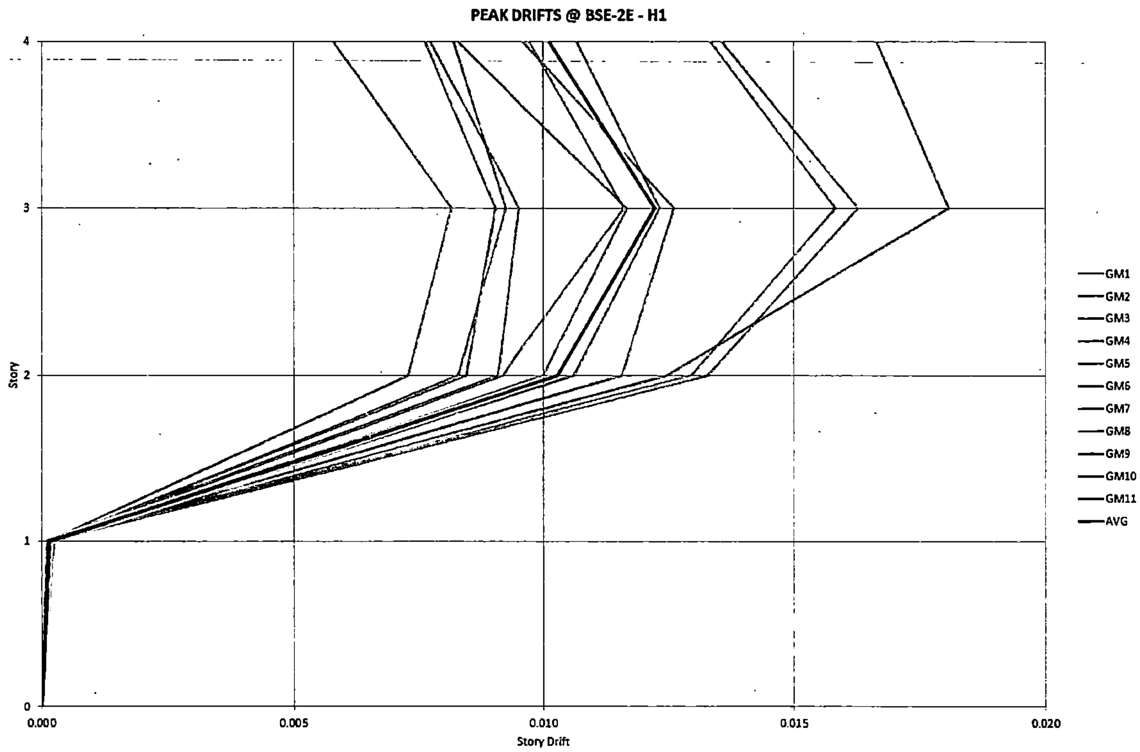

Figure 14-1 Peak Drifts at the BSE-2E Hazard Level in the H1 Direction

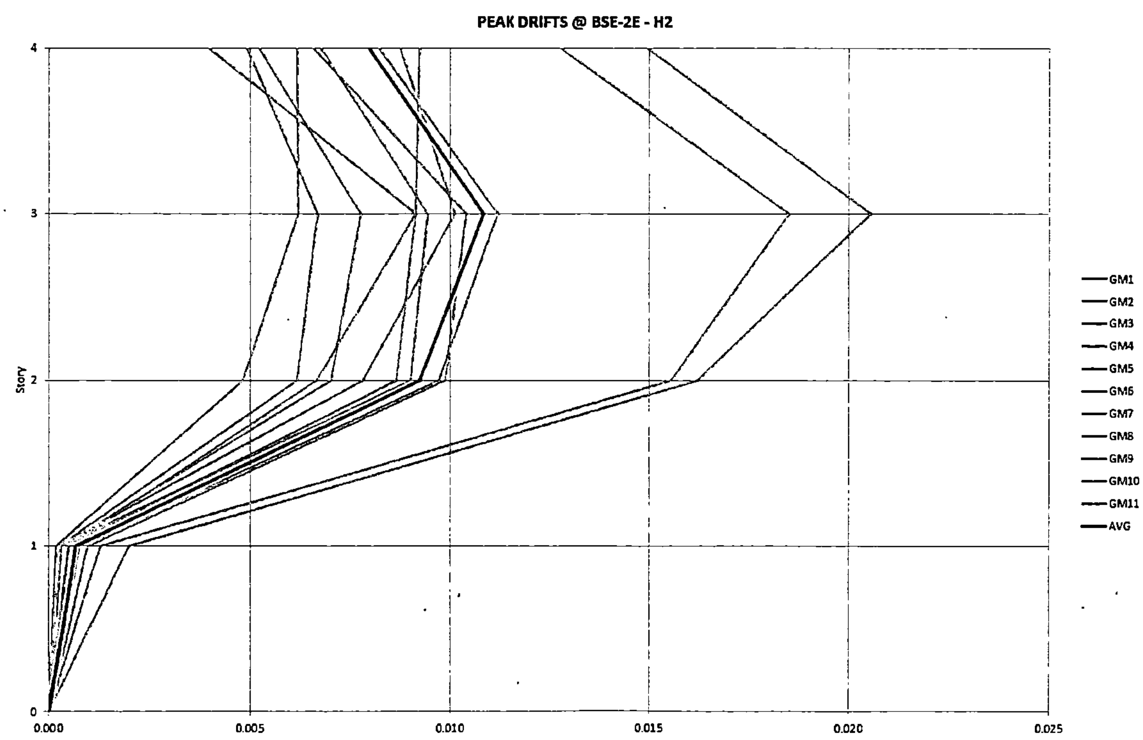

Figure 14-2 Peak Drifts at the BSE-2E Hazard Level in the H2 Direction

kpff 700 South Flower Street, Suite 2100 Los Angeles, CA 90017 (213) 418-0201	project City of Inglewood - Library location Inglewood, CA client Preliminary Global Results	by JL date 6/24/21 job no. 2000362	sheet no. 14-4

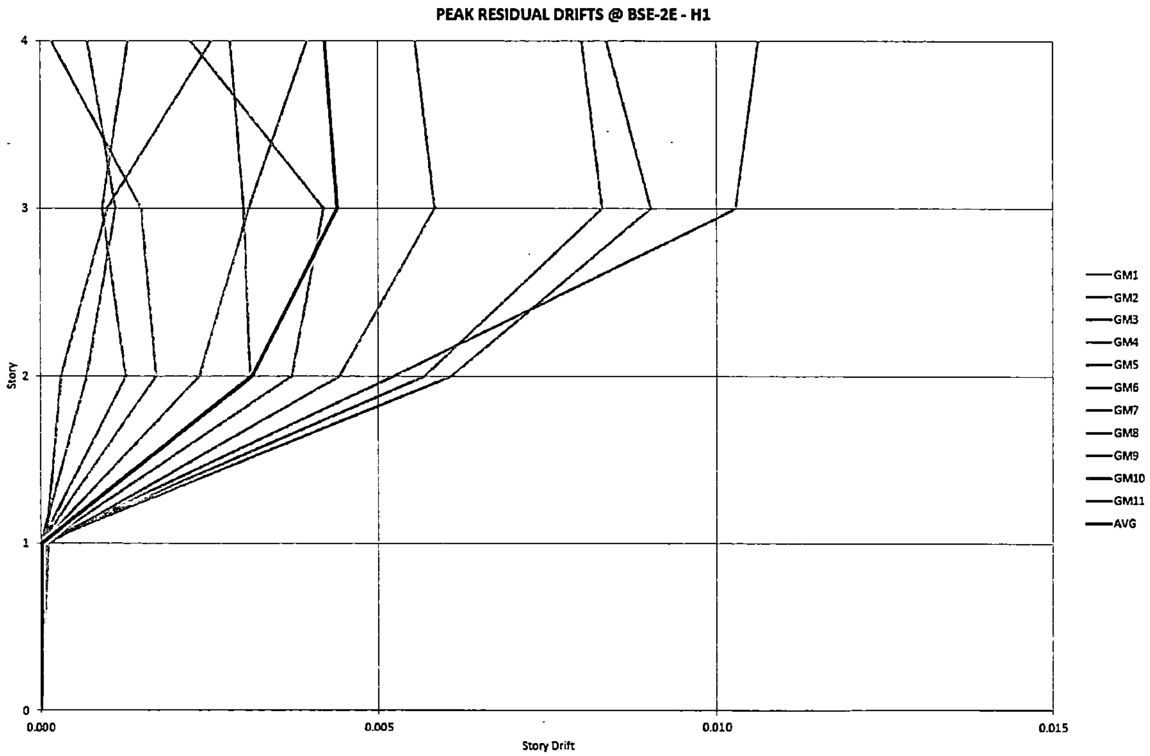

Figure 14-3 Peak Residual Drifts at the BSE-2E Hazard Level in the H1 Direction

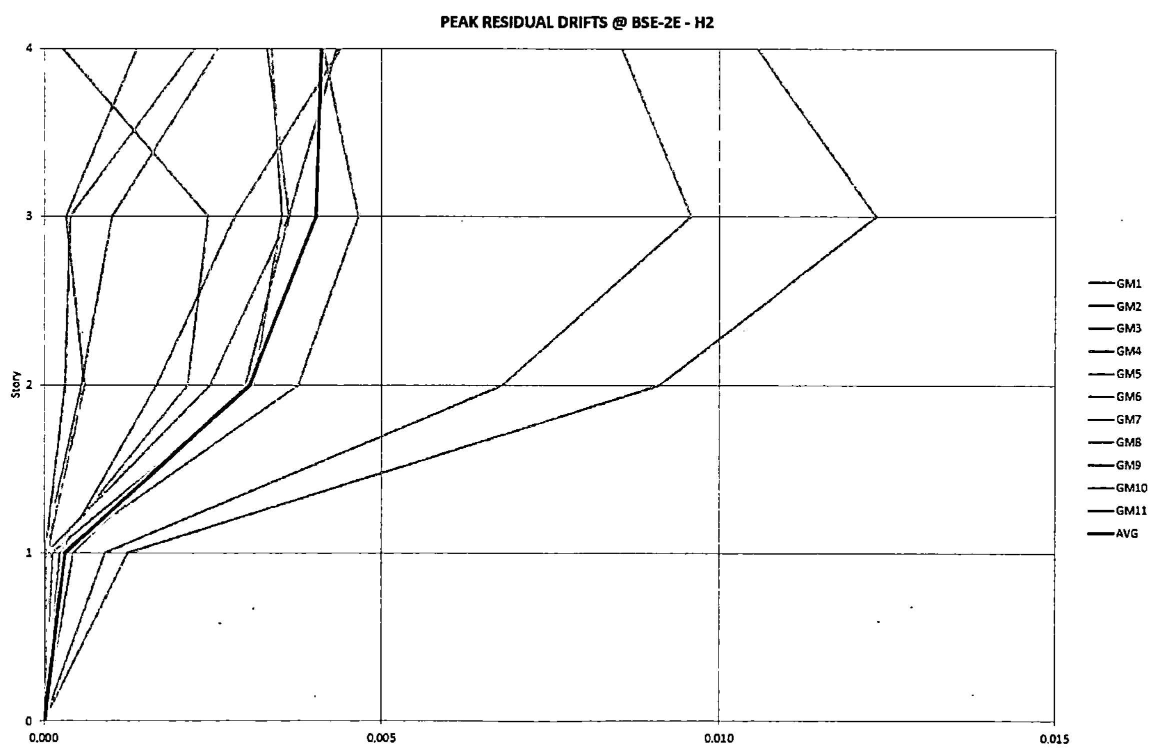

Figure 14-4 Peak Residual Drifts at the BSE-2E Hazard Level in the H2 Direction

kpff 700 South Flower Street, Suite 2100 Los Angeles, CA 90017 (213) 418-0201	project City of Inglewood - Library location Inglewood, CA client Preliminary Global Results	by JL date 6/24/21 job no. 2000362	sheet no. 14-5

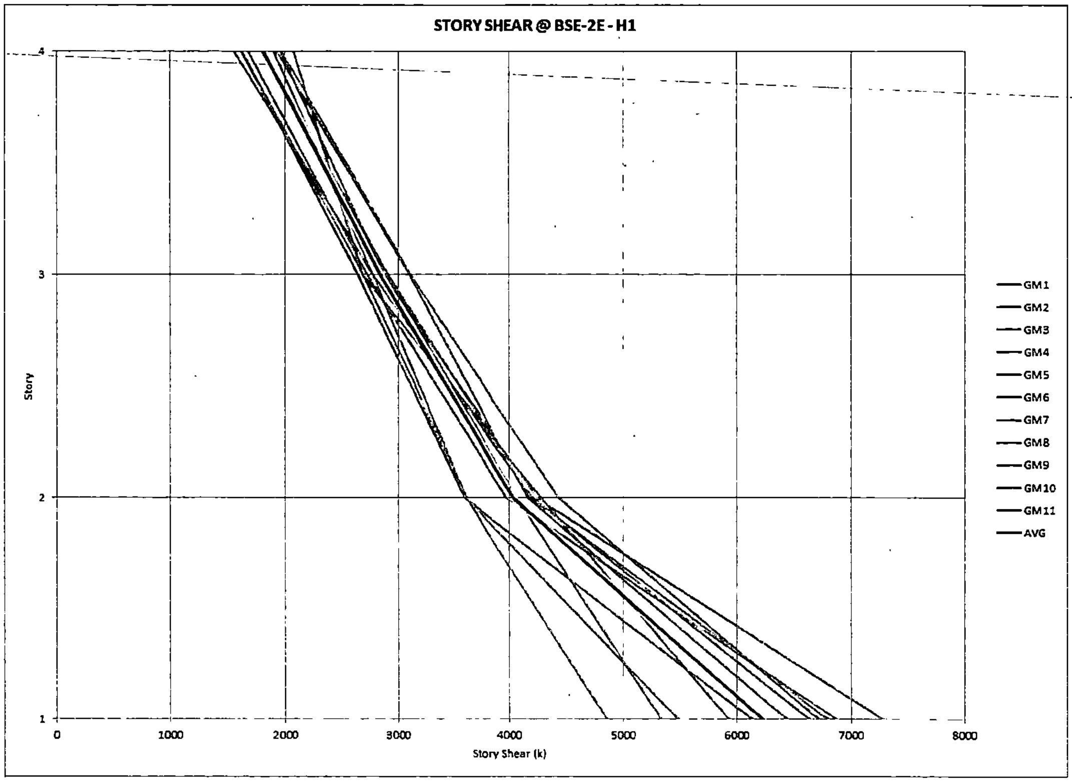

Figure 14-5 Peak Story Shears at the BSE-2E Hazard Level in the H1 Direction

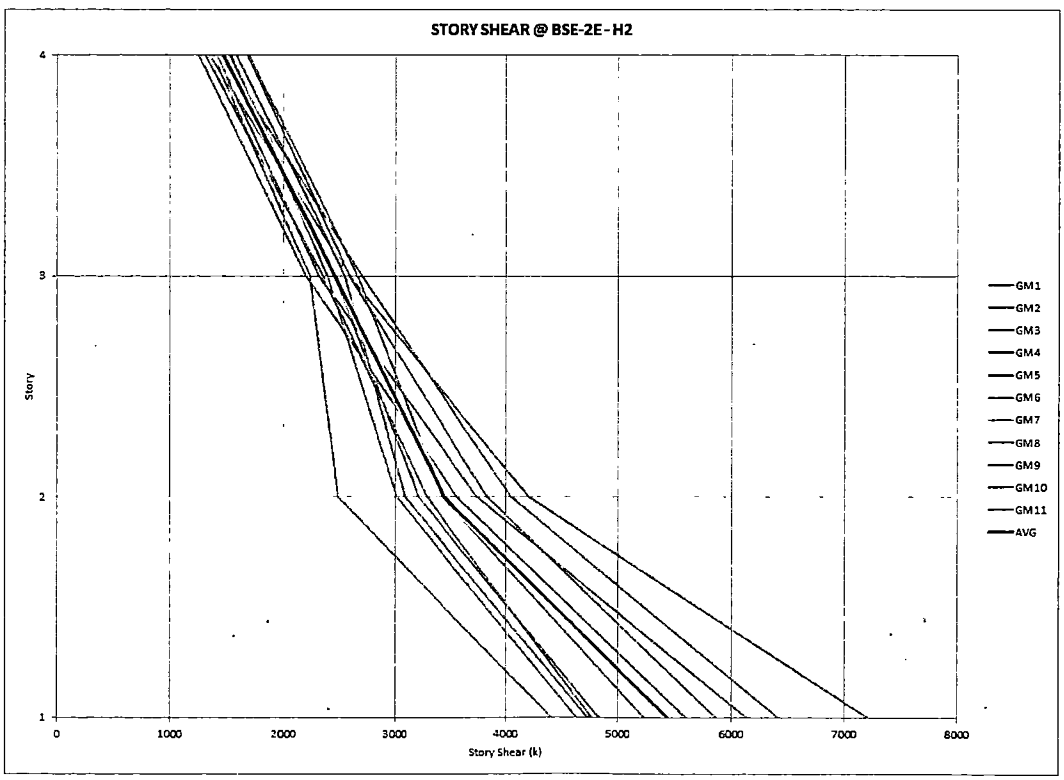

Figure 14-6 Peak Story Shears at the BSE-2E Hazard Level in the H2 Direction

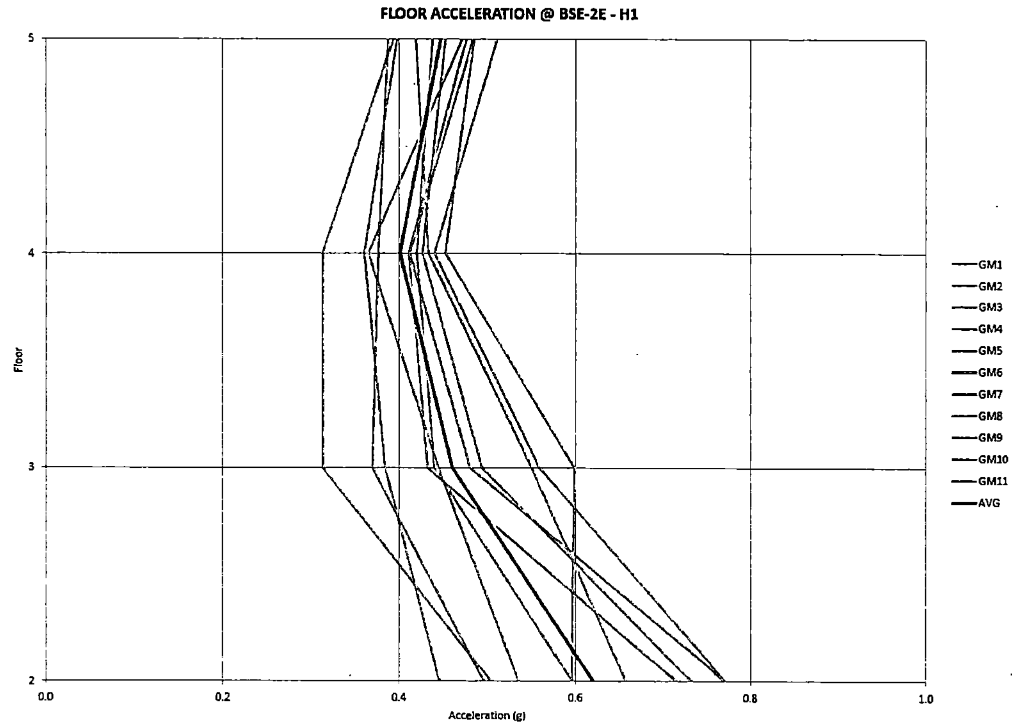

Figure 14-7 Peak Floor Acceleration at the BSE-2E Hazard Level in the H1 Direction

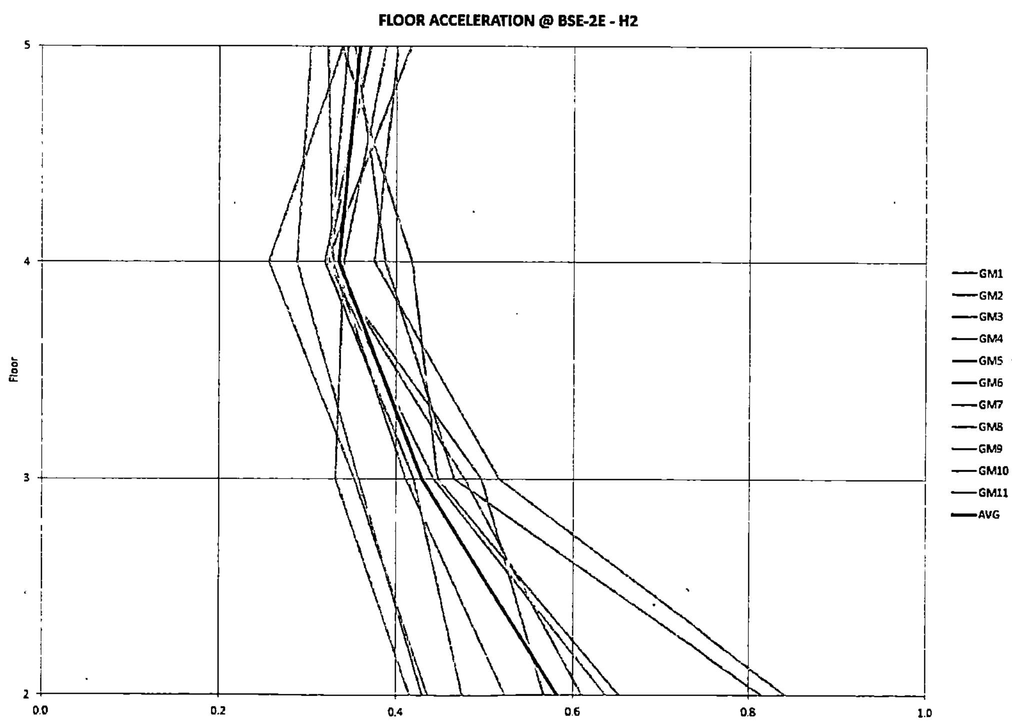

Figure 14-8 Peak Floor Acceleration at the BSE-2E Hazard Level in the H2 Direction

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	client	job no. 2000362	
	Preliminary Global Results		

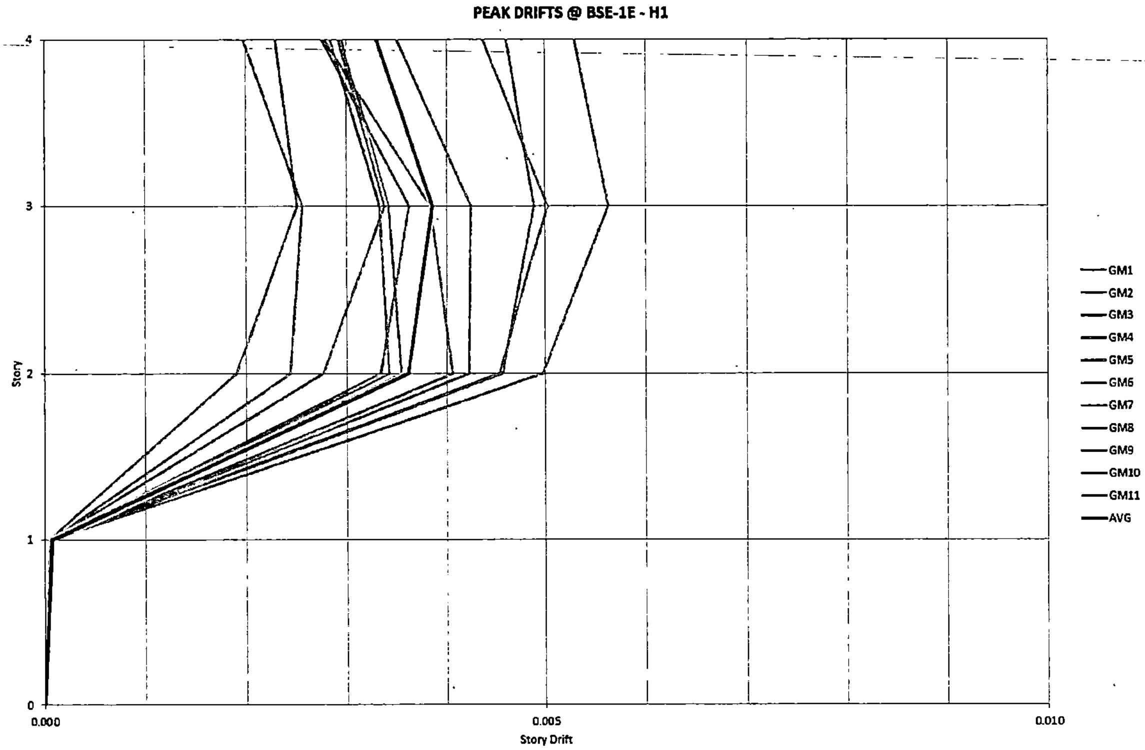

Figure 14-9 Peak Drifts at the BSE-1E Hazard Level in the H1 Direction

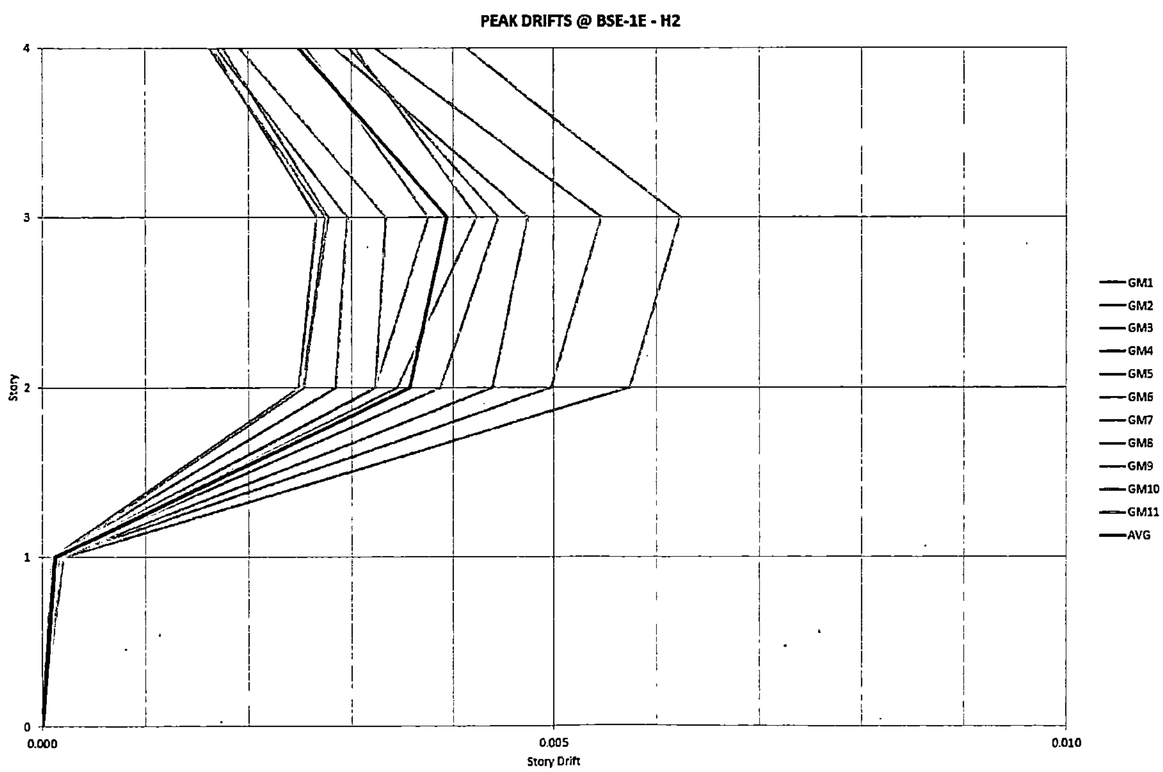

Figure 14-10 Peak Drifts at the BSE-1E Hazard Level in the H2 Direction

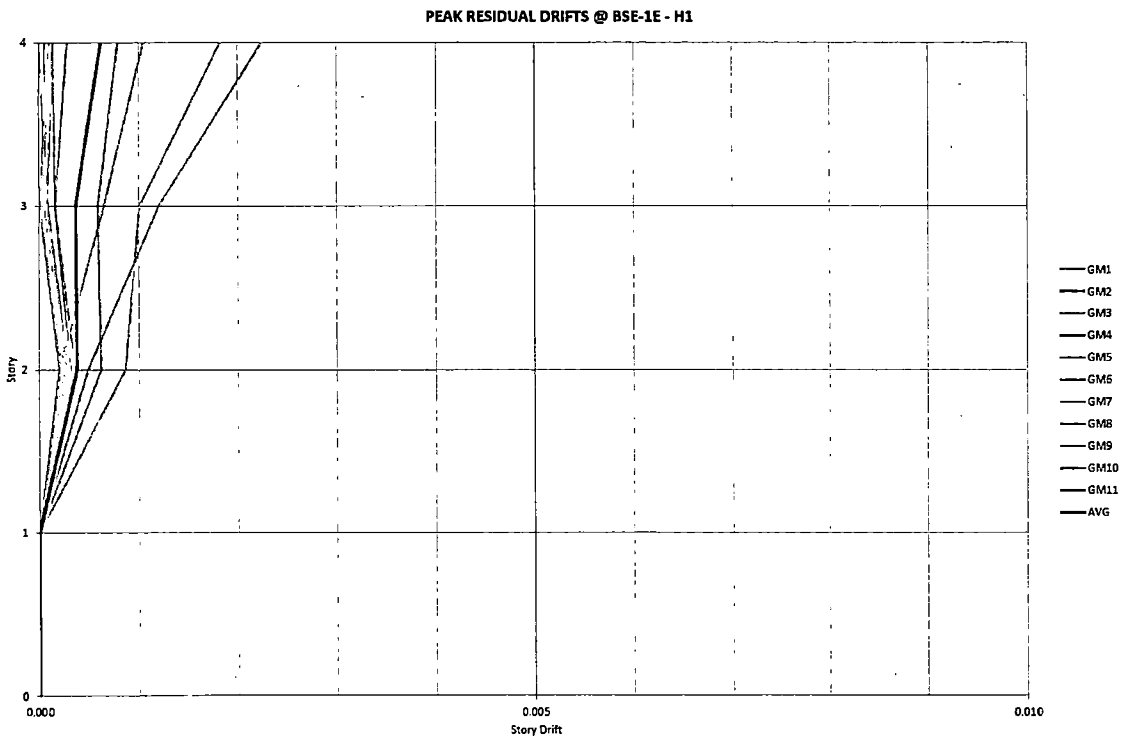

Figure 14-11 Peak Residual Drifts at the BSE-1E Hazard Level in the H1 Direction

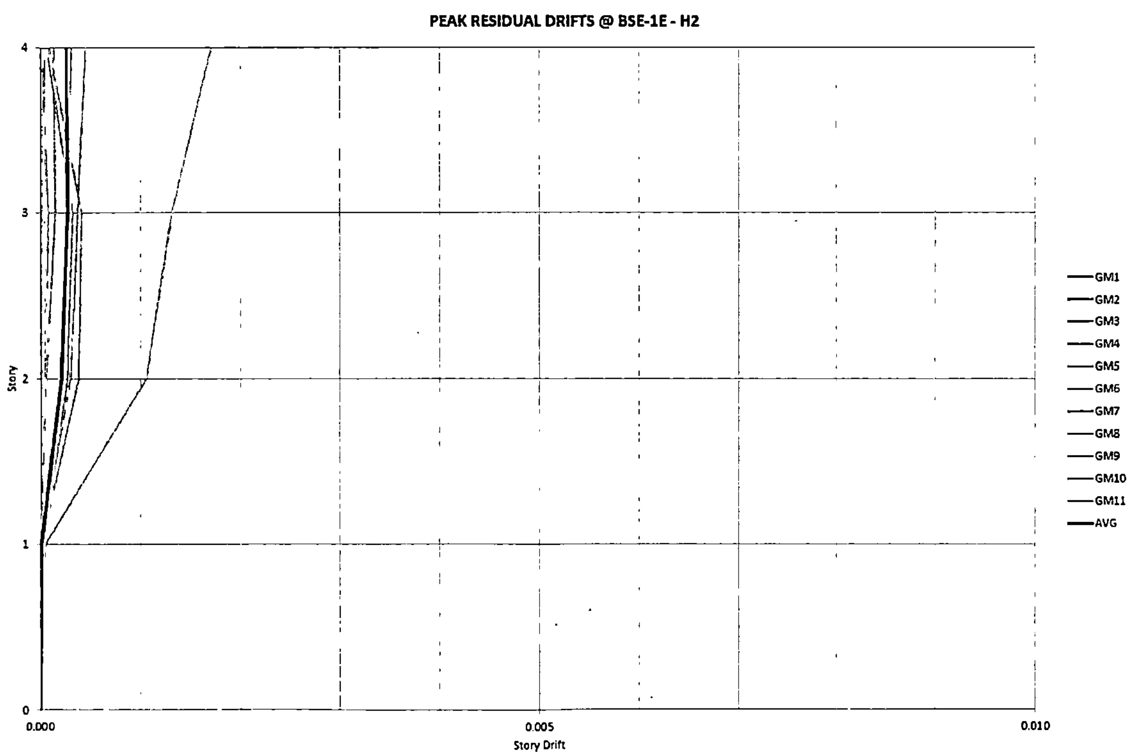

Figure 14-12 Peak Residual Drifts at the BSE-1E Hazard Level in the H2 Direction

kpff	project City of Inglewood - Library	by JL	sheet no. 14-9
	location Inglewood, CA	date 6/25/21	
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	Preliminary Global Results		

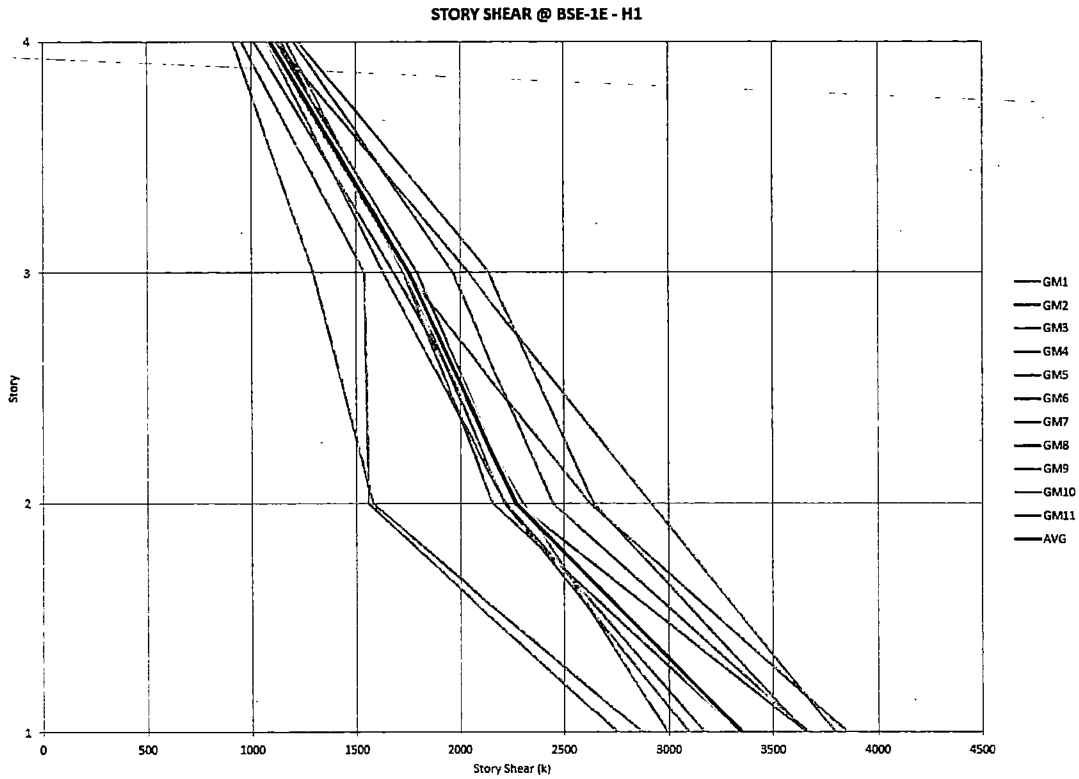

Figure 14-13 Peak Story Shears at the BSE-1E Hazard Level in the H1 Direction

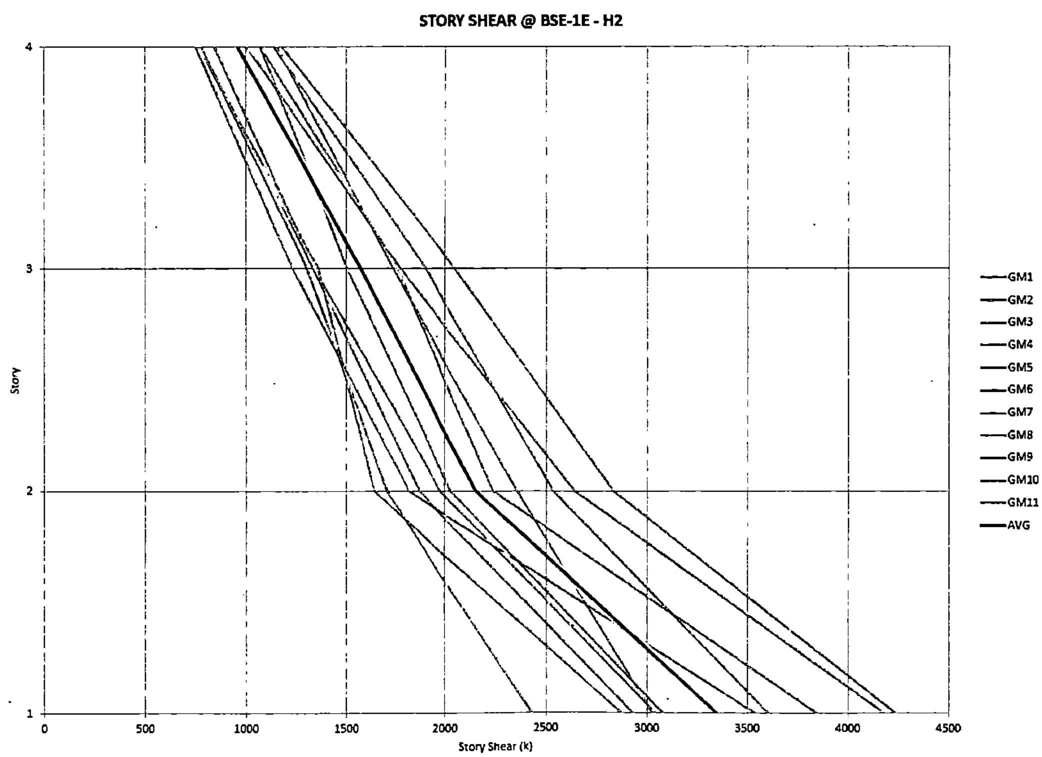

Figure 14-14 Peak Story Shears at the BSE-1E Hazard Level in the H2 Direction

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	location Inglewood, CA	date 6/25/21	
	client	job no. 2000362	
	Preliminary Global Results		

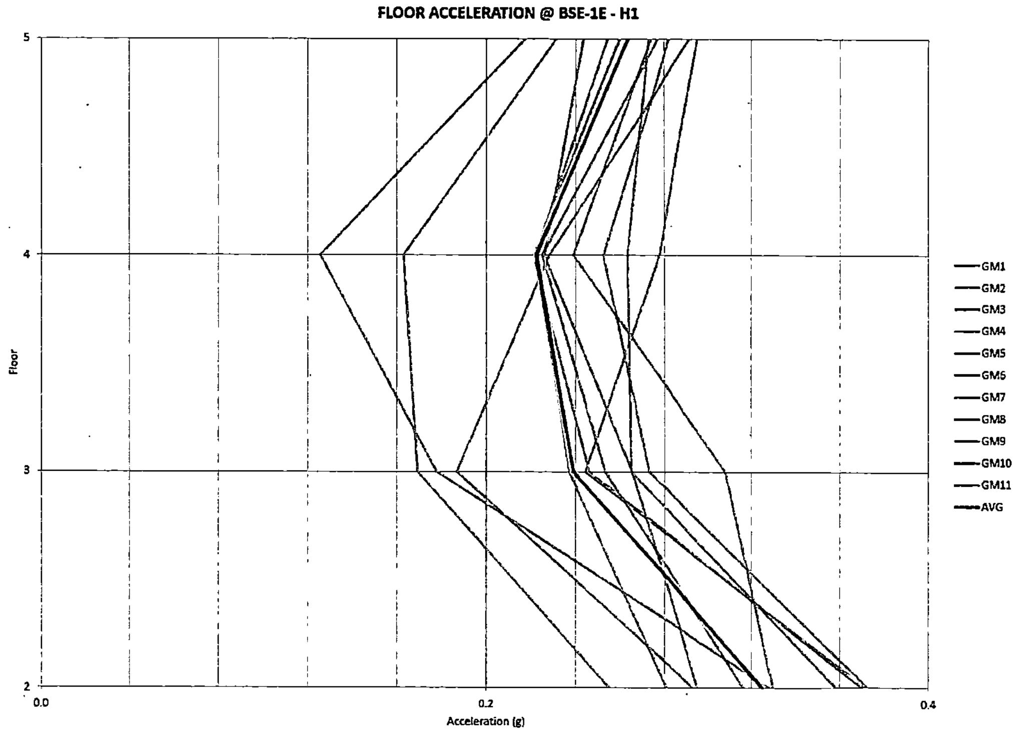

Figure 14-15 Peak Floor Acceleration at the BSE-1E Hazard Level in the H1 Direction

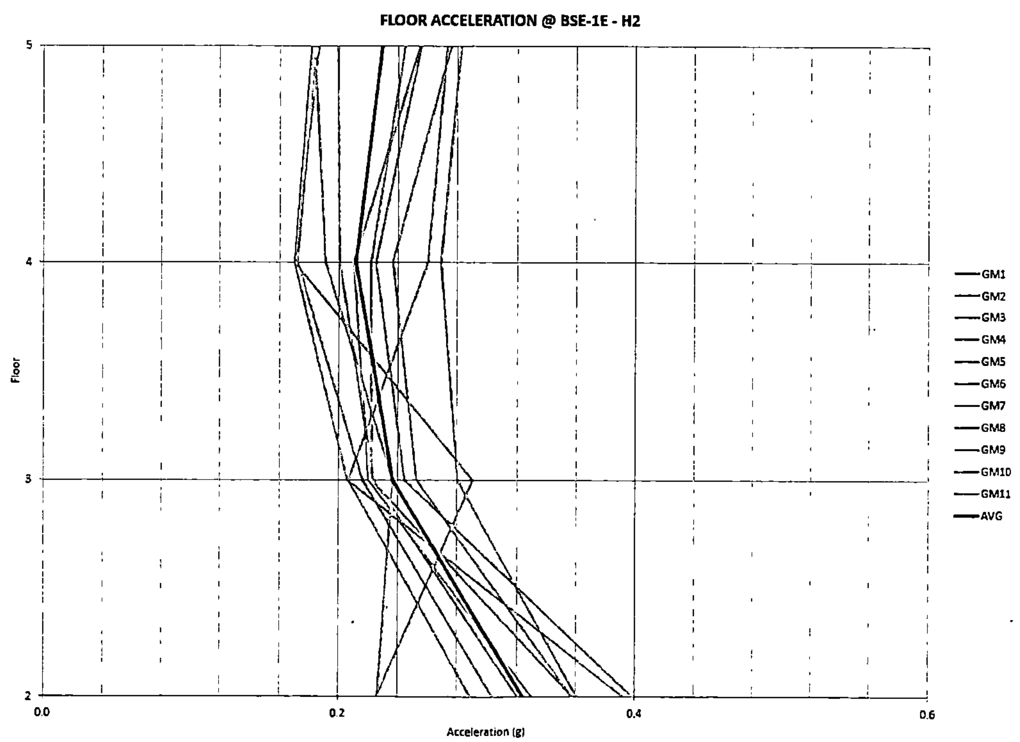

Figure 14-16 Peak Floor Acceleration at the BSE-1E Hazard Level in the H2 Direction

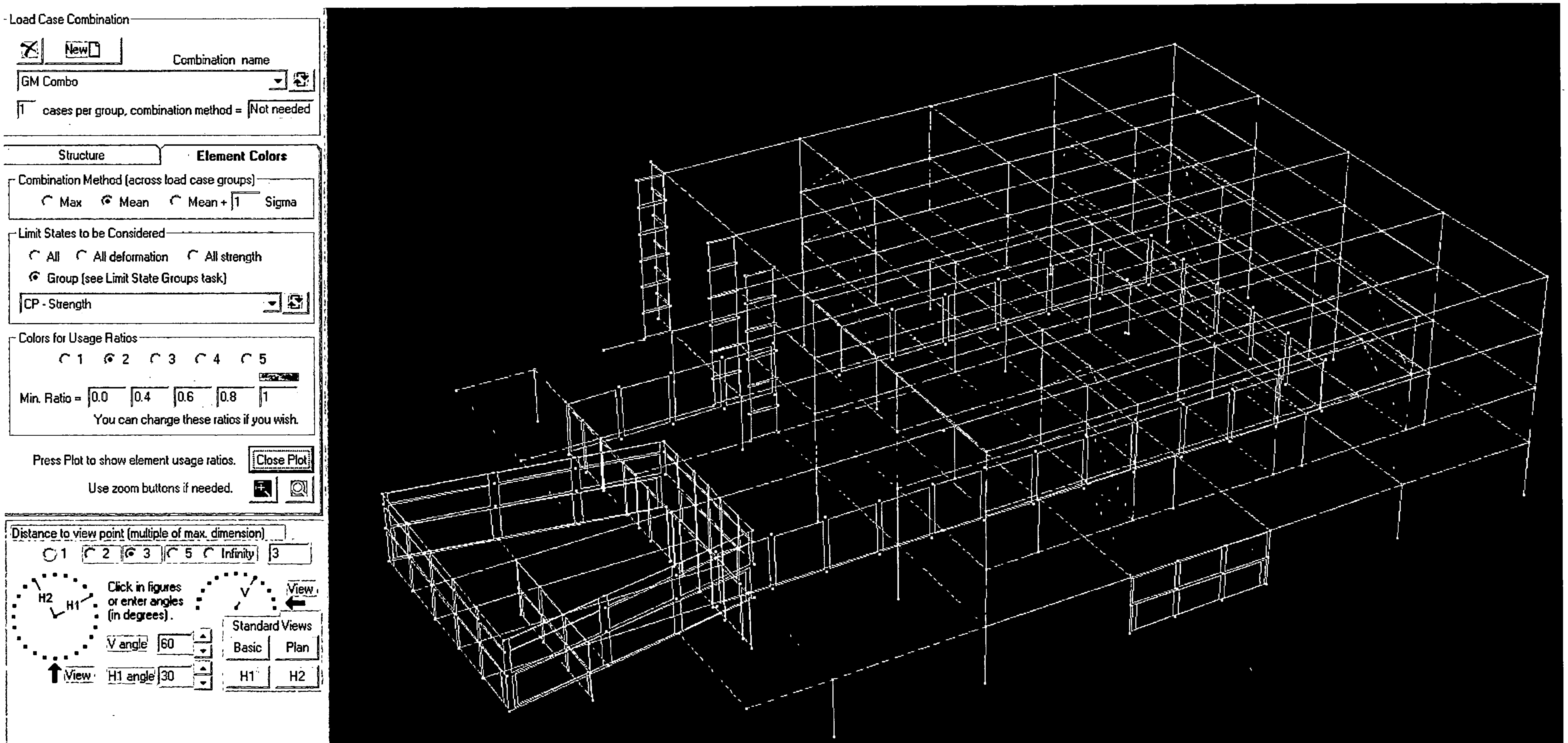

Figure 14-19 Average of 11 Ground Motions, BSE-2E, Strength Limits

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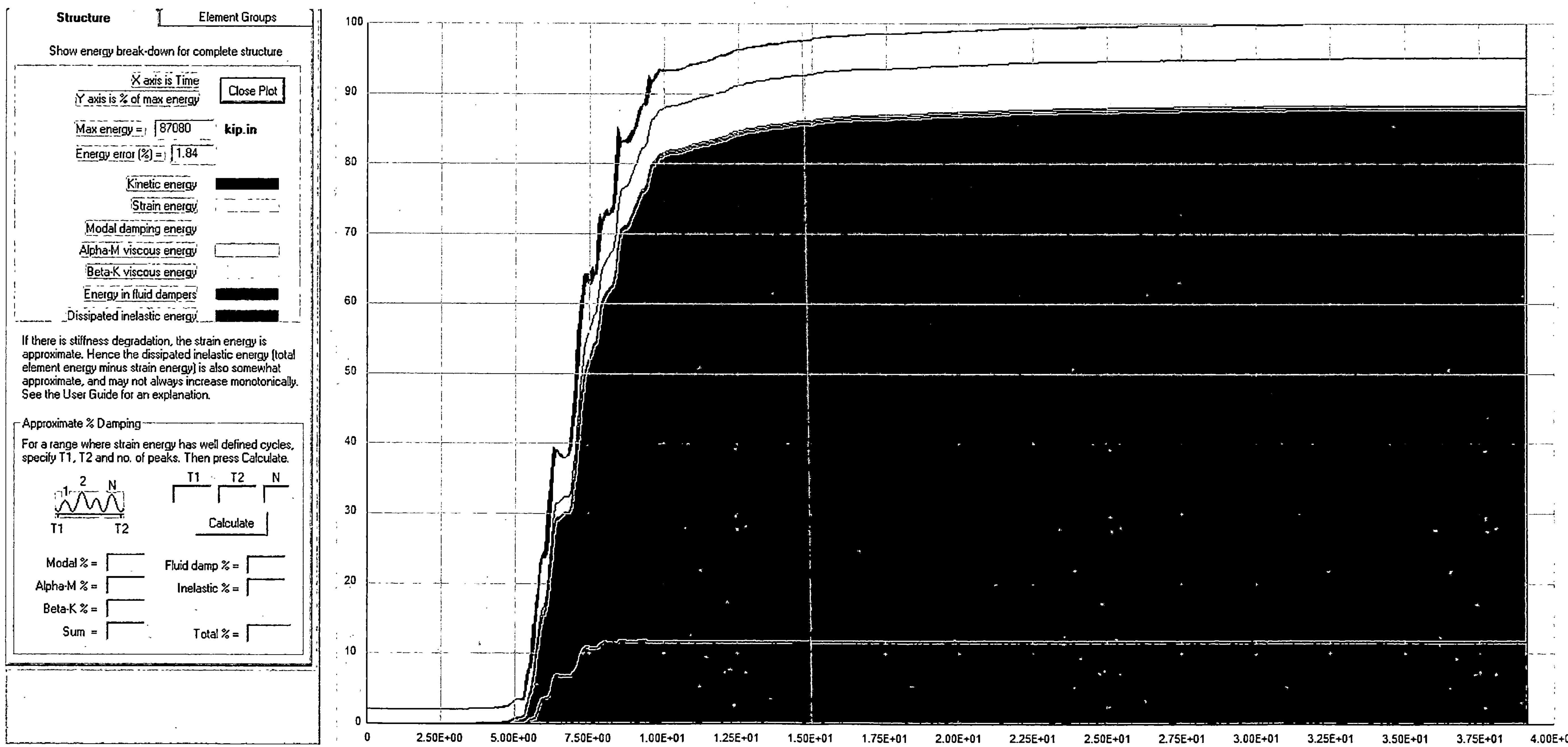

Figure 14-20 Energy Balance Plot for BSE-2E GM1 (Approximate Added Damping = 32.1%, Average Added Damping from All 11 GM's = 34.4%)

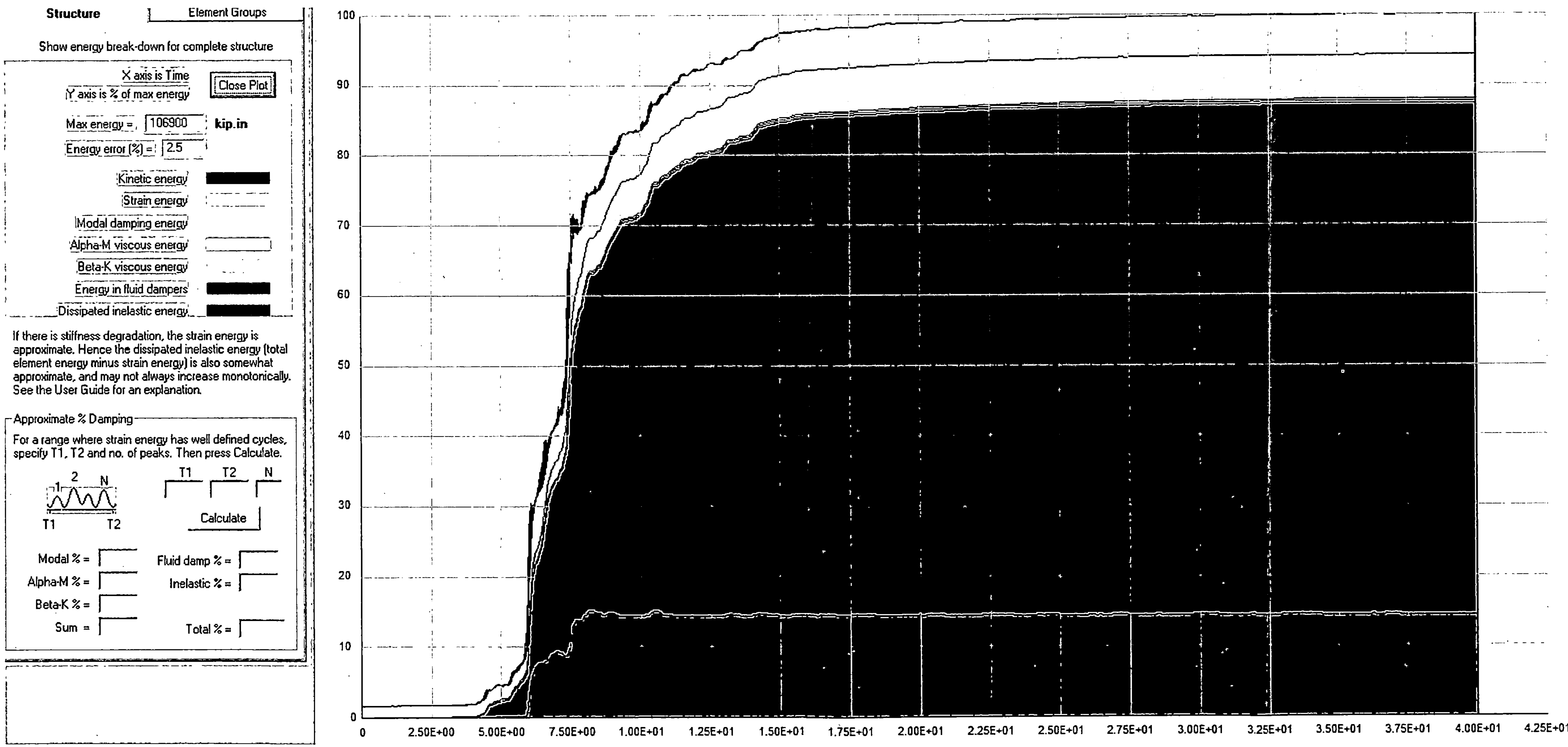

Figure 14-21 Energy Balance Plot for BSE-2E GM2 (Approximate Added Damping = 30.4%, Average Added Damping from All 11 GM's = 34.4%)

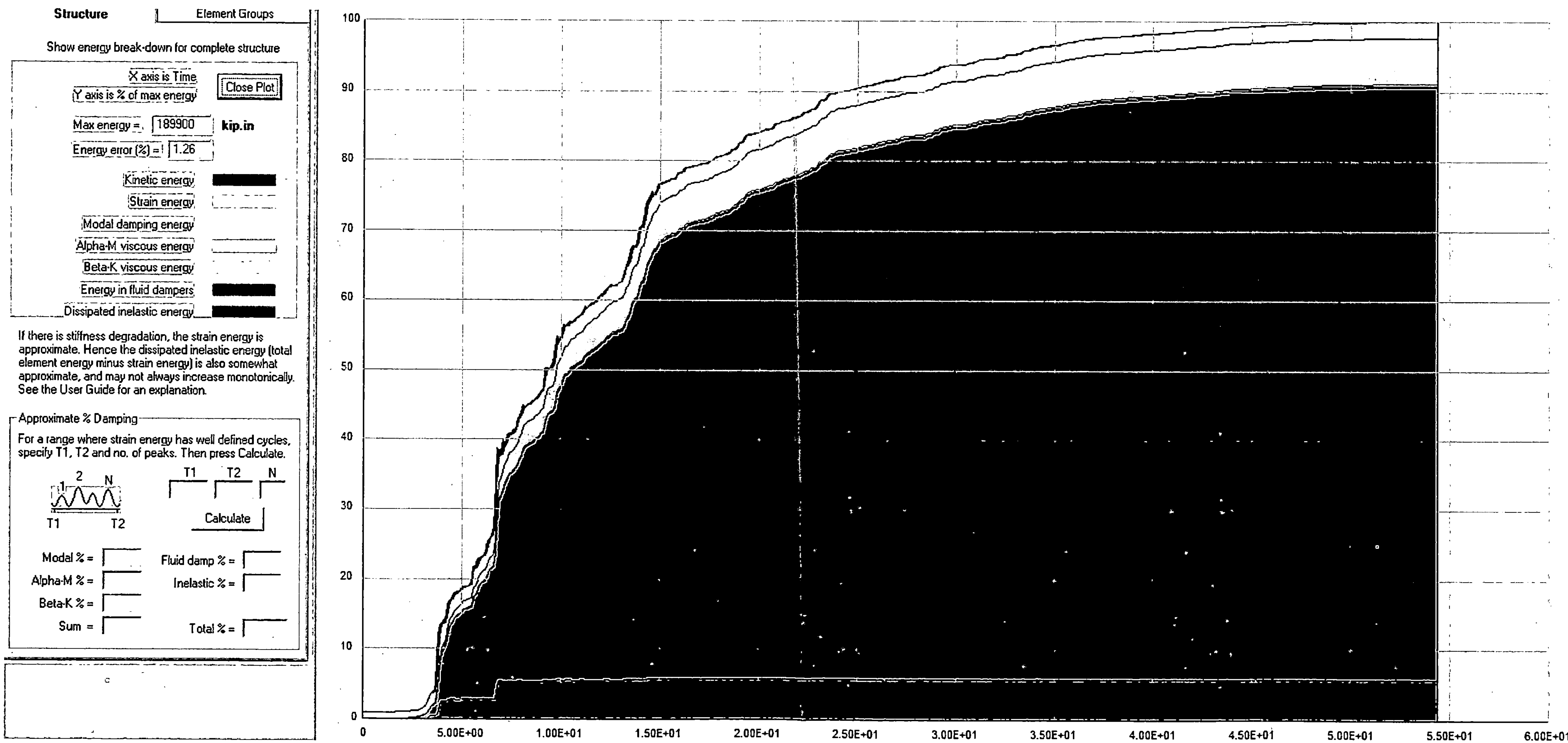

Figure 14-22 Energy Balance Plot for BSE-2E GM3 (Approximate Added Damping = 37.8%, Average Added Damping from All 11 GM's = 34.4%)

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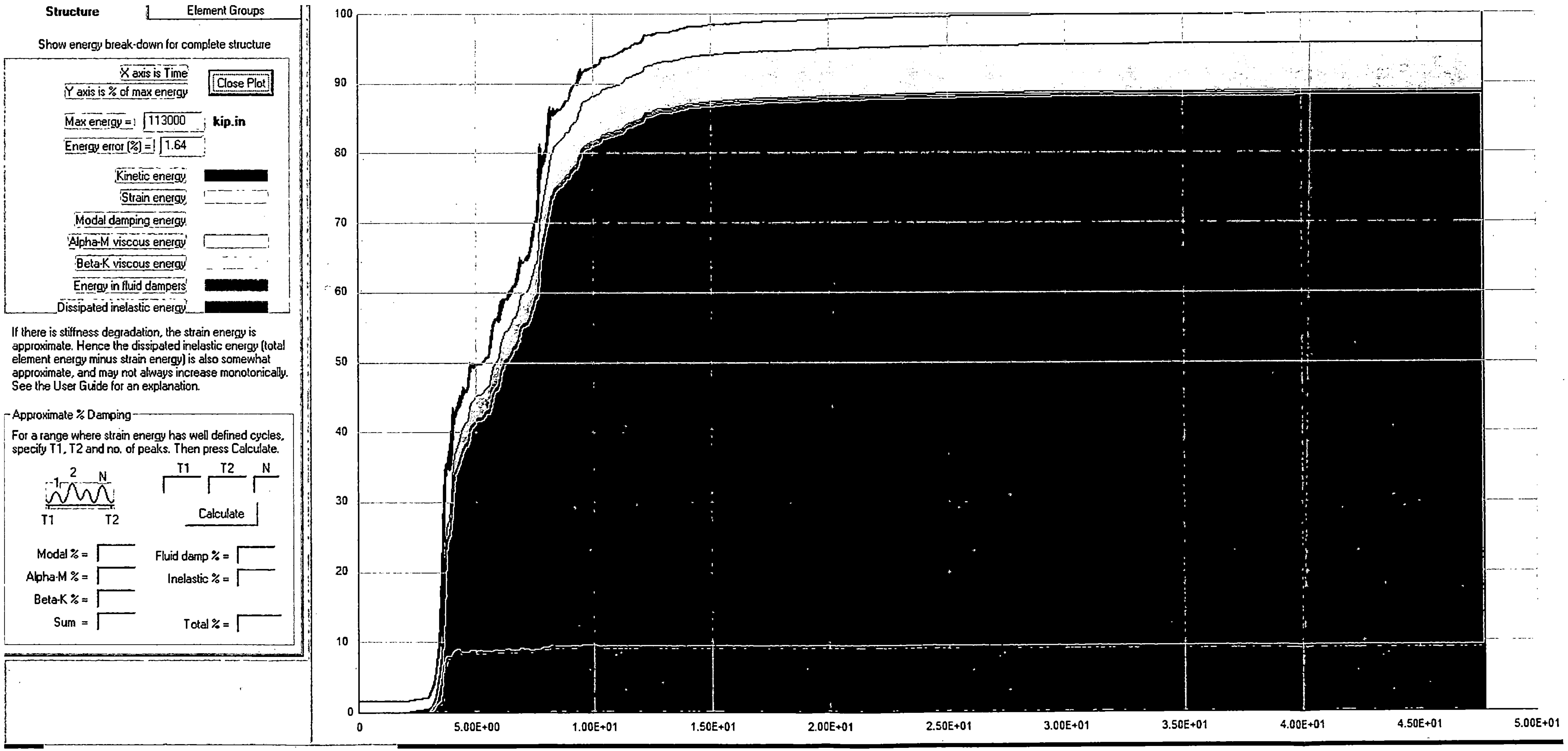

Figure 14-24 Energy Balance Plot for BSE-2E GM4 (Approximate Added Damping = 31.1%, Average Added Damping from All 11 GM's = 34.4%)

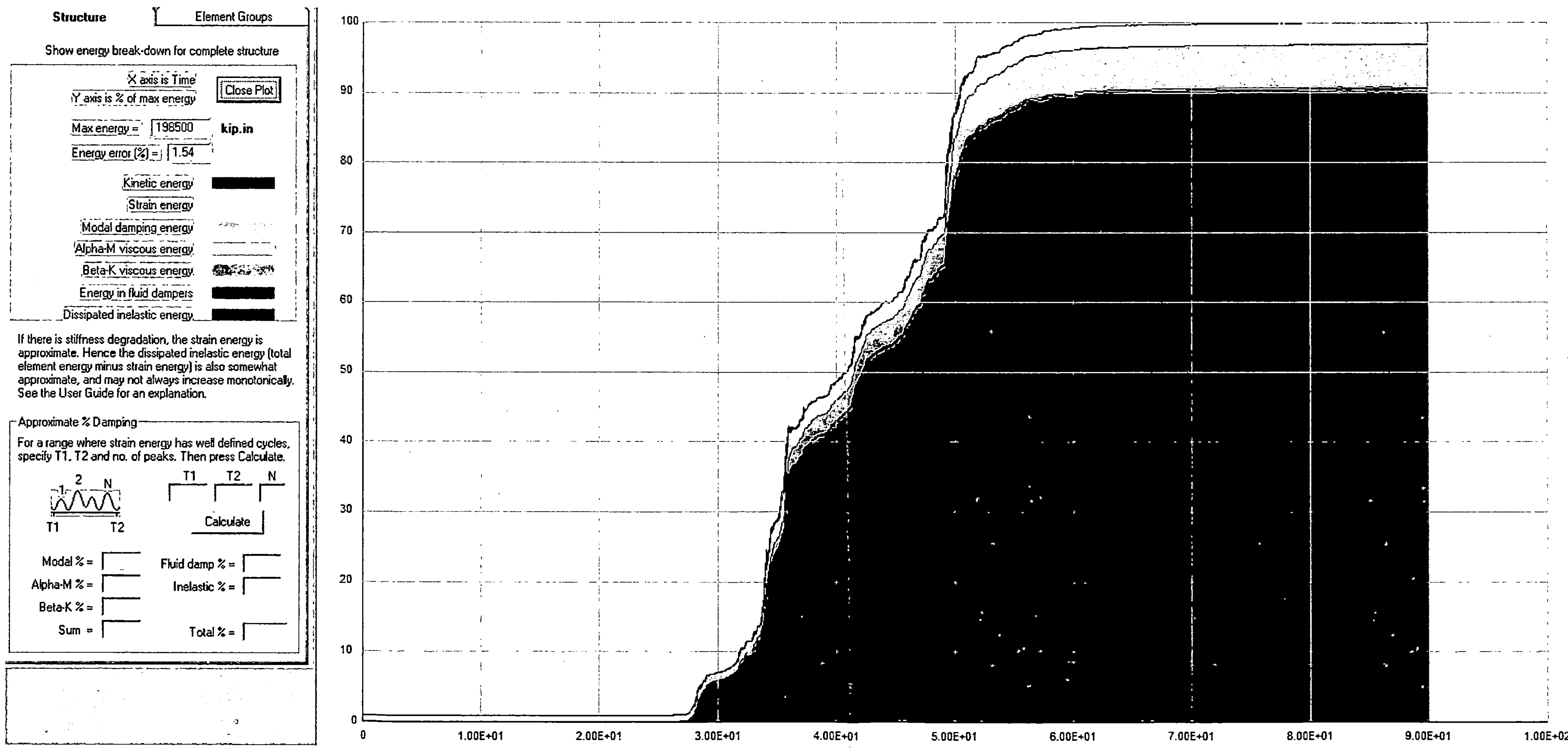

Figure 14-25 Energy Balance Plot for BSE-2E GM5 (Approximate Added Damping = 37.7%, Average Added Damping from All 11 GM's = 34.4%)

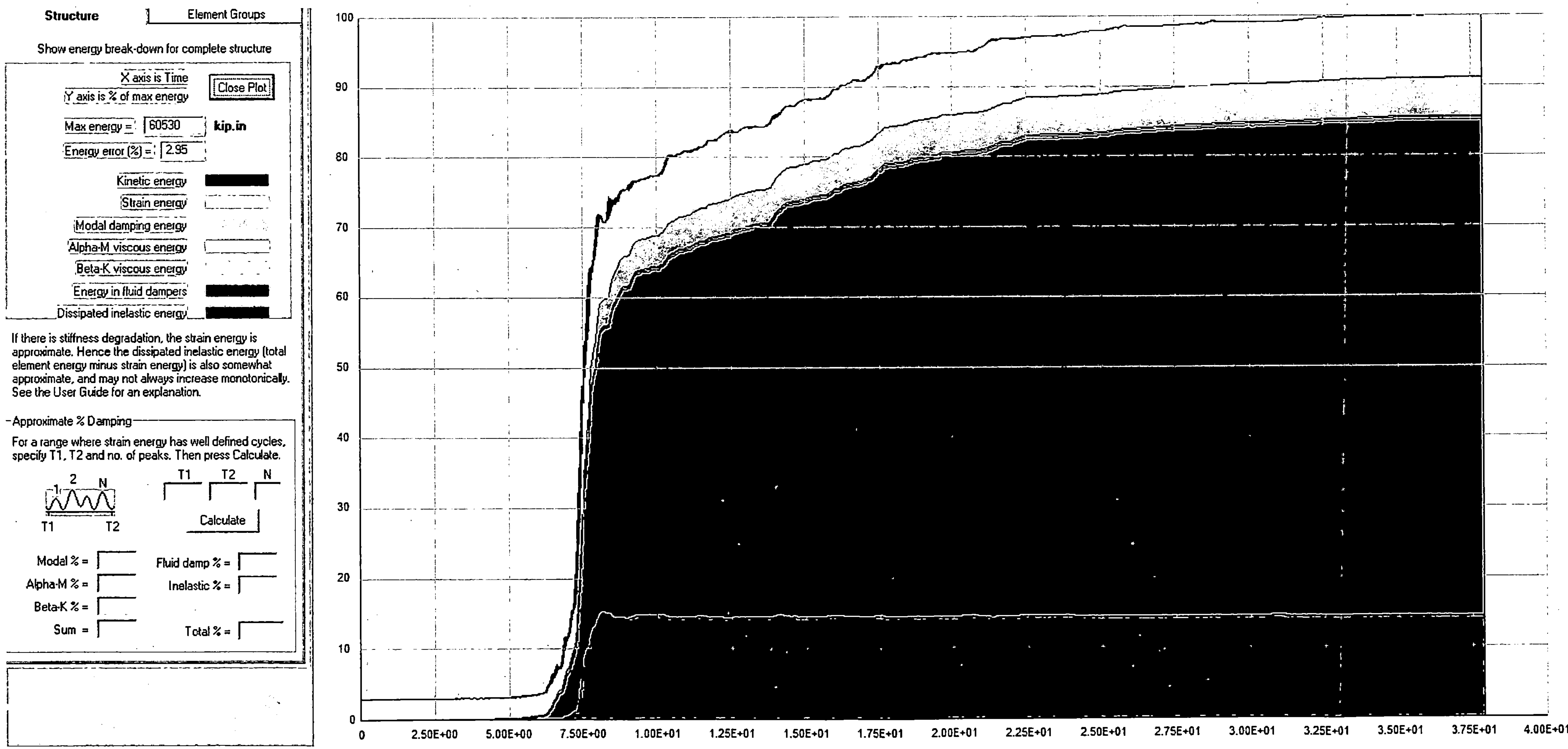

Figure 14-26 Energy Balance Plot for BSE-2E GM6 (Approximate Added Damping = 36.5%, Average Added Damping from All 11 GM's = 34.4%)

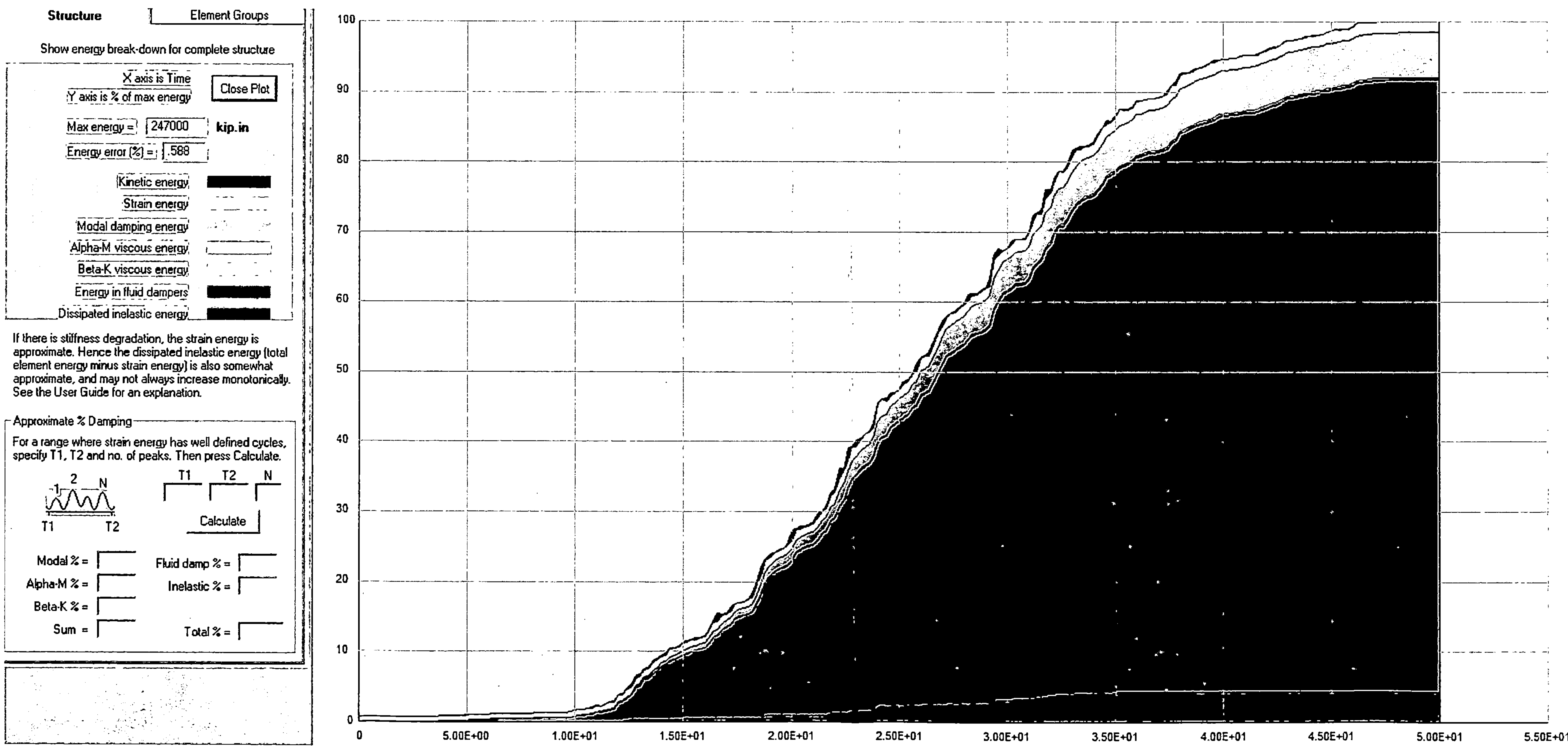

Figure 14-27 Energy Balance Plot for BSE-2E GM7 (Approximate Added Damping = 37.8%, Average Added Damping from All 11 GM's = 34.4%)

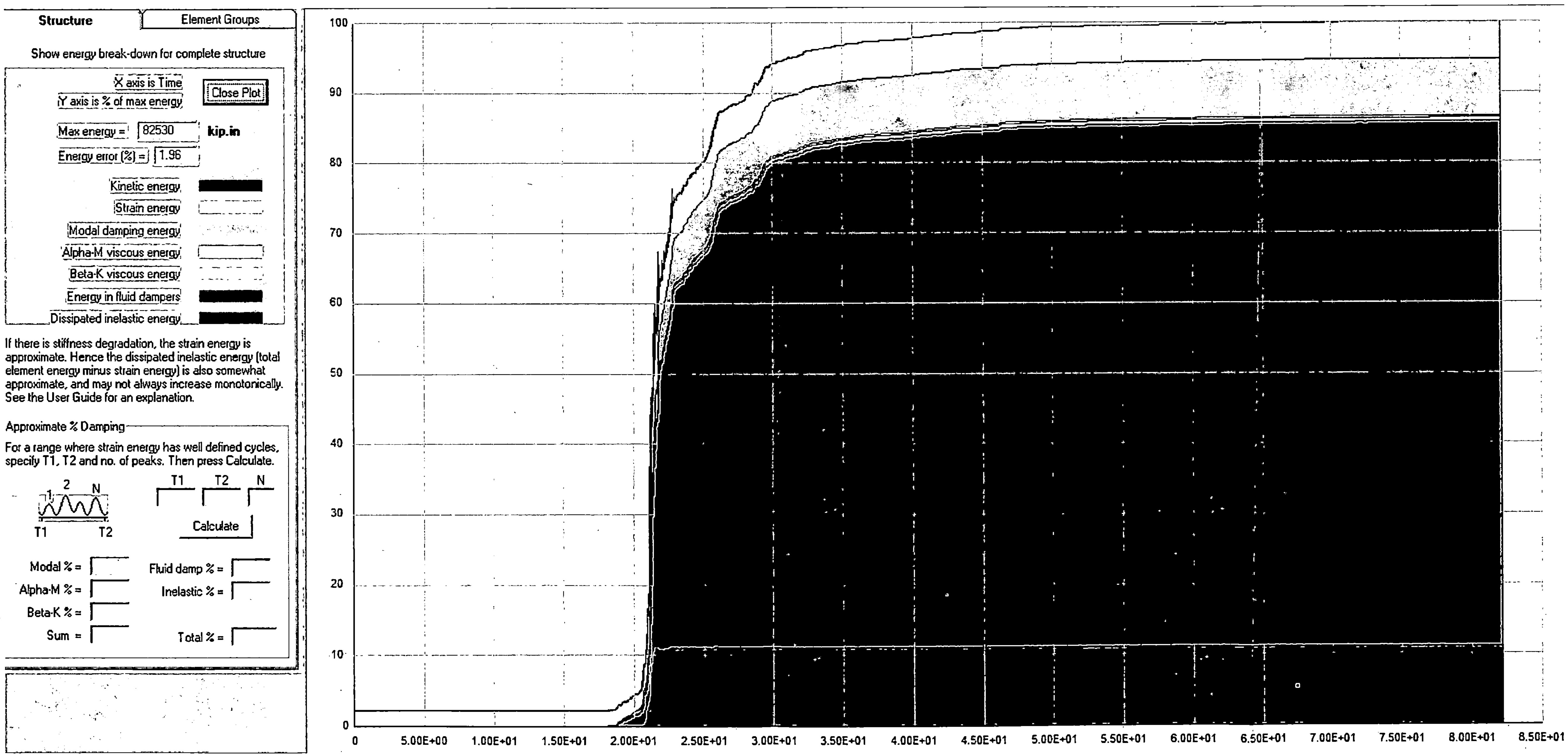

Figure 14-28 Energy Balance Plot for BSE-2E GM8 (Approximate Added Damping = 26.5%, Average Added Damping from All 11 GM's = 34.4%)

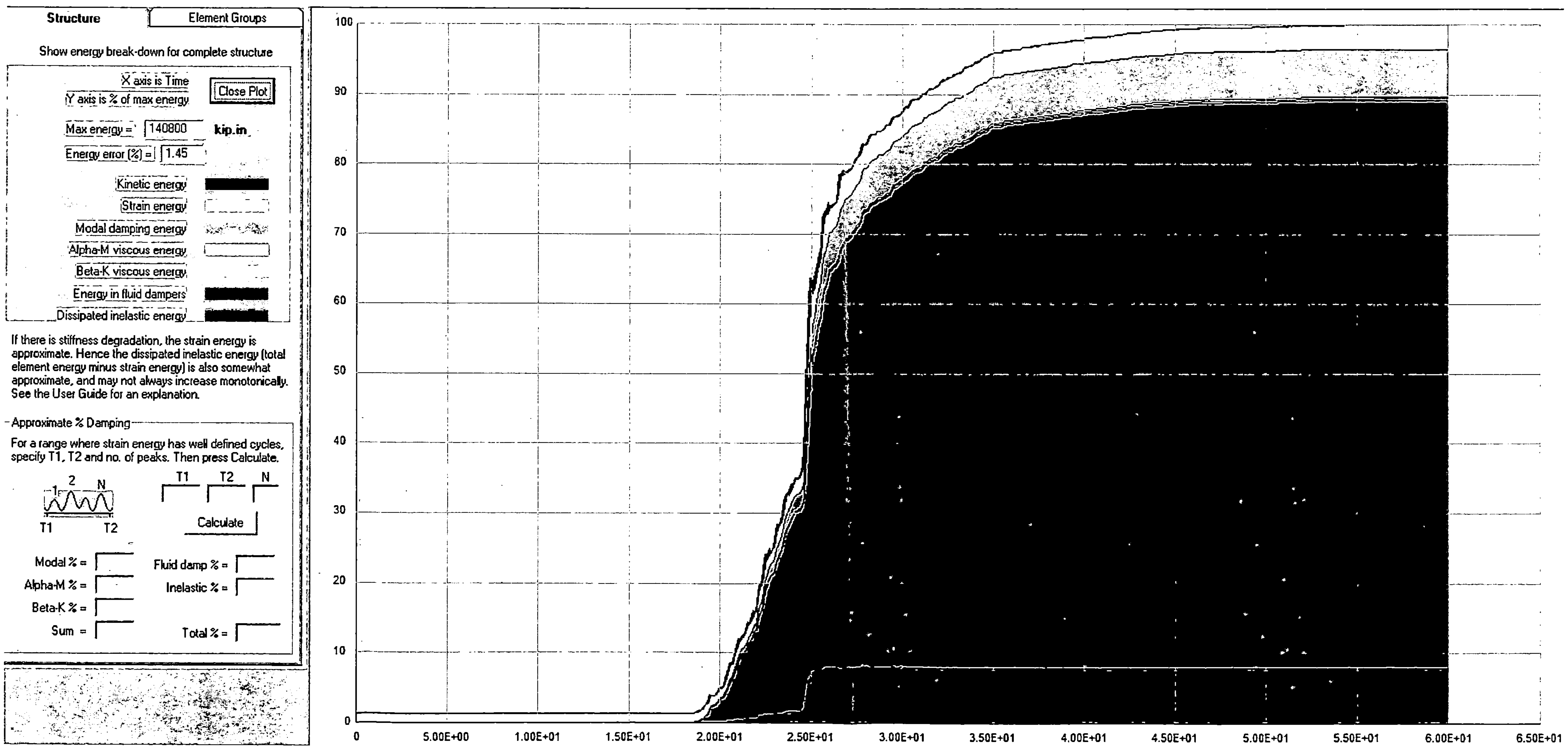

Figure 14-29 Energy Balance Plot for BSE-2E GM9 (Approximate Added Damping = 35.4%, Average Added Damping from All 11 GM's = 34.4%)

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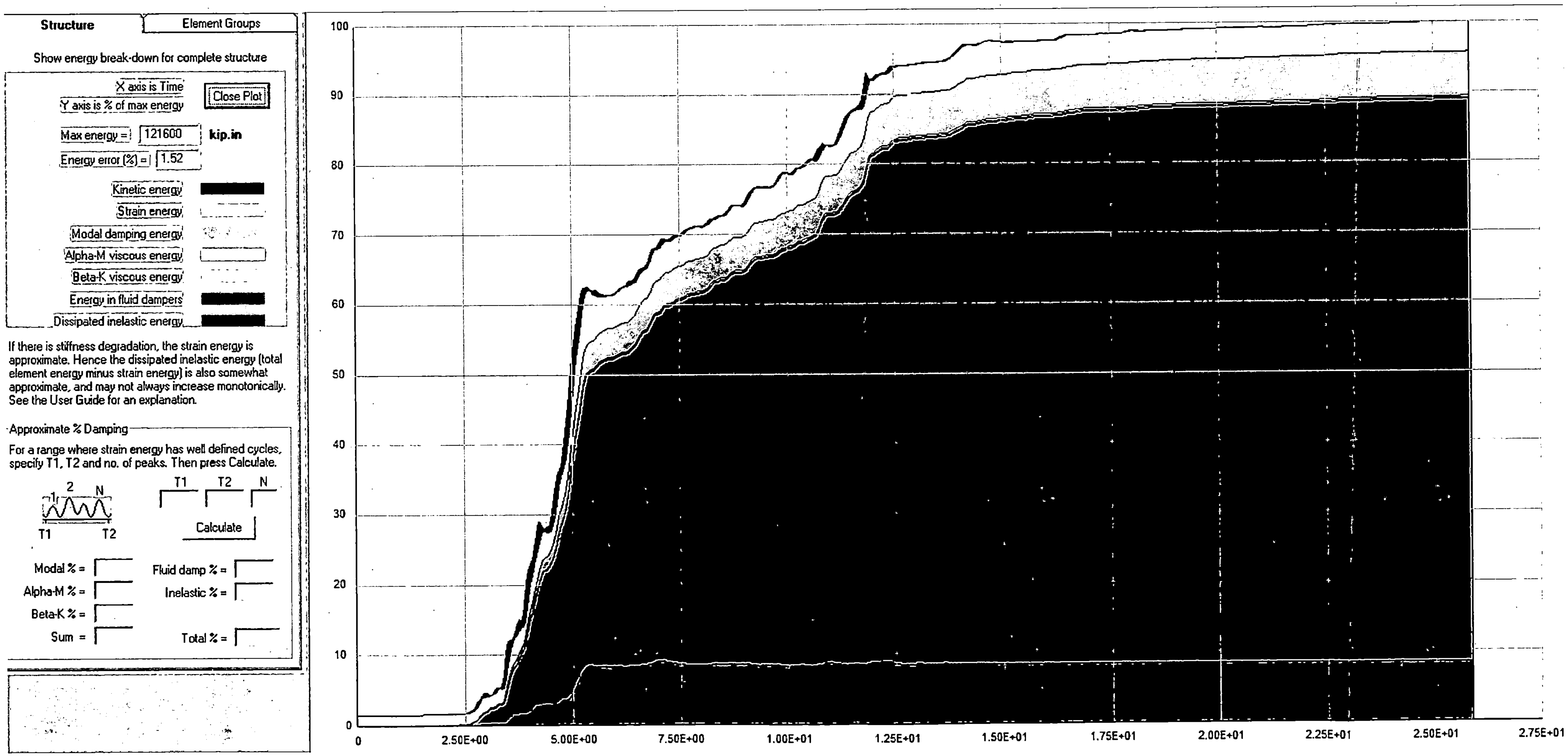

Figure 14-30 Energy Balance Plot for BSE-2E GM10 (Approximate Added Damping = 35.7%, Average Added Damping from All 11 GM's = 34.4%)

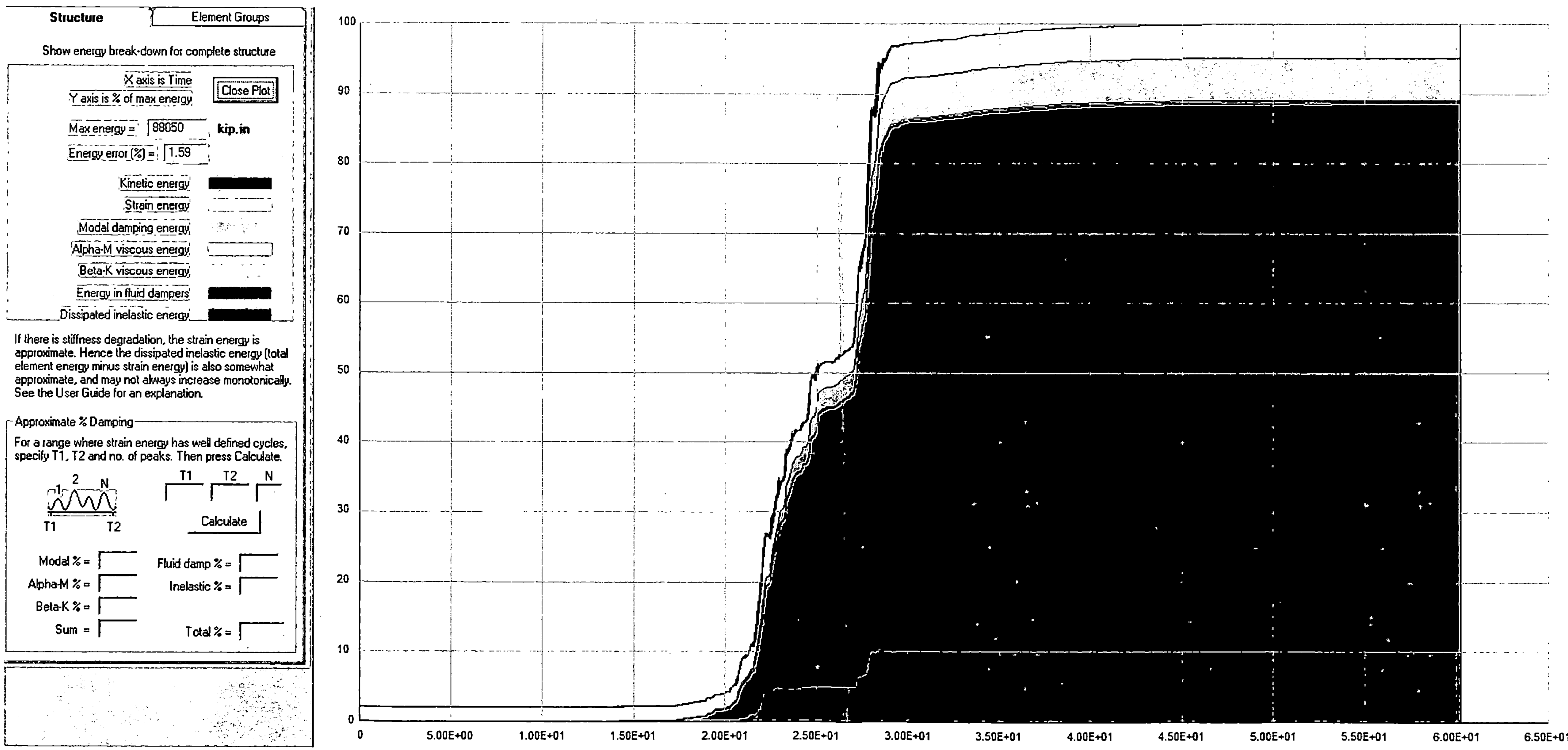

Figure 14-31 Energy Balance Plot for BSE-2E GM11 (Approximate Added Damping = 37.2%, Average Added Damping from All 11 GM's = 34.4%)

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		client	job no. 2000362	

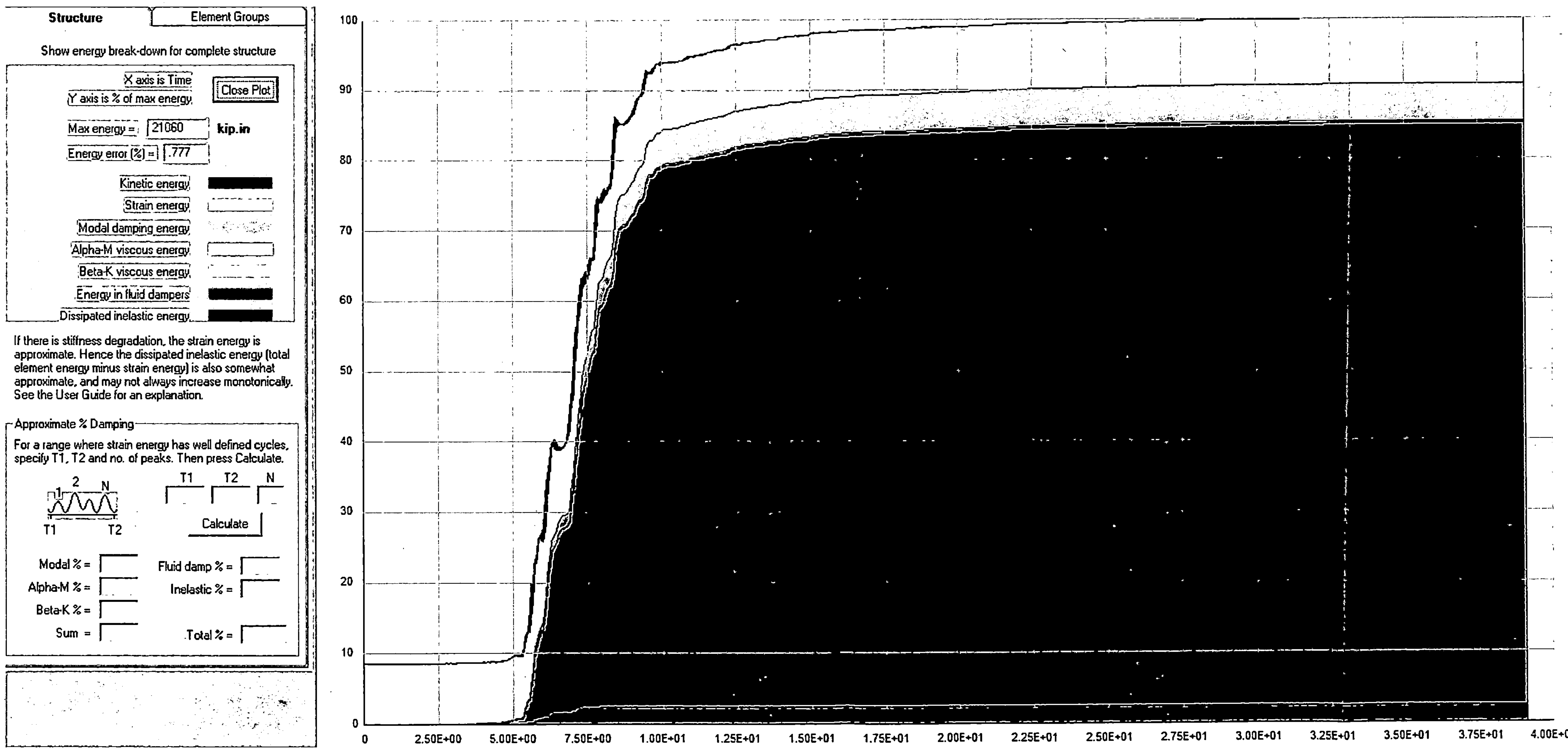

Figure 14-32 Energy Balance Plot for BSE-1E GM1 (Approximate Added Damping = 44.5%, Average Added Damping from All 11 GM's = 44.6%)

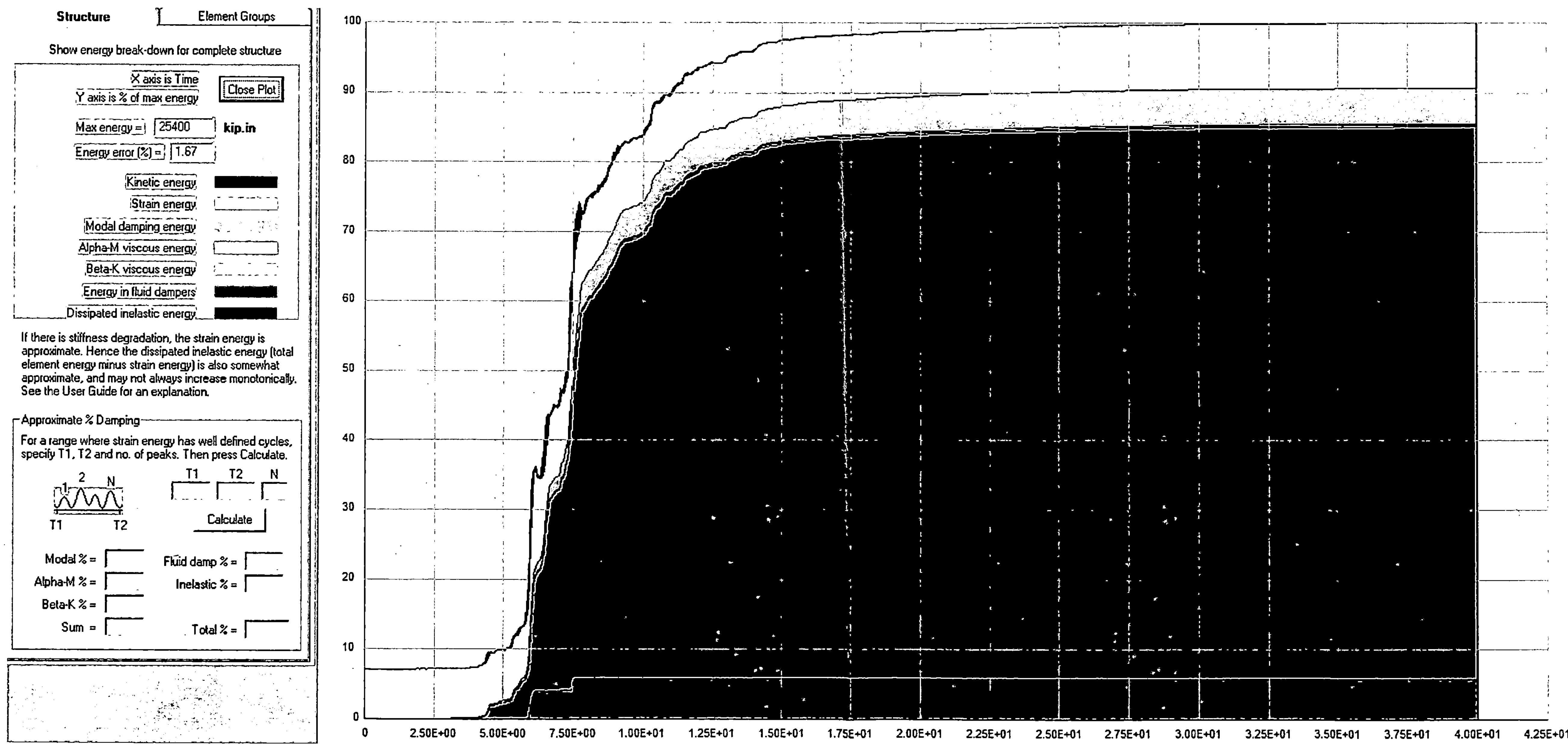

Figure 14-33 Energy Balance Plot for BSE-1E GM2 (Approximate Added Damping = 45.1%, Average Added Damping from All 11 GM's = 44.6%)

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client	job no. 2000362		

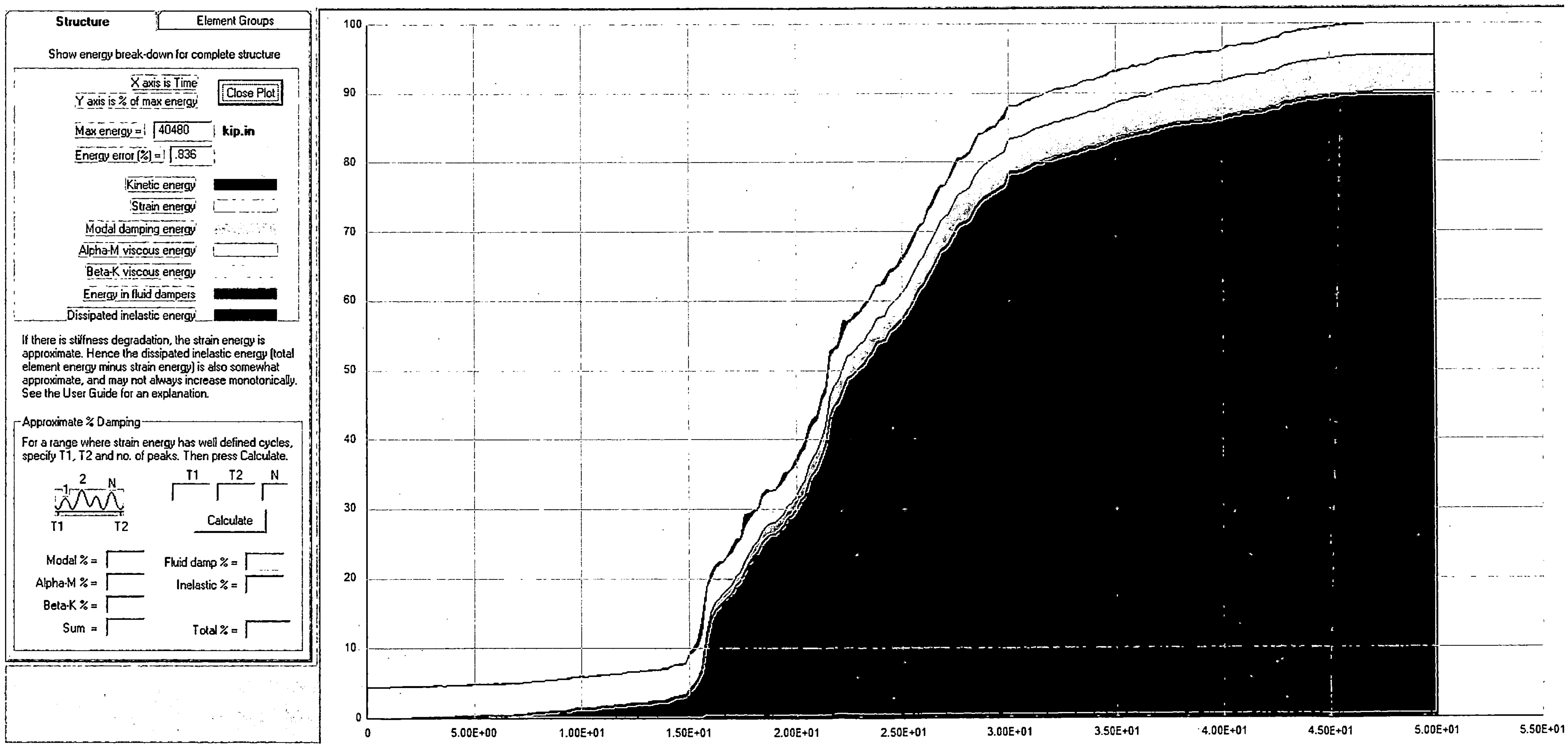

Figure 14-34 Energy Balance Plot for BSE-1E GM3 (Approximate Added Damping = 50.4%, Average Added Damping from All 11 GM's = 44.6%)

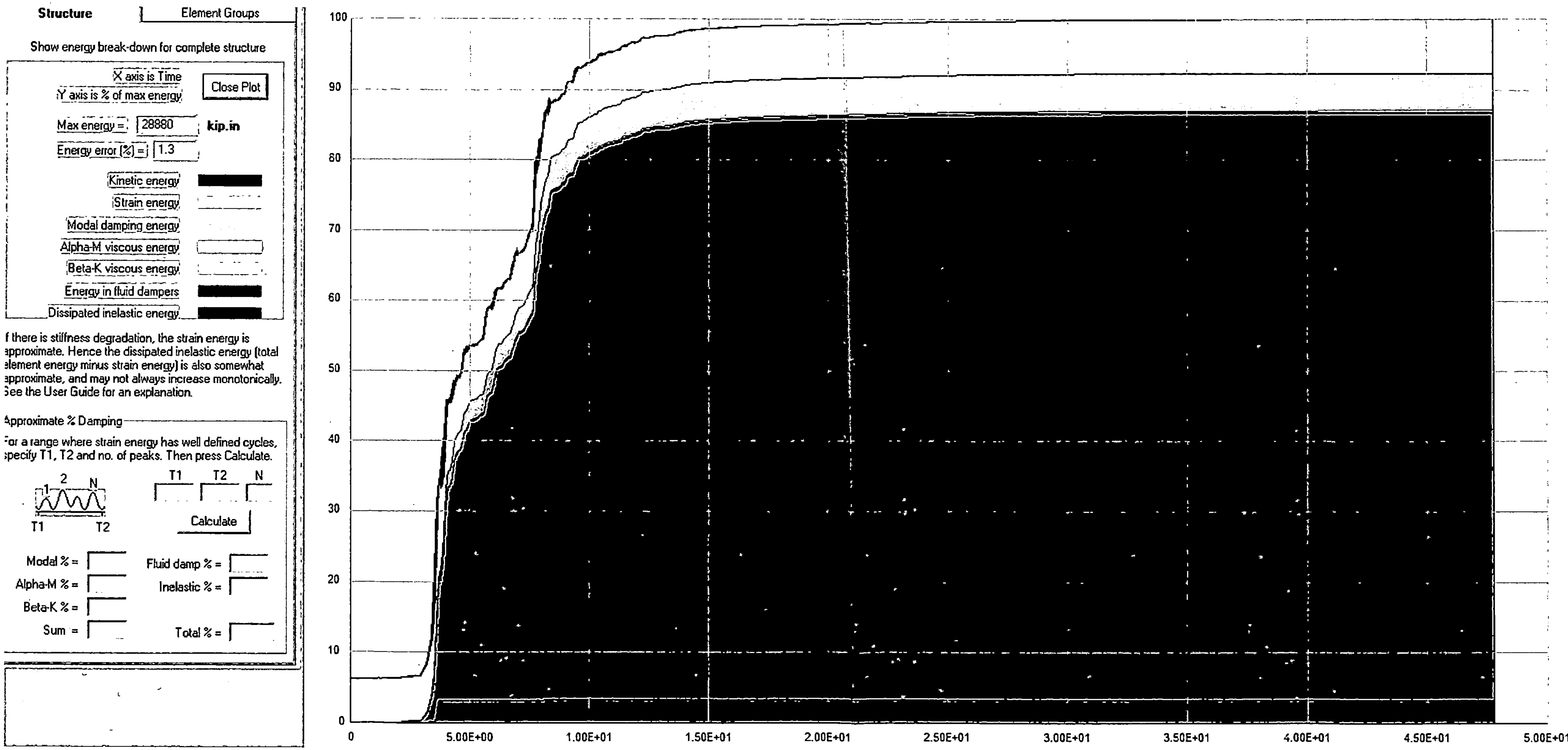

Figure 14-35 Energy Balance Plot for BSE-1E GM4 (Approximate Added Damping = 46.3%, Average Added Damping from All 11 GM's = 44.6%)

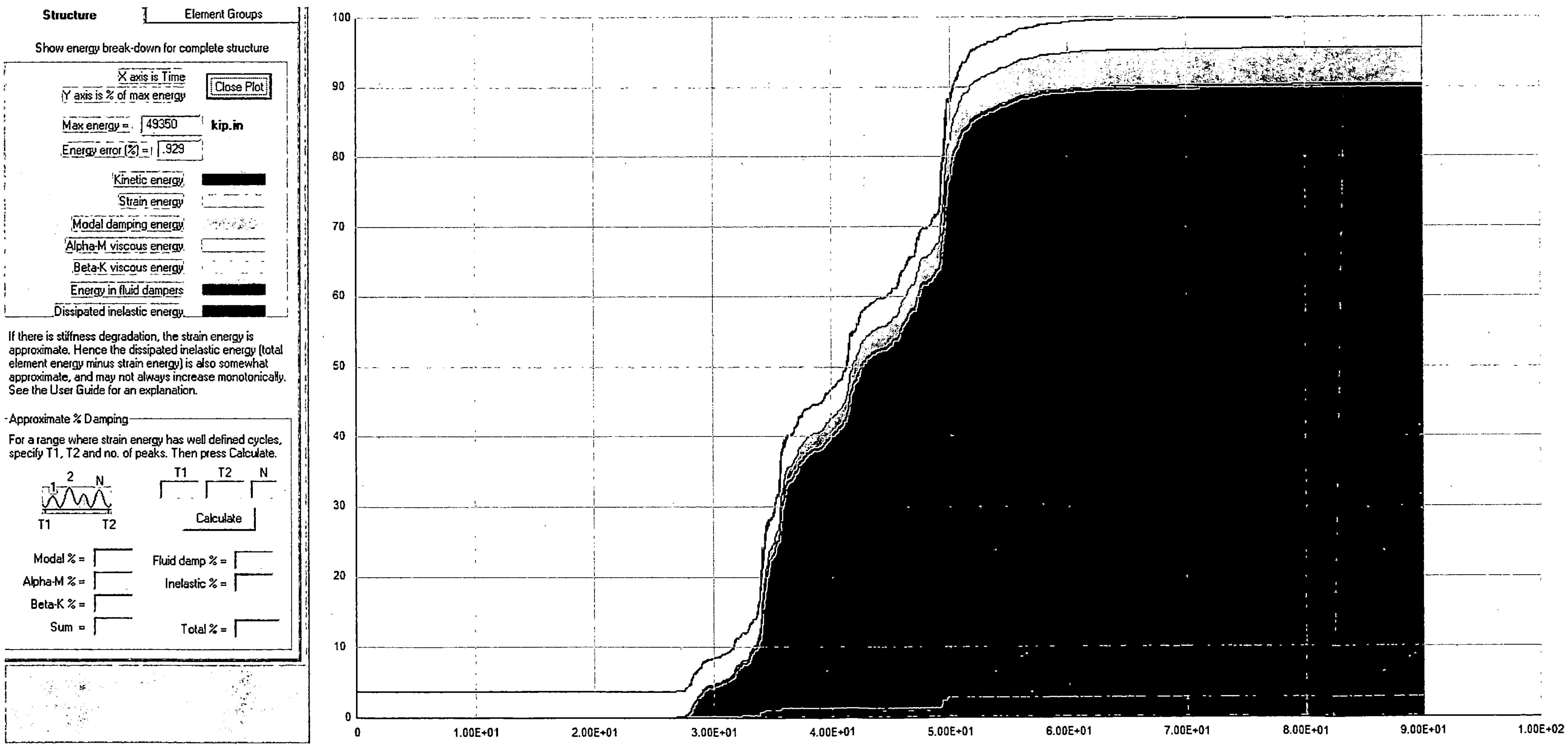

Figure 14-36 Energy Balance Plot for BSE-1E GM5 (Approximate Added Damping = 48.1%, Average Added Damping from All 11 GM's = 44.6%)

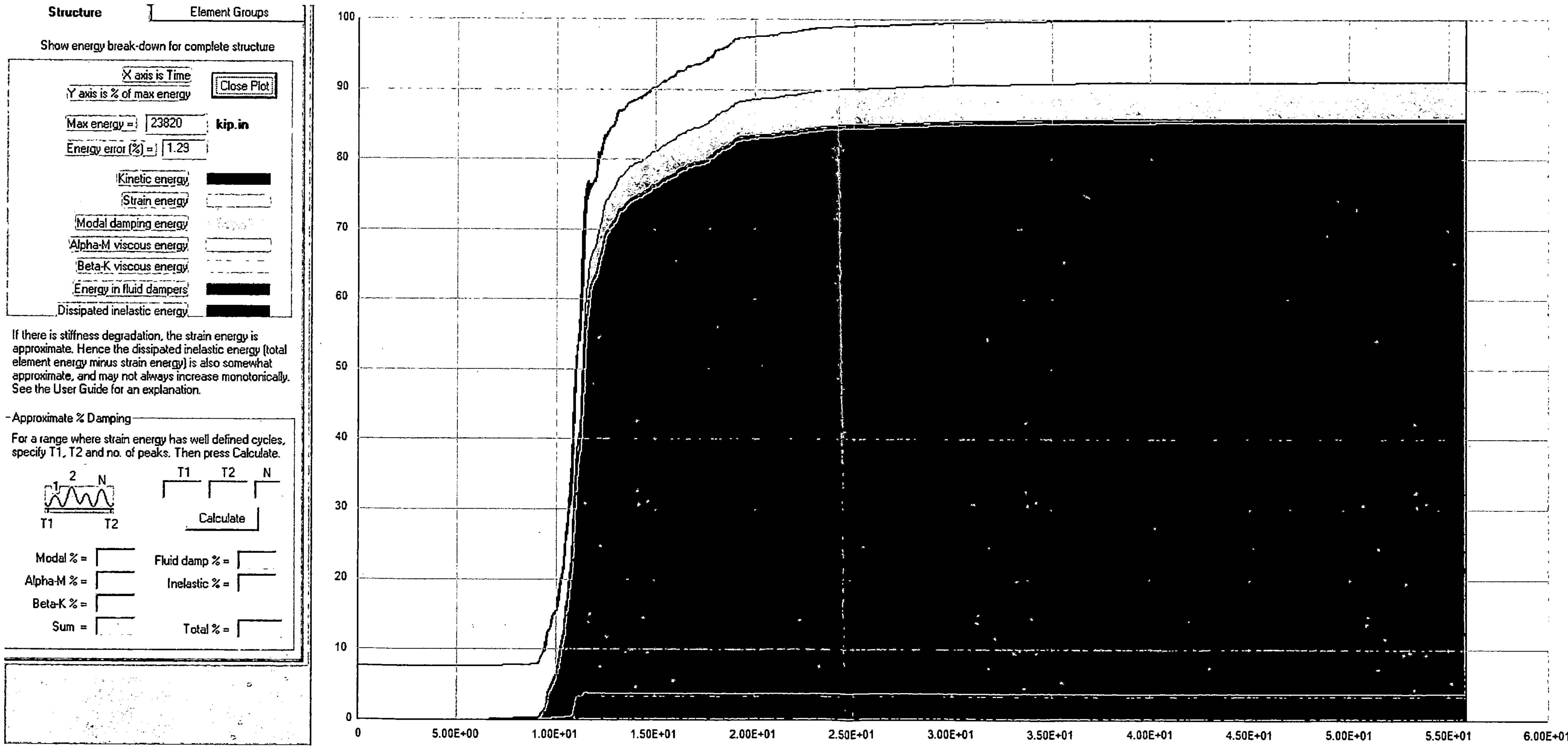

Figure 14-37 Energy Balance Plot for BSE-1E GM6 (Approximate Added Damping = 44.1%, Average Added Damping from All 11 GM's = 44.6%)

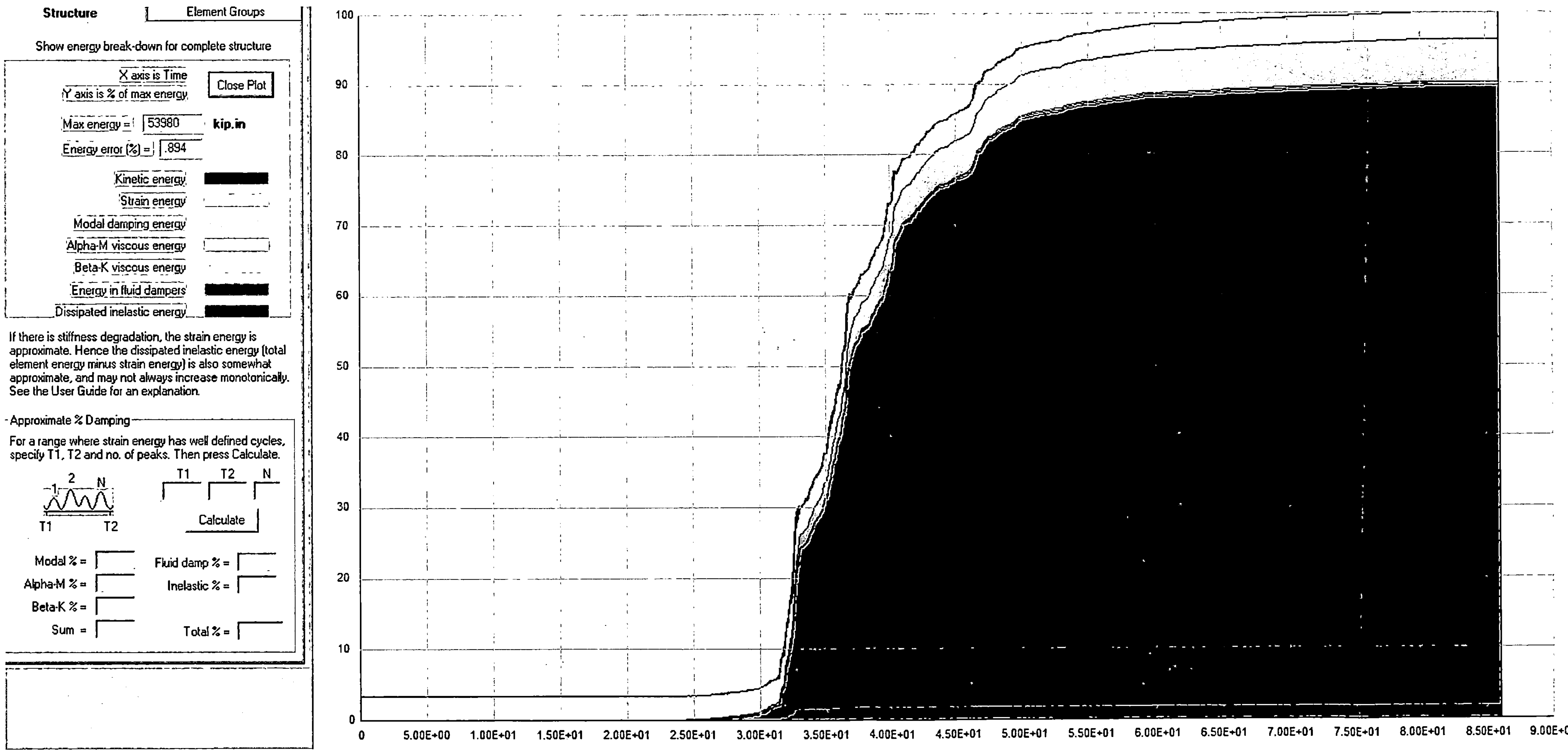

Figure 14-38 Energy Balance Plot for BSE-1E GM7 (Approximate Added Damping = 40.9%, Average Added Damping from All 11 GM's = 44.6%)

kpff 700 South Flower Street, Suite 2100 Los Angeles, CA 90017 (213) 418-0201	project City of Inglewood - Library	by JL	sheet no. 14-32
	location	date 6/25/21	
	client	job no. 2000362	

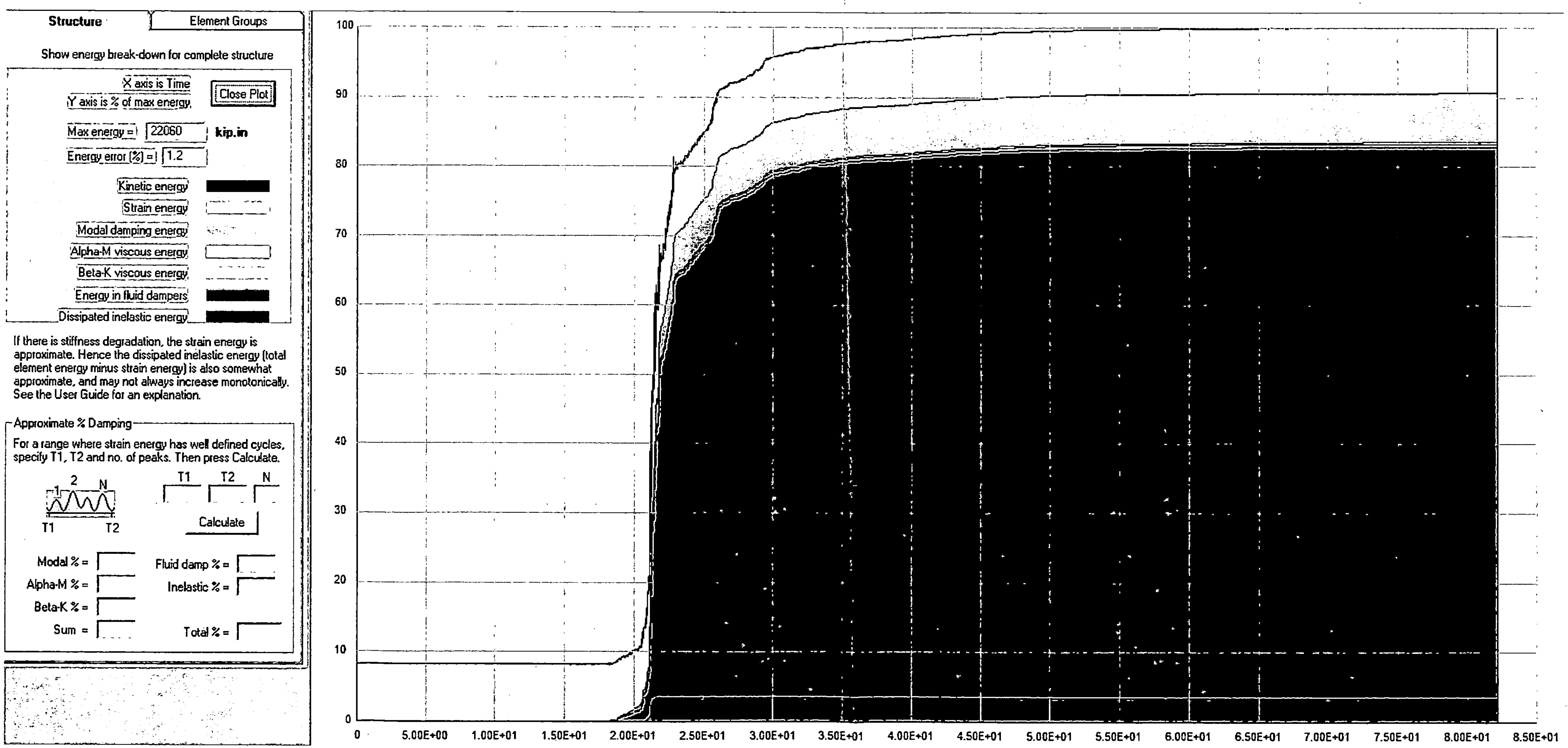

Figure 14-39 Energy Balance Plot for BSE-1E GM8 (Approximate Added Damping = 31.8%, Average Added Damping from All 11 GM's = 44.6%)

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		location	date 6/25/21	
		client	job no. 2000362	

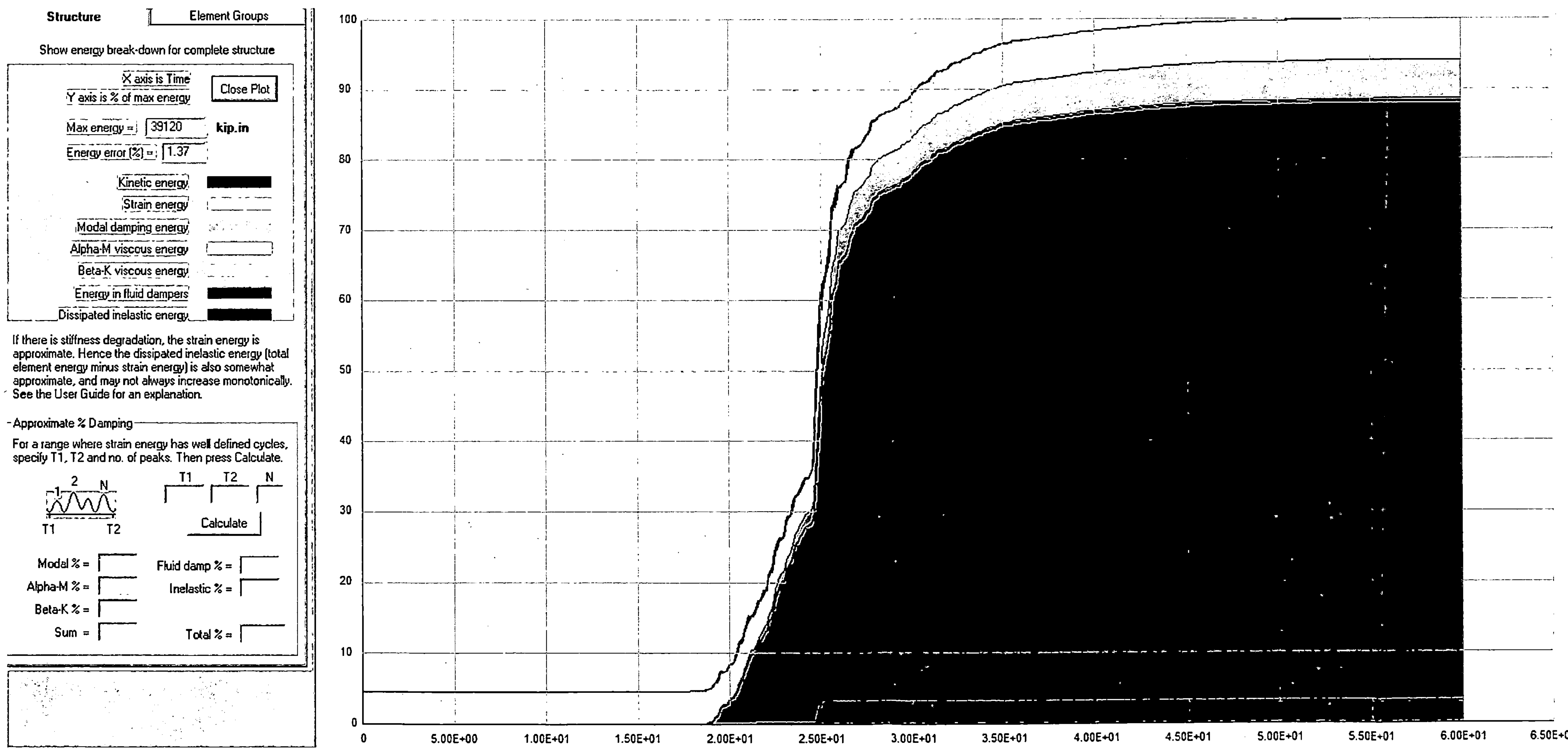


Figure 14-40 Energy Balance Plot for BSE-1E GM9 (Approximate Added Damping = 44.0%, Average Added Damping from All 11 GM's = 44.6%)

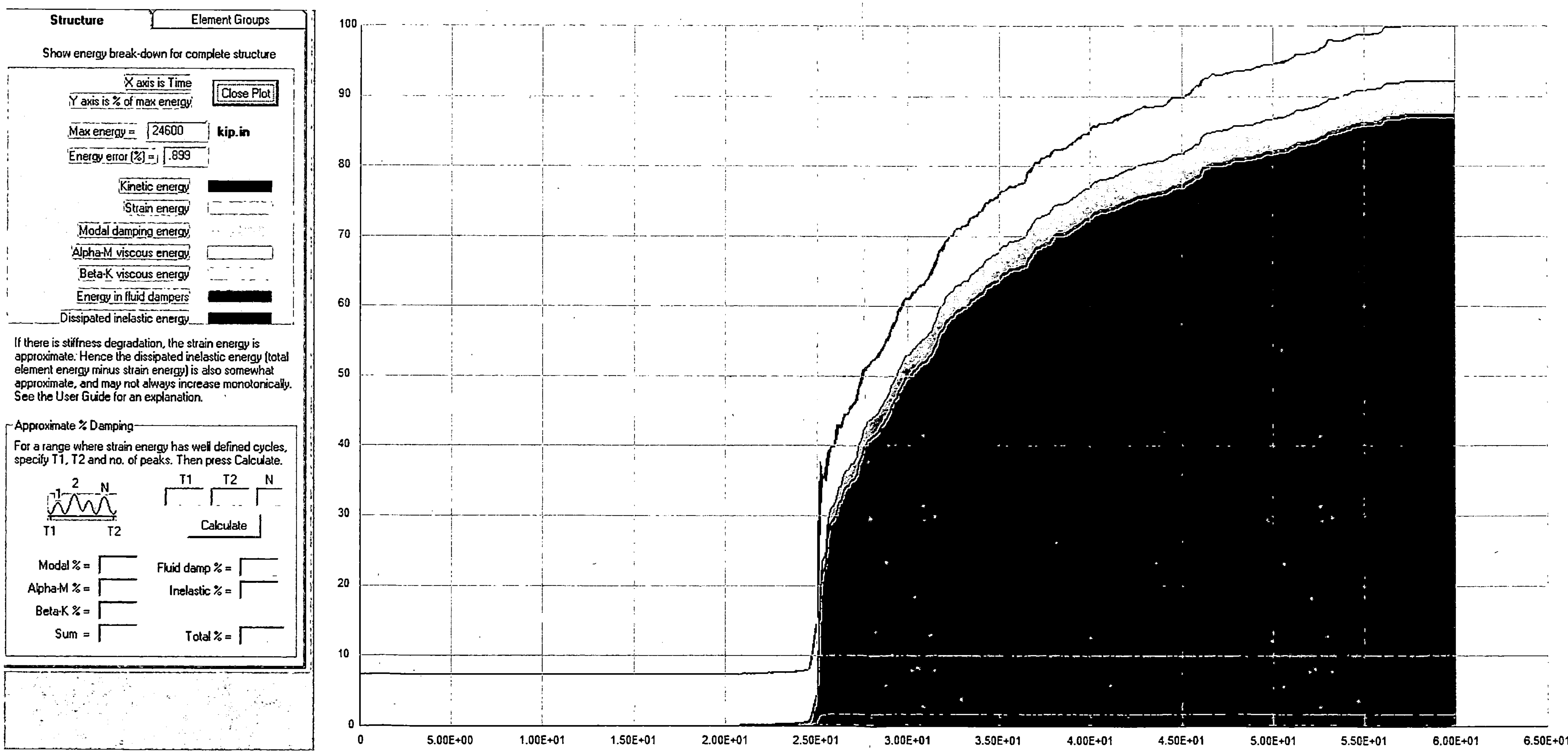


Figure 14-41 Energy Balance Plot for BSE-1E GM10 (Approximate Added Damping = 47.7%, Average Added Damping from All 11 GM's = 44.6%)

kpff 700 South Flower Street, Suite 2100 Los Angeles, CA 90017 (213) 418-0201	project City of Inglewood - Library	by JL	sheet no. 14-35
	location	date 6/25/21	
	client	job no. 2000362	

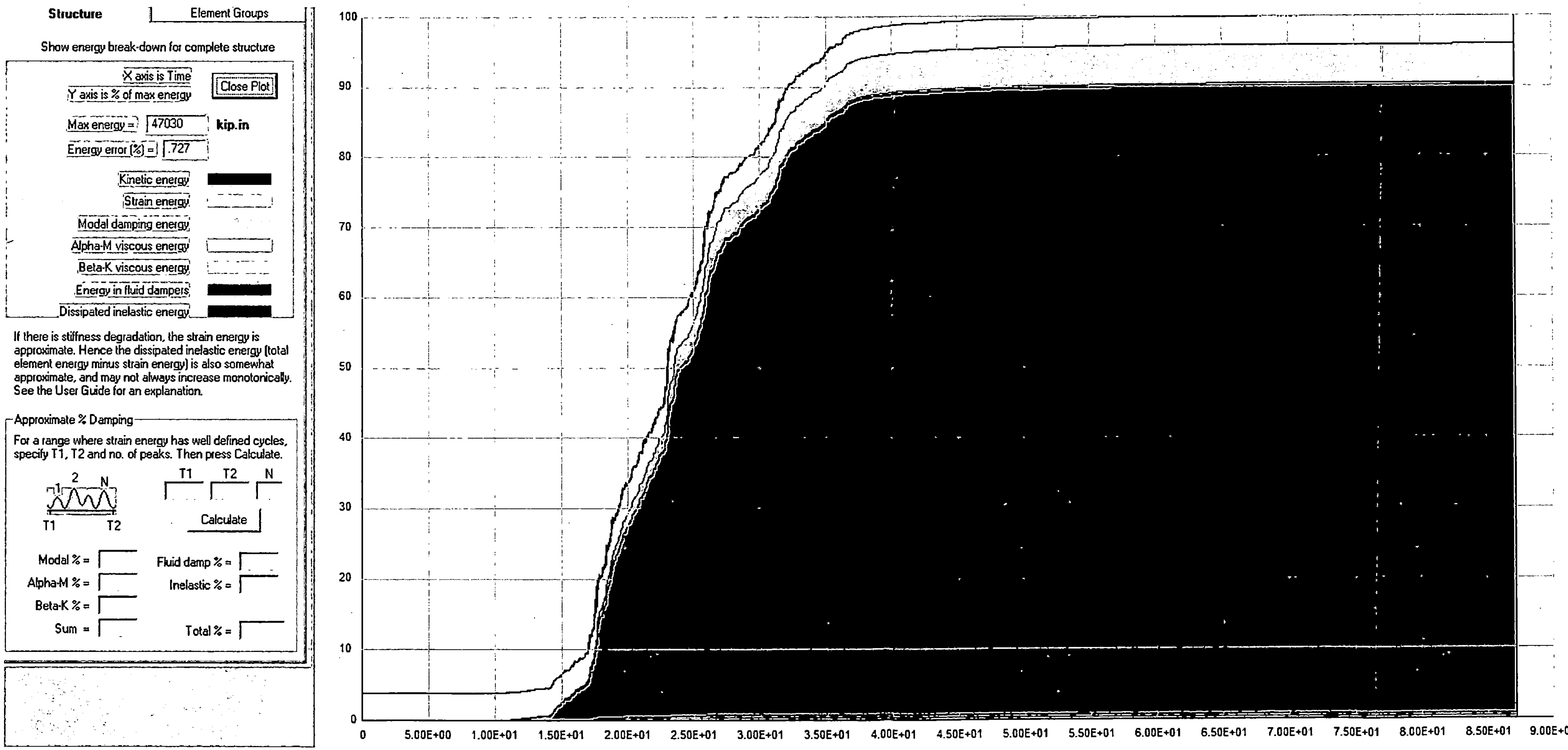


Figure 14-42 Energy Balance Plot for BSE-1E GM11 (Approximate Added Damping = 47.8%, Average Added Damping from All 11 GM's = 44.6%)

15 - Cyclic Degradation Procedure

Cyclic Degradation has been incorporated into the perform models for all beams and columns. The parameters for cyclic degradation were evaluated based on the procedure below.

12 column test specimens were chosen with similar characteristics to the columns in the City Hall and Library. A summary of the 12 specimens is included below.

ID	Column Experimental tests	Span to depth	Axial Load Ratio	Long reinf Ratio
1	Paultre and Legeron, 2000, No. 1006015	6.56	0.14	0.0215
2	Paultre and Legeron, 2000, No. 1006025	6.56	0.277	0.0215
3	Paultre and Legeron, 2000, No. 1006040	6.56	0.394	0.0215
4	Paultre and Legeron, 2000, No. 10013015	6.56	0.136	0.0215
5	Paultre and Legeron, 2000, No. 10013025	6.56	0.264	0.0215
6	Paultre and Legeron, 2000, No. 10013040	6.56	0.371	0.0215
7	Paultre et al., 2001, No. 806040	6.56	0.396	0.0215
8	Paultre et al., 2001, No. 1206040	6.56	0.413	0.0215
9	Paultre et al., 2001, No. 1005540	6.56	0.412	0.0215
10	Paultre et al., 2001, No. 1008040	6.56	0.371	0.0215
11	Paultre et al., 2001, No. 1005552	6.56	0.53	0.0215
12	Paultre et al., 2001, No. 1006052	6.56	0.506	0.0215

Because Perform3Ds implementation of cyclic degradation only allows for stiffness degradation due to cyclic loading, only the stiffness degradation in the tests was considered. To calculate the parameters for stiffness degradation, first each column hysteresis was broken up into individual cycles. The maximum rotation and the median stiffness were extracted from each cycle. The median stiffness of the first cycle was determined to be the elastic stiffness of the element because the tests were set up such that in the first cycle, the horizontal force reached 75% of the yield force.

Each cycles median stiffness was converted into a relative stiffness relative to the elastic stiffness. This allows a plot to be generated that displays relative stiffness vs drift. This plot is analogous to the energy factor plot that Perform3D generates based on the user inputs since Perform can only adjust the stiffness to calculate the area ratio corresponding to the energy plot. All 12 stiffness degradation curves are plotted together and shown below.

The Perform Energy factor curve was determined to closely match this stiffness degradation curve within the rotations of interest. The curve was developed using the YX+3 model to allow for more control of the energy factors.

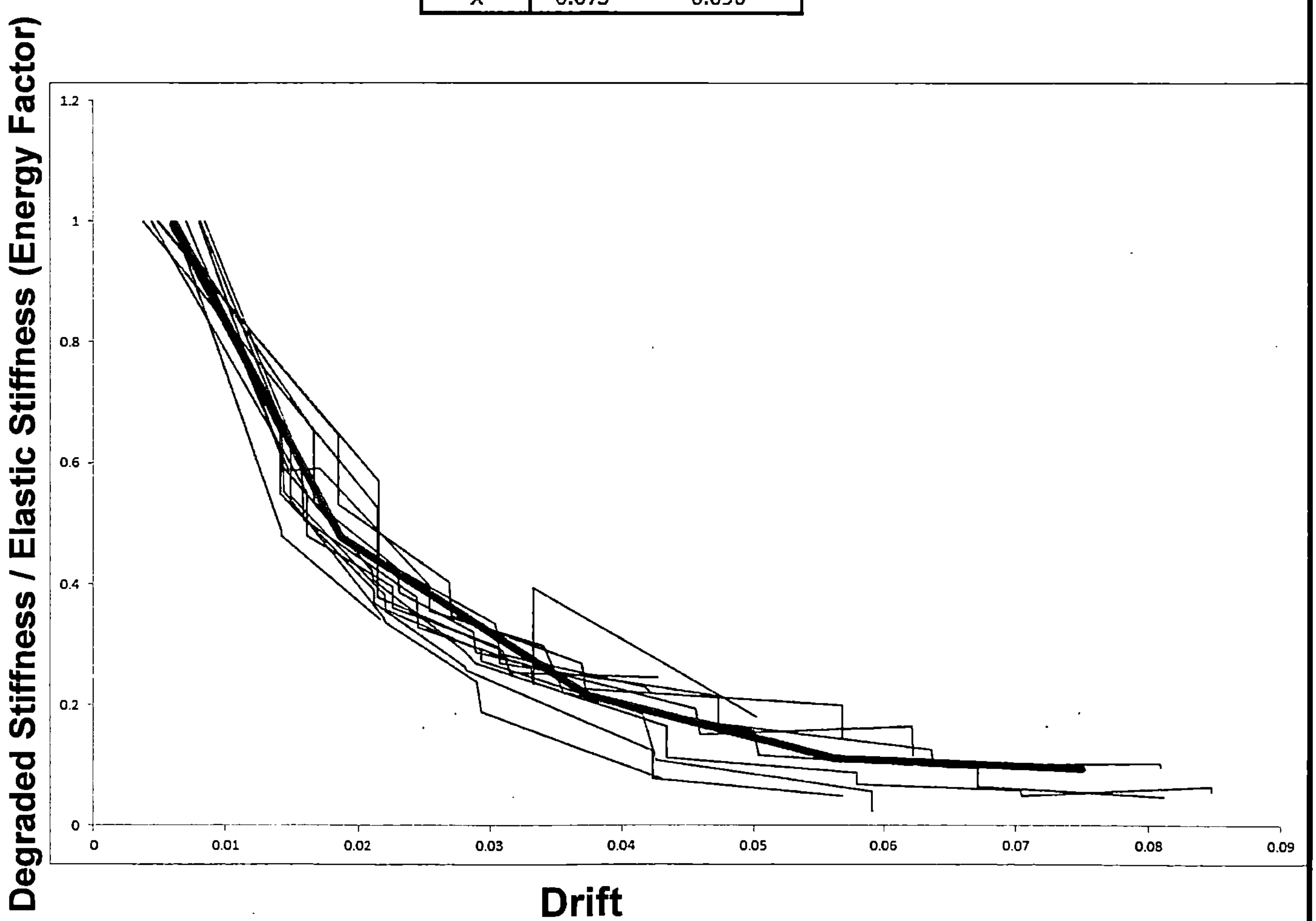
The 3 deformation inputs used are DX/4, DX/2, and 3DX/4. The energy factors are calculated using the polynomial trend line equation below.

$y=153199x^4-30517x^3+2310.5x^2-83.938x+1.4214$

Below is a sample of the energy factors for a hinge with DX=0.075

	Rotation	Energy Factor
Y	0.006	1.000
1	0.019	0.478
2	0.038	0.217
3	0.056	0.113
X	0.075	0.096

*Nominal Yield rotation of 0.006 is used here. This is not an input to Perform. Energy factor at yield = 1



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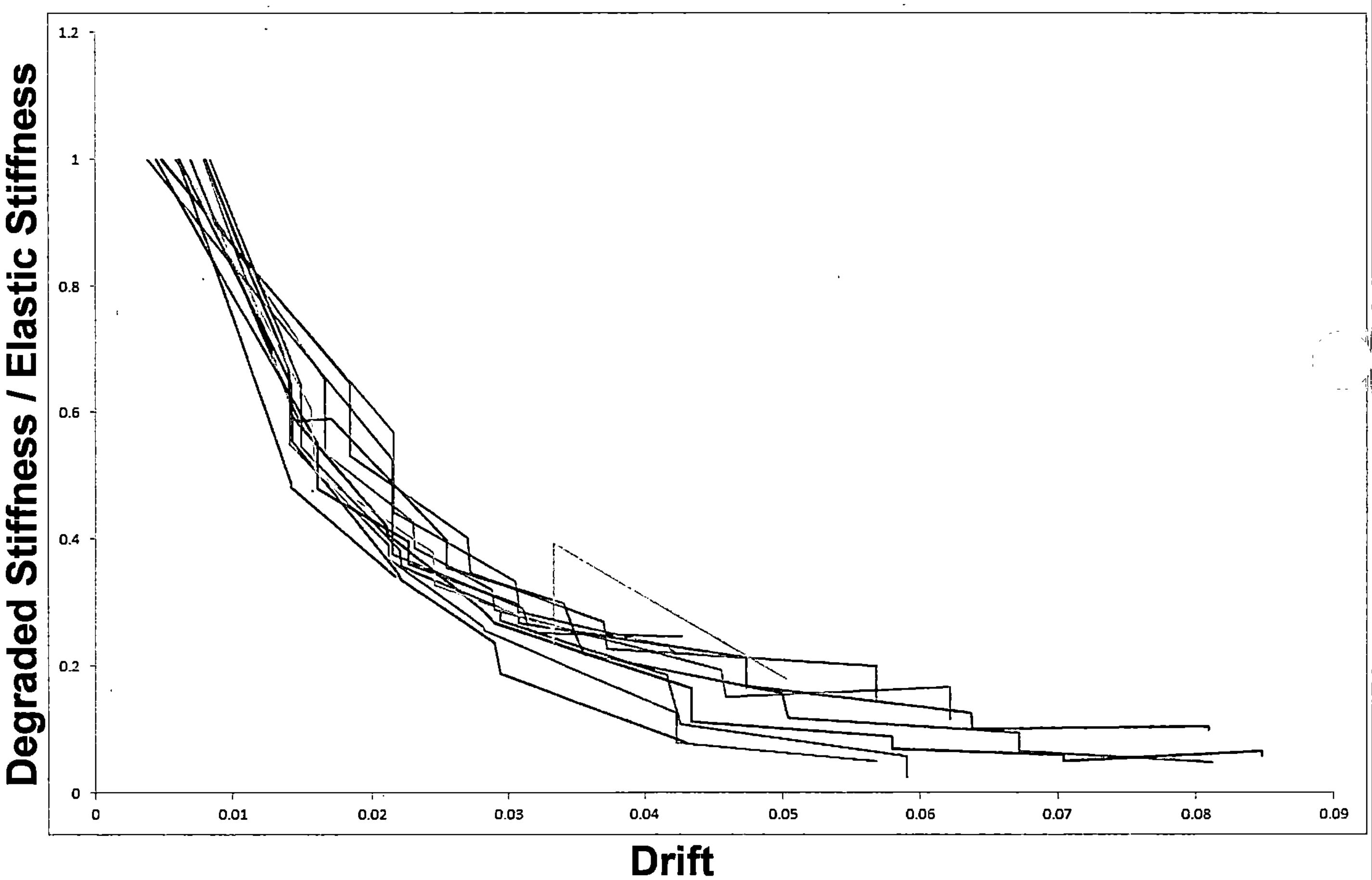
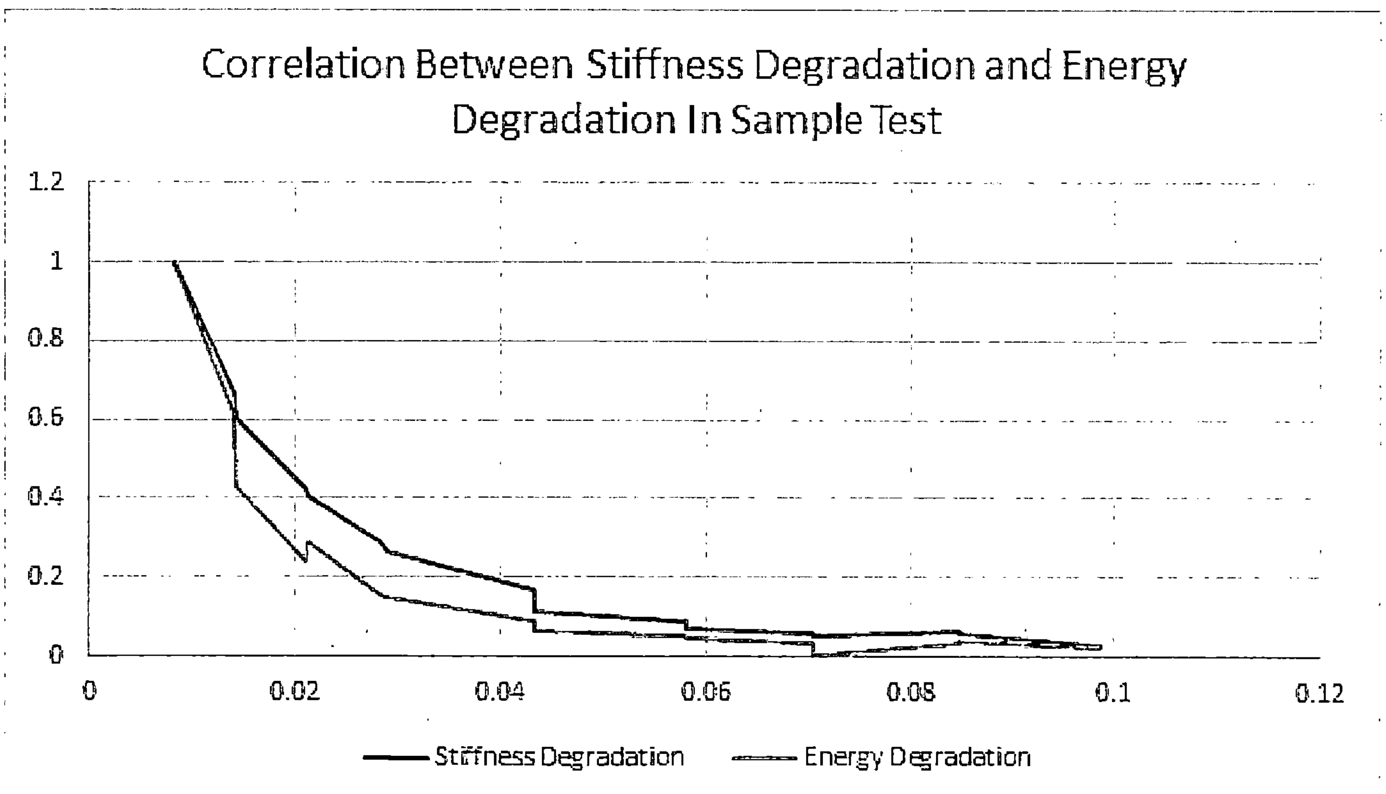
	Cyclic Degradation		

Stiffness Degradation Curve



To confirm that the stiffness degradation curve is closely representative of the energy degradation factor that Perform uses, a single test was analyzed to plot both the stiffness degradation parameter and the energy factor. The energy factor was calculated by finding the area in each hysteretic cycle of the test, normalizing it to a unit drift, and finally normalizing it to a unit area to get an area ratio.

The two plots are sufficiently similar in shape and magnitude so it is a good approximation to use the stiffness degradation curve to calculate energy factors.



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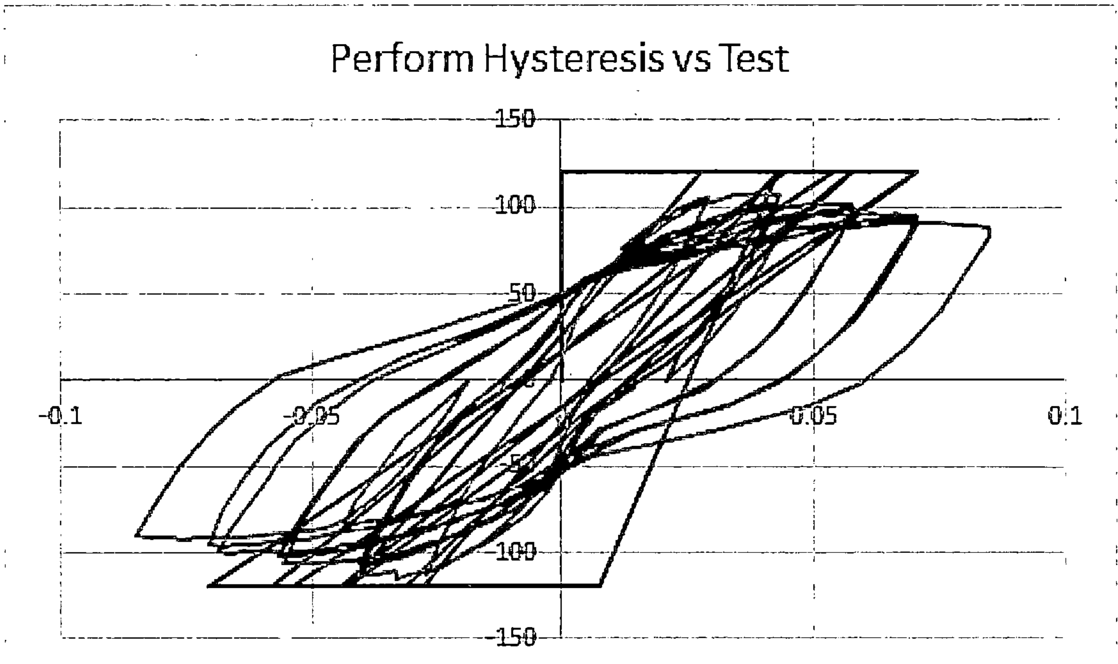
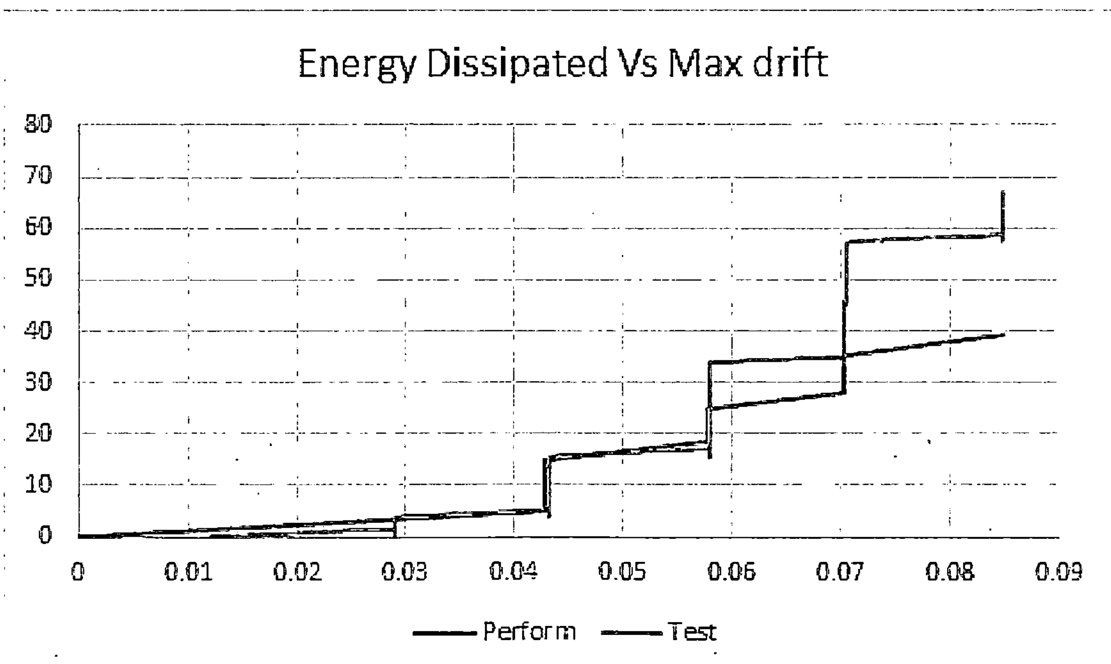
	client	job no. 2000362	
	Cyclic Degradation		

Finally, the approach was validated by plotting the hysteretic curves of Perform and the test atop one another. The shape of the perform backbone is not able to closely match the test data due to the limitations of the Perform model and the inclusion of elastic deformations in the test data. However, the energy dissipated in the two tests is very similar and so deemed acceptable.





This calculation for energy factors is applied to both columns and beams due to a lack of available beam test data and for simplicity.

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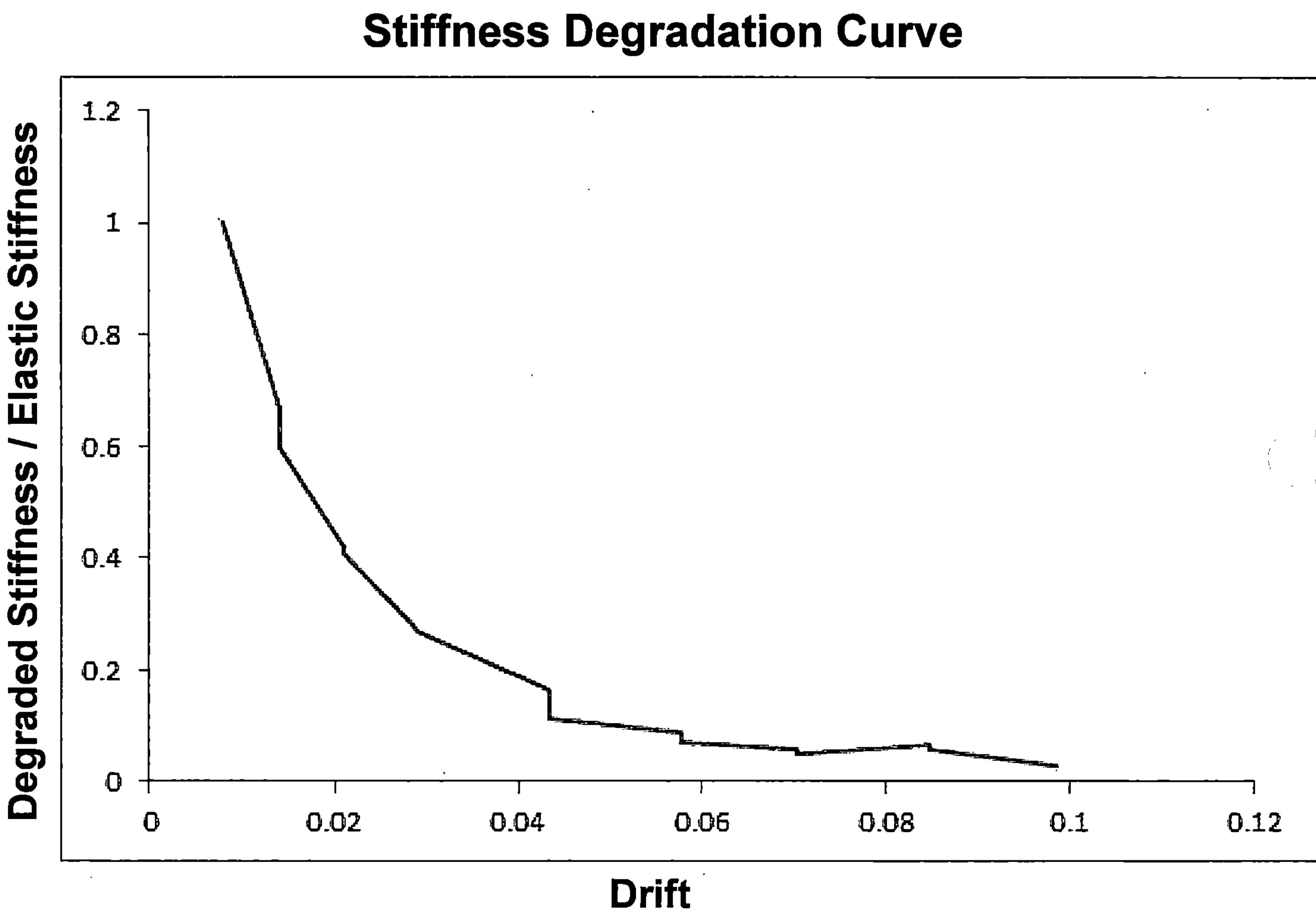
	client	job no. 2000362	
	Cyclic Degradation		

All the plots generated for Test ID 1 are included below as a sample



	Maximum Drift in Cycle	Median Stiffness/ Elastic Stiffness
Cycle	Total Drift	Stiffness / Elastic
1	0.0081	1.0000
2	0.0141	0.6693
3	0.0141	0.5981
4	0.0210	0.4212
5	0.0211	0.4069
6	0.0282	0.2879
7	0.0290	0.2678
8	0.0434	0.1656
9	0.0434	0.1128
10	0.0579	0.0882
11	0.0579	0.0697
12	0.0704	0.0592
13	0.0705	0.0499
14	0.0848	0.0661
15	0.0848	0.0574
16	0.0986	0.0309

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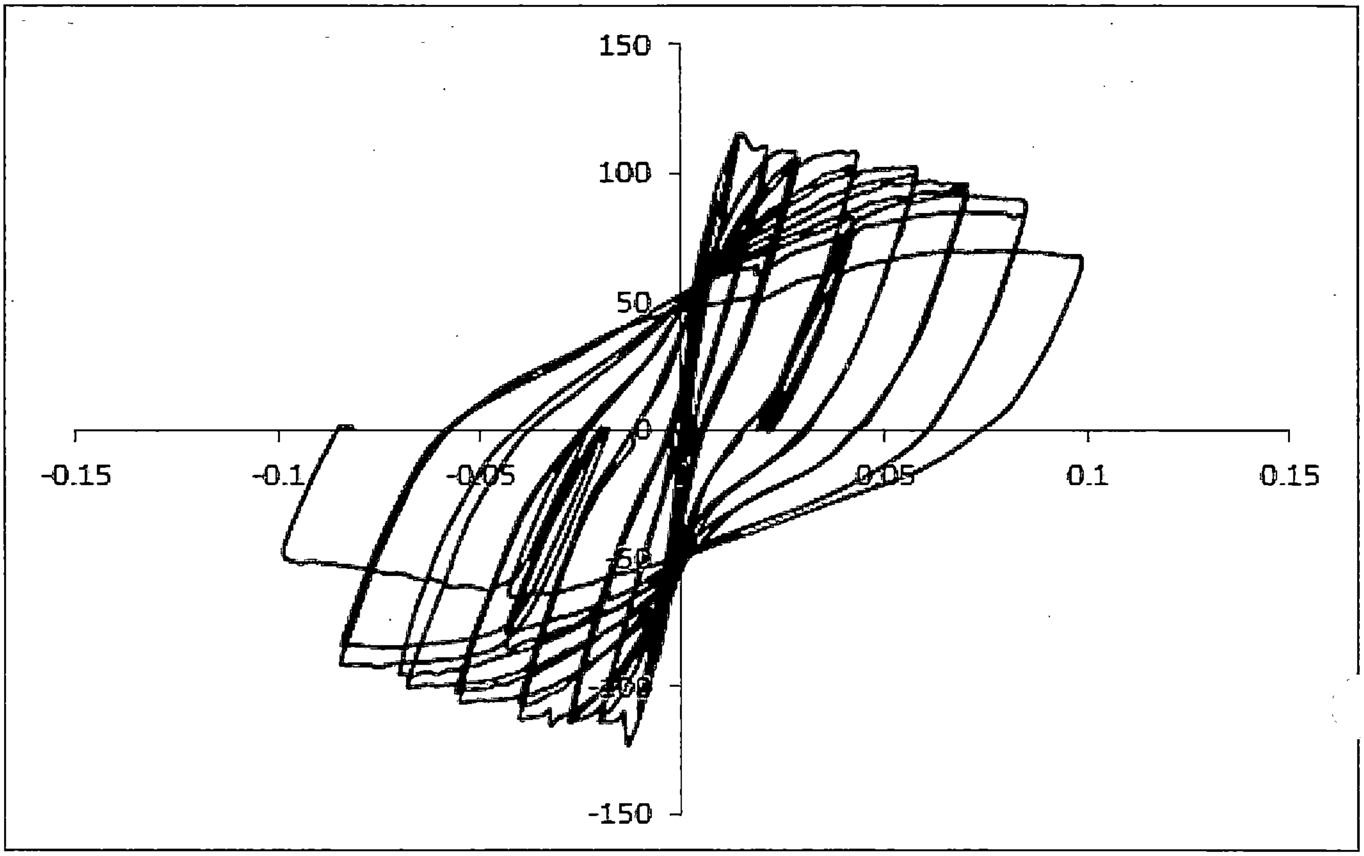
	Cyclic Degradation		

Full Hysteris



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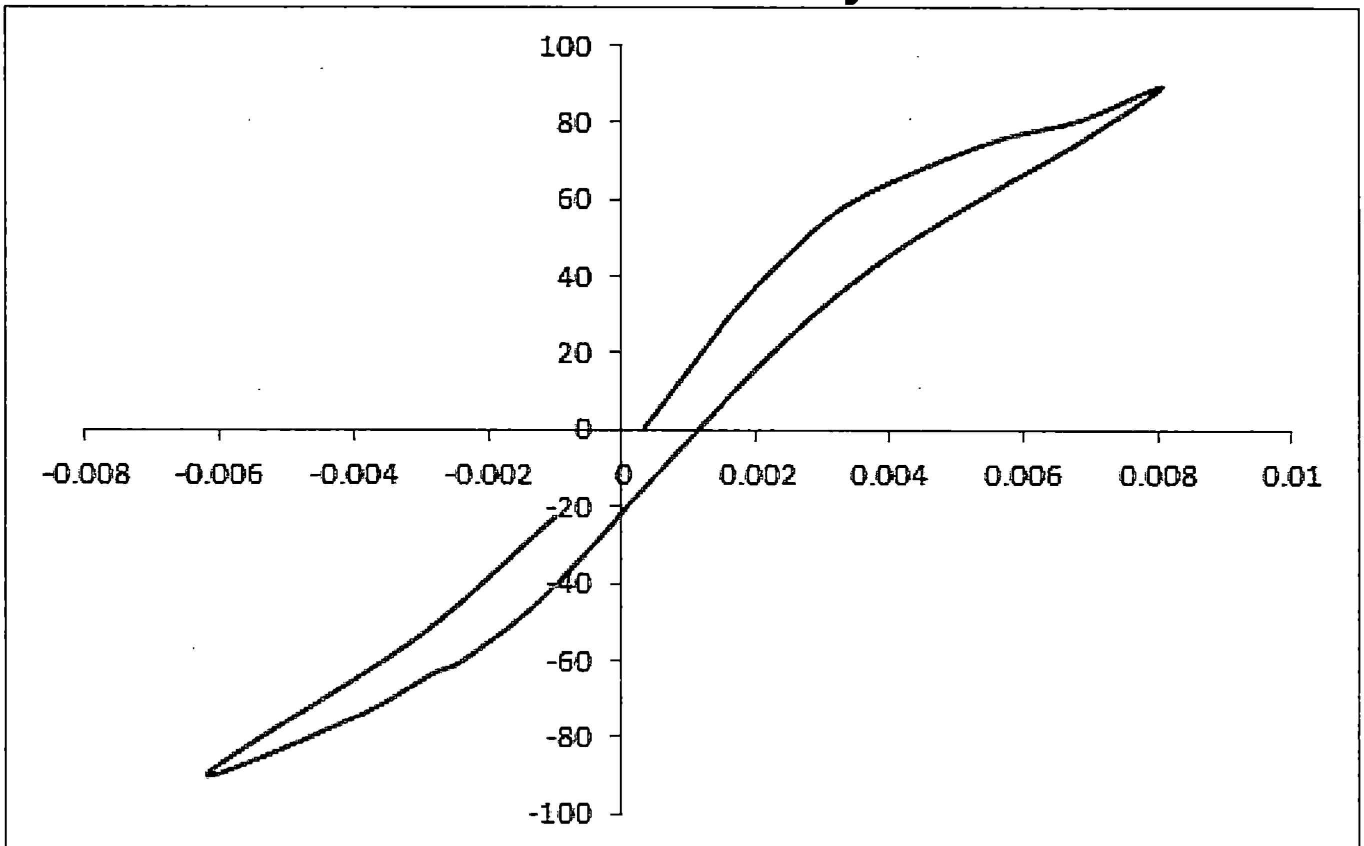
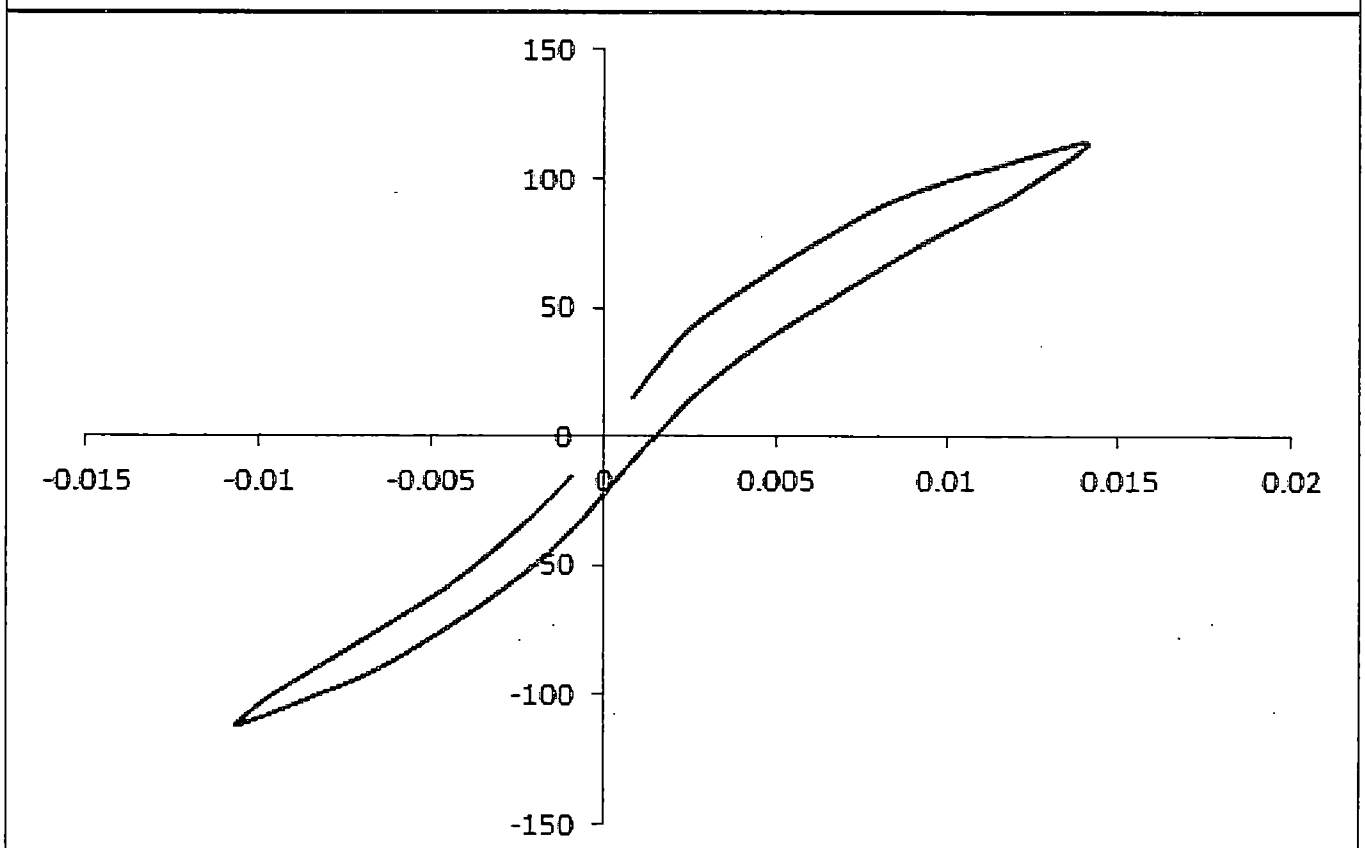
Each Individual Cycle





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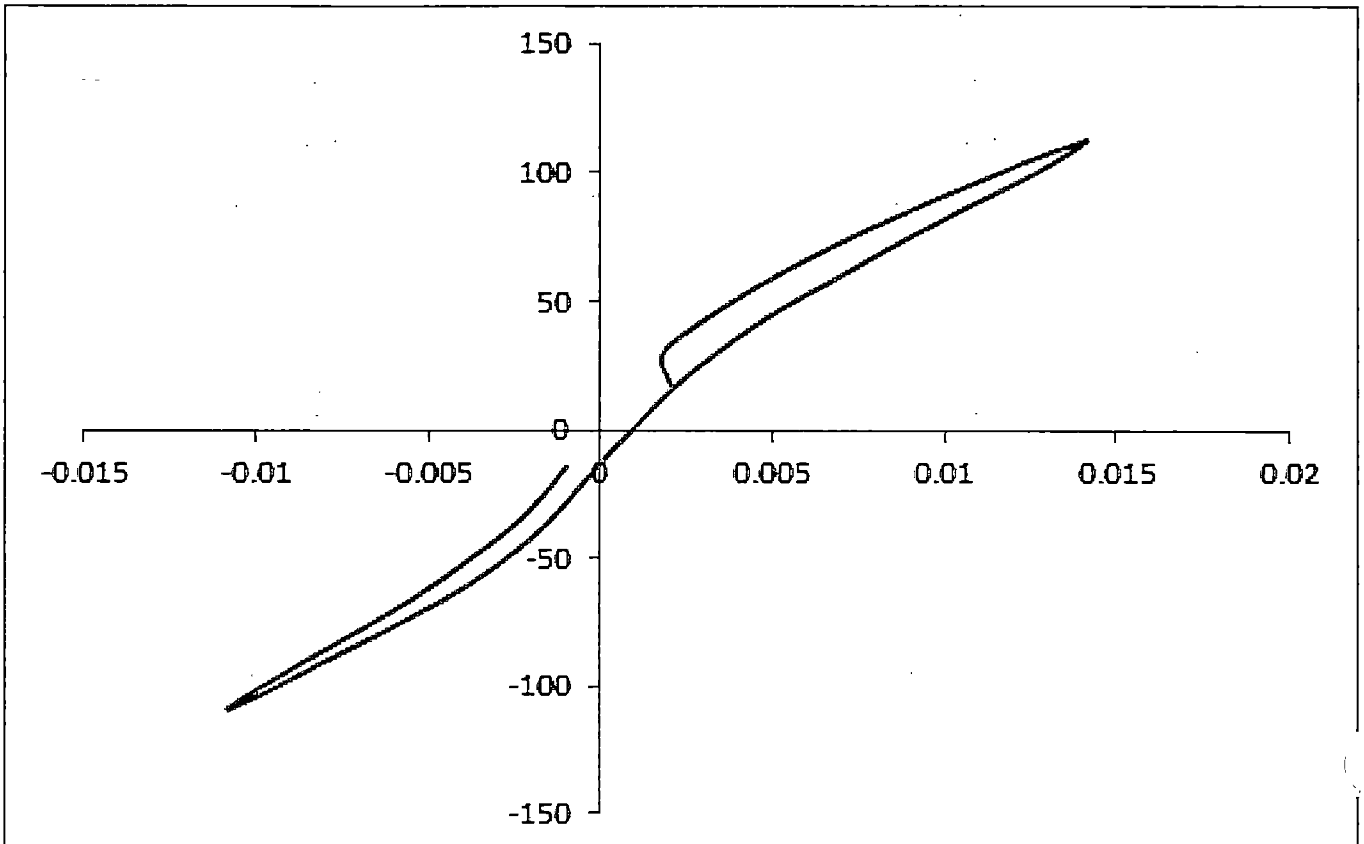

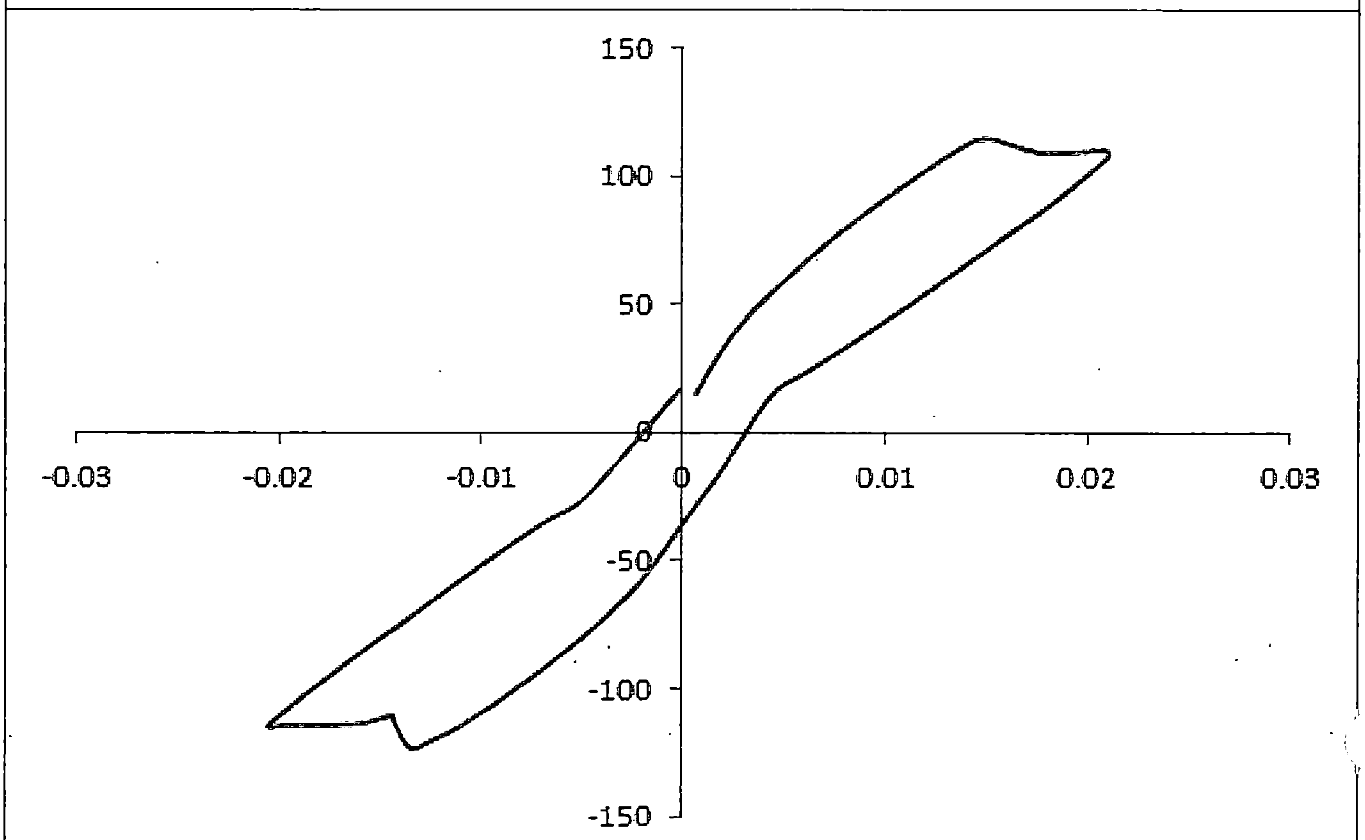

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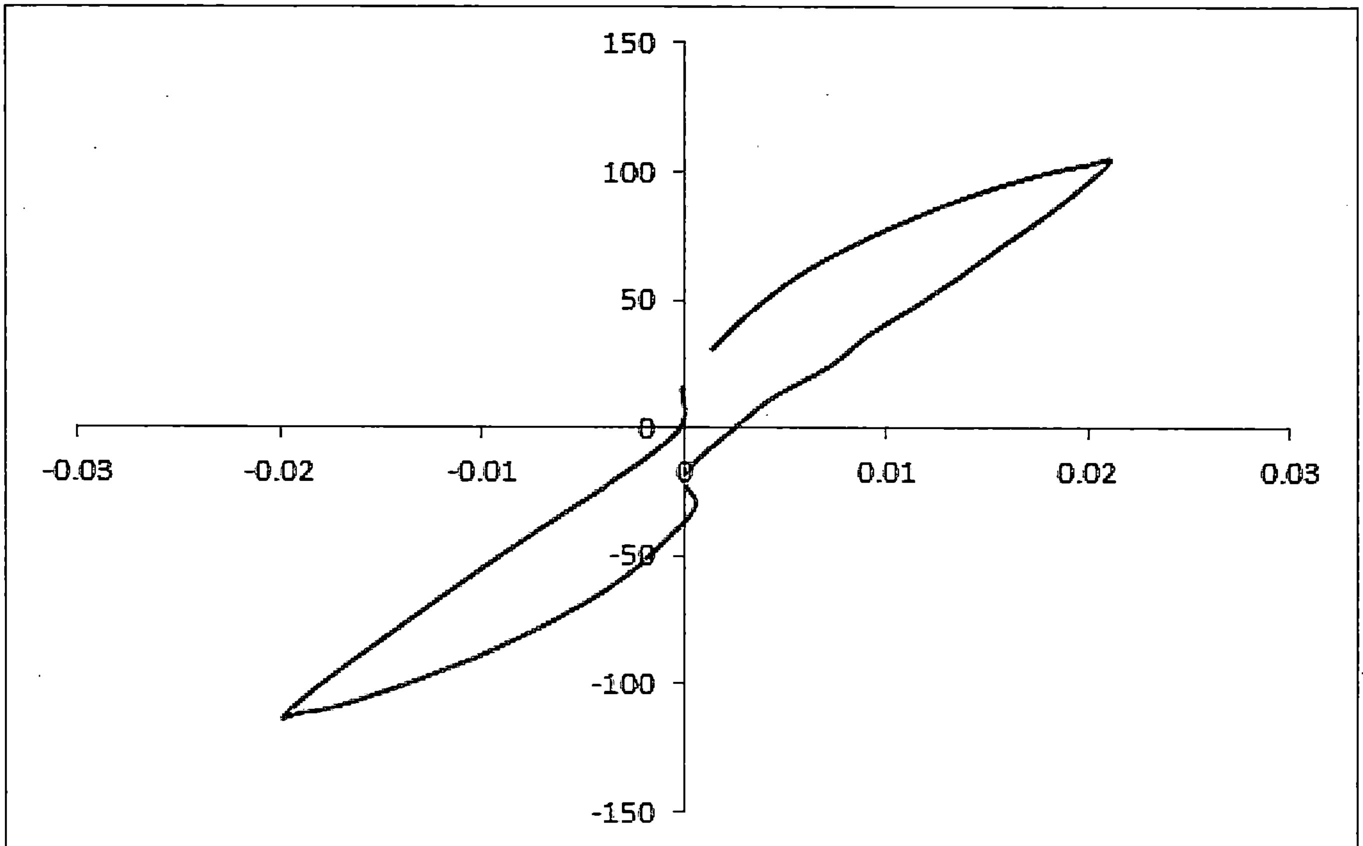
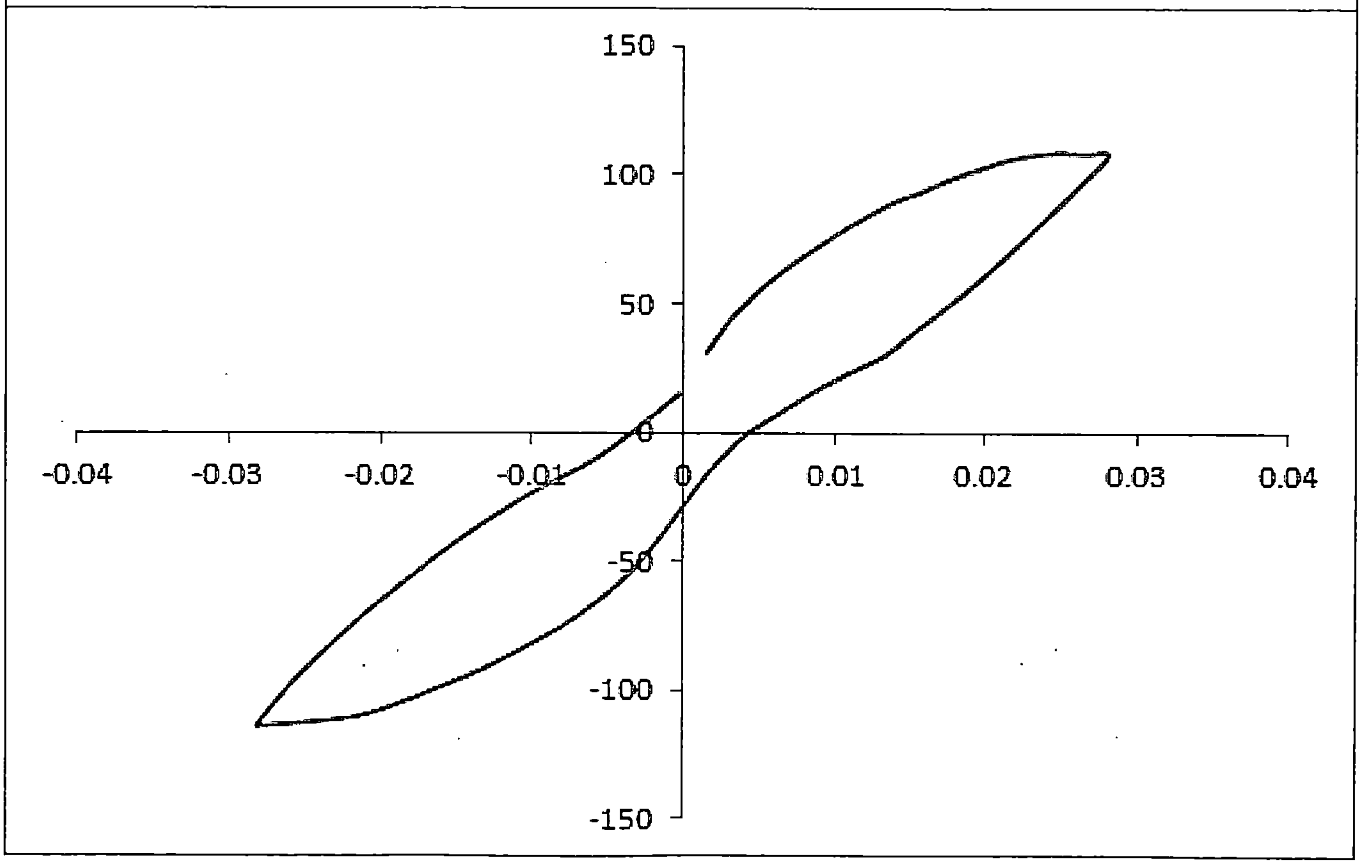
700 South Flower Street, Suite 2100 Los Angeles, CA 90017 (213) 418-0201	Cyclic Degradation		





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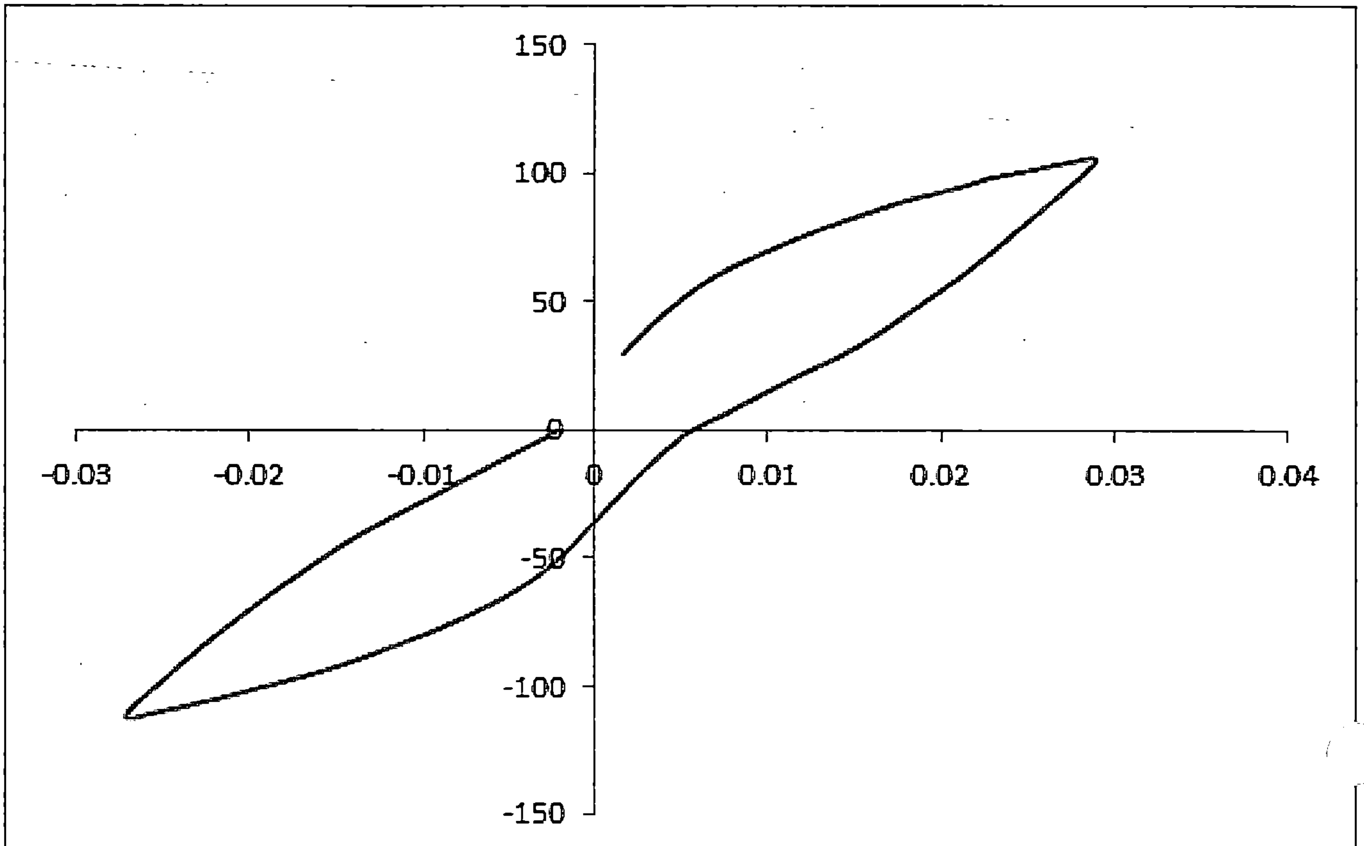

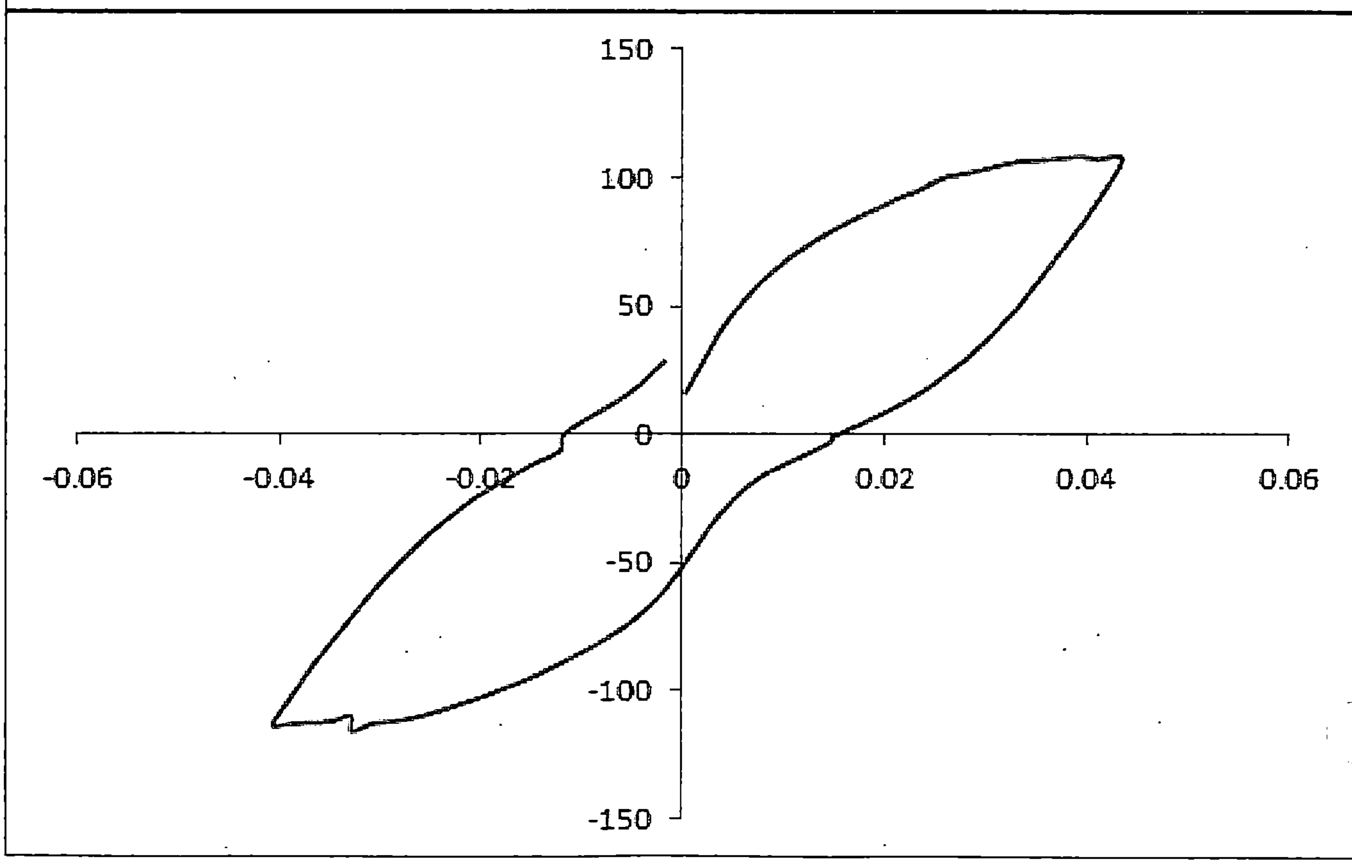

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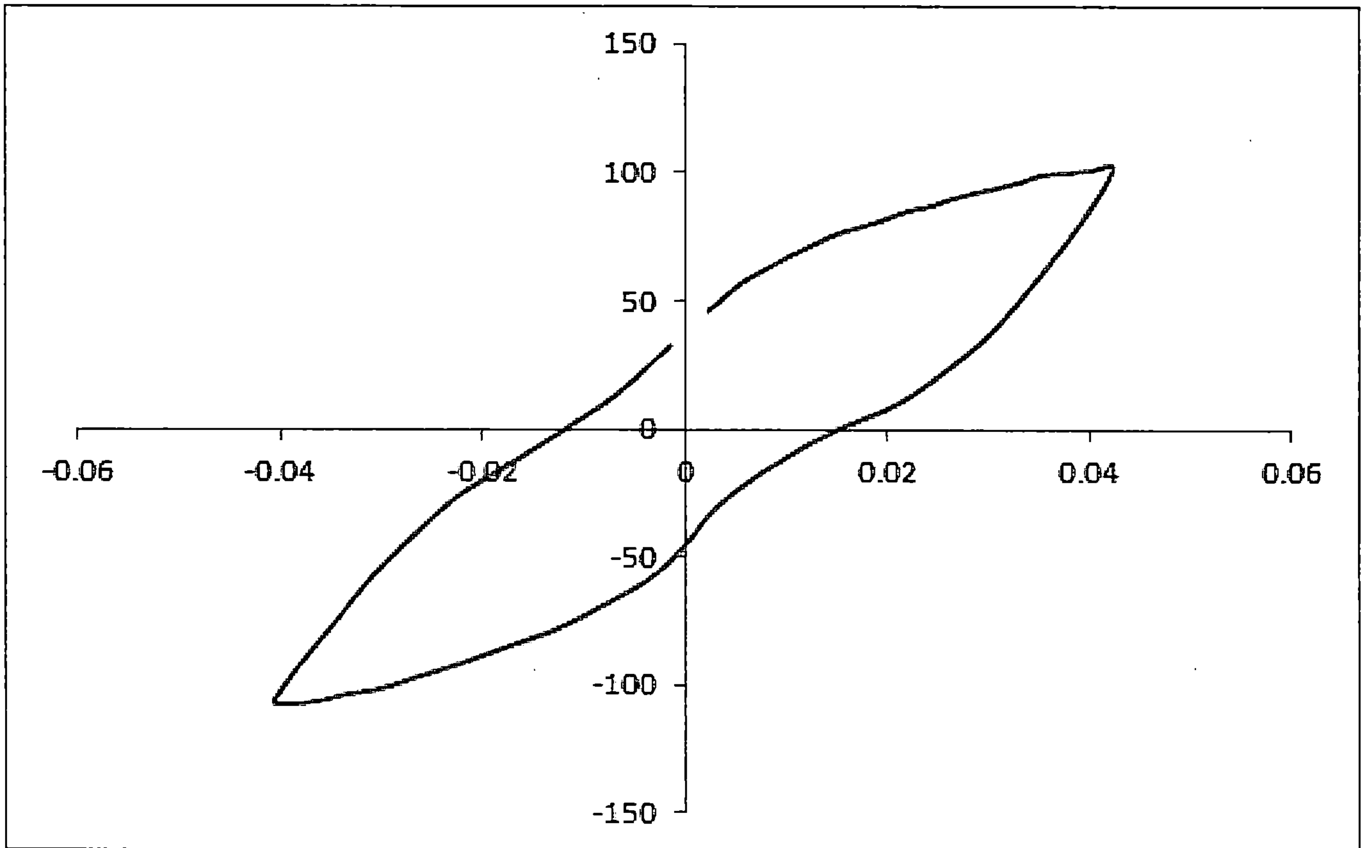

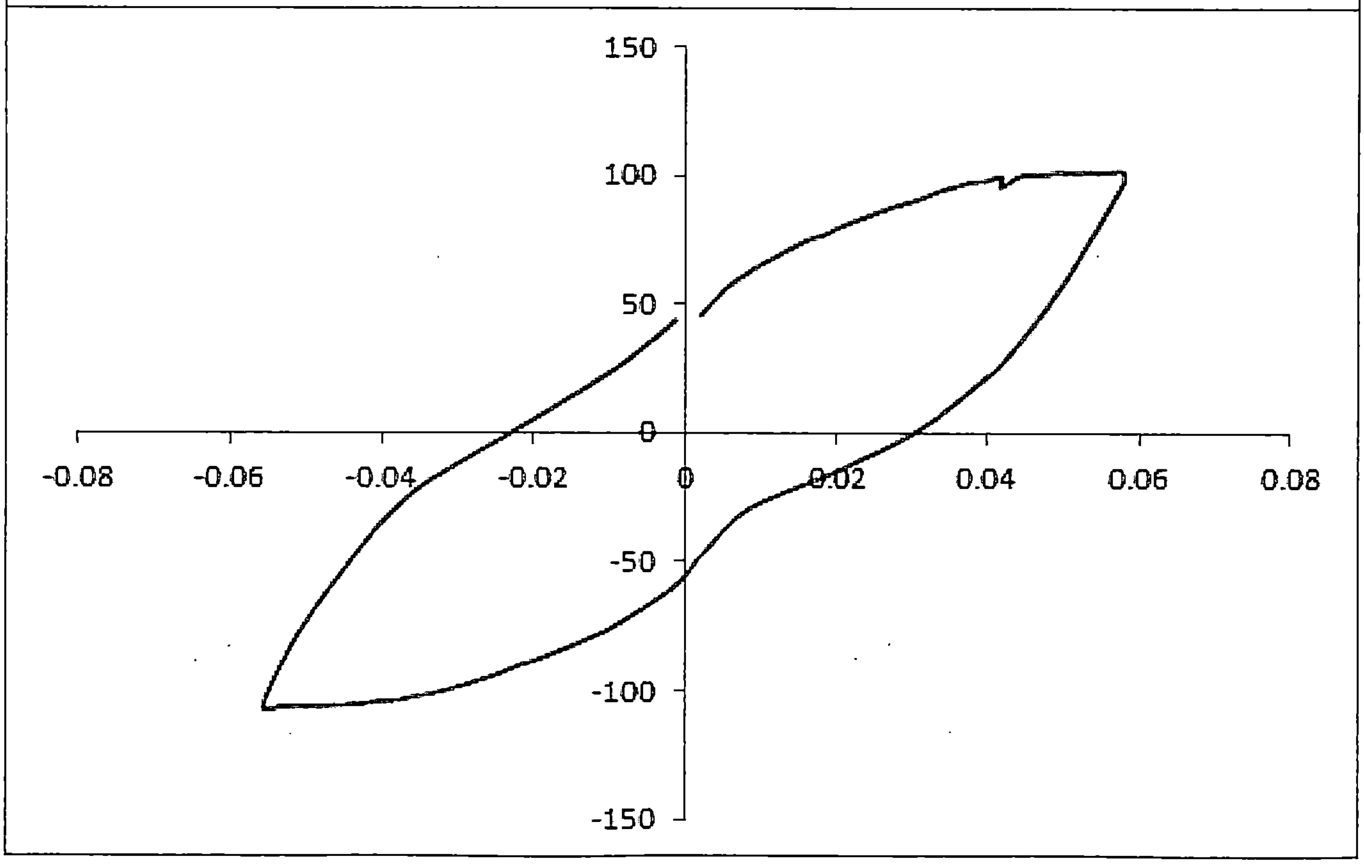

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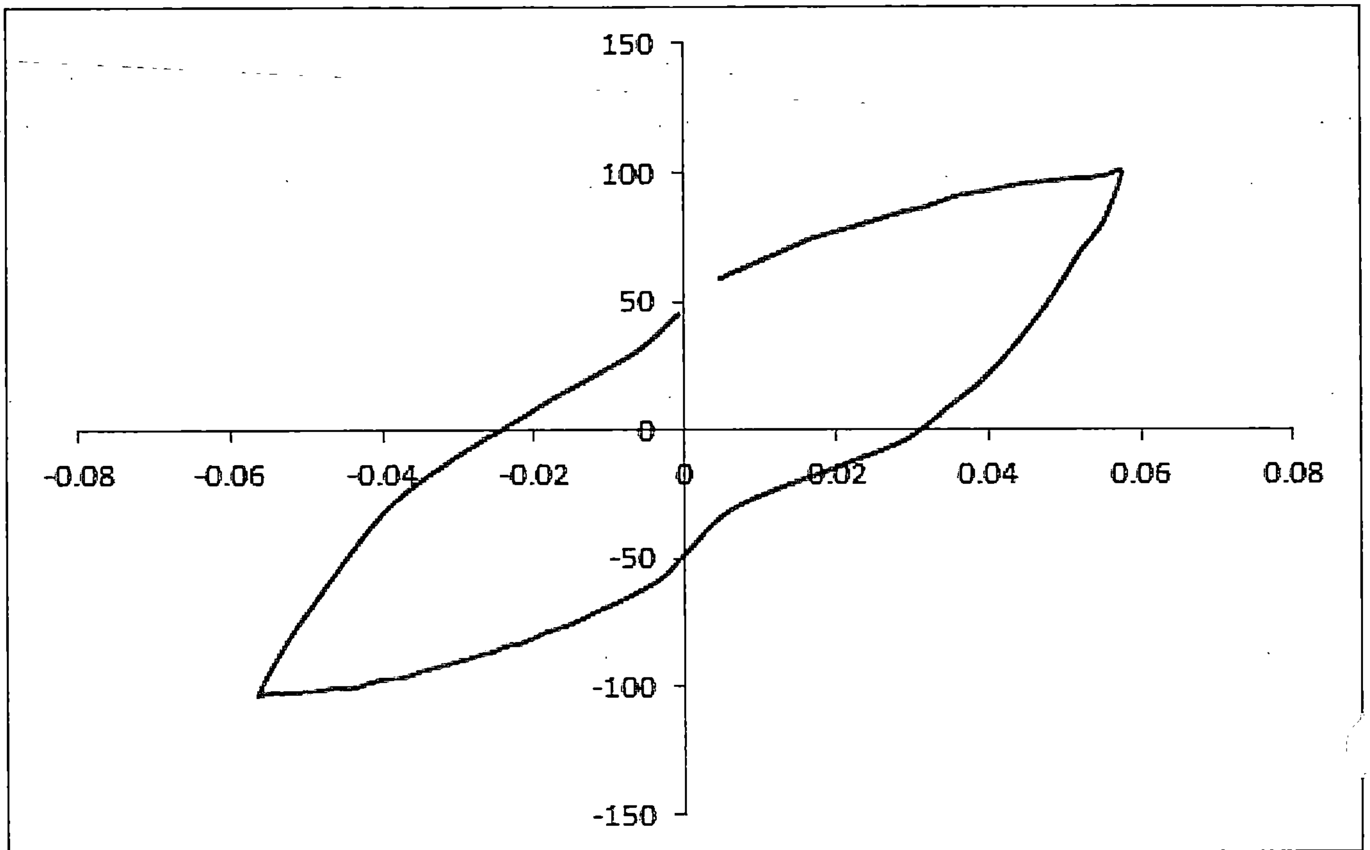

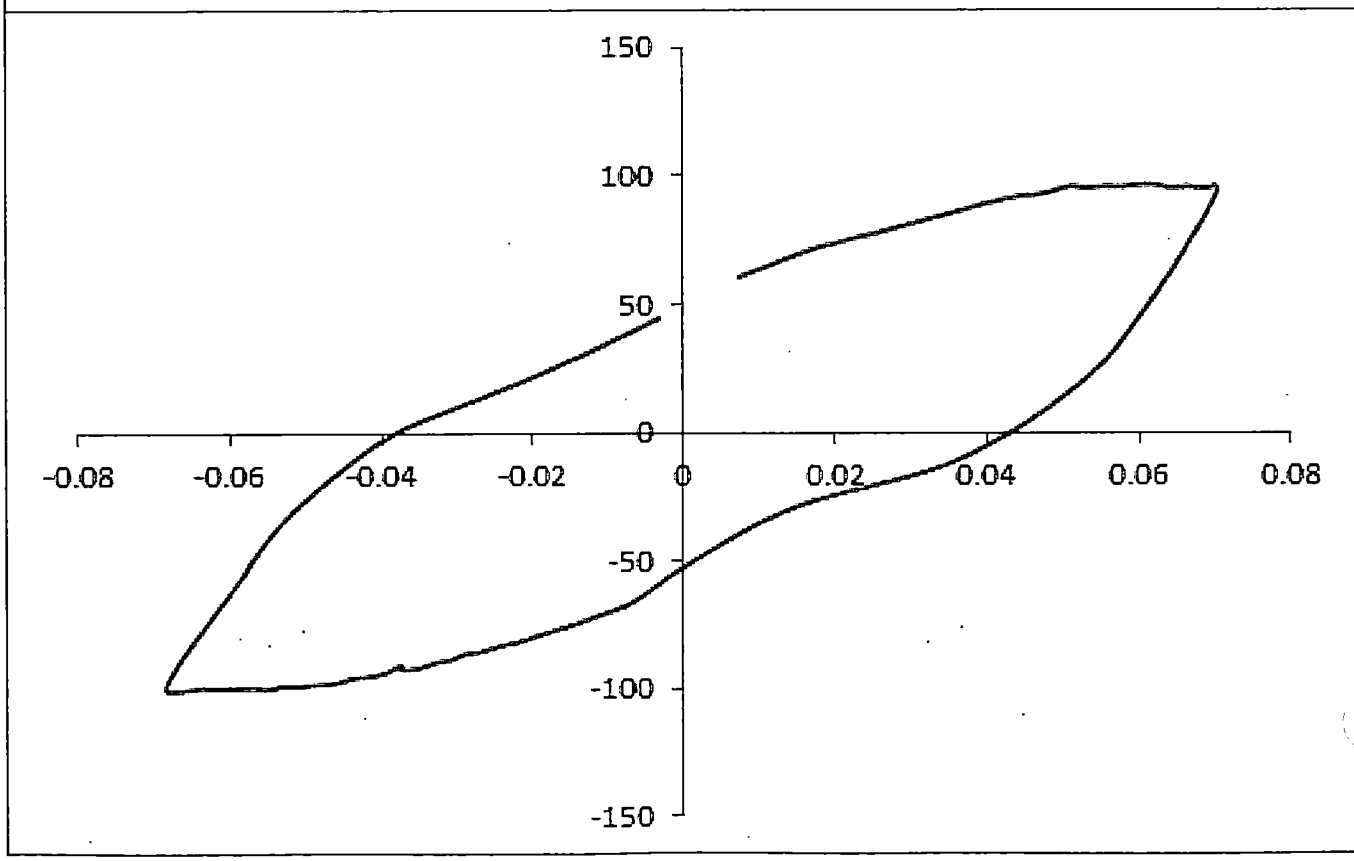

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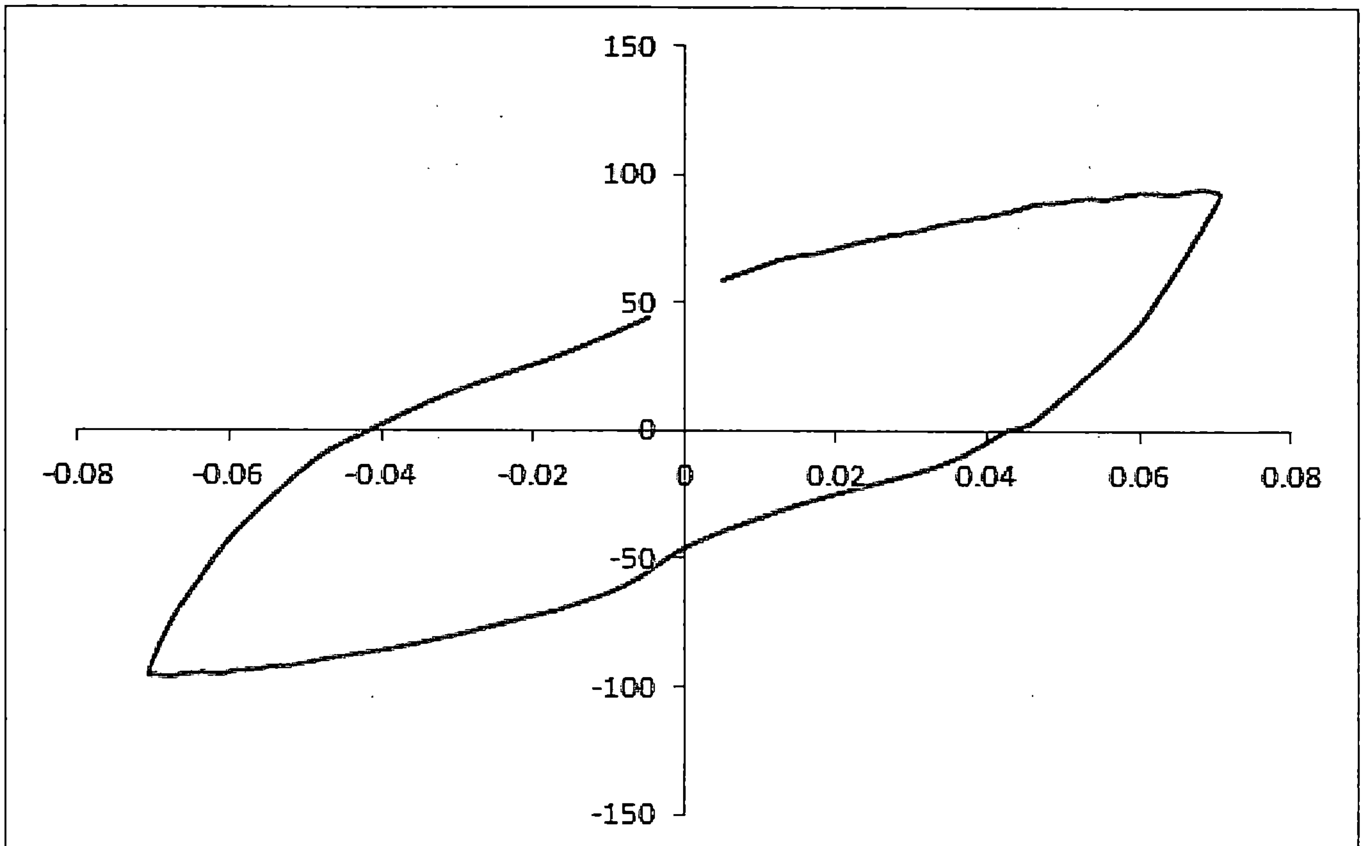
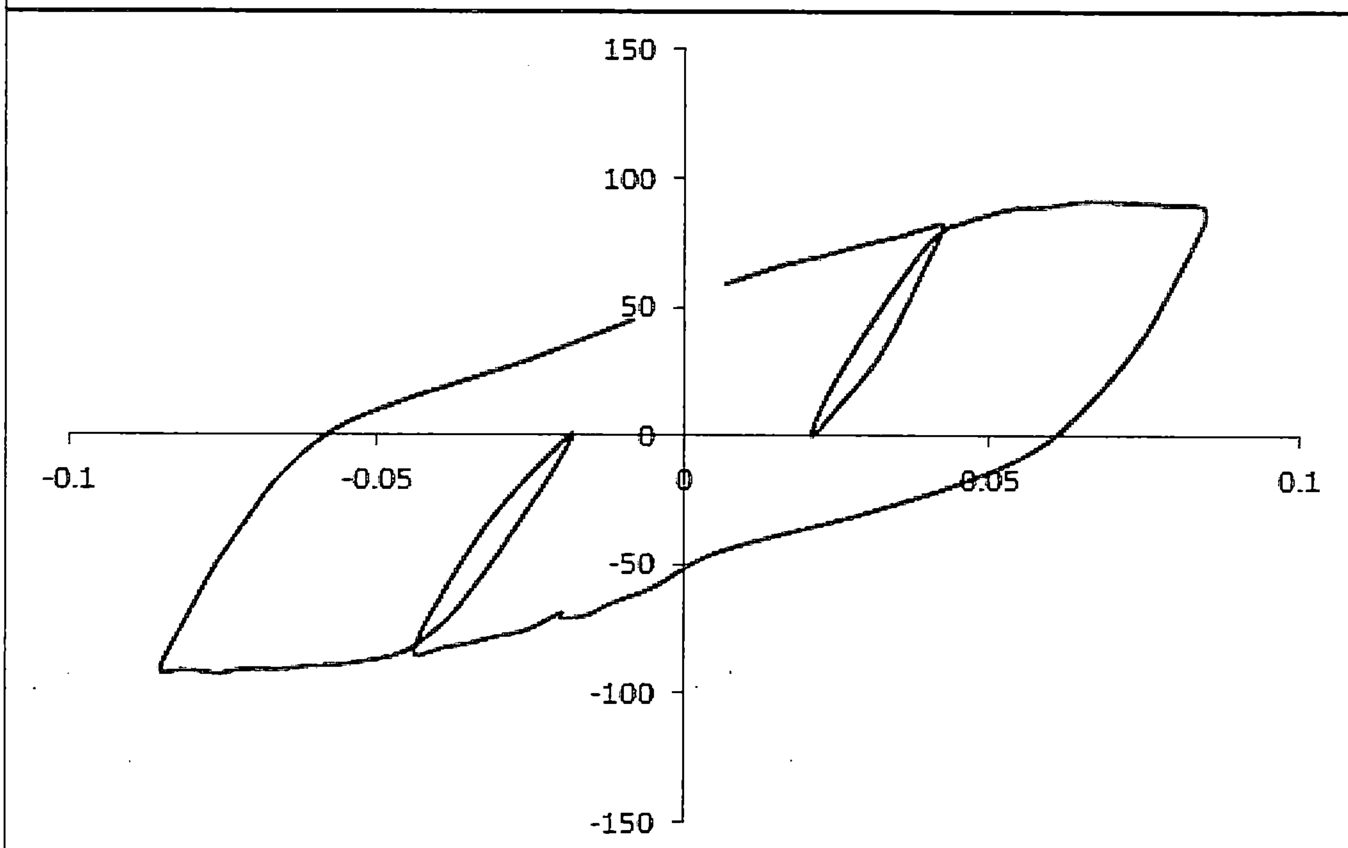
location	date	15-17
client	job no.	





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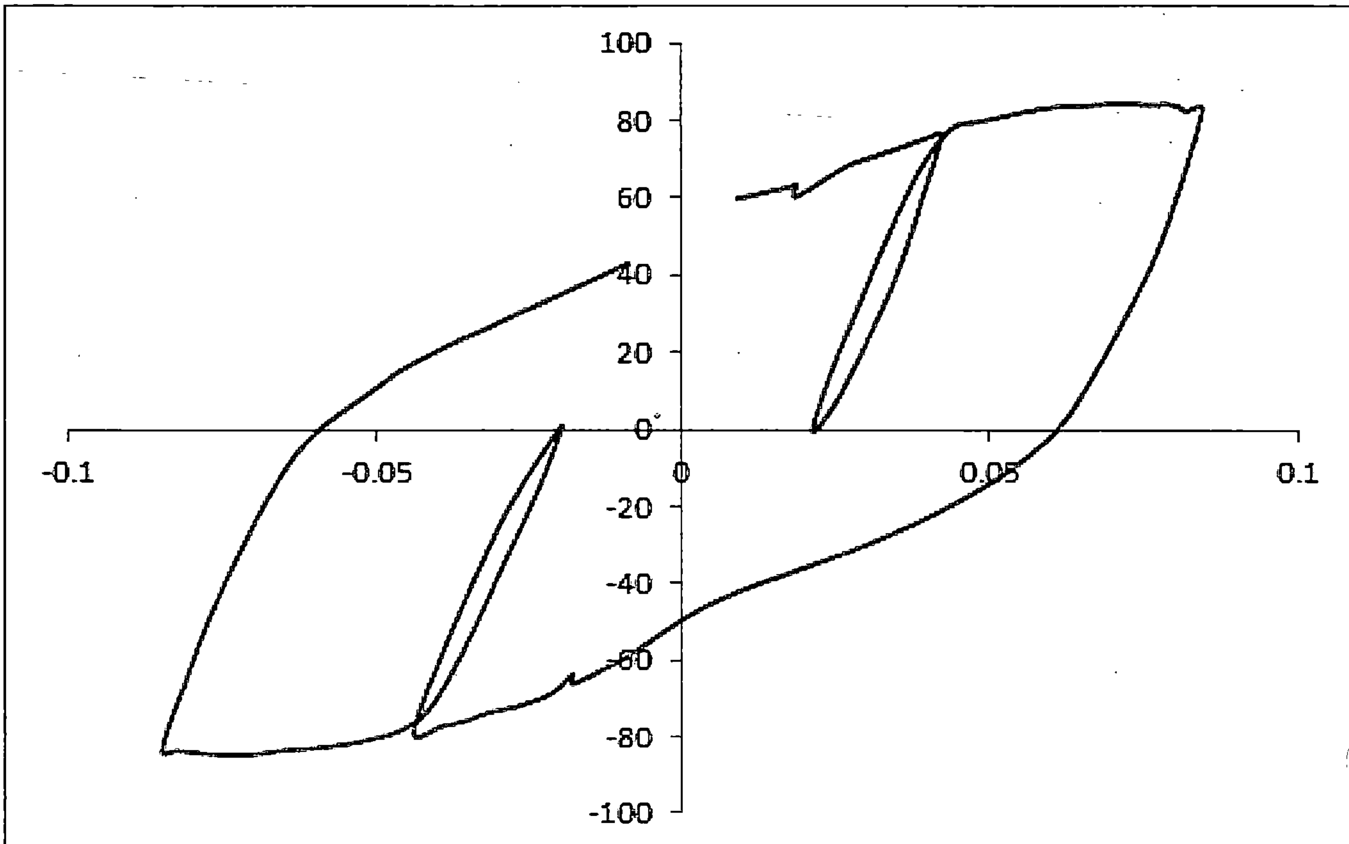
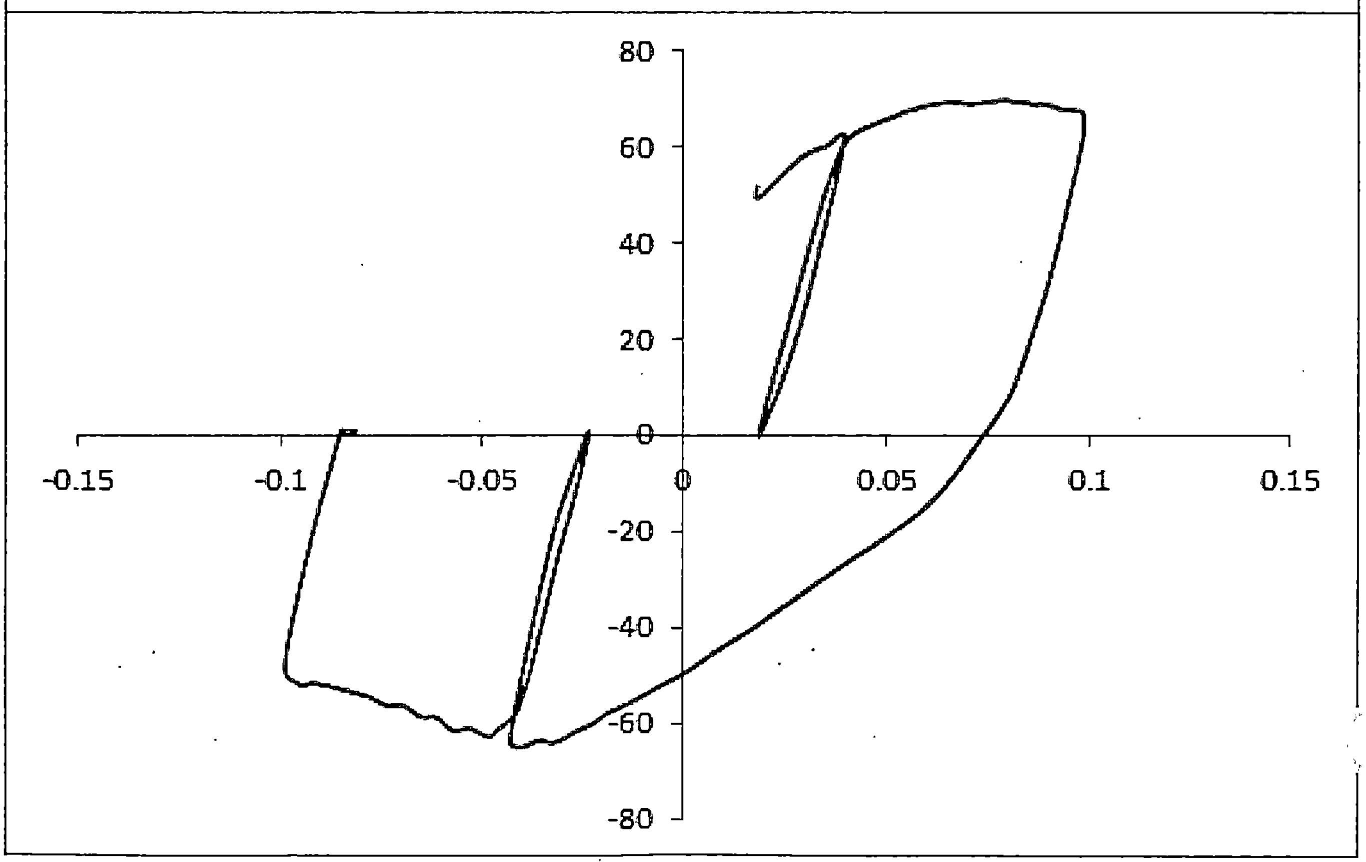
client		job no. 2000362	
Cyclic Degradation			





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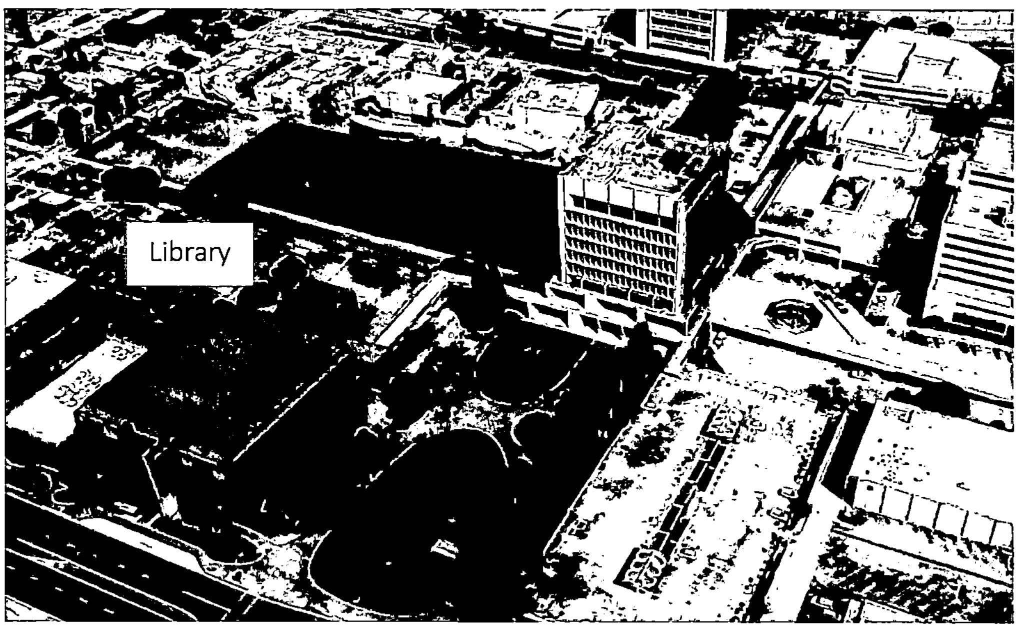
City of Inglewood, California

Voluntary Seismic Improvement of Civic Center: Library Building

Based on Nonlinear Analysis Procedures

Structural Calculations
Volume 2



KPFF JOB # 10012000362

October 22, 2021

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Appendix

A - Nonlinear Analysis Results & Performance Assessment

A.1 - Global Response Results

Executive Summary

This section includes global results for both hazard levels including Upper and Lower Bound Damper properties. All results are the peak average of 11 ground motions.

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	client	job no. 2000362	
	Global Response Results		

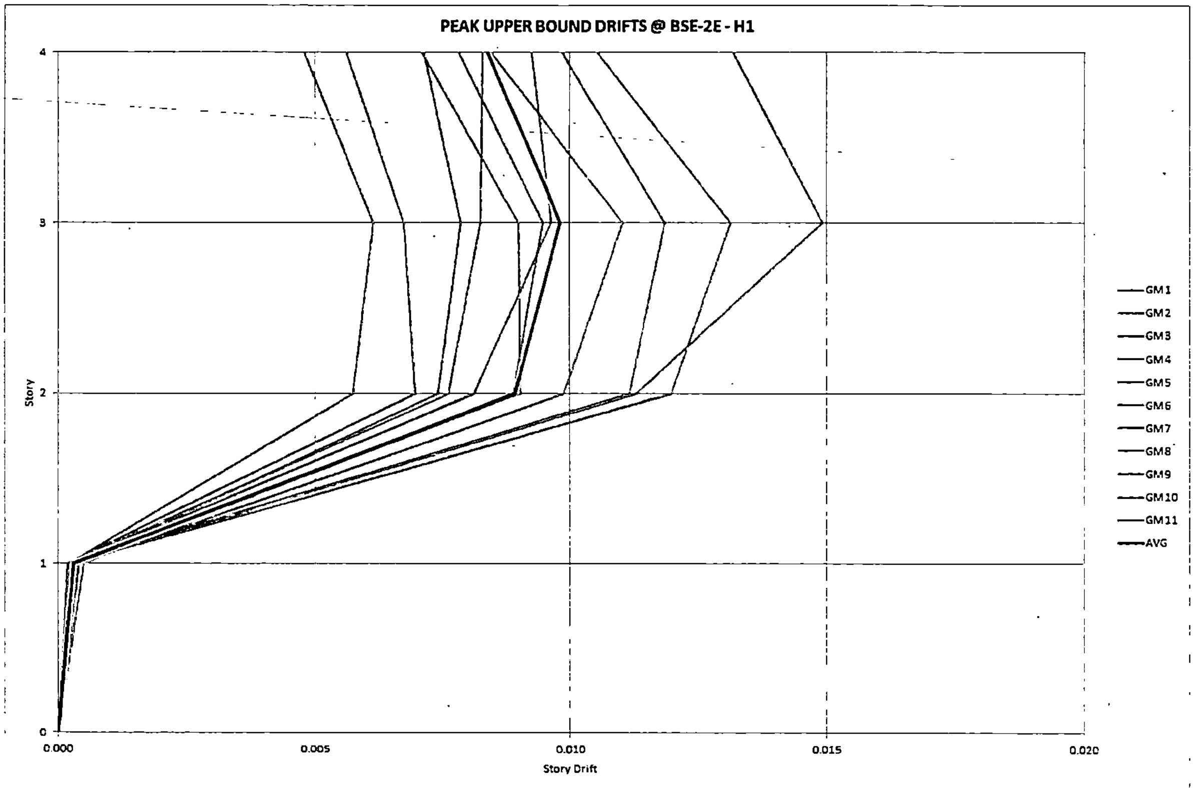

Figure A.1-1 Peak Upper Bound Drifts at the BSE-2E Hazard Level in the H1 Direction

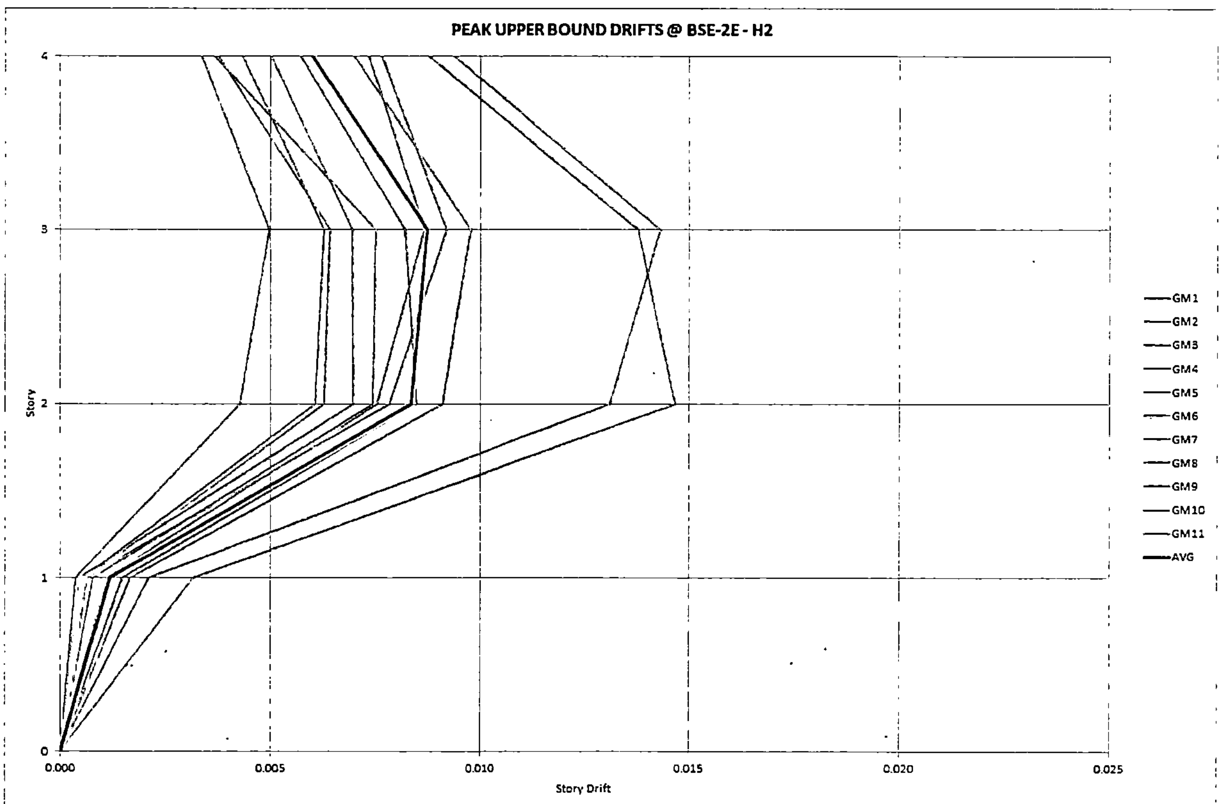

Figure A.1-2 Peak Upper Bound Drifts at the BSE-2E Hazard Level in the H2 Direction

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	Global Response Results		

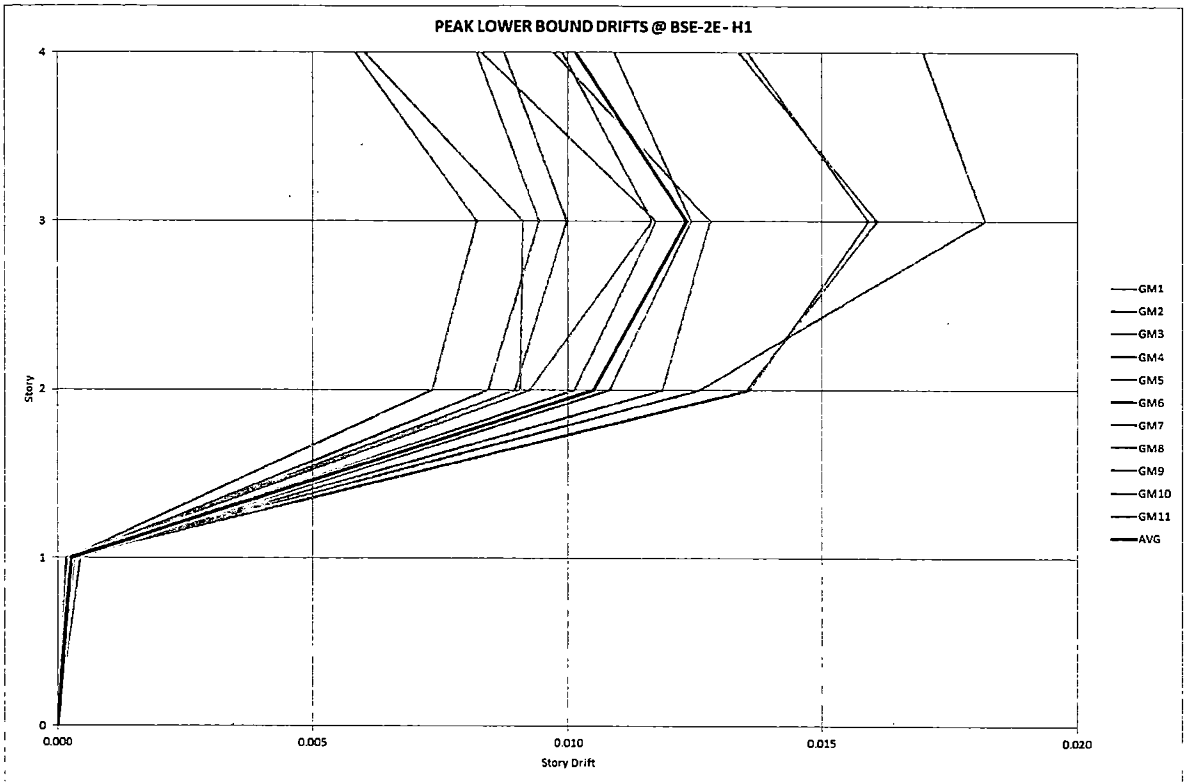

Figure A.1-3 Peak Lower Bound Drifts at the BSE-2E Hazard Level in the H1 Direction

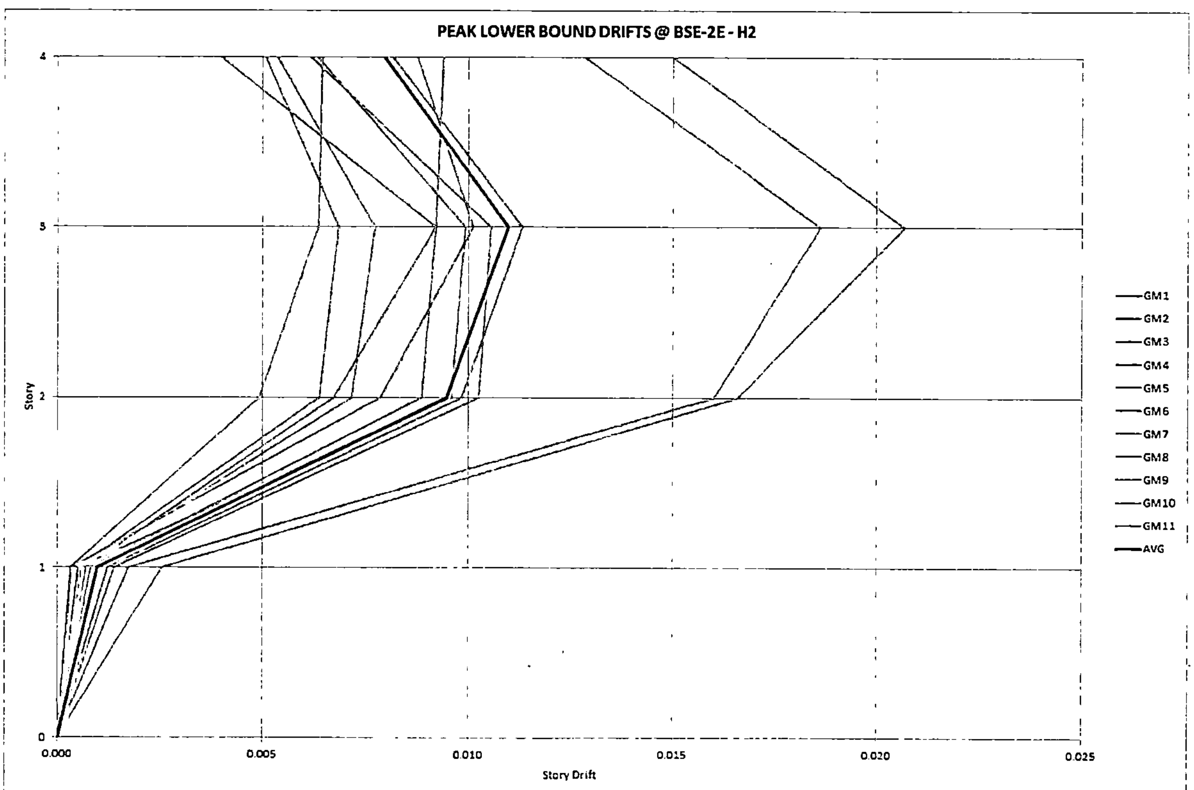

Figure A.1-4 Peak Lower Bound Drifts at the BSE-2E Hazard Level in the H2 Direction

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	location Inglewood, CA	date 10/18/21	
	client	job no. 2000362	
	Global Response Results		

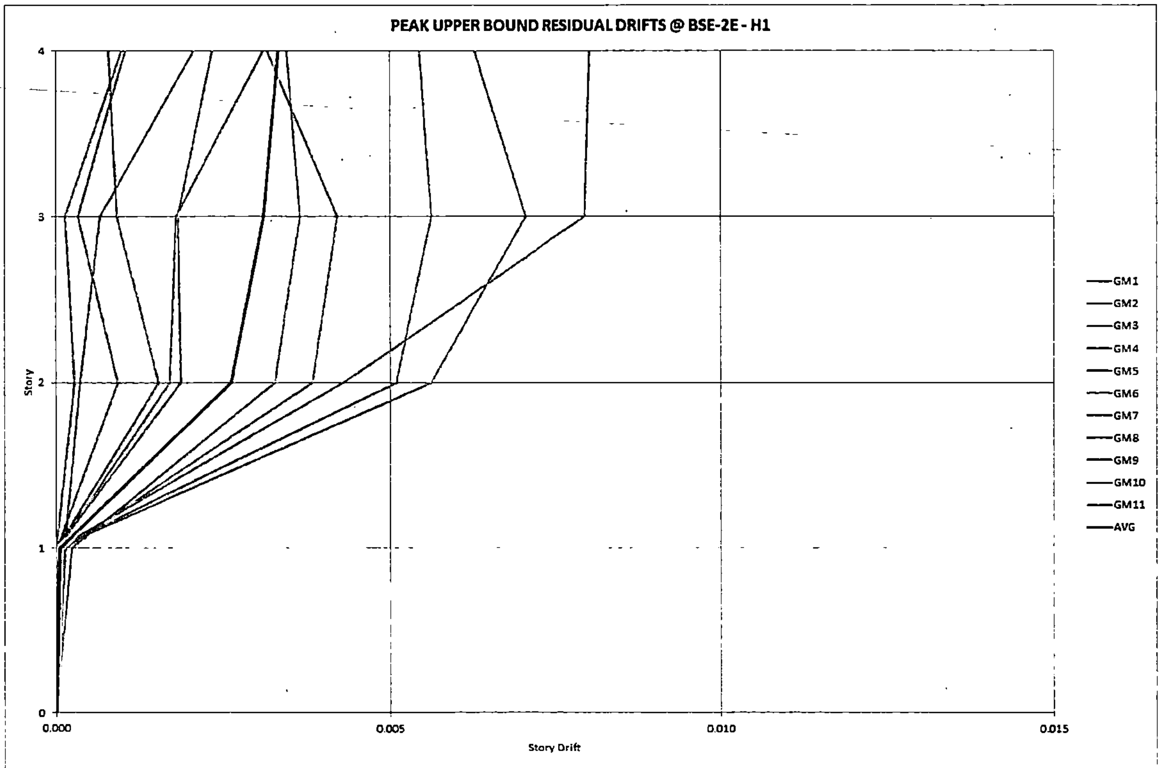

Figure A.1-5 Peak Upper Bound Residual Drifts at the BSE-2E Hazard Level in the H1 Direction

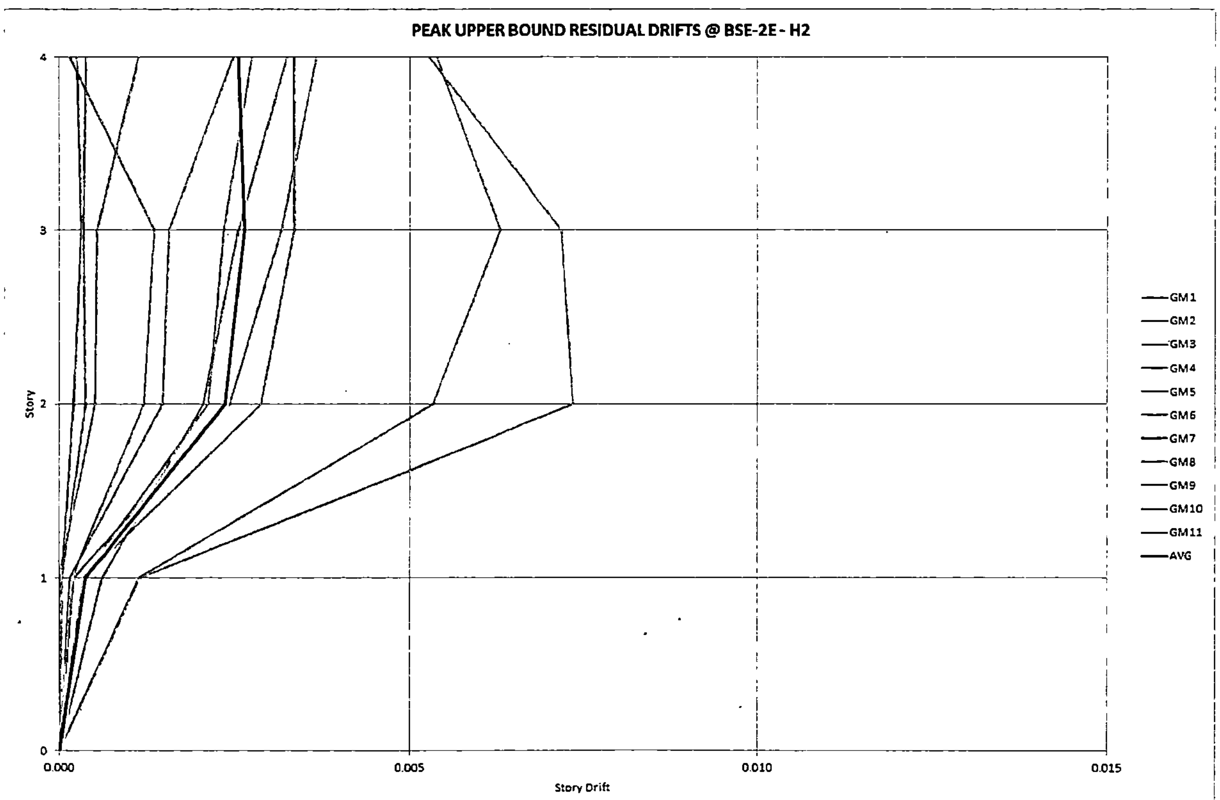

Figure A.1-6 Peak Upper Bound Residual Drifts at the BSE-2E Hazard Level in the H2 Direction

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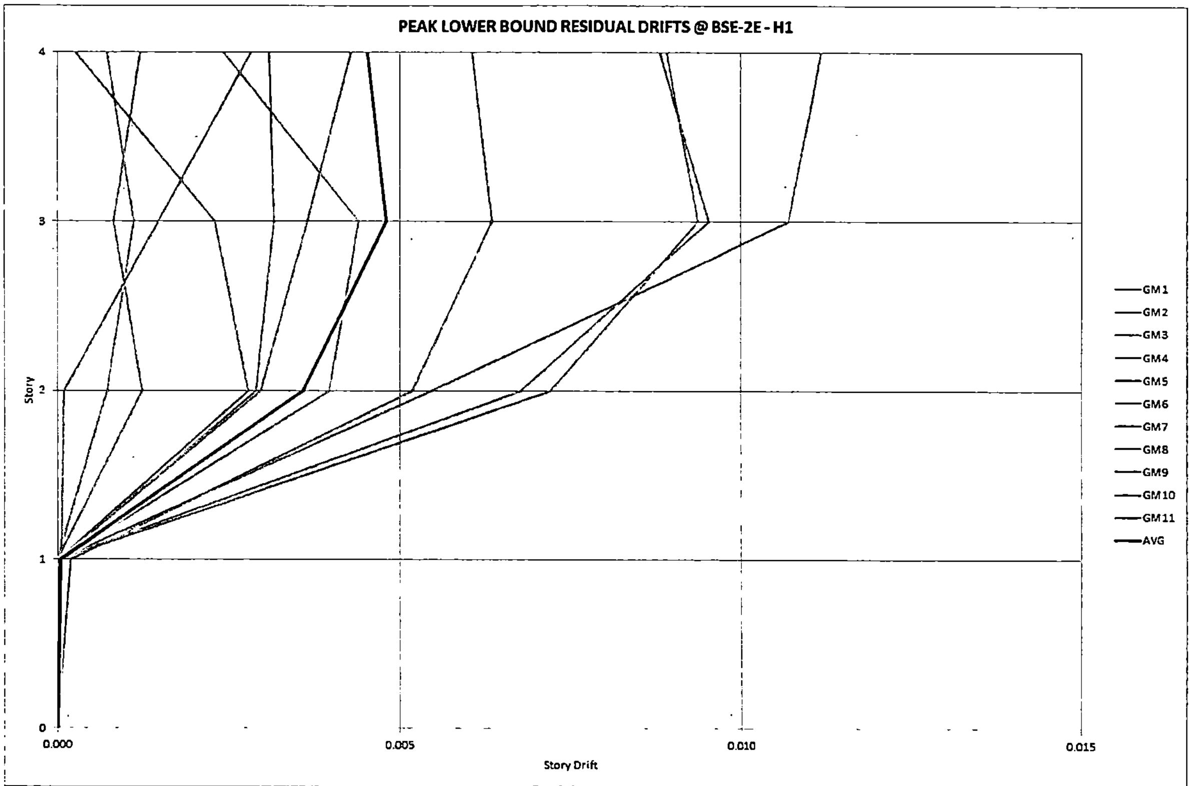

Figure A.1-7 Peak Lower Bound Residual Drifts at the BSE-2E Hazard Level in the H1 Direction

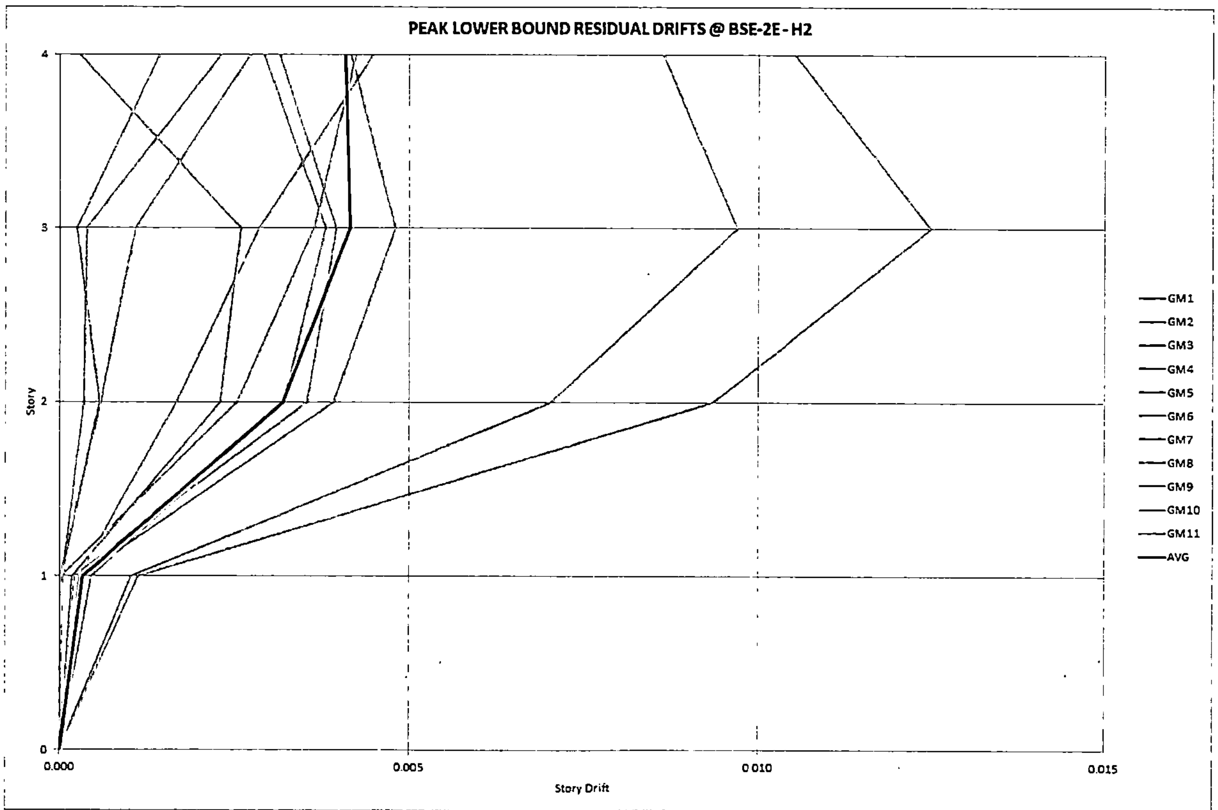

Figure A.1-8 Peak Lower Bound Residual Drifts at the BSE-2E Hazard Level in the H2 Direction

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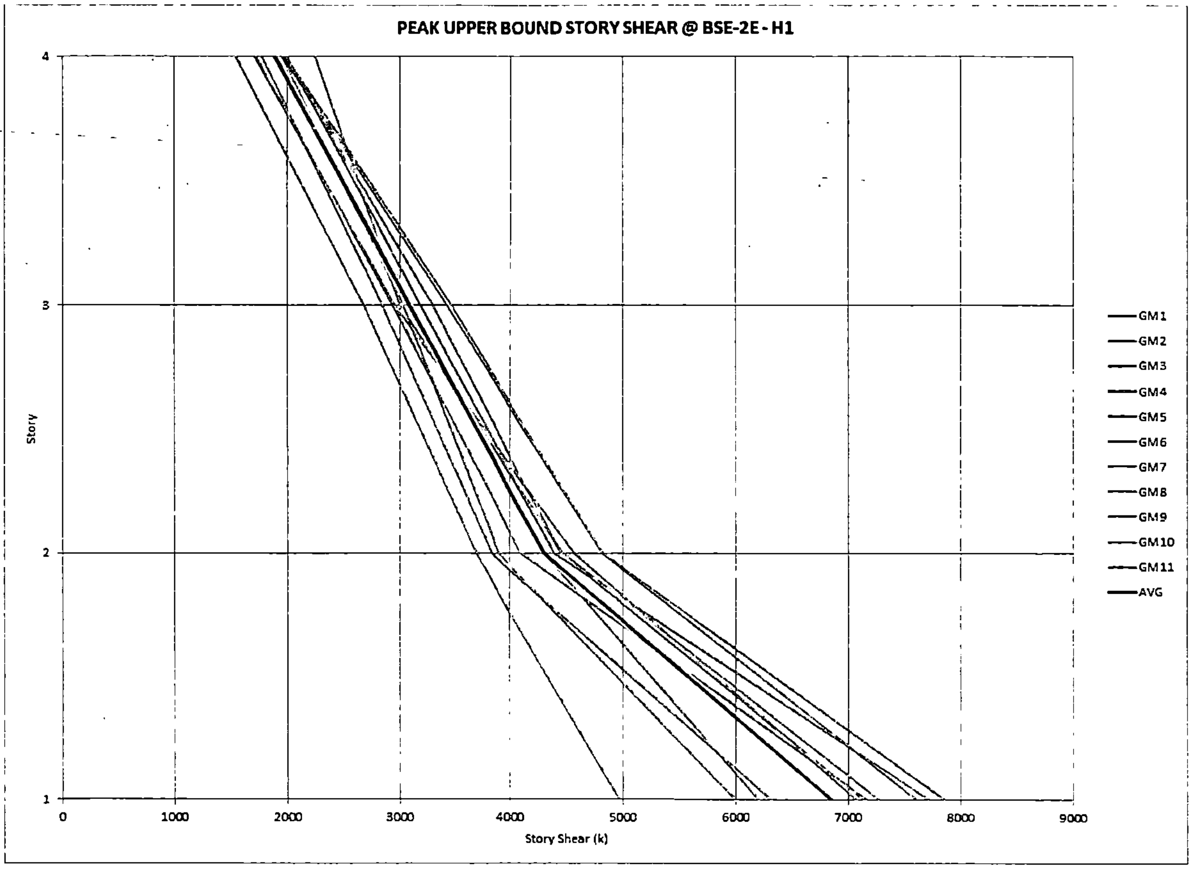

Figure A.1-9 Peak Upper Bound Story Shears at the BSE-2E Hazard Level in the H1 Direction

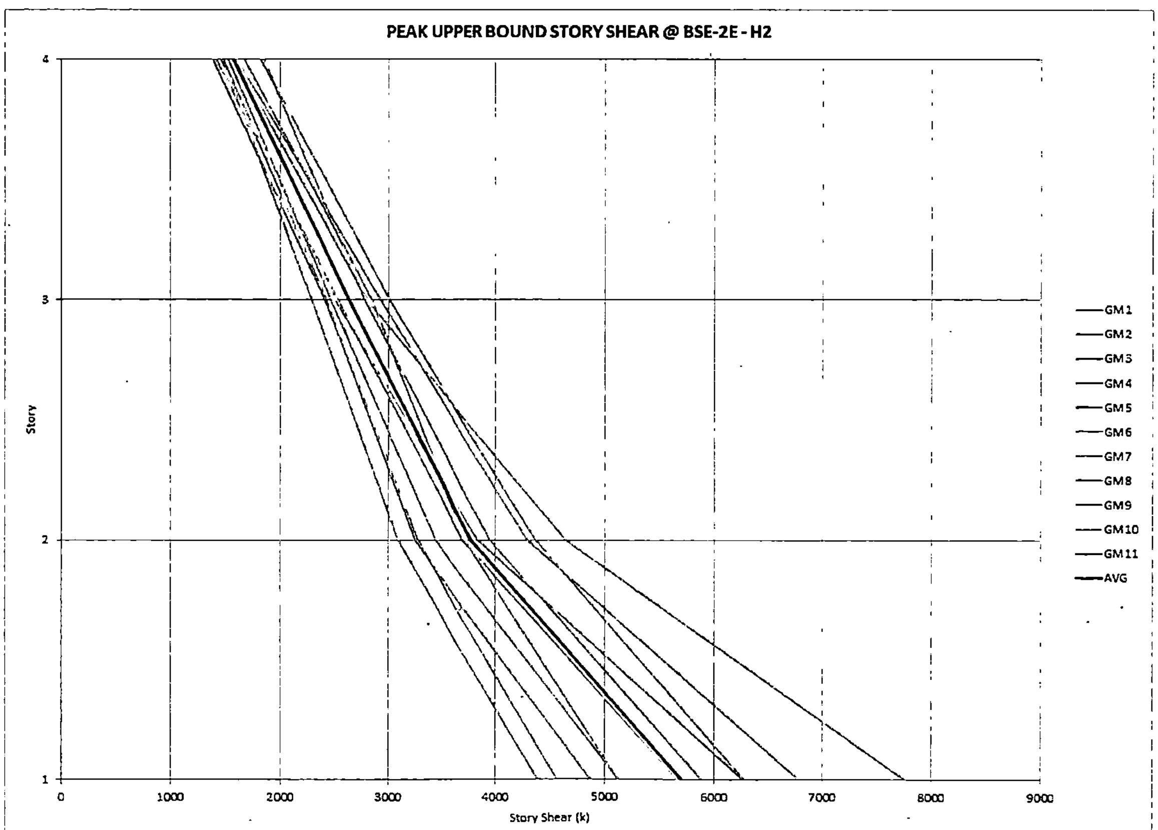

Figure A.1-10 Peak Upper Bound Story Shears at the BSE-2E Hazard Level in the H2 Direction

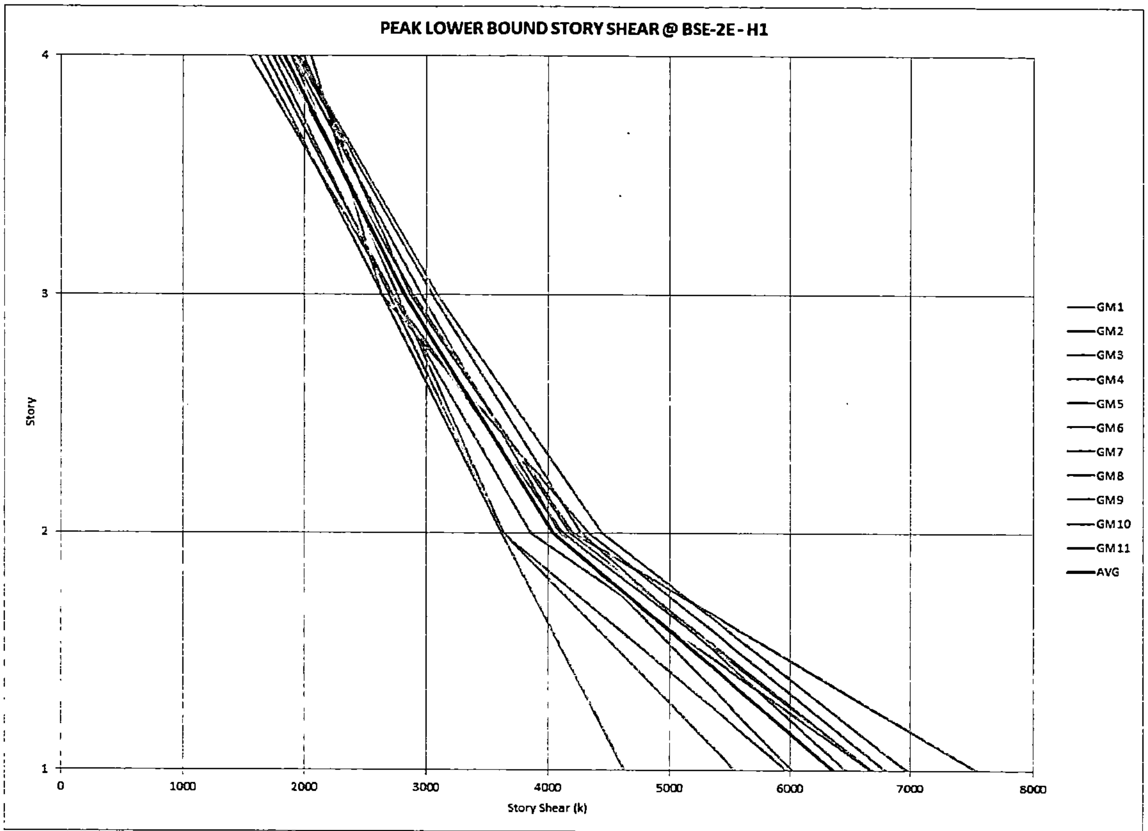

Figure A.1-11 Peak Lower Bound Story Shears at the BSE-2E Hazard Level in the H1 Direction

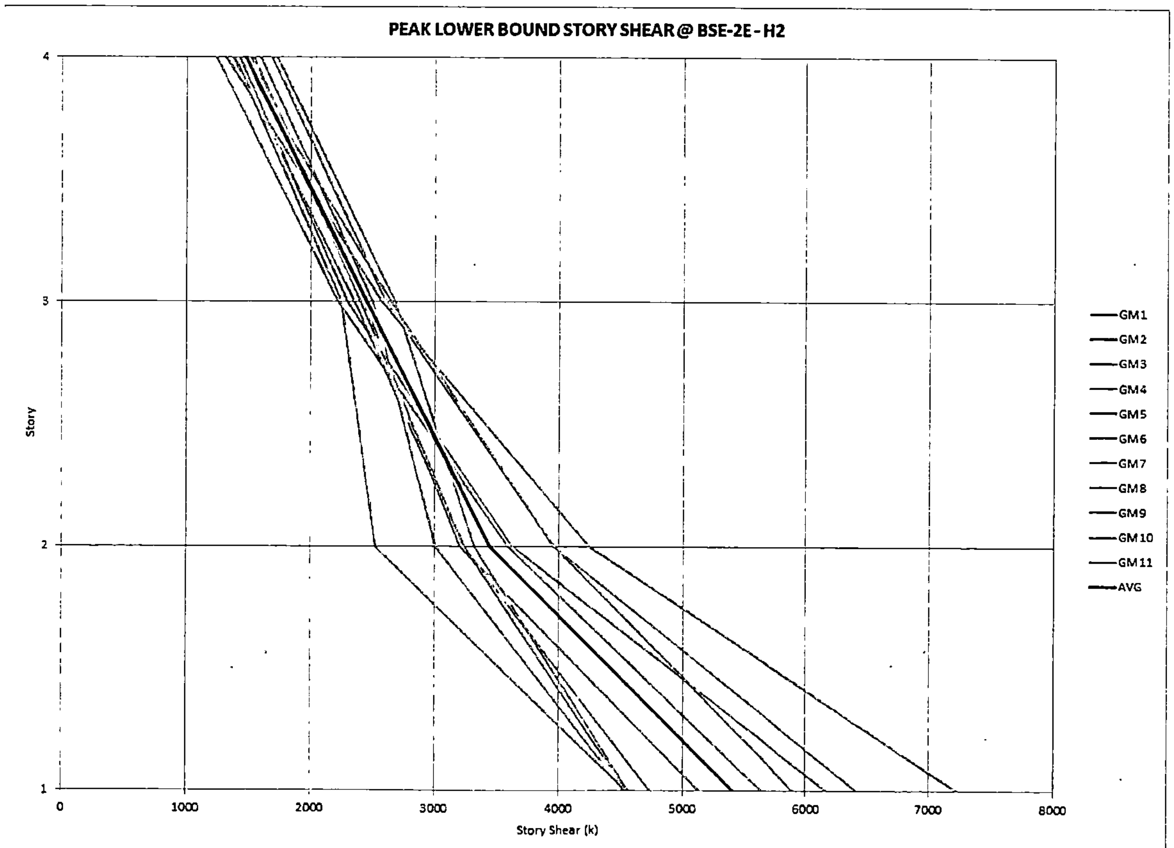

Figure A.1-12 Peak Lower Bound Story Shears at the BSE-2E Hazard Level in the H2 Direction

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	location Inglewood, CA	date 10/18/21	
	client	job no. 2000362	
	Global Response Results		

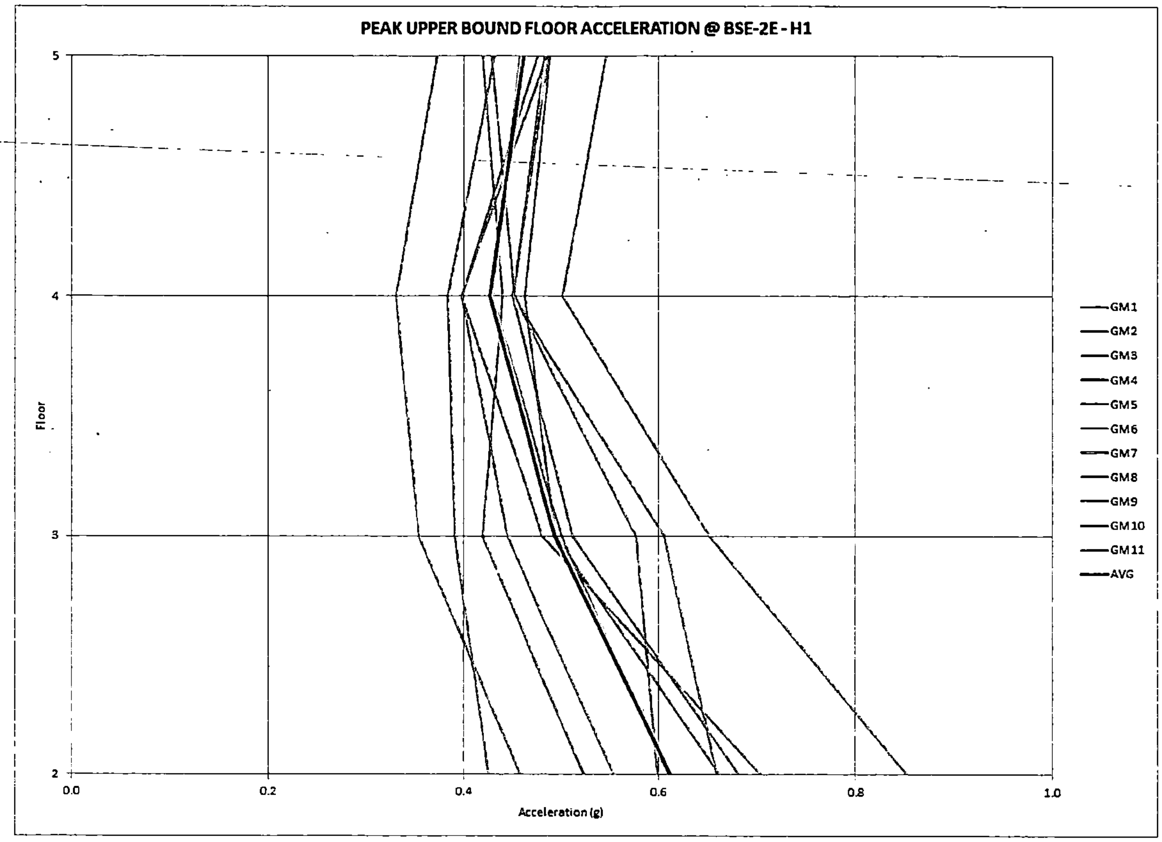

Figure A.1-13 Peak Upper Bound Floor Acceleration at the BSE-2E Hazard Level in the H1 Direction

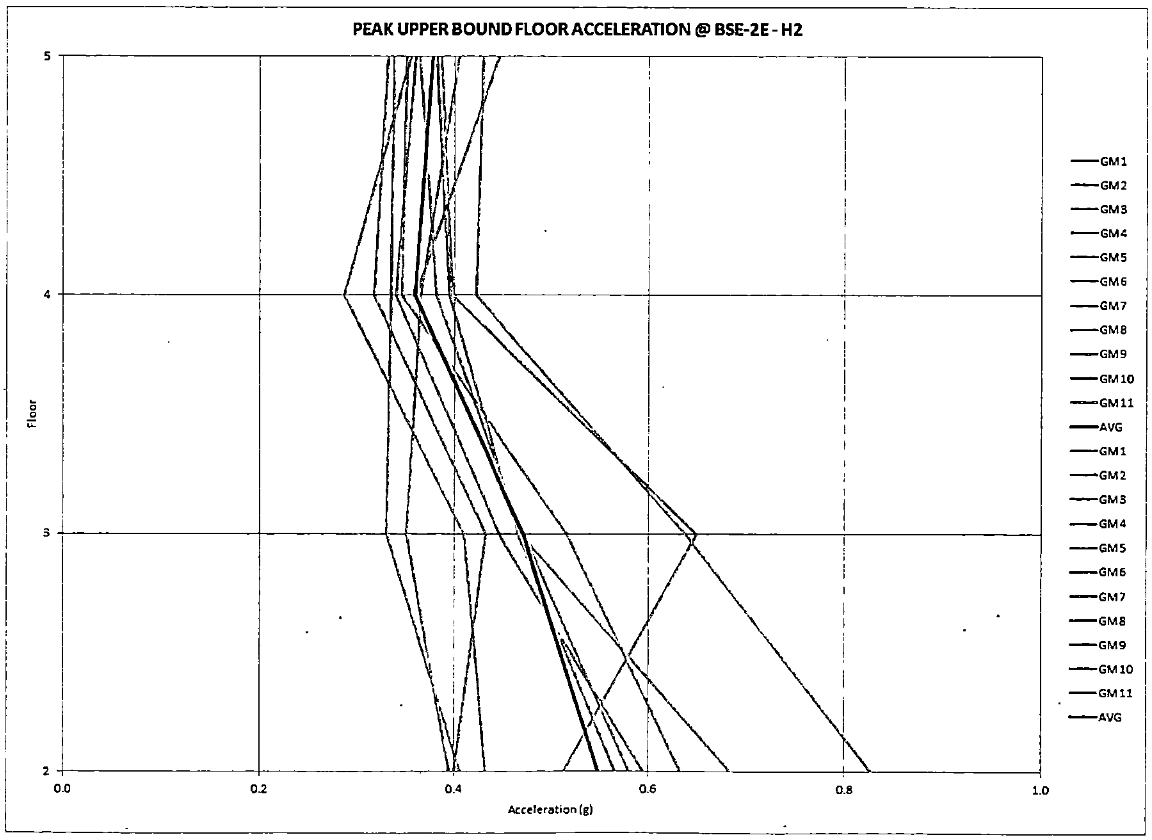

Figure A.1-14 Peak Upper Bound Floor Acceleration at the BSE-2E Hazard Level in the H2 Direction

kpff 700 South Flower Street, Suite 2100 Los Angeles, CA 90017 (213) 418-0201	project City of Inglewood - Library	by JL	sheet no. A.1-10
	location Inglewood, CA	date 10/18/21	
	client	job no. 2000362	
	Global Response Results		

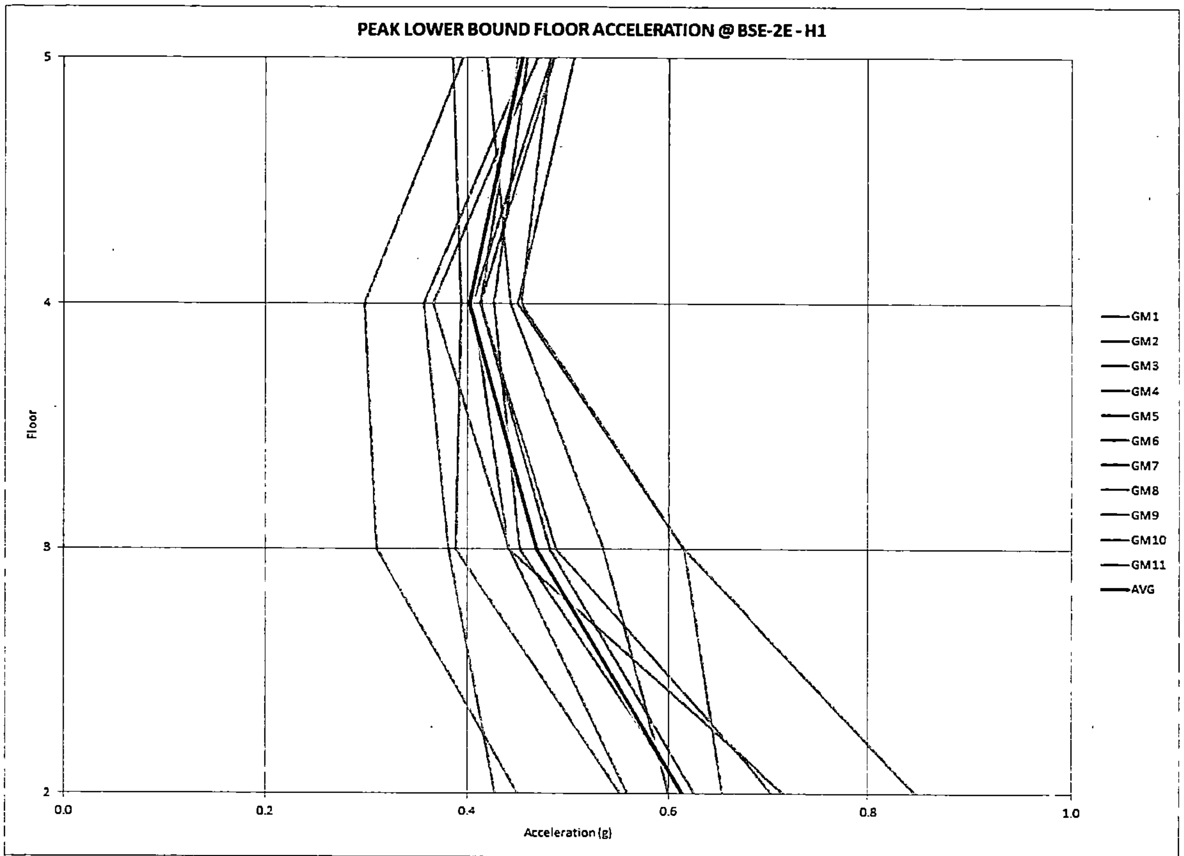

Figure A.1-15 Peak Lower Bound Floor Acceleration at the BSE-2E Hazard Level in the H1 Direction

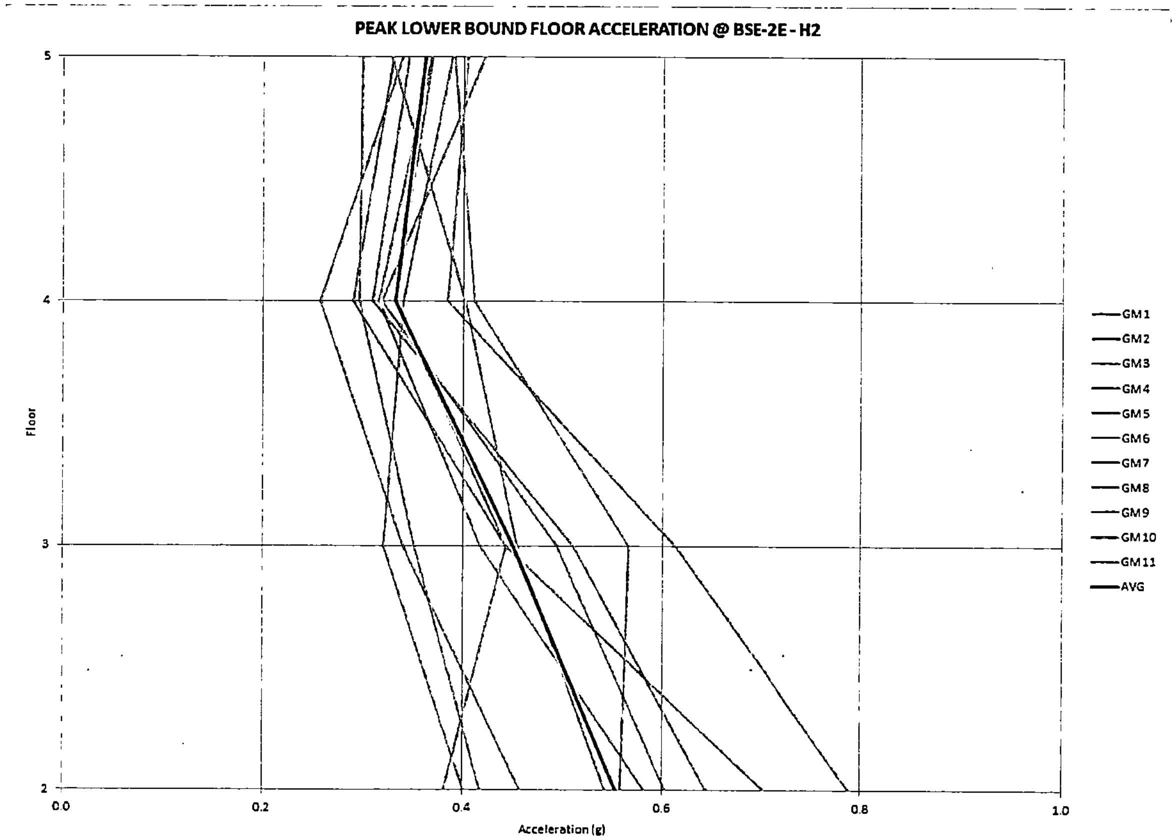

Figure A.1-16 Peak Lower Bound Floor Acceleration at the BSE-2E Hazard Level in the H2 Direction

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	client	job no. 2000362	
	Global Response Results		

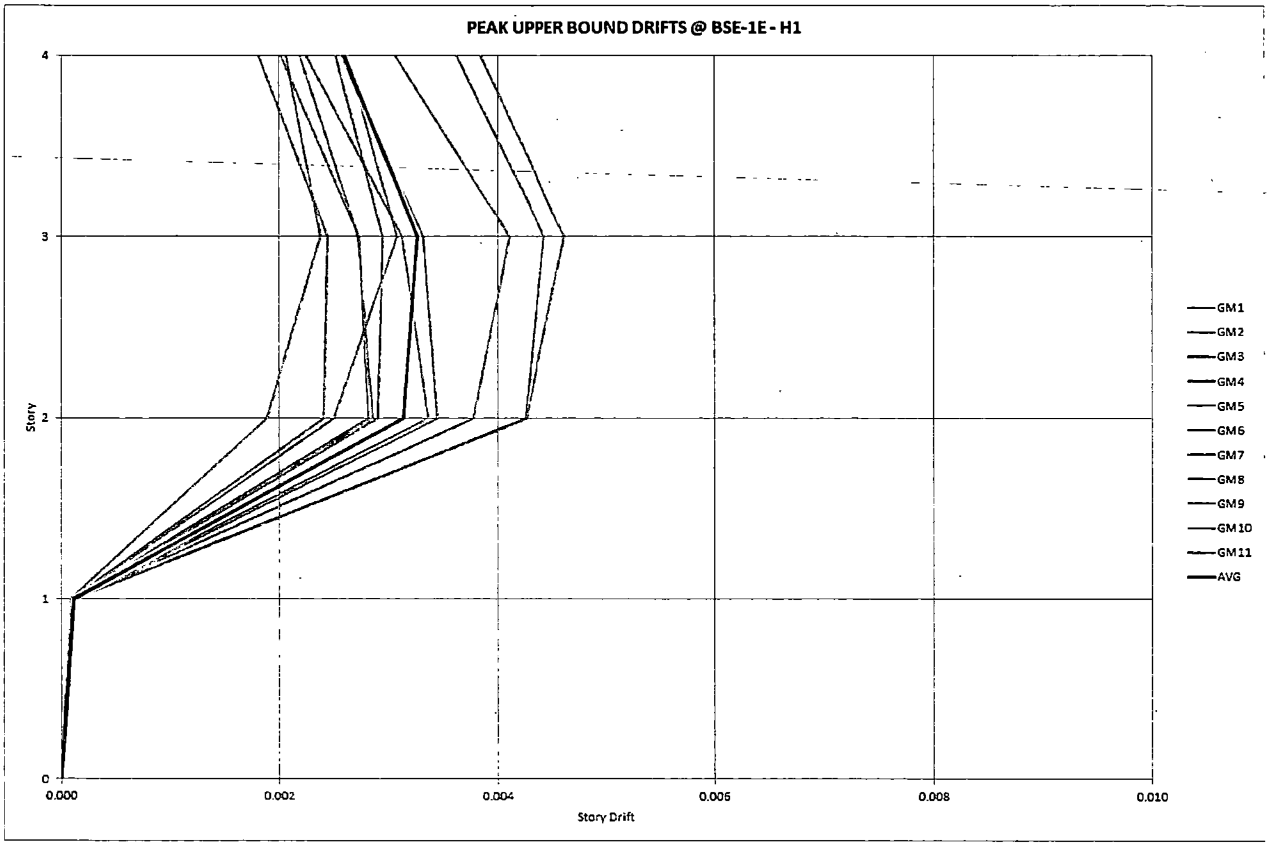

Figure A.1-17 Peak Upper Bound Drifts at the BSE-1E Hazard Level in the H1 Direction

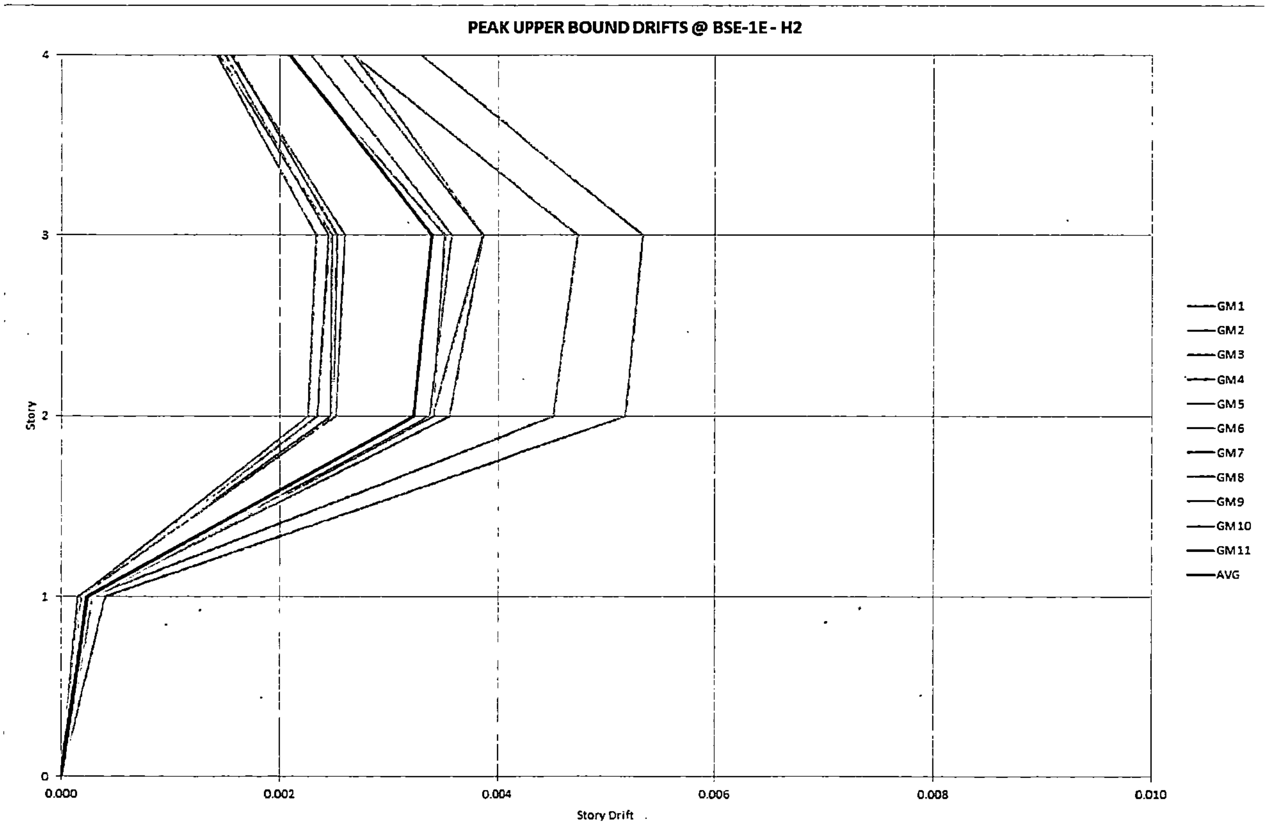

Figure A.1-18 Peak Upper Bound Drifts at the BSE-1E Hazard Level in the H2 Direction

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Global Response Results		

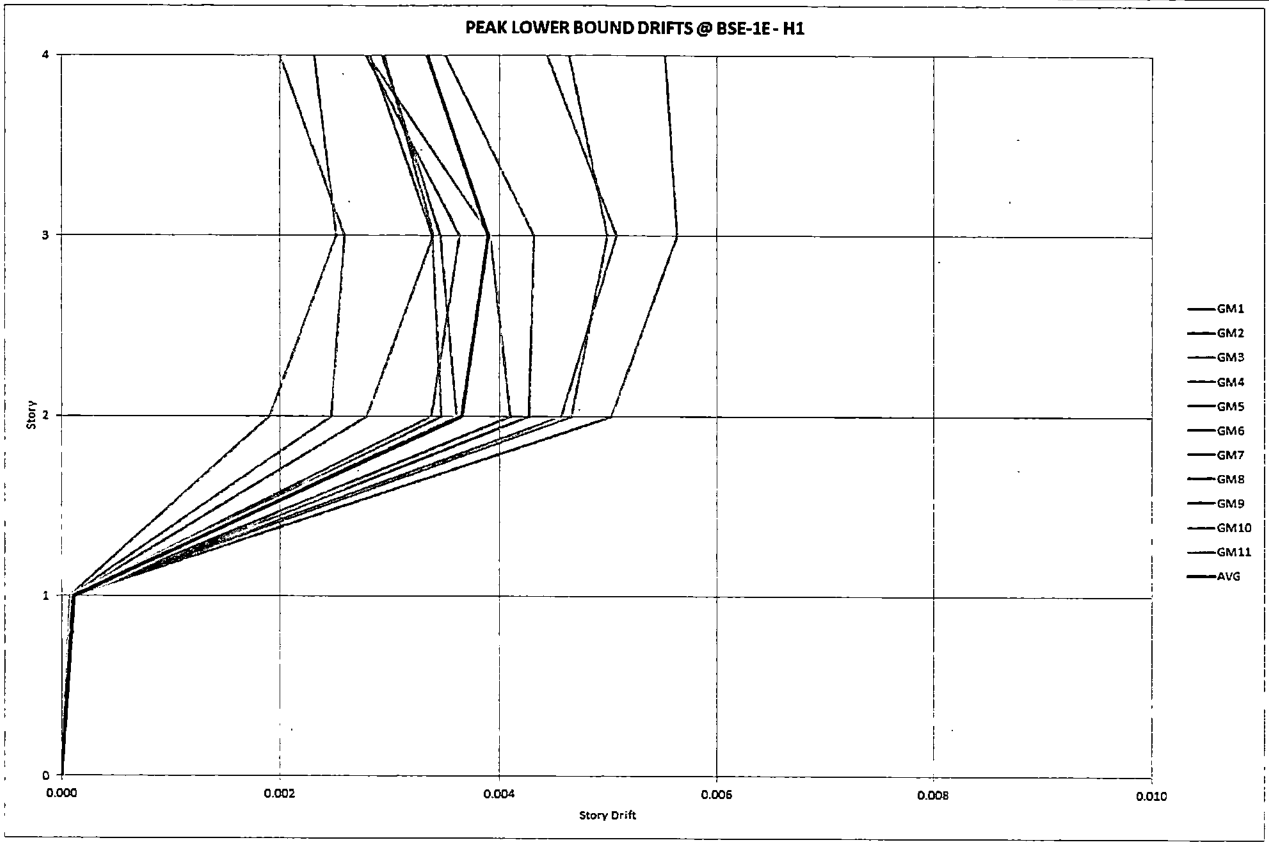

Figure A.1-19 Peak Lower Bound Drifts at the BSE-1E Hazard Level in the H1 Direction

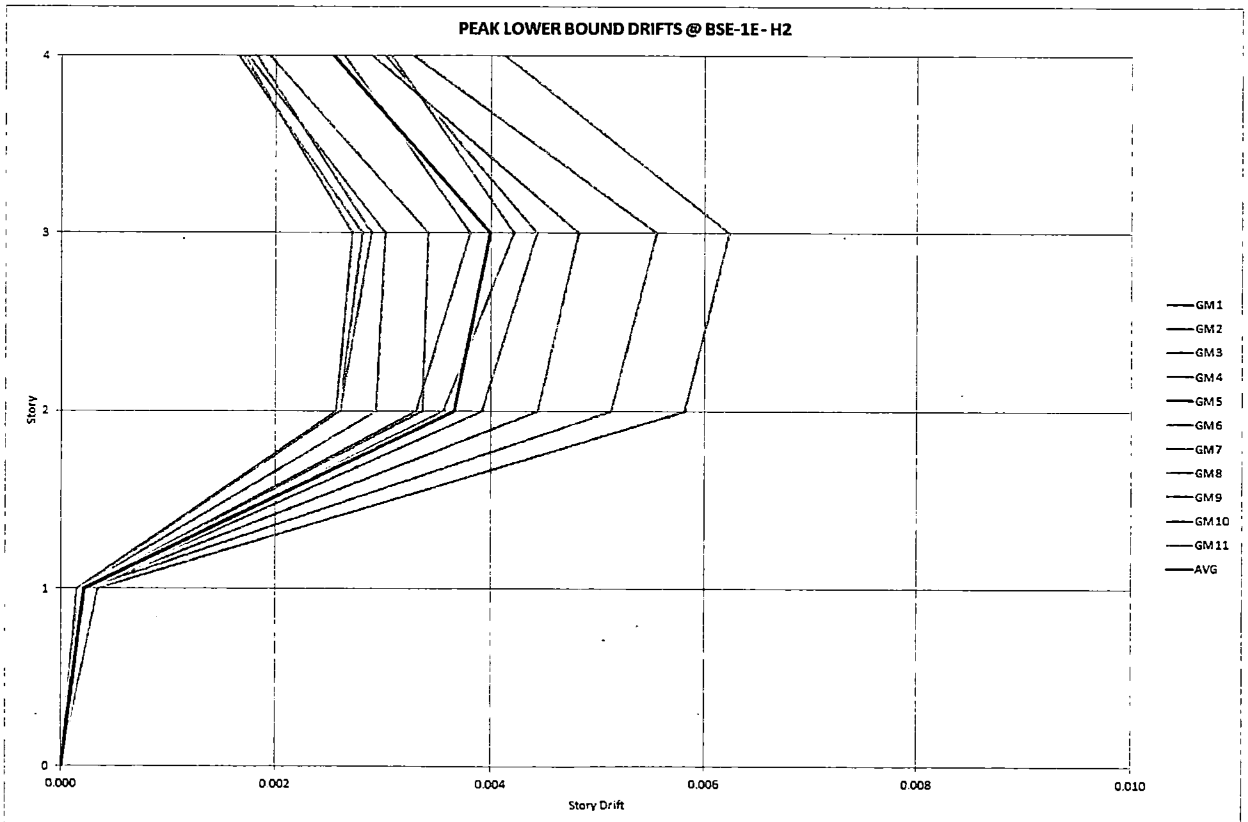

Figure A.1-20 Peak Lower Bound Drifts at the BSE-1E Hazard Level in the H2 Direction

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	client	job no. 2000362	
	Global Response Results		

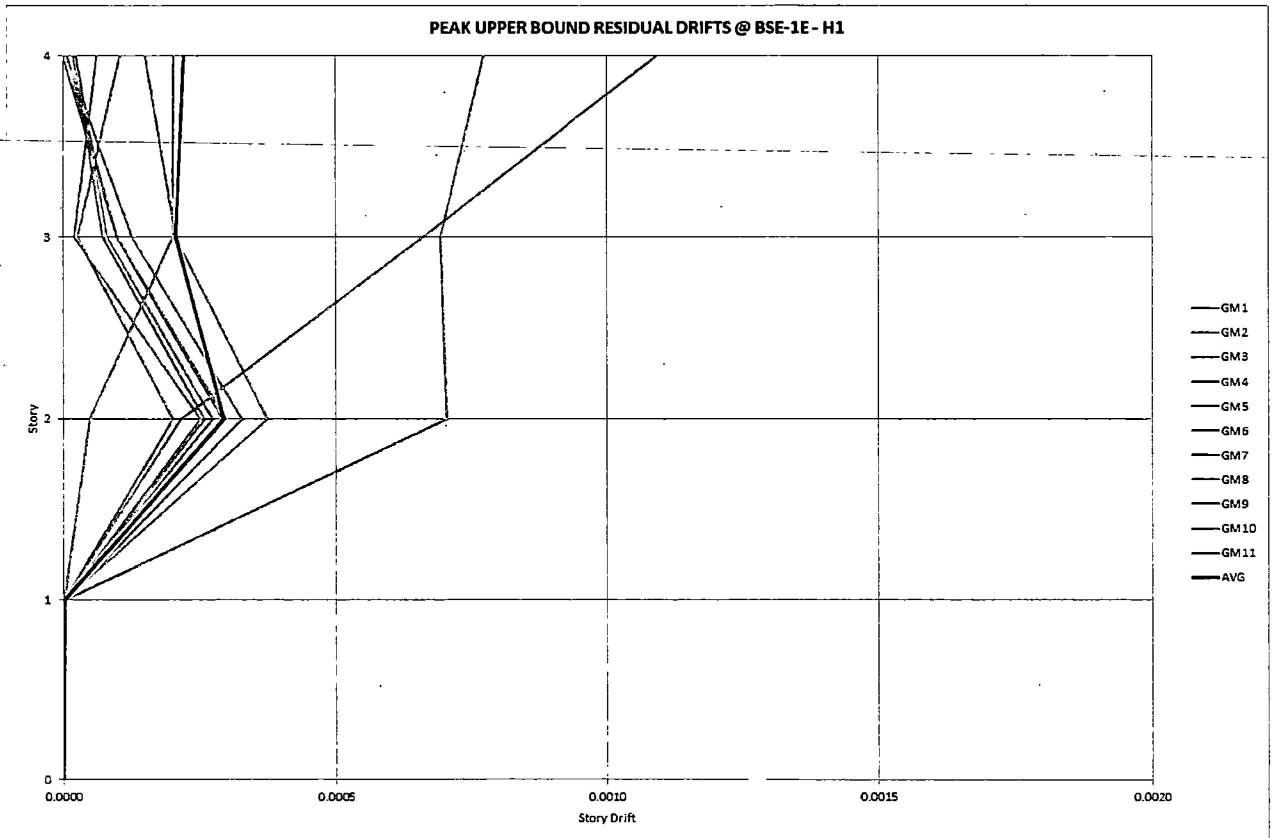

Figure A.1-21 Peak Upper Bound Residual Drifts at the BSE-1E Hazard Level in the H1 Direction

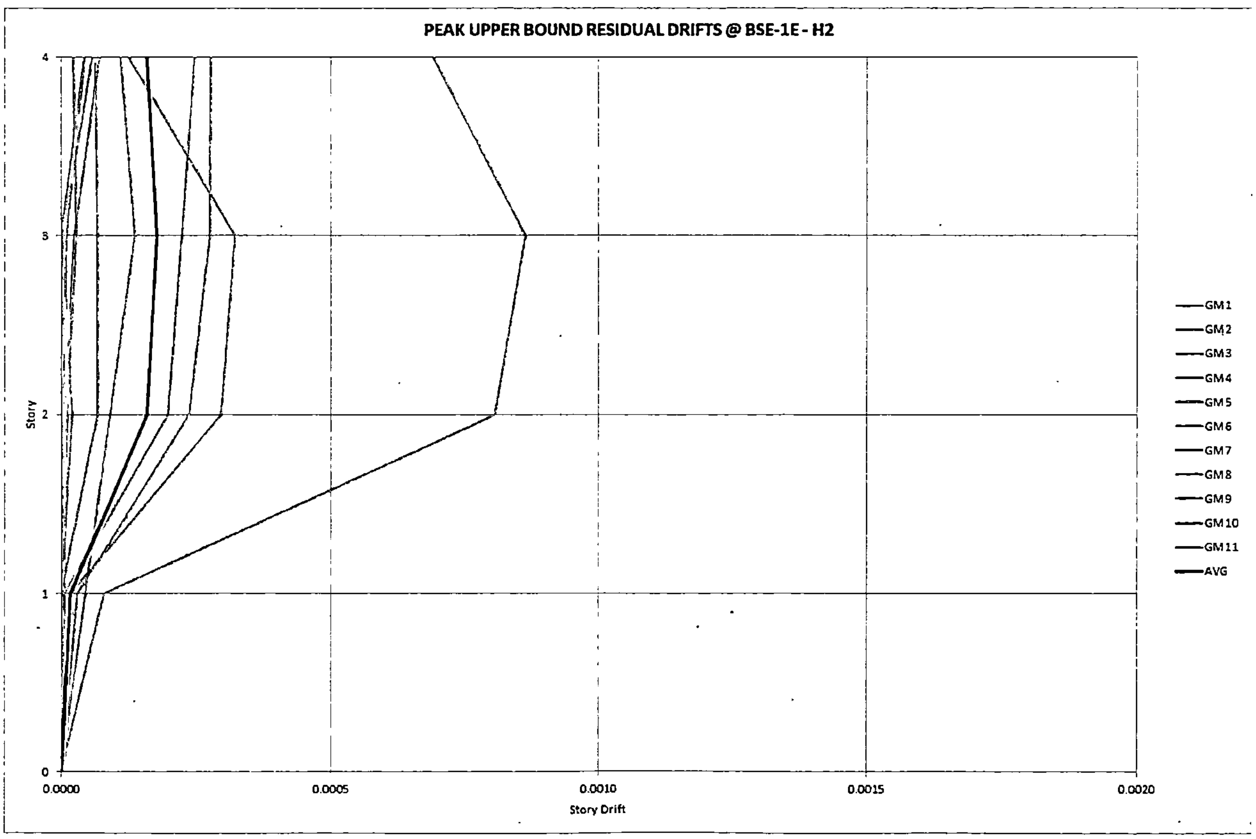

Figure A.1-22 Peak Upper Bound Residual Drifts at the BSE-1E Hazard Level in the H2 Direction

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	location Inglewood, CA	date 10/18/21	
	client	job no. 2000362	
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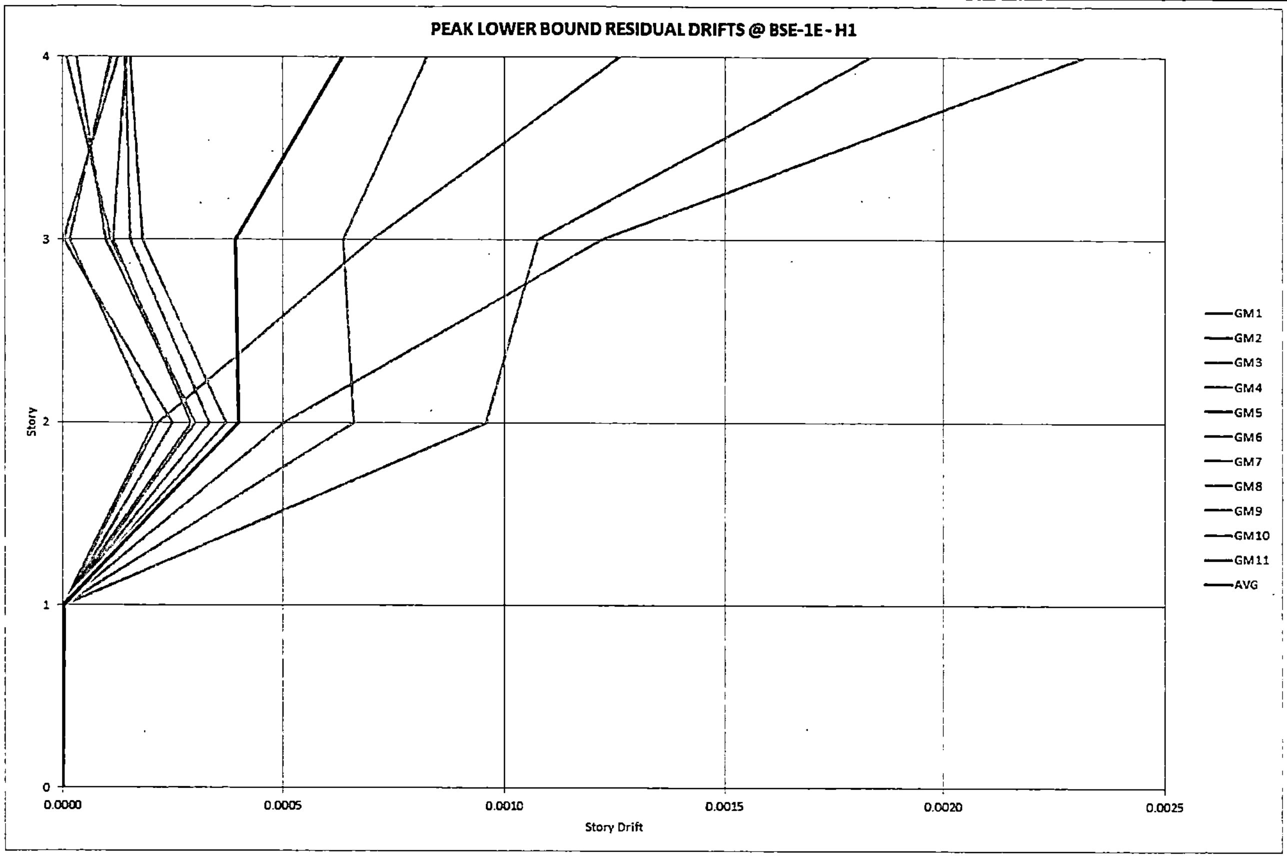

Figure A.1-23 Peak Lower Bound Residual Drifts at the BSE-1E Hazard Level in the H1 Direction

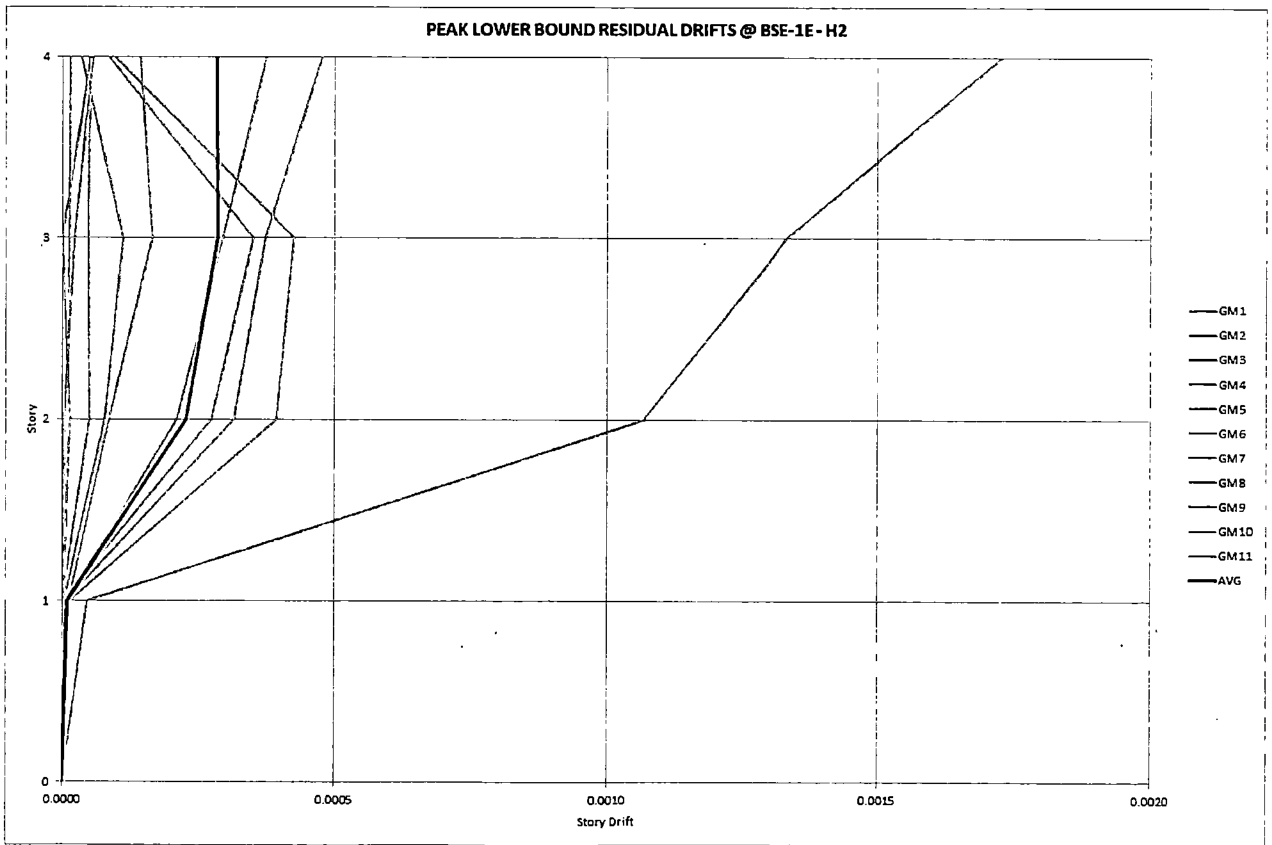

Figure A.1-24 Peak Lower Bound Residual Drifts at the BSE-1E Hazard Level in the H2 Direction

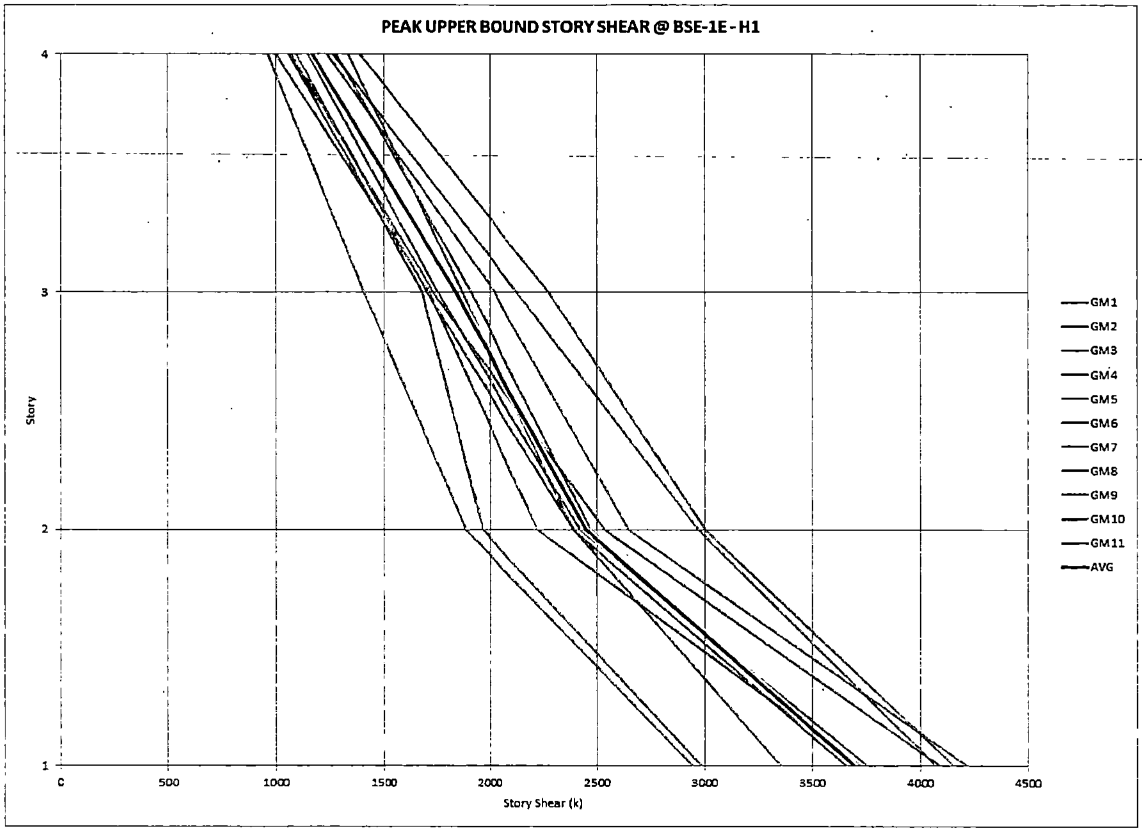

Figure A.1-25 Peak Upper Bound Story Shears at the BSE-1E Hazard Level in the H1 Direction

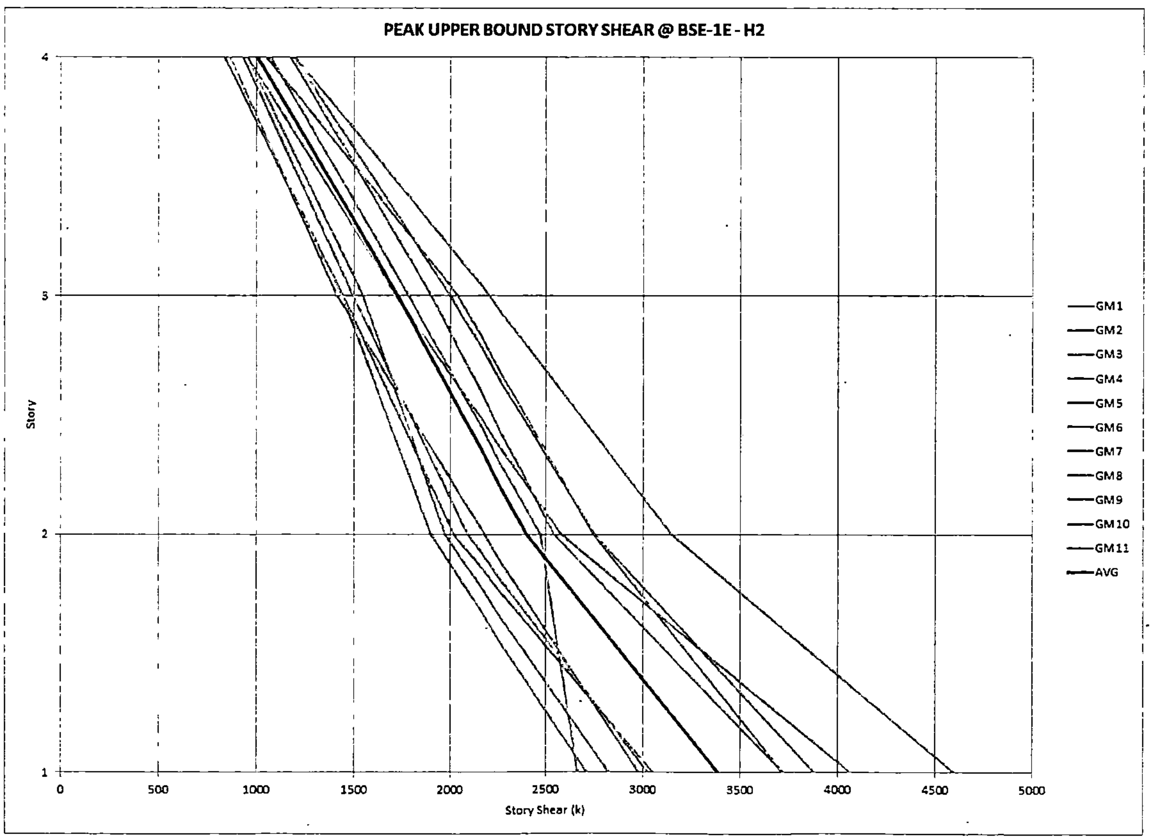

Figure A.1-26 Peak Upper Bound Story Shears at the BSE-1E Hazard Level in the H2 Direction

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client	job no. 2000362	
Global Response Results		

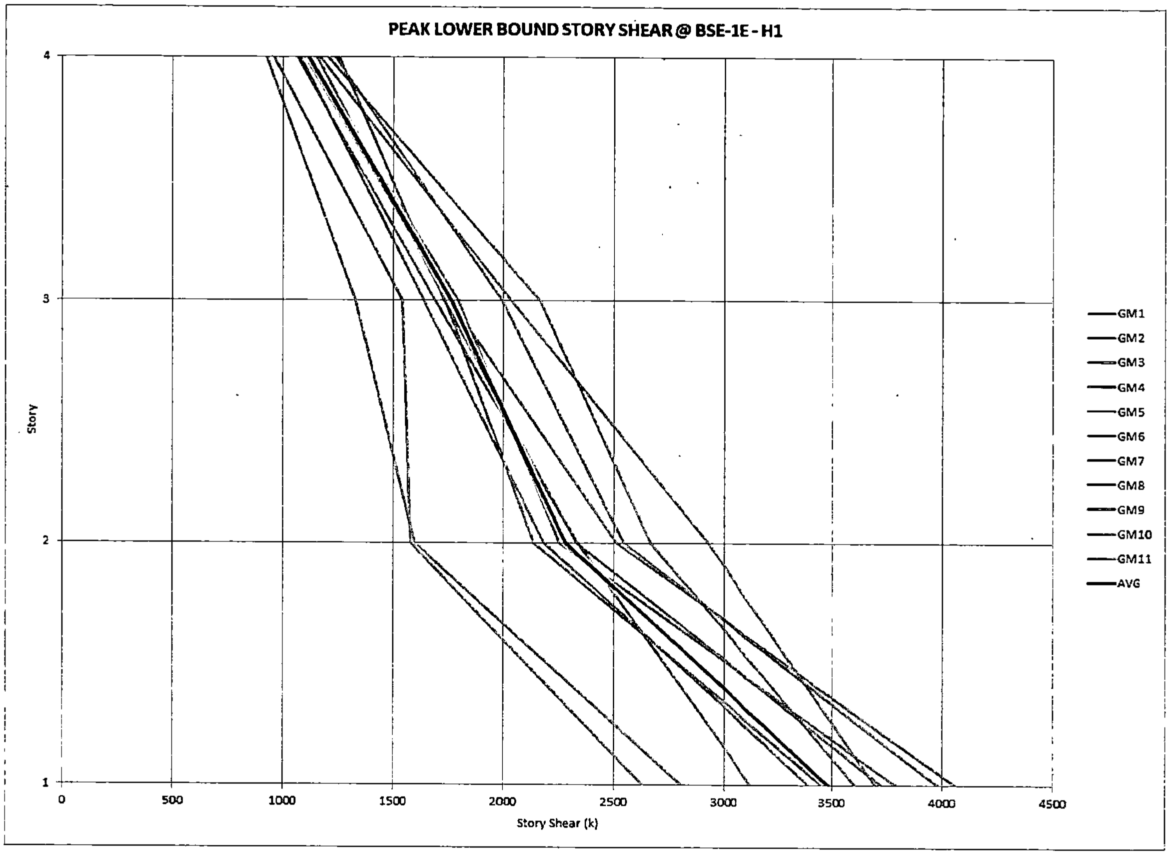

Figure A.1-27 Peak Lower Bound Story Shears at the BSE-1E Hazard Level in the H1 Direction

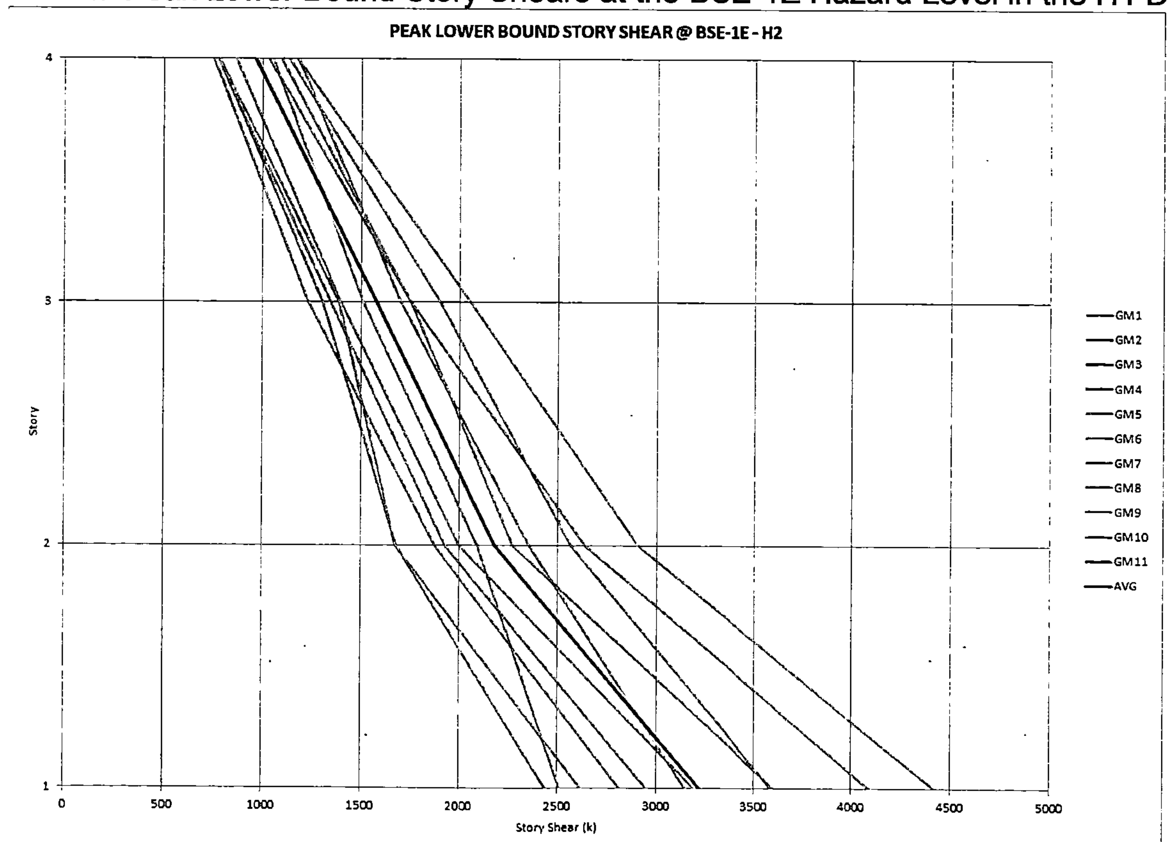

Figure A.1-28 Peak Lower Bound Story Shears at the BSE-1E Hazard Level in the H2 Direction

kpff 700 South Flower Street, Suite 2100 Los Angeles, CA 90017 (213) 418-0201	project City of Inglewood - Library	by JL	sheet no. A.1-17
	location Inglewood, CA	date 10/18/21	
	client	job no. 2000362	
	Global Response Results		

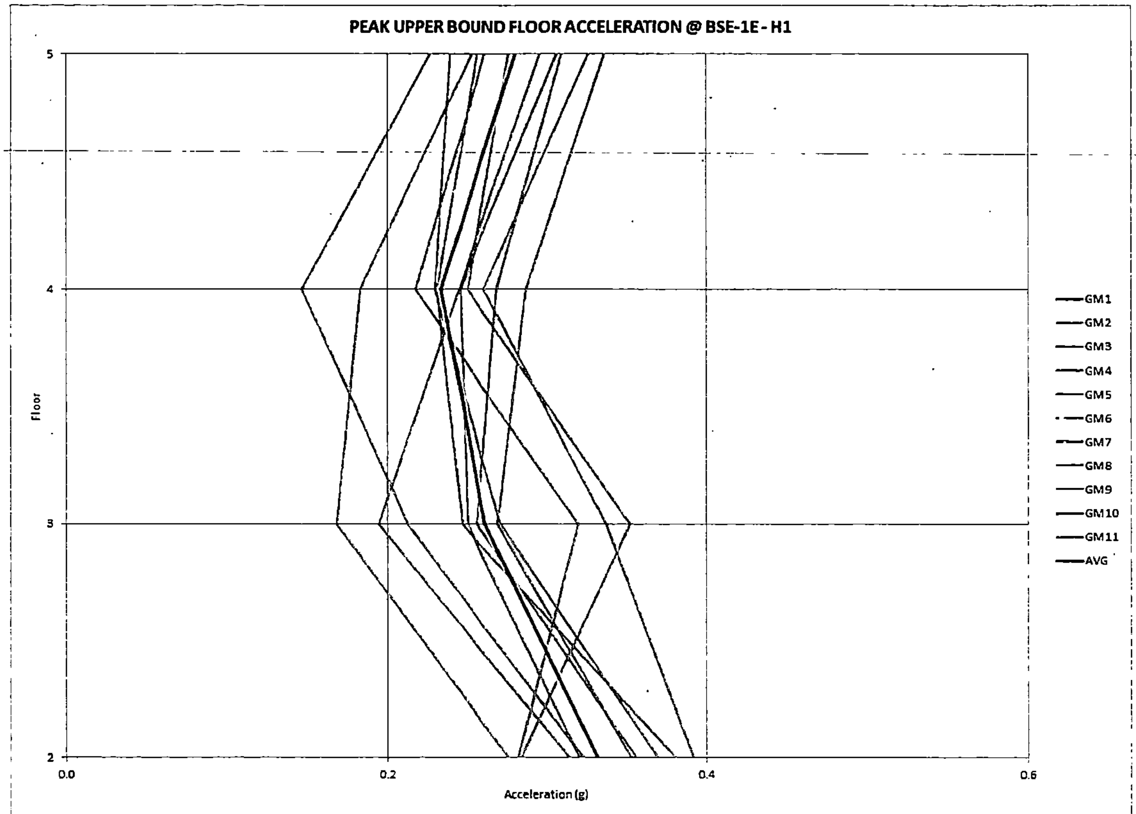

Figure A.1-29 Peak Upper Bound Floor Acceleration at the BSE-1E Hazard Level in the H1 Direction

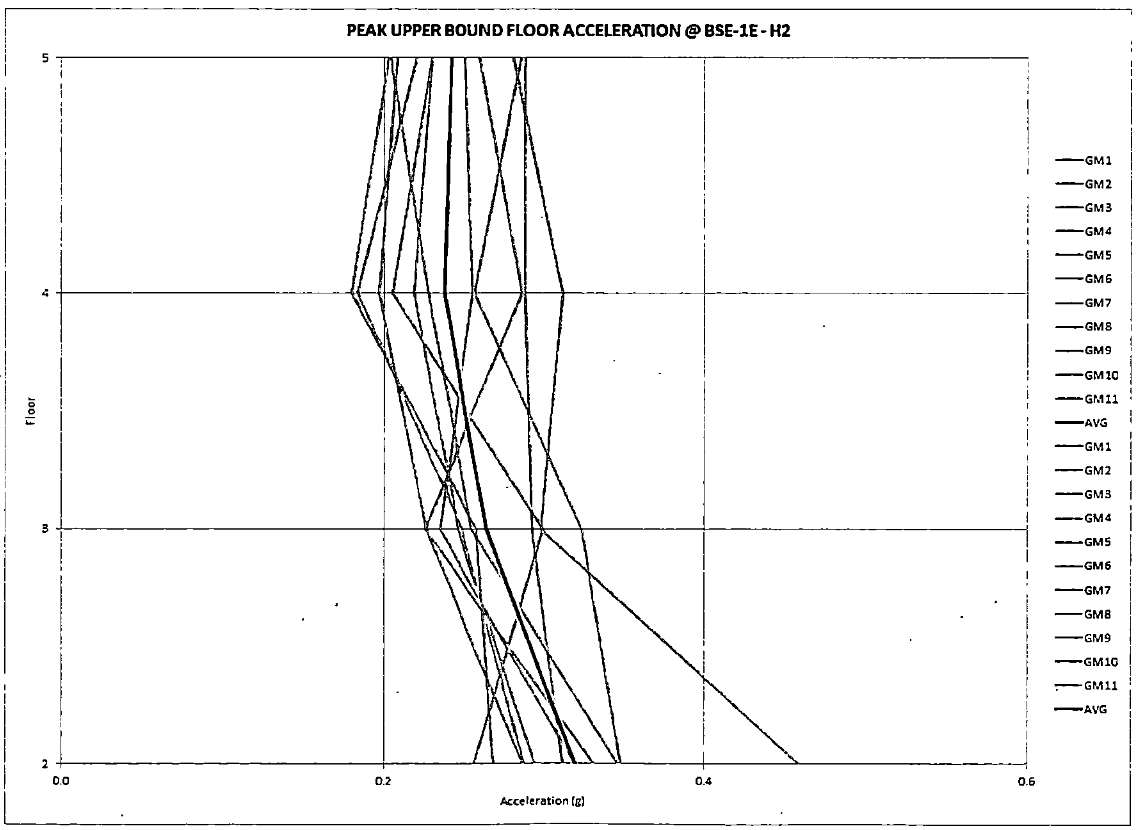

Figure A.1-30 Peak Upper Bound Floor Acceleration at the BSE-1E Hazard Level in the H2 Direction

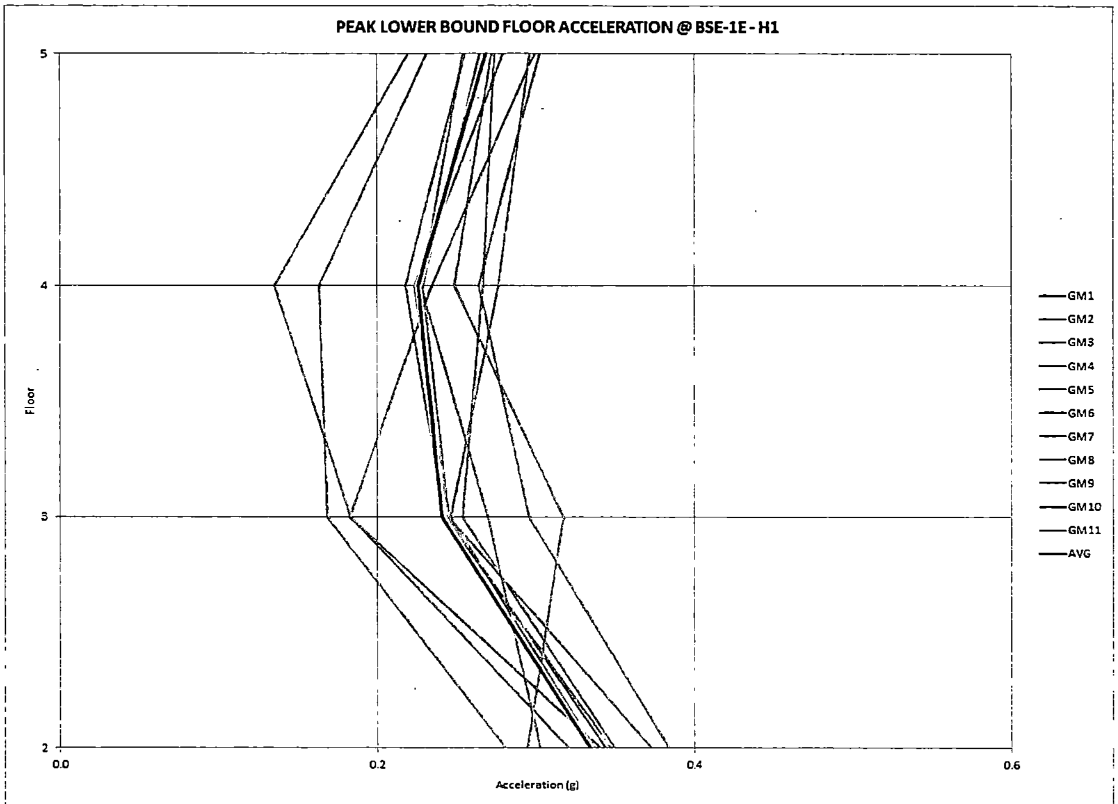

Figure A.1-31 Peak Lower Bound Floor Acceleration at the BSE-1E Hazard Level in the H1 Direction

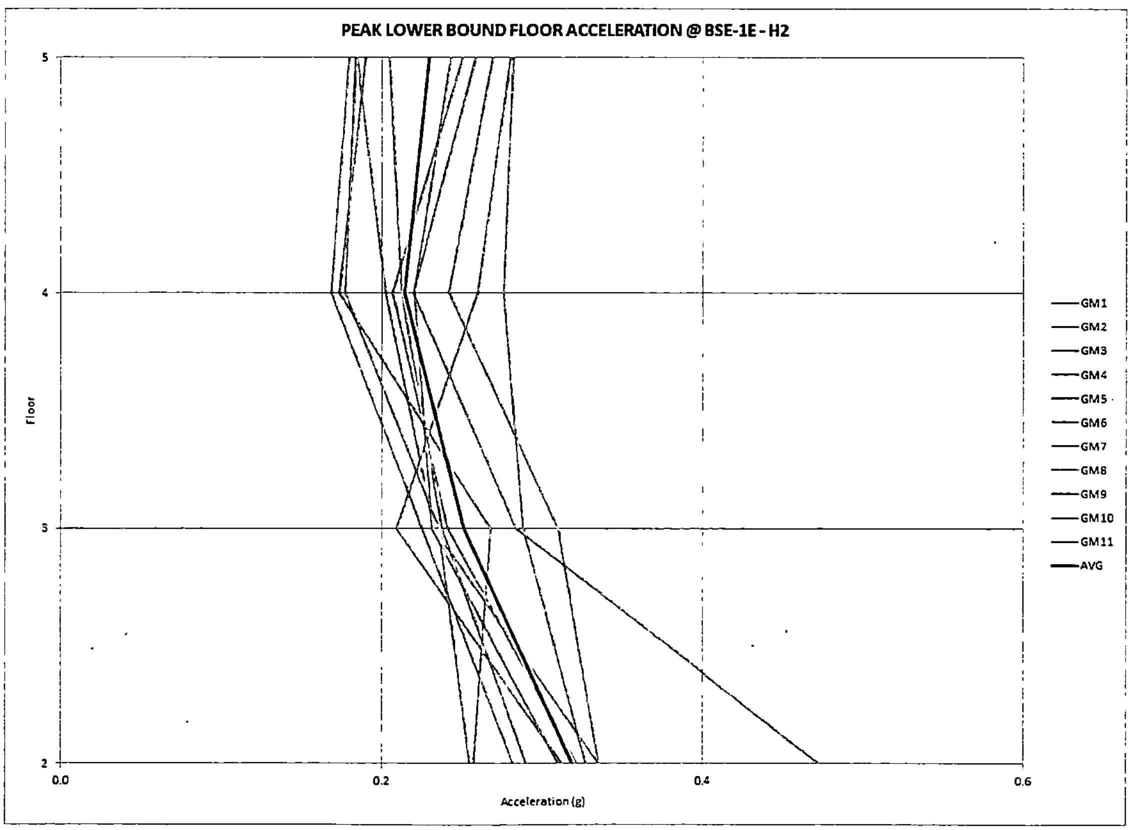

Figure A.1-32 Peak Lower Bound Floor Acceleration at the BSE-1E Hazard Level in the H2 Direction

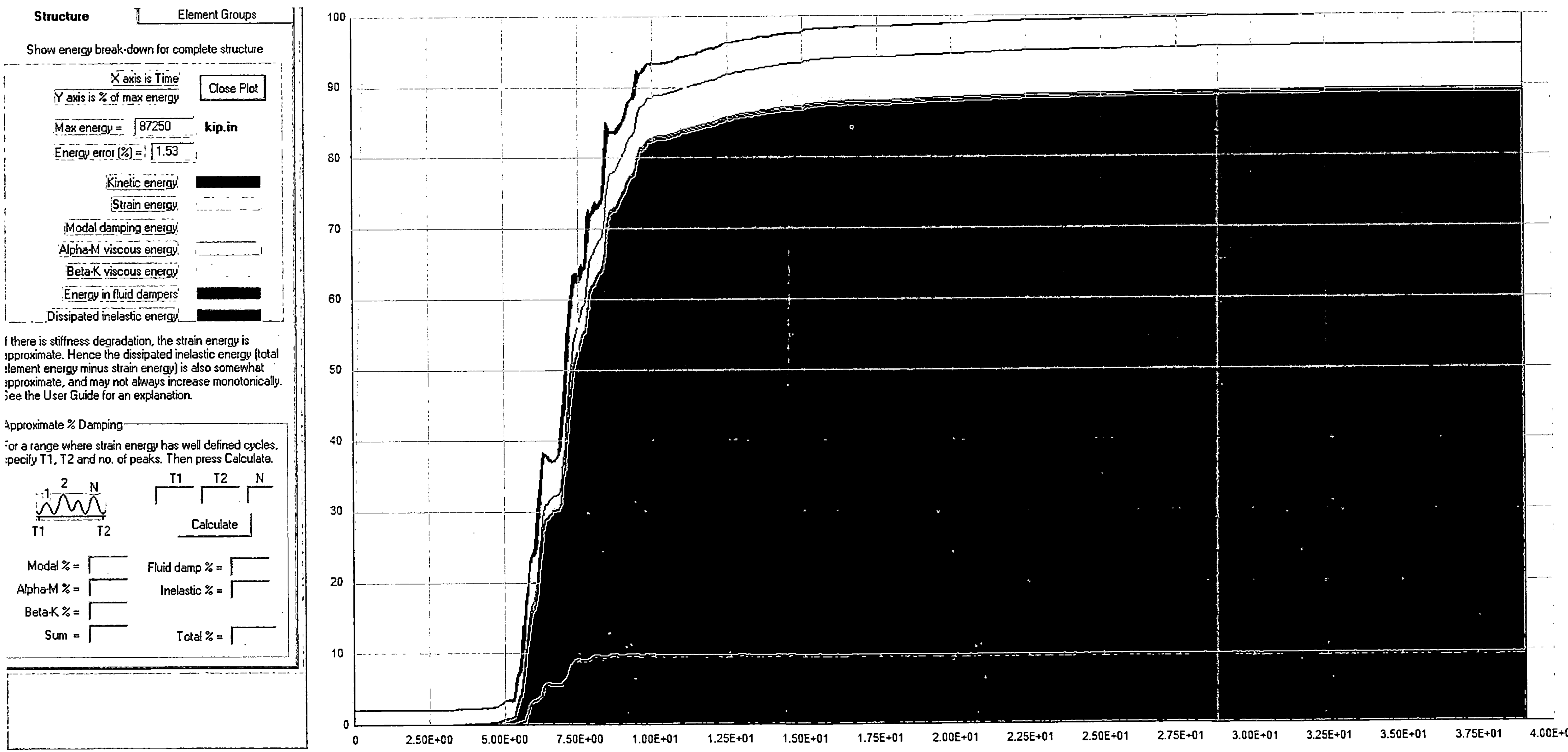

Figure A.1-33 Energy Balance Plot Using Nominal Damper Properties for BSE-2E GM1 (Approximate Added Damping = 34.2%, Average Added Damping from All 11 GM's = 33.4%)

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700 South Flower Street, Suite 2100 Los Angeles, CA 90017 (213) 418-0201		location	date 10/19/21	
		client	job no. 2000362	

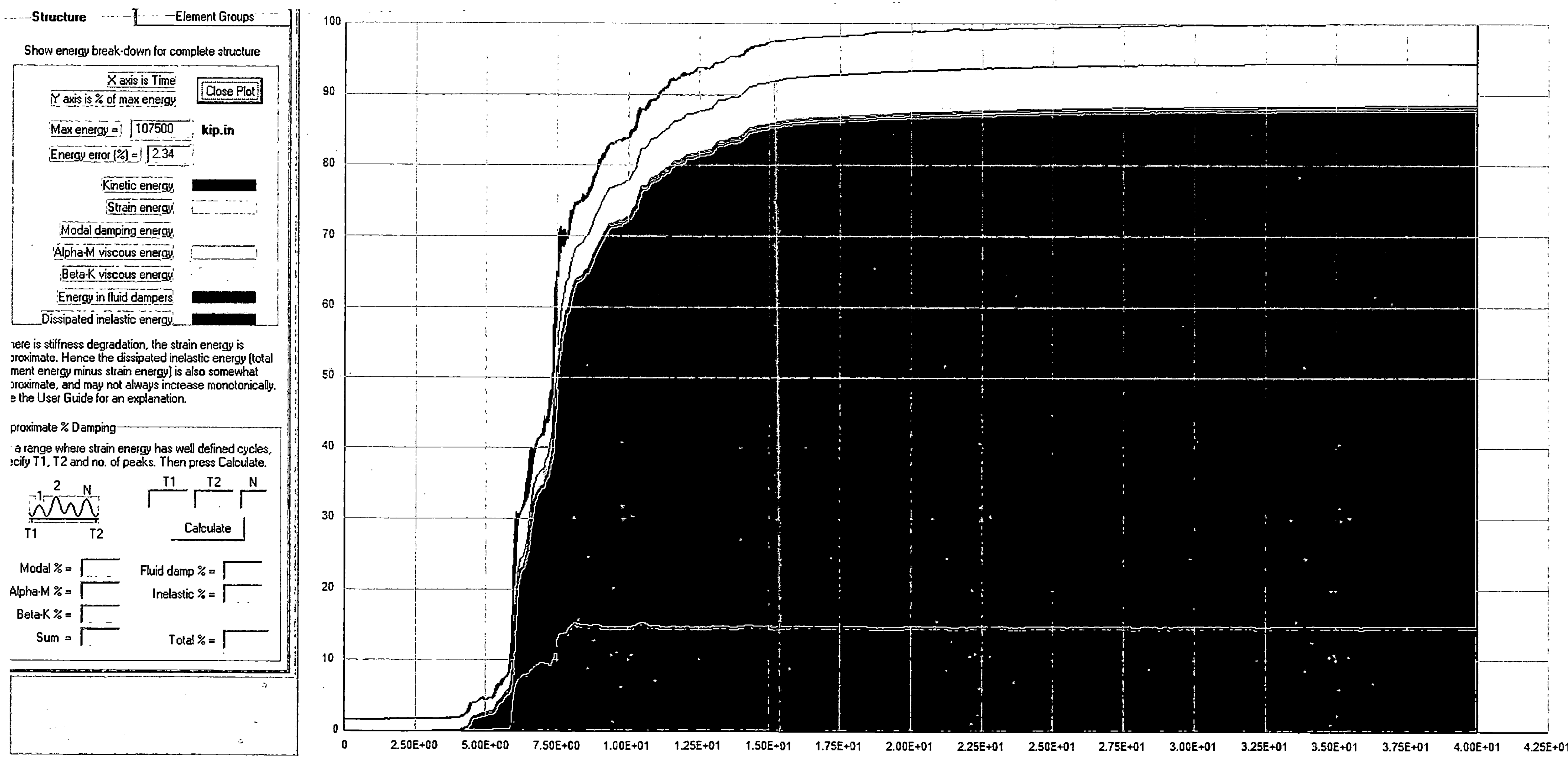

Figure A.1-34 Energy Balance Plot Using Nominal Damper Properties for BSE-2E GM2 (Approximate Added Damping = 29.6%, Average Added Damping from All 11 GM's = 33.4%)

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location	date 10/19/21	
client	job no. 2000362	

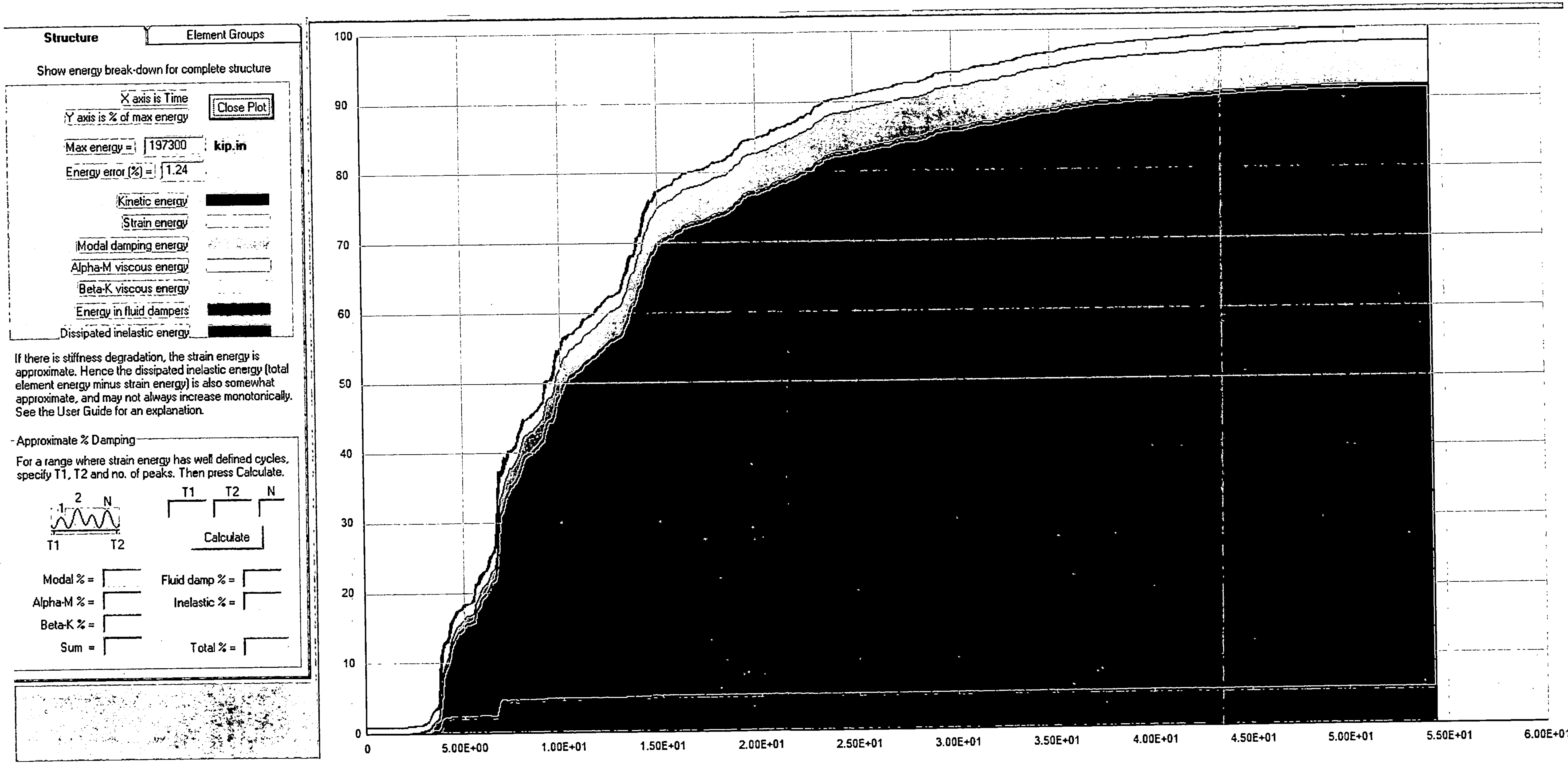

Figure A.1-35 Energy Balance Plot Using Nominal Damper Properties for BSE-2E GM3 (Approximate Added Damping = 37.1%, Average Added Damping from All 11 GM's = 33.4%)

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location	date 10/19/21	
client	job no. 2000362	

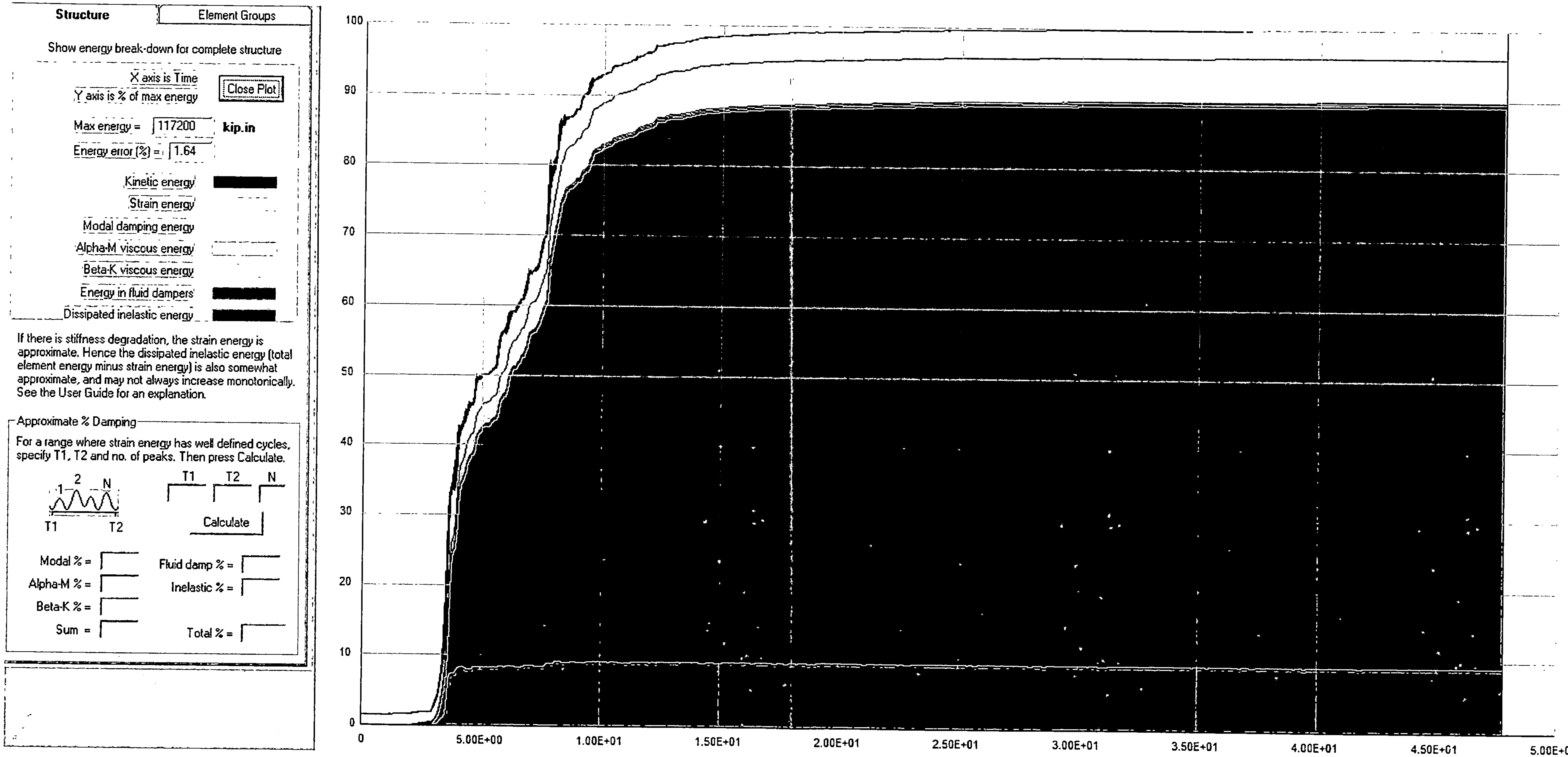

Figure A.1-36 Energy Balance Plot Using Nominal Damper Properties for BSE-2E GM4 (Approximate Added Damping = 32.4%, Average Added Damping from All 11 GM's = 33.4%)

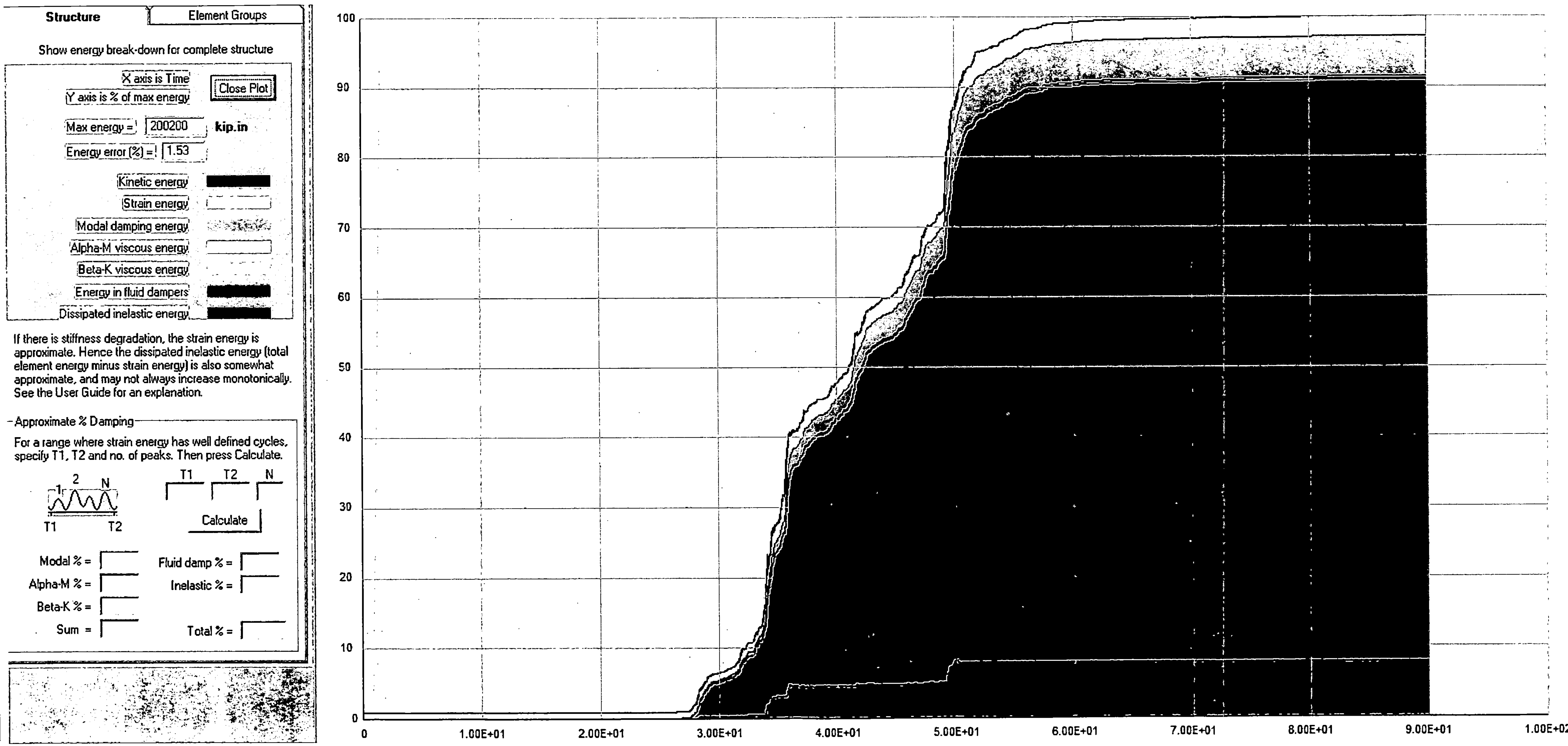

Figure A.1-37 Energy Balance Plot Using Nominal Damper Properties for BSE-2E GM5 (Approximate Added Damping = 36.2%, Average Added Damping from All 11 GM's = 33.4%)

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project City of Inglewood - Library	by JL	sheet no. A.1-24
location	date 10/19/21	
client	job no. 2000362	

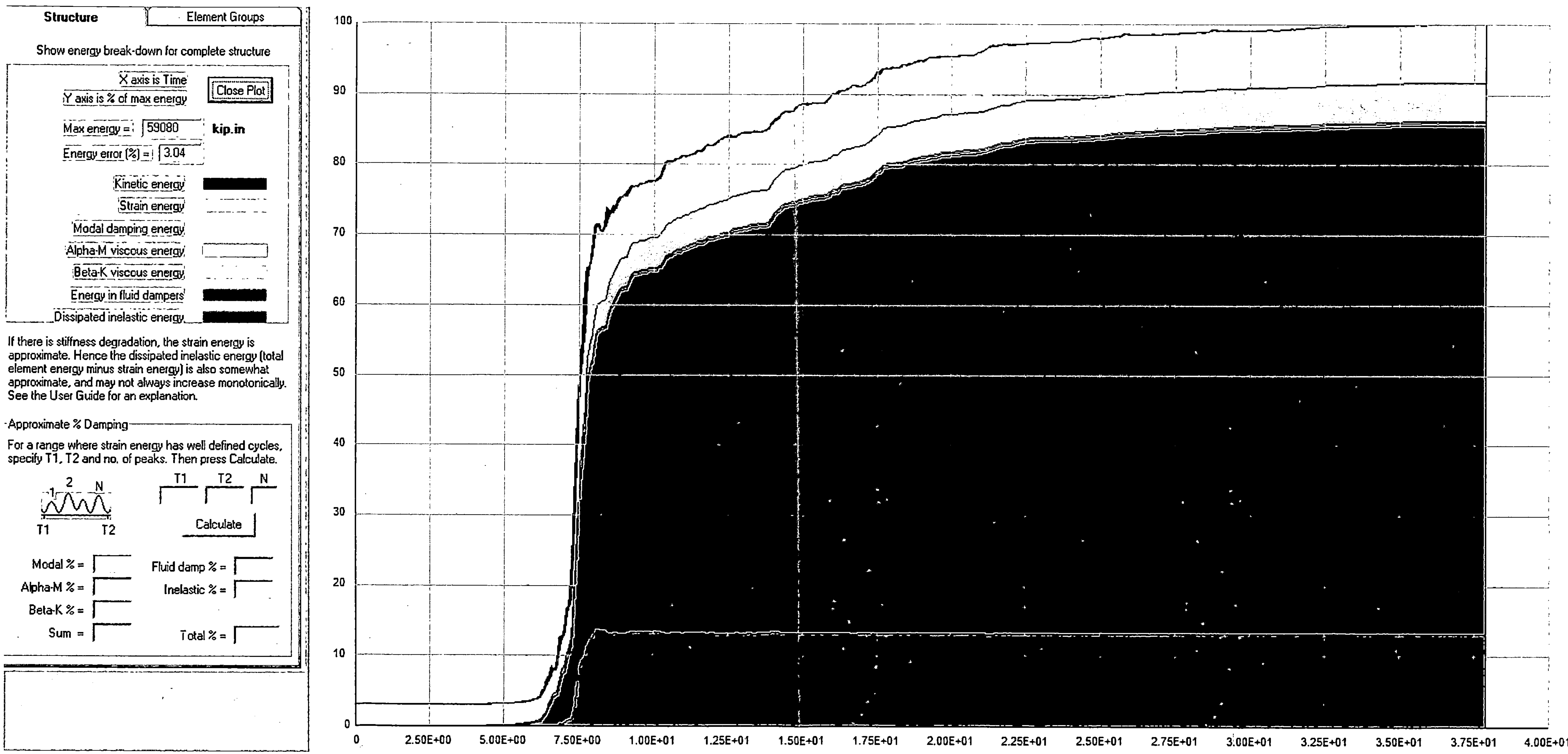

Figure A.1-38 Energy Balance Plot Using Nominal Damper Properties for BSE-2E GM6 (Approximate Added Damping = 32.3%, Average Added Damping from All 11 GM's = 33.4%)

kpff 700 South Flower Street, Suite 2100 Los Angeles, CA 90017 (213) 418-0201	project City of Inglewood - Library	by JL	sheet no. A.1-25
	location	date 10/19/21	
	client	job no. 2000362	

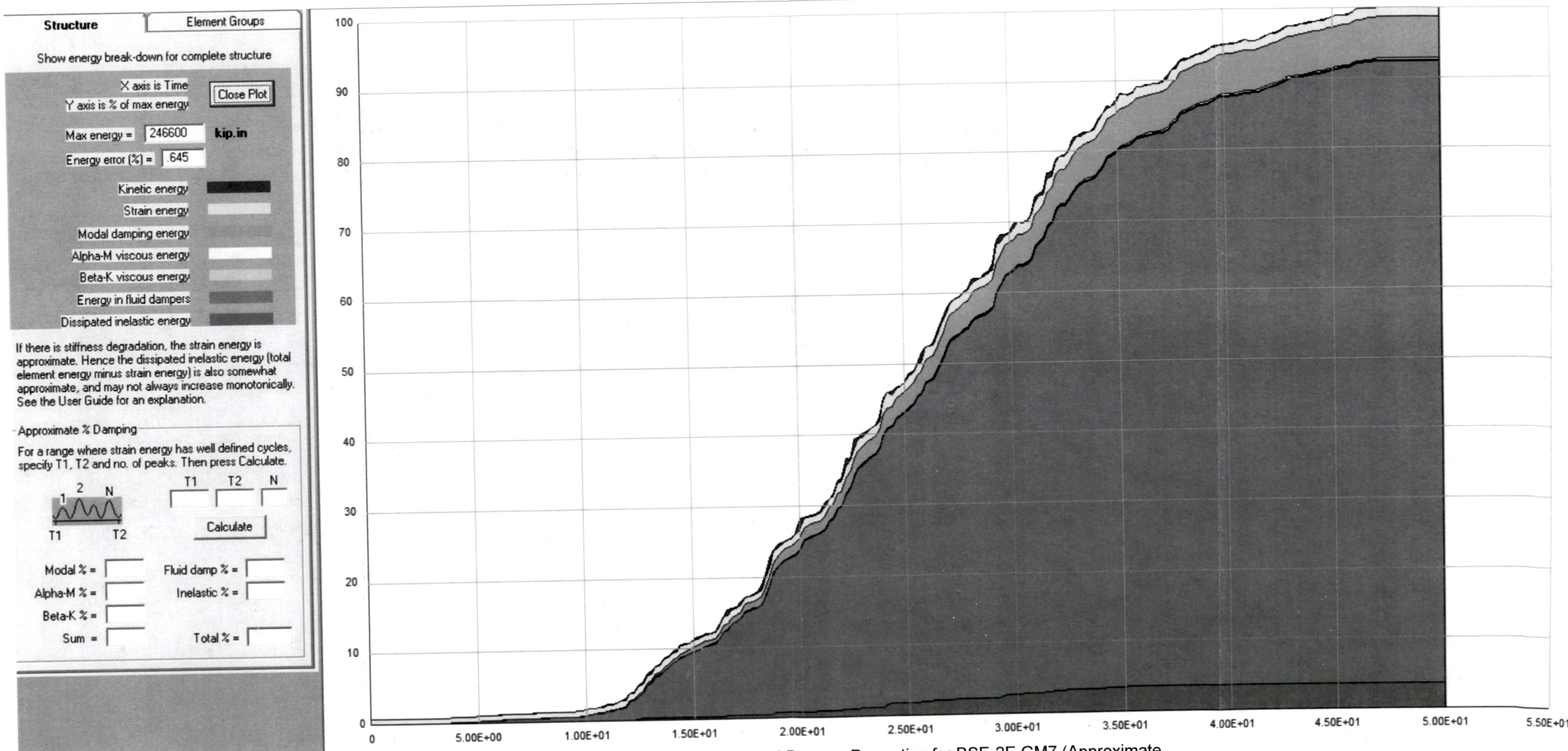

Figure A.1-39 Energy Balance Plot Using Nominal Damper Properties for BSE-2E GM7 (Approximate Added Damping = 39.7%, Average Added Damping from All 11 GM's = 33.4%)

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location	date 10/19/21	
client	job no. 2000362	

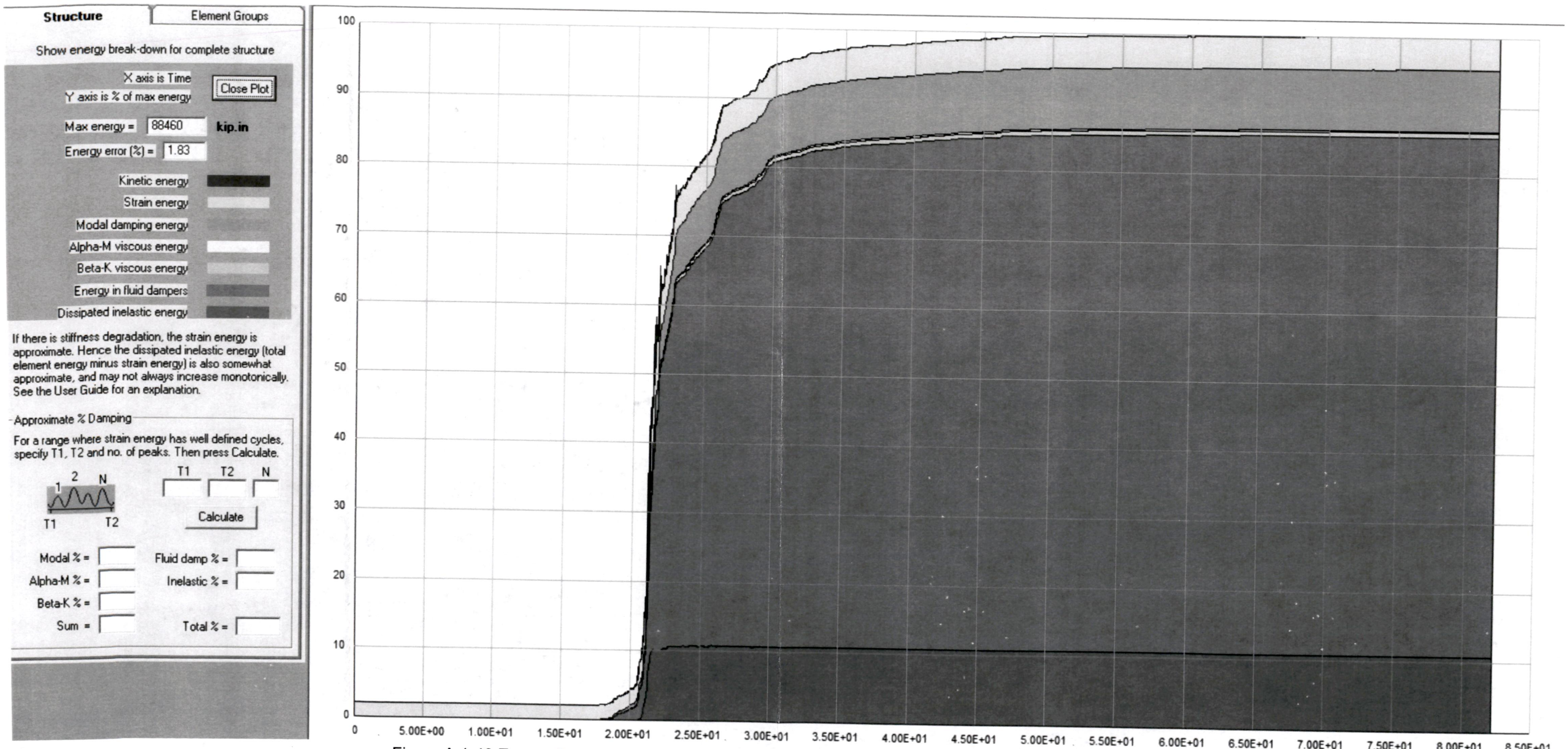

Figure A.1-40 Energy Balance Plot Using Nominal Damper Properties for BSE-2E GM8 (Approximate Added Damping = 20.4%, Average Added Damping from All 11 GM's = 33.4%)

kpff 700 South Flower Street, Suite 2100 Los Angeles, CA 90017 (213) 418-0201	project City of Inglewood - Library	by JL
	location	date 10/19/21
	client	job no. 2000362
		sheet no. A.1-27

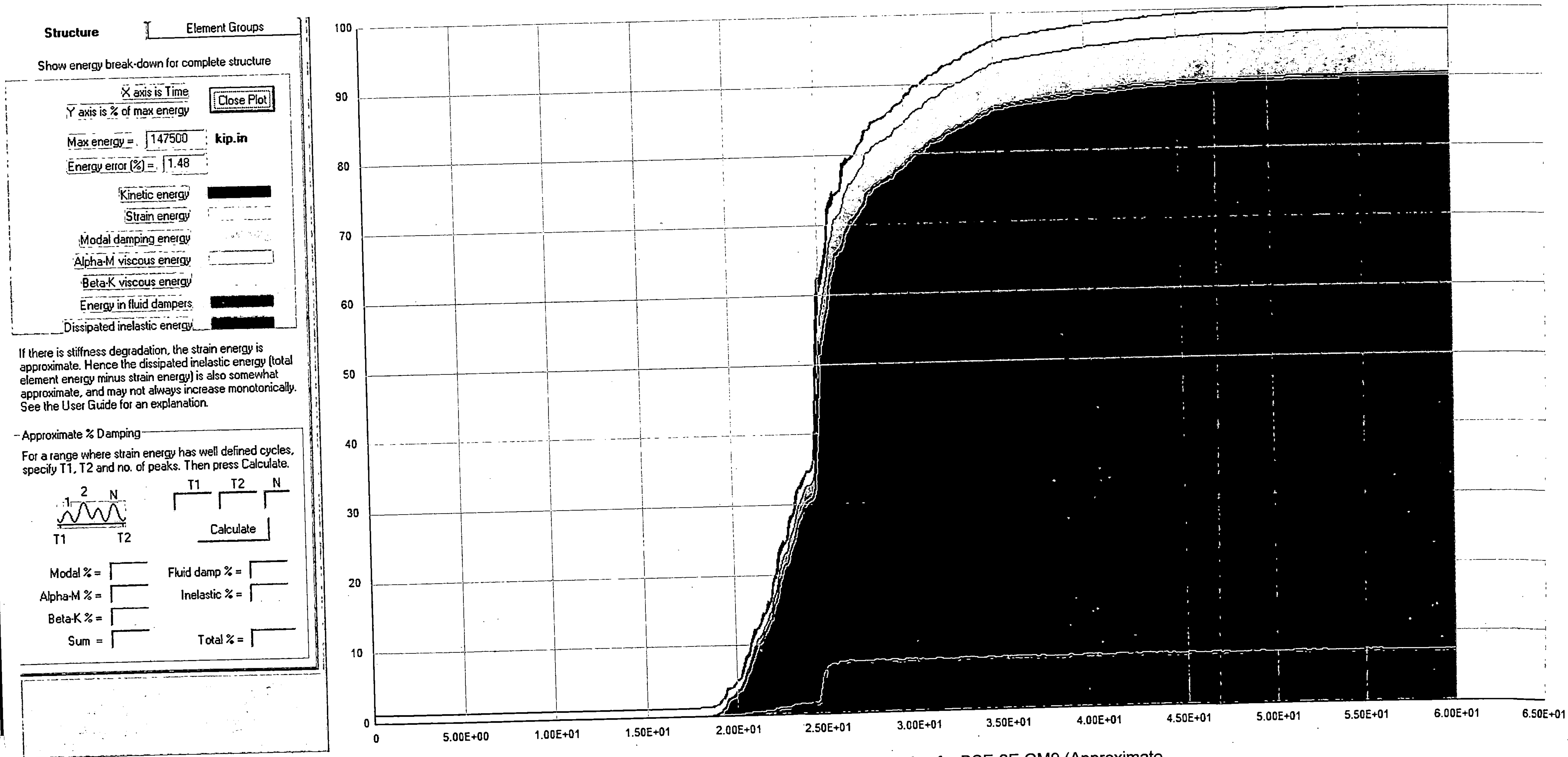

Figure A.1-41 Energy Balance Plot Using Nominal Damper Properties for BSE-2E GM9 (Approximate Added Damping = 32.7%, Average Added Damping from All 11 GM's = 33.4%)

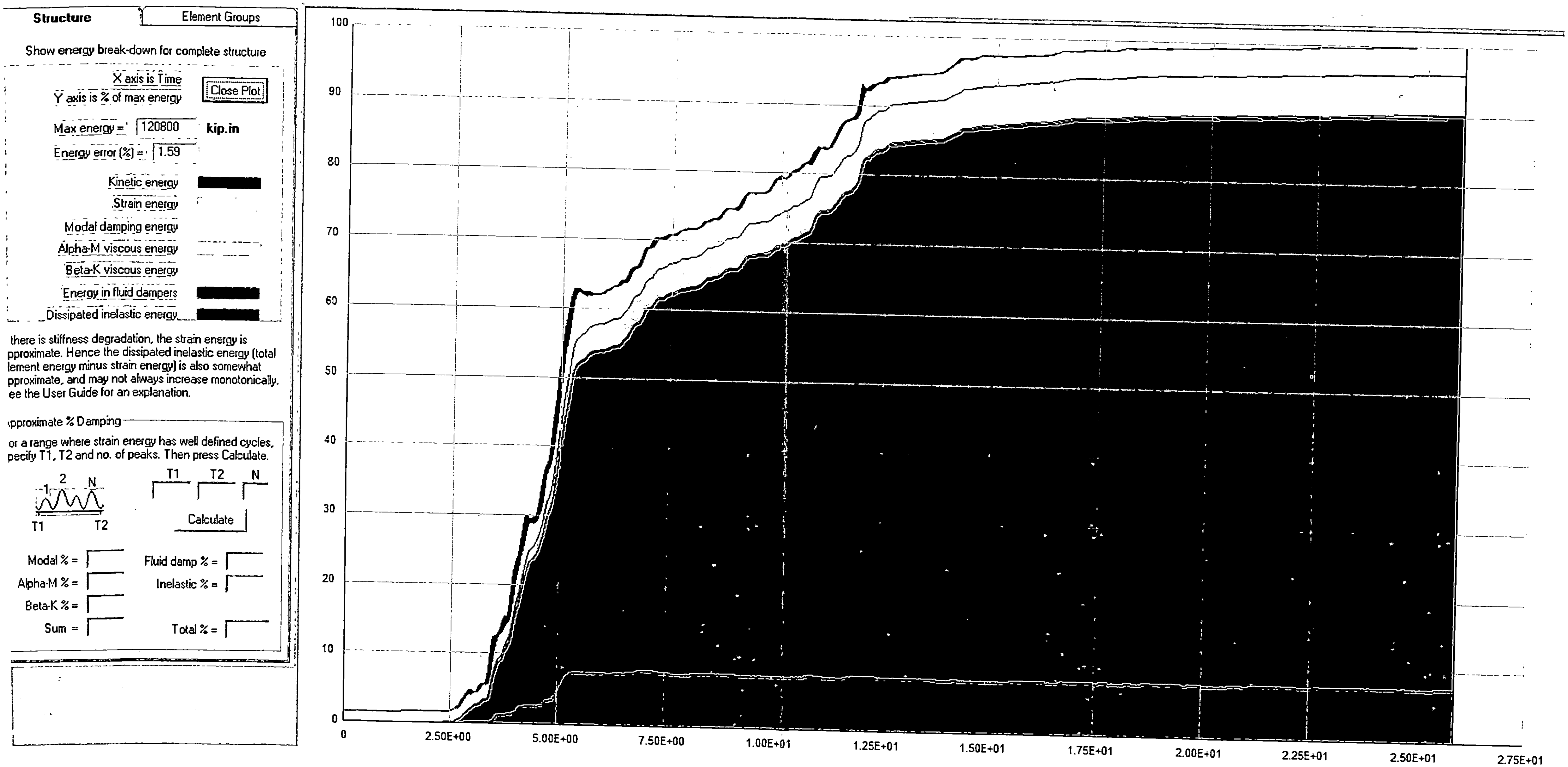

Figure A.1-42 Energy Balance Plot Using Nominal Damper Properties for BSE-2E GM10
(Approximate Added Damping = 34.5%, Average Added Damping from All 11 GM's = 33.4%)

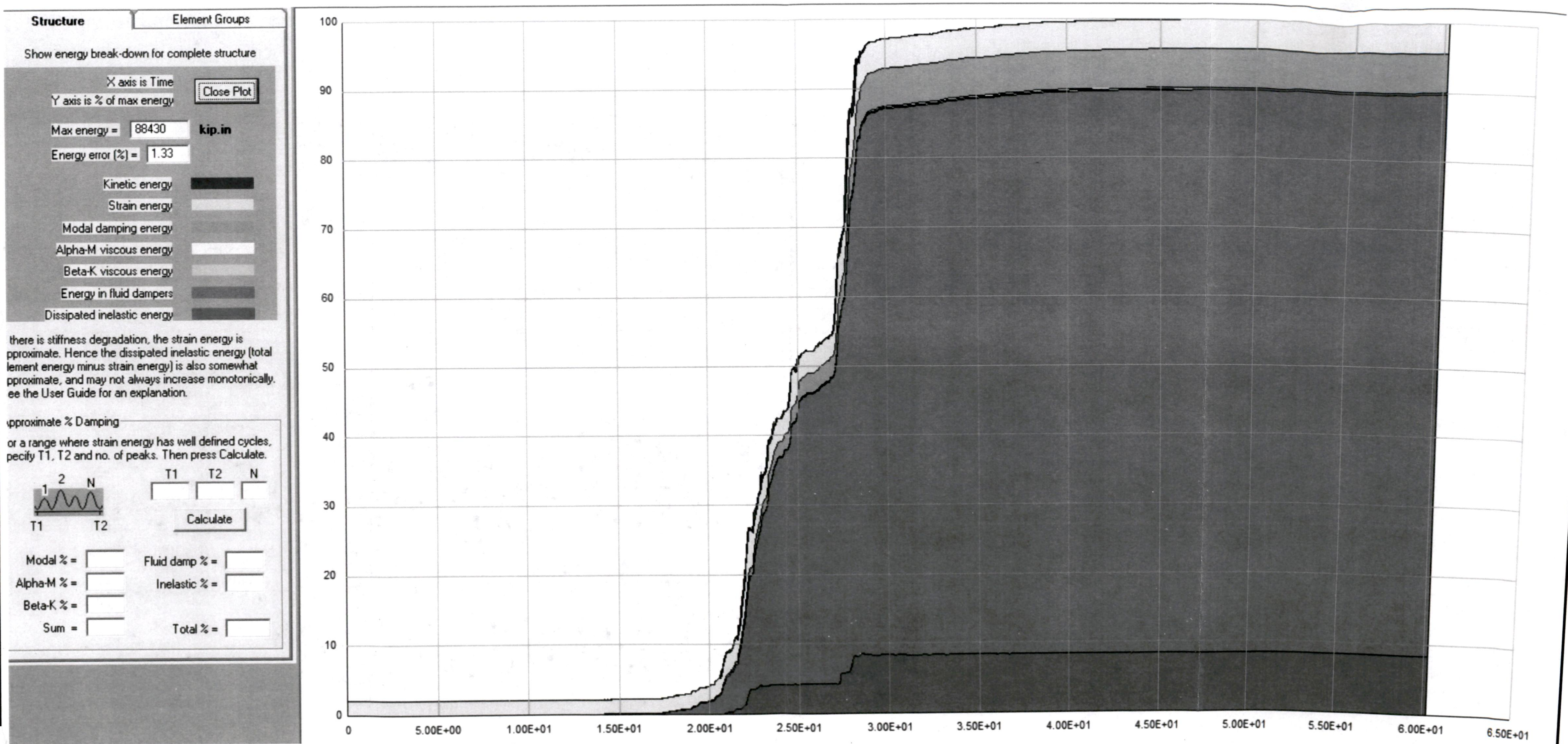

Figure A.1-43 Energy Balance Plot Using Nominal Damper Properties for BSE-2E GM11
(Approximate Added Damping = 38.3%, Average Added Damping from All 11 GM's = 33.4%)

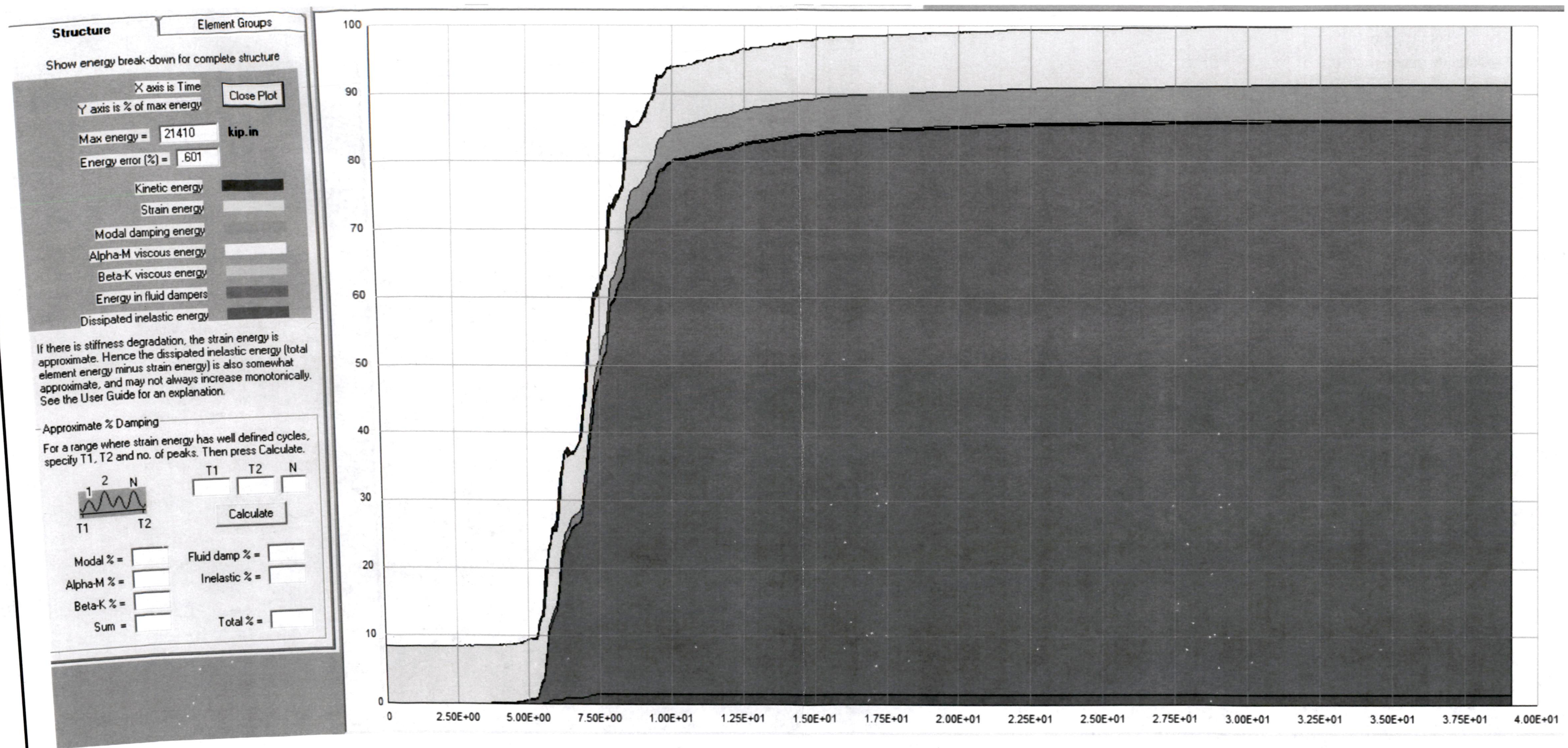

Figure A.1-44 Energy Balance Plot Using Nominal Damper Properties for BSE-1E GM1 (Approximate Added Damping = 42.3%, Average Added Damping from All 11 GM's = 41.0%)

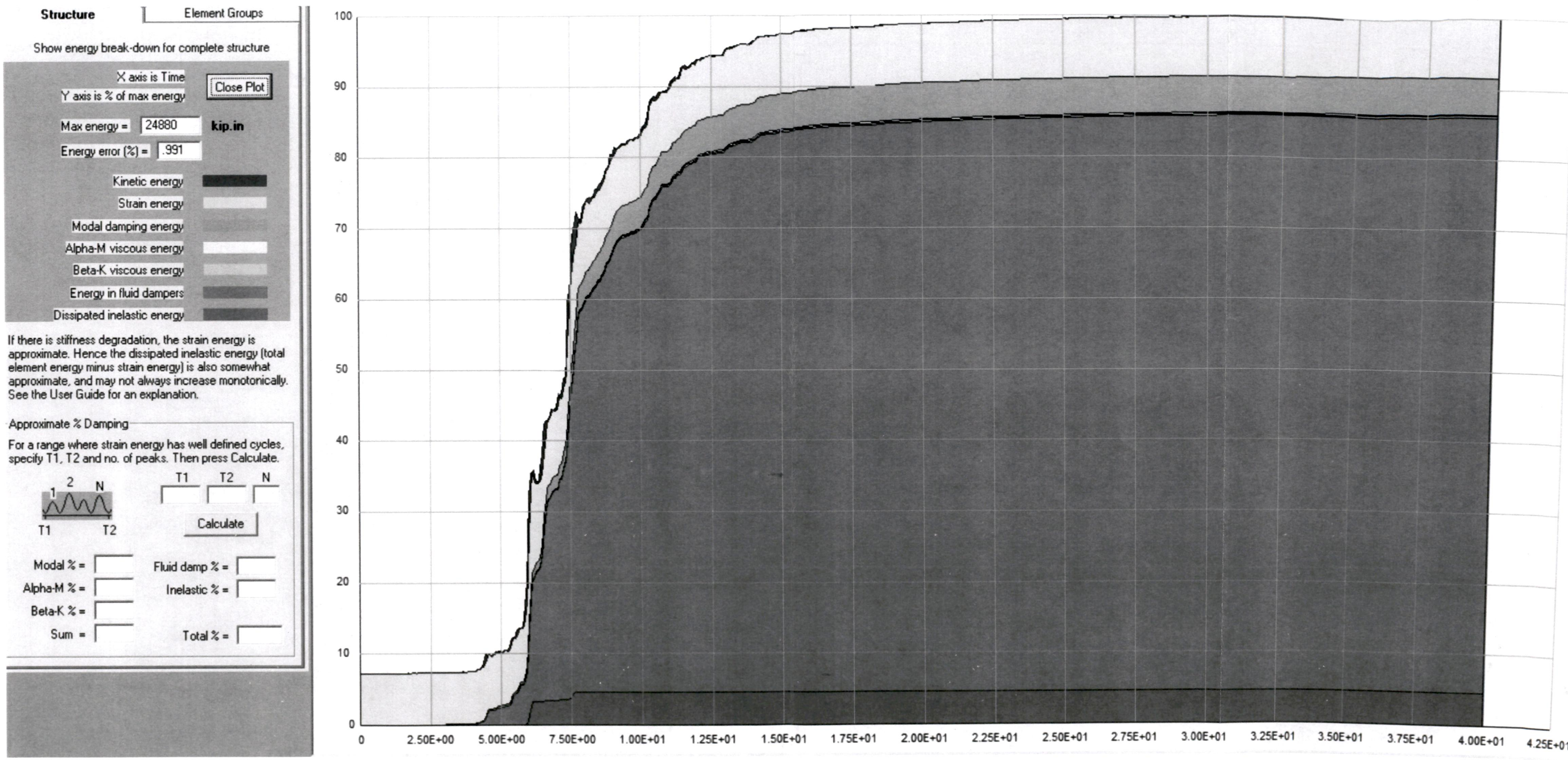

Figure A.1-45 Energy Balance Plot Using Nominal Damper Properties for BSE-1E GM2 (Approximate Added Damping = 41.1%, Average Added Damping from All 11 GM's = 41.0%)

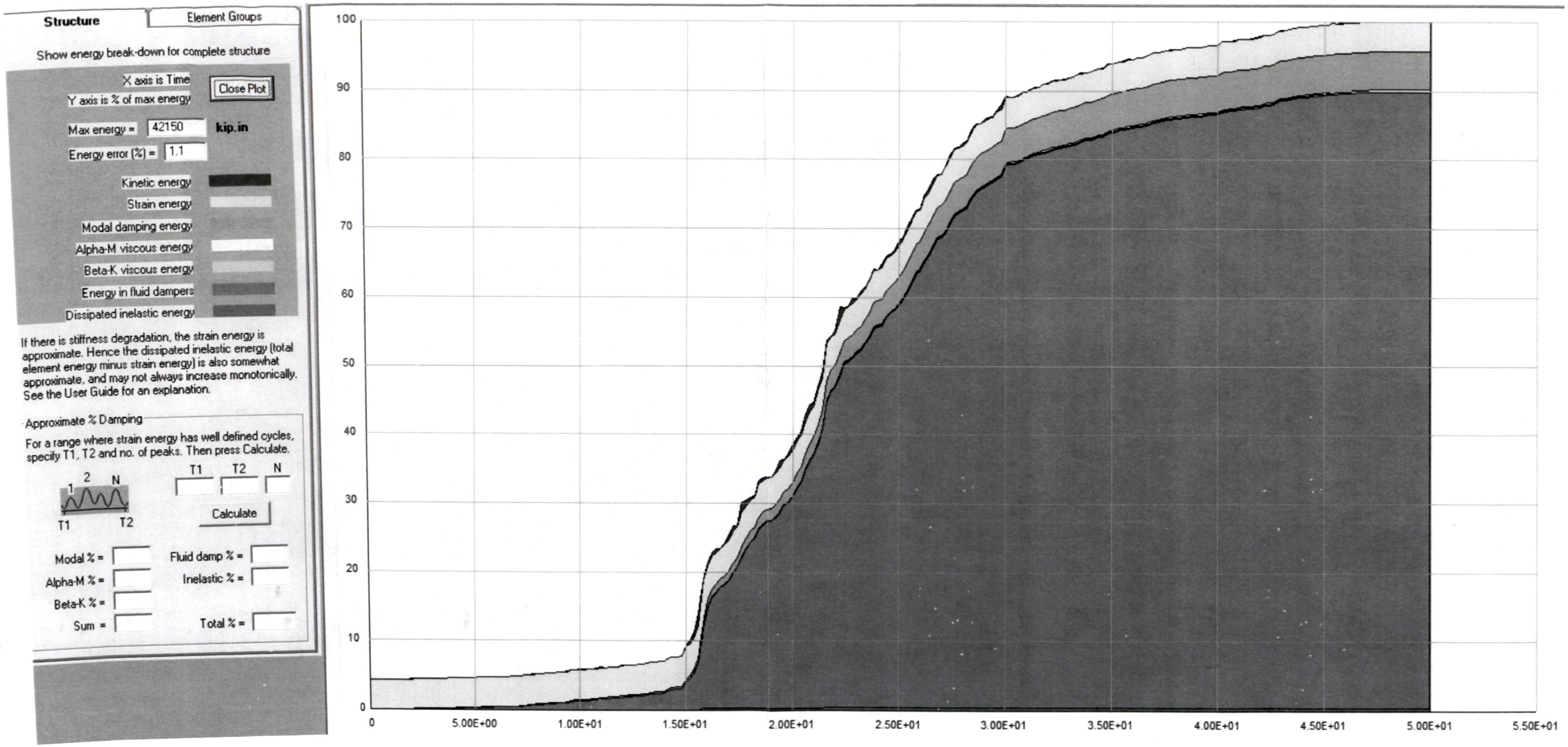

Figure A.1-46 Energy Balance Plot Using Nominal Damper Properties for BSE-1E GM3 (Approximate Added Damping = 41.6%, Average Added Damping from All 11 GM's = 41.0%)

kpff		project City of Inglewood - Library	by JL	sheet no. A.1-33
700 South Flower Street, Suite 2100 Los Angeles, CA 90017 (213) 418-0201		location	date 10/19/21	
		client	job no. 2000362	

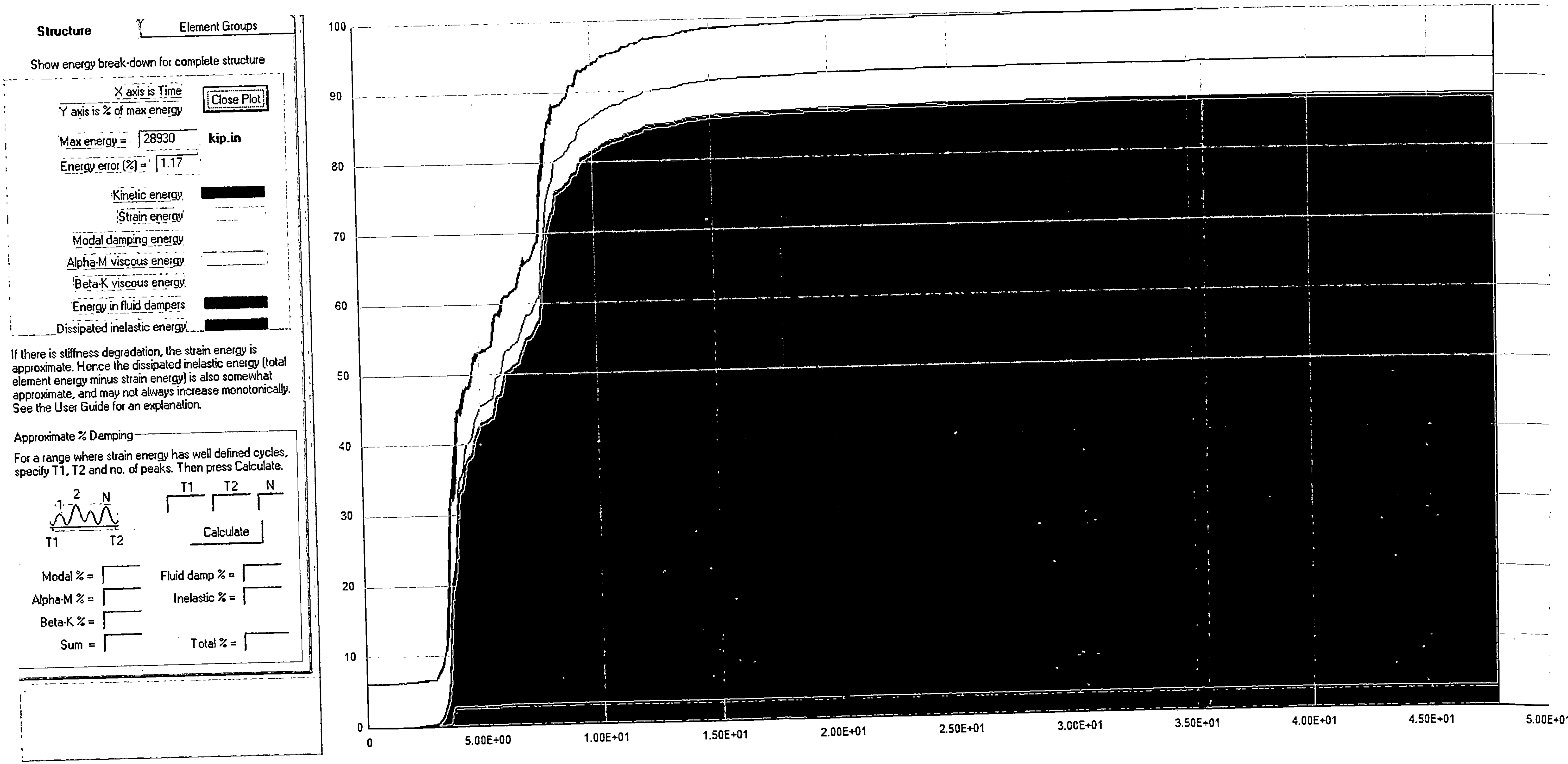

Figure A.1-47 Energy Balance Plot Using Nominal Damper Properties for BSE-1E GM4 (Approximate Added Damping = 43.8%, Average Added Damping from All 11 GM's = 41.0%)

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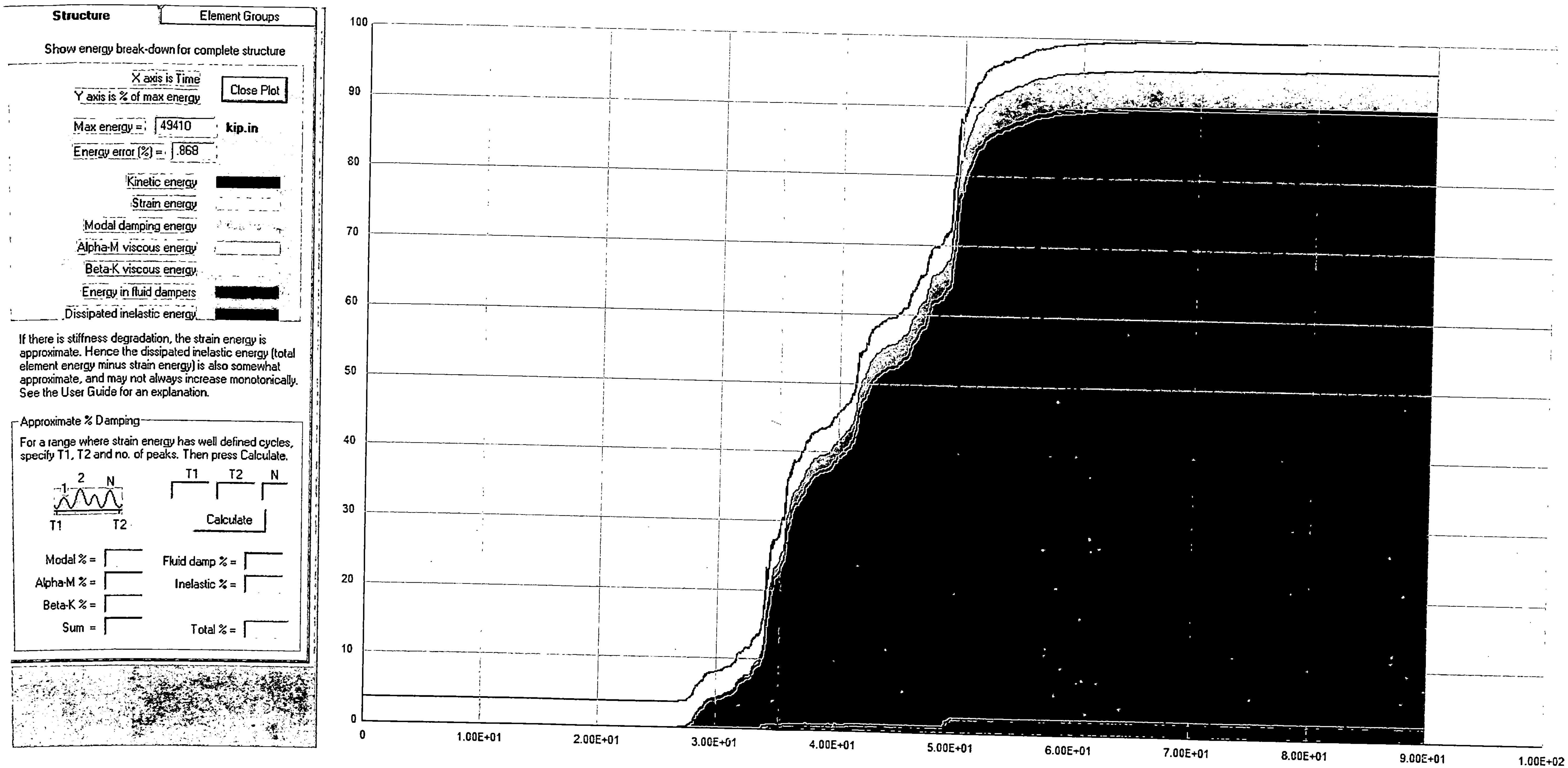

Figure A.1-48 Energy Balance Plot Using Nominal Damper Properties for BSE-1E GM5 (Approximate Added Damping = 42.3%, Average Added Damping from All 11 GM's = 41.0%)

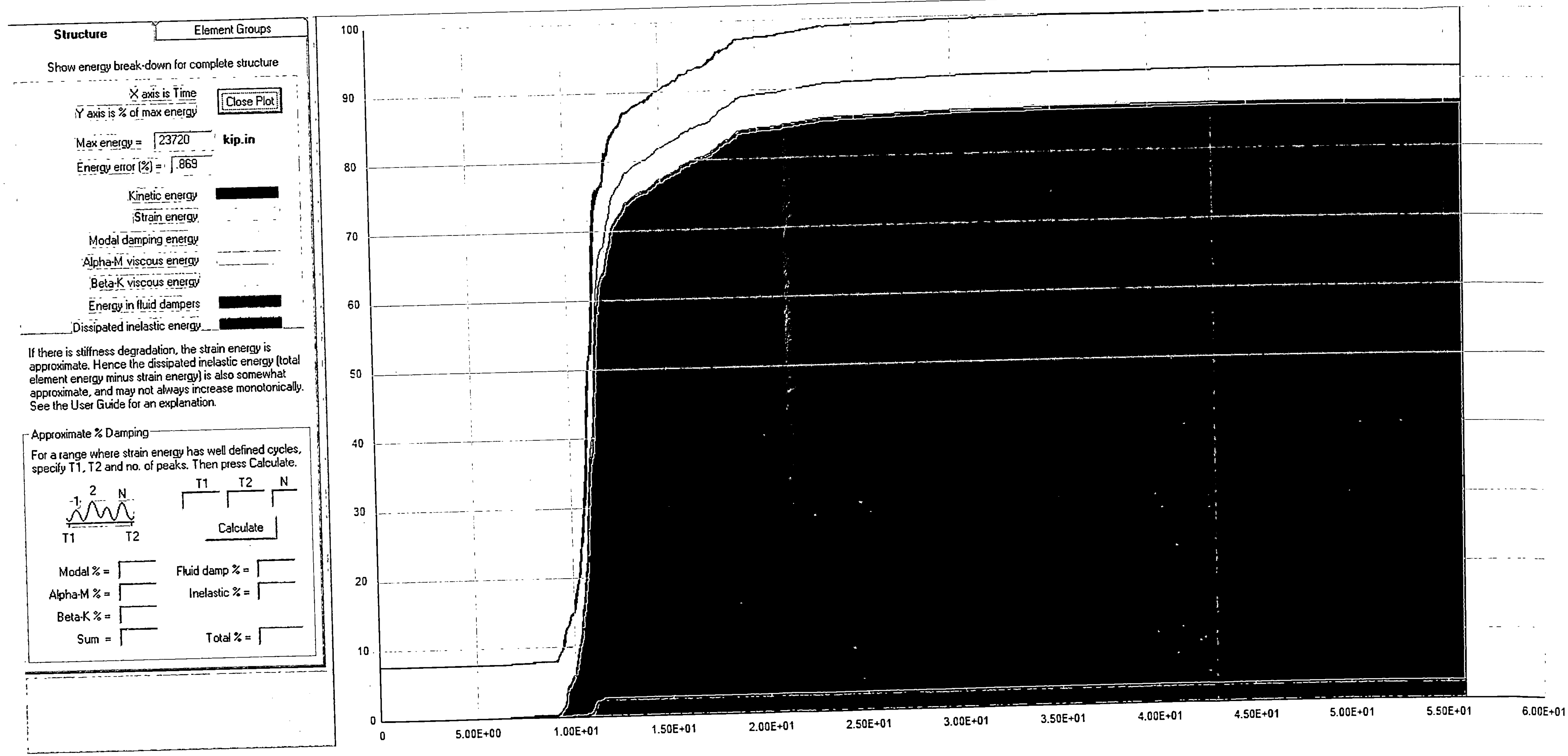

Figure A.1-49 Energy Balance Plot Using Nominal Damper Properties for BSE-1E GM6 (Approximate Added Damping = 45.0%, Average Added Damping from All 11 GM's = 41.0%)

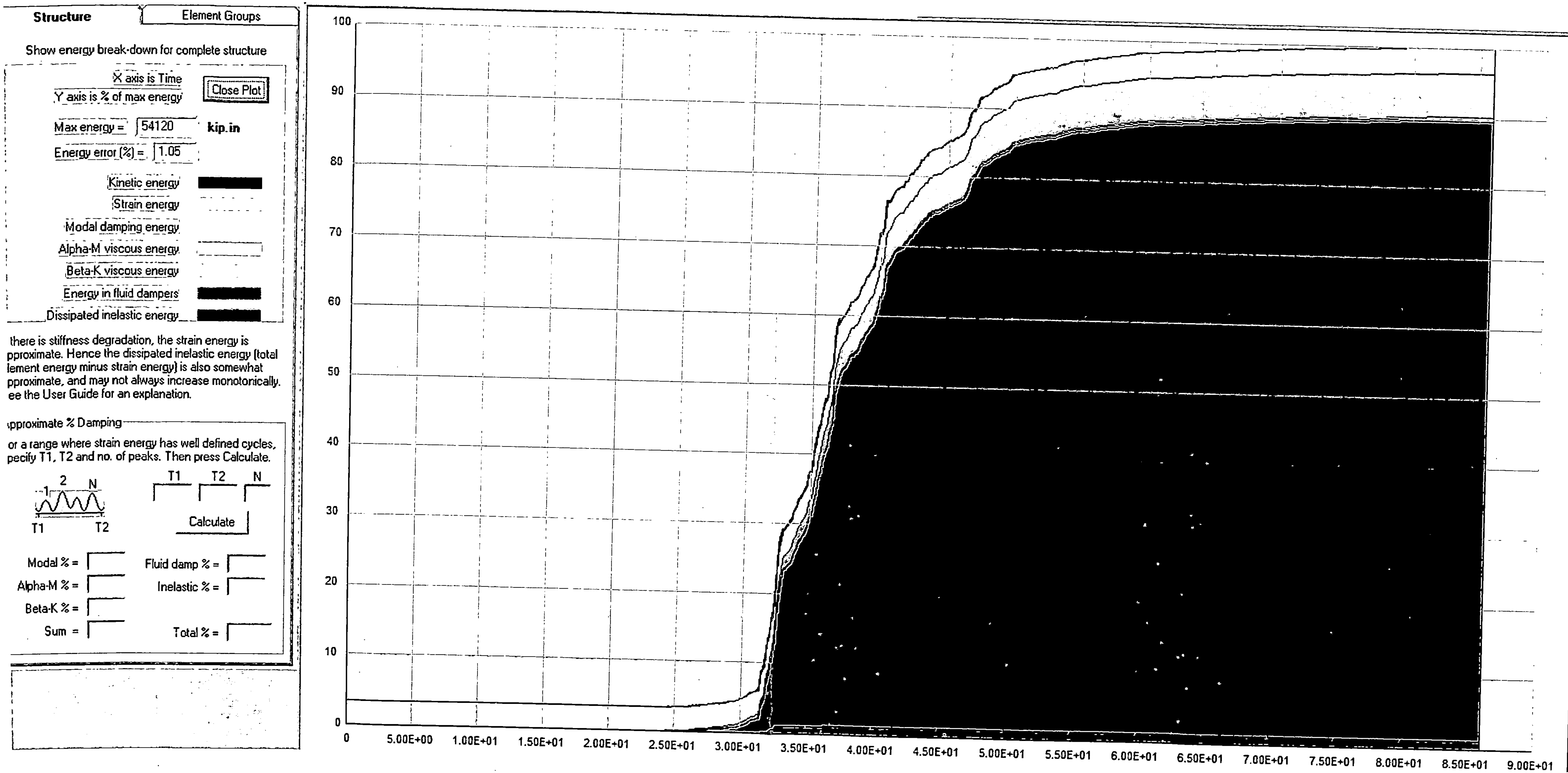

Figure A.1-50 Energy Balance Plot Using Nominal Damper Properties for BSE-1E GM7 (Approximate Added Damping = 36%, Average Added Damping from All 11 GM's = 41.0%)

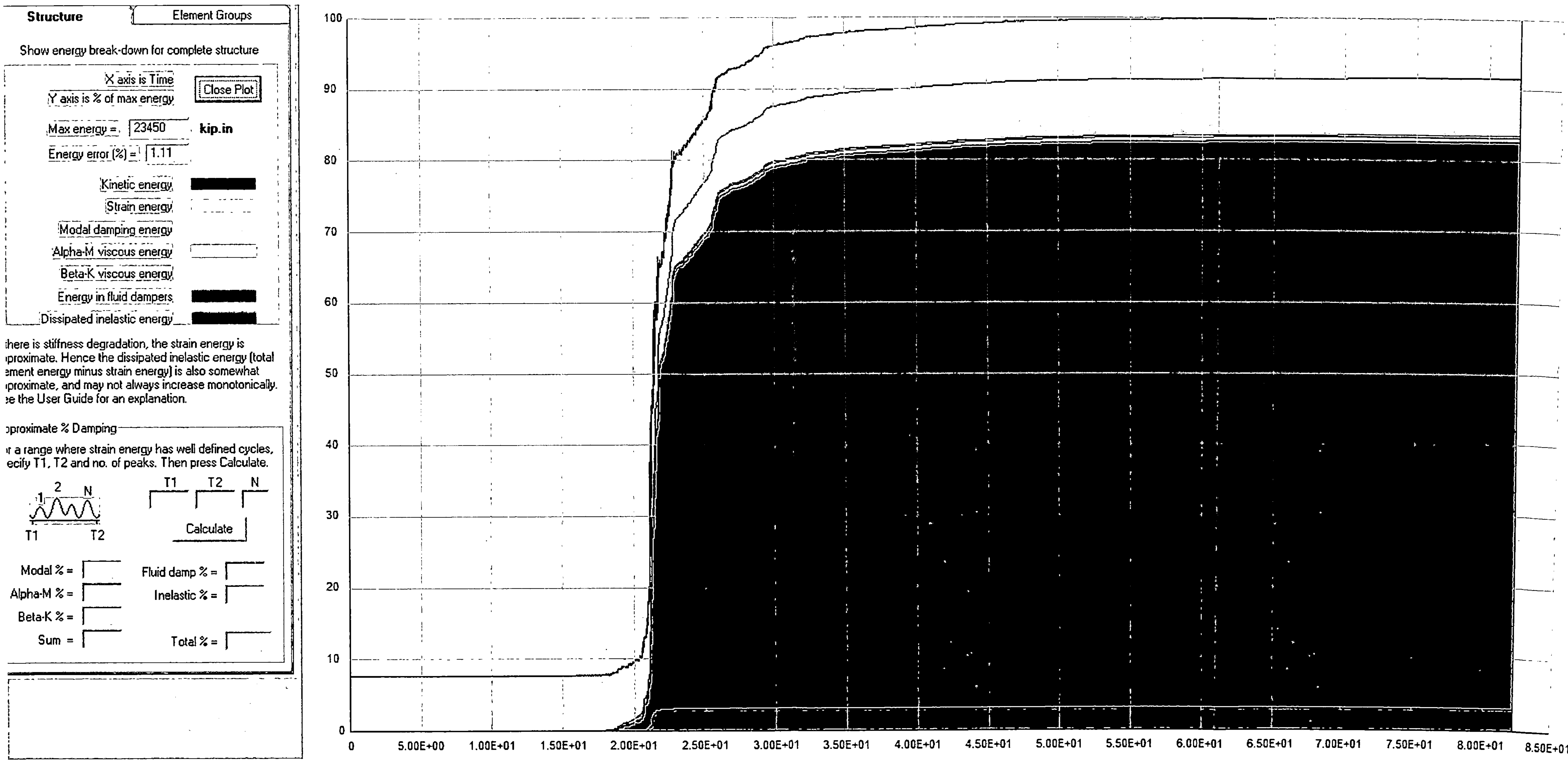

Figure A.1-51 Energy Balance Plot Using Nominal Damper Properties for BSE-1E GM8 (Approximate Added Damping = 26.3%, Average Added Damping from All 11 GM's = 41.0%)

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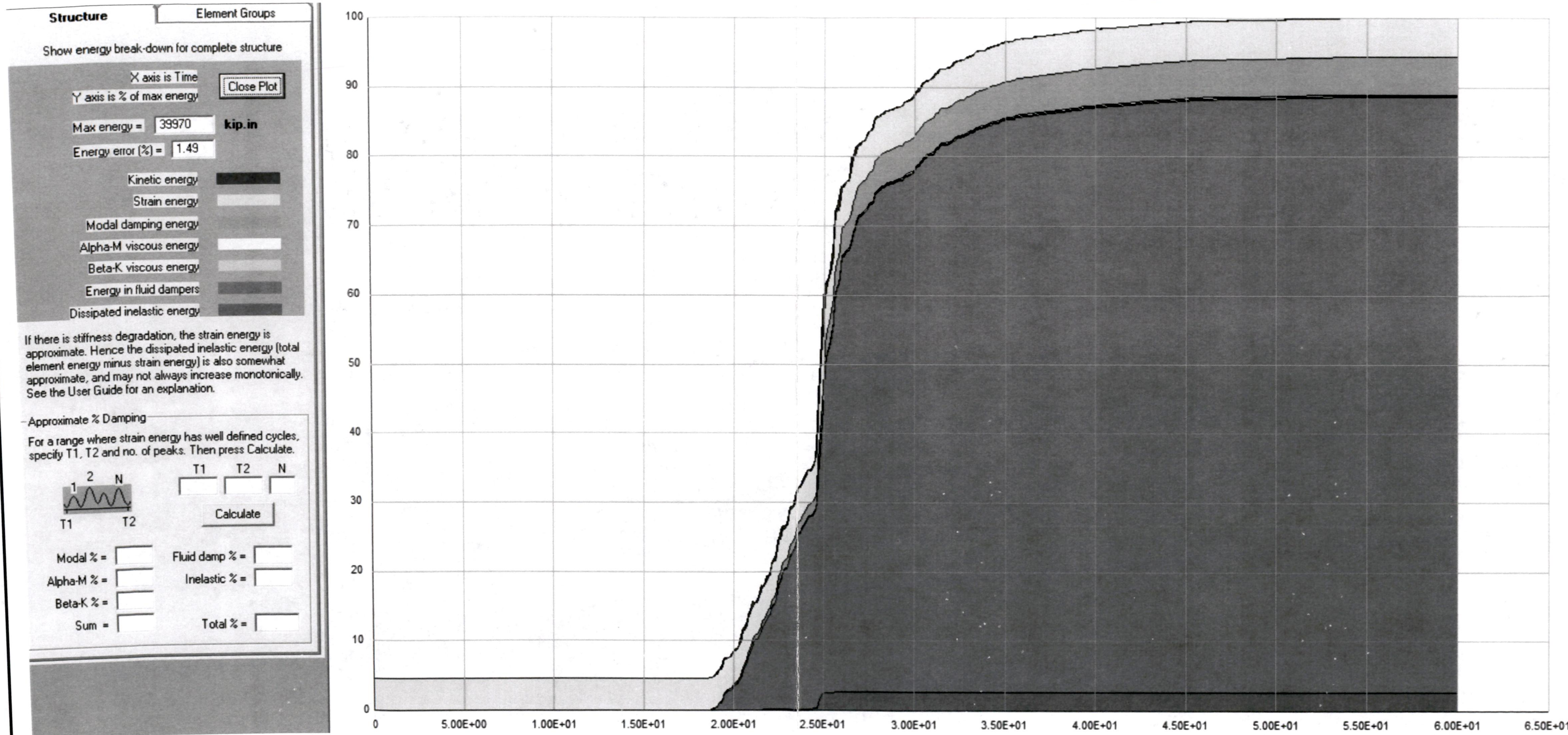

Figure A.1-52 Energy Balance Plot Using Nominal Damper Properties for BSE-1E GM9 (Approximate Added Damping = 41.2%, Average Added Damping from All 11 GM's = 41.0%)

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location	date 10/19/21	
client	job no. 2000362	

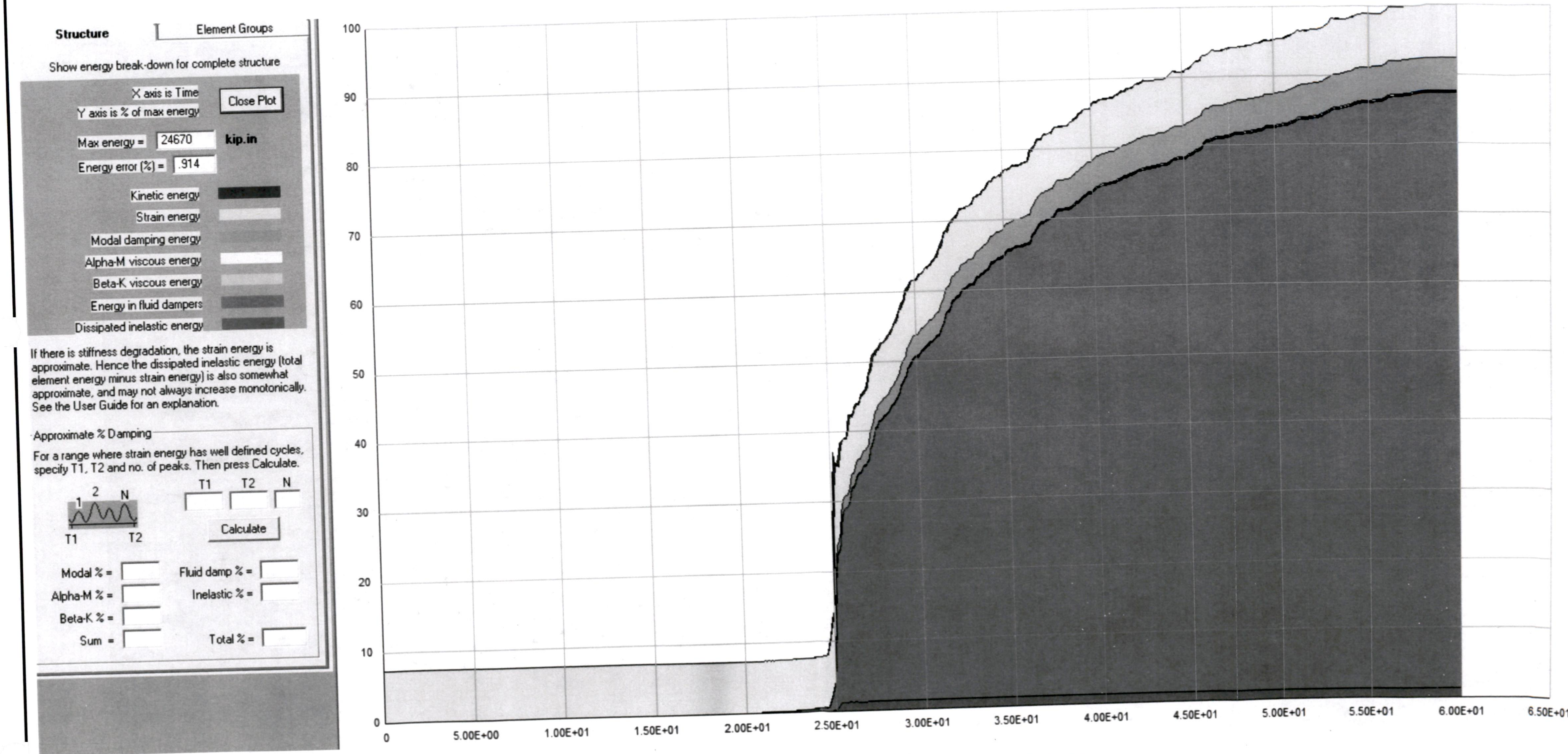

Figure A.1-53 Energy Balance Plot Using Nominal Damper Properties for BSE-1E GM10
(Approximate Added Damping = 46.1%, Average Added Damping from All 11 GM's = 41.0%)

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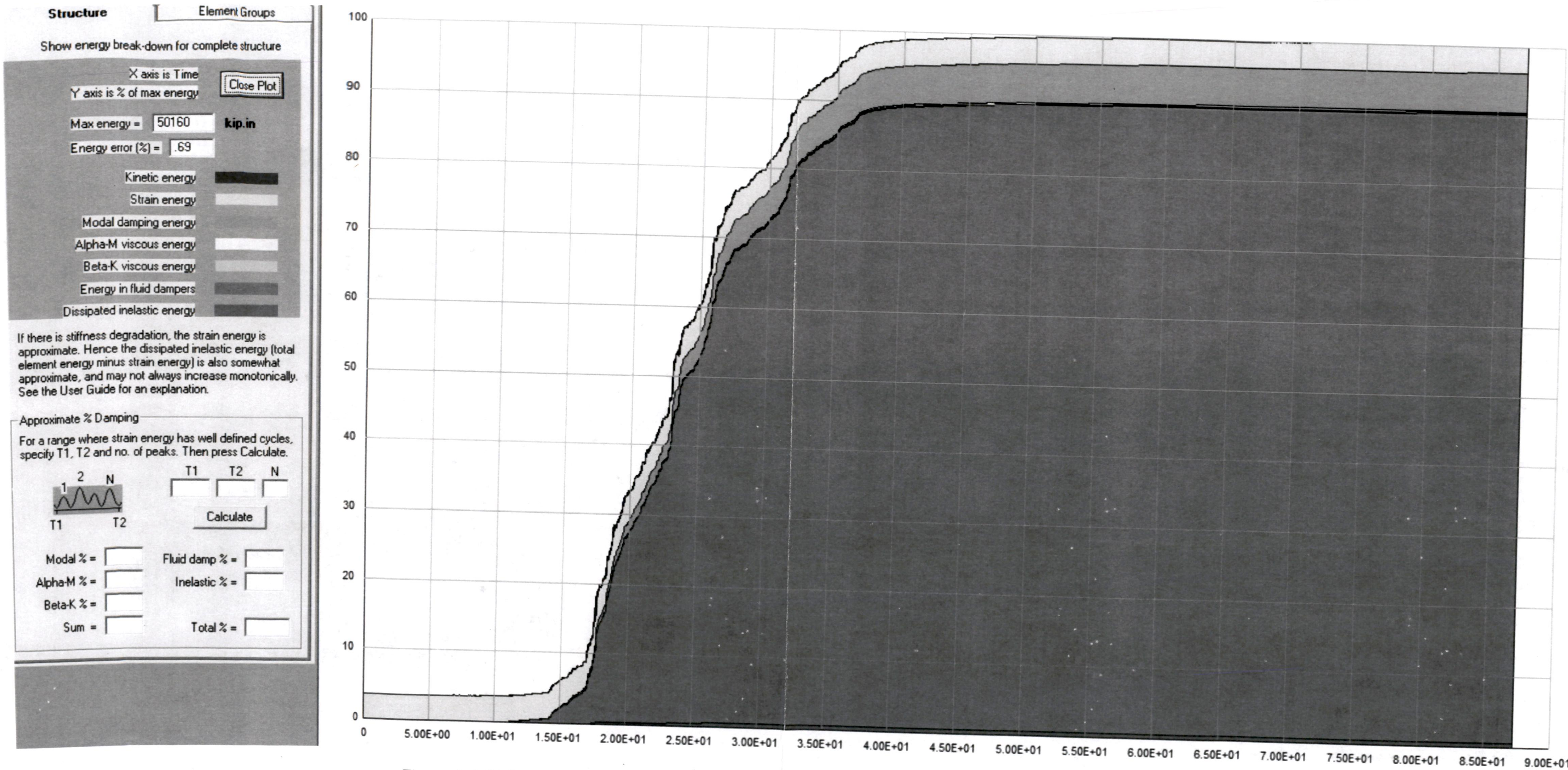

Figure A.1-54 Energy Balance Plot Using Nominal Damper Properties for BSE-1E GM11
(Approximate Added Damping = 45.4%, Average Added Damping from All 11 GM's = 41.0%)

A.2 - Performance Assessment

Executive Summary

The following sections includes the assessment of the lateral force resisting elements in the library building, Moment Frame Beams, Moment Frame Columns, Beam-Column Joints, Shear Walls and Foundation elements. Diaphragms are evaluated in section A.3.

A.2.a - Beams

Executive Summary

The following section includes the assessment of Moment Frame Beams under both hazard levels. All results shown are for the lower bound damper properties which provide the worst case deformation demand on the beam plastic hinges. All moment frame beams meet Collapse Prevention and Life Safety acceptance criteria at the BSE-2E and BSE-1E Hazard levels respectively.

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client	job no. 2000362		

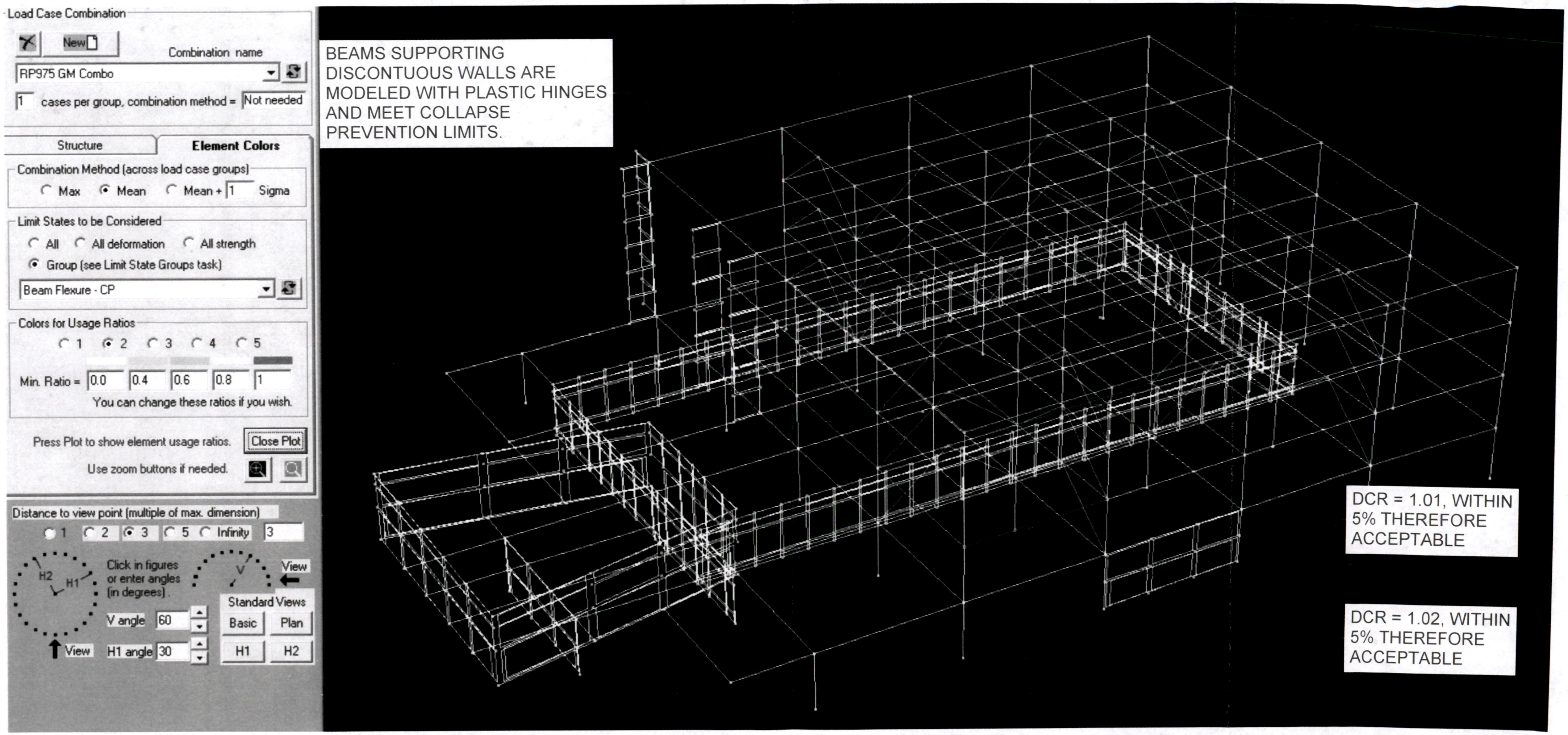

Figure A.2.a-1 Average of 11 Ground Motions, BSE-2E, Collapse Prevention, Lower Bound Damper Properties, Deformation Limits

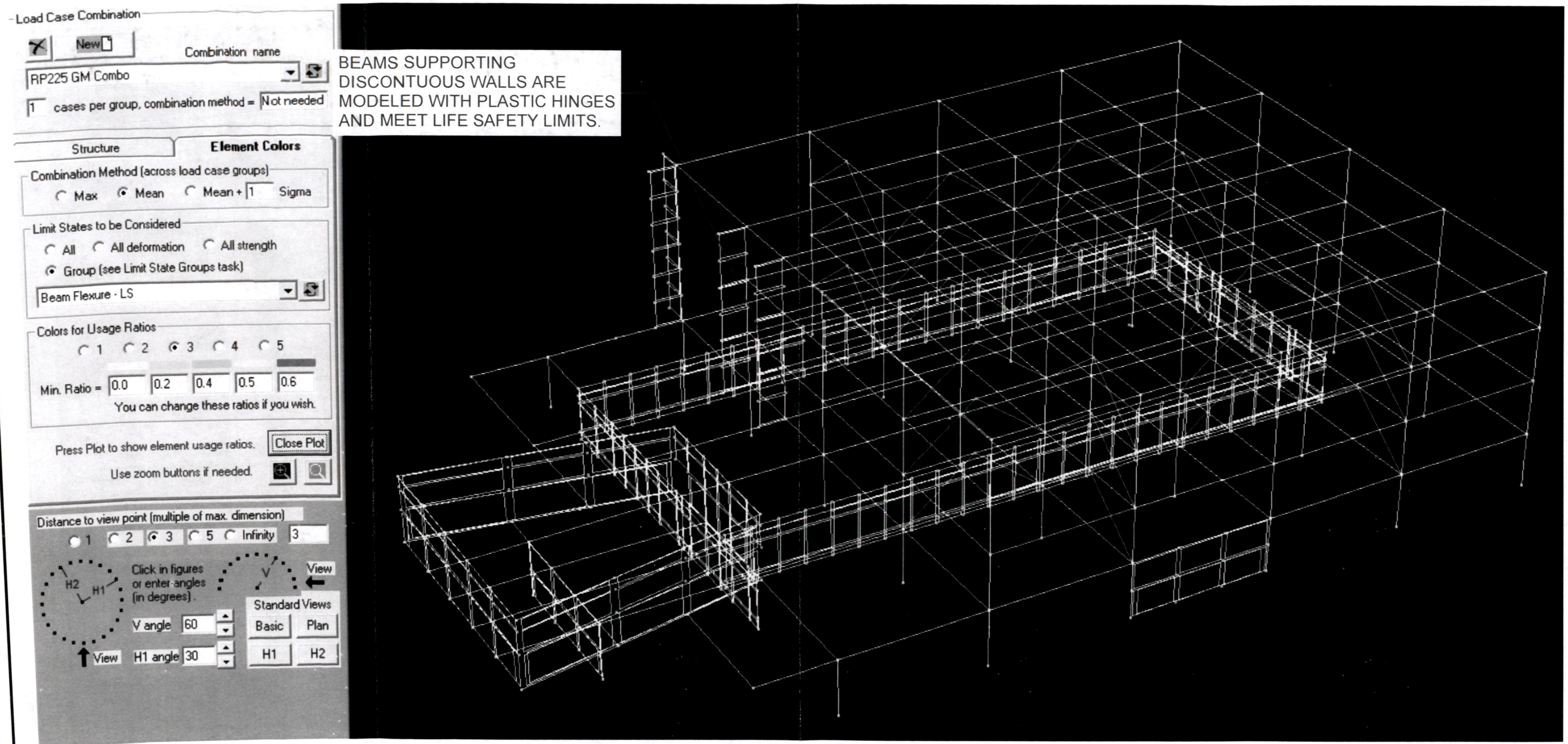

Figure A.2.a-2 Average of 11 Ground Motions, BSE-1E, Life Safety, Lower Bound Damper Properties, Deformation Limits

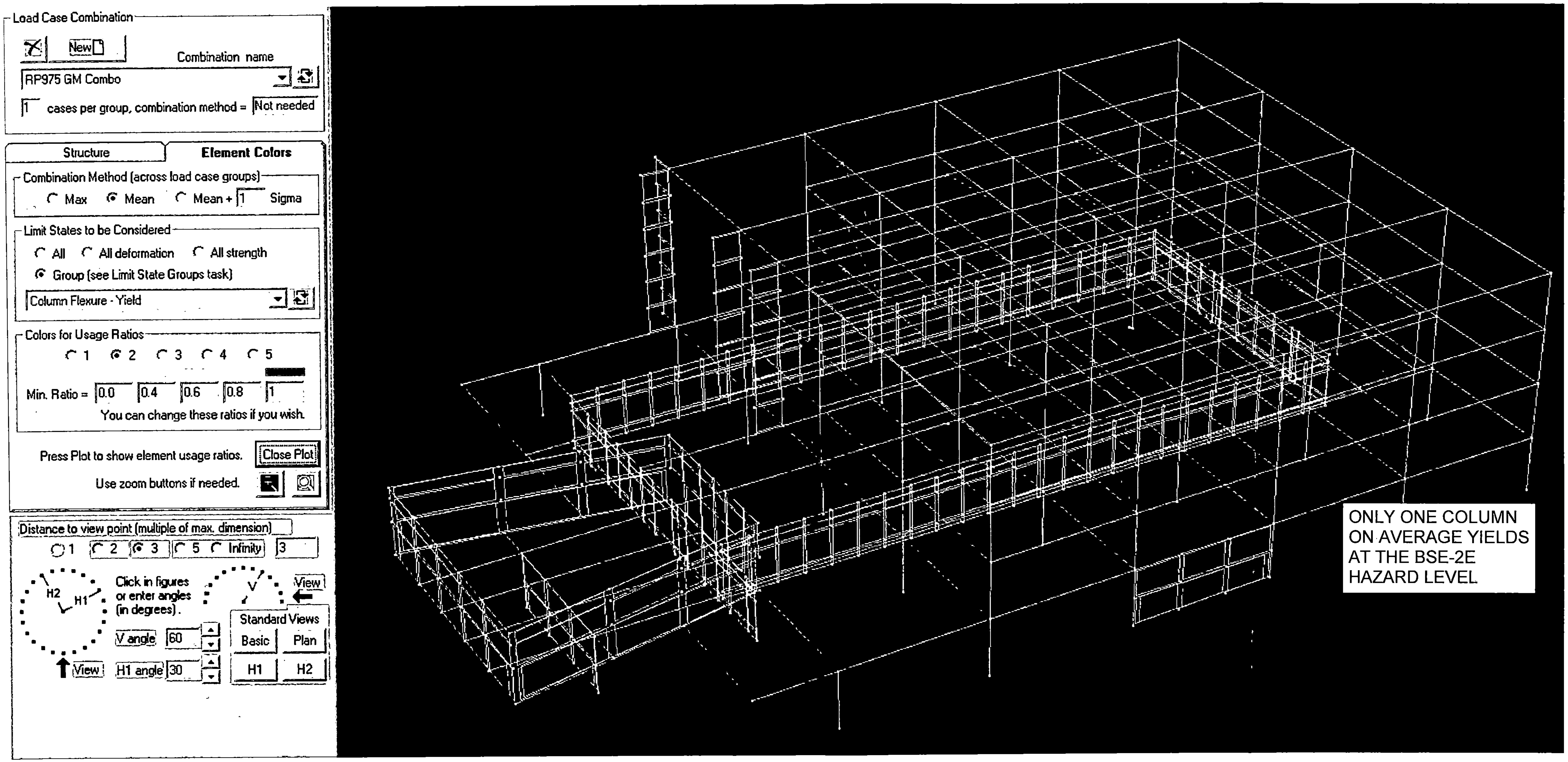

Figure A.2.b-1 Average of 11 Ground Motions, BSE-2E, Flexural Yielding, Lower Bound Damper Properties, Deformation Limits

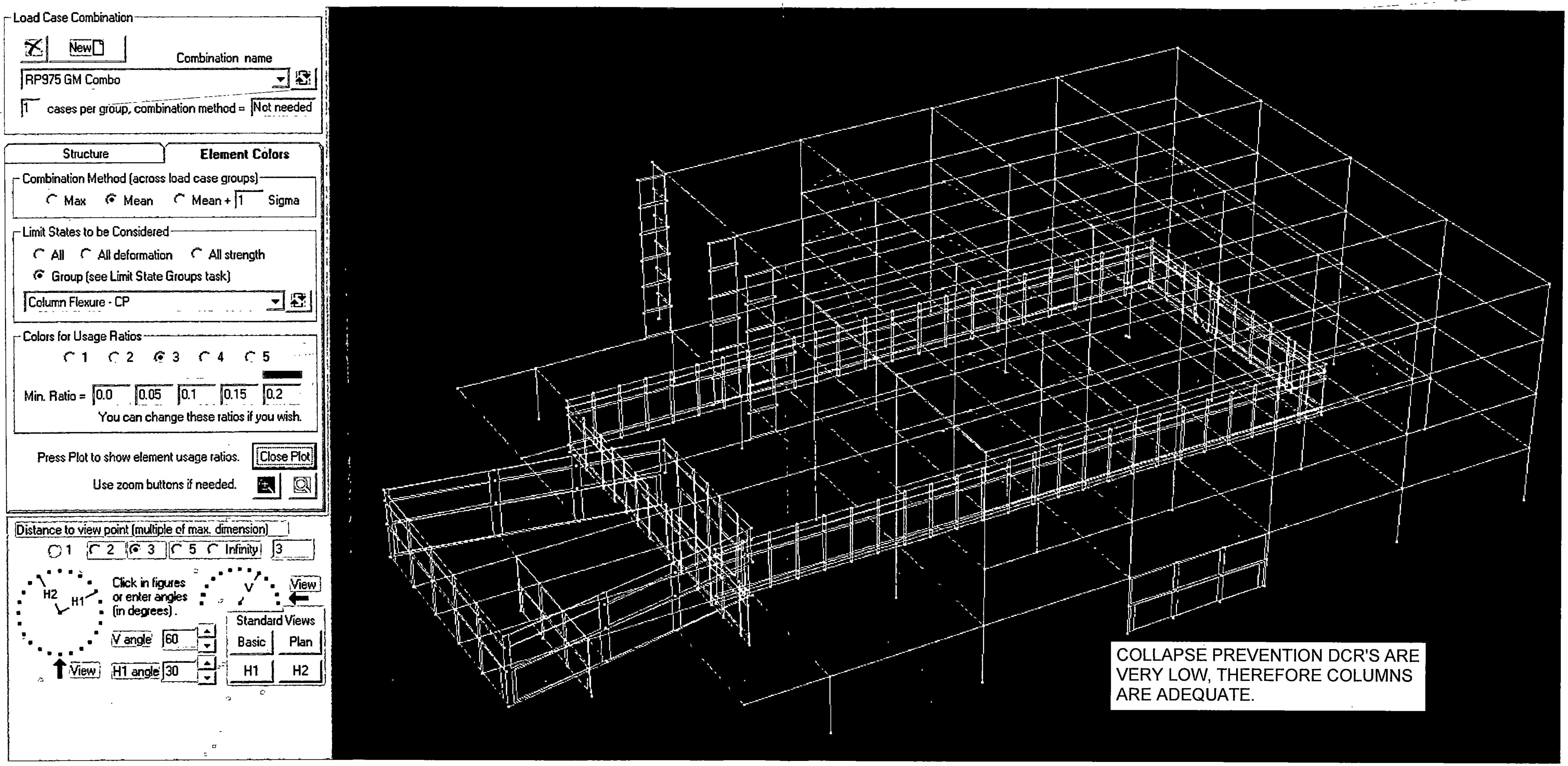

Figure A.2.b-2 Average of 11 Ground Motions, BSE-2E, Collapse Prevention, Lower Bound Damper Properties, Deformation Limits

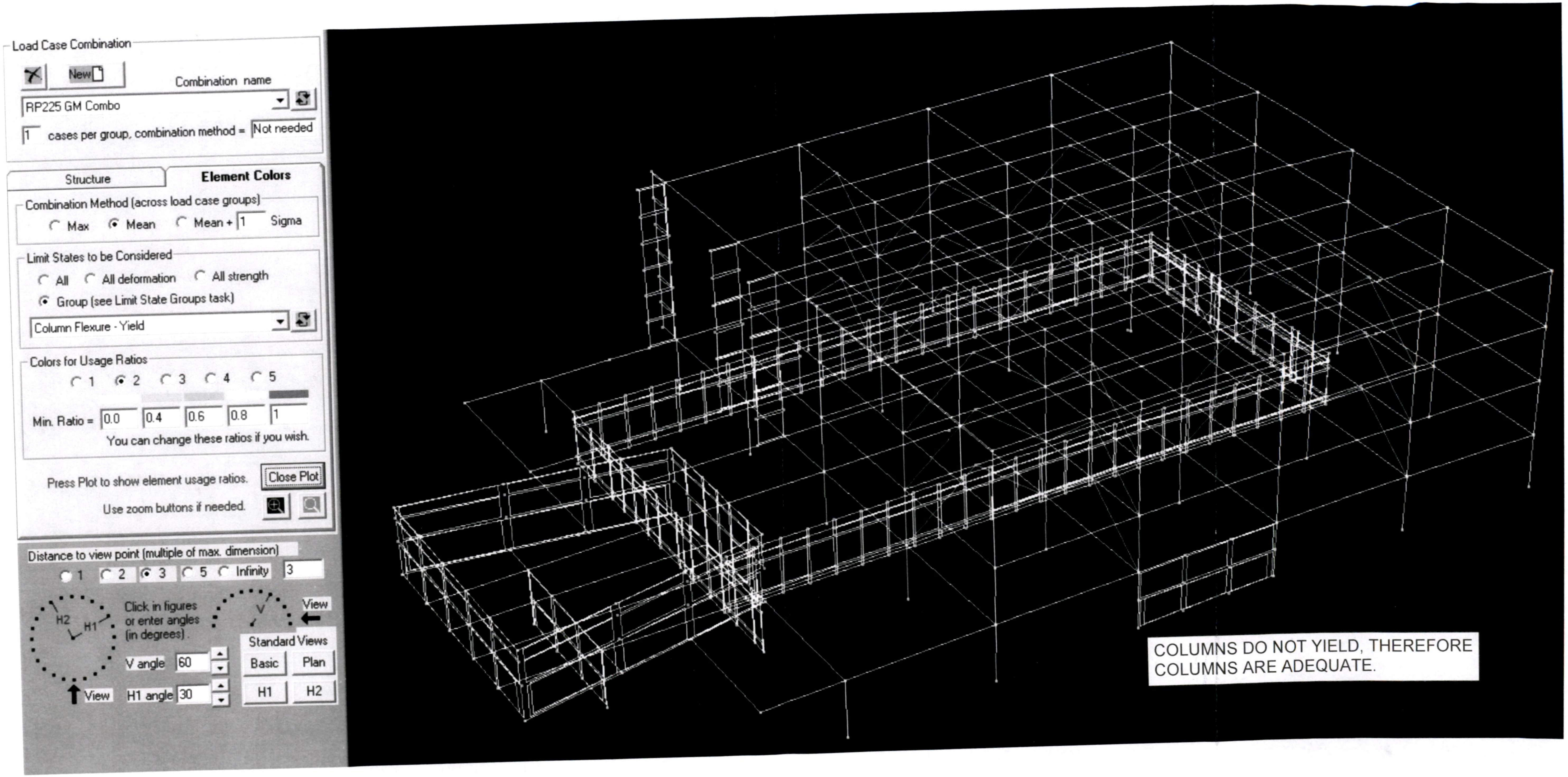

Figure A.2.a-3 Average of 11 Ground Motions, BSE-1E, Flexural Yielding, Lower Bound Damper Properties, Deformation Limits

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Beam-Column Joints Inputs & Results - Part 1

Beam ID's follow those presented in Section 6.1 of Volume 1 calculations

Joint Shear DCR's are all within 5% therefore Adequate

In-framing Beam Inputs

Joint Inputs				Column Inputs					Left Beam												Right Beam												Results					
Joint ID	Level	Joint Classification	λ	h_c (in)	h_b (in)	L_c (in)	$f'_{c,B,C}$ (ksi)	s (in)	Beam ID	$b_{b,L}$ (in)	$f'_{c,E,b,L}$ (ksi)	$A_{s,bot,L}$ (in^2)	$A_{s,top,L}$ (in^2)	$f_{s,bot,L}$ (ksi)	$f_{s,top,L}$ (ksi)	$SF_{T\,Beam\,Pos.\,L}$	$SF_{T\,Beam\,Neg.\,L}$	Mn^+_L (k-in)	Mn^-_L (k-in)	$V_{pr,L}$ (k)	Beam ID	$b_{b,R}$ (in)	$f'_{c,E,b,R}$ (ksi)	$A_{s,bot,R}$ (in^2)	$A_{s,top,R}$ (in^2)	$f_{s,bot,R}$ (ksi)	$f_{s,top,R}$ (ksi)	$SF_{T\,Beam\,Pos.\,R}$	$SF_{T\,Beam\,Neg.\,R}$	Mn^+_R (k-in)	Mn^-_R (k-in)	$V_{pr,R}$ (k)	V_j (k)	A_j in^2	f'c (ksi)	γ	Vn (k)	DCR
S1_J_A4-EW	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_A5-A4-j	24	5.436	3.12	1.2	73.00	44.08	1.51	1.64	11097.56	9272.13	112.97	S1_B_A4-A3-i	24	5.436	3.12	1.2	73.00	44.08	1.51	1.64	11097.56	9949.77	112.97	496.66	576	5.436	15	477.77	1.04
S1_J_A4-NS	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B2-B1-j	24	5.436	3.12	1.2	31.91	44.08	1.63	1.64	5331.12	10390.73	119.58	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	236.81	576	5.436	15	477.77	0.50
S1_J_A3-EW	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_A4-A3-j	24	5.436	3.12	1.2	73.00	44.08	1.51	1.64	11097.56	9949.77	112.97	S1_B_A4-A3-i	24	5.436	3.12	1.2	73.00	44.08	1.51	1.64	11097.56	9949.77	112.97	496.66	576	5.436	15	477.77	1.04
S1_J_A3-NS	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B2-B1-j	24	5.436	3.12	1.2	31.91	44.08	1.63	1.64	5331.12	10390.73	119.58	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	236.81	576	5.436	15	477.77	0.50
S1_J_A2-EW	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_A4-A3-j	24	5.436	3.12	1.2	73.00	44.08	1.51	1.64	11097.56	9949.77	112.97	S1_B_A2-A1-i	24	5.436	3.12	1.2	73.00	44.08	1.51	1.64	11097.56	6870.31	112.97	496.66	576	5.436	15	477.77	1.04
S1_J_A2-NS	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B2-B1-j	24	5.436	3.12	1.2	31.91	44.08	1.63	1.64	5331.12	10390.73	119.58	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	236.81	576	5.436	15	477.77	0.50
S1_J_A1-EW	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_A2-A1-j	24	5.436	3.12	1.2	31.91	44.08	1.51	1.64	4938.65	9949.77	112.97	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	226.87	576	5.436	15	477.77	0.47
S1_J_A1-NS	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_A2-A1-j	24	5.436	3.12	1.2	31.91	44.08	1.51	1.64	4938.65	9949.77	112.97	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	226.87	576	5.436	15	477.77	0.47
S1_J_B4-EW	2	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B5-B4-j	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	9659.24	119.58	S1_B_B4-B3-i	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	528.21	576	5.436	20	637.02	0.83
S1_J_B4-NS	2	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B4-B3-j	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	S1_B_B2-B1-i	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	7066.55	119.58	528.21	576	5.436	20	637.02	0.83
S1_J_B3-EW	2	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B4-B3-j	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	S1_B_B4-B3-i	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	528.21	576	5.436	20	637.02	0.83
S1_J_B3-NS	2	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B4-B3-j	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	S1_B_B2-B1-i	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	7066.55	119.58	528.21	576	5.436	20	637.02	0.83
S1_J_B2-EW	2	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B4-B3-j	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	S1_B_B2-B1-i	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	7066.55	119.58	528.21	576	5.436	20	637.02	0.83
S1_J_B2-NS	2	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B4-B3-j	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	S1_B_B2-B1-i	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	7066.55	119.58	528.21	576	5.436	20	637.02	0.83
S1_J_B1-EW	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B2-B1-j	24	5.436	3.12	1.2	31.91	44.08	1.63	1.64	5331.12	10390.73	119.58	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	236.81	576	5.436	15	477.77	0.50
S1_J_B1-NS	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_A4-A3-j	24	5.436	3.12	1.2	73.00	44.08	1.51	1.64	11097.56	9949.77	112.97	S1_B_A2-A1-i	24	5.436	3.12	1.2	73.00	44.08	1.51	1.64	11097.56	6870.31	112.97	496.66	576	5.436	15	477.77	1.04
S1_J_C4-EW	2	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B5-B4-j	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	9659.24	119.58	S1_B_B4-B3-i	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	528.21	576	5.436	20	637.02	0.83
S1_J_C4-NS	2	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B4-B3-j	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	S1_B_B4-B3-i	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	528.21	576	5.436	20	637.02	0.83
S1_J_C3-EW	2	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B4-B3-j	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	S1_B_B4-B3-i	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	528.21	576	5.436	20	637.02	0.83
S1_J_C3-NS	2	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B4-B3-j	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	S1_B_B4-B3-i	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	528.21	576	5.436	20	637.02	0.83
S1_J_C2-EW	2	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B4-B3-j	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	S1_B_B2-B1-i	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	7066.55	119.58	528.21	576	5.436	20	637.02	0.83
S1_J_C2-NS	2	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B4-B3-j	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	S1_B_B4-B3-i	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	528.21	576	5.436	20	637.02	0.83
S1_J_C1-EW	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B2-B1-j	24	5.436	3.12	1.2	31.91	44.08	1.63	1.64	5331.12	10390.73	119.58	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	236.81	576	5.436	15	477.77	0.50
S1_J_C1-NS	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_A4-A3-j	24	5.436	3.12	1.2	73.00	44.08	1.51	1.64	11097.56	9949.77	112.97	S1_B_A4-A3-i	24	5.436	3.12	1.2	73.00	44.08	1.51	1.64	11097.56	9949.77	112.97	496.66	576	5.436	15	477.77	1.04
S1_J_D4-EW	2	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B5-B4-j	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	9659.24	119.58	S1_B_B4-B3-i	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.43	10390.73	119.58	528.21	576	5.436	20	637.02	0.83
S1_J_D4-NS	2	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_5E-5D-j	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	7066.55	119.58	S1_B_B4-B3-i	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	528.21	576	5.436	20	637.02	0.83
S1_J_D3-EW	2	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B4-B3-j	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	S1_B_B4-B3-i	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	528.21	576	5.436	20	637.02	0.83
S1_J_D3-NS	2	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_5E-5D-j	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	7066.55	119.58	S1_B_B4-B3-i	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.53	528.21	576	5.436	20	637.02	0.83
S1_J_D2-EW	2	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B4-B3-j	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	S1_B_B2-B1-i	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	7066.55	119.58	528.21	576	5.436	20	637.02	0.83
S1_J_D2-NS	2	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_5E-5D-j	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	7066.55	119.58	S1_B_B4-B3-i	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	528.21	576	5.436	20	637.02	0.83
S1_J_D1-EW	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B2-B1-j	24	5.436	3.12	1.2	31.91	44.08	1.63	1.64	5331.12	10390.73	119.58	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	236.81	576	5.436	15	477.77	0.50
S1_J_D1-NS	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_1E-1D-j	24	5.436	3.12	1.2	73.00	44.08	1.51	1.64	11097.56	6870.31	112.97	S1_B_A4-A3-i	24	5.436	3.12	1.2	73.00	44.08	1.51	1.64	11097.56	9949.77	112.97	496.66	576	5.436	15	477.77	1.04
S1_J_E4-EW	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_A5-A4-j	24	5.436	3.12	1.2	73.00	44.08	1.51	1.64	11097.56	9272.13	112.97	S1_B_A4-A3-i	24	5.436	3.12	1.2	73.00	44.08	1.51	1.64	11097.56	9949.77	112.97	496.66	576	5.436	15	477.77	1.04
S1_J_E4-NS	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_5E-5D-i	24	5.436	3.12	1.2	31.91	44.08	1.63	1.64	5331.12	10390.73	119.58	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	236.81	576	5.436	15	477.77	0.50
S1_J_E3-EW	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_A4-A3-j	24	5.436	3.12	1.2	73.00	44.08	1.51	1.64	11097.56	9949.77	112.97	S1_B_A4-A3-i	24	5.436	3.12	1.2	73.00	44.08	1.51	1.64	11097.56	9949.77	112.97	496.66	576	5.436	15	477.77	1.04
S1_J_E3-NS	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_5E-5D-i	24	5.436	3.12	1.2	31.91	44.08	1.63	1.64	5331.12	10390.73	119.58	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	236.81	576	5.436	15	477.77	0.50
S1_J_E2-EW	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_A4-A3-j	24	5.436	3.12	1.2	73.00	44.08	1.51	1.64	11097.56	9949.77	112.97	S1_B_A2-A1-i	24	5.436	3.12	1.2	73.00	44.08	1.51	1.64	11097.56	6870.31	112.97	496.66	576	5.436	15	477.77	1.04
S1_J_E2-NS	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_5E-5D-i	24	5.436	3.12	1.2	31.91	44.08	1.63	1.64	5331.12	10390.73	119.58	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	236.81	576	5.436	15	477.77	0.50
S1_J_E1-EW	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_A2-A1-j	24	5.436	3.12	1.2	31.91	44.08	1.51	1.64	4938.65	9949.77	112.97	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	226.87	576	5.436	15	477.77	0.47
S1_J_E1-NS	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_1E-1D-i	24	5.436	3.12	1.2	31.91	44.08	1.51	1.64	4938.65	9949.77	112.97	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	226.87	576	5.436	15	477.77	0.47
S2_J_A4-EW	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_A4-A3-i	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3499.57	8332.91	104.20	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	189.32	576	5.436	15	477.77	0.40
S2_J_A4-NS	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_4B-4A-j	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3499.57	7852.73	66.74	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	180.65	576	5.436	15	477.77	0.38
S2_J_A3-EW	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_A4-A3-j	24	5.436	3.12	1.2	73.00	44.08	1.07	1.64	7863.83	6150.77	104.20	S2_B_A3-A2-i	24	5.436	3.12	1.2	73.00	44.08	1.07	1.64	7863.83	8332.91	104.20	378.77	576	5.436	15	477.77	0.79
S2_J_A3-NS	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_B2-B1-j	28	5.436	4.5	1.2	26.58	44.08	1.18	1.64	3767.20	7326.70	97.24	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	212.44	576	5.436	15	477.77	0.44
S2_J_A2-EW	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_A3-A2-j	24	5.436	3.12	1.2	73.00	44.08	1.07	1.64	7863.83	8332.91	104.20	S2_B_A2-A1-i	24	5.436	3.12	1.2	73.00	44.08	1.07	1.64	7863.83	6150.77	104.20	378.77	576	5.436	15	477.77	0.79
S2_J_A2-NS	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_2B-2A-j	24	5.436	4.5	1.2	26.58	44.08	1.18	1.64	3756.33	8459.59	105.60	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	246.14	576	5.436	15	477.77	0.52
S2_J_A1-EW	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_A2-A1-j	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3499.57	8332.91	104.20	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	189.32	576	5.436	15	477.77	0.40
S2_J_A1-NS	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_A2-A1-j	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3499.57	8332.91	104.20	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	189.32	576	5.436	15	477.77	0.40
S2_J_B5-EW	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_B5-B4-i	23	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3497.49	7847.22	66.70	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	180.60	576	5.436	15	477.77	0.38
S2_J_B5-NS	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_4C-4B-j	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3499.57	8332.91	89.26	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	190.38	576	5.436	15	477.77	0.40
S2_J_B4-EW	3	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_B5-B4-j	23	5.436	3.12	1.2	63.83	44.08	1.07	1.64	6895.15	6148.39	66.70	S2_B_B4-B3-i	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	7326.70	97.24	379.73	576	5.436	20	637.02	0.60
S2_J_B4-NS	3	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_B4-B3-j	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	7326.70	97.24	S2_B_4B-4A-i	24	5.436	3.12	1.2	63.83	44.08	1.07	1.64	6903.47	6150.77	66.74	379.67	576	5.436	20	637.02	0.60
S2_J_B3-EW	3	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_B4-B3-j	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	7326.70	97.24	S2_B_B4-B3-i	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	7326.70	97.24	443.71	576	5.436	20	637.02	0.70
S2_J_B3-NS	3	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_B4-B3-j	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	7326.70	97.24	S2_B_B2-B1-i	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	5508.34	97.24	443.71	576	5.436	20	637.02	0.70
S2_J_B2-EW	3	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_B4-B3-j	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	7326.70	97.24	S2_B_B2-B1-i	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	5508.34	97.24	443.71	576	5.436	20	637.02	0.70
S2_J_B2-NS	3	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_B4-B3-j	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	7326.70	97.24	S2_B_2B-2A-i	24	5.436	4.5	1.2	70.88	44.08	1.18	1.64	9678.58	5498.47	105.60	523.66	576	5.436	20	637.02	0.82
S2_J_B1-EW	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_B2-B1-j	28	5.436	4.5	1.2	26.58	44.08	1.18	1.64	3767.20	7326.70	97.24	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	212.44	576	5.436	15	477.77	0.44
S2_J_B1-NS	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_A3-A2-j	24	5.436	3.12	1.2	73.00	44.08	1.07	1.64	7863.83	8332.91	104.20	S2_B_A2-A1-i	24	5.436	3.12	1.2	73.00	44.08	1.07	1.64	7863.83	6150.77	104.20	378.77	576	5.436	15	477.77	0.79
S2_J_C5-EW	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_C5-C4-i	28	5.436	4.5	1.2	26.58	44.08	1.18	1.64	3767.20	7326.70	97.24	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	212.44	576	5.436	15	477.77	0.44
S2_J_C5-NS	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_4D-4C-j	24	5.436	3.12	1.2	73.00	44.08	1.07	1.64	7863.83	8332.91	89.26	S2_B_4C-4B-i	24	5.436	3.12	1.2	73.00	44.08	1.07	1.64	7863.83	6150.77	89.26	380.90	576	5.436	15	477.77	0.80
S2_J_C4-EW	3	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_C5-C4-j	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	5508.34	97.24	S2_B_B4-B3-i	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	7326.70	97.24	443.71	576	5.436	20	637.02	0.70
S2_J_C4-NS	3	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_B4-B3-j	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	7326.70	97.24	S2_B_B4-B3-i	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	7326.70	97.24	443.71	576	5.436	20	637.02	0.70
S2_J_C3-EW	3	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_B4-B3-j	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	7326.70	97.24	S2_B_C3-C2-i	24	5.436	3.12	1.2	63.83	44.08	1.18	1.64	7613.18	8207.58	99.92	417.93	576	5.436	20	637.02	0.66
S2_J_C3-NS	3	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_C3-C2-j	24	5.436	3.12	1.2	63.83	44.08	1.18	1.64	7613.18	8207.58	99.92	S2_B_B4-B3-i	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	7326.70	97.24	417.93	576	5.436	20	637.02	0.66
S2_J_C2-EW	3	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_C3-C2-j	24	5.436	3.12	1.2	63.83	44.08	1.18	1.64	7613.18	8207.58	99.92	S2_B_B2-B1-i	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	5508.34	97.24	417.93	576	5.436	20	637.02	0.66
S2_J_C2-NS	3	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_C3-C2-j	24	5.436	3.12	1.2	63.83	44.08	1.18	1.64	7613.18	8207.58	99.92	S2_B_B4-B3-i	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	7326.70	97.24	417.93	576	5.436	20	637.02	0.66
S2_J_C1-EW	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_B2-B1-j	28	5.436	4.5	1.2	26.58	44.08	1.18	1.64	3767.20	7326.70	97.24	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	212.44	576	5.436	15	477.77	0.44
S2_J_C1-NS	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_A3-A2-j	24	5.436	3.12	1.2	73.00	44.08	1.07	1.64	7863.83	8332.91	104.20	S2_B_A3-A2-i	24	5.436	3.12	1.2	73.00	44.08	1.07	1.64	7863.83	8332.91	104.20	378.77	576	5.436	15	477.77	0.79
S2_J_D5-EW	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_C5-C4-i	28	5.436	4.5	1.2	26.58	44.08	1.18	1.64	3767.20	7326.70	97.24	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	212.44	576	5.436	15	477.77	0.44
S2_J_D5-NS	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_4E-4D-j	24	5.436	3.12	1.2	73.00	44.08	1.07	1.64	7863.83	6150.77	89.26	S2_B_4D-4C-i	24	5.436	3.12	1.2	73.00	44.08	1.07	1.64	7863.83	8332.91	89.26	380.90	576	5.436	15	477.77	0.80
S2_J_D4-EW	3	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_C5-C4-j	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	5508.34	97.24	S2_B_B4-B3-i	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	7326.70	97.24	443.71	576	5.436	20	637.02	0.70
S2_J_D4-NS	3	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_C5-C4-j	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	5508.34	97.24	S2_B_B4-B3-i	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	7326.70	97.24	443.71	576	5.436	20	637.02	0.70
S2_J_D3-EW	3	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_B4-B3-j	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	7326.70	97.24	S2_B_C3-C2-i	24	5.436	3.12	1.2	63.83	44.08	1.18	1.64	7613.18	8207.58	99.92	417.93	576	5.436	20	637.02	0.66
S2_J_D3-NS	3	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_C5-C4-j	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	5508.34	97.24	S2_B_C3-C2-i	24	5.436	3.12	1.2	63.83	44.08	1.18	1.64	7613.18	8207.58	99.92	417.93	576	5.436	20	637.02	0.66

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Beam-Column Joints Inputs & Results - Part 2

									In-framing Beam Inputs																													
Joint Inputs				Column Inputs					Left Beam												Right Beam												Results					
Joint ID	Level	Joint Classification	λ	h_c (in)	h_b (in)	L_c (in)	$f'c_{LB,c}$ (ksi)	s (in)	Beam ID	$b_{b,L}$ (in)	$f'c_{E,b,L}$ (ksi)	$A_{s,bot,L}$ (in^2)	$A_{s,top,L}$ (in^2)	$f_{s,bot,L}$ (ksi)	$f_{s,top,L}$ (ksi)	$SF_{T\ Beam\ Pos,L}$	$SF_{T\ Beam\ Neg,L}$	$Mn_E^+{}_L$ (k-in)	$Mn_E^-{}_L$ (k-in)	$V_{pr,L}$ (k)	Beam ID	$b_{b,R}$ (in)	$f'c_{E,b,R}$ (ksi)	$A_{s,bot,R}$ (in^2)	$A_{s,top,R}$ (in^2)	$f_{s,bot,R}$ (ksi)	$f_{s,top,R}$ (ksi)	$SF_{T\ Beam\ Pos,R}$	$SF_{T\ Beam\ Neg,R}$	$Mn_E^+{}_R$ (k-in)	$Mn_E^-{}_R$ (k-in)	$V_{pr,R}$ (k)	V_j (k)	A_j in^2	f'c (ksi)	γ	Vn (k)	DCR
S2_J_D2-EW	3	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_C3-C2-j	24	5.436	3.12	1.2	63.83	44.08	1.18	1.64	7613.18	8207.58	99.92	S2_B_B2-B1-i	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	5508.34	97.24	417.93	576	5.436	20	637.02	0.66
S2_J_D2-NS	3	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_C5-C4-j	28	5.436	4.5	1.2	53.16	44.08	1.18	1.64	7403.92	5508.34	97.24	S2_B_C3-C2-i	24	5.436	3.12	1.2	63.83	44.08	1.18	1.64	7613.18	8207.58	99.92	417.93	576	5.436	20	637.02	0.66
S2_J_D1-EW	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_B2-B1-j	28	5.436	4.5	1.2	26.58	44.08	1.18	1.64	3767.20	7326.70	97.24	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	212.44	576	5.436	15	477.77	0.44
S2_J_D1-NS	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_A4-A3-j	24	5.436	3.12	1.2	73.00	44.08	1.07	1.64	7863.83	6150.77	104.20	S2_B_A3-A2-i	24	5.436	3.12	1.2	73.00	44.08	1.07	1.64	7863.83	8332.91	104.20	378.77	576	5.436	15	477.77	0.79
S2_J_E5-EW	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_A4-A3-i	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3499.57	8332.91	104.20	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	189.32	576	5.436	15	477.77	0.40
S2_J_E5-NS	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_4E-4D-i	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3499.57	8332.91	89.26	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	190.38	576	5.436	15	477.77	0.40
S2_J_E4-EW	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_A4-A3-j	24	5.436	3.12	1.2	73.00	44.08	1.07	1.64	7863.83	6150.77	104.20	S2_B_A3-A2-i	24	5.436	3.12	1.2	73.00	44.08	1.07	1.64	7863.83	8332.91	104.20	378.77	576	5.436	15	477.77	0.79
S2_J_E4-NS	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_C5-C4-i	28	5.436	4.5	1.2	26.58	44.08	1.18	1.64	3767.20	7326.70	97.24	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	212.44	576	5.436	15	477.77	0.44
S2_J_E3-EW	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_A3-A2-j	24	5.436	3.12	1.2	73.00	44.08	1.07	1.64	7863.83	8332.91	104.20	S2_B_A3-A2-i	24	5.436	3.12	1.2	73.00	44.08	1.07	1.64	7863.83	8332.91	104.20	378.77	576	5.436	15	477.77	0.79
S2_J_E3-NS	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_C5-C4-i	28	5.436	4.5	1.2	26.58	44.08	1.18	1.64	3767.20	7326.70	97.24	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	212.44	576	5.436	15	477.77	0.44
S2_J_E2-EW	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_A3-A2-j	24	5.436	3.12	1.2	73.00	44.08	1.07	1.64	7863.83	8332.91	104.20	S2_B_A2-A1-i	24	5.436	3.12	1.2	73.00	44.08	1.07	1.64	7863.83	6150.77	104.20	378.77	576	5.436	15	477.77	0.79
S2_J_E2-NS	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_C5-C4-i	28	5.436	4.5	1.2	26.58	44.08	1.18	1.64	3767.20	7326.70	97.24	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	212.44	576	5.436	15	477.77	0.44
S2_J_E1-EW	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_A2-A1-j	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3499.57	8332.91	104.20	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	189.32	576	5.436	15	477.77	0.40
S2_J_E1-NS	3	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S2_B_A4-A3-i	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3499.57	8332.91	104.20	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	189.32	576	5.436	15	477.77	0.40
S4_J_A5-EW	5	Knee Joint	0.75	24	24	84	5.99	6	S4_B_A5-A4-i	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3499.57	6150.77	72.63	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	181.85	576	5.436	8	254.81	0.71
S4_J_A5-NS	5	Knee Joint	0.75	24	24	84	5.99	6	S4_B_5B-5A-j	24	5.436	3.12	1.2	39.01	44.08	1.07	1.64	4264.26	6150.77	80.80	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	181.85	576	5.436	8	254.81	0.71
S4_J_A4-EW	5	T Joint	0.75	24	24	84	5.99	6	S4_B_A5-A4-j	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3499.57	6150.77	72.63	S4_B_A4-A3-i	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	2981.37	5631.45	75.58	283.50	576	5.436	12	382.21	0.74
S4_J_A4-NS	5	Knee Joint	0.75	24	24	84	5.99	6	S4_B_4B-4A-j	24	5.436	3.12	1.2	39.01	44.08	1.18	1.64	4702.64	6330.66	84.01	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	187.16	576	5.436	8	254.81	0.73
S4_J_A3-EW	5	T Joint	0.75	24	24	84	5.99	6	S4_B_A4-A3-j	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	2981.37	5631.45	75.53	S4_B_A4-A3-i	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	2981.37	5631.45	75.58	273.26	576	5.436	12	382.21	0.71
S4_J_A3-NS	5	Knee Joint	0.75	24	24	84	5.99	6	S4_B_B2-B1-j	28	5.436	3.12	1.2	39.01	44.08	1.18	1.64	3852.25	5205.68	78.98	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	186.86	576	5.436	8	254.81	0.73
S4_J_A2-EW	5	T Joint	0.75	24	24	84	5.99	6	S4_B_A4-A3-j	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	2981.37	5631.45	75.58	S4_B_A2-A1-i	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3286.48	5784.00	76.70	283.50	576	5.436	12	382.21	0.74
S4_J_A2-NS	5	Knee Joint	0.75	24	24	84	5.99	6	S4_B_B2-B1-j	28	5.436	3.12	1.2	39.01	44.08	1.18	1.64	3852.25	5205.68	78.98	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	186.86	576	5.436	8	254.81	0.73
S4_J_A1-EW	5	Knee Joint	0.75	24	24	84	5.99	6	S4_B_A2-A1-j	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3286.48	5784.00	76.70	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	181.75	576	5.436	8	254.81	0.71
S4_J_A1-NS	5	Knee Joint	0.75	24	24	84	5.99	6	S4_B_A2-A1-j	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3286.48	5784.00	76.70	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	181.75	576	5.436	8	254.81	0.71
S4_J_B5-EW	5	Knee Joint	0.75	24	24	84	5.99	6	S4_B_B5-B4-i	24	5.436	3.12	1.2	39.01	44.08	1.18	1.64	4702.64	6330.66	84.01	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	187.16	576	5.436	8	254.81	0.73
S4_J_B5-NS	5	T Joint	0.75	24	24	84	5.99	6	S4_B_5C-5B-j	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	2981.37	5631.45	70.09	S4_B_5B-5A-i	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3499.57	6533.12	80.80	289.45	576	5.436	12	382.21	0.76
S4_J_B4-EW	5	T Joint	0.75	24	24	84	5.99	6	S4_B_B5-B4-j	24	5.436	3.12	1.2	31.91	44.08	1.18	1.64	3859.34	6752.31	84.01	S4_B_B4-B3-i	28	5.436	2.54	1.2	35.43	44.08	1.18	1.64	2869.22	5059.35	83.40	305.83	576	5.436	12	382.21	0.80
S4_J_B4-NS	5	T Joint	0.75	24	24	84	5.99	6	S4_B_B4-B3-j	28	5.436	2.54	1.2	35.43	44.08	1.18	1.64	2869.22	5059.35	83.40	S4_B_4B-4A-i	24	5.436	3.12	1.2	31.91	44.08	1.18	1.64	3859.34	6752.31	84.01	305.83	576	5.436	12	382.21	0.80
S4_J_B3-EW	5	T Joint	0.75	24	24	84	5.99	6	S4_B_B4-B3-j	28	5.436	2.54	1.2	35.43	44.08	1.18	1.64	2869.22	5059.35	83.40	S4_B_B4-B3-i	28	5.436	2.54	1.2	35.43	44.08	1.18	1.64	2869.22	5059.35	83.40	287.81	576	5.436	12	382.21	0.75
S4_J_B3-NS	5	T Joint	0.75	24	24	84	5.99	6	S4_B_C4-C3-j	28	5.436	2.54	1.2	35.43	44.08	1.18	1.64	2869.22	5059.35	91.43	S4_B_B2-B1-i	28	5.436	3.12	1.2	31.91	44.08	1.18	1.64	3161.89	5550.86	78.98	305.45	576	5.436	12	382.21	0.80
S4_J_B2-EW	5	T Joint	0.75	24	24	84	5.99	6	S4_B_B4-B3-j	28	5.436	2.54	1.2	35.43	44.08	1.18	1.64	2869.22	5059.35	83.40	S4_B_B2-B1-i	28	5.436	3.12	1.2	31.91	44.08	1.18	1.64	3161.89	5550.86	78.98	305.45	576	5.436	12	382.21	0.80
S4_J_B2-NS	5	T Joint	0.75	24	24	84	5.99	6	S4_B_B4-B3-j	28	5.436	2.54	1.2	35.43	44.08	1.18	1.64	2869.22	5059.35	83.40	S4_B_B2-B1-i	28	5.436	3.12	1.2	31.91	44.08	1.18	1.64	3161.89	5550.86	78.98	305.45	576	5.436	12	382.21	0.80
S4_J_B1-EW	5	Knee Joint	0.75	24	24	84	5.99	6	S4_B_B2-B1-j	28	5.436	3.12	1.2	39.01	44.08	1.18	1.64	3852.25	5205.68	78.98	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	186.86	576	5.436	8	254.81	0.73
S4_J_B1-NS	5	T Joint	0.75	24	24	84	5.99	6	S4_B_A4-A3-j	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	2981.37	5631.45	75.58	S4_B_A2-A1-i	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3286.48	5784.00	76.70	283.50	576	5.436	12	382.21	0.74
S4_J_C5-EW	5	Knee Joint	0.75	24	24	84	5.99	6	S4_B_C5-C4-i	28	5.436	3.12	1.2	39.01	44.08	1.18	1.64	3852.25	5205.68	78.98	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	186.86	576	5.436	8	254.81	0.73
S4_J_C5-NS	5	T Joint	0.75	24	24	84	5.99	6	S4_B_5C-5B-j	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	2981.37	5631.45	70.09	S4_B_5C-5B-i	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	2981.37	5631.45	70.09	273.26	576	5.436	12	382.21	0.71
S4_J_C4-EW	5	T Joint	0.75	24	24	84	5.99	6	S4_B_C5-C4-j	28	5.436	3.12	1.2	31.91	44.08	1.18	1.64	3161.89	5550.86	78.98	S4_B_C4-C3-i	28	5.436	2.54	1.2	35.43	44.08	1.18	1.64	2869.22	5059.35	91.43	305.45	576	5.436	12	382.21	0.80
S4_J_C4-NS	5	T Joint	0.75	24	24	84	5.99	6	S4_B_B4-B3-j	28	5.436	2.54	1.2	35.43	44.08	1.18	1.64	2869.22	5059.35	83.40	S4_B_B4-B3-i	28	5.436	2.54	1.2	35.43	44.08	1.18	1.64	2869.22	5059.35	83.40	287.81	576	5.436	12	382.21	0.75
S4_J_C3-EW	5	T Joint	0.75	24	24	84	5.99	6	S4_B_C4-C3-j	28	5.436	2.54	1.2	35.43	44.08	1.18	1.64	2869.22	5059.35	91.43	S4_B_C3-C2-i	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	3173.97	5987.97	58.46	283.23	576	5.436	12	382.21	0.74
S4_J_C3-NS	5	T Joint	0.75	24	24	84	5.99	6	S4_B_C3-C2-j	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	3173.97	5987.97	58.46	S4_B_C4-C3-i	28	5.436	2.54	1.2	35.43	44.08	1.18	1.64	2869.22	5059.35	91.43	283.23	576	5.436	12	382.21	0.74
S4_J_C2-EW	5	T Joint	0.75	24	24	84	5.99	6	S4_B_C3-C2-j	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	3173.97	5987.97	58.46	S4_B_B2-B1-i	28	5.436	3.12	1.2	31.91	44.08	1.18	1.64	3161.89	5550.86	78.98	295.55	576	5.436	12	382.21	0.77
S4_J_C2-NS	5	T Joint	0.75	24	24	84	5.99	6	S4_B_D3-D2-j	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	3173.97	5987.97	50.42	S4_B_B4-B3-i	28	5.436	2.54	1.2	35.43	44.08	1.18	1.64	2869.22	5059.35	83.40	283.23	576	5.436	12	382.21	0.74
S4_J_C1-EW	5	Knee Joint	0.75	24	24	84	5.99	6	S4_B_B2-B1-j	28	5.436	3.12	1.2	39.01	44.08	1.18	1.64	3852.25	5205.68	78.98	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	186.86	576	5.436	8	254.81	0.73
S4_J_C1-NS	5	T Joint	0.75	24	24	84	5.99	6	S4_B_A4-A3-j	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	2981.37	5631.45	75.58	S4_B_A4-A3-i	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	2981.37	5631.45	75.58	273.26	576	5.436	12	382.21	0.71
S4_J_D5-EW	5	Knee Joint	0.75	24	24	84	5.99	6	S4_B_C5-C4-i	28	5.436	3.12	1.2	39.01	44.08	1.18	1.64	3852.25	5205.68	78.98	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	186.86	576	5.436	8	254.81	0.73
S4_J_D5-NS	5	T Joint	0.75	24	24	84	5.99	6	S4_B_5E-5D-j	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3286.48	5784.00	71.21	S4_B_5C-5B-i	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	2981.37	5631.45	70.09	283.50	576	5.436	12	382.21	0.74
S4_J_D4-EW	5	T Joint	0.75	24	24	84	5.99	6	S4_B_C5-C4-j	28	5.436	3.12	1.2	31.91	44.08	1.18	1.64	3161.89	5550.86	78.98	S4_B_B4-B3-i	28	5.436	2.54	1.2	35.43	44.08	1.18	1.64	2869.22	5059.35	83.40	305.45	576	5.436	12	382.21	0.80
S4_J_D4-NS	5	T Joint	0.75	24	24	84	5.99	6	S4_B_C5-C4-j	28	5.436	3.12	1.2	31.91	44.08	1.18	1.64	3161.89	5550.86	78.98	S4_B_B4-B3-i	28	5.436	2.54	1.2	35.43	44.08	1.18	1.64	2869.22	5059.35	83.40	305.45	576	5.436	12	382.21	0.80
S4_J_D3-EW	5	T Joint	0.75	24	24	84	5.99	6	S4_B_B4-B3-j	28	5.436	2.54	1.2	35.43	44.08	1.18	1.64	2869.22	5059.35	83.40	S4_B_D3-D2-i	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	3173.97	5987.97	50.42	283.23	576	5.436	12	382.21	0.74
S4_J_D3-NS	5	T Joint	0.75	24	24	84	5.99	6	S4_B_C5-C4-j	28	5.436	3.12	1.2	31.91	44.08	1.18	1.64	3161.89	5550.86	78.98	S4_B_C3-C2-i	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	3173.97	5987.97	58.46	295.55	576	5.436	12	382.21	0.77
S4_J_D2-EW	5	T Joint	0.75	24	24	84	5.99	6	S4_B_D3-D2-j	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	3173.97	5987.97	50.42	S4_B_B2-B1-i	28	5.436	3.12	1.2	31.91	44.08	1.18	1.64	3161.89	5550.86	78.98	295.55	576	5.436	12	382.21	0.77
S4_J_D2-NS	5	T Joint	0.75	24	24	84	5.99	6	S4_B_C5-C4-j	28	5.436	3.12	1.2	31.91	44.08	1.18	1.64	3161.89	5550.86	78.98	S4_B_D3-D2-i	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	3173.97	5987.97	50.42	295.55	576	5.436	12	382.21	0.77
S4_J_D1-EW	5	Knee Joint	0.75	24	24	84	5.99	6	S4_B_B2-B1-j	28	5.436	3.12	1.2	39.01	44.08	1.18	1.64	3852.25	5205.68	78.98	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	186.86	576	5.436	8	254.81	0.73
S4_J_D1-NS	5	T Joint	0.75	24	24	84	5.99	6	S4_B_A2-A1-j	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3286.48	5784.00	76.70	S4_B_A4-A3-i	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	2981.37	5631.45	75.58	283.50	576	5.436	12	382.21	0.74
S4_J_E5-EW	5	Knee Joint	0.75	24	24	84	5.99	6	S4_B_A2-A1-i	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3286.48	5784.00	76.70	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	181.75	576	5.436	8	254.81	0.71
S4_J_E5-NS	5	Knee Joint	0.75	24	24	84	5.99	6	S4_B_5E-5D-i	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3286.48	5784.00	71.21	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	181.75	576	5.436	8	254.81	0.71
S4_J_E4-EW	5	T Joint	0.75	24	24	84	5.99	6	S4_B_A2-A1-j	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3286.48	5784.00	76.70	S4_B_A4-A3-i	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	2981.37	5631.45	75.58	283.50	576	5.436	12	382.21	0.74
S4_J_E4-NS	5	Knee Joint	0.75	24	24	84	5.99	6	S4_B_C5-C4-i	28	5.436	3.12	1.2	39.01	44.08	1.18	1.64	3852.25	5205.68	78.98	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	186.86	576	5.436	8	254.81	0.73
S4_J_E3-EW	5	T Joint	0.75	24	24	84	5.99	6	S4_B_A4-A3-j	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	2981.37	5631.45	75.58	S4_B_A4-A3-i	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	2981.37	5631.45	75.58	273.26	576	5.436	12	382.21	0.71
S4_J_E3-NS	5	Knee Joint	0.75	24	24	84	5.99	6	S4_B_C5-C4-i	28	5.436	3.12	1.2	39.01	44.08	1.18	1.64	3852.25	5205.68	78.98	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	186.86	576	5.436	8	254.81	0.73
S4_J_E2-EW	5	T Joint	0.75	24	24	84	5.99	6	S4_B_A4-A3-j	24	5.436	2.54	1.2	35.43	44.08	1.07	1.64	2981.37	5631.45	75.58	S4_B_A2-A1-i	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3286.48	5784.00	76.70	283.50	576	5.436	12	382.21	0.74
S4_J_E2-NS	5	Knee Joint	0.75	24	24	84	5.99	6	S4_B_C5-C4-i	28	5.436	3.12	1.2	39.01	44.08	1.18	1.64	3852.25	5205.68	78.98	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	186.86	576	5.436	8	254.81	0.73
S4_J_E1-EW	5	Knee Joint	0.75	24	24	84	5.99	6	S4_B_A2-A1-j	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3286.48	5784.00	76.70	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	181.75	576	5.436	8	254.81	0.71
S4_J_E1-NS	5	Knee Joint	0.75	24	24	84	5.99	6	S4_B_A2-A1-j	24	5.436	3.12	1.2	31.91	44.08	1.07	1.64	3286.48	5784.00	76.70	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	181.75	576	5.436	8	254.81	0.71
S1_J_A5-NS	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_5B-5A-j	24	5.436	3.12	1.2	31.91	44.08	1.63	1.64	5331.12	10390.73	124.93	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	236.43	576	5.436	15	477.77	0.49
S1_J_A5-EW	2	Ext Joint w/o Transverse Beams	0.75	24	24	168	5.99	6	S1_B_A5-A4-i	24	5.436	3.12	1.2	63.83	44.08	1.51	1.64	9742.28	9949.77	112.97	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	234.66	576	5.436	12	382.21	0.61
S1_J_B5-NS	2	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B4-B3-j	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	S1_B_5B-5A-i	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	7066.55	124.93	527.83	576	5.436	20	637.02	0.83
S1_J_B5-EW	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B5-B4-i	24	5.436	3.12	1.2	63.83	44.08	1.63	1.64	10516.51	10390.73	119.58	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	253.47	576	5.436	15	477.77	0.53
S1_J_C5-NS	2	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_B4-B3-j	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	S1_B_B4-B3-i	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	528.21	576	5.436	20	637.02	0.83
S1_J_D5-NS	2	Int Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_5E-5D-j	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	7066.55	119.58	S1_B_B4-B3-i	24	5.436	3.12	1.2	73.00	44.08	1.63	1.64	11979.48	10390.73	119.58	528.21	576	5.436	20	637.02	0.83
S1_J_E5-NS	2	Ext Joint w/ Transverse Beams	0.75	24	24	168	5.99	6	S1_B_5E-5D-i	24	5.436	3.12	1.2	31.91	44.08	1.63	1.64	5331.12	10390.73	119.58	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	236.81	576	5.436	15	477.77	0.50

Sample Beam-Column Joint Calculation

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By :	JL

Joint ID & Story: **S1_J_B4-EW at 2**

Step 1: Summarize Joint Properties, Other Inputs

fs values are determined per development length requirements, used to develop hinge capacities, TYP.

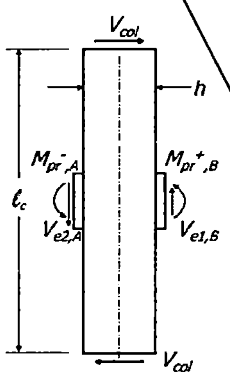
Joint Classification = Int Joint w/ Transverse Beams
λ = 0.75

Column Inputs:

Depth, h_c =	24	in	
Width, h_b =	24	in	taken as half height of story above and below
Column Height, L_c =	168	in	
$f'c_{E,c}$ =	5.99	ksi	
Hoop Spacing, s =	6	in	spacing through joint

Left Beam Inputs:			Right Beam Inputs:		
Beam ID =	S1_B_B5-B4-j		Beam ID =	S1_B_B4-B3-i	
width, $b_{b,L}$ =	24	in	width, $b_{b,R}$ =	24	in
$f'c_{E,b,L}$ =	5.436	ksi	$f'c_{E,b,R}$ =	5.436	ksi
$A_{s,bot,L}$ =	3.12	in^2	$A_{s,bot,R}$ =	3.12	in^2
$A_{s,top,L}$ =	1.2	in^2	$A_{s,top,R}$ =	1.2	in^2
$f_{s,bot,L}$ =	73.00	ksi	$f_{s,bot,R}$ =	73	ksi
$f_{s,top,L}$ =	44.08	ksi	$f_{s,top,R}$ =	44.08	ksi
$SF_{T\ Beam\ Pos,\ L}$ =	1.63		$SF_{T\ Beam\ Pos,\ R}$ =	1.63	
$SF_{T\ Beam\ Neg,\ L}$ =	1.64		$SF_{T\ Beam\ Neg,\ R}$ =	1.64	
$Mn_E{}^+{}_L$ =	11979.48	k-in	$Mn_E{}^+{}_R$ =	11979.48	k-in
$Mn_E{}^-{}_L$ =	9659.24	k-in	$Mn_E{}^-{}_R$ =	10390.73	k-in
$V_{pr,L}$ =	119.58	k	$V_{pr,R}$ =	119.58	k
$SF_{2h,\ L}$ =	3.29		$SF_{2h,\ R}$ =	3.54	

Scale factor to account for T beam increase in strength per Volume 1 calculations in Section 6.1.



$$V_{col} = \left[(M_{pr}^+{}_{,B} + M_{pr}^-{}_{,A}) + (V_{e2,A} + V_{e1,B})\frac{h}{2}\right]/\ell_c$$

Figure 5-4 – Free body diagram of column used to calculate column shear V_{col}.

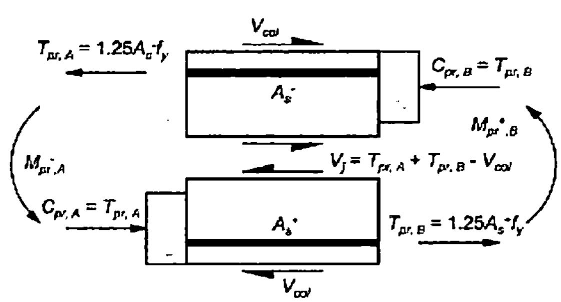


Figure 5-5 - Joint shear free body diagram.

Moment capacities used in hinge capacities.

Scale factor to account for assumption of placing Negative moment hinge at 1/3rd point of beam at the ends of the beam.

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Step 2: Calculate Shear Demand in Joint

Step 2a: Calculate Shear in Column

$V_{col,1} = ((M_{nE}^{-}{}_{L}+M_{nE}^{+}{}_{R})+(V_{pr,L}+V_{pr,R})(h/2))/L_c =$ = 145.88 k — Column Shear when frame sways to the Right. For Knee or T joints Vcol assumed N/A

$V_{col,2} = ((M_{nE}^{+}{}_{L}+M_{nE}^{-}{}_{R})+(V_{pr,L}+V_{pr,R})(h/2))/L_c =$ = 150.24 k — Column Shear when frame sways to the Left. For Knee or T joints Vcol assumed N/A

Step 2b: Calculate Forces at Joint Face

$T_{pr,L,1} = A_{s,top,L}*f_{s,top,L}*SF_{T\ Beam\ Neg,\ L} * SF_{2h,\ L} =$ 285.57 k — Tension at Left joint face when frame sways to the Right

$C_{pr,R,1} = T_{pr,R,1} = A_{s,bot,R}*f_{s,bot,R}*SF_{T\ Beam\ Pos,\ R} =$ = 371.25 k — Compression at Right joint face when frame sways to the Right

$T_{pr,R,2} = A_{s,top,R}*f_{s,top,R}*SF_{T\ Beam\ Neg,\ R}*SF_{2h,\ R} =$ 307.20 k — Tension at Right joint face when frame sways to the Left

$C_{pr,L,2} = T_{pr,L,2} = A_{s,bot,L}*f_{s,bot,L}*SF_{T\ Beam\ Pos,\ L} =$ = 371.25 k — Compression at Left joint face when frame sways to the Left

Step 2c: Calculate Resultant Shear Forces in Joint

$V_{j,1} = T_{pr,L,1} + C_{pr,R,1} - V_{col,1} =$ 510.94 k — Joint shear when frame sways to the Right

$V_{j,2} = T_{pr,R,2} + C_{pr,L,2} - V_{col,2} =$ 528.21 k — Joint shear when frame sways to the Left

$V_j = Max(V_{j,1}, V_{j,2}) =$ 528.21 k

Step 3: Calculate Joint Shear Capacity per ASCE 41-17 10.4.2.3.2

Step 3a: Determine Joint Area

$h_j = h_c =$ 24 in

b_j = min of the following:

$h_b =$ 24 in

$b_b + h_j =$

Where $b_b = (b_{b,L}+b_{b,R})/2 =$ 24 in

Therefore $b_b + h_j =$ 48 in

$b_b + 2x =$

Where $x = (h_b-b_b)/2 =$ 0 in

Therefore $b_b + 2x =$ 24 in

Therefore $b_j =$ 24 in

$A_j = h_j*b_j =$ 576 in^2

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Step 3b: Determine γ per ASCE 41-17 Table 10-12

Step 3b.i: Determine if transverse reinforcement in joint is conforming

s = 6 in

If $s \le h_c/2$ → Conforming

If $s > h_c/2$ → Non Conforming

Therefore Conforming

Step 3b.ii: Determine γ

γ per ASCE 41-17 Table 10-2						
Transverse Reinforcement	Int Joint w/ Transverse Beams	Int Joint w/o Transverse Beams	Ext Joint w/ Transverse Beams	Ext Joint w/o Transverse Beams	Knee Joint	T Joint
Conforming	20	15	15	12	8	12
Non Conforming	12	10	8	6	4	6

Therefore γ = 20

Step 3c: Calculate Joint Shear Capacity

$f'c = \min(f'c_{LB,c}, f'c_{LB,b,L}, f'c_{LB,b,R}) =$ 5.436 ksi

$V_n = \lambda \gamma \sqrt{f'c_E} A_j =$ **637.02 k** **DCR =** 0.83 OK

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Joint ID & Story: **S1_J_A4-NS at 2**

Step 1: Summarize Joint Properties, Other Inputs

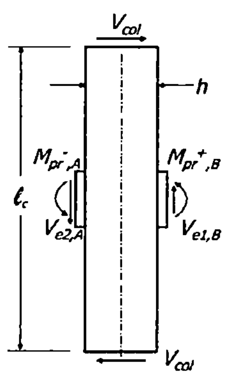
Joint Classification = Ext Joint w/ Transverse Beams
λ = 0.75

Joint only has one in-framing beam in the North-South Direction, but two in-framing beams East-West.

Column Inputs:

Depth, h_c =	24	in	
Width, h_b =	24	in	taken as half height of story above and below
Column Height, L_c =	168	in	
$f'c_{E,c}$ =	5.99	ksi	
Hoop Spacing, s =	6	in	spacing through joint

Left Beam Inputs:			Right Beam Inputs:		
Beam ID =	S1_B_B2-B1-j		Beam ID =	N/A	
width, $b_{b,L}$ =	24	in	width, $b_{b,R}$ =	N/A	in
$f'c_{E,b,L}$ =	5.436	ksi	$f'c_{E,b,R}$ =	N/A	ksi
$A_{s,bot,L}$ =	3.12	in^2	$A_{s,bot,R}$ =	N/A	in^2
$A_{s,top,L}$ =	1.2	in^2	$A_{s,top,R}$ =	N/A	in^2
$f_{s,bot,L}$ =	31.91	ksi	$f_{s,bot,R}$ =	N/A	ksi
$f_{s,top,L}$ =	44.08	ksi	$f_{s,top,R}$ =	N/A	ksi
$SF_{T\ Beam\ Pos,\ L}$ =	1.63		$SF_{T\ Beam\ Pos,\ R}$ =	N/A	
$SF_{T\ Beam\ Neg,\ L}$ =	1.64		$SF_{T\ Beam\ Neg,\ R}$ =	N/A	
$Mn_E{}^+{}_L$ =	5331.12	k-in	$Mn_E{}^+{}_R$ =	N/A	k-in
$Mn_E{}^-{}_L$ =	10390.73	k-in	$Mn_E{}^-{}_R$ =	N/A	k-in
$V_{pr,L}$ =	119.58	k	$V_{pr,R}$ =	N/A	k
$SF_{2h,\ L}$ =	3.54		$SF_{2h,\ R}$ =	N/A	



$$V_{col} = \left[(M_{pr}^+{}_{,B} + M_{pr}^-{}_{,A}) + (V_{e2,A} + V_{e1,B})\frac{h}{2}\right]/\ell_c$$

Figure 5-4 – Free body diagram of column used to calculate column shear V_{col}.

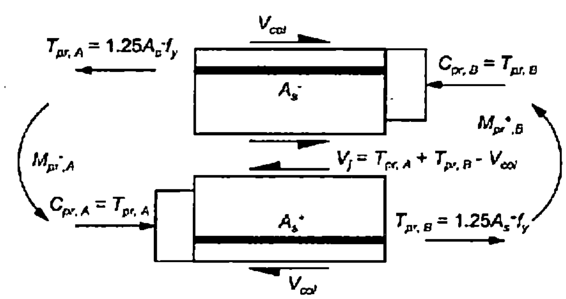


Figure 5-5 - Joint shear free body diagram.

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Step 2: Calculate Shear Demand in Joint

Step 2a: Calculate Shear in Column

$V_{col,1} = ((M_{nE}^{-}{}_{L}+M_{nE}^{+}{}_{R})+(V_{pr,L}+V_{pr,R})(h/2))/L_c =$ Column Shear when frame sways to the Right
= 70.39 k For Knee or T joints Vcol assumed N/A

$V_{col,2} = ((M_{nE}^{+}{}_{L}+M_{nE}^{-}{}_{R})+(V_{pr,L}+V_{pr,R})(h/2))/L_c =$ Column Shear when frame sways to the Left
= 40.27 k For Knee or T joints Vcol assumed N/A

Step 2b: Calculate Forces at Joint Face

$T_{pr,L,1} = A_{s,top,L}*f_{s,top,L}*SF_{T\ Beam\ Neg,\ L} * SF_{2h,\ L} =$ 307.20 k Tension at Left joint face when frame sways to the Right

$C_{pr,R,1} = T_{pr,R,1} = A_{s,bot,R}*f_{s,bot,R}*SF_{T\ Beam\ Pos,\ R} =$ Compression at Right joint face when frame sways to
= N/A k the Right

$T_{pr,R,2} = A_{s,top,R}*f_{s,top,R}*SF_{T\ Beam\ Neg,\ R}*SF_{2h,\ R} =$ N/A k Tension at Right joint face when frame sways to the Left

$C_{pr,L,2} = T_{pr,L,2} = A_{s,bot,L}*f_{s,bot,L}*SF_{T\ Beam\ Pos,\ L} =$ Compression at Left joint face when frame sways to
= 162.31 k the Left

Step 2c: Calculate Resultant Shear Forces in Joint

$V_{j,1} = T_{pr,L,1} + C_{pr,R,1} - V_{col,1} =$ 236.81 k Joint shear when frame sways to the Right

$V_{j,2} = T_{pr,R,2} + C_{pr,L,2} - V_{col,2} =$ 122.03 k Joint shear when frame sways to the Left

$V_j = Max(V_{j,1}, V_{j,2}) =$ 236.81 k

Step 3: Calculate Joint Shear Capacity per ASCE 41-17 10.4.2.3.2

Step 3a: Determine Joint Area

$h_j = h_c =$ 24 in

b_j = min of the following:

$h_b =$ 24 in

$b_b + h_j =$

Where $b_b = (b_{b,L}+b_{b,R})/2 =$ 24 in

Therefore $b_b + h_j =$ 48 in

$b_b + 2x =$

Where $x = (h_b-b_b)/2 =$ 0 in

Therefore $b_b + 2x =$ 24 in

Therefore $b_j =$ 24 in

$A_j = h_j*b_j =$ 576 in^2

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Step 3b: Determine γ per ASCE 41-17 Table 10-12

Step 3b.i: Determine if transverse reinforcement in joint is conforming

s =	6	in
If s <= $h_c/2$	→	Conforming
If s > $h_c/2$	→	Non Conforming

Therefore **Conforming**

Step 3b.ii: Determine γ

γ per ASCE 41-17 Table 10-2						
Transverse Reinforcement	Int Joint w/ Transverse Beams	Int Joint w/o Transverse Beams	Ext Joint w/ Transverse Beams	Ext Joint w/o Transverse Beams	Knee Joint	T Joint
Conforming	20	15	15	12	8	12
Non Conforming	12	10	8	6	4	6

Therefore γ = **15**

Step 3c: Calculate Joint Shear Capacity

$f'c = \min(f'c_{LB,c}, f'c_{LB,b,L}, f'c_{LB,b,R}) =$ 5.436 ksi

$\mathbf{V_n = \lambda\gamma\sqrt{f'c_E}\,A_j =}$ **477.77** **k** **DCR =** 0.50 OK

Beam-Column Joints at C5, D5, and E5 at the 1st Floor

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Joint ID & Story: **S1_J_C5-EW at 2**

Step 1: Summarize Joint Properties, Other Inputs

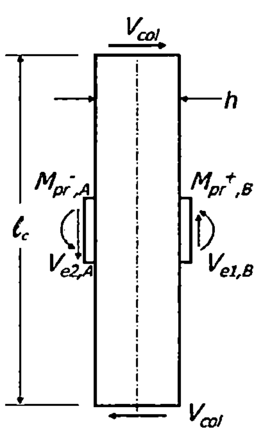
Joint Classification = Int Joint w/ Transverse Beams
λ = 0.75

fs values are stress ir steel due to moment demand, see pages A.2.c-13 and A.2.c-14 for calculation.

Column Inputs:

Depth, h_c =	24	in	
Width, h_b =	24	in	taken as half height of story above and below
Column Height, L_c =	168	in	
$f'c_{E,c}$ =	5.99	ksi	
Hoop Spacing, s =	6	in	spacing through joint

Left Beam Inputs:			Right Beam Inputs:		
Beam ID =	S1_B_B5-B4-i		Beam ID =	B43 - Grid C G5 End	
width, $b_{b,L}$ =	24	in	width, $b_{b,R}$ =	24	in
$f'c_{E,b,L}$ =	5.436	ksi	$f'c_{E,b,R}$ =	5.436	ksi
$A_{s,bot,L}$ =	3.12	in^2	$A_{s,bot,R}$ =	4.5	in^2
$A_{s,top,L}$ =	1.2	in^2	$A_{s,top,R}$ =	16	in^2
$f_{s,bot,L}$ =	63.83	ksi	$f_{s,bot,R}$ =	0.3	ksi
$f_{s,top,L}$ =	44.08	ksi	$f_{s,top,R}$ =	15.48	ksi
$SF_{T\ Beam\ Pos,\ L}$ =	1.63		$SF_{T\ Beam\ Pos,\ R}$ =	1.51	
$SF_{T\ Beam\ Neg,\ L}$ =	1.64		$SF_{T\ Beam\ Neg,\ R}$ =	1.64	
$Mn_E{}^+{}_L$ =	10516.51	k-in	$Mn_E{}^+{}_R$ =	40.21	k-in
$Mn_E{}^-{}_L$ =	10390.73	k-in	$Mn_E{}^-{}_R$ =	6361.03	k-in
$V_{pr,L}$ =	119.58	k	$V_{pr,R}$ =	66.69	k
$SF_{2h,\ L}$ =	3.54		$SF_{2h,\ R}$ =	N/A	



$$V_{col} = \left[(M_{pr}^+{}_{,B} + M_{pr}^-{}_{,A}) + (V_{o2,A} + V_{o1,B})\frac{h}{2}\right]/\ell_c$$

Figure 5-4 – Free body diagram of column used to calculate column shear V_{col}.

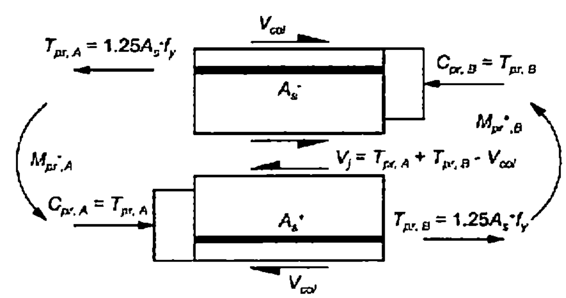


Figure 5-5 - Joint shear free body diagram.

Average moment demands from the PERFORM 3D model.

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Step 2: Calculate Shear Demand in Joint

Step 2a: Calculate Shear in Column

$V_{col,1} = ((M_{nE}^{-}{}_{L}+M_{nE}^{+}{}_{R})+(V_{pr,L}+V_{pr,R})(h/2))/L_c =$ Column Shear when frame sways to the Right

$=$ 75.39 k For Knee or T joints Vcol assumed N/A

$V_{col,2} = ((M_{nE}^{+}{}_{L}+M_{nE}^{-}{}_{R})+(V_{pr,L}+V_{pr,R})(h/2))/L_c =$ Column Shear when frame sways to the Left

$=$ 113.77 k For Knee or T joints Vcol assumed N/A

Step 2b: Calculate Forces at Joint Face

$T_{pr,L,1} = A_{s,top,L}*f_{s,top,L}*SF_{T\ Beam\ Neg,\ L} * SF_{2h,\ L} =$ 307.20 k Tension at Left joint face when frame sways to the Right

$C_{pr,R,1} = T_{pr,R,1} = A_{s,bot,R}*f_{s,bot,R}*SF_{T\ Beam\ Pos,\ R} =$ Compression at Right joint face when frame sways to the

$=$ 2.04 k

$T_{pr,R,2} = A_{s,top,R}*f_{s,top,R}*SF_{T\ Beam\ Neg,\ R} =$ 406.20 k Tension at Right joint face when frame sways to the Left

$C_{pr,L,2} = T_{pr,L,2} = A_{s,bot,L}*f_{s,bot,L}*SF_{T\ Beam\ Pos,\ L} =$ Compression at Left joint face when frame sways to the l

$=$ 324.61 k

Step 2c: Calculate Resultant Shear Forces in Joint

$V_{j,1} = T_{pr,L,1} + C_{pr,R,1} - V_{col,1} =$ 233.84 k Joint shear when frame sways to the Right

$V_{j,2} = T_{pr,R,2} + C_{pr,L,2} - V_{col,2} =$ 617.04 k Joint shear when frame sways to the Left

$V_j = Max(V_{j,1}, V_{j,2}) =$ 617.04 k

Step 3: Calculate Joint Shear Capacity per ASCE 41-17 10.4.2.3.2

Step 3a: Determine Joint Area

$h_j = h_c =$ 24 in

b_j = min of the following:

$h_b =$ 24 in

$b_b + h_j =$

Where $b_b = (b_{b,L}+b_{b,R})/2 =$ 24 in

Therefore $b_b + h_j =$ 48 in

$b_b + 2x =$

Where $x = (h_b-b_b)/2 =$ 0 in

Therefore $b_b + 2x =$ 24 in

Therefore $b_j =$ 24 in

$A_j = h_j*b_j =$ 576 in^2

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Step 3b: Determine γ per ASCE 41-17 Table 10-12

Step 3b.i: Determine if transverse reinforcement in joint is conforming

s =	6	in
If s <= $h_c/2$	→	Conforming
If s > $h_c/2$	→	Non Conforming

Therefore **Conforming**

Step 3b.ii: Determine γ

γ per ASCE 41-17 Table 10-2						
Transverse Reinforcement	Int Joint w/ Transverse Beams	Int Joint w/o Transverse Beams	Ext Joint w/ Transverse Beams	Ext Joint w/o Transverse Beams	Knee Joint	T Joint
Conforming	20	15	15	12	8	12
Non Conforming	12	10	8	6	4	6

Therefore γ = **20**

Step 3c: Calculate Joint Shear Capacity

$f'c = \min(f'c_{LB,c}, f'c_{LB,b,L}, f'c_{LB,b,R}) =$ 5.436 ksi

$\mathbf{V_n = \lambda\gamma\sqrt{f'c_E}\,A_j =}$ **637.02** **k** **DCR =** 0.97 OK

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Beam Flexural Stress - B-43 - Grid C G5 End

Step 1: Summarize Beam Properties, Other Inputs

General Beam Properties

f'_{cE} =	5,436	psi
f_{yE} =	73	ksi
Unit Weight =	120	pcf
Ec =	3198.347	ksi
Es =	29,000	ksi
n = Es/Ec =	9.07	
b =	24	in

Positive Moment Demand Properties

d =	33.15	in	
A_s =	4.5	in^2	
M =	40.21	k-in	Average over 11 ground Motions

Negative Moment Demand Properties

d =	30.36	in	
A_s =	16	in^2	
M =	6,361.03	k-in	Average over 11 ground Motions

Step 2: Check Positive Moment Demand Compressive Stress Assuming the Section is Cracked and A Linear Flexural Stress Profile

ρ = As/(bd) =	0.0057	
$k = \sqrt{(\rho n)^2+2\rho n}-\rho n$ =	0.273	
j = 1-(k/3) =	0.909	
Compressive Stress = $f_c = (2M)/(kjbd^2)$ =	0.012	ksi

if fc ≤ 0.7f'c → Assumption Valid
if fc > 0.7f'c → Use Hognestad Model

Therefore Assumption Valid

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Step 3: Check Positive Moment Demand Tensile Stress Assuming the Section is Cracked and A Linear Flexural Stress Profile

$f_s = M/(A_s jd) =$ $\boxed{0.30 \text{ ksi}}$ ← Fs value used in joint shear calculation.

if fs ≤ fy → Assumption Valid
if fs > fy → Use Hognestad Model
Therefore Assumption Valid

Step 4: Check Negative Moment Demand Compressive Stress Assuming the Section is Cracked and A Linear Flexural Stress Profile

$\rho = As/(bd) =$	0.022	
$k = \sqrt{((\rho n)^2+2\rho n)}-\rho n =$	0.463	
$j = 1-(k/3) =$	0.846	
$f_c = (2M)/(kjbd^2) =$	1.470	ksi

if fc ≤ 0.7f'c → Assumption Valid
if fc > 0.7f'c → Use Hognestad Model
Therefore Assumption Valid

Step 5: Check Negative Moment Demand Tensile Stress Assuming the Section is Cracked and A Linear Flexural Stress Profile

$f_s = M/(A_s jd) =$ $\boxed{15.48 \text{ ksi}}$ ← Fs value used in joint shear calculation.

if fs ≤ fy → Assumption Valid
if fs > fy → Use Hognestad Model
Therefore Assumption Valid

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Joint ID & Story: **S1_J_D5-EW at 2**

Step 1: Summarize Joint Properties, Other Inputs

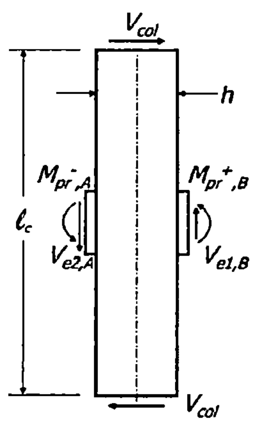
Joint Classification = Int Joint w/ Transverse Beams
λ = 0.75

Column Inputs:

Depth, h_c =	24	in	
Width, h_b =	24	in	taken as half height of story above and below
Column Height, L_c =	168	in	
$f'c_{E,c}$ =	5.99	ksi	
Hoop Spacing, s =	6	in	spacing through joint

fs values are stress in steel due to moment demand, see pages A.2.c-18 and A.2.c-19 for calculation.

Left Beam Inputs:			Right Beam Inputs:		
Beam ID =	S1_B_B5-B4-i		Beam ID =	3 - Grid D G5 End	
width, $b_{b,L}$ =	24	in	width, $b_{b,R}$ =	24	in
$f'c_{E,b,L}$ =	5.436	ksi	$f'c_{E,b,R}$ =	5.436	ksi
$A_{s,bot,L}$ =	3.12	in^2	$A_{s,bot,R}$ =	4.5	in^2
$A_{s,top,L}$ =	1.2	in^2	$A_{s,top,R}$ =	16	in^2
$f_{s,bot,L}$ =	63.83	ksi	$f_{s,bot,R}$ =	0	ksi
$f_{s,top,L}$ =	44.08	ksi	$f_{s,top,R}$ =	15.09	ksi
$SF_{T\ Beam\ Pos,\ L}$ =	1.63		$SF_{T\ Beam\ Pos,\ R}$ =	1.51	
$SF_{T\ Beam\ Neg,\ L}$ =	1.64		$SF_{T\ Beam\ Neg,\ R}$ =	1.64	
$Mn_E{}^+{}_L$ =	10516.51	k-in	$Mn_E{}^+{}_R$ =	0.00	k-in
$Mn_E{}^-{}_L$ =	10390.73	k-in	$Mn_E{}^-{}_R$ =	6200.17	k-in
$V_{pr,L}$ =	119.58	k	$V_{pr,R}$ =	66.24	k
$SF_{2h,\ L}$ =	3.54		$SF_{2h,\ R}$ =	N/A	



$$V_{col} = [(M_{pr}^+{}_{,B} + M_{pr}^-{}_{,A}) + (V_{e2,A} + V_{e1,B})\frac{h}{2}]/\ell_c$$

Figure 5-4 – Free body diagram of column used to calculate column shear V_{col}.

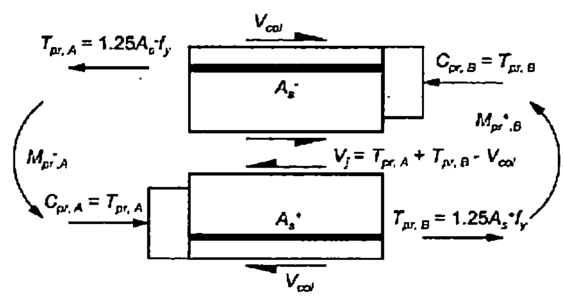


Figure 5-5 - Joint shear free body diagram.

Average moment demands from the PERFORM 3D model.

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Step 2: Calculate Shear Demand in Joint

Step 2a: Calculate Shear in Column

$V_{col,1} = ((M_{nE}^{-}{}_{L}+M_{nE}^{+}{}_{R})+(V_{pr,L}+V_{pr,R})(h/2))/L_c =$ Column Shear when frame sways to the Right
$=$ 75.12 k For Knee or T joints Vcol assumed N/A

$V_{col,2} = ((M_{nE}^{+}{}_{L}+M_{nE}^{-}{}_{R})+(V_{pr,L}+V_{pr,R})(h/2))/L_c =$ Column Shear when frame sways to the Left
$=$ 112.78 k For Knee or T joints Vcol assumed N/A

Step 2b: Calculate Forces at Joint Face

$T_{pr,L,1} = A_{s,top,L}*f_{s,top,L}*SF_{T\ Beam\ Neg,\ L} * SF_{2h,\ L} =$ 307.20 k Tension at Left joint face when frame sways to the Right

$C_{pr,R,1} = T_{pr,R,1} = A_{s,bot,R}*f_{s,bot,R}*SF_{T\ Beam\ Pos,\ R} =$ Compression at Right joint face when frame sways to the
$=$ 0.00 k

$T_{pr,R,2} = A_{s,top,R}*f_{s,top,R}*SF_{T\ Beam\ Neg,\ R} =$ 395.96 k Tension at Right joint face when frame sways to the Left

$C_{pr,L,2} = T_{pr,L,2} = A_{s,bot,L}*f_{s,bot,L}*SF_{T\ Beam\ Pos,\ L} =$ Compression at Left joint face when frame sways to the l
$=$ 324.61 k

Step 2c: Calculate Resultant Shear Forces in Joint

$V_{j,1} = T_{pr,L,1} + C_{pr,R,1} - V_{col,1} =$ 232.08 k Joint shear when frame sways to the Right

$V_{j,2} = T_{pr,R,2} + C_{pr,L,2} - V_{col,2} =$ 607.80 k Joint shear when frame sways to the Left

$V_j = Max(V_{j,1}, V_{j,2}) =$ 607.80 k

Step 3: Calculate Joint Shear Capacity per ASCE 41-17 10.4.2.3.2

Step 3a: Determine Joint Area

$h_j = h_c =$ 24 in
b_j = min of the following:
$h_b =$ 24 in
$b_b + h_j =$
Where $b_b = (b_{b,L}+b_{b,R})/2 =$ 24 in
Therefore $b_b + h_j =$ 48 in
$b_b + 2x =$
Where $x = (h_b-b_b)/2 =$ 0 in
Therefore $b_b + 2x =$ 24 in

Therefore $b_j =$ 24 in

$A_j = h_j*b_j =$ 576 in^2

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Step 3b: Determine γ per ASCE 41-17 Table 10-12

Step 3b.i: Determine if transverse reinforcement in joint is conforming

s =	6	in
If s <= $h_c/2$	→	Conforming
If s > $h_c/2$	→	Non Conforming

Therefore **Conforming**

Step 3b.ii: Determine γ

γ per ASCE 41-17 Table 10-2						
Transverse Reinforcement	Int Joint w/ Transverse Beams	Int Joint w/o Transverse Beams	Ext Joint w/ Transverse Beams	Ext Joint w/o Transverse Beams	Knee Joint	T Joint
Conforming	20	15	15	12	8	12
Non Conforming	12	10	8	6	4	6

Therefore γ = **20**

Step 3c: Calculate Joint Shear Capacity

$f'c = \min(f'c_{LB,c}, f'c_{LB,b,L}, f'c_{LB,b,R}) =$ 5.436 ksi

$\mathbf{V_n = \lambda\gamma\sqrt{f'c_E}\,A_j =}$ **637.02** **k** **DCR =** 0.95 OK

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Beam Flexural Stress - B-44 - Grid D G5 End

Step 1: Summarize Beam Properties, Other Inputs

General Beam Properties

f'_{cE} =	5,436	psi
f_{yE} =	73	ksi
Unit Weight =	120	pcf
Ec =	3198.347	ksi
Es =	29,000	ksi
n = Es/Ec =	9.07	
b =	24	in

Positive Moment Demand Properties

d =	33.15	in	
A_s =	4.5	in^2	
M =	0.000	k-in	Average over 11 ground Motions

Negative Moment Demand Properties

d =	30.36	in	
A_s =	16	in^2	
M =	6,200.17	k-in	Average over 11 ground Motions

Step 2: Check Positive Moment Demand Compressive Stress Assuming the Section is Cracked and A Linear Flexural Stress Profile

$\rho = As/(bd) =$	0.0057	
$k = \sqrt{(\rho n)^2+2\rho n}-\rho n =$	0.273	
$j = 1-(k/3) =$	0.909	
Compressive Stress = $f_c = (2M)/(kjbd^2)$ =	0.000	ksi

if $fc \leq 0.7f'c$ → Assumption Valid

if $fc > 0.7f'c$ → Use Hognestad Model

Therefore Assumption Valid

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Step 3: Check Positive Moment Demand Tensile Stress Assuming the Section is Cracked and A Linear Flexural Stress Profile

$f_s = M/(A_s jd) =$ $\boxed{0.00 \quad \text{ksi}}$ ← Fs value used in joint shear calculation.

if fs ≤ fy	→	Assumption Valid
if fs > fy	→	Use Hognestad Model
	Therefore	**Assumption Valid**

Step 4: Check Negative Moment Demand Compressive Stress Assuming the Section is Cracked and A Linear Flexural Stress Profile

$\rho = As/(bd) =$	0.022	
$k = \sqrt{((\rho n)^2+2\rho n)}-\rho n =$	0.463	
$j = 1-(k/3) =$	0.846	
$f_c = (2M)/(kjbd^2) =$	1.433	ksi

if fc ≤ 0.7f'c	→	Assumption Valid
if fc > 0.7f'c	→	Use Hognestad Model
	Therefore	**Assumption Valid**

Step 5: Check Negative Moment Demand Tensile Stress Assuming the Section is Cracked and A Linear Flexural Stress Profile

$f_s = M/(A_s jd) =$ $\boxed{15.09 \quad \text{ksi}}$ ← Fs value used in joint shear calculation.

if fs ≤ fy	→	Assumption Valid
if fs > fy	→	Use Hognestad Model
	Therefore	**Assumption Valid**

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Joint ID & Story: **S1_J_D5-EW at 2**

Step 1: Summarize Joint Properties, Other Inputs

Joint Classification = Int Joint w/ Transverse Beams
λ = 0.75

Column Inputs:

Depth, h_c =	24	in	
Width, h_b =	24	in	
Column Height, L_c =	168	in	taken as half height of story above and below
$f'c_{E,c}$ =	5.99	ksi	
Hoop Spacing, s =	6	in	spacing through joint

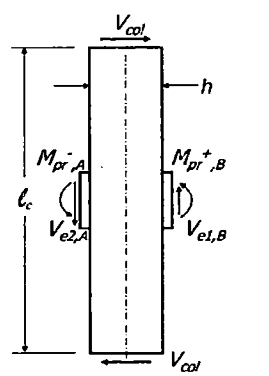
fs values are stress ir steel due to moment demand, see pages A.2.c-23 and A.2.c-24 for calculation.

Left Beam Inputs:

Beam ID =	S1_B_A5-A4-i	
width, $b_{b,L}$ =	24	in
$f'c_{E,b,L}$ =	5.436	ksi
$A_{s,bot,L}$ =	3.12	in^2
$A_{s,top,L}$ =	1.2	in^2
$f_{s,bot,L}$ =	63.83	ksi
$f_{s,top,L}$ =	44.08	ksi
$SF_{T\ Beam\ Pos,\ L}$ =	1.51	
$SF_{T\ Beam\ Neg,\ L}$ =	1.64	
$Mn_{E}{}^{+}{}_{L}$ =	9742.28	k-in
$Mn_{E}{}^{-}{}_{L}$ =	9949.77	k-in
$V_{pr,L}$ =	112.97	k
$SF_{2h,\ L}$ =	3.39	

Right Beam Inputs:

Beam ID =	4 - Grid E G5 End	
width, $b_{b,R}$ =	24	in
$f'c_{E,b,R}$ =	5.436	ksi
$A_{s,bot,R}$ =	4.5	in^2
$A_{s,top,R}$ =	16	in^2
$f_{s,bot,R}$ =	0	ksi
$f_{s,top,R}$ =	12.65	ksi
$SF_{T\ Beam\ Pos,\ R}$ =	1.51	
$SF_{T\ Beam\ Neg,\ R}$ =	1.64	
$Mn_{E}{}^{+}{}_{R}$ =	0.00	k-in
$Mn_{E}{}^{-}{}_{R}$ =	5196.13	k-in
$V_{pr,R}$ =	59.33	k
$SF_{2h,\ R}$ =	N/A	



$$V_{col} = [(M_{pr}{}^{+}{}_{,B} + M_{pr}{}^{-}{}_{,A}) + (V_{o2,A} + V_{o1,B})\frac{h}{2}]/\ell_c$$

Figure 5-4 – Free body diagram of column used to calculate column shear V_{col}.

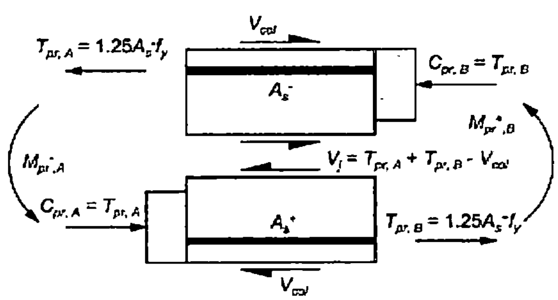


Figure 5-5 - Joint shear free body diagram.

Average moment demands from the PERFORM 3D model.

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Step 2: Calculate Shear Demand in Joint

Step 2a: Calculate Shear in Column

$V_{col,1} = ((M_{nE}^{-}{}_{L}+M_{nE}^{+}{}_{R})+(V_{pr,L}+V_{pr,R})(h/2))/L_c =$ Column Shear when frame sways to the Right
$= 71.53$ k For Knee or T joints Vcol assumed N/A

$V_{col,2} = ((M_{nE}^{+}{}_{L}+M_{nE}^{-}{}_{R})+(V_{pr,L}+V_{pr,R})(h/2))/L_c =$ Column Shear when frame sways to the Left
$= 101.23$ k For Knee or T joints Vcol assumed N/A

Step 2b: Calculate Forces at Joint Face

$T_{pr,L,1} = A_{s,top,L}*f_{s,top,L}*SF_{T\ Beam\ Neg,\ L} * SF_{2h,\ L} =$ 294.16 k Tension at Left joint face when frame sways to the Right

$C_{pr,R,1} = T_{pr,R,1} = A_{s,bot,R}*f_{s,bot,R}*SF_{T\ Beam\ Pos,\ R} =$ Compression at Right joint face when frame sways to the
$= 0.00$ k

$T_{pr,R,2} = A_{s,top,R}*f_{s,top,R}*SF_{T\ Beam\ Neg,\ R} =$ 331.94 k Tension at Right joint face when frame sways to the Left

$C_{pr,L,2} = T_{pr,L,2} = A_{s,bot,L}*f_{s,bot,L}*SF_{T\ Beam\ Pos,\ L} =$ Compression at Left joint face when frame sways to the l
$= 300.71$ k

Step 2c: Calculate Resultant Shear Forces in Joint

$V_{j,1} = T_{pr,L,1} + C_{pr,R,1} - V_{col,1} =$ 222.63 k Joint shear when frame sways to the Right

$V_{j,2} = T_{pr,R,2} + C_{pr,L,2} - V_{col,2} =$ 531.42 k Joint shear when frame sways to the Left

$V_j = \mathrm{Max}(V_{j,1}, V_{j,2}) =$ 531.42 k

Step 3: Calculate Joint Shear Capacity per ASCE 41-17 10.4.2.3.2

Step 3a: Determine Joint Area

$h_j = h_c =$ 24 in

b_j = min of the following:

$h_b =$ 24 in

$b_b + h_j =$

Where $b_b = (b_{b,L}+b_{b,R})/2 =$ 24 in

Therefore $b_b + h_j =$ 48 in

$b_b + 2x =$

Where $x = (h_b-b_b)/2 =$ 0 in

Therefore $b_b + 2x =$ 24 in

Therefore $b_j =$ 24 in

$A_j = h_j*b_j =$ 576 in^2

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Step 3b: Determine γ per ASCE 41-17 Table 10-12

Step 3b.i: Determine if transverse reinforcement in joint is conforming

s =	6	in
If s <= $h_c/2$	→	Conforming
If s > $h_c/2$	→	Non Conforming

Therefore **Conforming**

Step 3b.ii: Determine γ

γ per ASCE 41-17 Table 10-2						
Transverse Reinforcement	Int Joint w/ Transverse Beams	Int Joint w/o Transverse Beams	Ext Joint w/ Transverse Beams	Ext Joint w/o Transverse Beams	Knee Joint	T Joint
Conforming	20	15	15	12	8	12
Non Conforming	12	10	8	6	4	6

Therefore γ = **20**

Step 3c: Calculate Joint Shear Capacity

$f'c = \min(f'c_{LB,c}, f'c_{LB,b,L}, f'c_{LB,b,R}) =$ 5.436 ksi

$V_n = \lambda\gamma\sqrt{f'c_E}A_j =$ **637.02** **k** **DCR =** 0.83 OK

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Beam Flexural Stress - B-44 - Grid E G5 End

Step 1: Summarize Beam Properties, Other Inputs

General Beam Properties

f'_{cE} =	5,436	psi
f_{yE} =	73	ksi
Unit Weight =	120	pcf
Ec =	3198.347	ksi
Es =	29,000	ksi
n = Es/Ec =	9.07	
b =	24	in

Positive Moment Demand Properties

d =	33.15	in	
A_s =	4.5	in^2	
M =	0.000	k-in	Average over 11 ground Motions

Negative Moment Demand Properties

d =	30.36	in	
A_s =	16	in^2	
M =	5,196.13	k-in	Average over 11 ground Motions

Step 2: Check Positive Moment Demand Compressive Stress Assuming the Section is Cracked and A Linear Flexural Stress Profile

$\rho = As/(bd) =$ 0.0057

$k = \sqrt{((\rho n)^2+2\rho n)}-\rho n =$ 0.273

$j = 1-(k/3) =$ 0.909

Compressive Stress = $f_c = (2M)/(kjbd^2) =$ 0.000 ksi

if fc ≤ 0.7f'c → Assumption Valid
if fc > 0.7f'c → Use Hognestad Model
Therefore Assumption Valid

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Step 3: Check Positive Moment Demand Tensile Stress Assuming the Section is Cracked and A Linear Flexural Stress Profile

$f_s = M/(A_s jd) =$ $\boxed{0.00 \text{ ksi}}$ ← Fs value used in joint shear calculation.

if fs ≤ fy	→	Assumption Valid
if fs > fy	→	Use Hognestad Model
Therefore		**Assumption Valid**

Step 4: Check Negative Moment Demand Compressive Stress Assuming the Section is Cracked and A Linear Flexural Stress Profile

$\rho = As/(bd) =$	0.022	
$k = \sqrt{(\rho n)^2+2\rho n}-\rho n =$	0.463	
$j = 1-(k/3) =$	0.846	
$f_c = (2M)/(kjbd^2) =$	1.201	ksi

if fc ≤ 0.7f'c	→	Assumption Valid
if fc > 0.7f'c	→	Use Hognestad Model
Therefore		**Assumption Valid**

Step 5: Check Negative Moment Demand Tensile Stress Assuming the Section is Cracked and A Linear Flexural Stress Profile

$f_s = M/(A_s jd) =$ $\boxed{12.65 \text{ ksi}}$ ← Fs value used in joint shear calculation.

if fs ≤ fy	→	Assumption Valid
if fs > fy	→	Use Hognestad Model
Therefore		**Assumption Valid**

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	location Inglewood, CA	date 10/19/21	
	client	job no. 2000362	

A.2.d - Walls

Executive Summary

The following section includes the assessment of Shear Walls under both hazard levels. All walls on average remain elastic in shear therefore all walls meet Collapse Prevention and Life Safety acceptance criteria at the BSE-2E and BSE-1E Hazard levels respectively for shear. In flexure only the discontinuous walls in the upper floors of the library yield and have relatively low rotation demands at the base of the wall that meet the Collapse Prevention and Life Safety acceptance criteria at the BSE-2E and BSE-1E Hazard levels respectively.

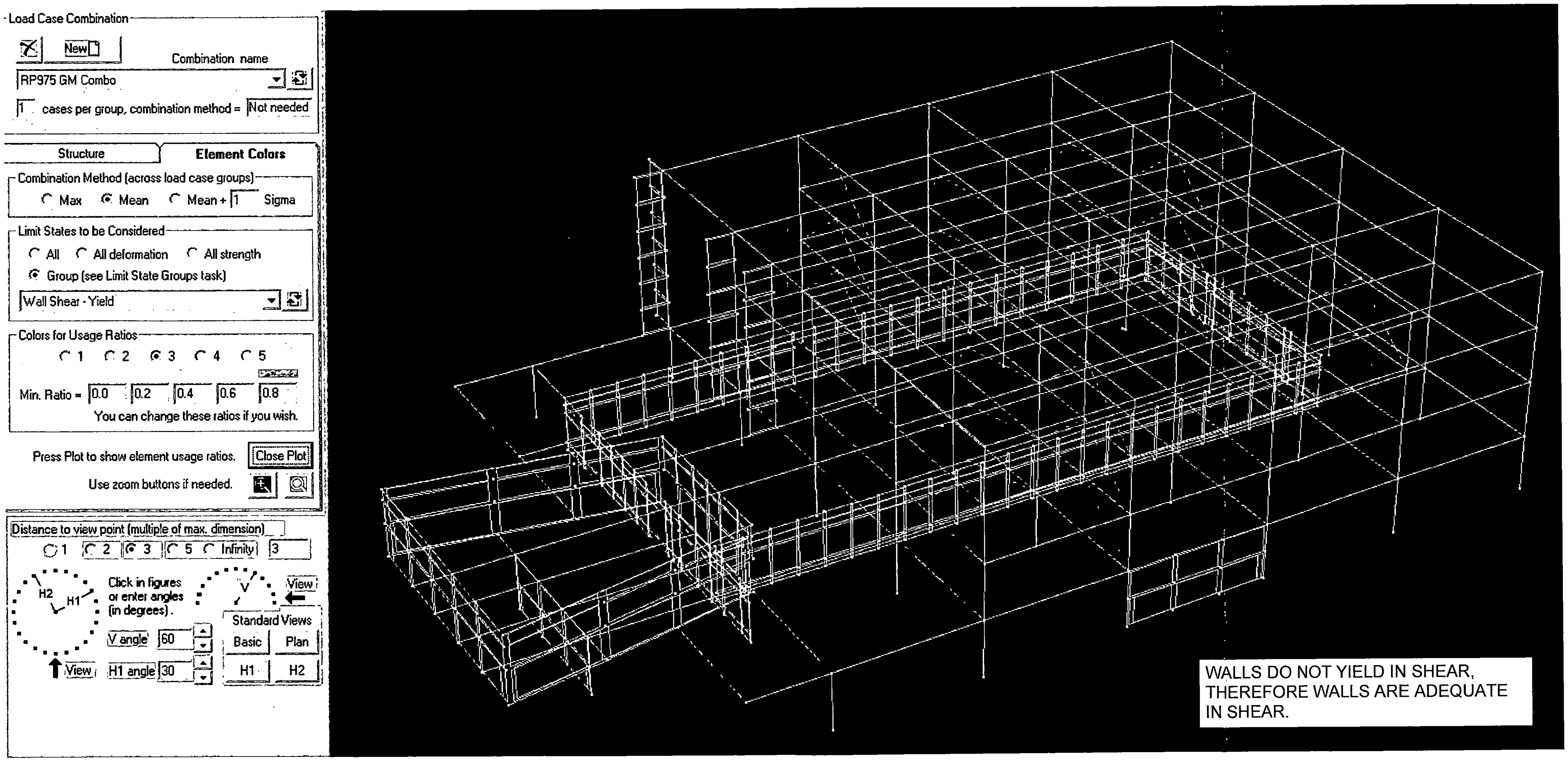

Figure A.2.d-1 Average of 11 Ground Motions, BSE-2E, Shear Yielding, Upper Bound Damper Properties, Deformation Limits

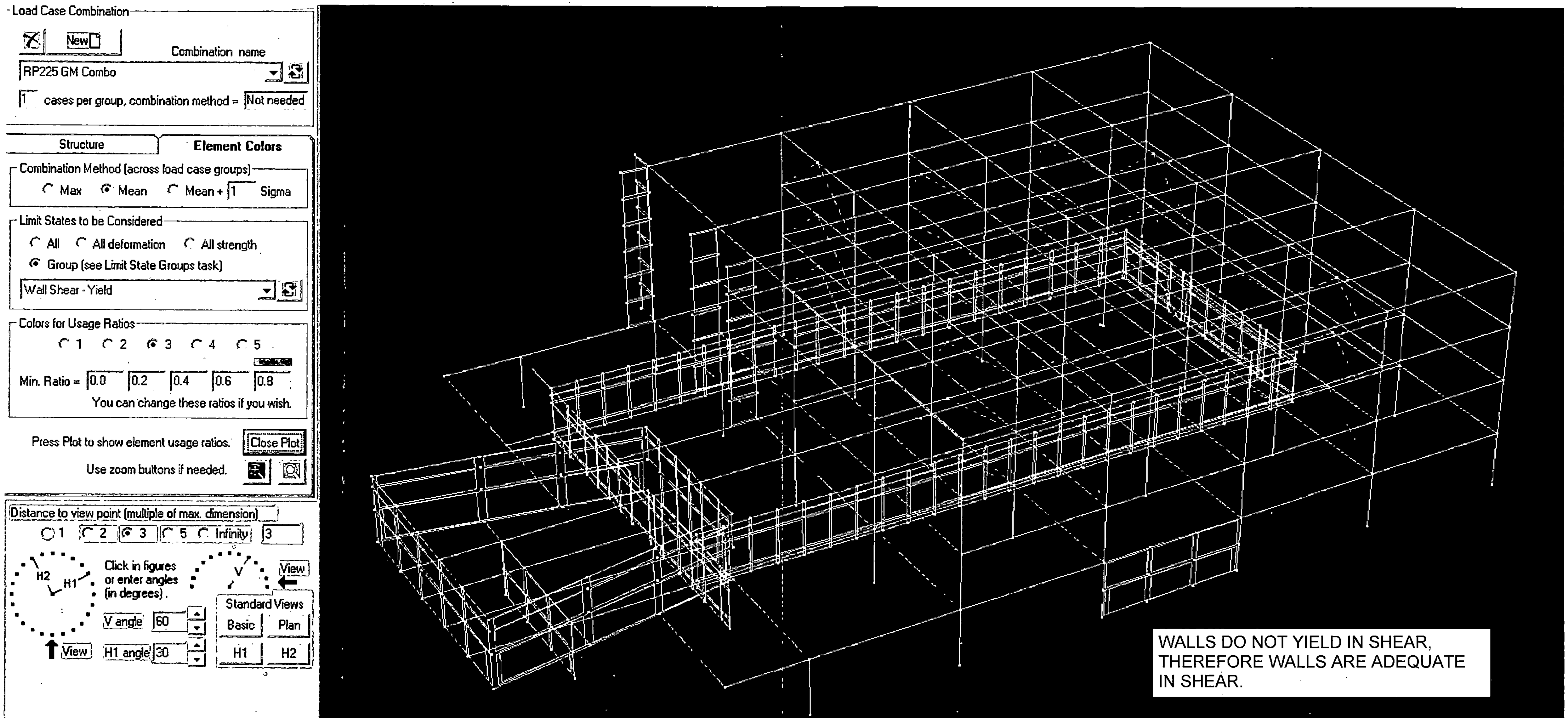

Figure A.2.d-2 Average of 11 Ground Motions, BSE-1E, Shear Yielding, Upper Bound Damper Properties, Deformation Limits

A.2.b - Columns

Executive Summary

The following section includes the assessment of Moment Frame Columns under both hazard levels. All results shown are for the lower bound damper properties which provide the worst case deformation demand on the column plastic hinges. Most columns on average remain elastic and those that do yield experience very little plastic rotation therefore all moment frame columns meet Collapse Prevention and Life Safety acceptance criteria at the BSE-2E and BSE-1E Hazard levels respectively.

A.2.c - Beam-Column Joints

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700 South Flower Street, Suite 2100 Los Angeles, CA 90017 (213) 418-0201	location Inglewood, CA	date 10/19/21	
	client	job no. 2000362	
	Beam-Column Joints		

Executive Summary

The following section includes the assessment of Beam-Column Joints. Beam-Column joints were checked for joint shear outside of the PERFORM-3D model. Joint shear capacities are per ASCE 41-17 10.4.2.3.2. The typical Beam-Column joint was assessed assuming beams on both sides of the joint are yielding. 1st Floor joints on the Grid Intersection A5 and B5 were checked as a joint with only 1 in-framing beam in the East-West direction due to the beams West of Grid 5 being integral with the discontinuous wall above. 1st Floor joints on the Grid intersections C5, D5, and E5 were checked using the average moment demand at the ends of the beams to the west of Grid 5 and the moment capacities of the beams to the east of Grid 5. Moment demands from the analysis were used due to the beams remaining elastic under the BSE-2E.

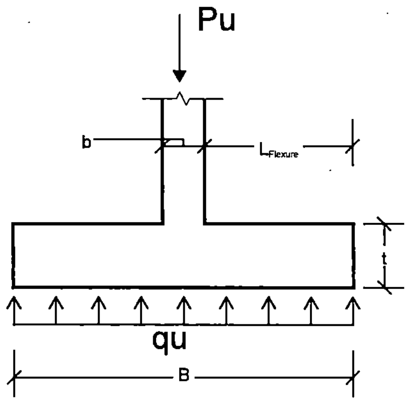
The Joint naming convention is as follows: S(Story #)_J_(Grid Intersection)-(Direction, EW = East-West, NS = North South)
Ex: S1_J_A4-EW, Story 1 joint at the intersection of Grids A and 4 in the East-West Direction.

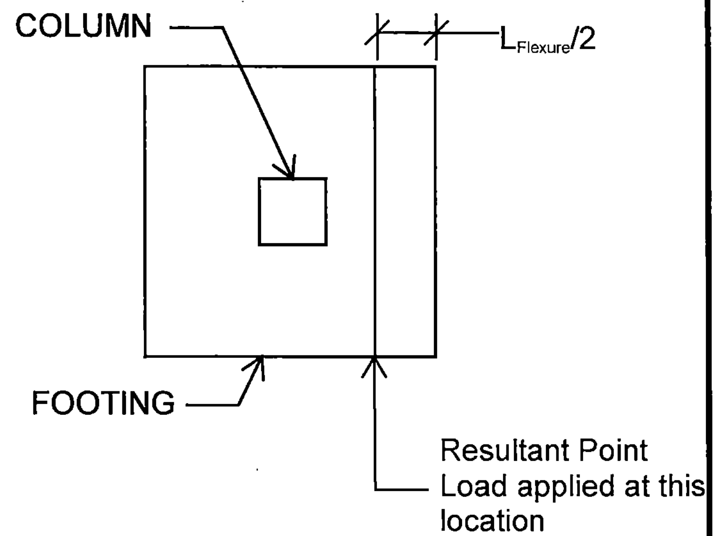
The following pages contain a summary of all joint inputs and results a sample calculation of a typical joint and calculations of the atypical joints at the first floor at the grid intersections C5, D5, and E5.

All joint shear DCR's are within 5% therefore Beam-Column joints are adequate.

Footing Flexural Check

Column D4
Footing Type A
Pu = 1505.28k; load obtained as the peak average load from the Perform 3D models.





Footing Dimensions:
B = 14'
L = 14'
t = 40"
b = 24"

(11) #9's Bottom EW
$A_s = 11in^2$
d = 40"-3"-(1.128") - (1.128"/2) = 35.31" (Assuming resisting flexural reinforcement is the second mat of reinforcement)
$f'c_{LB}$ = 5.287ksi
fy_{LB} = 65ksi
qu = Pu/(B*L) = 7.68ksf

$L_{Flexure}$ = (14'/2) - (24"/12/2) = 6'
Mu = L*$L_{Flexure}$*qu*($L_{Flexure}$/2) = 1935.35 k-ft

a = (As*fy)/(0.85*f'c*L) = 0.95"
Mn = As*fy*(d-a/2) = 2075.55 k-ft

DCR = 0.93

Therefore Footing is adequate in flexure.

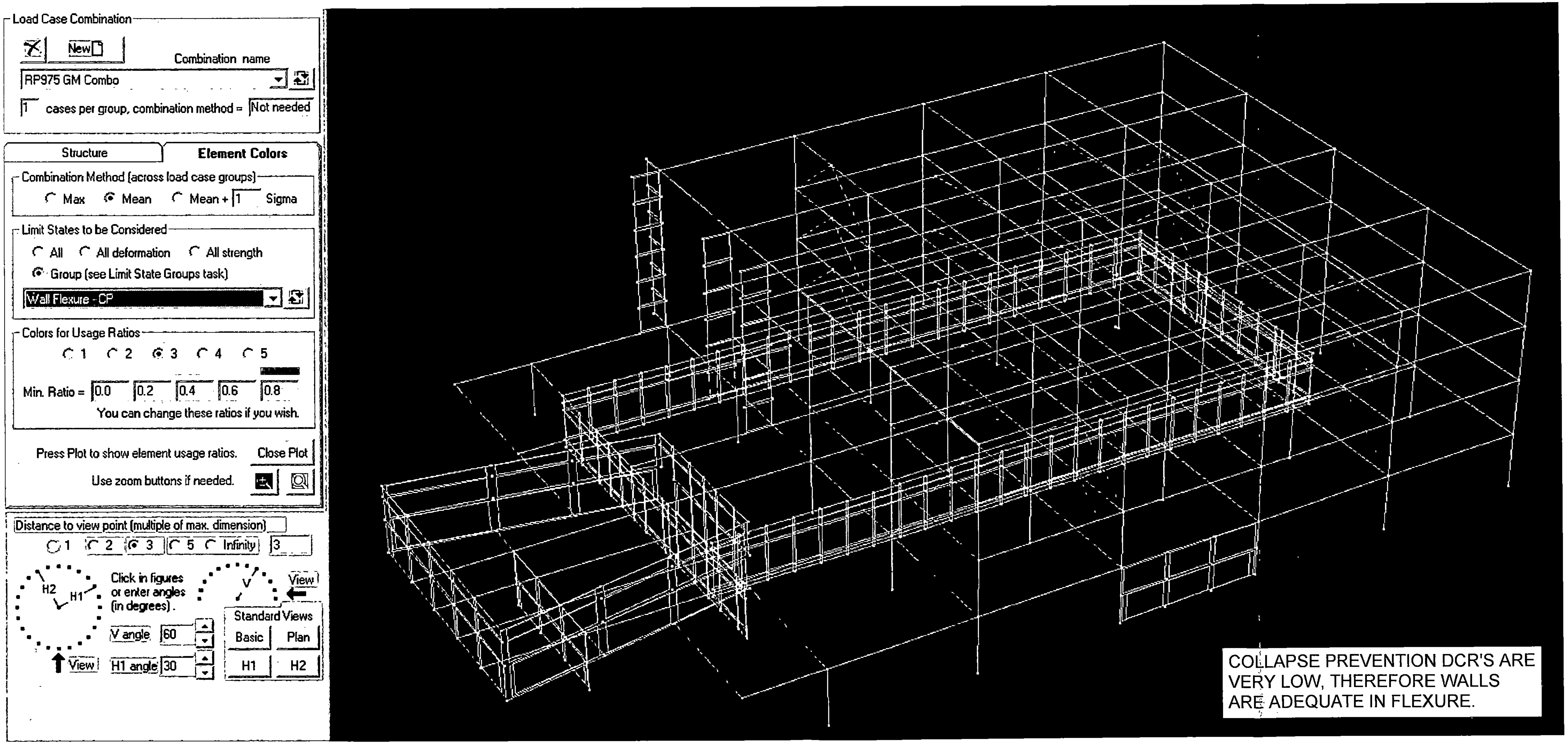


Figure A.2.d-3 Average of 11 Ground Motions, BSE-2E, Flexural Rotation Collapse Prevention, Lower Bound Damper Properties, Deformation Limits

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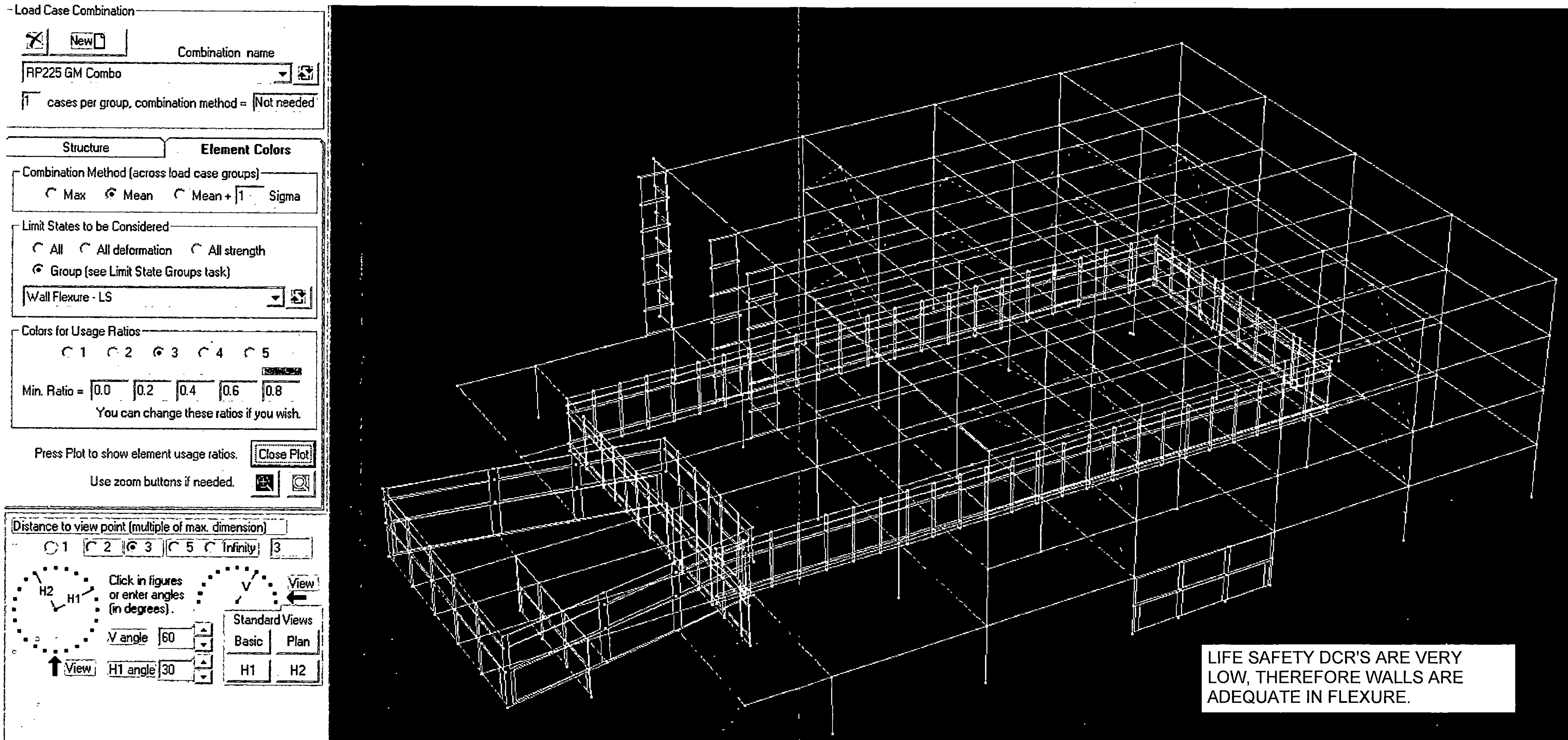


Figure A.2.d-4 Average of 11 Ground Motions, BSE-1E, Flexural Rotation Life Safety, Lower Bound Damper Properties, Deformation Limits

A.2.e - Foundation

Executive Summary

The following section includes the assessment of Foundation elements. Foundation elements were checked for stability and strength outside of the PERFORM-3D model.

The following pages contain a summary of all footing strength calculations and the assessment of stability under BSE-2E forces using upper bound damper properties.

All existing footings were found to be adequate in strength and stability under BSE-2E forces and previous preliminary scope to strengthen footings has been found to no longer be needed.

Column Spread Footing Checks

Allowable bearing pressures per Geotechnical Report

Column	Footing B (ft)	Footing L (ft)	Footing Area (ft^2)	B	t (in)	Df (ft)	q'_{all} (ksf)	q'_E (ksf)
D4	14.00	14.00	196.00	14.00	40	4.33	15.93	47.79
D2	14.00	14.00	196.00	14.00	40	4.33	15.93	47.79
C2	14.00	14.00	196.00	14.00	40	4.33	15.93	47.79
B2	14.00	14.00	196.00	14.00	40	4.33	15.93	47.79
E4	13.00	13.00	169.00	13.00	40	4.33	15.66	46.98
D1	13.00	13.00	169.00	13.00	40	4.33	15.66	46.98
B1	13.00	13.00	169.00	13.00	40	4.33	15.66	46.98
A4	13.00	13.00	169.00	13.00	40	4.33	15.66	46.98
B4	14.00	14.00	196.00	14.00	40	4.33	15.93	47.79
B3	14.00	14.00	196.00	14.00	40	4.33	15.93	47.79
D3	14.00	14.00	196.00	14.00	40	4.33	15.93	47.79
E2	13.00	13.00	169.00	13.00	40	4.33	15.66	46.98
A1	9.33	9.33	87.11	9.33	40	4.33	14.67	44.01
A2	13.00	13.00	169.00	13.00	40	4.33	15.66	46.98
A3	13.00	13.00	169.00	13.00	40	4.33	15.66	46.98
A5	9.33	9.33	87.11	9.33	40	4.33	14.67	44.01
A6	7.75	7.75	60.06	7.75	32	3.67	13.74	41.23
B5	13.00	13.00	169.00	13.00	40	4.33	15.66	46.98
B6	7.75	7.75	60.06	7.75	32	3.67	13.74	41.23
C1	13.00	13.00	169.00	13.00	40	4.33	15.66	46.98
C3	14.00	14.00	196.00	14.00	40	4.33	15.93	47.79
C4	14.00	14.00	196.00	14.00	40	4.33	15.93	47.79
C5	13.00	13.00	169.00	13.00	40	4.33	15.66	46.98
C6	10.00	10.00	100.00	10.00	36	4.00	14.60	43.80
C7	13.50	13.50	182.25	13.50	40	4.33	15.80	47.39
D5	13.00	13.00	169.00	13.00	40	4.33	15.66	46.98
D6	10.00	10.00	100.00	10.00	36	4.00	14.60	43.80
D7	13.50	13.50	182.25	13.50	40	4.33	15.80	47.39
E1	9.33	9.33	87.11	9.33	40	4.33	14.67	44.01
E3	13.00	13.00	169.00	13.00	40	4.33	15.66	46.98
E5	9.33	9.33	87.11	9.33	40	4.33	14.67	44.01
E6	7.75	7.75	60.06	7.75	32	3.67	13.74	41.23

Flexural Check of Footing Capacity

						Column Info					Bottom Reinf			Moment Capacity							
Column	Pu (k)	Footing B (ft)	Footing L (ft)	Footing Area (ft^2)	qu (ksf)	b (in)	h (in)	Equivalent b (in)	$L_{flexure}$ (ft)	Mu (k-ft)	Bottom Layer Bar Size	# of Bars	Clear Cover (in)	t (in)	d (in)	As (in^2)	f'c (ksi)	fy (ksi)	a (in)	Mn (k-ft)	DCR
D4	1505.28	14.00	14.00	196.00	7.68	24	24	24.00	6.00	1935.35	9	11	4.13	40	35.31	11	5.287	65	0.95	2075.55	0.93
D2	1457.05	14.00	14.00	196.00	7.43	24	24	24.00	6.00	1873.34	9	11	4.13	40	35.31	11	5.287	65	0.95	2075.55	0.90
C2	1189.25	14.00	14.00	196.00	6.07	24	24	24.00	6.00	1529.04	9	11	4.13	40	35.31	11	5.287	65	0.95	2075.55	0.74
B2	1469.55	14.00	14.00	196.00	7.50	24	24	24.00	6.00	1889.42	9	11	4.13	40	35.31	11	5.287	65	0.95	2075.55	0.91
E4	758.91	13.00	13.00	169.00	4.49	24	24	24.00	5.50	882.96	9	13	4.13	40	35.31	13	5.287	65	1.21	2443.83	0.36
D1	783.24	13.00	13.00	169.00	4.63	24	24	24.00	5.50	911.27	9	13	4.13	40	35.31	13	5.287	65	1.21	2443.83	0.37
B1	787.80	13.00	13.00	169.00	4.66	24	24	24.00	5.50	916.58	9	13	4.13	40	35.31	13	5.287	65	1.21	2443.83	0.38
A4	1019.92	13.00	13.00	169.00	6.04	24	24	24.00	5.50	1186.64	9	13	4.13	40	35.31	13	5.287	65	1.21	2443.83	0.49
B4	1419.32	14.00	14.00	196.00	7.24	24	24	24.00	6.00	1824.84	9	11	4.13	40	35.31	11	5.287	65	0.95	2075.55	0.88
B3	869.06	14.00	14.00	196.00	4.43	24	24	24.00	6.00	1117.37	9	11	4.13	40	35.31	11	5.287	65	0.95	2075.55	0.54
D3	1254.95	14.00	14.00	196.00	6.40	24	24	24.00	6.00	1613.50	9	11	4.13	40	35.31	11	5.287	65	0.95	2075.55	0.78
E2	1128.76	13.00	13.00	169.00	6.68	24	24	24.00	5.50	1313.27	9	13	4.13	40	35.31	13	5.287	65	1.21	2443.83	0.54
A1	673.14	9.33	9.33	87.11	7.73	24	24	24.00	3.67	484.82	7	10	3.88	40	35.69	6	5.287	65	0.77	1147.25	0.42
A2	768.96	13.00	13.00	169.00	4.55	24	24	24.00	5.50	894.65	9	13	4.13	40	35.31	13	5.287	65	1.21	2443.83	0.37
A3	782.78	13.00	13.00	169.00	4.63	24	24	24.00	5.50	910.74	9	13	4.13	40	35.31	13	5.287	65	1.21	2443.83	0.37
A5	505.35	9.33	9.33	87.11	5.80	24	24	24.00	3.67	363.97	7	10	3.88	40	35.69	6	5.287	65	0.77	1147.25	0.32
A6	201.61	7.75	7.75	60.06	3.36	24	24	24.00	2.88	107.51	7	8	3.88	32	27.69	4.8	5.287	65	0.75	710.17	0.15
B5	688.14	13.00	13.00	169.00	4.07	24	24	24.00	5.50	800.63	9	13	4.13	40	35.31	13	5.287	65	1.21	2443.83	0.33
B6	75.59	7.75	7.75	60.06	1.26	24	24	24.00	2.88	40.31	7	8	3.88	32	27.69	4.8	5.287	65	0.75	710.17	0.06
C1	790.72	13.00	13.00	169.00	4.68	24	24	24.00	5.50	919.97	9	13	4.13	40	35.31	13	5.287	65	1.21	2443.83	0.38
C3	890.07	14.00	14.00	196.00	4.54	24	24	24.00	6.00	1144.37	9	11	4.13	40	35.31	11	5.287	65	0.95	2075.55	0.55
C4	859.82	14.00	14.00	196.00	4.39	24	24	24.00	6.00	1105.48	9	11	4.13	40	35.31	11	5.287	65	0.95	2075.55	0.53
C5	754.95	13.00	13.00	169.00	4.47	24	24	24.00	5.50	878.36	9	13	4.13	40	35.31	13	5.287	65	1.21	2443.83	0.36
C6	117.08	10.00	10.00	100.00	1.17	24	24	24.00	4.00	93.67	7	11	3.88	40	35.69	6.6	5.287	65	0.80	1261.61	0.07
C7	677.28	13.50	13.50	182.25	3.72	24	24	24.00	5.75	829.36	10	10	4.27	40	35.10	12.7	5.287	65	1.13	2375.24	0.35
D5	1146.42	13.00	13.00	169.00	6.78	24	24	24.00	5.50	1333.81	9	13	4.13	40	35.31	13	5.287	65	1.21	2443.83	0.55
D6	329.94	10.00	10.00	100.00	3.30	24	24	24.00	4.00	263.95	7	11	3.88	40	35.69	6.6	5.287	65	0.80	1261.61	0.21
D7	645.02	13.50	13.50	182.25	3.54	24	24	24.00	5.75	789.85	10	10	4.27	40	35.10	12.7	5.287	65	1.13	2375.24	0.33
E1	667.73	9.33	9.33	87.11	7.67	24	24	24.00	3.67	480.92	7	10	3.88	40	35.69	6	5.287	65	0.77	1147.25	0.42
E3	559.46	13.00	13.00	169.00	3.31	24	24	24.00	5.50	650.91	9	13	4.13	40	35.31	13	5.287	65	1.21	2443.83	0.27
E5	660.44	9.33	9.33	87.11	7.58	24	24	24.00	3.67	475.67	7	10	3.88	40	35.69	6	5.287	65	0.77	1147.25	0.41
E6	157.49	7.75	7.75	60.06	2.62	24	24	24.00	2.88	83.98	7	8	3.88	32	27.69	4.8	5.287	65	0.75	710.17	0.12

Note: All footings experience bearing pressures less than the expected bearing pressure.

Note: All footings in there existing condition can resist flexural demands.

See Next Page for a sample Calculation.

Punching Shear Check of Footing Capacity

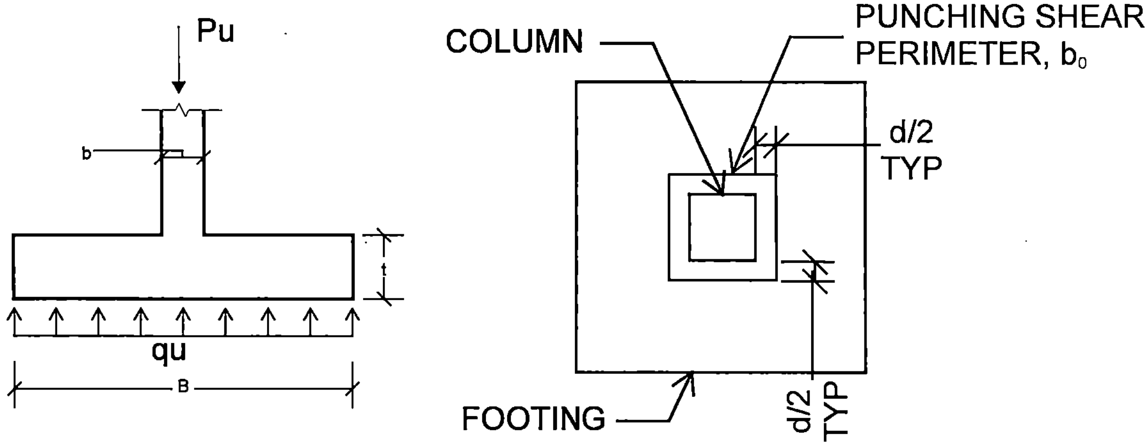
Column	Pu (k)	Footing B (ft)	Footing L (ft)	Footing Area (ft^2)	qu (ksf)	b (in)	h (in)	Equivalent b (in)	Bottom Layer Bar Size	# of Bars	Clear Cover (in)	t (in)	d (in)	b_o (in)	Vu (k)	f'c (ksi)	Vn (k)	DCR
D4	1505.28	14.00	14.00	196.00	7.68	24	24	24.00	9	11	4.13	40	35.31	237.23	1317.68	5.287	2436.19	0.54
D2	1457.05	14.00	14.00	196.00	7.43	24	24	24.00	9	11	4.13	40	35.31	237.23	1275.46	5.287	2436.19	0.52
C2	1189.25	14.00	14.00	196.00	6.07	24	24	24.00	9	11	4.13	40	35.31	237.23	1041.04	5.287	2436.19	0.43
B2	1469.55	14.00	14.00	196.00	7.50	24	24	24.00	9	11	4.13	40	35.31	237.23	1286.40	5.287	2436.19	0.53
E4	758.91	13.00	13.00	169.00	4.49	24	24	24.00	9	13	4.13	40	35.31	237.23	649.22	5.287	2436.19	0.27
D1	783.24	13.00	13.00	169.00	4.63	24	24	24.00	9	13	4.13	40	35.31	237.23	670.03	5.287	2436.19	0.28
B1	787.80	13.00	13.00	169.00	4.66	24	24	24.00	9	13	4.13	40	35.31	237.23	673.94	5.287	2436.19	0.28
A4	1019.92	13.00	13.00	169.00	6.04	24	24	24.00	9	13	4.13	40	35.31	237.23	872.50	5.287	2436.19	0.36
B4	1419.32	14.00	14.00	196.00	7.24	24	24	24.00	9	11	4.13	40	35.31	237.23	1242.44	5.287	2436.19	0.51
B3	869.06	14.00	14.00	196.00	4.43	24	24	24.00	9	11	4.13	40	35.31	237.23	760.75	5.287	2436.19	0.31
D3	1254.95	14.00	14.00	196.00	6.40	24	24	24.00	9	11	4.13	40	35.31	237.23	1098.55	5.287	2436.19	0.45
E2	1128.76	13.00	13.00	169.00	6.68	24	24	24.00	9	13	4.13	40	35.31	237.23	965.62	5.287	2436.19	0.40
A1	673.14	9.33	9.33	87.11	7.73	24	24	24.00	7	10	3.88	40	35.69	238.75	481.97	5.287	2478.13	0.19
A2	768.96	13.00	13.00	169.00	4.55	24	24	24.00	9	13	4.13	40	35.31	237.23	657.81	5.287	2436.19	0.27
A3	782.78	13.00	13.00	169.00	4.63	24	24	24.00	9	13	4.13	40	35.31	237.23	669.64	5.287	2436.19	0.27
A5	505.35	9.33	9.33	87.11	5.80	24	24	24.00	7	10	3.88	40	35.69	238.75	361.82	5.287	2478.13	0.15
A6	201.61	7.75	7.75	60.06	3.36	24	24	24.00	7	8	3.88	32	27.69	206.75	139.33	5.287	1664.92	0.08
B5	688.14	13.00	13.00	169.00	4.07	24	24	24.00	9	13	4.13	40	35.31	237.23	588.68	5.287	2436.19	0.24
B6	75.59	7.75	7.75	60.06	1.26	24	24	24.00	7	8	3.88	32	27.69	206.75	52.24	5.287	1664.92	0.03
C1	790.72	13.00	13.00	169.00	4.68	24	24	24.00	9	13	4.13	40	35.31	237.23	676.43	5.287	2436.19	0.28
C3	890.07	14.00	14.00	196.00	4.54	24	24	24.00	9	11	4.13	40	35.31	237.23	779.14	5.287	2436.19	0.32
C4	859.82	14.00	14.00	196.00	4.39	24	24	24.00	9	11	4.13	40	35.31	237.23	752.66	5.287	2436.19	0.31
C5	754.95	13.00	13.00	169.00	4.47	24	24	24.00	9	13	4.13	40	35.31	237.23	645.84	5.287	2436.19	0.27
C6	117.08	10.00	10.00	100.00	1.17	24	24	24.00	7	11	3.88	40	35.69	238.75	88.12	5.287	2478.13	0.04
C7	677.28	13.50	13.50	182.25	3.72	24	24	24.00	10	10	4.27	40	35.10	236.38	587.16	5.287	2412.80	0.24
D5	1146.42	13.00	13.00	169.00	6.78	24	24	24.00	9	13	4.13	40	35.31	237.23	980.72	5.287	2436.19	0.40
D6	329.94	10.00	10.00	100.00	3.30	24	24	24.00	7	11	3.88	40	35.69	238.75	248.31	5.287	2478.13	0.10
D7	645.02	13.50	13.50	182.25	3.54	24	24	24.00	10	10	4.27	40	35.10	236.38	559.19	5.287	2412.80	0.23
E1	667.73	9.33	9.33	87.11	7.67	24	24	24.00	7	10	3.88	40	35.69	238.75	478.09	5.287	2478.13	0.19
E3	559.46	13.00	13.00	169.00	3.31	24	24	24.00	9	13	4.13	40	35.31	237.23	478.60	5.287	2436.19	0.20
E5	660.44	9.33	9.33	87.11	7.58	24	24	24.00	7	10	3.88	40	35.69	238.75	472.87	5.287	2478.13	0.19
E6	157.49	7.75	7.75	60.06	2.62	24	24	24.00	7	8	3.88	32	27.69	206.75	108.84	5.287	1664.92	0.07

Note: All footings in there existing condition can resist shear demands.

See Next Page for a sample Calculation.

Footing Punching Shear Check

Column D4
Footing Type A
Pu = 1505.28k; load obtained as the peak average load from the Perform 3D models.



Footing Dimensions:
B = 14'
L = 14'
t = 40"
b = 24"

(11) #9's Bottom EW
As = $11 in^2$
d = 40"-3"-(1.128") - (1.128"/2) = 35.31" (Assuming resisting flexural reinforcement is the second mat of reinforcement)
$f'c_{LB}$ = 5.287ksi
fy_{LB} = 65ksi
qu = Pu/(B*L) = 7.68ksf

b_0 =4* (24"+35.31") = 237.23"
Vu = qu*(B*L - ((b*d)^2)) = 1317.68 k

Vn = $4*\sqrt{f'c}*b_0*d$ = 2436.19 k

DCR = 0.54

Therefore Footing is adequate for punching shear.

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One-Way Shear Check of Footing Capacity

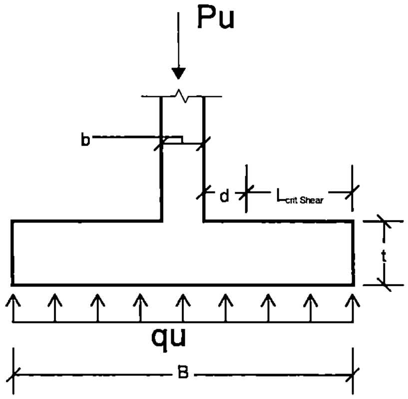
Column	Pu (k)	Footing B (ft)	Footing L (ft)	Footing Area (ft^2)	qu (ksf)	b (in)	h (in)	Equivalent b (in)	Bottom Layer Bar Size	# of Bars	Clear Cover (in)	t (in)	d (in)	$L_{crit\ Shear}$ (ft)	Vu (k)	f'c (ksi)	Vn (k)	DCR
D4	1505.28	14.00	14.00	196.00	7.68	24	24	24.00	9	11	4.13	40	35.31	3.06	328.76	5.287	862.62	0.38
D2	1457.05	14.00	14.00	196.00	7.43	24	24	24.00	9	11	4.13	40	35.31	3.06	318.23	5.287	862.62	0.37
C2	1189.25	14.00	14.00	196.00	6.07	24	24	24.00	9	11	4.13	40	35.31	3.06	259.74	5.287	862.62	0.30
B2	1469.55	14.00	14.00	196.00	7.50	24	24	24.00	9	11	4.13	40	35.31	3.06	320.96	5.287	862.62	0.37
E4	758.91	13.00	13.00	169.00	4.49	24	24	24.00	9	13	4.13	40	35.31	2.56	149.31	5.287	801.00	0.19
D1	783.24	13.00	13.00	169.00	4.63	24	24	24.00	9	13	4.13	40	35.31	2.56	154.10	5.287	801.00	0.19
B1	787.80	13.00	13.00	169.00	4.66	24	24	24.00	9	13	4.13	40	35.31	2.56	155.00	5.287	801.00	0.19
A4	1019.92	13.00	13.00	169.00	6.04	24	24	24.00	9	13	4.13	40	35.31	2.56	200.66	5.287	801.00	0.25
B4	1419.32	14.00	14.00	196.00	7.24	24	24	24.00	9	11	4.13	40	35.31	3.06	309.99	5.287	862.62	0.36
B3	869.06	14.00	14.00	196.00	4.43	24	24	24.00	9	11	4.13	40	35.31	3.06	189.81	5.287	862.62	0.22
D3	1254.95	14.00	14.00	196.00	6.40	24	24	24.00	9	11	4.13	40	35.31	3.06	274.09	5.287	862.62	0.32
E2	1128.76	13.00	13.00	169.00	6.68	24	24	24.00	9	13	4.13	40	35.31	2.56	222.08	5.287	801.00	0.28
A1	673.14	9.33	9.33	87.11	7.73	24	24	24.00	7	10	3.88	40	35.69	0.69	49.96	5.287	581.26	0.09
A2	768.96	13.00	13.00	169.00	4.55	24	24	24.00	9	13	4.13	40	35.31	2.56	151.29	5.287	801.00	0.19
A3	782.78	13.00	13.00	169.00	4.63	24	24	24.00	9	13	4.13	40	35.31	2.56	154.01	5.287	801.00	0.19
A5	505.35	9.33	9.33	87.11	5.80	24	24	24.00	7	10	3.88	40	35.69	0.69	37.51	5.287	581.26	0.06
A6	201.61	7.75	7.75	60.06	3.36	24	24	24.00	7	8	3.88	32	27.69	0.57	14.77	5.287	374.46	0.04
B5	688.14	13.00	13.00	169.00	4.07	24	24	24.00	9	13	4.13	40	35.31	2.56	135.39	5.287	801.00	0.17
B6	75.59	7.75	7.75	60.06	1.26	24	24	24.00	7	8	3.88	32	27.69	0.57	5.54	5.287	374.46	0.01
C1	790.72	13.00	13.00	169.00	4.68	24	24	24.00	9	13	4.13	40	35.31	2.56	155.57	5.287	801.00	0.19
C3	890.07	14.00	14.00	196.00	4.54	24	24	24.00	9	11	4.13	40	35.31	3.06	194.40	5.287	862.62	0.23
C4	859.82	14.00	14.00	196.00	4.39	24	24	24.00	9	11	4.13	40	35.31	3.06	187.79	5.287	862.62	0.22
C5	754.95	13.00	13.00	169.00	4.47	24	24	24.00	9	13	4.13	40	35.31	2.56	148.53	5.287	801.00	0.19
C6	117.08	10.00	10.00	100.00	1.17	24	24	24.00	7	11	3.88	40	35.69	1.03	12.01	5.287	622.78	0.02
C7	677.28	13.50	13.50	182.25	3.72	24	24	24.00	10	10	4.27	40	35.10	2.83	141.75	5.287	826.79	0.17
D5	1146.42	13.00	13.00	169.00	6.78	24	24	24.00	9	13	4.13	40	35.31	2.56	225.55	5.287	801.00	0.28
D6	329.94	10.00	10.00	100.00	3.30	24	24	24.00	7	11	3.88	40	35.69	1.03	33.85	5.287	622.78	0.05
D7	645.02	13.50	13.50	182.25	3.54	24	24	24.00	10	10	4.27	40	35.10	2.83	135.00	5.287	826.79	0.16
E1	667.73	9.33	9.33	87.11	7.67	24	24	24.00	7	10	3.88	40	35.69	0.69	49.56	5.287	581.26	0.09
E3	559.46	13.00	13.00	169.00	3.31	24	24	24.00	9	13	4.13	40	35.31	2.56	110.07	5.287	801.00	0.14
E5	660.44	9.33	9.33	87.11	7.58	24	24	24.00	7	10	3.88	40	35.69	0.69	49.02	5.287	581.26	0.08
E6	157.49	7.75	7.75	60.06	2.62	24	24	24.00	7	8	3.88	32	27.69	0.57	11.54	5.287	374.46	0.03

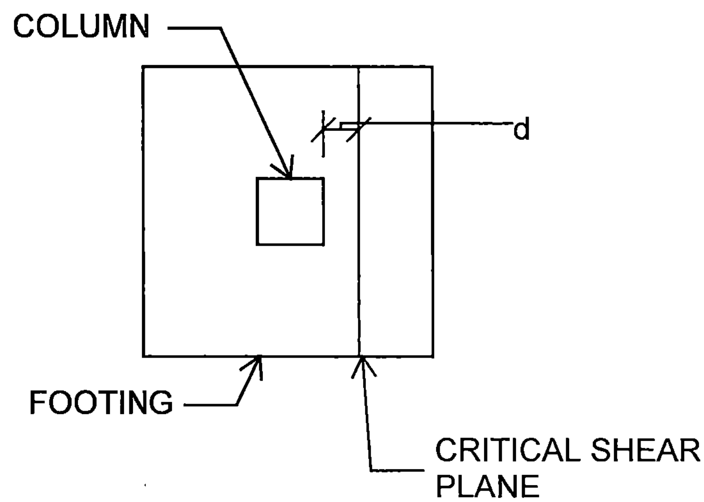
Note: All footings in there existing condition can resist shear demands.

See Next Page for a sample Calculation.

Footing One-Way Shear Check

Column D4
Footing Type A
Pu = 1505.28k; load obtained as the peak average load from the Perform 3D models.





Footing Dimensions:
B = 14'
L = 14'
t = 40"
b = 24"

(11) #9's Bottom EW
$As = 11in^2$
d = 40"-3"-(1.128") - (1.128"/2) = 35.31" (Assuming resisting flexural reinforcement is the second mat of reinforcement)
$f'c_{LB} = 5.287ksi$
$fy_{LB} = 65ksi$
qu = Pu/(B*L) = 7.68ksf

$L_{crit\ Shear} = B/2 - b/2 - d = 3.06'$
$Vu = qu*L*L_{crit\ Shear} = 328.76$ k

$Vn = 2*\sqrt{f'c}*B*d = 862.62$ k

DCR = 0.38

Therefore Footing is adequate for one-way shear.

New Wall Combined Footing Overturning Checks

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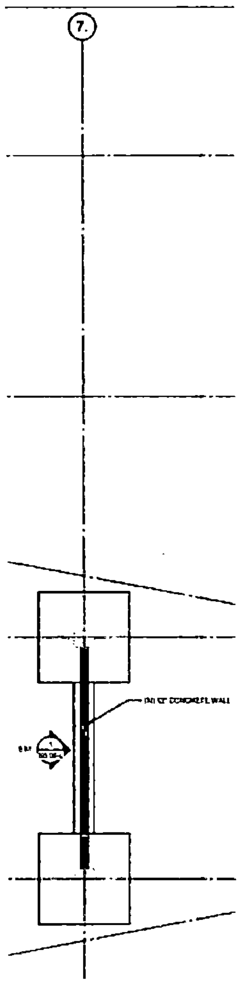
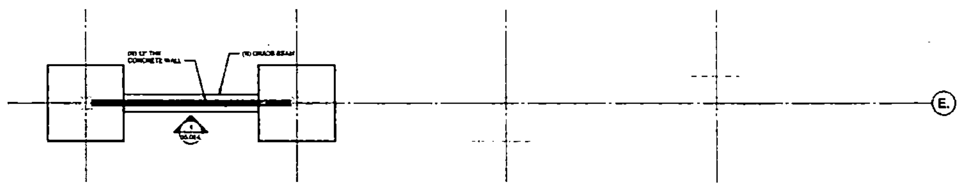
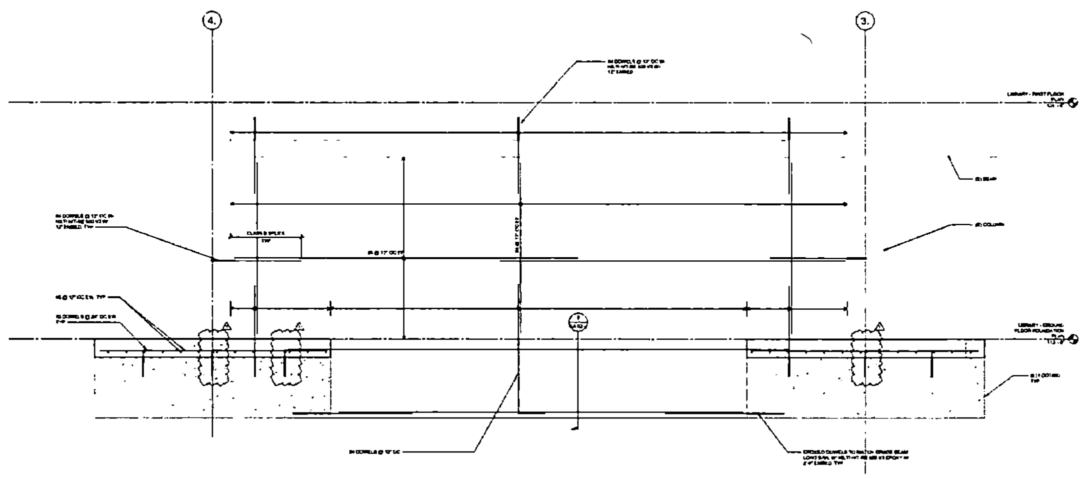
Overturning checks for New Wall Combined Footings

The following Walls have been checked for overturning:





Plan



Plan

Typical Section

Overturning was checked using ASCE 41-17 Eq. 8-10. All forces used are the peak average loads at the bottom of walls and columns.

Per the following locations both wall combined footings are adequate to resist overturning under the BSE-2E.

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Project :	COI Library
Job no. :	2000362
Date :	10/20/2021
By :	JL

Wall I-Shaped Footing - Overturning Check per ASCE 41-17

Grid E - Pier PE

P_{UD} =	2401.31	k	Combined Axial Load of Walls and Columns
$M_{UD, H2}$ =	165605.91	k-in	Moment Demand from Wall Section Cut
$V_{UD, H1}$ =	1328.69	k	Shear Demand from Wall Section Cut
M/H =	124.64	in	
L_f =	588	in	Length of footing, from edge to edge
B_f =	36	in	Conservatively, width of grade beam
$q = P_{UD}/(L_fB_f)$ =	16.34	ksf	
D_f =	54	in	Depth to bottom of footing
$B = \text{sqrt}(B_f x L_f)$ =	12.12		
$q_{all} = 6.85+0.75xD_f+0.34*B$ =	14.35	ksf	Per Geotechnical Report for continuous footings, conservative
$q_E = 3*q_{all}$ =	43.04	ksf	
$M_{CE} = ((L_fP_{UD})/2)(1-(q/q_c))$ =	36503.89	k-ft	Per ASCE 41-17 Eq. 8-10
M_{CE} =	438046.7	k-in	
DCR =	**0.38**	**OK**	

Note: All Forces are taken as the peak average demand from the PERFORM Model

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Wall I-Shaped Footing - Overturning Check per ASCE 41-17

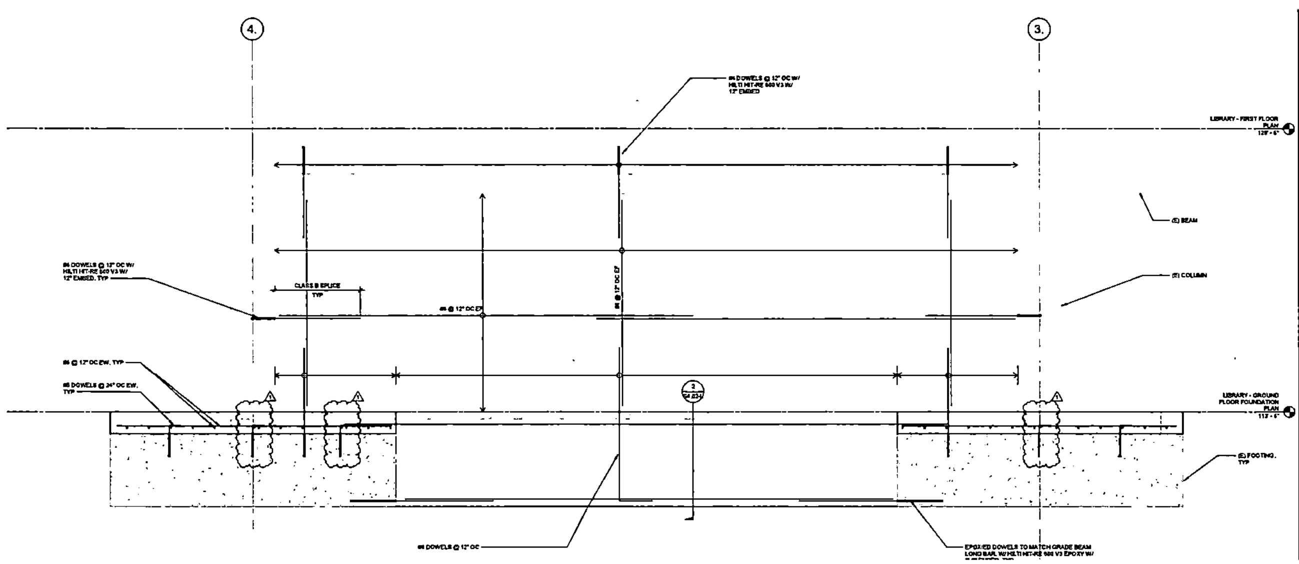
Grid 7 - Pier P7

P_{UD} =	1748.49	k	Combined Axial Load of Walls and Columns
$M_{UD,\,H1}$ =	95520.84	k-in	Moment Demand from Wall Section Cut
$V_{UD,\,H2}$ =	1249.90	k	Shear Demand from Wall Section Cut
M/H =	76.42	in	
L_f =	594	in	Length of footing, from edge to edge
B_f =	36	in	Conservatively, width of grade beam
$q = P_{UD}/(L_f B_f)$ =	11.77	ksf	
D_f =	54	in	Depth to bottom of footing
$B = \text{sqrt}(B_f x L_f)$ =	12.19		
$q_{all} = 6.85+0.75xD_f+0.34*B$ =	14.37	ksf	Per Geotechnical Report for continuous footings, conservative
$q_E = 3*q_{all}$ =	43.10	ksf	
$M_{CE} = ((L_f P_{UD})/2)(1-(q/q_c))$ =	31454.23	k-ft	Per ASCE 41-17 Eq. 8-10
M_{CE} =	377450.8	k-in	
DCR =	**0.25**	**OK**	

Note: All Forces are taken as the peak average demand from the PERFORM Model

Overturning checks for New Wall Combined Footings

Per the previously shown calculations for overturning both combined footings are adequate to resist overturning. Per the verification of existing footing capacities the existing footings are sufficient to resist the forces from the analysis therefore the footing thickening shown in the typical section (highlighted in blue below) is no longer needed and will be removed from future drawing submittals.



Shotcrete Wall Core Foundations

As part of the retrofit scope shotcrete walls will be added at the ground floor on top of the existing exterior CMU walls. The shotcrete walls will then share the same continuous footings as the CMU walls. To investigate whether the footings need to be widened and strengthened a ETABS model of the shotcrete wall core was created. At the base of the ETABS model the walls are supported by slab elements representing the existing CMU wall core footing which is then supported by compression-only area soil springs. The subgrade modulus used to calculate the stiffness of the area springs was calculated using the BSE-2E shear modulus, G, provided by Group Delta in their Geotechnical report and ASCE 41-17 equation 8-11 for Method 3 of evaluating shallow foundations. Conservatively columns C6, D6 and their footings are not integrated into the continuous footing.

The global shear forces acting at the top of the shotcrete wall core was obtained through a section cut in the PERFORM-3D model. The average of the peak shear in each direction in each Ground Motion and its corresponding shear in the perpendicular direction at the same time step was calculated, averaged over the 11 Ground Motions, and applied at the center of a rigid diaphragm that connects all of the wall core within ETABS.Forces were applied in a nonlinear static case.

Gravity loads applied to the tops of the walls include dead load and superimposed dead load from the slabs and beams above using the tributary area map provided later in this section, 2' of 4" thick slab on grade on either side of the existing footing (total of 4'), the weight of 8" partially grouted CMU walls, live load using the same tributary area as the dead loads, and the average peak vertical loads at the top of each wall segment from the PERFORM-3D model. All the previously listed loads were applied as line loads or point loads to the top of each wall. Self weight of the shotcrete walls and the footings are implicitly included in the ETABS model through the section property definitions.

The following pages contain an overview of the ETABS model, calculations of the soil spring stiffness, allowable bearing pressures, capacity of the existing footings, gravity loading used, and model results.

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Shotcrete Wall Core Foundations		

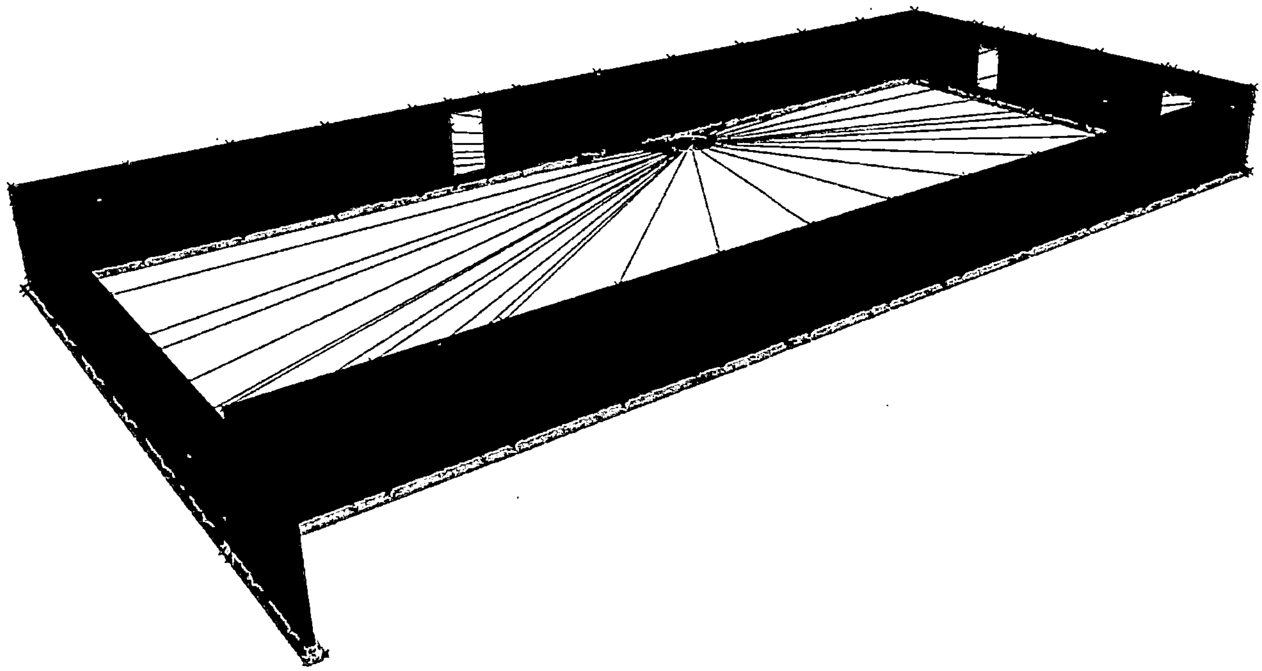

Figure A.2.e-1 ETABS Model, Isometric View

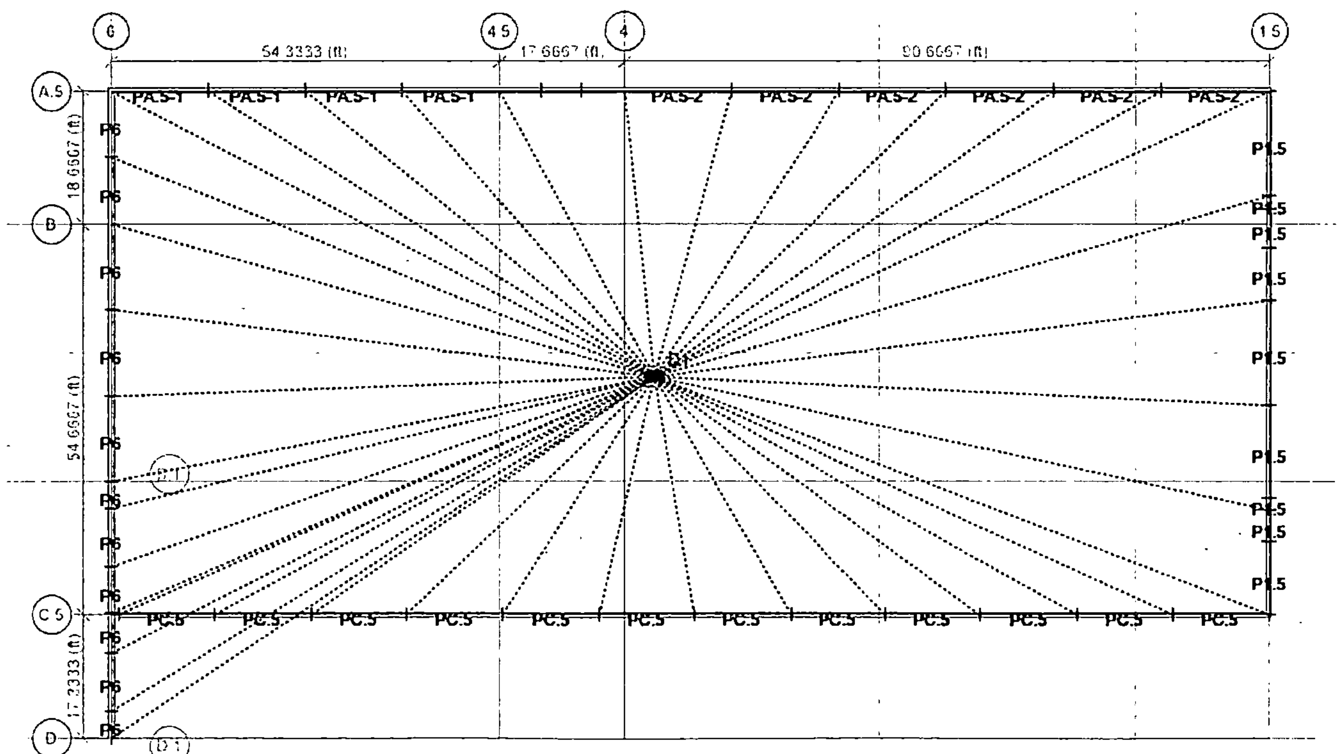

Figure A.2.e-2 ETABS Model, Plan View

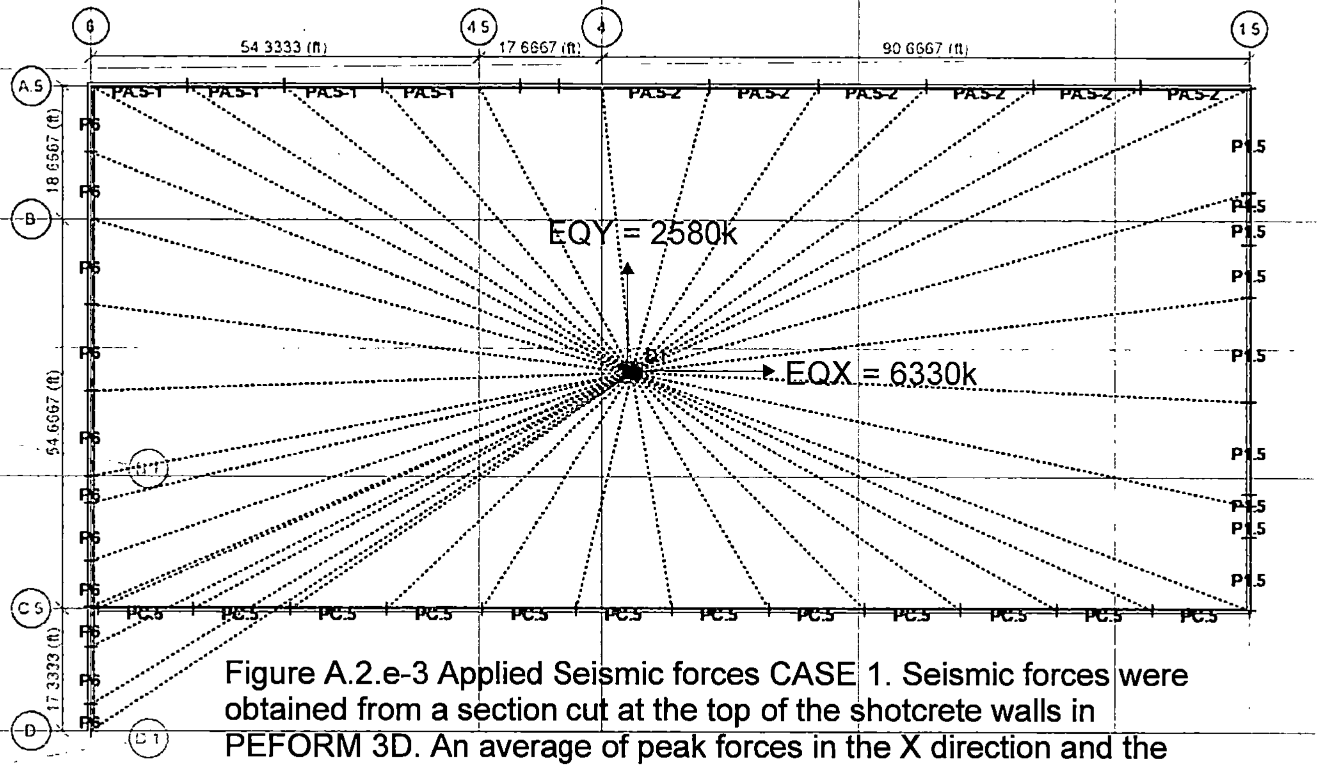

Figure A.2.e-3 Applied Seismic forces CASE 1. Seismic forces were obtained from a section cut at the top of the shotcrete walls in PEFORM 3D. An average of peak forces in the X direction and the corresponding Y force at the same time step for each Ground Motion was calculated.

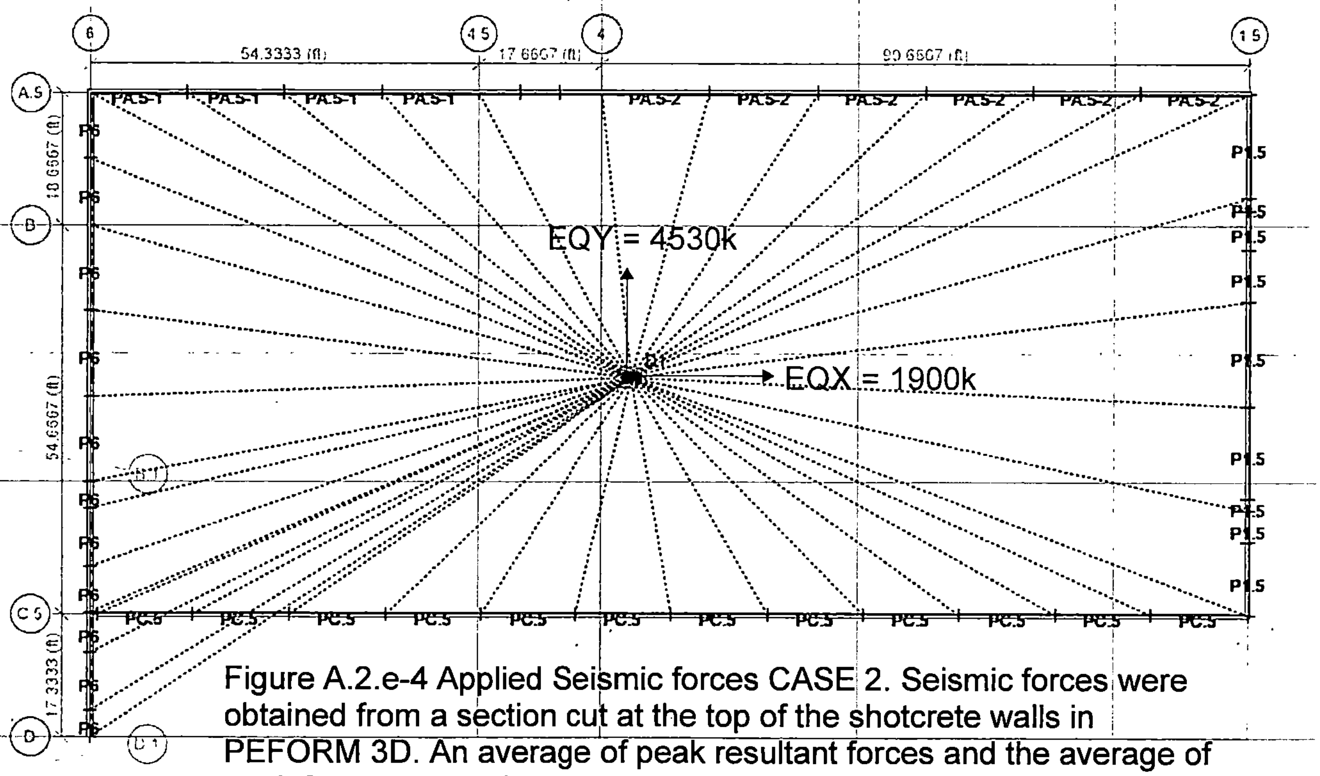

Figure A.2.e-4 Applied Seismic forces CASE 2. Seismic forces were obtained from a section cut at the top of the shotcrete walls in PEFORM 3D. An average of peak resultant forces and the average of peak forces in the Y direction and the corresponding X force at the same time step for each Ground Motion was calculated.

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sheet no. A.2.e-20

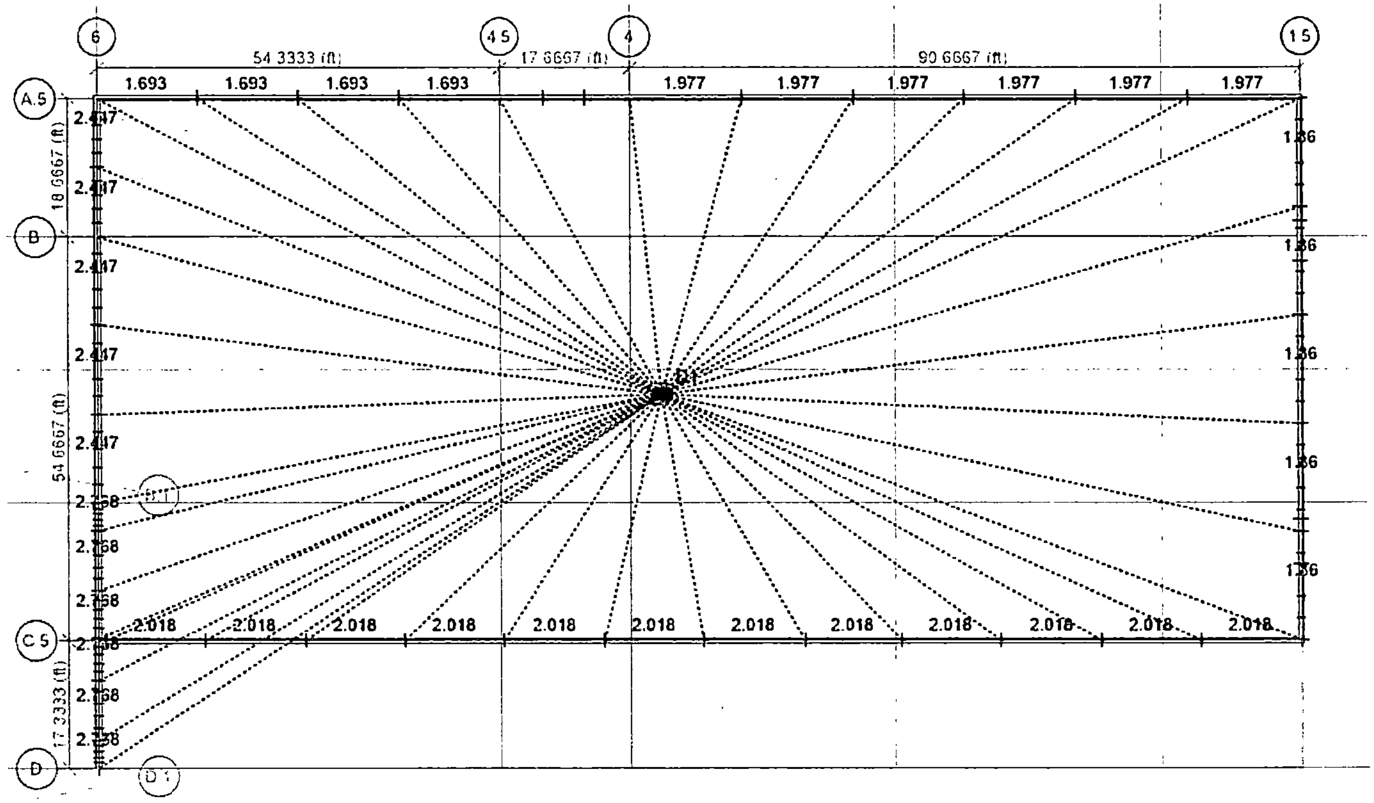

Figure A.2.e-5 Applied Super Imposed Dead load (klf)

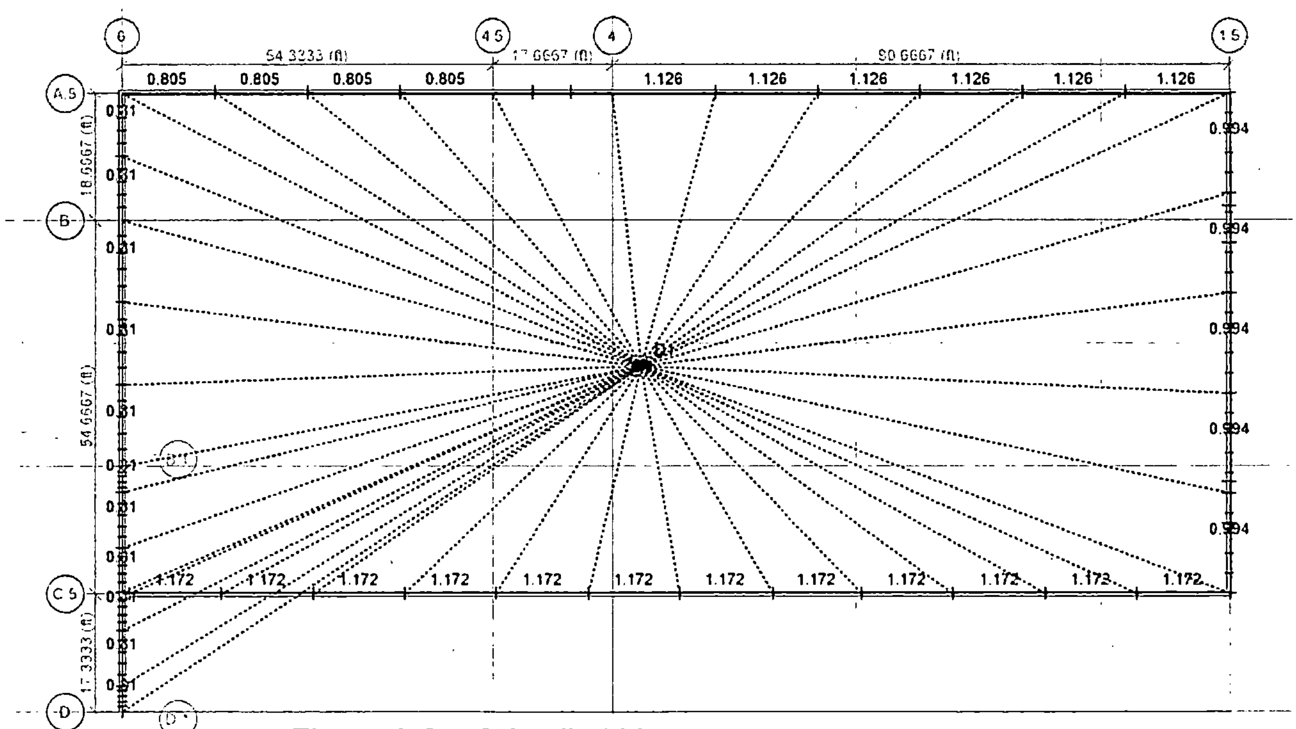

Figure A.2.e-6 Applied Live Load (klf).

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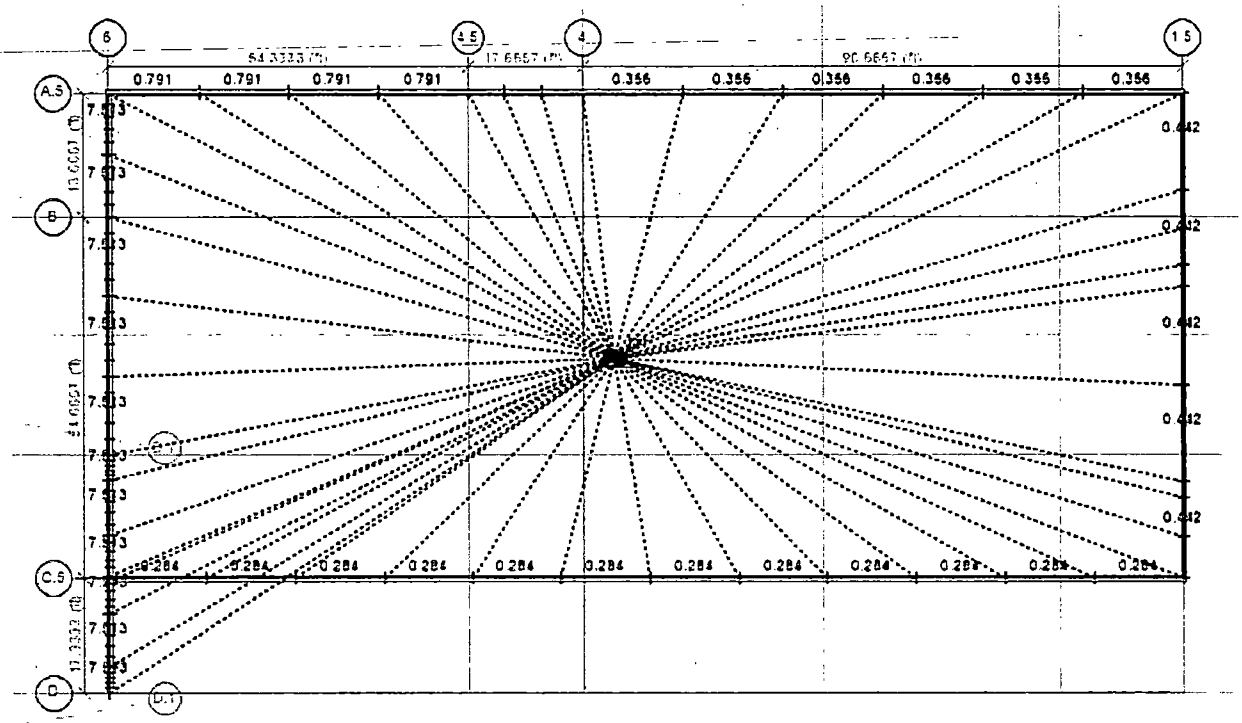


Figure A.2.e-7 Applied Axial load at top of walls from PERFORM-3D section cut (klf) (EQV). Loads from PERFORM are the vertical axial load from Ground Motions.

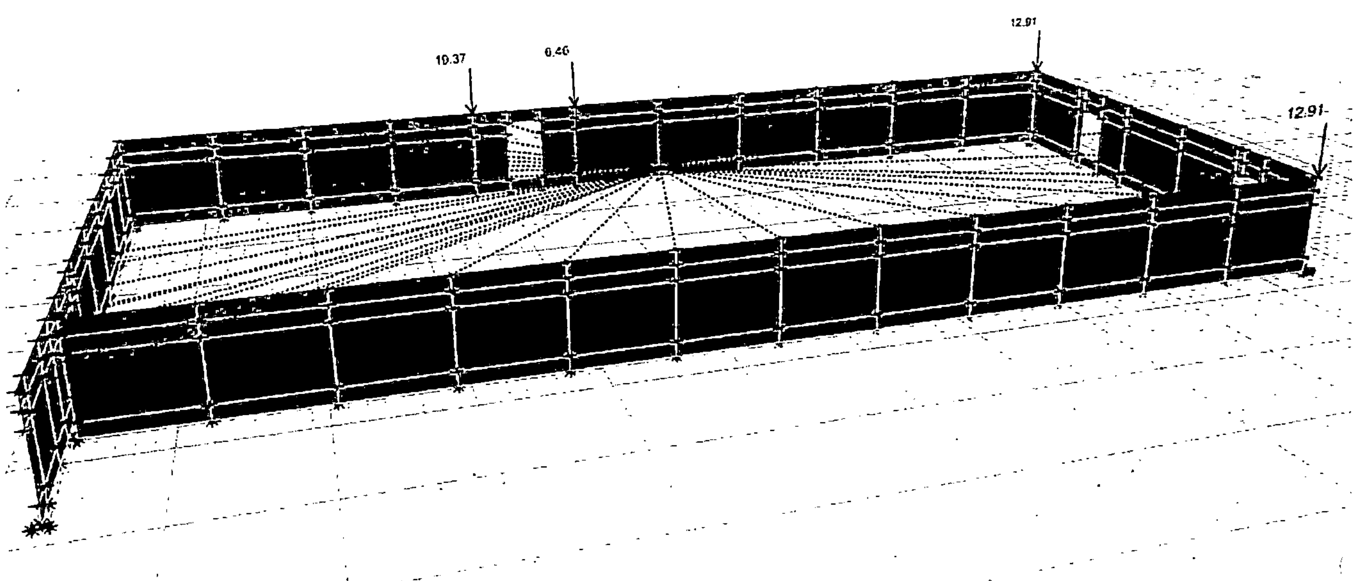


Figure A.2.e-8 Applied Super Imposed Dead Load (k).

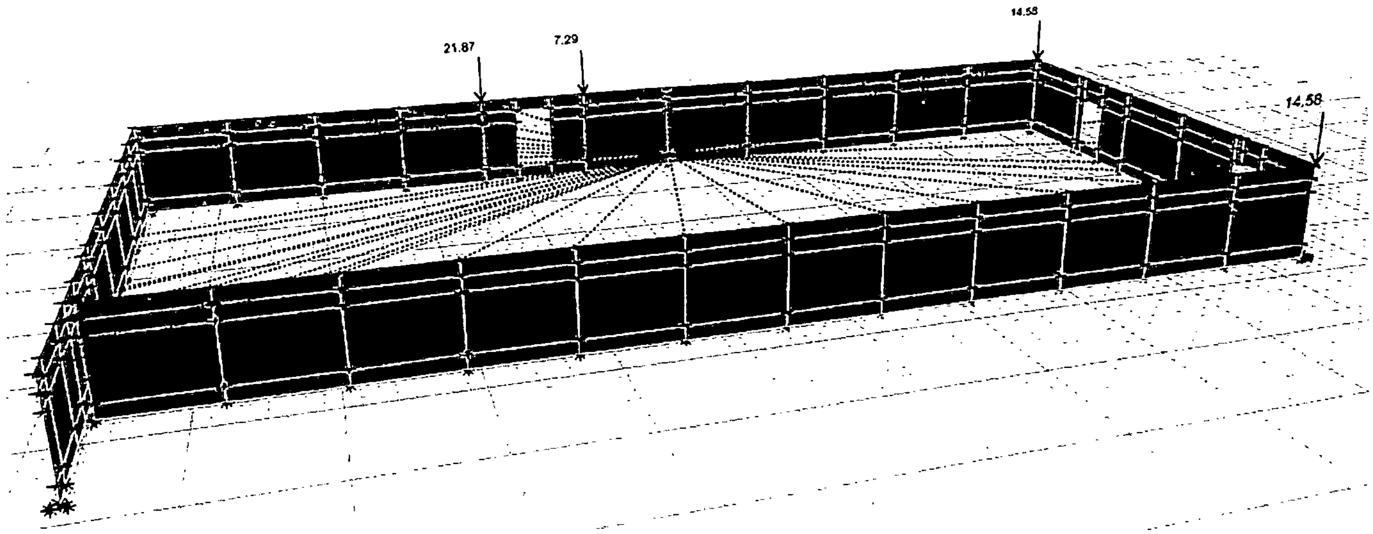


Figure A.2.e-9 Applied Live Load (k)

Shotcrete Wall Tributary Area

TRIB TO SHOTCRETE WALLS

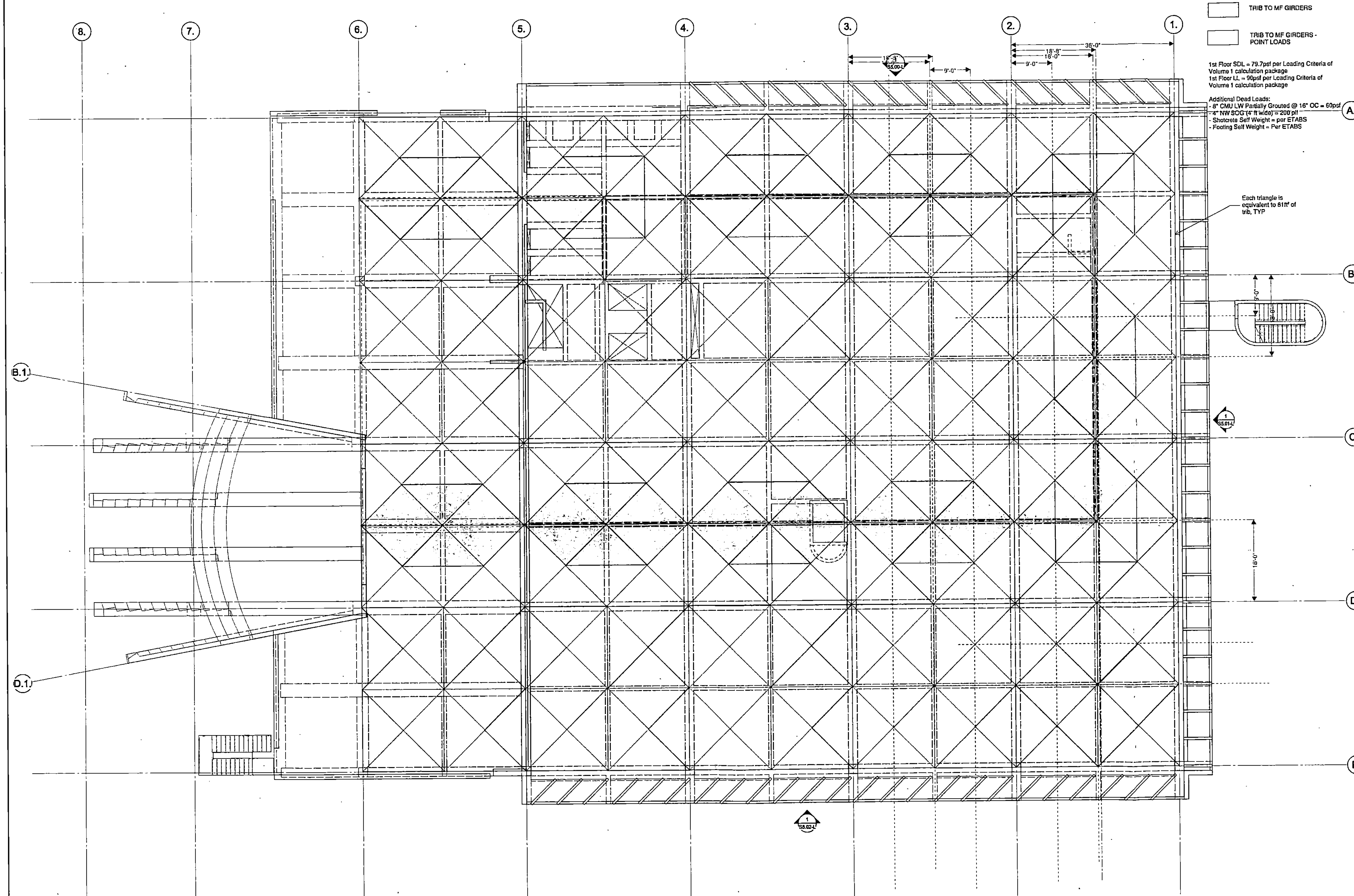
TRIB TO SHOTCRETE WALLS - CORNER POINT LOADS

TRIB TO MF GIRDERS

TRIB TO MF GIRDERS - POINT LOADS

1st Floor SDL = 79.7psf per Loading Criteria of Volume 1 calculation package
1st Floor LL = 90psf per Loading Criteria of Volume 1 calculation package

Additional Dead Loads:
- 8" CMU LW Partially Grouted @ 16" OC = 60psf
- 4" NW SOG (4' ft wide) = 200 plf
- Shotcrete Self Weight = per ETABS
- Footing Self Weight = Per ETABS



1 FIRST FLOOR - L
SCALE: 1/8" = 1'-0"

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LIBRARY - 1ST FLOOR PLAN

Drawn By:	Author
Designed By:	Designer
Project No:	2000362
Date:	10/26/20
Scale:	1/8" = 1'-0"
Drawing No:	S2.01-L

Calculation of Area Spring:

Per Geotechnical report by Group Delta dated 3/3/21, initial shear modulus G_0 = 4930ksf for library building

G/G_0 (BSE-2E) = 0.66
$G = G_0 * G/G_0$ = 4930ksf * 0.66 = 3253.8ksf

$k_{sv} = 1.3G/(B_f(1\text{-}v))$ ASCE 41-17 EQ. 8-11

B_f = footing width = 1.5' per 15/S5.1 of As-built drawings by Johnson & Nielson Associates dated 1/29/71

v = 0.25 per ASCE 41-17 8.4.2.2

k_{sv} = 1.3*(3253.8ksf)/(1.5'*(1-0.25)) = 3759.95 kcf

Therefore use 3759.95 kcf for area springs in ETABS.

Calculation of Allowable bearing pressures:

Per Geotechnical report by Group Delta dated 3/3/21, q'_{all} (ksf) = 6.85+0.75*D_f+0.34*B for continuous footings

D_f = 2.1667'
B = 1.5'
q'_{all} = 6.85+0.75*(2.1667')+0.34*(1.5') = 8.99 ksf

Per Geotechnical report expected $q_{Ult} = 3*q'_{all}$ = 3*8.99ksf = 26.97ksf

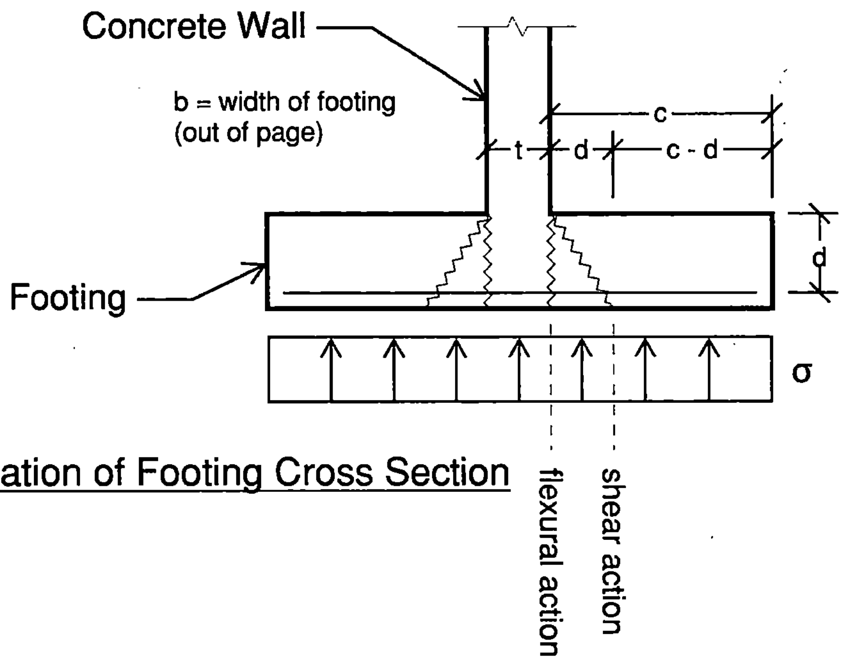
$q_{Ult,\,UB}$ = 2*26.97ksf = 53.94ksf
$q_{Ult,\,LB}$ = 0.5*26.97ksf = 13.49ksf

Expected Bearing Pressure = 26.97ksf Upper Bound Bearing Pressure = 53.94ksf Lower Bound Bearing Pressure = 13.49ksf

Calculation of Flexural Capacity of Continuous footing Flange:

Per 15/S5.1 of As-built drawings by Johnson & Nielson Associates dated 1/29/71 assume flanges of footing are unreinforced.

Per Appendix A of BOD:



Elevation of Footing Cross Section

Soil stress required to induce unreinforced flexural response in flanges, σ_F

$$\sigma_F = \frac{2M_n}{bc^2} \quad \text{where} \quad M_n = \min(5\lambda S_m\sqrt{f'_c},\ 0.85f'_cS_m)$$

(using expected material properties)

Assuming 8" CMU wall Per 15/S5.1, c = 5"
Check on a per foot basis therefore b = 12"
h = 14"
$Sm = bh^2/6 = (12)(14^2)/6 = 392\ in^3$

$f'c_E = 6718psi$

Mn = Min of: $(5*392in^{3}*\sqrt{6718psi}), (0.85*6718psi*392in^{3})$
Mn = Min of: (160,648.3 #-in), (2,238,437.6 #-in)
Mn = 160,648.3 #-in = 13.39k-ft

$\sigma_F = 2*(13.39k\text{-}ft)/(1'*(5''/12)^2) = 154.25ksf$

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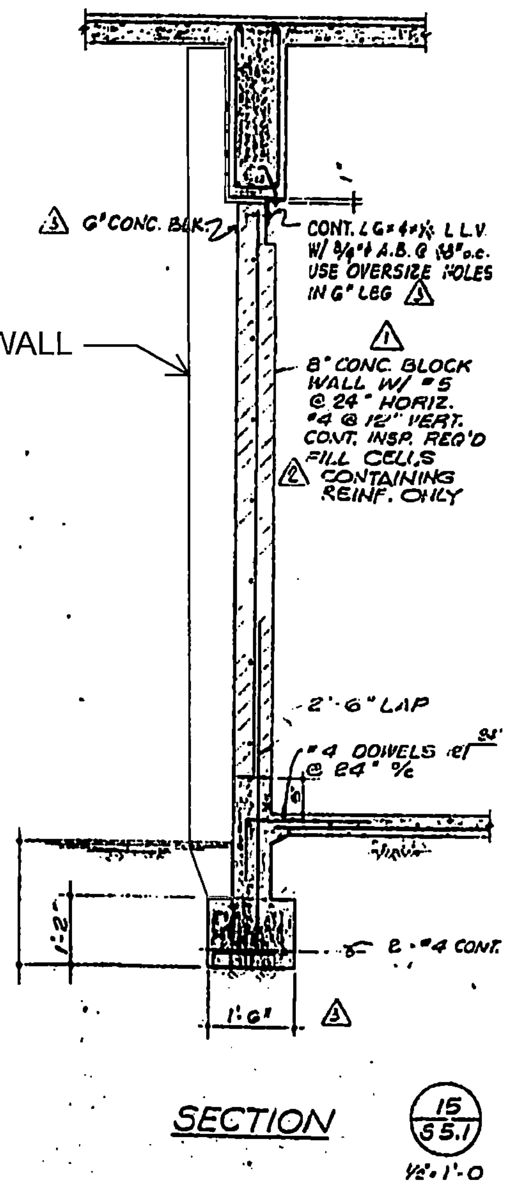
Calculation of Flexural Capacity of Continuous footing Flange:

Since bearing pressure required to crack the unreinforced flange is high assume the flange will not crack.



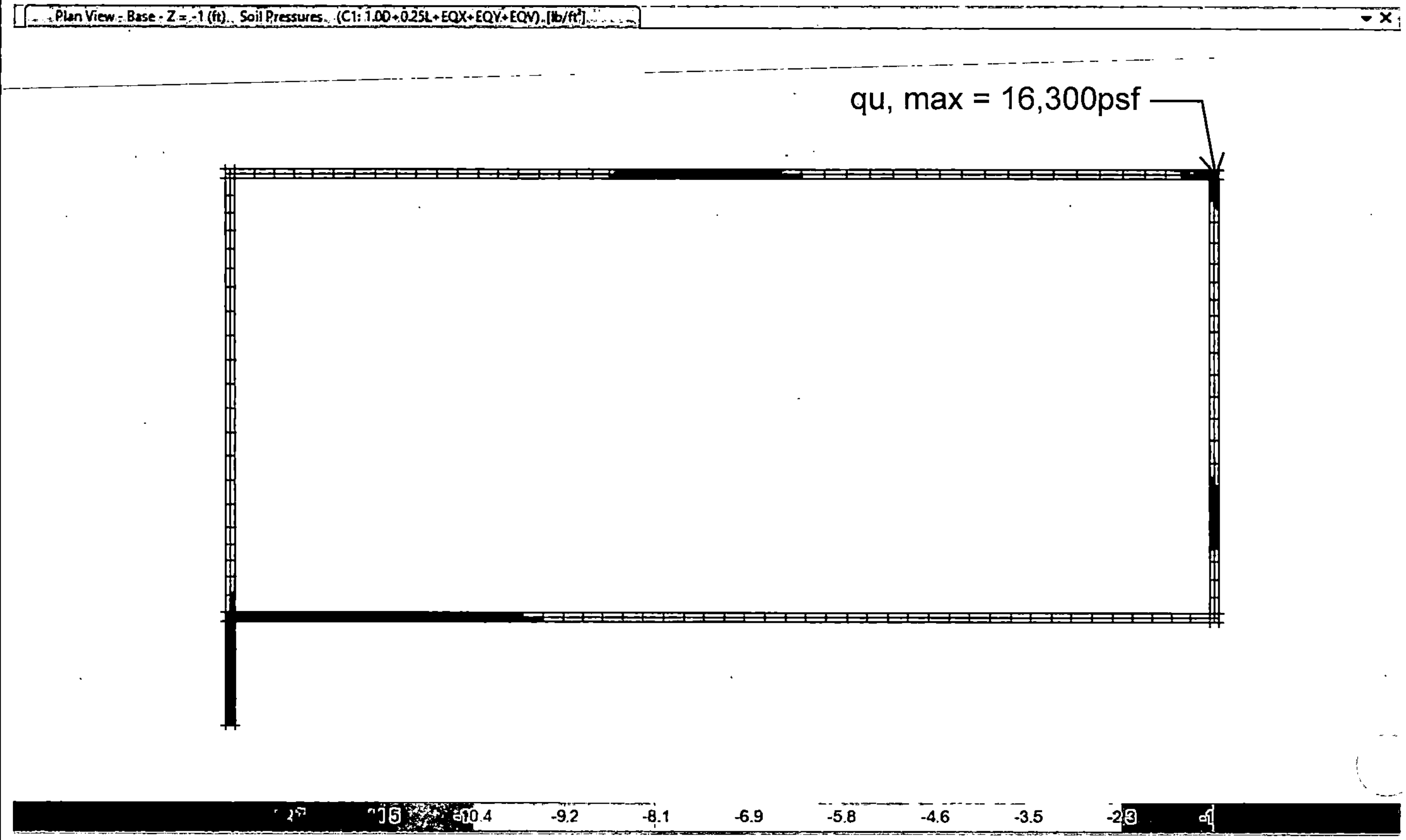


Figure A.2.e-10 Bearing pressures under CASE 1: 1.0D+0.25L+EQX+EQY+EQV (psf)

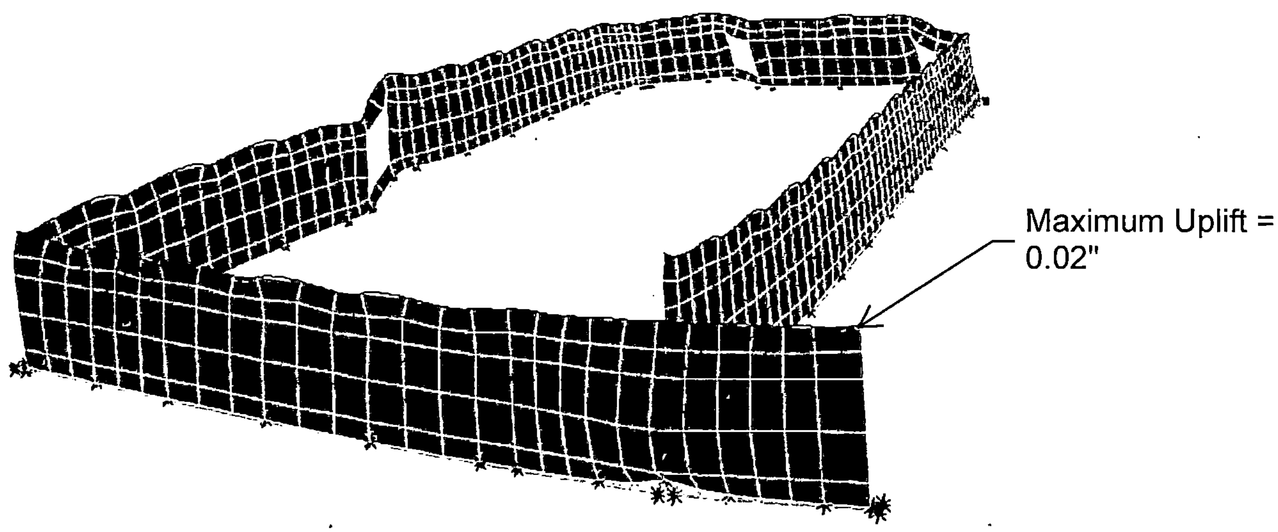


Figure A.2.e-11 Deflected shape under CASE 1: 1.0D+0.25L+EQX+EQY+EQV

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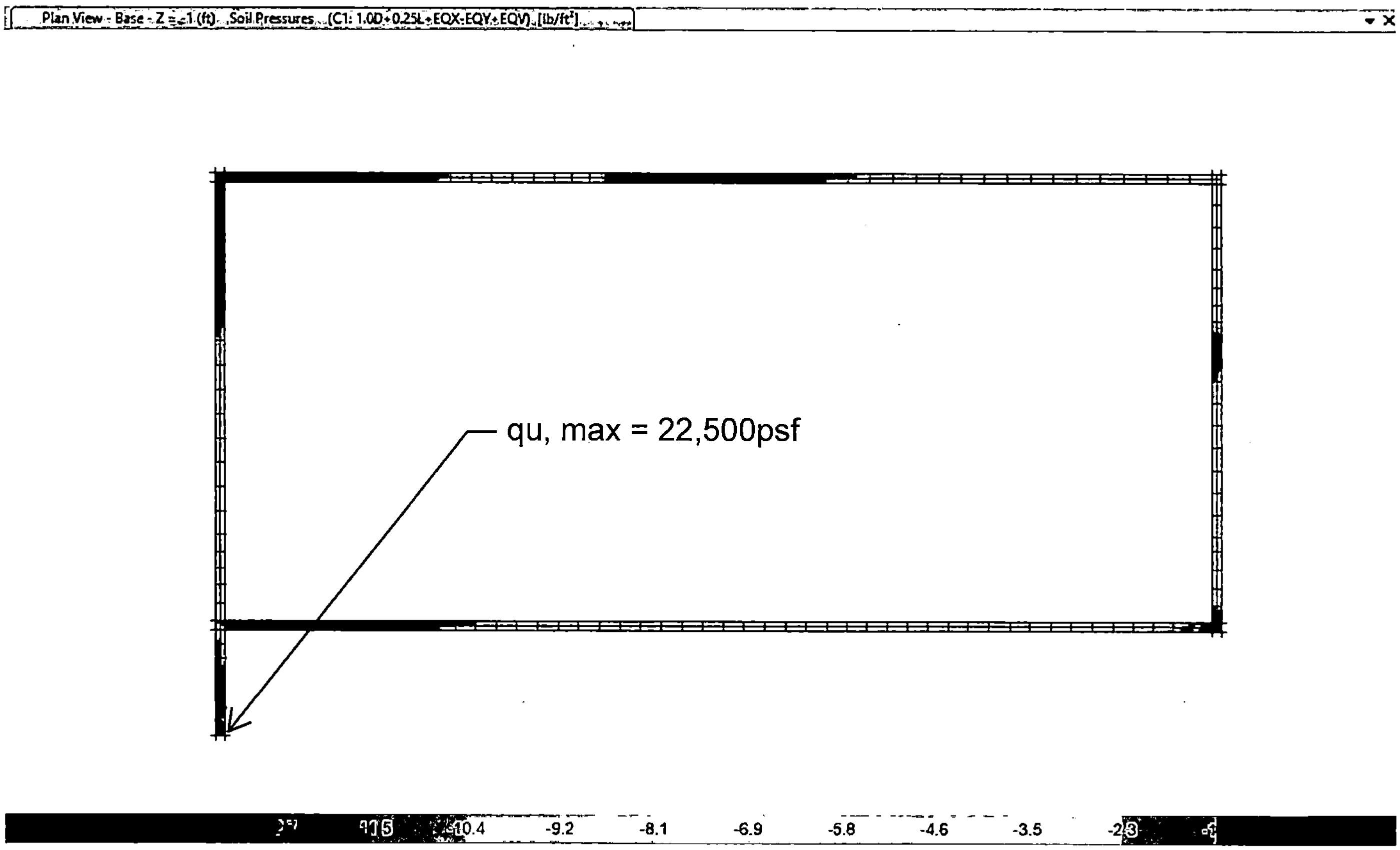

Figure A.2.e-12 Bearing pressures under CASE 1: 1.0D+0.25L+EQX-EQY+EQV (psf)

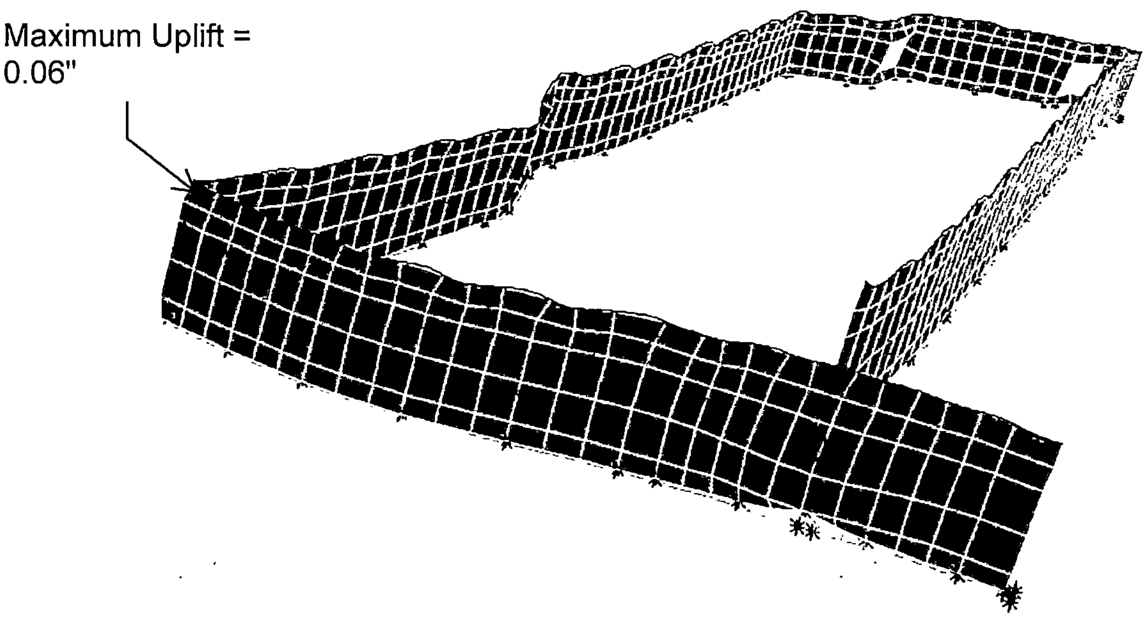

Figure A.2.e-13 Deflected shape under CASE 1: 1.0D+0.25L+EQX-EQY+EQV

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	location Inglewood, CA	date 9/20/21	
	client	job no. 2000362	
	Shotcrete Wall Core Foundations		

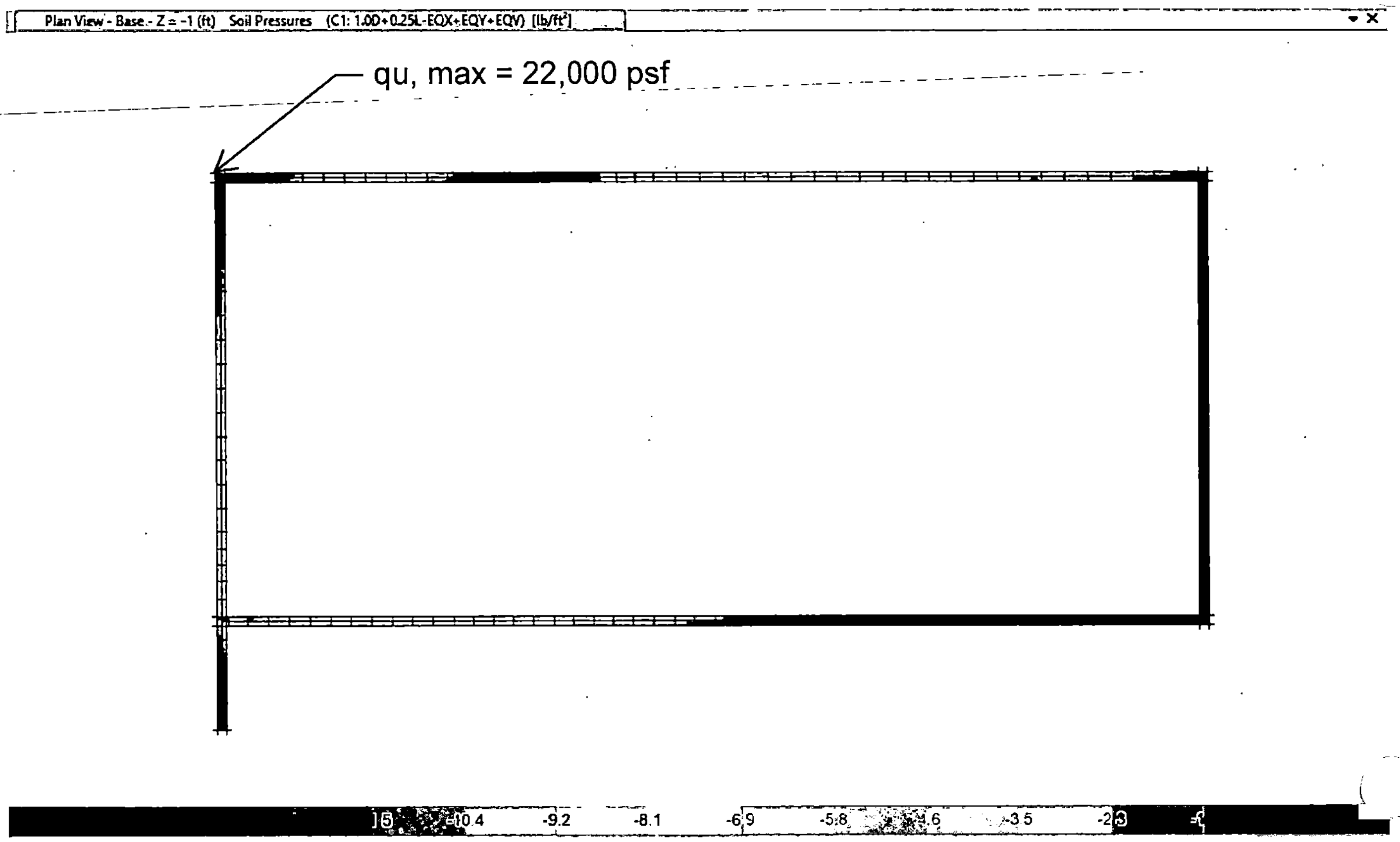

Figure A.2.e-14 Bearing pressures under CASE 1: 1.0D+0.25L-EQX+EQY+EQV (psf)

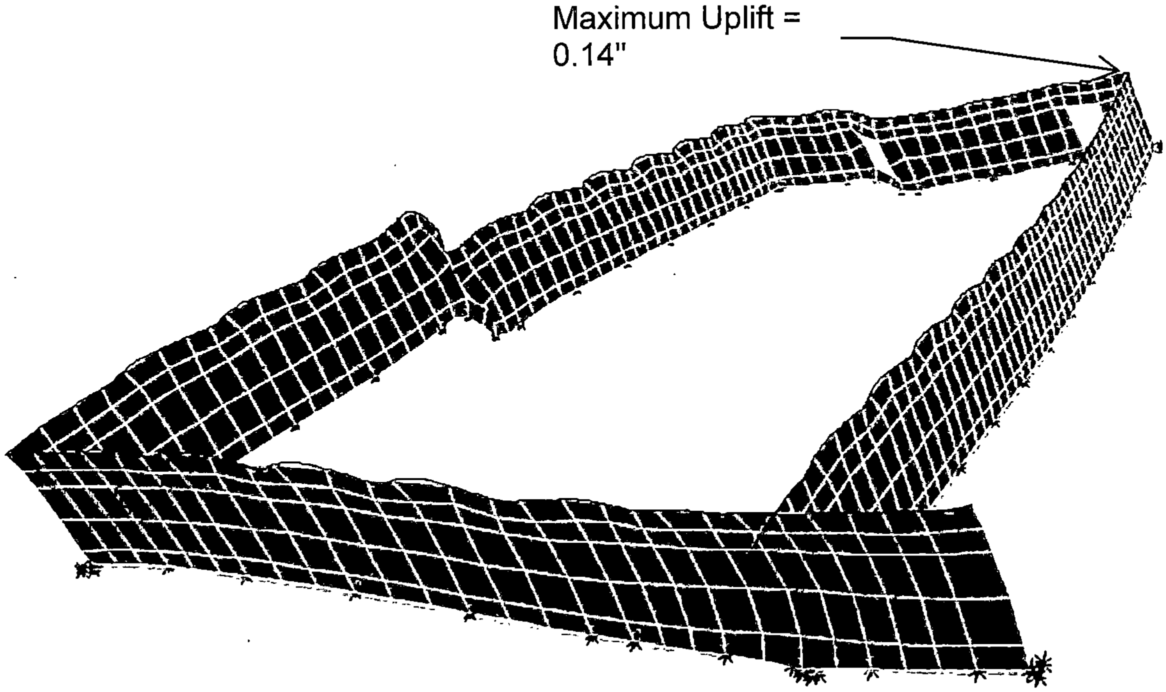

Figure A.2.e-15 Deflected shape under CASE 1: 1.0D+0.25L-EQX+EQY+EQV

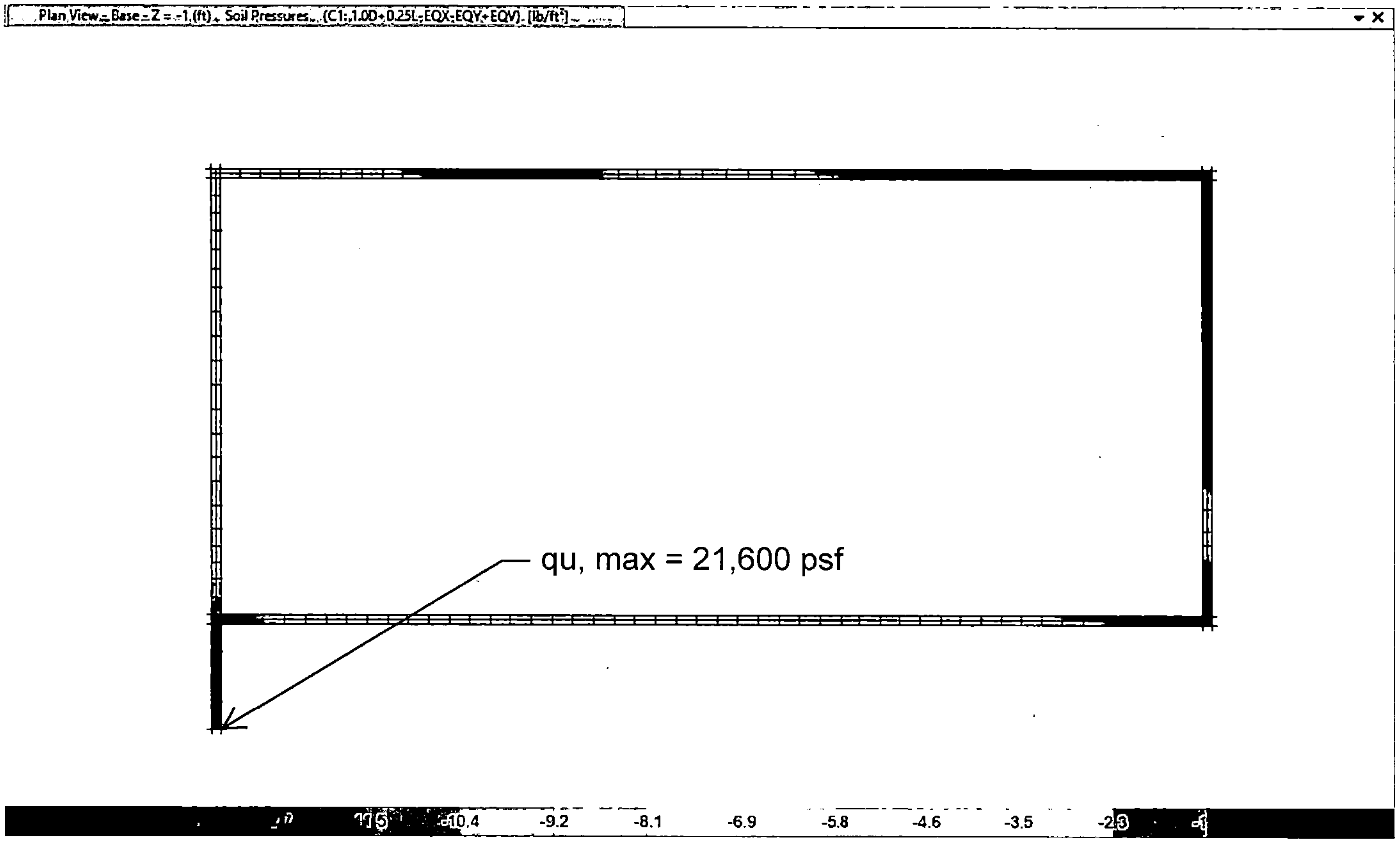

Figure A.2.e-16 Bearing pressures under CASE 1: 1.0D+0.25L-EQX-EQY+EQV (psf)

Maximum Uplift = 0.11"

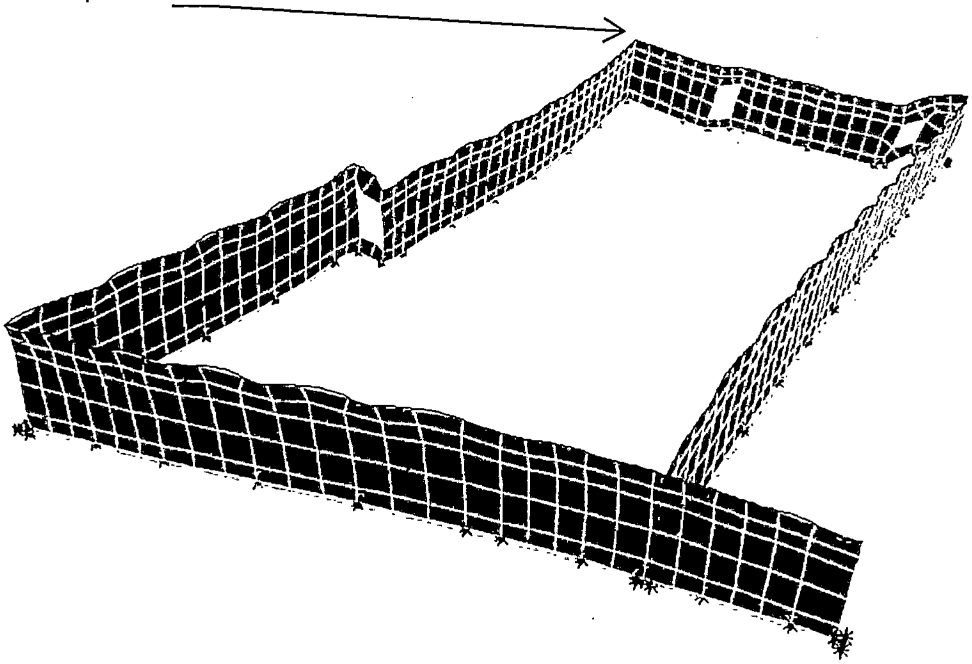

Figure A.2.e-17 Deflected shape under CASE 1: 1.0D+0.25L-EQX-EQY+EQV

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	location Inglewood, CA	date 9/20/21	
	client	job no. 2000362	
	Shotcrete Wall Core Foundations		

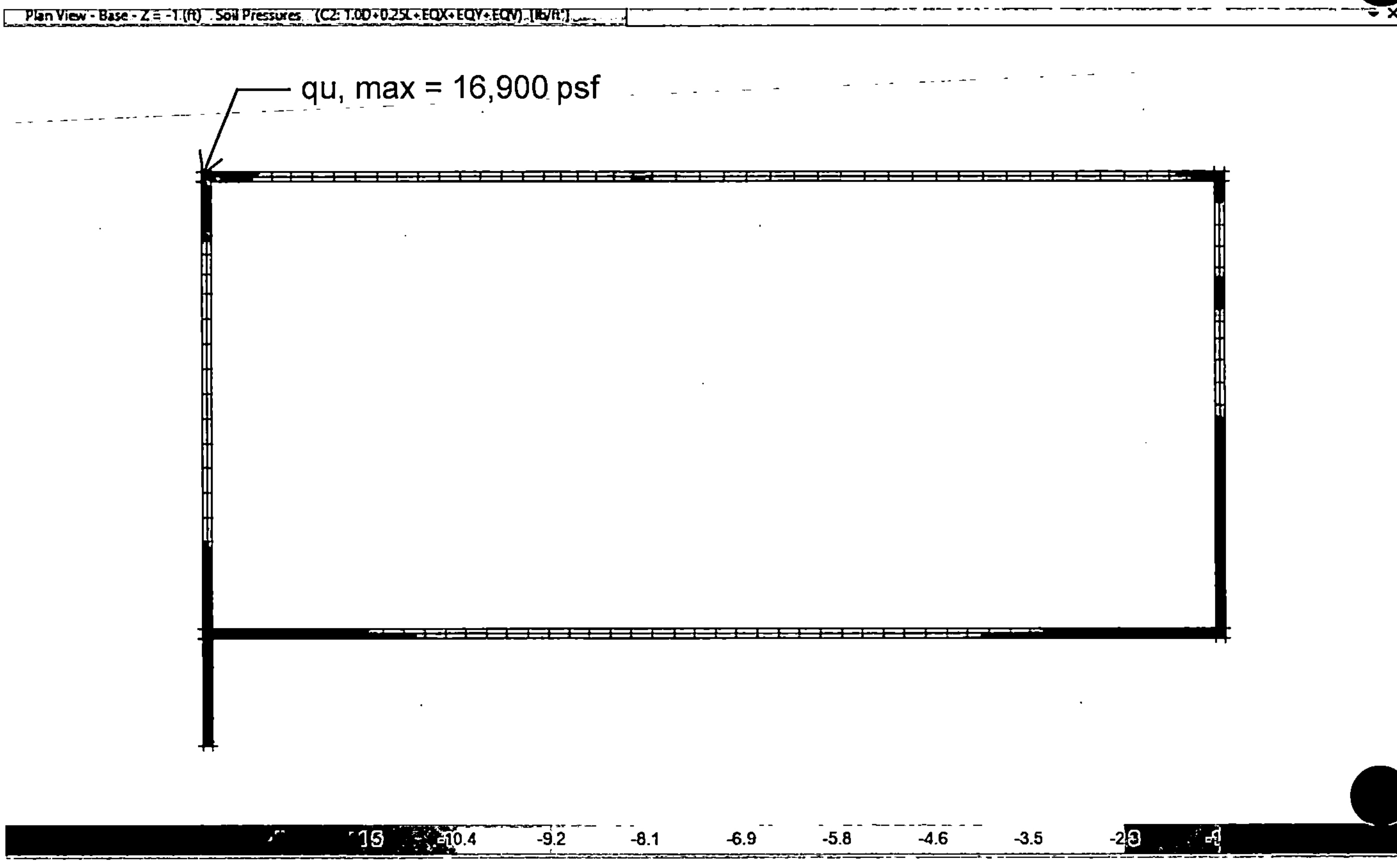

Figure A.2.e-18 Bearing pressures under CASE 2: 1.0D+0.25L+EQX+EQY+EQV (psf)

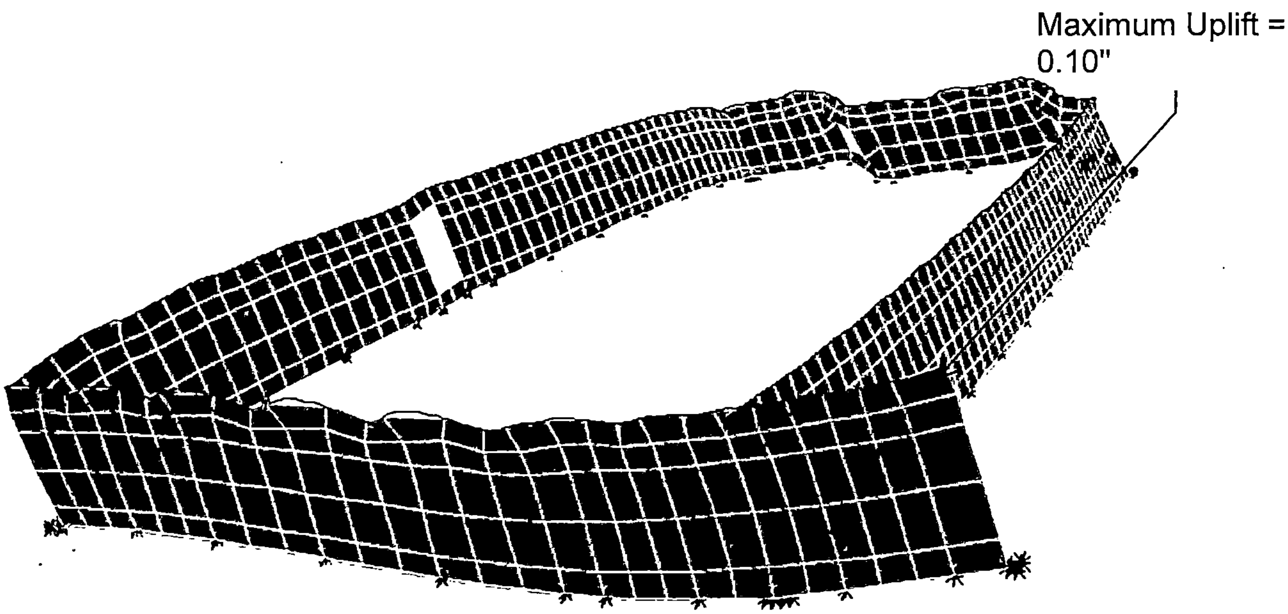

Figure A.2.e-19 Deflected shape under CASE 2: 1.0D+0.25L+EQX+EQY+EQV

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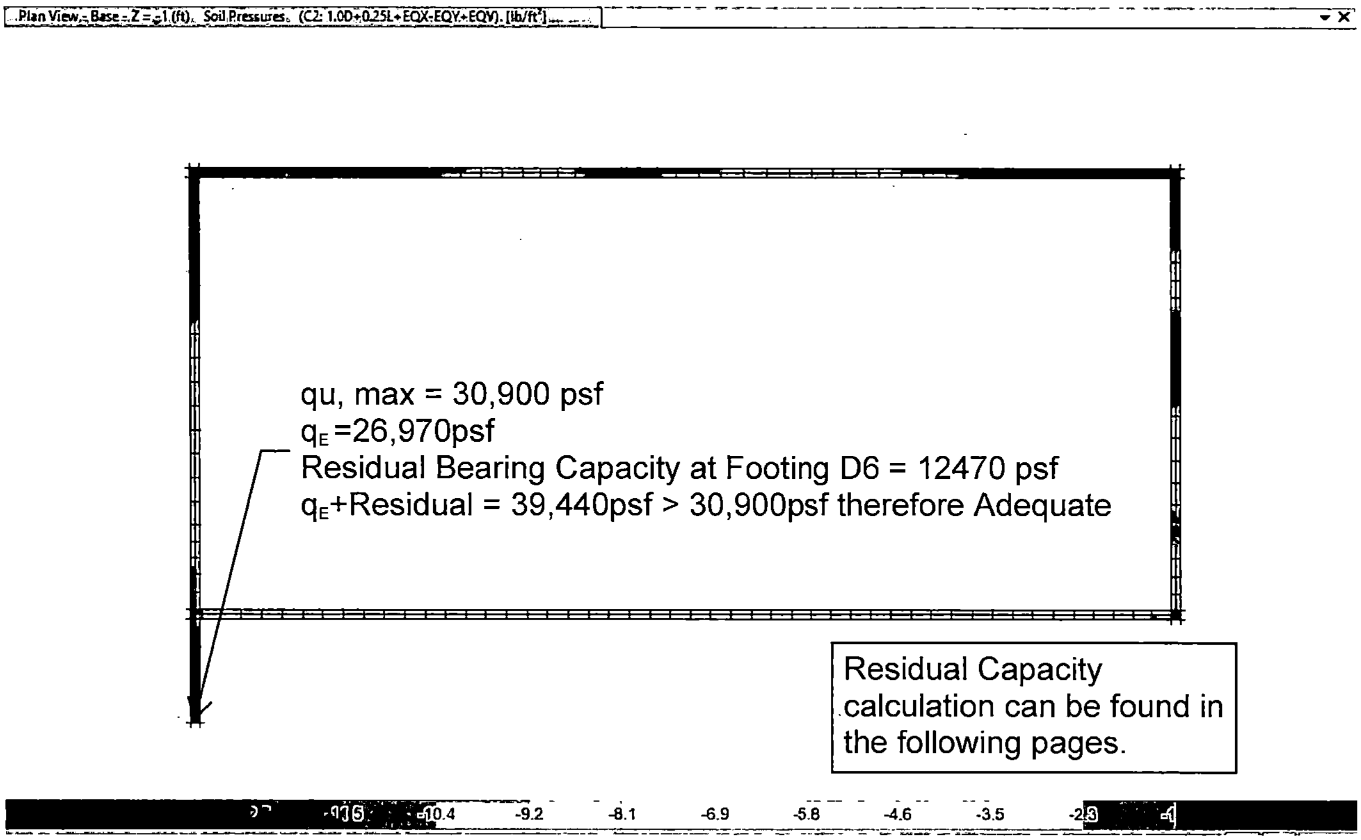

Figure A.2.e-20 Bearing pressures under CASE 2: 1.0D+0.25L+EQX-EQY+EQV (psf)

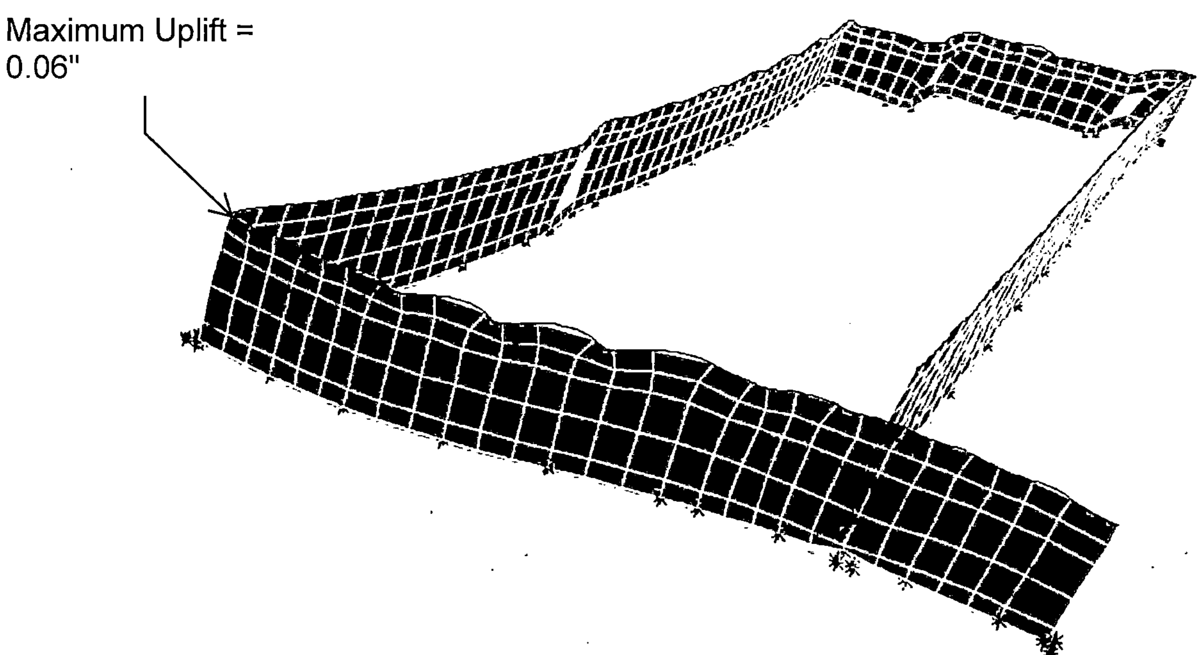

Figure A.2.e-21 Deflected shape under CASE 2: 1.0D+0.25L+EQX-EQY+EQV

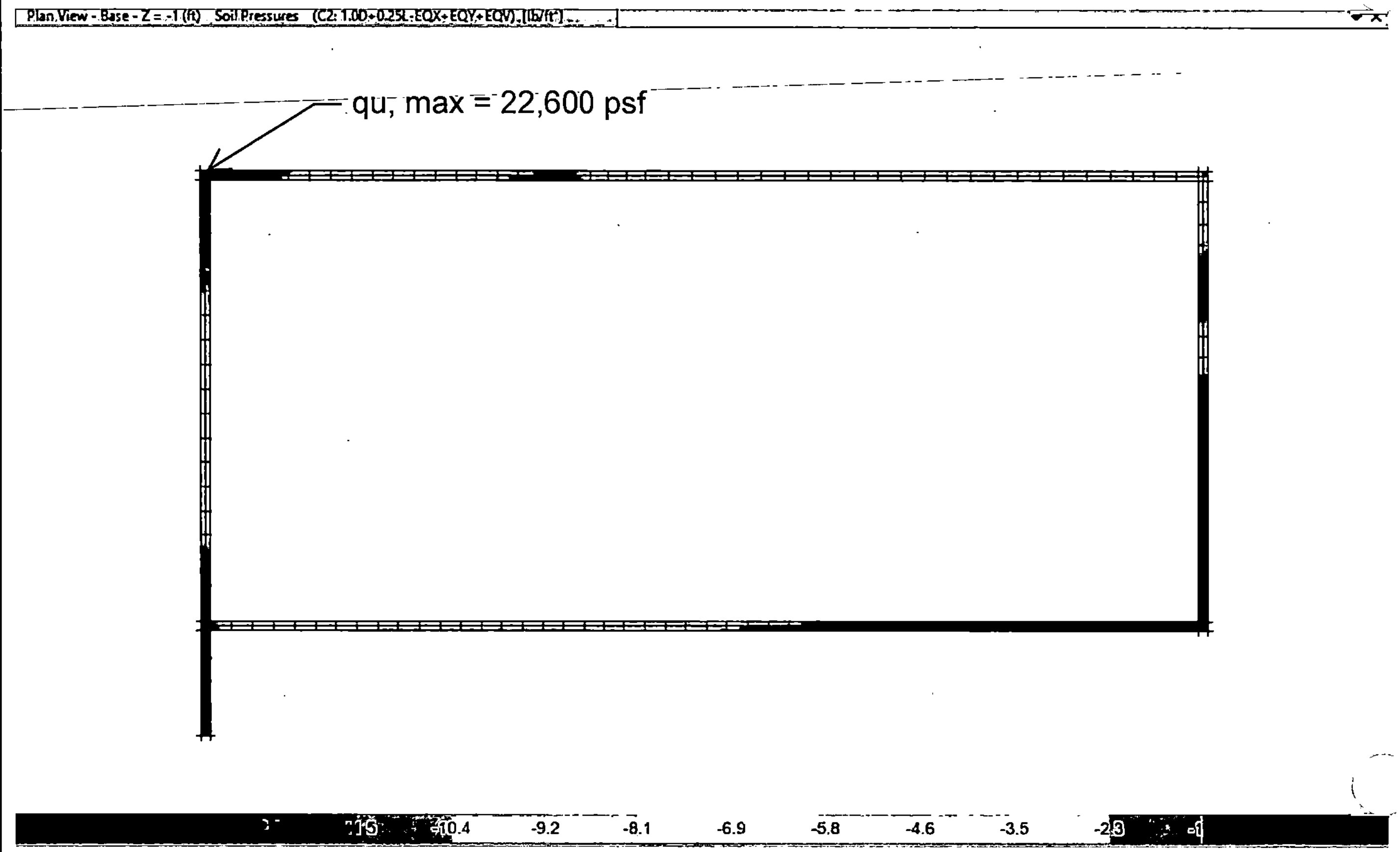

Figure A.2.e-22 Bearing pressures under CASE 2: 1.0D+0.25L-EQX+EQY+EQV (psf)

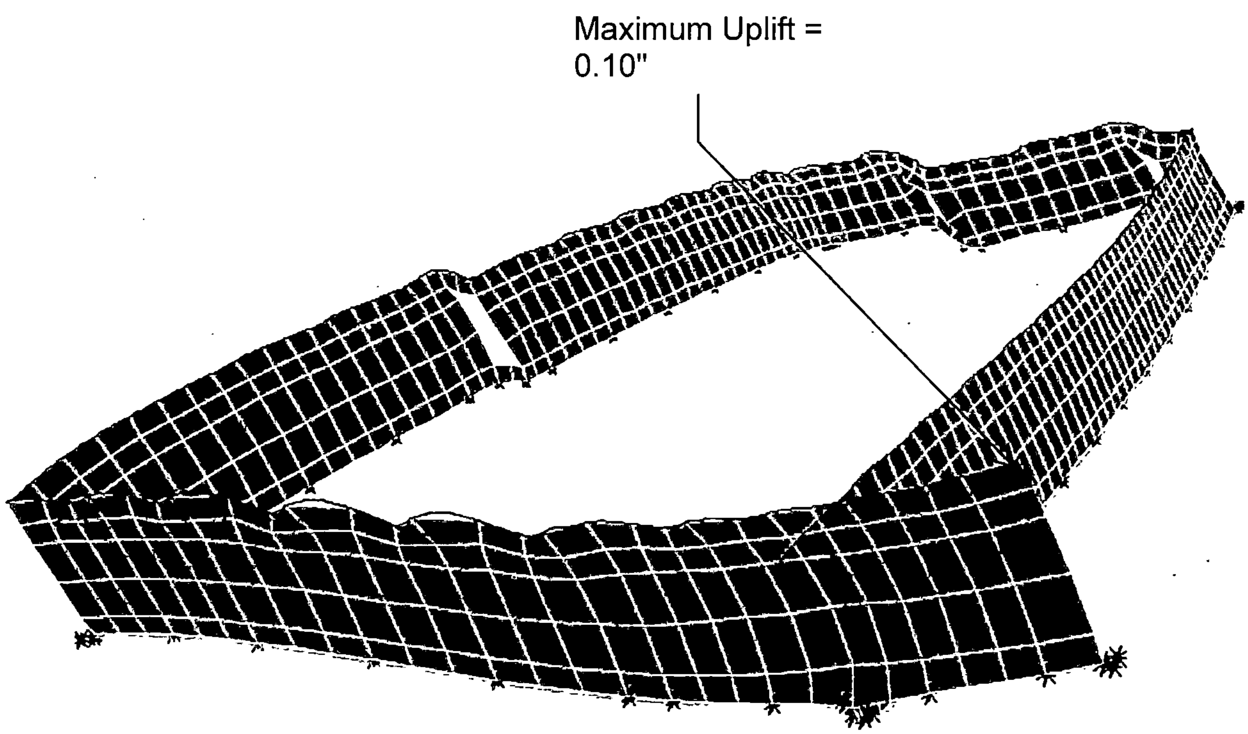

Figure A.2.e-23 Deflected shape under CASE 2: 1.0D+0.25L-EQX+EQY+EQV

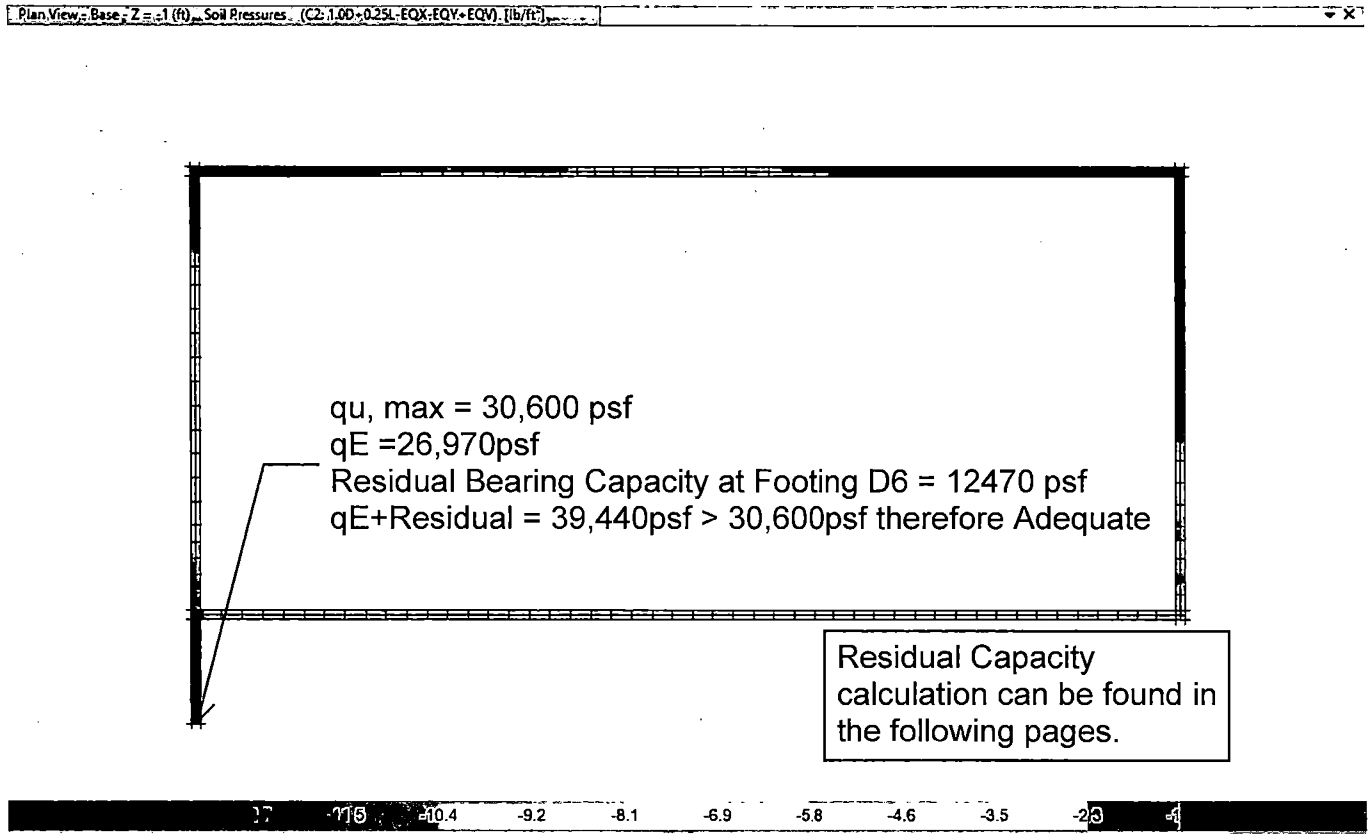

Figure A.2.e-24 Bearing pressures under CASE 2: 1.0D+0.25L-EQX-EQY+EQV (psf)

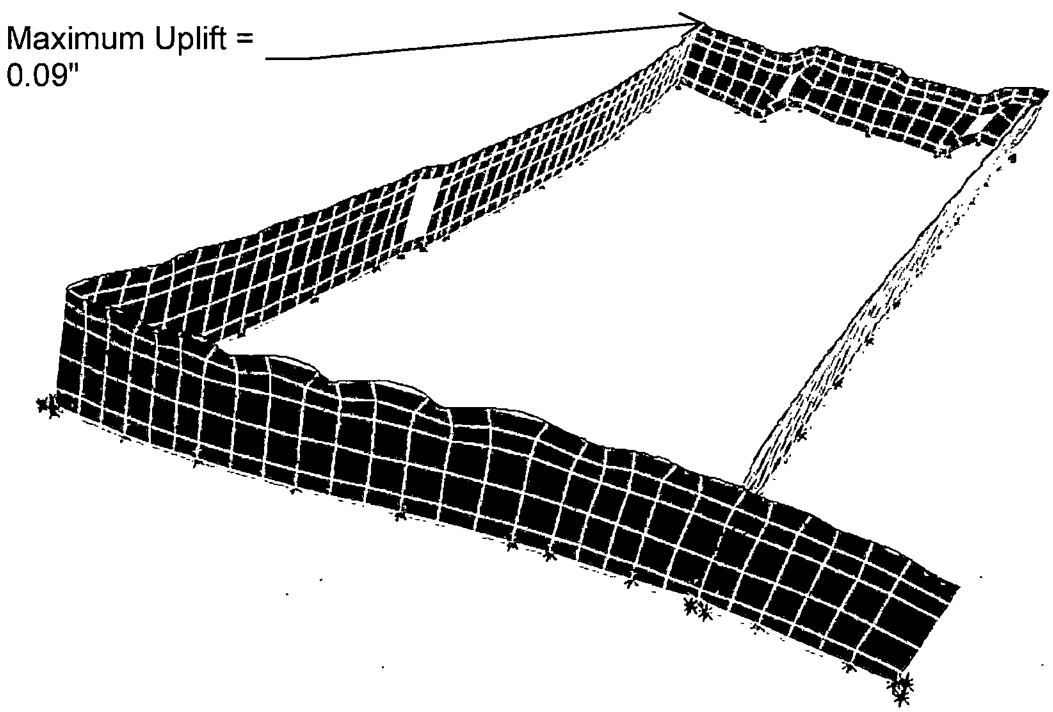

Figure A.2.e-25 Deflected shape under CASE 2: 1.0D+0.25L-EQX-EQY+EQV

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Calculation of Residual Bearing Capacity at Column/Footing D6:

Per Footing strength calculations, the highest DCR for footing D6 is 0.21 in flexure. The actual bearing to column loading, qu = 3.3 ksf

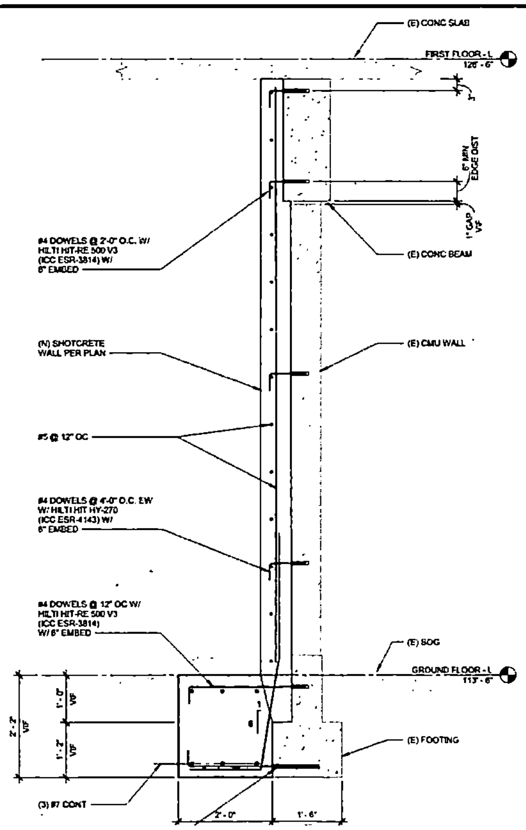
Capacity qn = 3.3ksf/0.21 = 15.77ksi
Residual capacity qr = qn-qu = 15.77ksf-3.3ksf = 12.47ksf

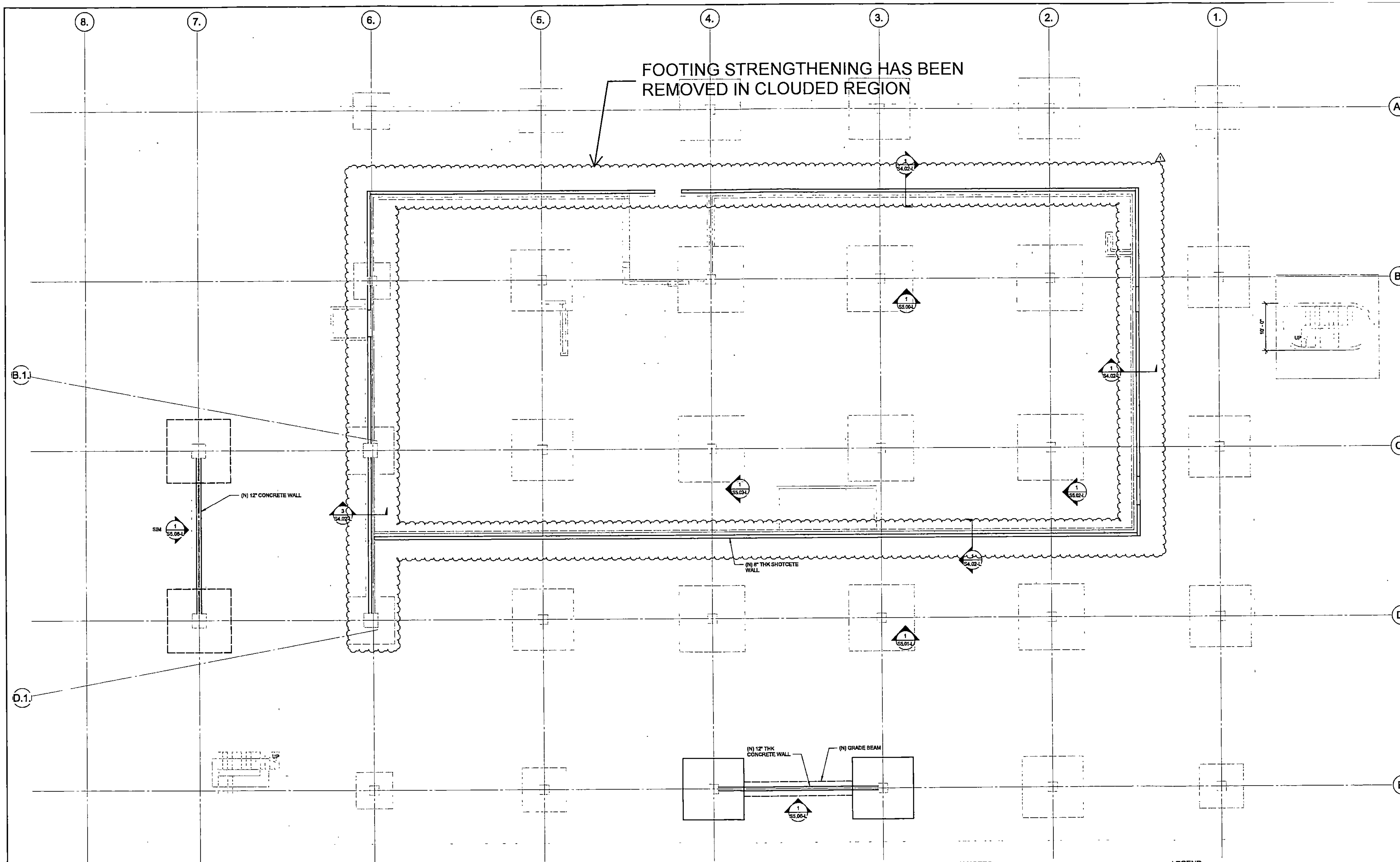
Due to column footing being excluded from the ETABS model the residual bearing capacity will be added to the expected allowable bearing pressure of the continuous footing. That net resultant bearing pressure will be used to check against pressures found in the ETABS model at Grid Intersection D6.
q_E + qr = 26.97+12.47 = 39.44ksf

Maximum Bearing Pressure per ETABS = 30,900psf

DCR = 30.9ksf/39.44ksf = 0.78.

Therefore since bearing pressures are less than the expected ultimate bearing pressure and uplift values are low, the existing continuous wall footing is adequate and extension/strengthening of the existing footing is not needed. Footing strengthening highlighted in blue below is no longer needed and will be removed from future drawing submittals. See updated plan on next page.





1 LIBRARY - GROUND FLOOR FOUNDATION PLAN
SCALE: 1/8" = 1'-0"

PLAN NOTES:

1. SEE SHEET S0.02 FOR GENERAL NOTES.
2. SEE SHEET S2.01 THROUGH S2.08 FOR VISCOUS DAMPER FRAME ELEVATIONS.
3. SEE ARCH DRAWINGS FOR DIMENSIONS NOT SHOWN.
4. CONTRACTOR TO VERIFY ALL EXISTING CONDITIONS, DIMENSIONS AND ELEVATIONS PRIOR TO FABRICATION AND ERECTION AND NOTIFY ARCHITECT OF ANY SIGNIFICANT DISCREPANCIES FROM THAT SHOWN ON THE DRAWINGS.
5. CONTRACTOR TO SHORE ALL EXISTING FRAMING AS REQUIRED FOR DEMOLITION AND REFRAMING WORK.

LEGEND:

XXX'-XXX"	INDICATES TOP OF (E) CONCRETE SLAB ELEVATION.
(E)	INDICATES EXISTING.
	INDICATES EXISTING STRUCTURE.
(N)	INDICATES NEW.
	INDICATES NEW CONSTRUCTION.
	INDICATES PORTION OF BUILDING TO BE DEMOLISHED.
STEEL CONNECTOR PLATE BELOW BEAM	INDICATES DAMPER ASSEMBLY ABOVE FLOOR LEVEL PER ELEVATIONS S5.00 THRU S5.01.
	INDICATES DAMPER ASSEMBLY BELOW FLOOR LEVEL PER ELEVATIONS S5.00 THRU S5.01.
#	INDICATES U-WRAP FRP OF BEAM PER DETAIL 1/S6.01 OR 2/S6.01 # INDICATES NUMBER OF FRP LAYERS
	INDICATES FRP STRENGTHENING BELOW THE SLAB.

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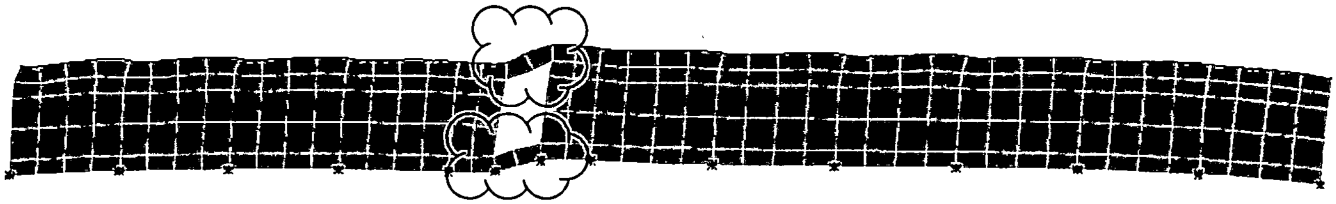
LIBRARY - FOUNDATION PLAN

Drawn By:	Author
Designed By:	Designer
Project No:	2000382
Date:	11/15/2021
Scale:	As Indicated

Drawing No:

S2.00-L

Coupling Beams



Coupling beams will be detailed in a ductile manner to allow ductile behavior under an event that causes uplift in the shotcrete wall foundations.

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A.3 - Evaluation of Diaphragms

Executive Summary

The following sections include the assessment of the diaphragms at all levels. Diaphragms are checked for bending, shear, and transfer loads at the interfaces with the lateral system. Per the calculations in the following sections. The existing diaphragms are adequate to transfer all inertial loads.

A.3.a - Diaphragm Bending and Shear

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	location Inglewood, CA	date 10/19/21	
	client	job no. 2000362	
	Diaphragm Bending and Shear		

Executive Summary

The following section includes general calculations of diaphragm bending and shear under the diaphragm accelerations taken from the analysis. The diaphragm accelerations were determined as the peak average acceleration at the BSE-2E hazard level using Upper Bound damper properties. Per the following calculations the diaphragm is adequate in bending, shear, and the slab reinforcement is adequate to transfer inertial forces into the lateral system.

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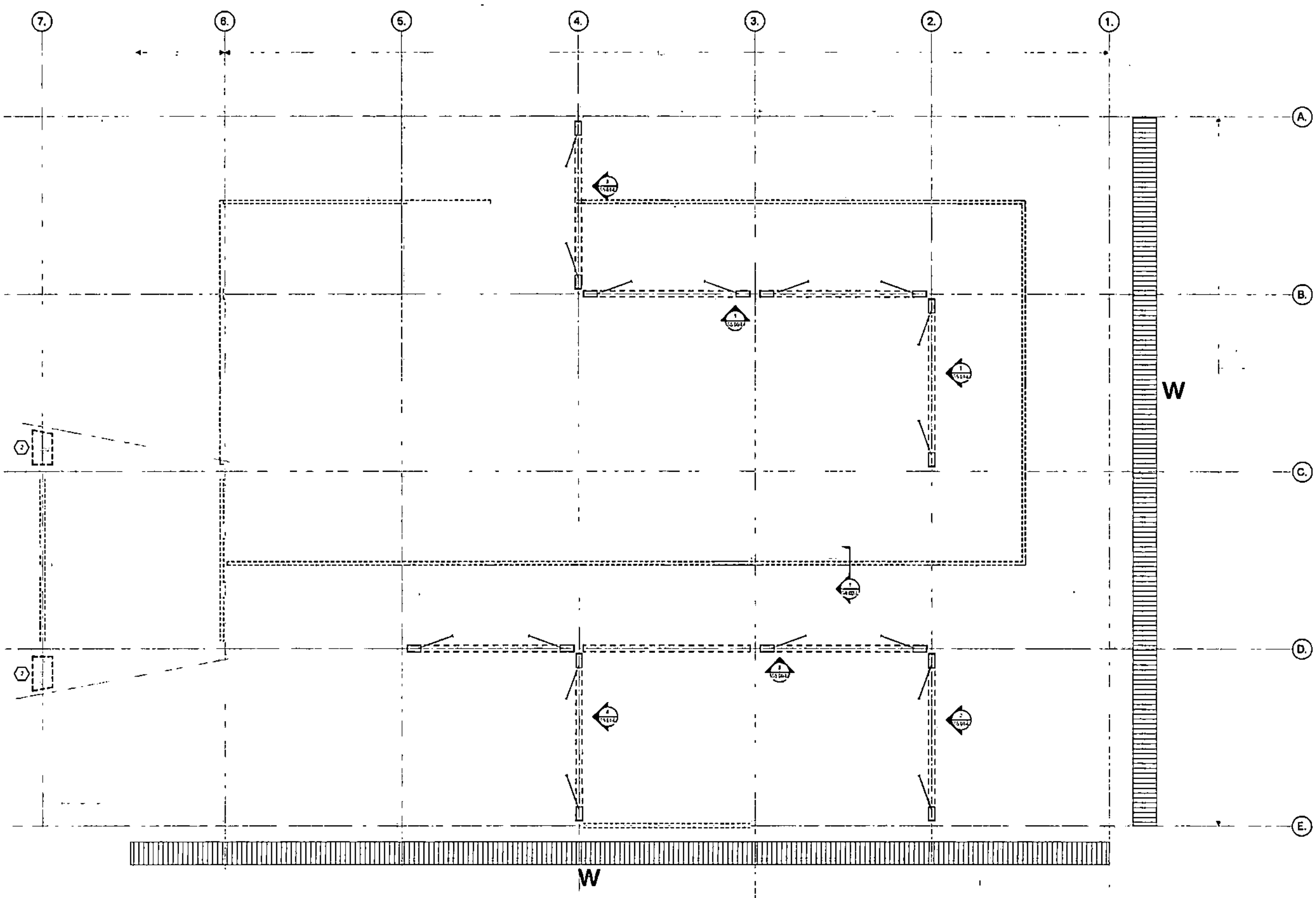
	location Inglewood, CA	date 10/4/21	
	client	job no. 2000362	
	Diaphragm Checks		

Story 1 Global Diaphragm Checks:



Story 1 Forces:

Total Story Mass = 5839.71k

X Dir:
Diaphragm Acceleration, a_x = 0.61g
L = 144'
D = 198'
Total V = 5839.71k*0.61g = 3562.22k
w = 3211.84k/144' = 22.3klf

Y Dir:
a_y = 0.55g
L = 198'
D = 144'
Total V = 5839.71k*0.55g = 3211.84k
w = 3562.22k/198' = 17.99klf

Diaphragm accelerations are peak average diaphragm acceleration from the PERFORM model.

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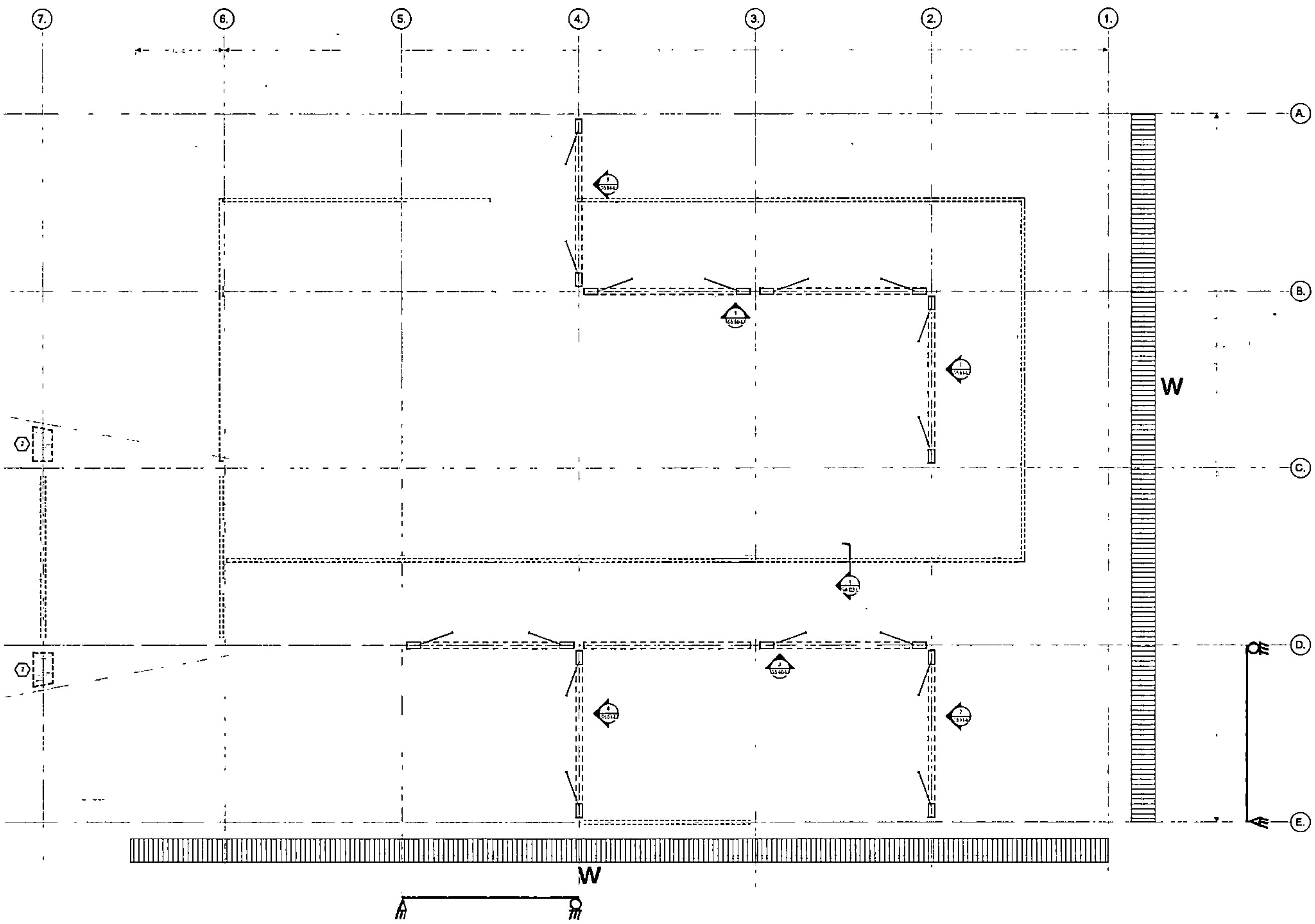
	location Inglewood, CA	date 10/4/21	
	client	job no. 2000362	
	Diaphragm Checks		

Story 1 Global Diaphragm Checks:



Conservatively assume simply supported between frames lines and check worst case diaphragm depth.

span Length, L = 36'

Vu = wL/2 = (22.3klf)*36'/2 = 401.4 k

Mu = $wL^2/8$ = (22.3klf)*(36^2)/8 = 3612.6 k-ft

Check Shear Capacity:

Conservatively assume only concrete resists shear

slab depth, t = 5"
diaphragm depth, h = 144'

Vn = 2λ√f'c * Acv
Acv = 144'*12*5" = 8640 in^2
$f'c_{LB}$ = 5042 psi

Check Shear Capacity Continued:

$\lambda = 0.75$

$Vn = 2*0.75*\sqrt{(5042psi)} * 8640\ in^2/1000 = 920.25k$

$DCR = 401.4k/920.25k = 0.44$

Therefore diaphragm is adequate in Shear.

Check Flexure Capacity:

Conservatively assume flexure will be resisted by concrete only. The capacity will be taken as the cracking moment of the concrete.

$f_{cr} = \lambda*7.5*\sqrt{f'c}$
$\lambda = 0.75$
$fcr = 0.75*7.5*\sqrt{(5042psi)} = 399.41psi$

$I_g = (1/12)bh^3$
$b = 5"$
$h = 144'$
$I_g = (1/12)(5"/12)(144^3) = 103,680\ ft^4$

$y_t = h/2 = 144'/2 = 72'$

$M_{cr} = f_{cr}*I_g / y_t = (399.41psi/1000*144)*103680ft^4/(72')$
$M_{cr} = 82,822.6\ k\text{-}ft$

$DCR = 3612.6k\text{-}ft/82,822.6k\text{-}ft = 0.04$

Therefore diaphragm is adequate in Flexure.

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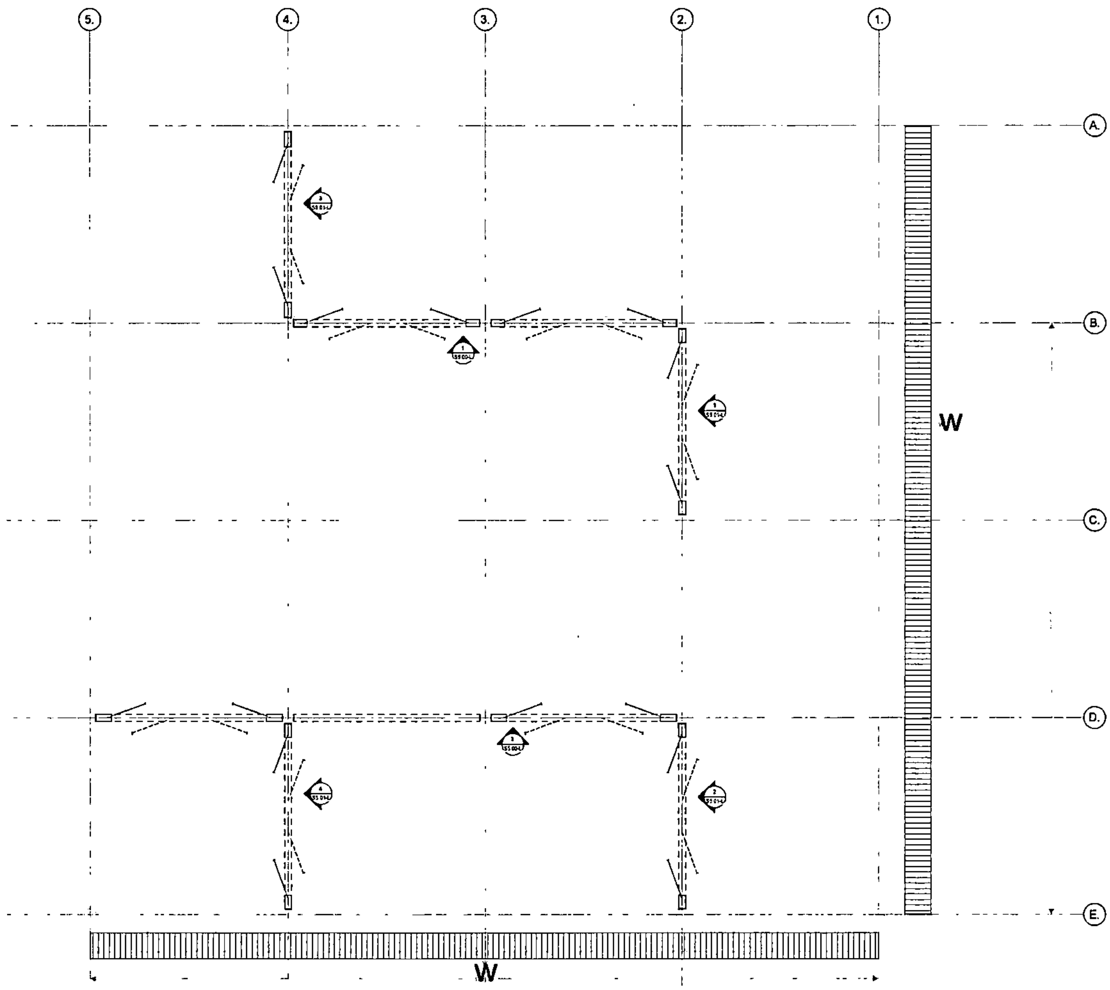
	location Inglewood, CA	date 10/4/21	
	client	job no. 2000362	
	Diaphragm Checks		

Story 2, 3, and 4 Global Diaphragm Checks:



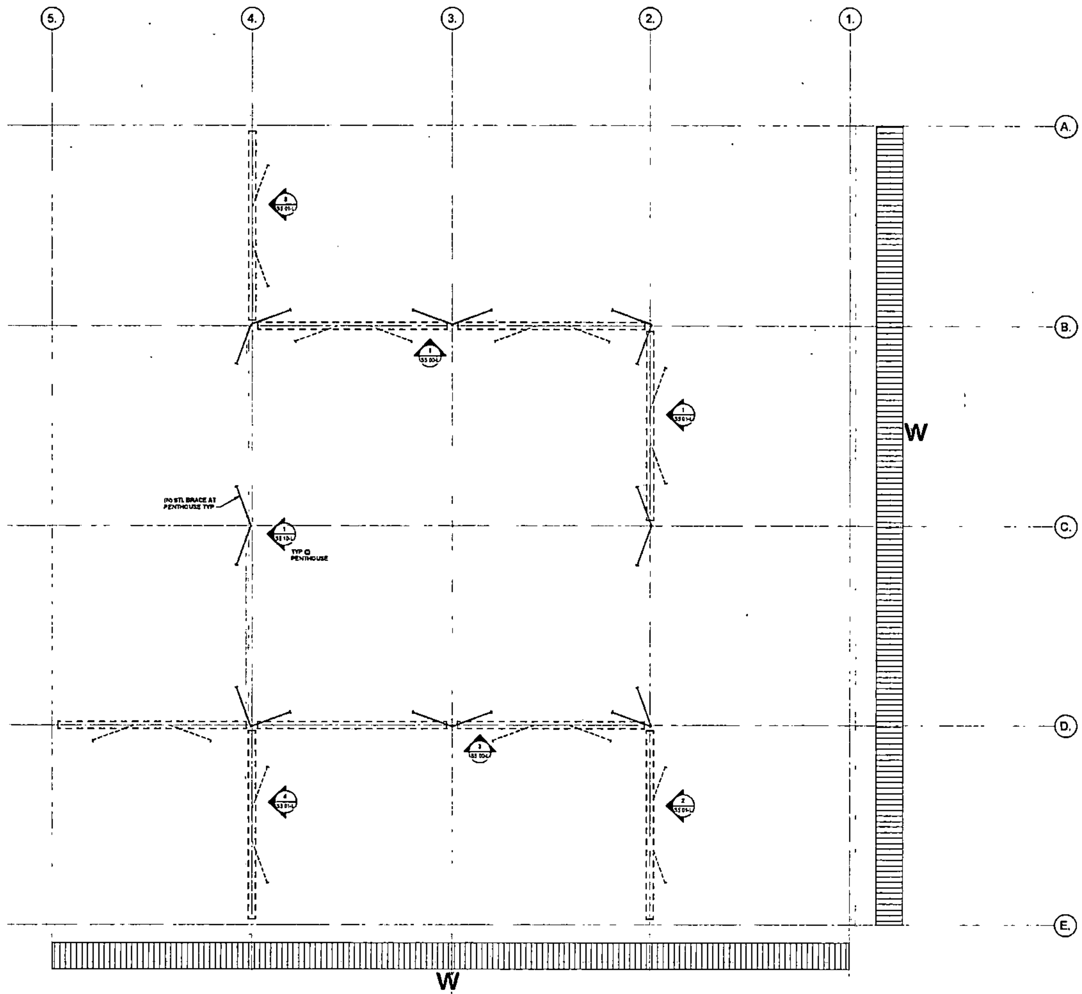
Story 2/3 Forces:
Total Story Mass = 3525.57k

X Dir:
Diaphragm Acceleration, a_x = 0.49g
L = 144'
D = 108' (worst case)
Total V = 3525.57k*0.49g = 1727.53k
w = 1727.53k/144' = 12.0klf

Y Dir:
a_y = 0.48g
L = 144'
D = 108' (worst case)
Total V = 3525.57k*0.48g = 1692.27k
w = 1692.27k/144' = 11.75klf

Diaphragm accelerations are peak average diaphragm acceleration from the PERFORM model.

Story 2, 3, and 4 Global Diaphragm Checks:



Story 4 Forces:
Total Story Mass = 4223.2k

X Dir:
Diaphragm Acceleration, a_x = 0.46g
L = 144'
D = 108' (worst case)
Total V = 4223.2k*0.46g = 1942.67k
w = 1942.67k/144' = 13.49klf

Y Dir:
a_y = 0.38g
L = 144'
D = 108' (worst case)
Total V = 4223.2k*0.38g = 1604.82k
w = 1604.82k/144' = 11.14klf

Diaphragm accelerations are peak average diaphragm acceleration from the PERFORM model.

Story 2, 3, and 4 Global Diaphragm Checks:

Conservatively assume simply supported between frames lines and check worst case diaphragm depth for worst case diaphragm forces.

span Length, L = 36'

Vu = wL/2 = (13.49klf)*36'/2 = 242.8 k

Mu = $wL^2/8$ = (13.49klf)*(36^2)/8 = 3496.6 k-ft

Check Shear Capacity:

Conservatively assume only concrete resists shear.

slab depth, t = 5"
diaphragm depth, h = 108'

Vn = 2λ√f'c * Acv
Acv = 108'*12*5" = 6480 in^2
$f'c_{LB}$ = 5042 psi

λ = 0.75

Vn = 2*0.75*√(5042psi) * 6480 in^2 /1000 = 690.2k

DCR = 242.8k/690.2k = 0.35

$\boxed{\text{Therefore diaphragm is adequate in Shear.}}$

Check Flexure Capacity:

Conservatively assume flexure will be resisted by concrete only. The capacity will be taken as the cracking moment of the concrete.

f_{cr} = λ*7.5*√f'c
λ = 0.75
fcr = 0.75*7.5*√(5042psi) = 399.41psi

$I_g = (1/12)bh^3$
b = 5"
h = 108'
I_g = (1/12)(5"/12)(108^3) = 43,740 ft^4

y_t = h/2 = 108'/2 = 54'

$M_{cr} = f_{cr}*I_g / y_t$ = (399.41psi/1000*144)*43740ft^4/(54')
M_{cr} = 46,587.7 k-ft

Check Flexure Capacity Continued:

DCR = 3496.6k-ft/46,587.7k-ft = 0.08

Therefore diaphragm is adequate in Flexure.

Check Shear Transfer @ Typical Frame Line:

Similar to Diaphragm shear and flexure checks assume diaphragm is simply supported between frame lines.

Use worst case shear demand at any floor with worth case diaphragm depth at any level.
vu = 401.4k/108' = 3.72 k/ft

Assume worst case slab top bar at any span: #4's @10" OC per S-2 slab type in As built drawings by Johnson & Nielson Associates dated 1/29/71.

ρ = .2/(5"*10") = 0.004, within 10% of Mattocks equation limits for LWC per BOD section 5.2.4.

Shear Friction Capacity:

$vn = 0.8*A_{vf}*fy_{LB}+A_c*K_1$
$A_{vf} = 0.2in^2(12/10) = 0.24in^2/ft$
$fy_{LB} = 65ksi$
$A_c = (5")(12") = 60in^2$
$K_1 = 200psi$

$vn = (0.8*0.24in^2*65{,}000psi + 60in^2*200psi)/1000 = 24.5k/ft$

$DCR_{Shear} = 3.72/24.5 = 0.15$

Check Gravity Usage of Slab Rebar:

Conservatively assume one-way slab force distribution and a 7-span condition.

1.0D+0.25L: 83.3psf (1st floor)+0.25*90psf(weighted average live load) = 105.8psf

typical slab span = 18'

Negative Moment at a 2-span condition = $0.106wl^2$
Assume a 1' strip

$Mu = 0.106*(105.8plf)*(18^2) = 43.6$ k-in

Check Shear Transfer @ Typical Frame Line Continued:

Check Gravity Usage of Slab Rebar:

Capacity:

h = 5"
clear cover = 0.75"

d = 5" - 0.75" - (0.5"/2) = 4"
As = 0.24in^2

a = As*fy/(0.85*f'c*b) = (0.24in^2*73ksi)/(0.85*5.436ksi*12")
a = 0.316 in

Mn = As*fy*(d-a/2) = 0.24in^2 * 73ksi * (4" - 0.316"/2)
Mn = 67.31 k-in

$DCR_{Gravity}$ = 43.6/67.31 = 0.65

Total DCR = DCR_{Shear} + $DCR_{Gravity}$ = 0.15+0.65 = 0.8.

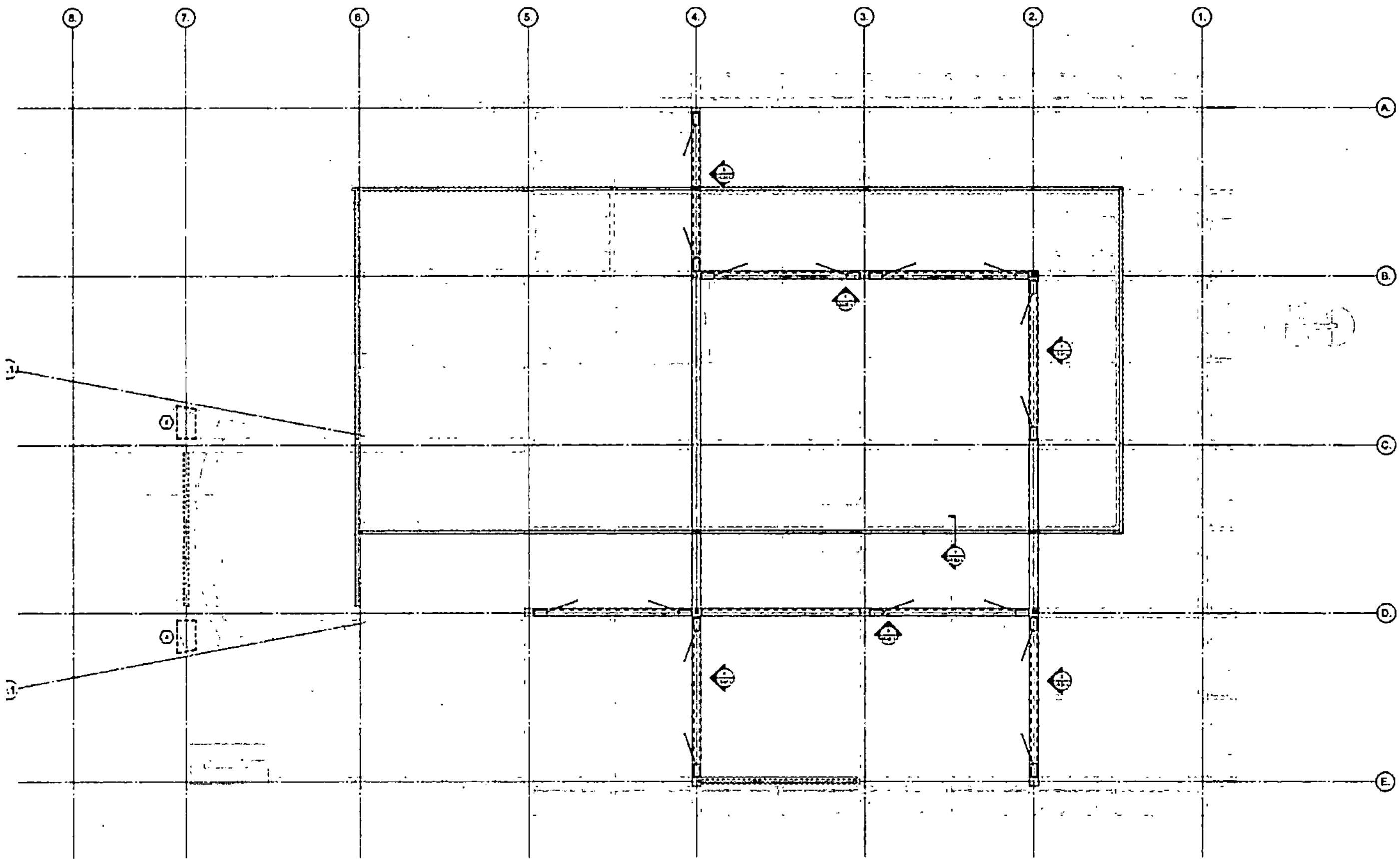
Therefore shear transfer at the typical frame is adequate.

A.3.b - Evaluation of Transfer Conditions at First Floor

Executive Summary

The following section includes calculations of force transfer at the 1st floor diaphragm where there are various vertical discontinuous lateral system transfers, and shear friction checks at all of the new shear walls to ensure inertial forces can transfer into the new walls. The diaphragm accelerations were determined as the peak average acceleration at the BSE-2E hazard level using Upper Bound damper properties. Damper reactions and wall shears were taken from section cuts in the PERFORM-3D model. Per the following calculations the diaphragm is adequate in bending, shear, and the slab reinforcement is adequate to transfer inertial forces into the lateral system.

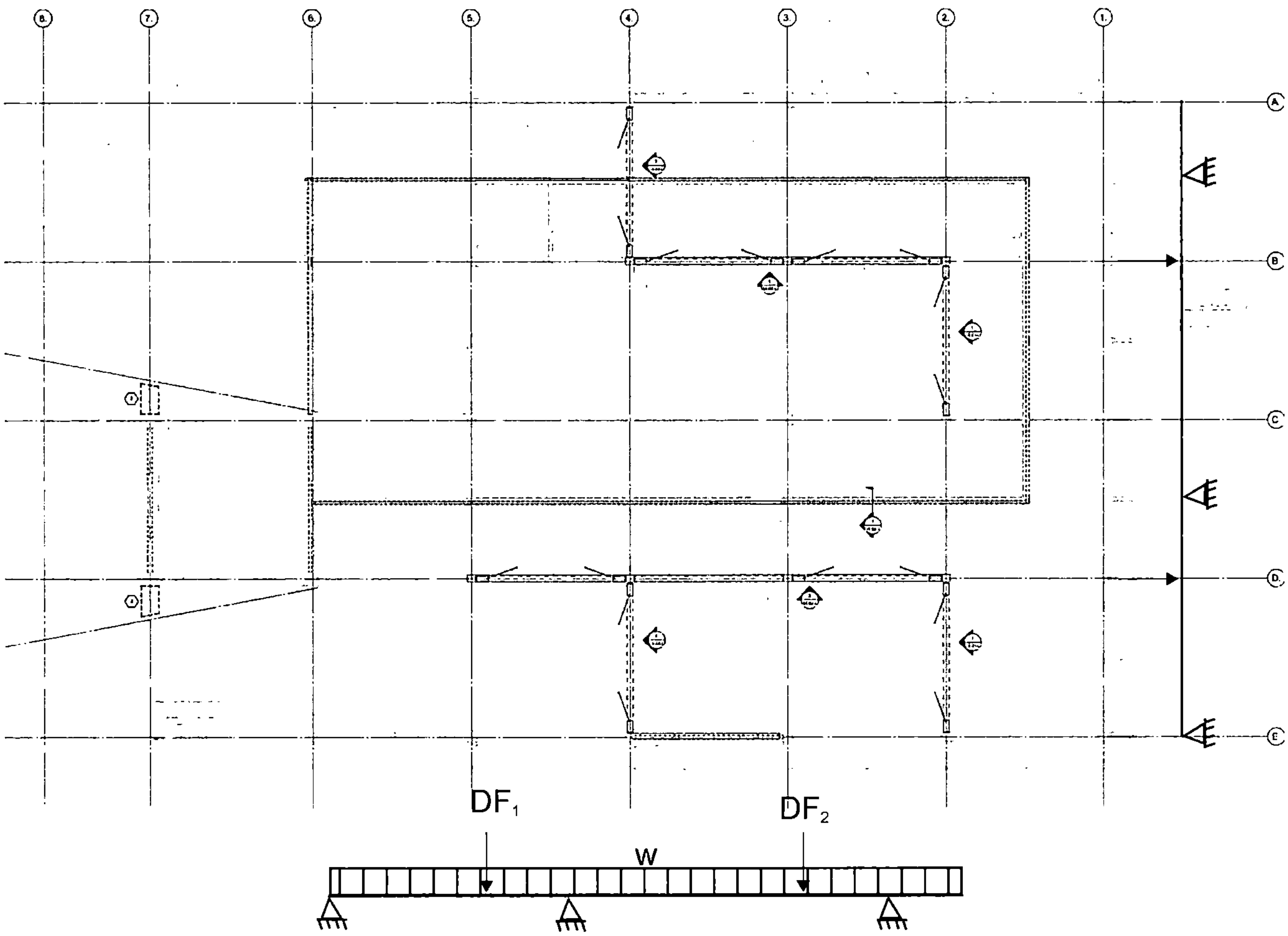
Story 1 Diaphragm Transfer Checks:



At the 1st floor of the Library building multiple transfer conditions exist from the damper lines to the shotcrete wall core below. The damper frame lines are shown in red in the figure above, and the walls receiving the transfer forces from the frames above are shown in green.

The diaphragm transfer force will be taken as the average peak horizontal force at the base of the dampers in the direction of interest. These forces at the base of the dampers will then be applied as point loads in a simplified beam model of the diaphragm. The simplified beam model will then be used to check shear and flexure in the diaphragm.

Story 1 Diaphragm Transfer Checks - X Direction Loading:



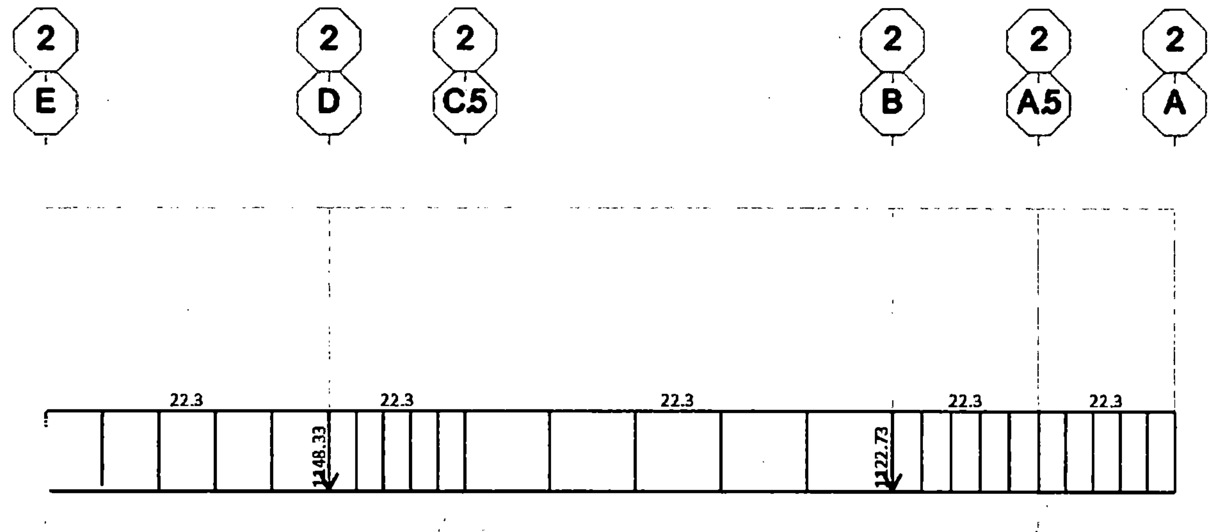
The simple beam model will be modeled in SAP2000 as shown above.

w = diaphragm Fp force per previous diaphragm checks at 1st floor = 22.3klf

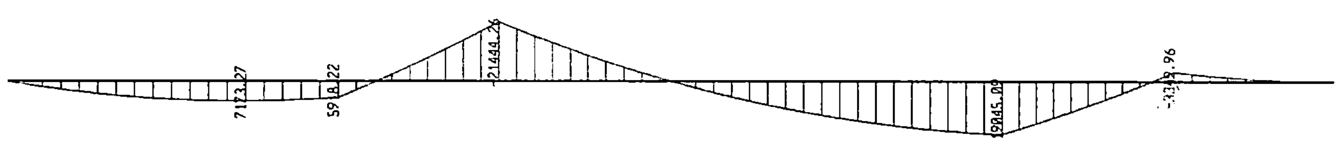
DF_1 = 1148.33k (shear at the bottom of dampers on Grid D)

DF_2 = 1122.73k (shear at the bottom of dampers on Grid B)

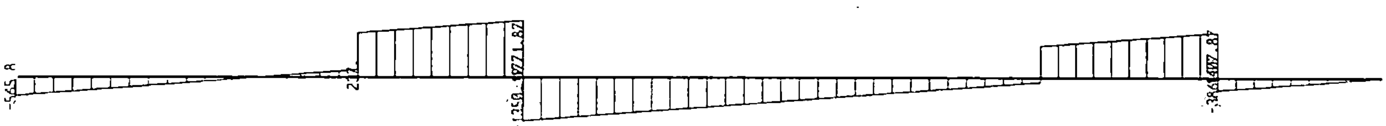
Story 1 Diaphragm Transfer Checks - X Direction Loading:



Overview of SAP2000 Model



Moment Diagram, Mu = 21,444.3 k-ft



Shear Diagram, Vu = 1771.9k

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Check Flexure Capacity:

Conservatively assume flexure will be resisted by concrete only. The capacity will be taken as the cracking moment of the concrete.

$f_{cr} = \lambda*7.5*\sqrt{f'c}$
$\lambda = 0.75$
$fcr = 0.75*7.5*\sqrt{}(5042psi) = 399.41psi$

$I_g = (1/12)bh^3$
$b = 5"$
h = 180' (Conservatively depth from Grid 6 to Grid 1)
$I_g = (1/12)(5"/12)(180^3) = 202{,}500\ ft^4$

$y_t = h/2 = 180'/2 = 90'$

$M_{cr} = f_{cr}*I_g / y_t = (399.41psi/1000*144)*202500ft^4/(90')$
$M_{cr} = 129{,}408.8$ k-ft

DCR = 21444.3k-ft/129,408.8k-ft = 0.17

Therefore diaphragm is adequate in Flexure.

Check Shear Capacity:

Conservatively assume only concrete resists shear

slab depth, t = 5"
diaphragm depth, h = 180'

$Vc = 2\lambda\sqrt{f'c} * Acv$
$Acv = 180'*12*5" = 10800\ in^2$
$f'c_{LB} = 5042$ psi
$\lambda = 0.75$

$Vc = 2*0.75*\sqrt{}(5042psi) * 10800\ in^2 /1000 = 1150.31k$

DCR = 401.4k/920.25k = 0.44

Check Gravity Usage of Slab Rebar:

Conservatively assume one-way slab force distribution and a 7-span condition for typical bay.

1.0D+0.25L: 83.3psf (1st floor)+0.25*90psf(weighted average live load) = 105.8psf

typical slab span = 18'

Check Gravity Usage of Slab Rebar:

Positive Moment at a 7-span condition = 0.078wl2
Assume a 1' strip

$Mu = 0.078*(105.8plf)*(18^2) = 32.09$ k-in

Capacity:

h = 5"
clear cover = 0.75"

d = 5" - 0.75" - (0.5"/2) = 4"
$As = 0.2in^2$ (12/14) = 0.171in2/ft (#4's @14"OC distributed over a 1' strip)

$a = As*fy/(0.85*f'c*b) = (0.171in^2*73ksi)/(0.85*5.436ksi*12")$
a = 0.225 in

$Mn = As*fy*(d-a/2) = 0.171in^2 * 73ksi * (4" - 0.225"/2)$
Mn = 48.53 k-in

$DCR_{Gravity} = 32.09/48.53 = 0.66$

34% of rebar capacity can be used for diagonal shear.

Rebar Shear Capacity:

Vs = Acv*ρ*fy

$\rho = 0.2\ in^2/(5*14)*0.34 = 0.000971$

fy = 65ksi

$Vs = 10800in^2 * 0.000971 * 65ksi = 681.9k$

Total Shear Capacity:

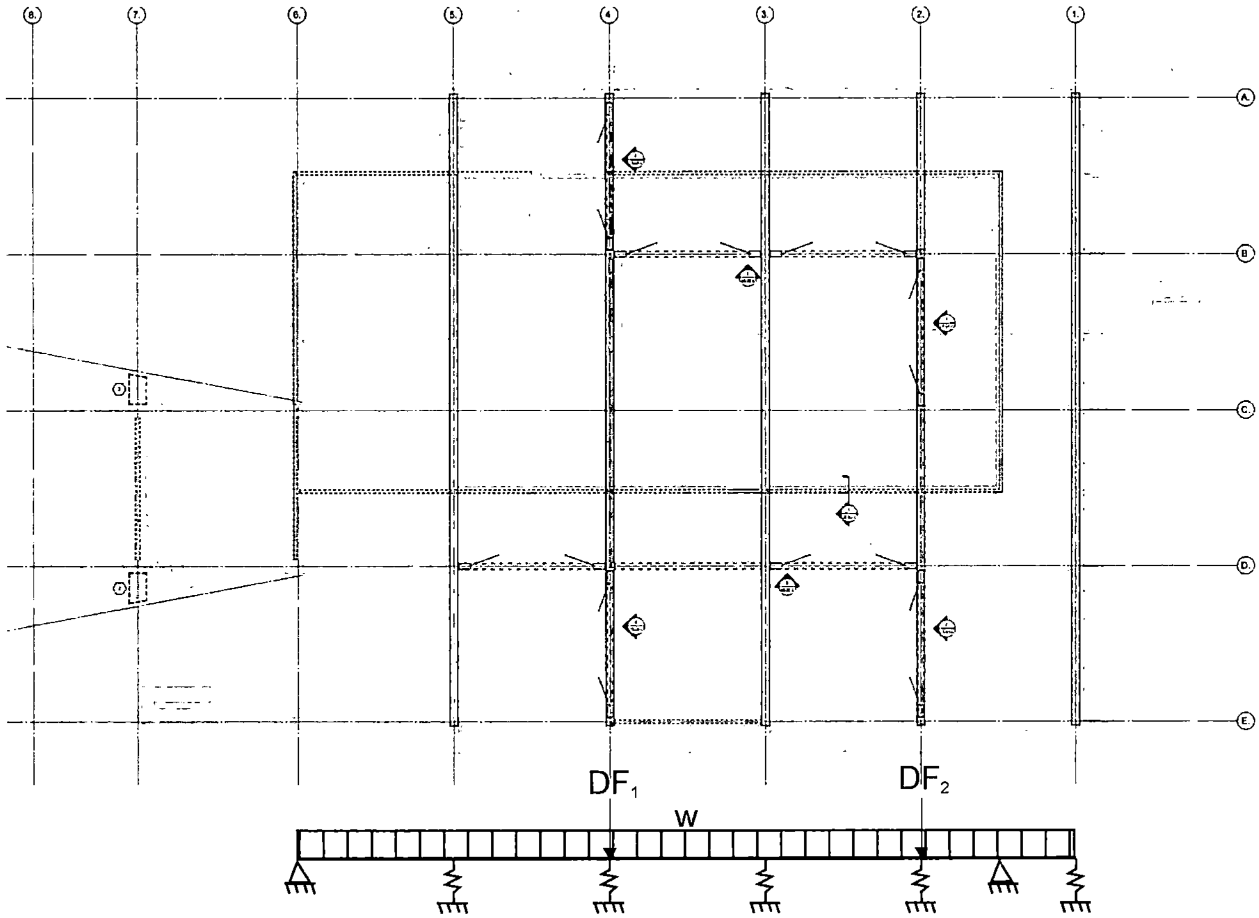
Vn = Vc + Vs = 1150.3k + 681.9k = 1832.2k

DCR = 1771.9k/1832.2k = 0.97

$\boxed{\text{Therefore diaphragm is adequate in Shear.}}$

kpff 700 South Flower Street, Suite 2100 Los Angeles, CA 90017 (213) 418-0201	project City of Inglewood - Library	by JL	sheet no. A.3.b-8
	location Inglewood, CA	date 10/4/21	
	client	job no. 2000362	
	Diaphragm Checks		

Story 1 Diaphragm Transfer Checks - Y Direction Loading:



A refined beam model will be modeled in SAP2000 as shown above. Springs represent the stiffness of the flexible moment frames below. Stiffness of the moment frames were obtained using a 1 story, 4 bay, 2D Frame of the typical ground floor columns and beams.

w = diaphragm Fp force per previous diaphragm checks at 1st floor = 17.99klf

DF_1 = 1020.41k (shear at the bottom of dampers on Grid 4)

DF_2 = 1054.96k (shear at the bottom of dampers on Grid 2)

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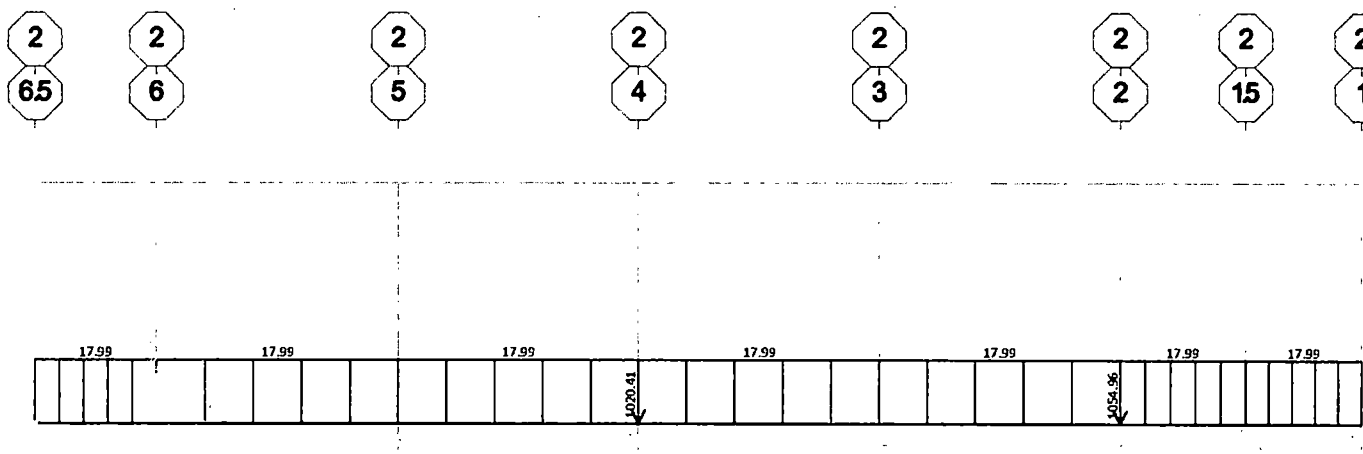
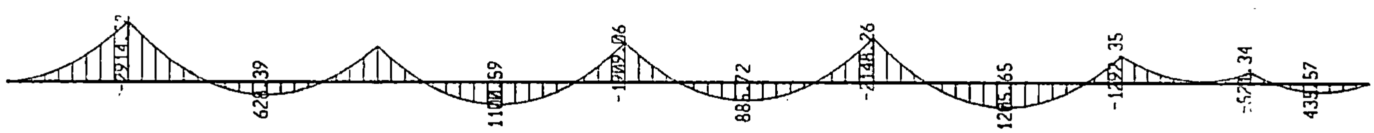
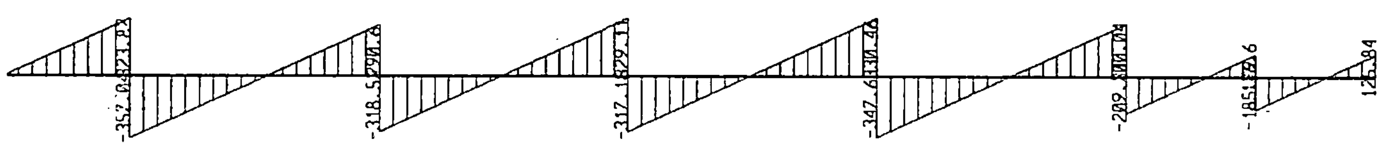
Story 1 Diaphragm Transfer Checks - Y Direction Loading:



Overview of SAP2000 Model



Moment Diagram, Mu = 2,914.4 k-ft



Shear Diagram, Vu = 357.04k

Per previous calculations of a 144' deep diaphragm, diaphragm is adequate in flexure and she

Wall Shear Transfer Checks:

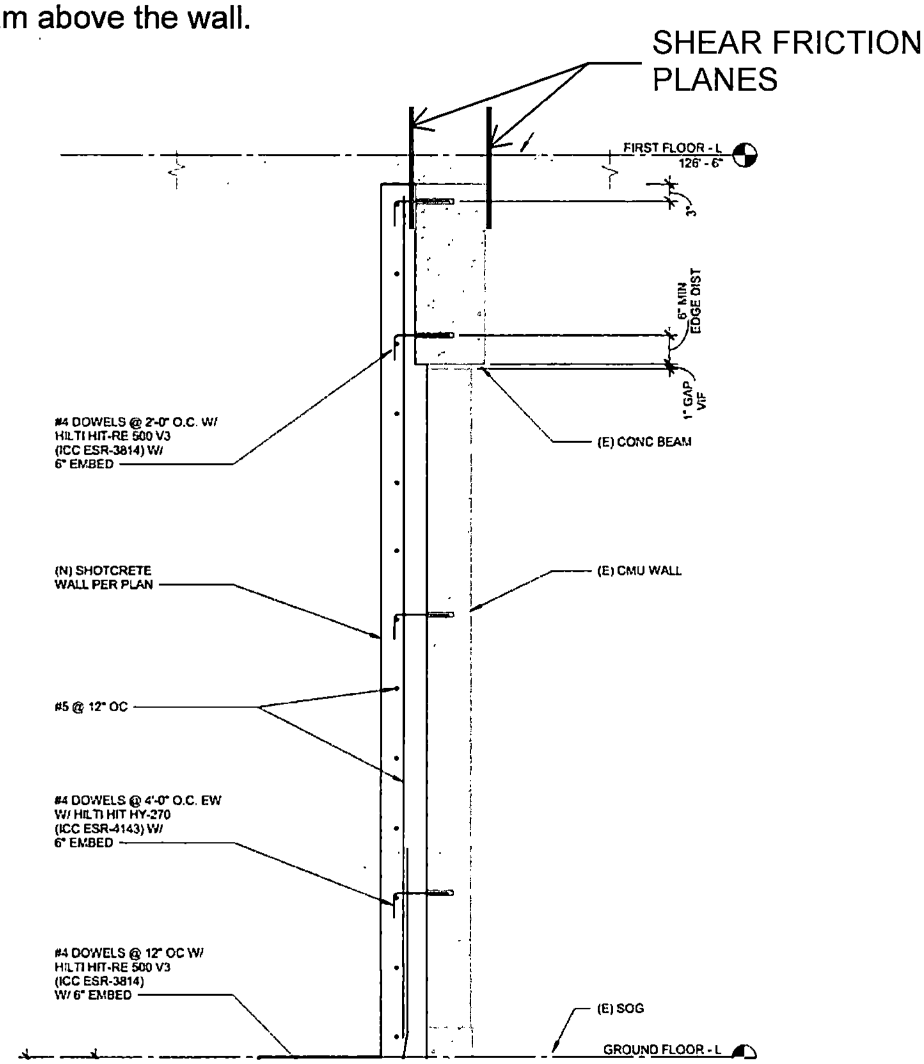
Shotcrete walls:

Total Shear in each Pier:

PA.5: Vu = 3833.86k; L = 162.6667'; vu = 3833.86k/162.667' = 23.6 klf
P1.5: Vu = 2005.2k; L = 73.333'; vu = 2005.2k/73.333' = 27.3 klf
PC.5: Vu = 3491.65k; L = 161.6667'; vu = 3491.65k/161.667' = 21.6 klf
P6: Vu = 2552.18k; L = 90.667'; vu = 2552.18k/90.667' = 28.1 klf

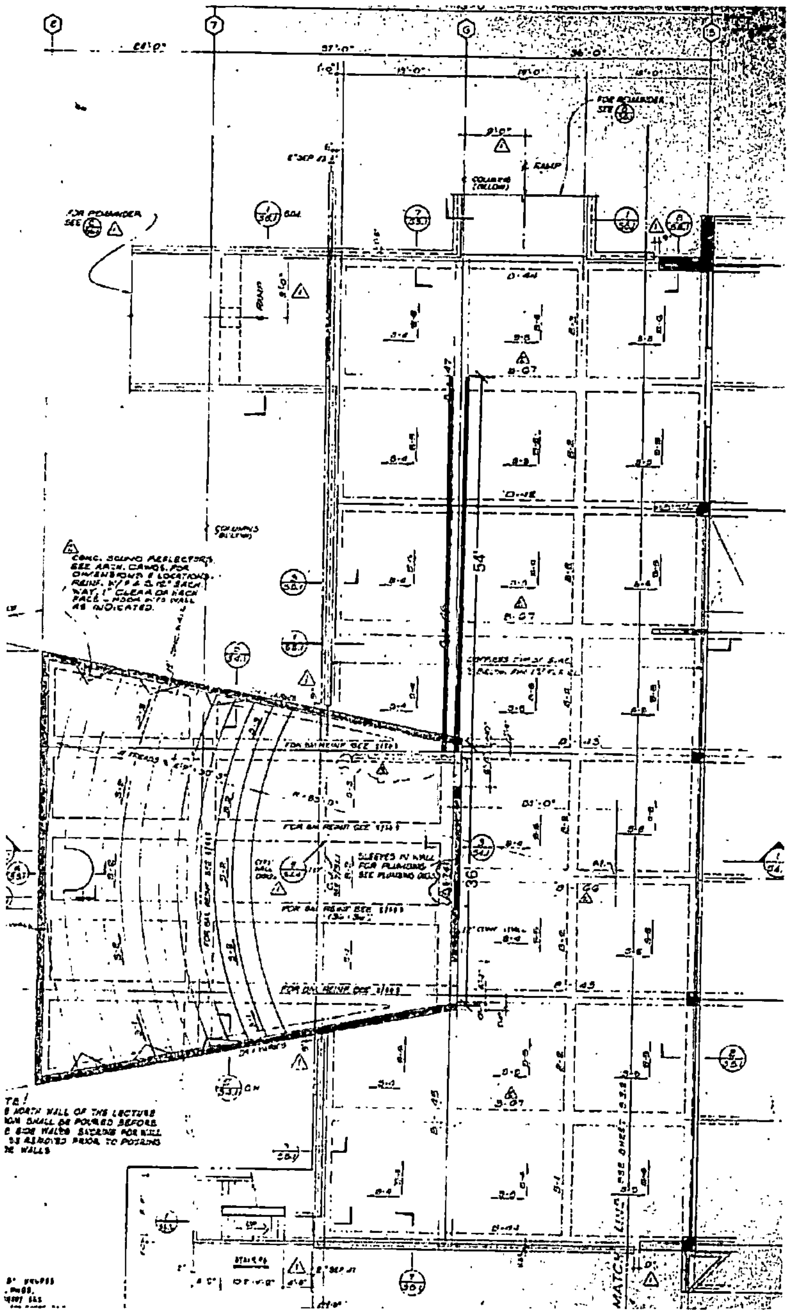
All shear forces are the peak average shear force from the PERFORM-3D model. All forces are taken from a section cut at the bottom of the wall.

All shotcrete walls are an interior condition where there are two planes of shear friction, one on either side of the beam above the wall.



Wall Shear Transfer Checks:

Shear Friction @ Pier P6 (Along Grid 6):



Along Grid 6 there are two types of dowels that are used to resist shear friction at the beam above the new shotcrete wall. The region highlighted in purple with a length of 54' uses the worst case top bar between slab type S-4 and S-5 that crosses over the beam along Grid 6, #5's @9" OC per type S-4. The capacity of the dowels in the purple region will be reduced to account for gravity loading. The second region highlighted in green with a length of 36' uses the temperature reinforcement for one way slabs. Per 1/S4.3 of as-builts temperature reinforcement is #4's @12" OC and will be fully used to resist shear friction.

Wall Shear Transfer Checks:

Shear Friction @ Pier P6 (Along Grid 6):

Check Gravity Usage of purple dowels:

Conservatively assume one-way slab force distribution and a 7-span condition.

1.0D+0.25L: 83.3psf (1st floor)+0.25*90psf(weighted average live load) = 105.8psf

typical slab span = 18'

Negative Moment at a 2-span condition = 0.106wl2
Assume a 1' strip

Mu = 0.106*(105.8plf)*(18^2) = 43.6 k-in

Capacity:

h = 5"
clear cover = 0.75"

d = 5" - 0.75" - (0.625"/2) = 3.9375"
As = 0.31in^2(12/9) = 0.413 in^2/ft

a = As*fy/(0.85*f'c*b) = (0.413in^2*73ksi)/(0.85*5.436ksi*12")
a = 0.544 in

Mn = As*fy*(d-a/2) = 0.413in^2 * 73ksi * (3.9375" - 0.544"/2)
Mn = 110.51 k-in

$DCR_{Gravity}$ = 43.6/110.51 = 0.39

Therefore 61% of capacity remaining to resist shear friction

Shear Friction Capacity of Purple Dowels:
ρ = .31/(5"*9") = 0.00689, within equation limits for Mattocks equation for LWC per BOD section 5.2.4.
vn = 0.8*A_{vf}*fy_{LB}+A_c*K_1
A_{vf} = 0.413in^2/ft
fy_{LB} = 65ksi
A_c = (5")(12") = 60in^2
K_1 = 200psi

vn = 0.61*(0.8*0.413in^2*65,000psi + 60in^2*200psi)/1000 = 20.42k/ft (accounting for gravity reduction)
Vn = 20.42*54' = 1102.7k

Wall Shear Transfer Checks:

Shear Friction @ Pier P6 (Along Grid 6):

Shear Friction Capacity of Green Dowels:
ρ = 0.2/(5"*12") = 0.00333, not within equation limits for Mattocks equation for LWC per BOD section 5.2.4. Therefore use equation 5-2 per BOD
$v_n = \lambda A_{vf} * fy_{LB} \mu$
$\lambda = 0.75$
μ = 1.4 for monolithic
$A_{vf} = 0.2 in^2/ft$
$fy_{LB} = 65ksi$

$vn = 0.75*0.2in^2*65ksi*1.4 = 13.65k/ft$
Vn = 13.65*36' = 491.4k

Total Shear Friction Capacity:
Vn = 491.4k+1102.7k = 1594.1k (1 shear friction plane)

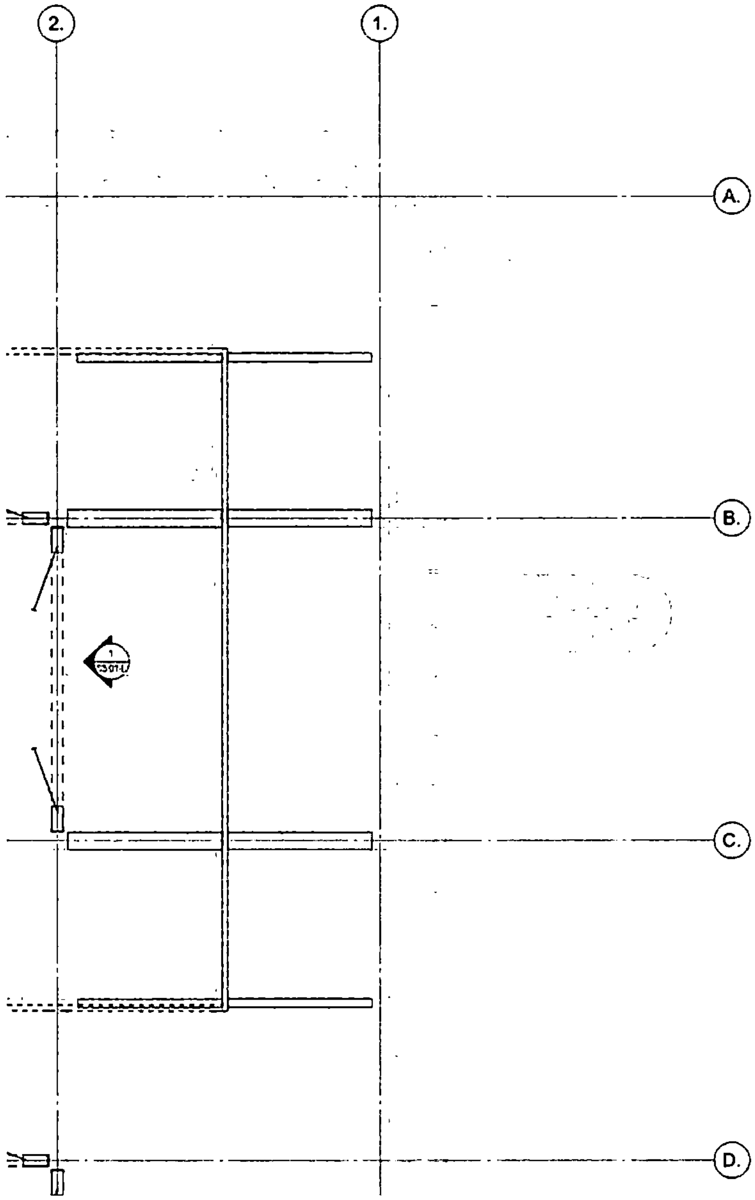
Vu = 2552.18k/2 (2 shear friction planes) = 1276.09k

DCR = 1276.09/1594.1 = 0.8

Therefore existing dowels are adequate for shear friction at wall Pier P6.

Wall Shear Transfer Checks:

Shear Friction @ Pier P1.5 (Between Grids 1 and 2):



Along Pier 1.5, beams shown in blue will be used to supplement shear friction capacity at the beam above. Pier 1.5 is located at the midspan of all beams shown in blue. Each beam is undergoing positive moment only at midspan therefore the full capacity of the Typical (2) #7 top bars at midspan will be used to resist shear friction along with the slab top bars.

Wall Shear Transfer Checks:

Shear Friction @ Pier P1.5 (Between Grids 1 and 2):

Along Pier P1.5 Shear friction dowels are #4's @10" OC top bars per slab type S-2. Per previous shear friction calculations at a typical frame line in section A.3.a, 35% of bar capacity can be used to resist shear friction.

Shear friction capacity per previous calculations is 24.5 k/ft

Accounting for Gravity, vn =24.5k/ft*0.35 = 8.6k/ft

Vu = 2005.2k/2 (2 shear friction planes) = 1002.6 k

Shear Friction Capacity of Beam Top Bars:

(2) # 7's per beam, a total of 5 beams per side
$vn = 0.8*A_{vf}*fy_{LB}+A_c*K_1$
$A_{vf} = 2*0.6in^2 = 1.2in^2/beam$
$fy_{LB} = 65ksi$
$A_c = (5")(12") = 60in^2$
$K_1 = 200psi$

$vn = (0.8*1.2in^2*65{,}000psi + 60in^{2}*200psi)/1000 = 74.4k/beam$
Vn = 74.4k*5 beams = 372k

Vn = 372k+8.6k/ft(73.33') = 1002.7k

DCR = 1002.6/1002.7 = 1.0

Therefore existing dowels are adequate for shear friction at wall Pier P1.5.

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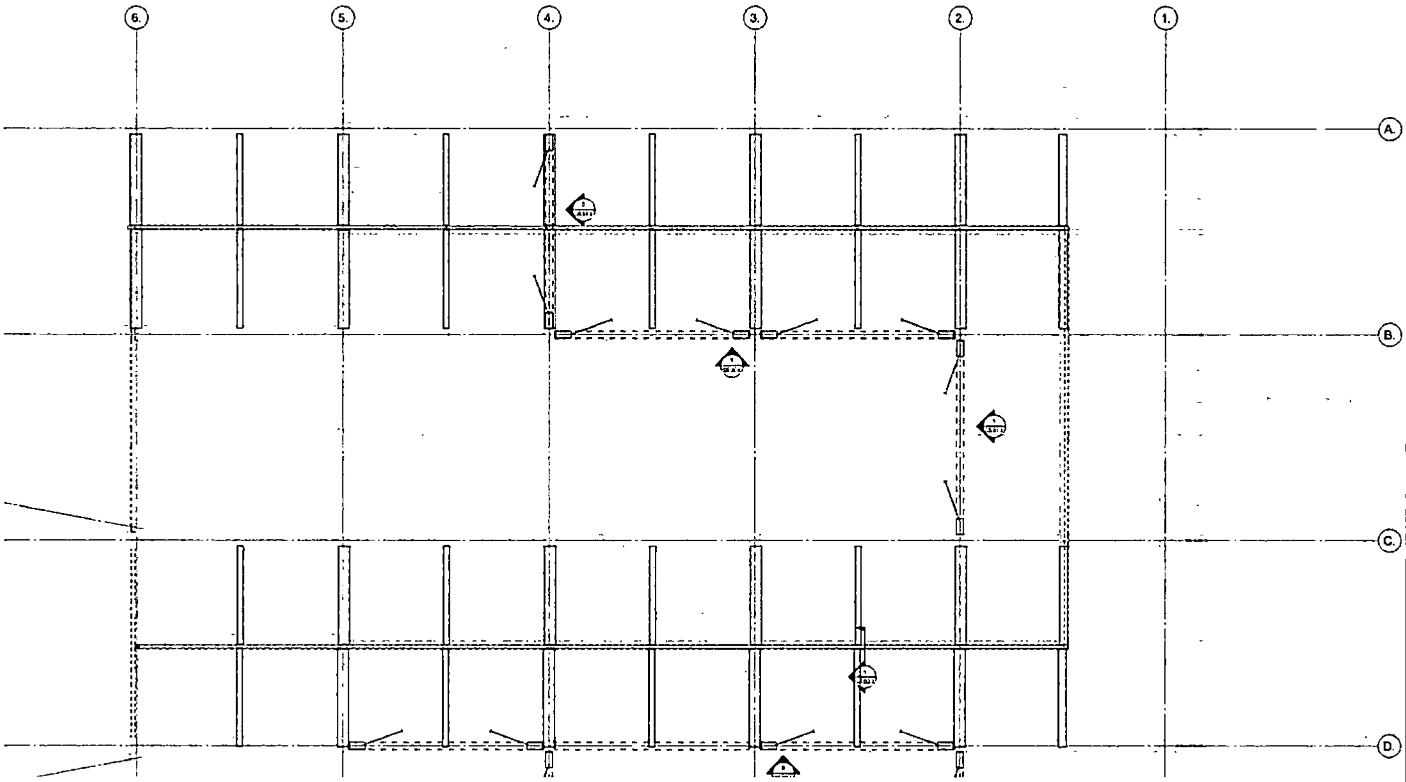
project City of Inglewood - Library	by JL
location Inglewood, CA	date 10/4/21
client	job no. 2000362
Diaphragm Checks	sheet no. A.3.b-16

Wall Shear Transfer Checks:

Shear Friction @ Piers PA.5 and PC.5 (Between Grids A and B, C and D):



Along Piers A.5 and C.5, beams shown in blue will be used to supplement shear friction capacity at the beam above. Piers A.5 and C.5 are located at the midspan of all beams shown in blue. Each beam is undergoing positive moment only at midspan therefore the full capacity of the Typical (2) #7 top bars at midspan will be used to resist shear friction along with the slab top bars.

Wall Shear Transfer Checks:

Shear Friction @ Piers PA.5 and PC.5 (Between Grids A and B, C and D):

Along Piers PA.5 and PC.5 Shear friction dowels are #4's @10" OC top bars per slab type S-2. Per previous shear friction calculations at a typical frame line, 35% of bar capacity can be used to resist shear friction.

Shear friction capacity per previous calculations is 24.5 k/ft

Accounting for Gravity, vn =24.5k/ft*0.35 = 8.6k/ft

Vu = 3833.86k/2 (2 shear friction planes) = 1916.9 k @ PA.5
Vu = 3491.65k/2 (2 shear friction planes) = 1745.8 k @ PC.5

Shear Friction Capacity of Beam Top Bars:

Per previous calculations, Vn = 74.4k/beam

Vn = 74.4k*10 beams+8.6k/ft(162.667') = 2142.9k @ PA.5

DCR = 1916.9/2142.9 = 0.89 @ PA.5

Vn = 74.4*9 beams + 8.6k/ft(161.667') = 2059.9k @ PC.5

DCR = 1745.8k/2059.9k = 0.85

Therefore existing dowels are adequate for shear friction at wall Piers PA.5 and PC.5.

Wall Shear Transfer Checks:

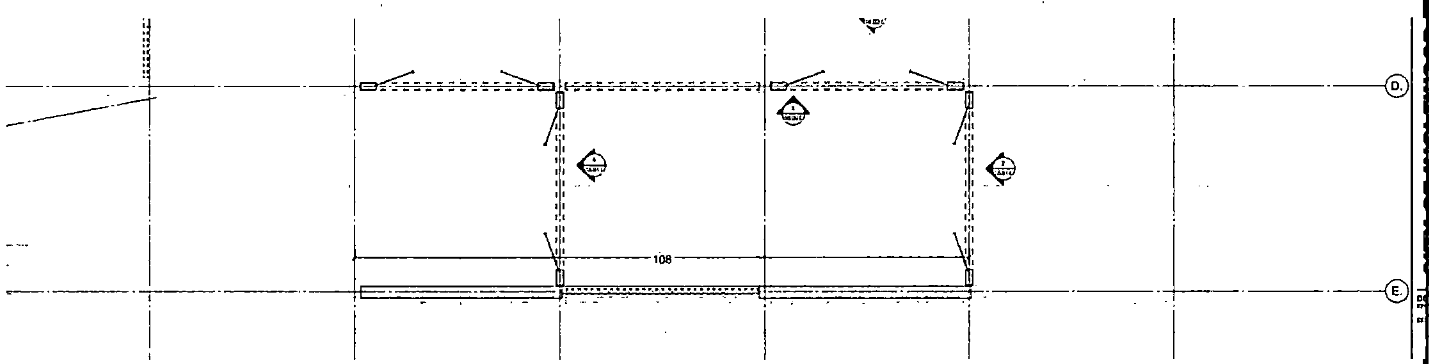
New Cast In Place Walls:

Total Shear in each Pier:

PE: Vu = 1328.7k; L = 36'; vu = 1328.7k/36' = 36.91 klf
P7: Vu = 1249.9k; L = 36'; vu = 1249.9k/36' = 34.72 klf

All shear forces are the peak average shear force from the PERFORM-3D model. All forces are taken from a section cut at the bottom of the wall.

Shear Friction @ Pier PE (Along Grid E):



Along Pier E, beams shown in red will be used as collectors to assist in the transfer of diaphragm forces into the wall.

Check Gravity usage of shear friction rebar:

Slab top bar at end span on Level 1: #5's @12" OC per S-1 slab type in As built drawings by Johnson & Nielson Associates dated 1/29/71.

Conservatively assume one-way slab force distribution and a 7-span condition.

1.0D+0.25L: 83.3psf (1st floor)+0.25*90psf(weighted average live load) = 105.8psf

typical slab span = 18'

Negative Moment at a 2-span condition = $0.106wl^2$
Assume a 1' strip

Wall Shear Transfer Checks:

Shear Friction @ Pier PE (Along Grid E):

Mu = 0.106*(105.8plf)*(18^2) = 43.6 k-in

Capacity:

h = 5"
clear cover = 0.75"

d = 5" - 0.75" - (0.625"/2) = 3.9375"
As = 0.31in^2/ft

a = As*fy/(0.85*f'c*b) = (0.31in^2*73ksi)/(0.85*5.436ksi*12")
a = 0.408 in

Mn = As*fy*(d-a/2) = 0.31in^2 * 73ksi * (3.9375" - 0.408"/2)
Mn = 84.49 k-in

$DCR_{Gravity}$ = 43.6/84.49 = 0.52

Therefore 48% can be used to resist shear friction.

Shear Friction Capacity:

ρ = .31/(5"*12") = 0.0052, within equation limits of Mattocks equation for LWC per BOD section 5.2.4.

vn = 0.8*A_{vf}*fy_{LB}+A_c*K_1
A_{vf} = 0.31in^2/ft
fy_{LB} = 65ksi
A_c = (5")(12") = 60in^2
K_1 = 200psi

vn = (0.8*0.31in^2*65,000psi + 60in^2*200psi)/1000 = 28.1k/ft

Accounting for Gravity vn = 13.5 k/ft

Vu = 1328.7k/108' = 12.3 k/ft

DCR = 12.3/13.5 = 0.91

Therefore existing dowels are adequate for shear friction at wall Pier PE.

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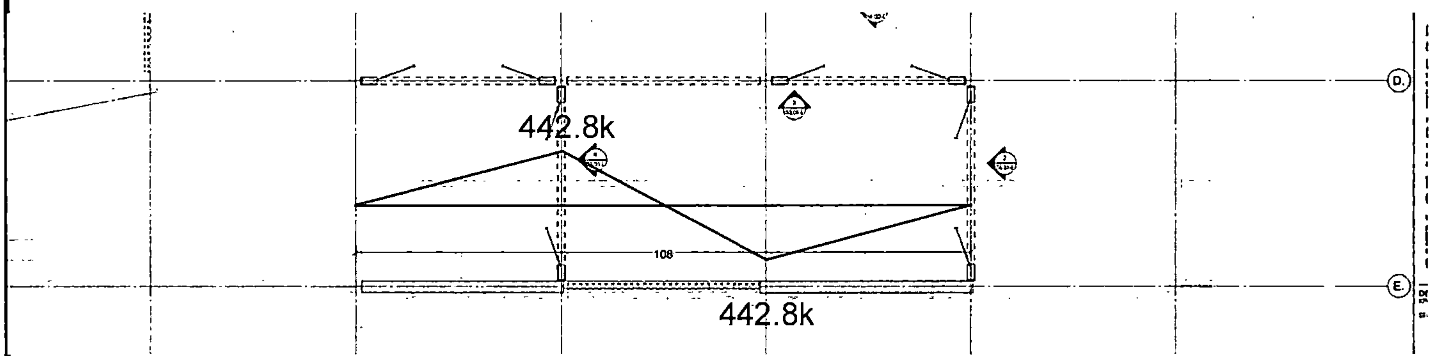
Wall Shear Transfer Checks:

Collectors @ Pier PE (Along Grid E):



Unit shear along entire line, vu = 1328.7k/108' = 12.3k/ft

Unit shear along wall length, vu_{wall} = 1328.7k/36' = 36.91 k/ft

Net unit shear along wall length, Δvu = (36.91-12.3) = 24.6 klf

See collector diagram above.

Worst case Collector Axial Force: Tu = Cu = 442.8k

Worst Case moment demands from Beam between Grids 4 and 5:
Mu+ = 98.2 k-in = 8.18 k-ft
Mu- = 7421.2 k-in = 618.4 k-ft

Worst Case moment demands from Beam between Grids 2 and 3:
Mu+ = 72.4 k-in = 6.03 k-ft
Mu- = 9448.0 k-in = 787.3 k-ft

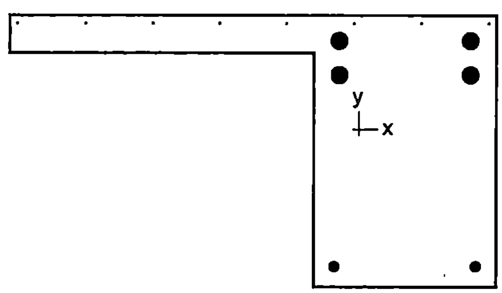
All moment demands are taken as the peak average demand from the PERFORM-3D model. Per model results neither beam experiences yielding in any ground motion therefore there is residual capacity for axial loads.
Both beams at the column faces have (4) #18's in two layers top bars with 11' of development length, and (2) #11's bottom bars with 4' of development length.

Both sets of bars are adequately developed following previously shown procedures of calculating development length in the BOD.

Slab top bar is #4's @10" OC per Slab type S-2. Per previous calculations 35% is available to resist seismic loads.

Per spColumn results in the following pages collectors are adequate along Grid E.

spColumn v7.00
Computer program for the Strength Design of Reinforced Concrete Sections



Contents

List of Figures

1. General Information

File Name	C:\Users\jlopez\Document...\Beam B26 @ Pier E.col
Project	---
Column	---
Engineer	---
Code	ACI 318-14
Bar Set	ASTM A615
Units	English
Run Option	Investigation
Run Axis	X - axis
Slenderness	Not Considered
Column Type	Structural
Capacity Method	Moment capacity

2. Material Properties

2.1. Concrete

Type	User-defined	
f'_c	5.436	ksi
E_c	3198.35	ksi
f_c	4.6206	ksi
ε_u	0.003	in/in
β_1	0.7782	

2.2. Steel

Type	Standard	
f_y	73	ksi
E_s	29000	ksi
ε_{yt}	0.00251724	in/in

3. Section

3.1. Shape and Properties

Type	Irregular	
A_g	1064	in^2
I_x	132747	in^4
I_y	234442	in^4
r_x	11.1697	in
r_y	14.8439	in
X_o	0	in
Y_o	0	in

3.2. Section Figure

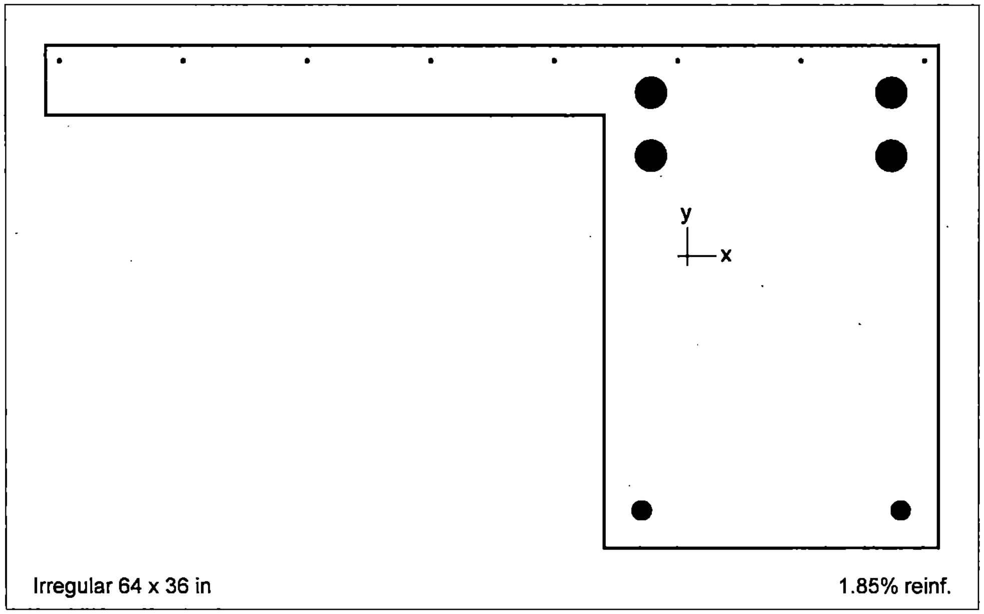


Figure 1: Column section

4. Reinforcement

4.1. Arrangement

Pattern	Irregular
Bar layout	---
Cover to	---
Clear cover	---
Bars	---
Total steel area, A_s	19.68 in²
Rho	1.85 %
Minimum clear spacing	1.70 in

4.2. Bars Provided

Area in²	X in	Y in	Area in²	X in	Y in	Area in²	X in	Y in
1.56	-3.3	-18.2	1.56	15.3	-18.2	4.00	-2.6	11.7
4.00	14.6	11.7	4.00	-2.6	7.2	4.00	14.6	7.2
0.07	-45.0	14.0	0.07	-36.1	14.0	0.07	-27.3	14.0
0.07	-18.4	14.0	0.07	-9.6	14.0	0.07	-0.7	14.0
0.07	8.2	14.0	0.07	17.0	14.0			

5. Factored Loads and Moments with Corresponding Capacity Ratios

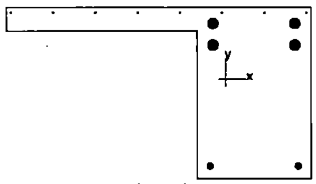
NOTE: Calculations are based on "Moment Capacity" Method.

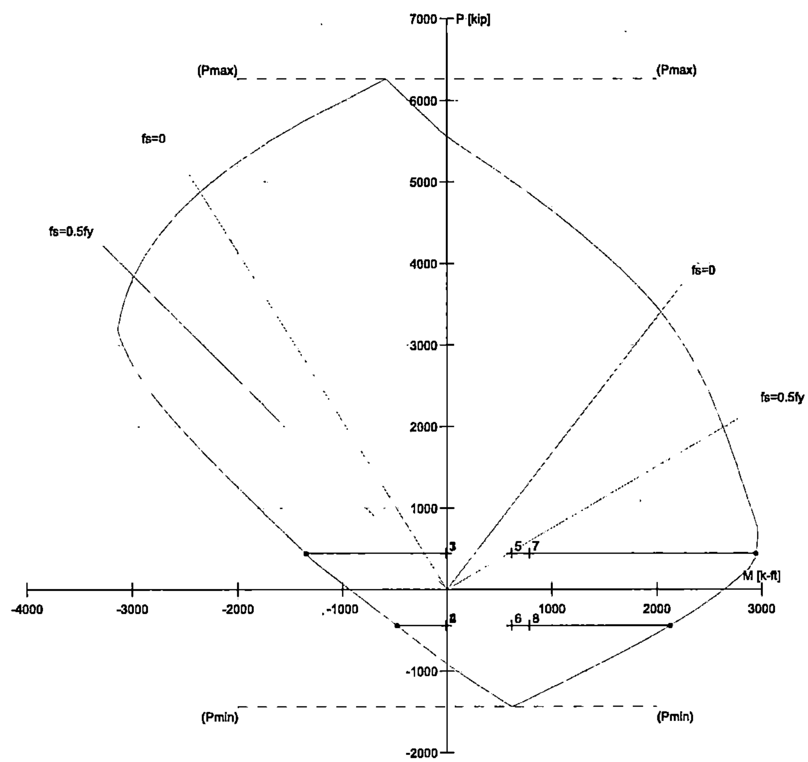
No.	Demand		Capacity		Parameters at Capacity			Capacity
	P_u kip	M_{ux} k-ft	ϕP_n kip	ϕM_{nx} k-ft	NA Depth in	ε_t	ϕ	Ratio
1	442.80	-8.18	442.80	-1346.13	4.48	0.01928	1.000	0.01
2	-442.80	-8.18	-442.80	-476.29	2.52	0.03661	1.000	0.02
3	442.80	-6.03	442.80	-1346.13	4.48	0.01928	1.000	0.00

No.	Demand		Capacity		Parameters at Capacity			Capacity Ratio
	P_u	M_{ux}	ϕP_n	ϕM_{nx}	NA Depth	ε_t	ϕ	
	kip	k-ft	kip	k-ft	in			
4	-442.80	-6.03	-442.80	-476.29	2.52	0.03661	1.000	0.01
5	442.80	618.40	442.80	2943.87	16.01	0.00354	1.000	0.21
6	-442.80	618.40	-442.80	2127.14	7.10	0.01176	1.000	0.29
7	442.80	787.30	442.80	2943.87	16.01	0.00354	1.000	0.27
8	-442.80	787.30	-442.80	2127.14	7.10	0.01176	1.000	0.37

6. Diagrams

6.1. PM at θ=0 [deg]





PM at 0.0 [deg]

General Information

Project	—
Column	—
Engineer	—
Code	ACI 318-14
Bar Set	ASTM A615
Units	English
Run Option	Investigation
Run Axis	X - axis
Slenderness	Not Considered
Column Type	Structural
Capacity Method	Moment capacity

Materials

f'_c	5.436	ksi
E_c	3198.35	ksi
f_y	73	ksi
E_s	29000	ksi

Section

Type	Irregular	
A_g	1064	in²
I_x	132747	in⁴
I_y	234442	in⁴

Reinforcement

Pattern	Irregular	
Bar layout	—	
Cover to	—	
Clear cover	—	
Bars	—	
Confinement type	Other	
Total steel area, A_s	19.68	in²
Rho	1.85	%
Min. clear spacing	1.70	in

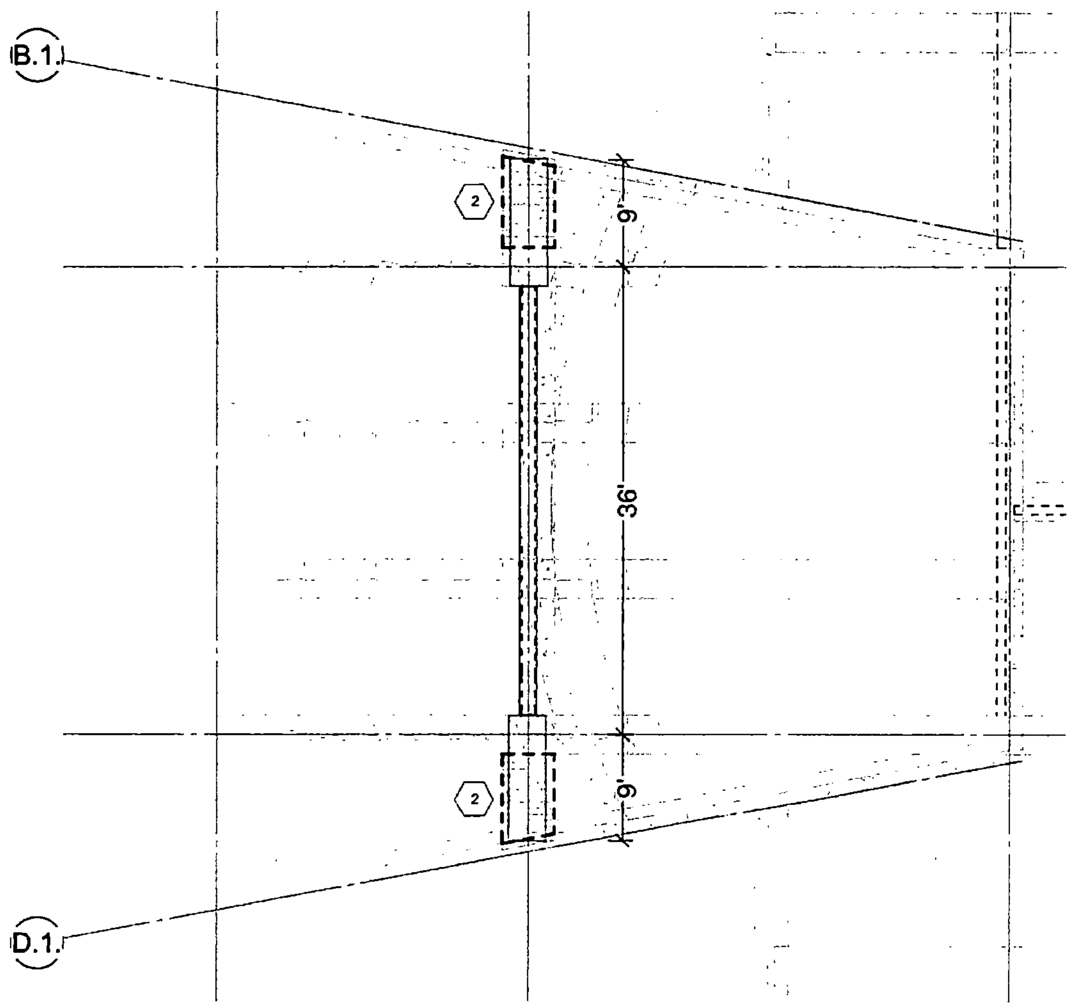
No.	P_u	M_{ux}	ϕP_n	ϕM_{nx}	Capacity
	kip	k-ft	kip	k-ft	Ratio
8	-442.8	787.3	-442.80	2127.14	0.37
6	-442.8	618.4	-442.80	2127.14	0.29
7	442.8	787.3	442.80	2943.87	0.27
5	442.8	618.4	442.80	2943.87	0.21
2	-442.8	-8.2	-442.80	-476.29	0.02
1	442.8	-8.2	442.80	-1346.13	0.01
4	-442.8	-6.0	-442.80	-476.29	0.01
3	442.8	-6.0	442.80	-1346.13	0.00

Max. Capacity Ratio: 0.37

Wall Shear Transfer Checks:

New Cast In Place Walls:

Shear Friction @ Pier P7 (Along Grid 7):



Along Pier 7, beams shown in red will be used as collectors to assist in the transfer of diaphragm forces into the wall.

Rebar used to resist shear friction at the lecture hall is the temperature reinforcement of one way slabs, #4's @12" OC. Per previous calculations at grid 6 temperature reinforcement can resist vn = 13.65k/ft

vu = 1249.9k/54' = 23.15 k/ft over two shear friction planes
vu = 23.15/2 (2 shear friction planes) = 11.6 k/ft

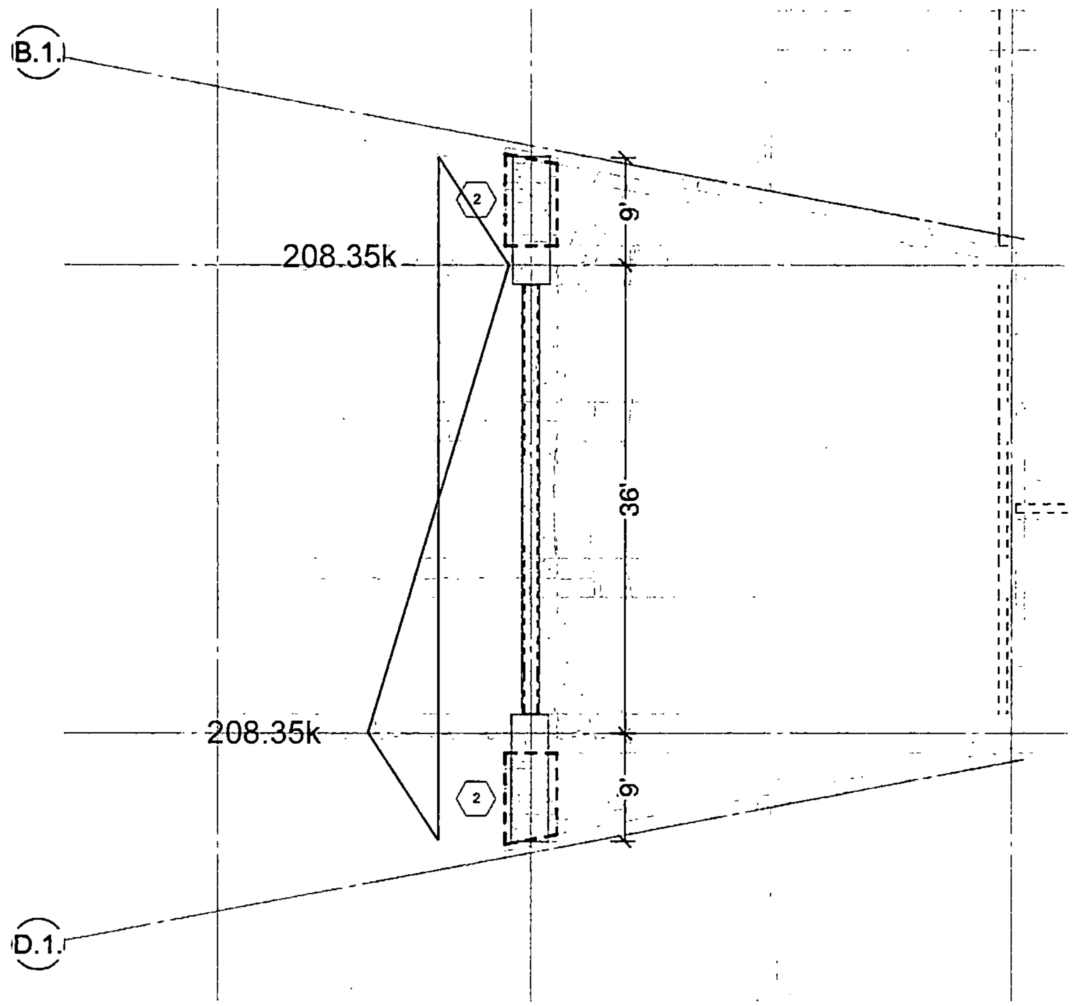
DCR = 11.6/13.65 = 0.85

Therefore existing dowels are adequate for shear friction at wall Pier P7.

Wall Shear Transfer Checks:

New Cast In Place Walls:

Collectors @ Pier P7 (Along Grid 7):



Unit shear along entire line, vu = 1249.9k/54' = 23.15k/ft

Unit shear along wall length, vu_{wall} = 1249.9k/36' = 34.72k/ft

Net unit shear along wall length, Δvu = (34.72-23.15) = 11.57 k/ft

See collector diagram above.

Wall Shear Transfer Checks:

Collectors @ Pier P7 (Along Grid 7):

Worst case Collector Axial Force: Tu = Cu = 208.35k

Worst Case moment demands from Beam between Grids D.1 and D:
Mu+ = 38.0 k-in = 3.17 k-ft
Mu- = 44761.8 k-in = 3730.2 k-ft

Worst Case moment demands from Beam between Grids C and B.1:
Mu+ = 643.5 k-in = 53.6 k-ft
Mu- = 44184.9 k-in = 3682.1 k-ft

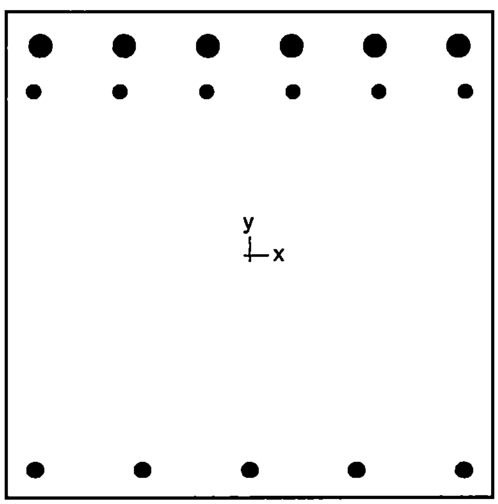
All moment demands are taken as the peak average demand from the PERFORM-3D model. Per model results neither beam experiences yielding in any ground motion therefore there is residual capacity for axial loads.
Both beams at the column faces have (6) #18's and (6) #11's in two layers top bars with 8.83' of development length, and (5) #11's bottom bars with 8.83' of development length.

Both sets of bars are adequately developed following previously shown procedures of calculating development length in the BOD.

Conservatively only the beam rebar will be used to resist collector forces.

Per spColumn results in the following pages collectors are adequate along Grid 7.

spColumn v7.00
Computer program for the Strength Design of Reinforced Concrete Sections



Contents

List of Figures

1. General Information

File Name	C:\Users\jlopez\Docume...\48x48 Beam @ Pier 7.col
Project	---
Column	---
Engineer	---
Code	ACI 318-19
Bar Set	ASTM A615
Units	English
Run Option	Investigation
Run Axis	X - axis
Slenderness	Not Considered
Column Type	Structural
Capacity Method	Moment capacity

2. Material Properties

2.1. Concrete

Type	Standard	
f'_c	5.723	ksi
E_c	4312.08	ksi
f_c	4.86455	ksi
ε_u	0.003	in/in
β_1	0.76385	

2.2. Steel

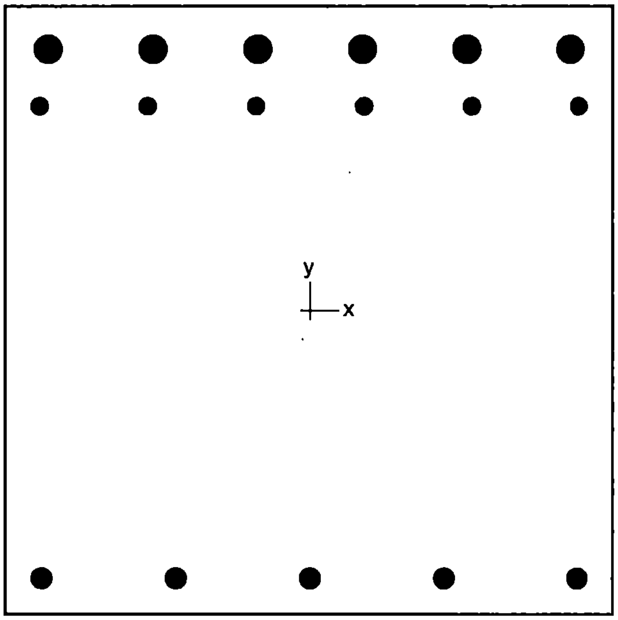
Type	Standard	
f_y	73	ksi
E_s	29000	ksi
ε_{yt}	0.00251724	in/in

3. Section

3.1. Shape and Properties

Type	Irregular	
A_g	2304	in²
I_x	442368	in⁴
I_y	442368	in⁴
r_x	13.8564	in
r_y	13.8564	in
X_o	0	in
Y_o	0	in

3.2. Section Figure



Irregular 48 x 48 in   1.94% reinf.

Figure 1: Column section

4. Reinforcement

4.1. Confinement and Factors

Confinement type	Other
For #10 bars or less	#3 ties
For larger bars	#4 ties
Capacity Reduction Factors	
Axial compression, (a)	1
Tension controlled ϕ, (b)	1
Compression controlled ϕ, (c)	1

4.2. Arrangement

Pattern	Irregular	
Bar layout	---	
Cover to	---	
Clear cover	---	
Bars	---	
Total steel area, A_s	44.61	in^2
Rho	1.94	%
Minimum clear spacing	2.68	in

4.3. Bars Provided

Area in²	X in	Y in	Area in²	X in	Y in	Area in²	X in	Y in
2.25	-21.2	-21.2	2.25	-10.6	-21.2	2.25	0.0	-21.2
2.25	10.6	-21.2	2.25	21.2	-21.2	4.00	-20.6	20.6
4.00	-12.4	20.6	4.00	-4.1	20.6	4.00	4.1	20.6
4.00	12.4	20.6	4.00	20.6	20.6	1.56	-21.3	16.1
1.56	-12.8	16.1	1.56	-4.3	16.1	1.56	4.3	16.1
1.56	12.8	16.1	1.56	21.3	16.1			

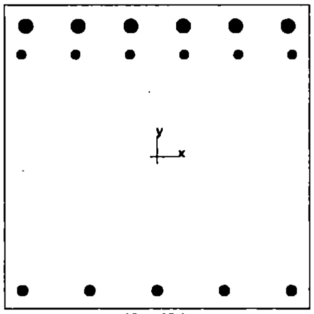
5. Factored Loads and Moments with Corresponding Capacity Ratios

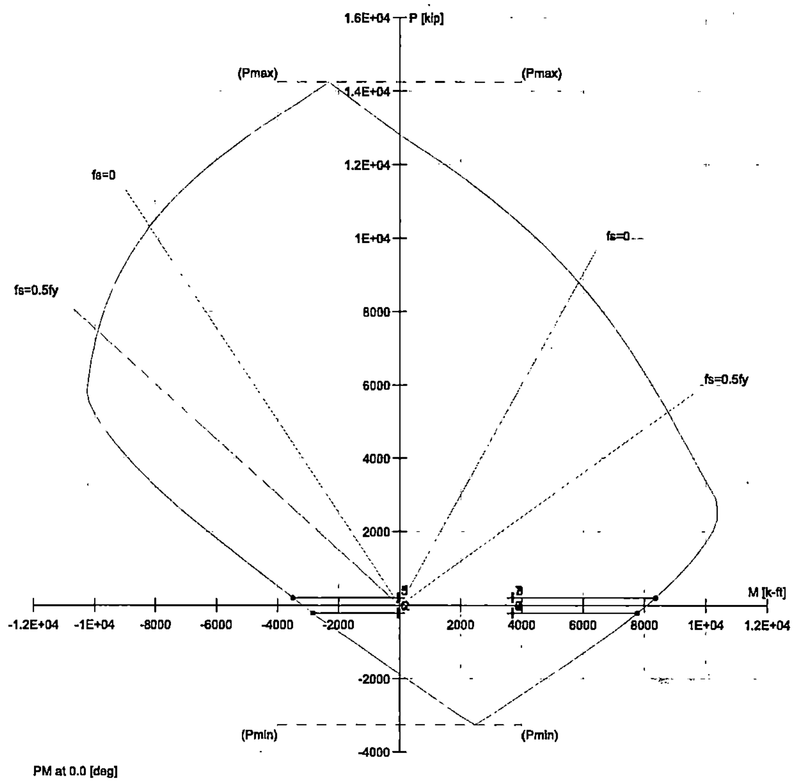
NOTE: Calculations are based on "Moment Capacity" Method.

No.	Demand		Capacity		Parameters at Capacity			Capacity
	P_u	M_{ux}	ϕP_n	ϕM_{nx}	NA Depth	ε_t	ϕ	Ratio
	kip	k-ft	kip	k-ft	in			
1	208.35	-3.17	208.35	-3496.43	5.07	0.02373	1.000	0.00
2	-208.35	-3.17	-208.35	-2839.98	4.52	0.02694	1.000	0.00
3	208.35	3730.20	208.35	8362.08	11.05	0.00911	1.000	0.45
4	-208.35	3730.20	-208.35	7772.47	9.03	0.01182	1.000	0.48
5	208.35	-53.60	208.35	-3496.43	5.07	0.02373	1.000	0.02
6	-208.35	-53.60	-208.35	-2839.98	4.52	0.02694	1.000	0.02
7	208.35	3682.10	208.35	8362.08	11.05	0.00911	1.000	0.44
8	-208.35	3682.10	-208.35	7772.47	9.03	0.01182	1.000	0.47

6. Diagrams

6.1. PM at θ=0 [deg]





General Information

Project	—
Column	—
Engineer	—
Code	ACI 318-19
Bar Set	ASTM A615
Units	English
Run Option	Investigation
Run Axis	X - axis
Slenderness	Not Considered
Column Type	Structural
Capacity Method	Moment capacity

Materials

f'_c	5.723 ksi
E_c	4312.08 ksi
f_y	73 ksi
E_s	29000 ksi

Section

Type	Irregular
A_g	2304 in²
I_x	442368 in⁴
I_y	442368 in⁴

Reinforcement

Pattern	Irregular
Bar layout	—
Cover to	—
Clear cover	—
Bars	—
Confinement type	Other
Total steel area, A_s	44.61 in²
Rho	1.94 %
Min. clear spacing	2.68 in

No.	P_u kip	M_{ux} k-ft	ϕP_n kip	ϕM_{nx} k-ft	Capacity Ratio
4	-208.4	3730.2	-208.35	7772.47	0.48
8	-208.4	3682.1	-208.35	7772.47	0.47
3	208.4	3730.2	208.35	8362.08	0.45
7	208.4	3682.1	208.35	8362.08	0.44
5	208.4	-53.6	208.35	-3496.43	0.02
6	-208.4	-53.6	-208.35	-2839.98	0.02
1	208.4	-3.2	208.35	-3496.43	0.00
2	-208.4	-3.2	-208.35	-2839.98	0.00

Max. Capacity Ratio: 0.48

A.3.c - Collector Diagrams at Damper Lines

Executive Summary

The following section includes calculations of collector diagrams at the damper lines. The following assumptions were used to create the collector diagrams:

-Because diaphragms are modeled as rigid and column section properties are nearly identical, all columns in a frame line will take the same amount of shear.

- The same assumptions as above will be used to distribute shears to dampers at each line.

-Dampers above and below a story act in opposite directions at any point in time.

-The length of the collector line is the entire horizontal direction of the building, 144ft.

From these assumptions, we calculate the unit shear in the collectors as follows at a level x:

$$v = (\Sigma V_{col,x} - \Sigma V_{col,x-1} + \Sigma V_{dampers,x} - \Sigma V_{dampers,x-1}) / 144ft$$

Demands are gathered as follows:

-While dampers and frames act out-of-phase, conservatively the full column shears and the full damper shears will be summed at each level and grid line to obtain the unit shear.

-Forces are read from section cuts in all of the columns in a give line above the level, in all the columns in a given line below the level, in the dampers above a level, and dampers below the level.

-The difference between these section cuts is found at every time step and the maximum difference is recorded for every ground motion then averaged. i.e. $\Delta V_{col} = MAX(\Sigma V_{col,x} - \Sigma V_{col,x-1})$ and $\Delta V_{damper} = MAX(\Sigma V_{dampers,x} - \Sigma V_{dampers,x-1})$ at every GM then averaged. These peak average differences are then used to calculate a unit shear at the level.

-To recreate the imbalance in damper forces above and below the level ΔV_{damper} is distributed using the ratio of (Total Damper shear in level x)/(Total Damper shear in level x-1). These ratios can be seen clearly in the damper results shown in Section B.3.a.

-Demands are obtained at the BSE-2E hazard level.

These collector forces are used to then design the size and extent of the collector plates located underneath the beams at each damper line in Section B.3.d.

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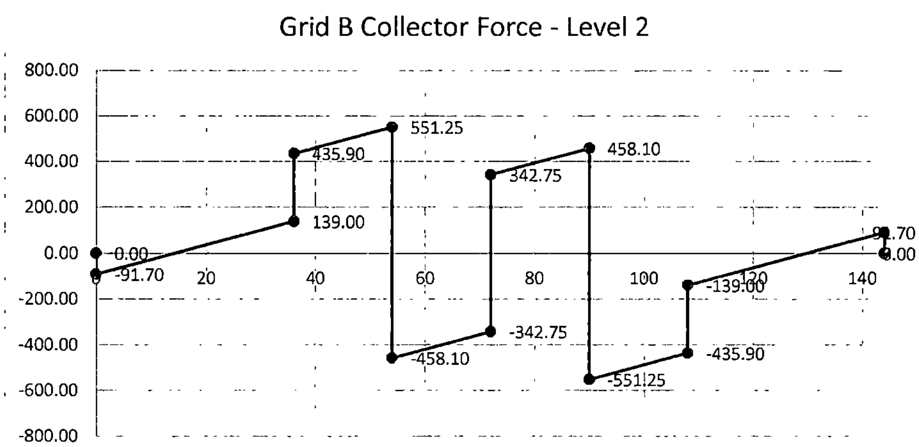
Job no. :	2000362
Date :	10/20/2021
By :	JL

Damper Lines Collector Diagrams

Grid B - Level 2

ΔV_{Col} =	458.5	k	See * below
n_c =	5		# of Columns
$\delta V_{Col} = \Delta V_{Col}/n_c$ =	91.70	k	Calculated assuming shear is the same in each column
ΔV_D =	464.3	k	See ** below
r = Above/Below =	0.77		Damper Force Ratio, see *** below
$F_{D, Above}$ =	1554.40	k	Total Damper Force Above Level
$F_{D, Below}$ =	2018.70	k	Total Damper Force below Level
$n_{D, Above}$ =	4		# of Dampers above level
$n_{D, Below}$ =	4		# of Dampers below level
$\delta V_{D, Above} = F_{D, Above}/n_{D, Above}$ =	388.60	k	Calculated assuming shear is the same in each damper
$\delta V_{D, Below} = F_{D, Below}/n_{D, Below}$ =	504.67	k	Calculated assuming shear is the same in each damper
L =	144	ft	Length of Entire Line
$v_u = (\Delta V_{Col} + \Delta V_D)/L$ =	6.41	klf	Unit shear across line

Grid	Location (ft)	Axial (k)
5	0	0.00
5	0	-91.70
4	36	139.00
4	36	435.90
	54	551.25
	54	-458.10
3	72	-342.75
3	72	342.75
	90	458.10
	90	-551.25
2	108	-435.90
2	108	-139.00
1	144	91.70
1	144	0.00



*: ΔV_{Col} is calculated as the peak average difference between the shear in the columns above and below the story among the 11 ground motions.
**: ΔV_D is calculated as the peak average difference between the shear in the dampers above and below the story among the 11 ground motions.
***: ratio of the total story shear in the dampers above the level over the total story shear in the dampers below the level. This ratio is then used to proportion the loads to the dampers above and below the level

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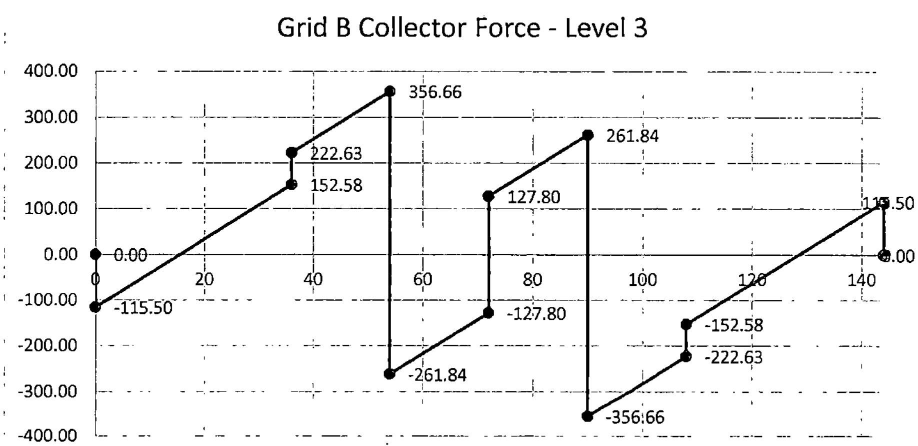
Damper Lines Collector Diagrams

Grid B - Level 3

$\Delta V_{Col} =$	577.5	k	See * below
$n_c =$	5		# of Columns
$\delta V_{Col} = \Delta V_{Col}/n_c =$	115.50	k	Calculated assuming shear is the same in each column
$\Delta V_D =$	494.8	k	See ** below
r = Above/Below =	0.6		Damper Force Ratio, see *** below
$F_{D, Above} =$	742.20	k	Total Damper Force Above Level
$F_{D, Below} =$	1237.00	k	Total Damper Force below Level
$n_{D, Above} =$	4		# of Dampers above level
$n_{D, Below} =$	4		# of Dampers below level
$\delta V_{D, Above} = F_{D, Above}/n_{D, Above} =$	185.55	k	Calculated assuming shear is the same in each damper
$\delta V_{D, Below} = F_{D, Below}/n_{D, Below} =$	309.25	k	Calculated assuming shear is the same in each damper
L =	144	ft	Length of Entire Line
$v_u = (\Delta V_{Col} + \Delta V_D)/L =$	7.45	klf	Unit shear across line

Grid	Location (ft)	Axial (k)
5	0	0.00
5	0	-115.50
4	36	152.58
4	36	222.63
	54	356.66
	54	-261.84
3	72	-127.80
3	72	127.80
	90	261.84
	90	-356.66
2	108	-222.63
2	108	-152.58
1	144	115.50
1	144	0.00



*: ΔV_{Col} is calculated as the peak average difference between the shear in the columns above and below the story among the 11 ground motions.

**: ΔV_D is calculated as the peak average difference between the shear in the dampers above and below the story among the 11 ground motions.

***: ratio of the total story shear in the dampers above the level over the total story shear in the dampers below the level. This ratio is then used to proportion the loads to the dampers above and below the level

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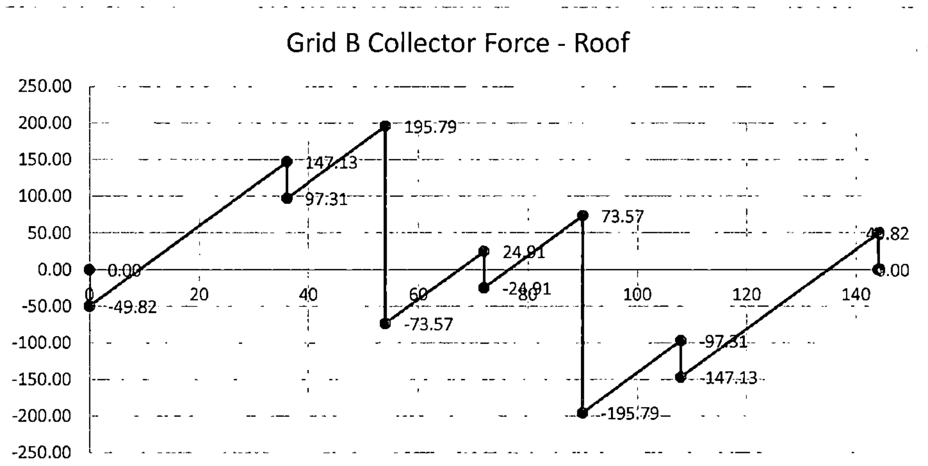
Damper Lines Collector Diagrams

Grid B - Roof

ΔV_{Col} =	249.1	k	See * below
n_c =	5		# of Columns
$\delta V_{Col} = \Delta V_{Col}/n_c$ =	49.82	k	Calculated assuming shear is the same in each column
ΔV_D =	538.7	k	See ** below
r = Above/Below =	0		Damper Force Ratio, see *** below
$F_{D, Above}$ =	0.00	k	Total Damper Force Above Level
$F_{D, Below}$ =	538.70	k	Total Damper Force below Level
$n_{D, Above}$ =	4		# of Dampers above level
$n_{D, Below}$ =	4		# of Dampers below level
$\delta V_{D, Above} = F_{D, Above}/n_{D, Above}$ =	0.00	k	Calculated assuming shear is the same in each damper
$\delta V_{D, Below} = F_{D, Below}/n_{D, Below}$ =	134.68	k	Calculated assuming shear is the same in each damper
L =	144	ft	Length of Entire Line
$v_u = (\Delta V_{Col} + \Delta V_D)/L$ =	5.47	klf	Unit shear across line

Grid	Location (ft)	Axial (k)
5	0	0.00
5	0	-49.82
4	36	147.13
4	36	97.31
	54	195.79
	54	-73.57
3	72	24.91
3	72	-24.91
	90	73.57
	90	-195.79
2	108	-97.31
2	108	-147.13
1	144	49.82
1	144	0.00



*: ΔV_{Col} is calculated as the peak average difference between the shear in the columns above and below the story among the 11 ground motions.

**: ΔV_D is calculated as the peak average difference between the shear in the dampers above and below the story among the 11 ground motions.

***: ratio of the total story shear in the dampers above the level over the total story shear in the dampers below the level. This ratio is then used to proportion the loads to the dampers above and below the level

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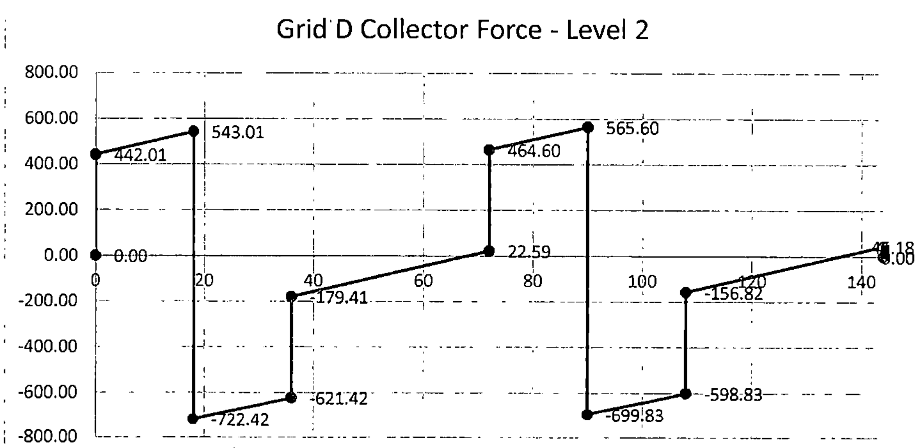
Damper Lines Collector Diagrams

Grid D - Level 2

$\Delta V_{Col} =$	225.9	k	See * below
$n_c =$	5		# of Columns
$\delta V_{Col} = \Delta V_{Col}/n_c =$	45.18	k	Calculated assuming shear is the same in each column
$\Delta V_D =$	582.1	k	See ** below
r = Above/Below =	0.77		Damper Force Ratio, see *** below
$F_{D,\,Above} =$	1948.77	k	Total Damper Force Above Level
$F_{D,\,Below} =$	2530.87	k	Total Damper Force below Level
$n_{D,\,Above} =$	4		# of Dampers above level
$n_{D,\,Below} =$	4		# of Dampers below level
$\delta V_{D,\,Above} = F_{D,\,Above}/n_{D,\,Above} =$	487.19	k	Calculated assuming shear is the same in each damper
$\delta V_{D,\,Below} = F_{D,\,Below}/n_{D,\,Below} =$	632.72	k	Calculated assuming shear is the same in each damper
L =	144	ft	Length of Entire Line
$v_u = (\Delta V_{Col} + \Delta V_D)/L =$	5.61	klf	Unit shear across line

Grid	Location (ft)	Axial (k)
5	0	0.00
5	0	442.01
	18	543.01
	18	-722.42
4	36	-621.42
4	36	-179.41
3	72	22.59
3	72	464.60
	90	565.60
	90	-699.83
2	108	-598.83
2	108	-156.82
1	144	45.18
1	144	0.00



*: ΔV_{Col} is calculated as the peak average difference between the shear in the columns above and below the story among the 11 ground motions.

**: ΔV_D is calculated as the peak average difference between the shear in the dampers above and below the story among the 11 ground motions.

***: ratio of the total story shear in the dampers above the level over the total story shear in the dampers below the level. This ratio is then used to proportion the loads to the dampers above and below the level

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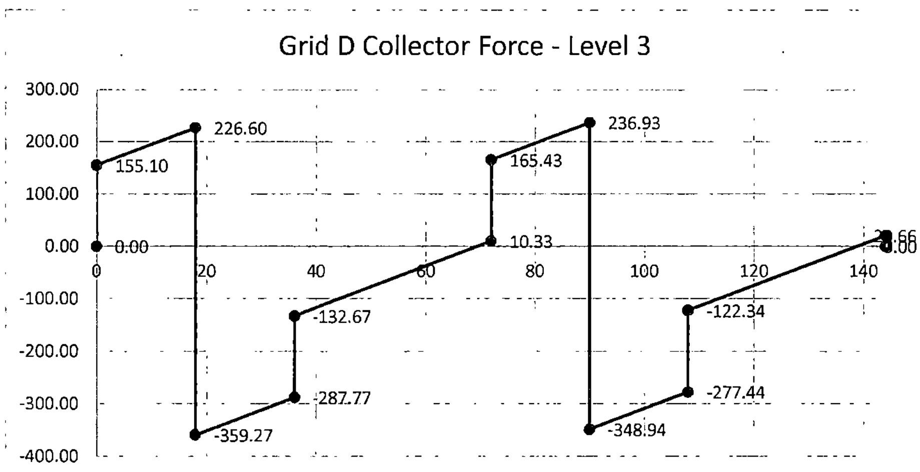
Damper Lines Collector Diagrams

Grid D - Level 3

$\Delta V_{Col} =$	103.3	k	See * below
$n_c =$	5		# of Columns
$\delta V_{Col} = \Delta V_{Col}/n_c =$	20.66	k	Calculated assuming shear is the same in each column
$\Delta V_D =$	468.7	k	See ** below
r = Above/Below =	0.6		Damper Force Ratio, see *** below
$F_{D, Above} =$	703.05	k	Total Damper Force Above Level
$F_{D, Below} =$	1171.75	k	Total Damper Force below Level
$n_{D, Above} =$	4		# of Dampers above level
$n_{D, Below} =$	4		# of Dampers below level
$\delta V_{D, Above} = F_{D, Above}/n_{D, Above} =$	175.76	k	Calculated assuming shear is the same in each damper
$\delta V_{D, Below} = F_{D, Below}/n_{D, Below} =$	292.94	k	Calculated assuming shear is the same in each damper
L =	144	ft	Length of Entire Line
$v_u = (\Delta V_{Col} + \Delta V_D)/L =$	3.97	klf	Unit shear across line

Grid	Location (ft)	Axial (k)
5	0	0.00
5	0	155.10
	18	226.60
	18	-359.27
4	36	-287.77
4	36	-132.67
3	72	10.33
3	72	165.43
	90	236.93
	90	-348.94
2	108	-277.44
2	108	-122.34
1	144	20.66
1	144	0.00



*: ΔV_{Col} is calculated as the peak average difference between the shear in the columns above and below the story among the 11 ground motions.
**: ΔV_D is calculated as the peak average difference between the shear in the dampers above and below the story among the 11 ground motions.
***: ratio of the total story shear in the dampers above the level over the total story shear in the dampers below the level. This ratio is then used to proportion the loads to the dampers above and below the level

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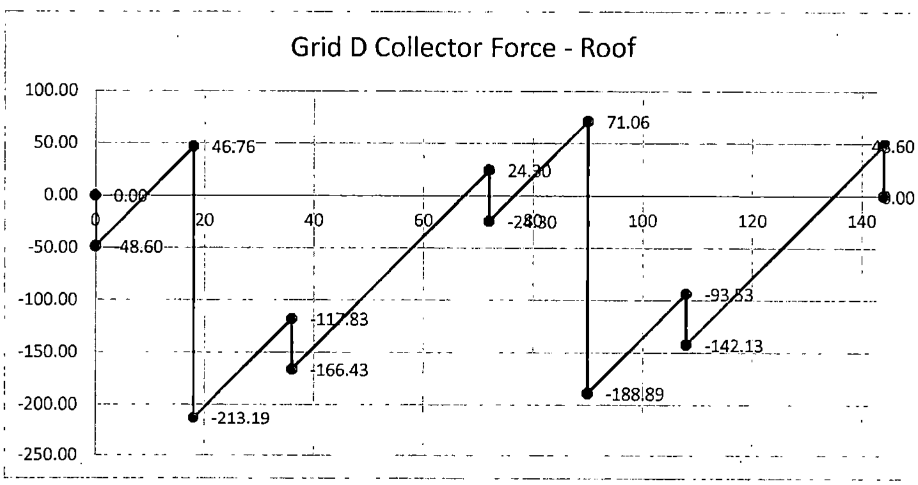
Damper Lines Collector Diagrams

Grid D - Roof

$\Delta V_{Col} =$	243	k	See * below
$n_c =$	5		# of Columns
$\delta V_{Col} = \Delta V_{Col}/n_c =$	48.60	k	Calculated assuming shear is the same in each column
$\Delta V_D =$	519.9	k	See ** below
r = Above/Below =	0		Damper Force Ratio, see *** below
$F_{D, Above} =$	0.00	k	Total Damper Force Above Level
$F_{D, Below} =$	519.90	k	Total Damper Force below Level
$n_{D, Above} =$	4		# of Dampers above level
$n_{D, Below} =$	4		# of Dampers below level
$\delta V_{D, Above} = F_{D, Above}/n_{D, Above} =$	0.00	k	Calculated assuming shear is the same in each damper
$\delta V_{D, Below} = F_{D, Below}/n_{D, Below} =$	129.98	k	Calculated assuming shear is the same in each damper
L =	144	ft	Length of Entire Line
$v_u = (\Delta V_{Col} + \Delta V_D)/L =$	5.30	klf	Unit shear across line

Grid	Location (ft)	Axial (k)
5	0	0.00
5	0	-48.60
	18	46.76
	18	-213.19
4	36	-117.83
4	36	-166.43
3	72	24.30
3	72	-24.30
	90	71.06
	90	-188.89
2	108	-93.53
2	108	-142.13
1	144	48.60
1	144	0.00



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**: ΔV_D is calculated as the peak average difference between the shear in the dampers above and below the story among the 11 ground motions.

***: ratio of the total story shear in the dampers above the level over the total story shear in the dampers below the level. This ratio is then used to proportion the loads to the dampers above and below the level

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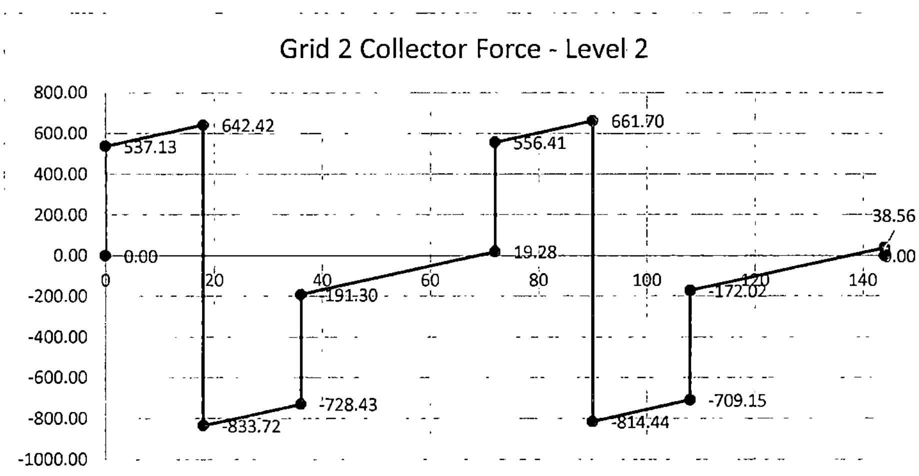
Damper Lines Collector Diagrams

Grid 2 - Level 2

ΔV_{Col} =	192.8	k	See * below
n_c =	5		# of Columns
$\delta V_{Col} = \Delta V_{Col}/n_c$ =	38.56	k	Calculated assuming shear is the same in each column
ΔV_D =	649.5	k	See ** below
r = Above/Below =	0.78		Damper Force Ratio, see *** below
$F_{D, Above}$ =	2302.77	k	Total Damper Force Above Level
$F_{D, Below}$ =	2952.27	k	Total Damper Force below Level
$n_{D, Above}$ =	4		# of Dampers above level
$n_{D, Below}$ =	4		# of Dampers below level
$\delta V_{D, Above} = F_{D, Above}/n_{D, Above}$ =	575.69	k	Calculated assuming shear is the same in each damper
$\delta V_{D, Below} = F_{D, Below}/n_{D, Below}$ =	738.07	k	Calculated assuming shear is the same in each damper
L =	144	ft	Length of Entire Line
$v_u = (\Delta V_{Col} + \Delta V_D)/L$ =	5.85	klf	Unit shear across line

Grid	Location (ft)	Axial (k)
E	0	0.00
E	0	537.13
	18	642.42
	18	-833.72
D	36	-728.43
D	36	-191.30
C	72	19.28
C	72	556.41
	90	661.70
	90	-814.44
B	108	-709.15
B	108	-172.02
A	144	38.56
A	144	0.00



*: ΔV_{Col} is calculated as the peak average difference between the shear in the columns above and below the story among the 11 ground motions.

**: ΔV_D is calculated as the peak average difference between the shear in the dampers above and below the story among the 11 ground motions.

***: ratio of the total story shear in the dampers above the level over the total story shear in the dampers below the level. This ratio is then used to proportion the loads to the dampers above and below the level

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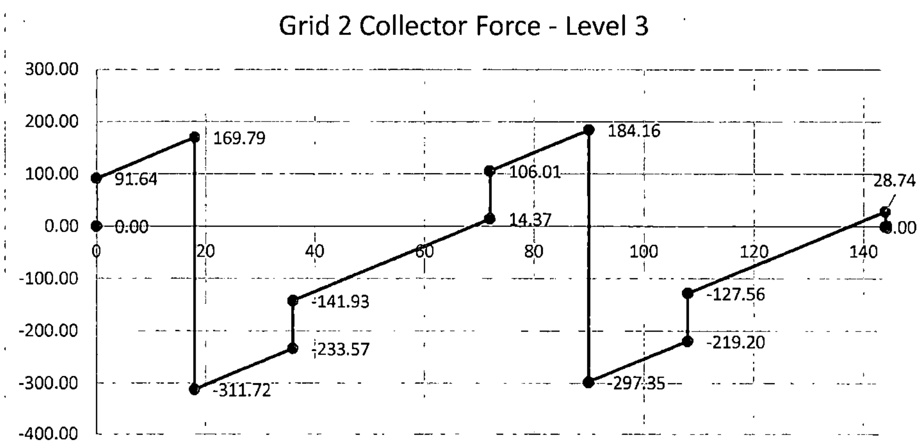
Damper Lines Collector Diagrams

Grid 2 - Level 3

$\Delta V_{Col} =$	143.7	k	See * below
$n_c =$	5		# of Columns
$\delta V_{Col} = \Delta V_{Col}/n_c =$	28.74	k	Calculated assuming shear is the same in each column
$\Delta V_D =$	481.5	k	See ** below
r = Above/Below =	0.5		Damper Force Ratio, see *** below
$F_{D, Above} =$	481.50	k	Total Damper Force Above Level
$F_{D, Below} =$	963.00	k	Total Damper Force below Level
$n_{D, Above} =$	4		# of Dampers above level
$n_{D, Below} =$	4		# of Dampers below level
$\delta V_{D, Above} = F_{D, Above}/n_{D, Above} =$	120.38	k	Calculated assuming shear is the same in each damper
$\delta V_{D, Below} = F_{D, Below}/n_{D, Below} =$	240.75	k	Calculated assuming shear is the same in each damper
L =	144	ft	Length of Entire Line
$v_u = (\Delta V_{Col} + \Delta V_D)/L =$	4.34	klf	Unit shear across line

Grid	Location (ft)	Axial (k)
E	0	0.00
E	0	91.64
	18	169.79
	18	-311.72
D	36	-233.57
D	36	-141.93
C	72	14.37
C	72	106.01
	90	184.16
	90	-297.35
B	108	-219.20
B	108	-127.56
A	144	28.74
A	144	0.00



*: ΔV_{Col} is calculated as the peak average difference between the shear in the columns above and below the story among the 11 ground motions.
**: ΔV_D is calculated as the peak average difference between the shear in the dampers above and below the story among the 11 ground motions.
***: ratio of the total story shear in the dampers above the level over the total story shear in the dampers below the level. This ratio is then used to proportion the loads to the dampers above and below the level

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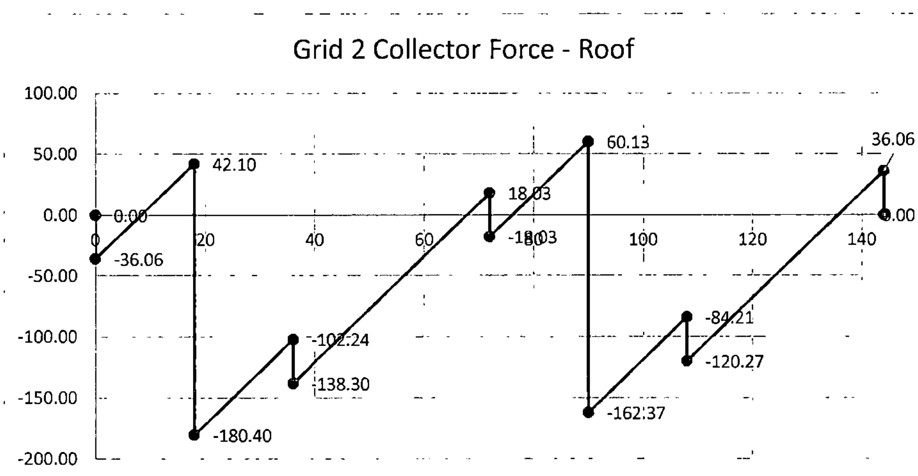
Damper Lines Collector Diagrams

Grid 2 - Roof

ΔV_{Col} =	180.3	k	See * below
n_c =	5		# of Columns
$\delta V_{Col} = \Delta V_{Col}/n_c$ =	36.06	k	Calculated assuming shear is the same in each column
ΔV_D =	445	k	See ** below
r = Above/Below =	0		Damper Force Ratio, see *** below
$F_{D,\,Above}$ =	0.00	k	Total Damper Force Above Level
$F_{D,\,Below}$ =	445.00	k	Total Damper Force below Level
$n_{D,\,Above}$ =	4		# of Dampers above level
$n_{D,\,Below}$ =	4		# of Dampers below level
$\delta V_{D,\,Above} = F_{D,\,Above}/n_{D,\,Above}$ =	0.00	k	Calculated assuming shear is the same in each damper
$\delta V_{D,\,Below} = F_{D,\,Below}/n_{D,\,Below}$ =	111.25	k	Calculated assuming shear is the same in each damper
L =	144	ft	Length of Entire Line
$v_u = (\Delta V_{Col} + \Delta V_D)/L$ =	4.34	klf	Unit shear across line

Grid	Location (ft)	Axial (k)
E	0	0.00
E	0	-36.06
	18	42.10
	18	-180.40
D	36	-102.24
D	36	-138.30
C	72	18.03
C	72	-18.03
	90	60.13
	90	-162.37
B	108	-84.21
B	108	-120.27
A	144	36.06
A	144	0.00



*: ΔV_{Col} is calculated as the peak average difference between the shear in the columns above and below the story among the 11 ground motions.
**: ΔV_D is calculated as the peak average difference between the shear in the dampers above and below the story among the 11 ground motions.
***: ratio of the total story shear in the dampers above the level over the total story shear in the dampers below the level. This ratio is then used to proportion the loads to the dampers above and below the level

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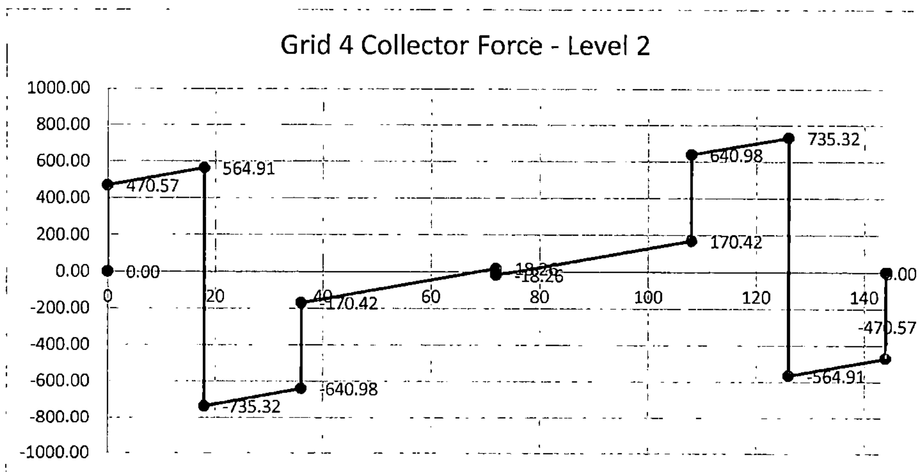
Damper Lines Collector Diagrams

Grid 4 - Level 2

$\Delta V_{Col} =$	182.6	k	See * below
$n_c =$	5		# of Columns
$\delta V_{Col} = \Delta V_{Col}/n_c =$	36.52	k	Calculated assuming shear is the same in each column
$\Delta V_D =$	572.1	k	See ** below
r = Above/Below =	0.78		Damper Force Ratio, see *** below
$F_{D, Above} =$	2028.35	k	Total Damper Force Above Level
$F_{D, Below} =$	2600.45	k	Total Damper Force below Level
$n_{D, Above} =$	4		# of Dampers above level
$n_{D, Below} =$	4		# of Dampers below level
$\delta V_{D, Above} = F_{D, Above}/n_{D, Above} =$	507.09	k	Calculated assuming shear is the same in each damper
$\delta V_{D, Below} = F_{D, Below}/n_{D, Below} =$	650.11	k	Calculated assuming shear is the same in each damper
L =	144	ft	Length of Entire Line
$v_u = (\Delta V_{Col} + \Delta V_D)/L =$	5.24	klf	Unit shear across line

Grid	Location (ft)	Axial (k)
E	0	0.00
E	0	470.57
	18	564.91
	18	-735.32
D	36	-640.98
D	36	-170.42
C	72	18.26
C	72	-18.26
B	108	170.42
B	108	640.98
	126	735.32
	126	-564.91
A	144	-470.57
A	144	0.00



*: ΔV_{Col} is calculated as the peak average difference between the shear in the columns above and below the story among the 11 ground motions.
**: ΔV_D is calculated as the peak average difference between the shear in the dampers above and below the story among the 11 ground motions.
***: ratio of the total story shear in the dampers above the level over the total story shear in the dampers below the level. This ratio is then used to proportion the loads to the dampers above and below the level

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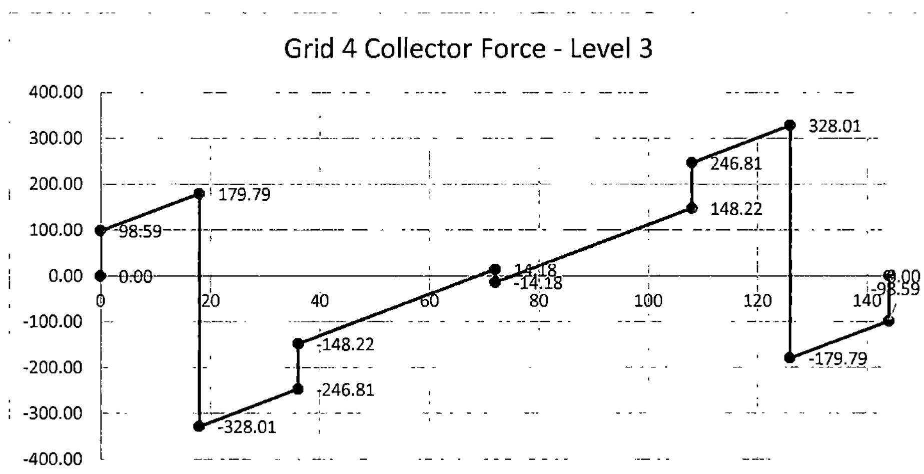
Damper Lines Collector Diagrams

Grid 4 - Level 3

$\Delta V_{Col} =$	141.8	k	See * below
$n_c =$	5		# of Columns
$\delta V_{Col} = \Delta V_{Col}/n_c =$	28.36	k	Calculated assuming shear is the same in each column
$\Delta V_D =$	507.8	k	See ** below
r = Above/Below =	0.5		Damper Force Ratio, see *** below
$F_{D, Above} =$	507.80	k	Total Damper Force Above Level
$F_{D, Below} =$	1015.60	k	Total Damper Force below Level
$n_{D, Above} =$	4		# of Dampers above level
$n_{D, Below} =$	4		# of Dampers below level
$\delta V_{D, Above} = F_{D, Above}/n_{D, Above} =$	126.95	k	Calculated assuming shear is the same in each damper
$\delta V_{D, Below} = F_{D, Below}/n_{D, Below} =$	253.90	k	Calculated assuming shear is the same in each damper
L =	144	ft	Length of Entire Line
$v_u = (\Delta V_{Col} + \Delta V_D)/L =$	4.51	klf	Unit shear across line

Grid	Location (ft)	Axial (k)
E	0	0.00
E	0	98.59
	18	179.79
	18	-328.01
D	36	-246.81
D	36	-148.22
C	72	14.18
C	72	-14.18
B	108	148.22
B	108	246.81
	126	328.01
	126	-179.79
A	144	-98.59
A	144	0.00



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**: ΔV_D is calculated as the peak average difference between the shear in the dampers above and below the story among the 11 ground motions.

***: ratio of the total story shear in the dampers above the level over the total story shear in the dampers below the level. This ratio is then used to proportion the loads to the dampers above and below the level

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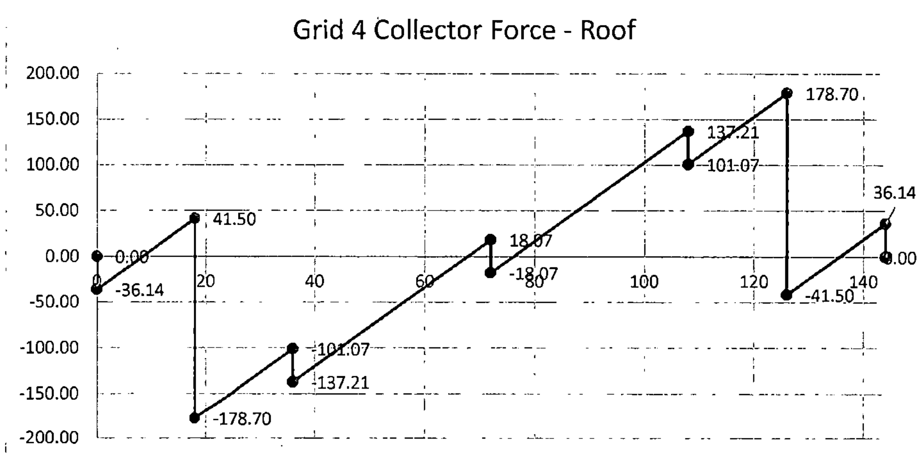
Damper Lines Collector Diagrams

Grid 4 - Roof

$\Delta V_{Col} =$	180.7	k	See * below
$n_c =$	5		# of Columns
$\delta V_{Col} = \Delta V_{Col}/n_c =$	36.14	k	Calculated assuming shear is the same in each column
$\Delta V_D =$	440.4	k	See ** below
r = Above/Below =	0		Damper Force Ratio, see *** below
$F_{D, Above} =$	0.00	k	Total Damper Force Above Level
$F_{D, Below} =$	440.40	k	Total Damper Force below Level
$n_{D, Above} =$	4		# of Dampers above level
$n_{D, Below} =$	4		# of Dampers below level
$\delta V_{D, Above} = F_{D, Above}/n_{D, Above} =$	0.00	k	Calculated assuming shear is the same in each damper
$\delta V_{D, Below} = F_{D, Below}/n_{D, Below} =$	110.10	k	Calculated assuming shear is the same in each damper
L =	144	ft	Length of Entire Line
$v_u = (\Delta V_{Col} + \Delta V_D)/L =$	4.31	klf	Unit shear across line

Grid	Location (ft)	Axial (k)
E	0	0.00
E	0	-36.14
	18	41.50
	18	-178.70
D	36	-101.07
D	36	-137.21
C	72	18.07
C	72	-18.07
B	108	137.21
B	108	101.07
	126	178.70
	126	-41.50
A	144	36.14
A	144	0.00



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**: ΔV_D is calculated as the peak average difference between the shear in the dampers above and below the story among the 11 ground motions.

***: ratio of the total story shear in the dampers above the level over the total story shear in the dampers below the level. This ratio is then used to proportion the loads to the dampers above and below the level

A.4 - Evaluation of Secondary Framing

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	location Inglewood, CA	date 10/19/21	
	client	job no. 2000362	
	Evaluation of Secondary Framing		

Executive Summary

The following sections includes the assessment of the secondary framing elements in the library building. As described in Section 9 of the Volume 1 calculations all secondary beams have been modeled at the lecture hall as elastic elements. All beams that support the discontinuous walls in the upper levels of the library have been modeled as inelastic elements and per the performance assessment provided in A.2.a the beams supporting discontinuous walls meet all acceptance criteria.

Elastic beams modeled in PERFORM-3D will be checked using strength sections. Conservatively to account for χ increasing to 1.3 at the BSE-1E the DCR's found through the strength sections in PERFORM will be multiplied by 1.3.

Per the assessment shown in the following pages all existing secondary beams meet the acceptance criteria.

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	location Inglewood, CA	date 10/19/21	
	client	job no. 2000362	
	Evaluation of Secondary Framing		

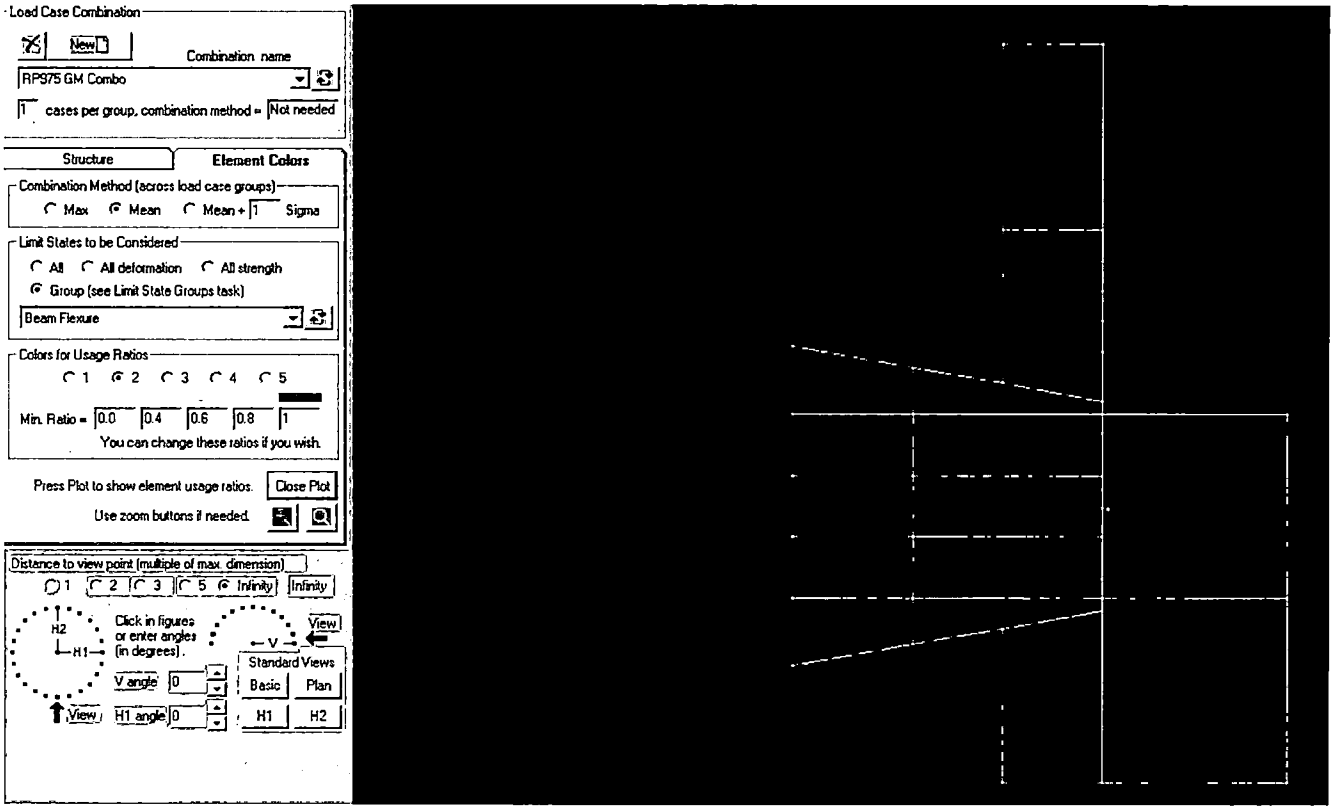
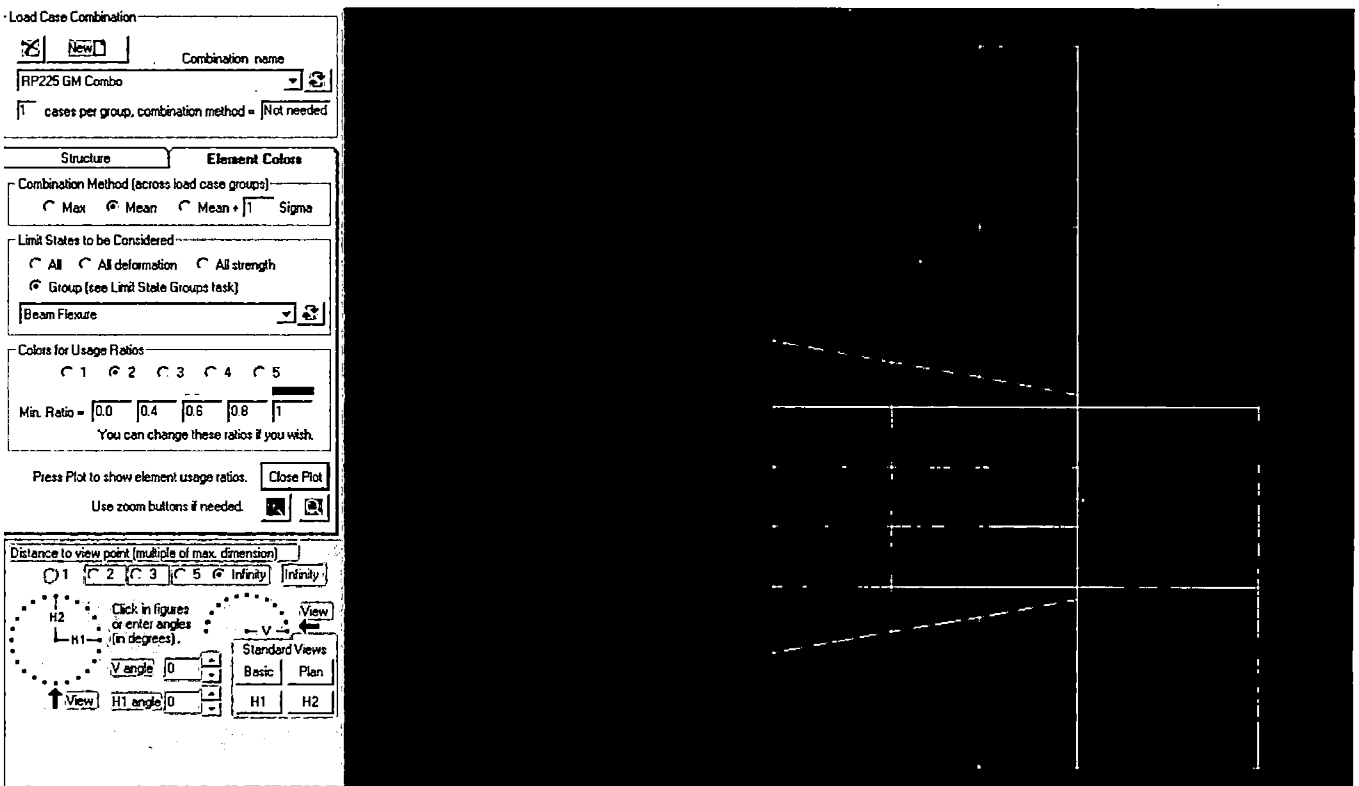


Figure A.4-1 Average of 11 Ground Motions, BSE-2E, Flexural Capacity, Lower Bound Damper Properties, Strength Limits



Max DCR = 0.62*1.3 = 0.81
Therefore Adequate

Figure A.4-2 Average of 11 Ground Motions, BSE-1E, Flexural Capacity, Lower Bound Damper Properties, Strength Limits

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location Inglewood, CA	date 10/19/21	
client	job no. 2000362	
Evaluation of Secondary Framing		

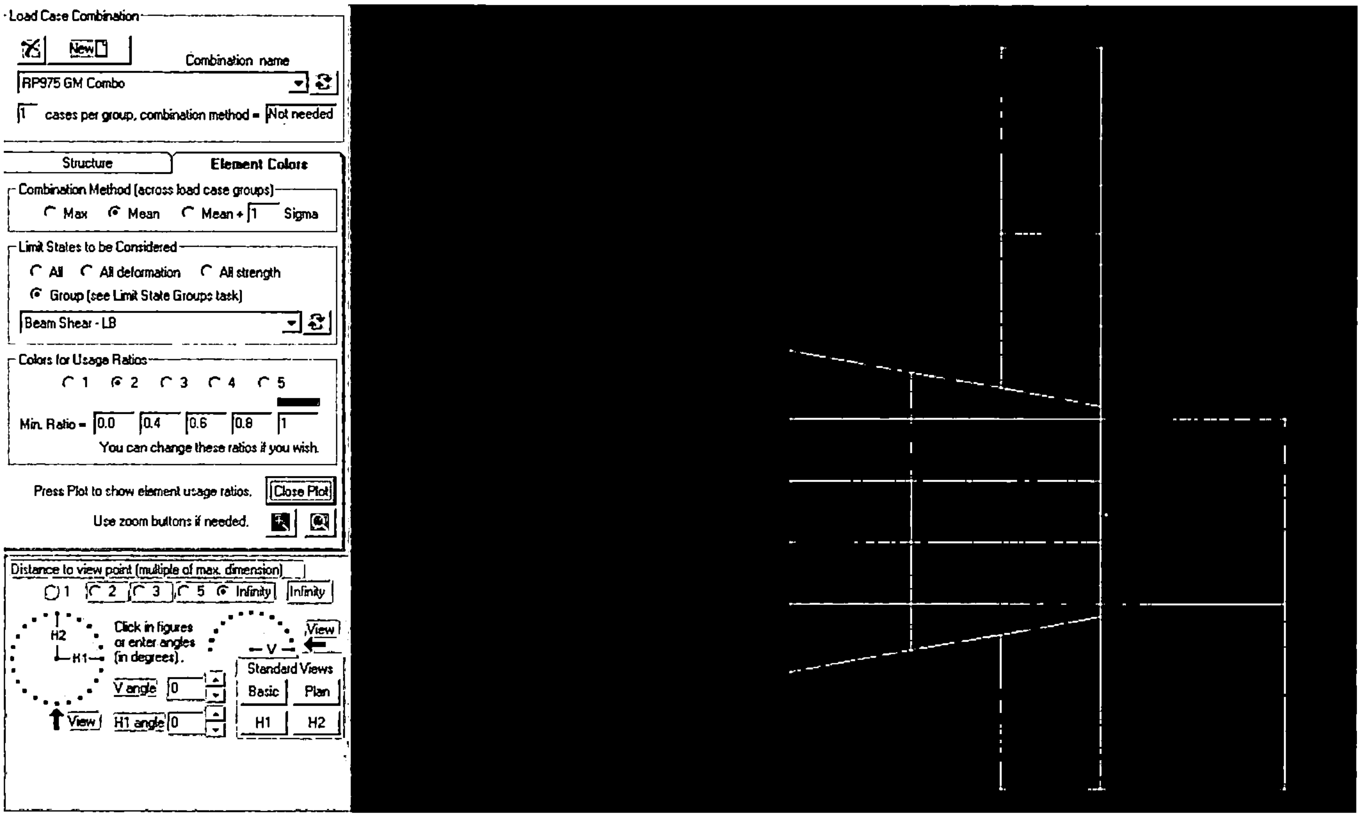
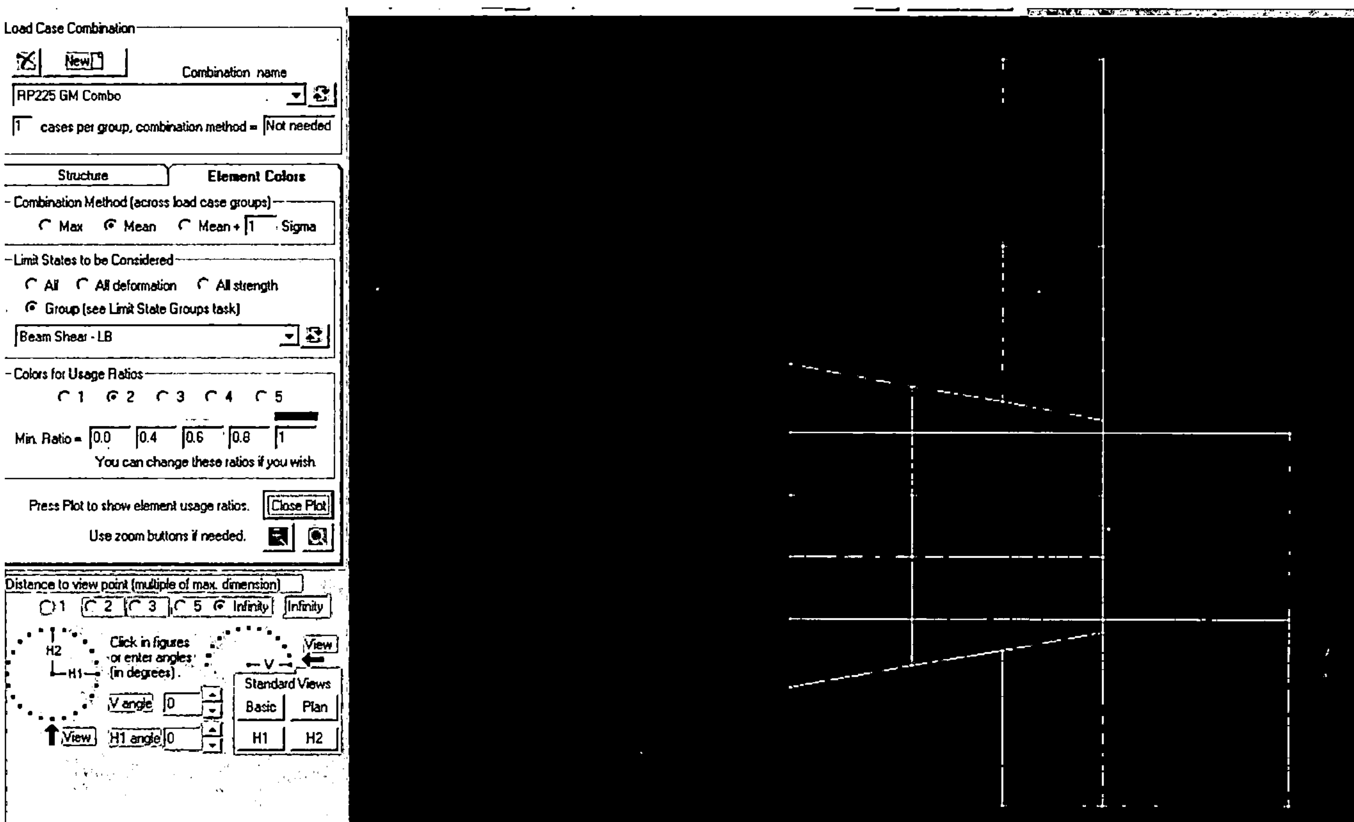


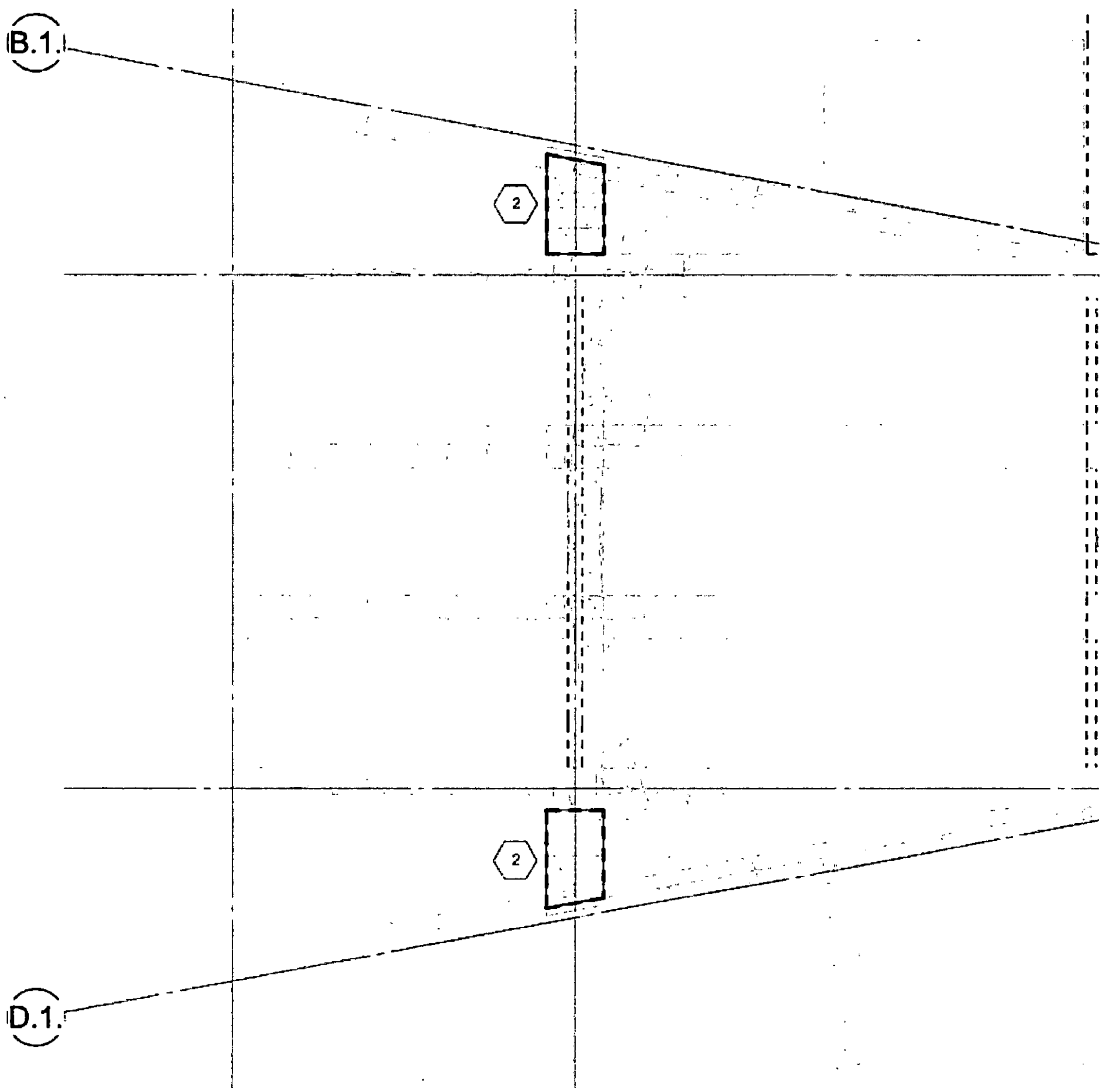
Figure A.4-4 Average of 11 Ground Motions, BSE-2E, Shear Capacity, Lower Bound Damper Properties, Strength Limits



Max DCR = 0.7*1.3 = 0.91
Therefore Adequate

Figure A.4-4 Average of 11 Ground Motions, BSE-1E, Shear Capacity, Lower Bound Damper Properties, Strength Limits

Per the DCR's shown in the previous pages and collector checks done on the lecture hall beams, see Section A.3.b, the proposed FRP strengthening at the beams on Grid 7, highlighted in blue below, is no longer needed and will be removed from future drawing submittals.



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B - Retrofit Design

B.1 - New Grade Beam Design

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	location Inglewood, CA	date 10/20/21	
	client	job no. 2000362	
	New Grade Beam Design		

Executive Summary

The following section includes calculations of the reinforcing required a the new grade beam. Stability is checked in Section A.1.e. Due to the grade beam acting as a continous wall footing and the lack of uplift in the combined footing, the grade beam longitudinal reinforcing will be designed for the minimum beam reinforcing. Longitudinal bars will be fully developed into the existing footing by providing the required development length per ACI 318 as embedment depth into the existing footings.

Minimum required Reinforcement:

Width, b = 36"
Height, h = 40" (to match existing footings)
f'c = 4000psi
fy = 60ksi

Assume #6 bars

d = 40" - 3" - 0.75"/2 = 36.625"

Per ACI 318-14 9.6.1.2, min As in a beam is

min of ((3√f'c)/fy)*b*d or (200/fy)*b*d

min(((3√4000psi)/60000psi)*36"*36.625", (200/60000psi)*36"*36.625")
min(4.17 in^2, 4.39 in^2)

Therefore use (10) #6's top and bottom.

Minimum skin Reinforcement required per ACI 318-14 9.7.2.3:

clear cover to skin reinforcement, c_c = 3"
required spacing, s = min(15(40000/fs)-2.5c_c, 12(40000/fs)) per ACI 318-14 table 24.3.2

Per 24.3.2.1 fs can be taken as (2/3)fy

Therefore required s = min(7.5", 12")
s = 7.5" min

Therefore use (4) #4's skin bars EF.

Check Development Length of Grade Beam Bars:

All bars will be #6's.
Existing foundations NWC, $f'c_E$ = 6718 psi

Fy_E = 75ksi

$$l_d = \left(\frac{3}{40} \frac{f_y}{\lambda \sqrt{f'_c}} \frac{\psi_t \psi_e \psi_s}{\left(\frac{c_b + K_{tr}}{d_b} \right)} \right) d_b \qquad (25.4.2.3a)$$

λ = 1.0 for NWC

ψ_t = 1.0 per ACI 318-14 Table 25.4.2.4
ψ_e = 1.0 per ACI 318-14 Table 25.4.2.4
ψ_s = 0.8 per ACI 318-14 Table 25.4.2.4

c_b = 3" (minimum concrete cover to a #6 cast against earth)

Conservatively assume K_{tr} = 0

c_b+K_{tr}/d_b = 4 > 2.5 Therefore use 2.5

$L_d = 21.96d_b$ = 16.5"

Therefore specify 18" of embedment for a #6 into footings.

B.2 - New Concrete Wall Design

Executive Summary

The following sections include calculations of the reinforcing required at the new concrete walls and the shear transfer reinforcement required at the existing footings and into the existing beams. Longitudinal bars will be fully developed where possible into the existing elements where possible by providing the required development length per ACI 318 as embedment depth into the existing footings.

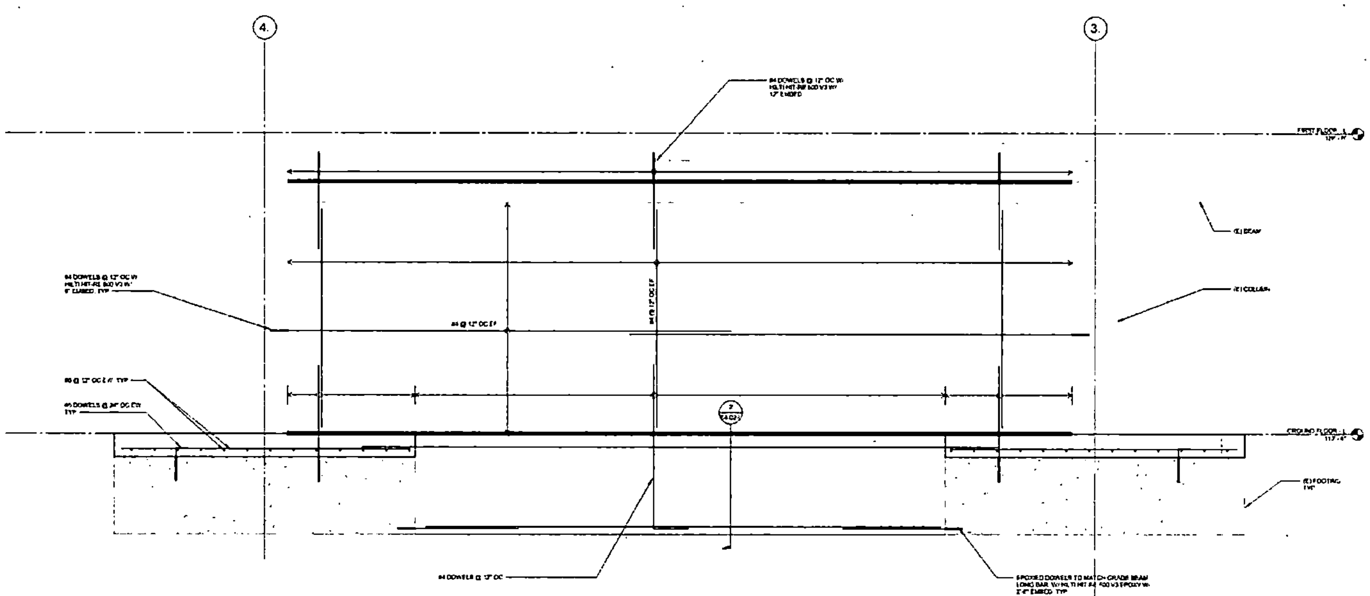
The new concrete walls will be split into two categories:
-Shotcrete walls - 8" Thick cast against CMU walls
-Cast-in-Place Walls - 12" Thick walls on Grids E and 7

B.2.a - Cast-in-Place Walls

Executive Summary

Per the performance assessment presented in section A.2.d the Cast-in-Place walls remain elastic in flexure and in shear. The walls were defined with the minimum reinforcing ratio requirement of ACI 318-14 18.10.2.1 of 0.0025, (2) layers of #4's @12" OC. Since walls remain elastic flexural and shear reinforcement are adequate. The follow section details calculations for the shear transfer reinforcement required at the top and bottom of these walls.

Shear Friction Dowels in New Cast In Place Walls:



1 (N) SHEARWALL ELEVATION

Shear Friction dowels at the top and bottom of the the new cast in place walls will be designed to resist the full shear capacity of the wall. These dowels will be embedded deeply enough into the beams and footings to provide full capacity of the rebar. Per ICC ESR-3814 for Hilti HIT-RE 500 V3 full strength of epoxied post installed bars can be achieved by fully developing the bar.

Shear Friction Dowels in New Cast In Place Walls:

Check Development Length of Dowels:

All dowels will be #4's. (4) different conditions occur at these dowels. Conservatively expected strengths will be used at all conditions.

1. Dowels into 1st floor Library beams LWC, f'c = 5436 psi
2. Dowels into Lecture Hall beams NWC, f'c = 5723 psi
3. Dowels into existing foundations NWC, f'c = 6718 psi
4. Dowels into new foundations NWC, f'c = 5200 psi
5. Dowels into existing columns NWC, f'c = 5990psi

Fy = 75ksi in all cases

$$l_d = \left(\frac{3}{40} \frac{f_y}{\lambda\sqrt{f_c'}} \frac{\psi_t \psi_e \psi_s}{\left(\frac{c_b + K_{tr}}{d_b}\right)} \right) d_b \qquad (25.4.2.3a)$$

λ = 0.75 for case 1, and 1.0 at all other cases

ψ_t = 1.0 per ACI 318-14 Table 25.4.2.4
ψ_e = 1.0 per ACI 318-14 Table 25.4.2.4
ψ_s = 0.8 per ACI 318-14 Table 25.4.2.4

c_b = 1.5" (minimum concrete cover to a #4 exposed to weather)

Conservatively assume K_{tr} = 0

c_b+K_{tr}/d_b = 3 > 2.5 Therefore use 2.5

$L_{d,1}$ = 32.55d_b = 16.3"

$L_{d,2}$ = 23.8db = 11.9"

$L_{d,3}$ = 22.0db = 11"

$L_{d,4}$ = 25.0db = 12.5"

$L_{d,5}$ = 23.26db = 11.6"

Therefore specify 18" of embedment at case 1, and 14" of embedment at all others.

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	client	job no. 2000362	
	Cast In Place Walls		

Shear Friction Dowels in New Cast In Place Walls:

Check Shear Friction Capacity of Dowels:

$As = 0.2in^2 * 2$ layers $= 0.4in^2/ft$
$\rho = .4/(12"*12") = 0.0028$, within the limits of Mattocks equation for NWC conc per BOD section 5.2.4. However $A_{vf}*fy_E/A_c > 200$ therefore use equation 5-2 of BOD.

$Vu = Acv(3\sqrt{f'c_E}+\rho fy_E) = (36'*12*12")*(3*(\sqrt{5200psi})+0.0028*75ksi*1000)/1000$
$Vu = 2210.11k$
$vu = 2210.11/36' = 61.4$ klf

using Mattocks equation

$vn = 0.8*A_{vf}*fy_E+A_c*K_1$
$fy_E = 75ksi$
$A_c = (12")(12") = 144in^2$
$K_1 = 200psi$ LWC, $400psi$ NWC

A_{vf} required $= (vu-A_c*K_1)/(0.8*fy)$

A_{vf} required, case 1 $= 0.543\ in^2/ft$

A_{vf} required, all other cases $= 0.0633\ in^2/ft$

Therefore specify (3) rows of #4's @12" OC, middle layer staggered, into existing library beams.
Specify (2) rows of #4's @ 12 OC at all other cases.

B.2.b - Shotcrete Walls

Executive Summary

Per the performance assessment presented in section A.2.d the shotcrete walls remain elastic in flexure and in shear. The walls were defined with the minimum reinforcing ratio requirement of ACI 318-14 18.10.2.1 of 0.0025, (1) layers of #5's @12" OC. Since walls remain elastic flexural and shear reinforcement are adequate. The follow section details calculations for the shear transfer reinforcement required at the top and bottom of these walls.

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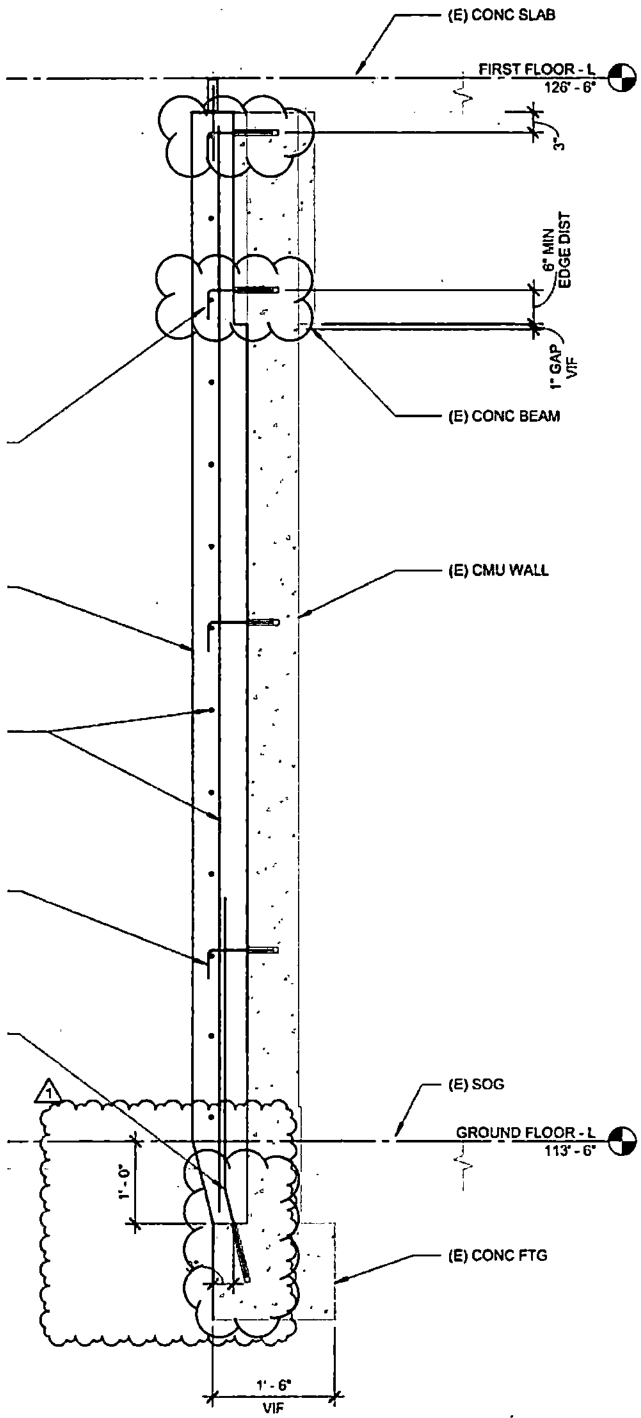
	location Inglewood, CA	date 10/16/21	
	client	job no. 2000362	
	Shotcrete Walls		

Shear Friction Dowels in Shotcrete Walls:



Shear Friction dowels at the top and bottom of the the new cast in place walls will be designed tc resist the shear demand of the wall. These dowels will be partially embedded deeply into the beams and footings and will be checked using Hilti Profis.

Shear Friction Dowels in Shotcrete Walls:

Check Shear Friction Capacity of Dowels @ Bottom of Wall:

Use worst case shear demand from PERFORM Model in shotcrete walls.
vu = 28.1klf (per Section A.3.b)

Try a #4 @12" OC embedded 11" per calculations in B.2.a to fully develop bar.
$vn = 0.8*A_{vf}*fy_{LB}+A_c*K_1$
$A_{vf} = 0.2in^2/ft$
$A_c = 5"*12" = 60in^2$
$K_1 = 400psi$
Check min of $A_{vf}fy/A_c \geq 200psi$
(0.2*60,000)/60 = 200psi therefore ok to use Mattock's equation

$vn = 0.8*0.2in^2*60ksi+60in^2*400psi =$ 33.6 k/ft

DCR = 0.84

Therefore specify #4's @12" OC w/ 11" embed at bottom of wall.

Check Dowels into Side of Beam and into slab @ Top of Wall:

Use worst case shear demand from PERFORM Model in shotcrete walls.
vu = 28.1klf (per Section A.3.b)

Demands at the top of the wall will be resisted by two groups at the top of the wall. One group will be an anchor embedded into the bottom of the slab and the other will be anchors into the side of the beam.

Into the top of the wall:
Hilti Profis does not allow phi to be changed to 1. Nominal Capacities will be obtained through the Profis results report, see the following pages.

Per profis report 7.359k/ft is the capacity of a #5 epoxied dowel at 12" OC. Can increase spacing to 9" OC without accounting for group effects
vn = 7.359k/ft (12/9) = 10.05 k/ft

Into side of the beam:
Due to the longitudinal bars in the beam a shear breakout failure should not occur. Hilti profis does not allow the user to remove failure mechanisms therefore only steel shear failure or shear pryout will be used to determine the capacity of the anchorage.

700 South Flower Street, Suite 2100
Los Angeles, CA 90017
(213) 418-0201

Try (3) #4's with 9" edge spacing, 9" embed and a 9" OC spacing. Model a typical 18' bay in Profis to account for group effects. See output in the following pages.

Per profis output vn = 358,316#/18'/1000 = 19.91 k/ft

Total vn = 19.91k/ft + 10.05k/t = 29.96k/ft

DCR = 28.1/29.96 = 0.94

Therefore specify (1) #5 @ 9" OC w/ 3" effective embed into bottom of slab. Specify (3) rows of #4's @9" OC w/ 9" edge distance & 9" effective embed into the side of the beam.

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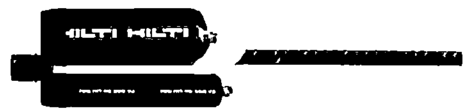
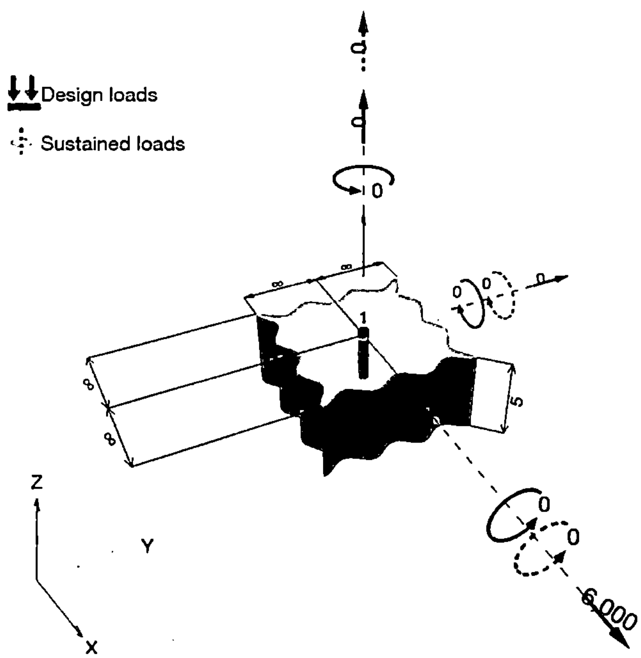
Specifier's comments:

1 Input data



Anchor type and diameter:	**HIT-RE 500 V3 + Rebar A706 Gr.60 #5**
Item number:	not available (element) / 2123401 HIT-RE 500 V3 (adhesive)
Effective embedment depth:	$h_{ef,act}$ = 3.000 in. ($h_{ef,limit}$ = - in.)
Material:	ASTM A 706 Gr.60
Evaluation Service Report:	ESR-3814
Issued I Valid:	3/1/2021 | 1/1/2023
Proof:	Design Method ACI 318-14 / Chem
Stand-off installation:	
Profile:	
Base material:	cracked lightweight concrete, 5000, f_c' = 5,000 psi; h = 5.000 in., Temp. short/long: 32/32 °F
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	tension: condition B, shear: condition B; no supplemental splitting reinforcement present edge reinforcement: none or < No. 4 bar
Seismic loads (cat. C, D, E, or F)	Tension load: yes (17.2.3.4.3 (d)) Shear load: yes (17.2.3.5.3 (c))

Geometry [in.] & Loading [lb, in.lb]



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1.1 Design results

Case	Description	Forces [lb] / Moments [in.lb]	Seismic	Max. Util. Anchor [%]
1	Combination 1	$N = 0; V_x = 6{,}000; V_y = 0;$ $M_x = 0; M_y = 0; M_z = 0;$ $N_{sus} = 0; M_{x,sus} = 0; M_{y,sus} = 0;$	yes	117

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2 Load case/Resulting anchor forces

Anchor reactions [lb]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	0	6,000	6,000	0

max. concrete compressive strain: - [‰]
max. concrete compressive stress: - [psi]
resulting tension force in (x/y)=(0.000/0.000): 0 [lb]
resulting compression force in (x/y)=(0.000/0.000): 0 [lb]

3 Tension load

	Load N_{ua} [lb]	Capacity ϕ N_n [lb]	Utilization $\beta_N = N_{ua}/\phi$ N_n	Status
Steel Strength*	N/A	N/A	N/A	N/A
Bond Strength**	N/A	N/A	N/A	N/A
Sustained Tension Load Bond Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Failure**	N/A	N/A	N/A	N/A

* highest loaded anchor **anchor group (anchors in tension)

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Fastening point:			

4 Shear load

	Load V_{ua} [lb]	Capacity ϕ V_n [lb]	Utilization $\beta_V = V_{ua}/\phi$ V_n	Status
Steel Strength*	6,000	6,770	89	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength (Bond Strength controls)**	6,000	5,151	117	not recommended
Concrete edge failure in direction **	N/A	N/A	N/A	N/A

* highest loaded anchor **anchor group (relevant anchors)

4.1 Steel Strength

$V_{sa,eq}$ = ESR value refer to ICC-ES ESR-3814

$\phi\ V_{steel} \geq V_{ua}$ ACI 318-14 Table 17.3.1.1

Variables

$A_{se,V}$ [in.^{2}]	f_{uta} [psi]	$\alpha_{V,seis}$
0.31	80,000	0.700

Calculations

$V_{sa,eq}$ [lb]
10,416

Results

$V_{sa,eq}$ [lb]	ϕ_{steel}	$\phi\ V_{sa,eq}$ [lb]	V_{ua} [lb]
10,416	0.650	6,770	6,000

NOMINAL CAPACITY OF A SINGLE ANCHOR

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4.2 Pryout Strength (Bond Strength controls)

$V_{cp} = k_{cp}\left[\left(\frac{A_{Na}}{A_{Na0}}\right) \psi_{ed,Na}\ \psi_{cp,Na}\ N_{ba}\right]$ ACI 318-14 Eq. (17.5.3.1a)

$\phi\ V_{cp} \geq V_{ua}$ ACI 318-14 Table 17.3.1.1

A_{Na} see ACI 318-14, Section 17.4.5.1, Fig. R 17.4.5.1(b)

$A_{Na0} = (2\ c_{Na})^2$ ACI 318-14 Eq. (17.4.5.1c)

$c_{Na} = 10\ d_a \sqrt{\frac{\tau_{uncr}}{1100}}$ ACI 318-14 Eq. (17.4.5.1d)

$\psi_{ed,Na} = 0.7 + 0.3 \left(\frac{c_{a,min}}{c_{Na}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.5.4b)

$\psi_{cp,Na} = \mathrm{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{c_{Na}}{c_{ac}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.5.5b)

$N_{ba} = \lambda_a \cdot \tau_{k,c} \cdot \alpha_{N,seis} \cdot \pi \cdot d_a \cdot h_{ef}$ ACI 318-14 Eq. (17.4.5.2)

Variables

k_{cp}	$\alpha_{overhead}$	$\tau_{k,c,uncr}$ [psi]	d_a [in.]	h_{ef} [in.]	$c_{a,min}$ [in.]	$\tau_{k,c}$ [psi]
2	1.000	2,045	0.625	3.000	∞	1,542

c_{ac} [in.]	λ_a	$\alpha_{N,seis}$
6.423	0.450	0.900

Calculations

c_{Na} [in.]	A_{Na} [in.^{2}]	A_{Na0} [in.^{2}]	$\psi_{ed,Na}$
8.484	287.93	287.93	1.000

$\psi_{cp,Na}$	N_{ba} [lb]
1.000	3,679

Results

V_{cp} [lb]	$\phi_{concrete}$	$\phi_{seismic}$	$\phi_{nonductile}$	$\phi\ V_{cp}$ [lb]	V_{ua} [lb]
7,359	0.700	1.000	1.000	5,151	6,000

NOMINAL
CAPACITY OF A
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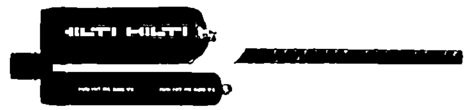
Specifier's comments:

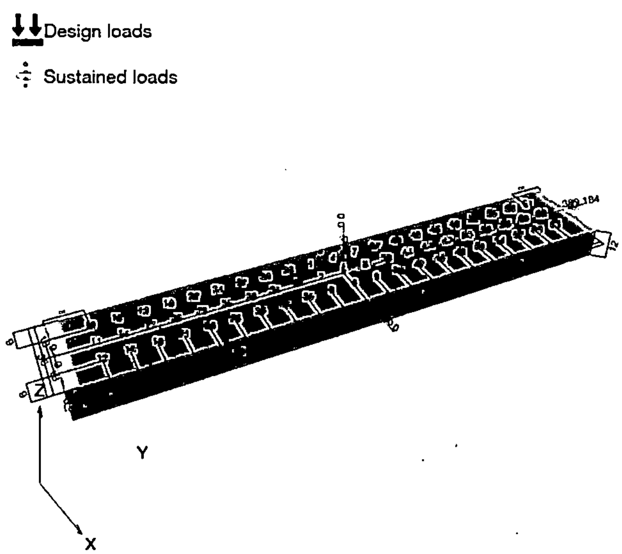
1 Input data



Anchor type and diameter:	**HIT-RE 500 V3 + Rebar A615 Gr.60 #4**
Item number:	not available (element) / 2123401 HIT-RE 500 V3 (adhesive)
Effective embedment depth:	$h_{ef,act}$ = 9.000 in. ($h_{ef,limit}$ = - in.)
Material:	ASTM A 615 Gr.60
Evaluation Service Report:	ESR-3814
Issued I Valid:	3/1/2021 | 1/1/2023
Proof:	Design Method ACI 318-14 / Chem
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.500 in.
Anchor plate^R :	l_x x l_y x t = 36.000 in. x 198.000 in. x 0.500 in.; (Recommended plate thickness: not calculated)
Profile:	no profile
Base material:	cracked lightweight concrete, 5000, f_c' = 5,000 psi; h = 12.000 in., Temp. short/long: 32/32 °F
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	tension: condition B, shear: condition B; no supplemental splitting reinforcement present edge reinforcement: none or < No. 4 bar
Seismic loads (cat. C, D, E, or F)	Tension load: yes (17.2.3.4.3 (d)) Shear load: yes (17.2.3.5.3 (c))

^{R} - The anchor calculation is based on a rigid anchor plate assumption.

Geometry [in.] & Loading [lb, in.lb]



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Fastening point:			

1.1 Design results

Case	Description	Forces [lb] / Moments [in.lb]	Seismic	Max. Util. Anchor [%]
1	Combination 1	$N = 0$; $V_x = 0$; $V_y = 329{,}184$; $M_x = 0$; $M_y = 0$; $M_z = 0$; $N_{sus} = 0$; $M_{x,sus} = 0$; $M_{y,sus} = 0$;	yes	379

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SECTIONS 4.1, 4.2 AND 4.3 OF HILIT
REPORT

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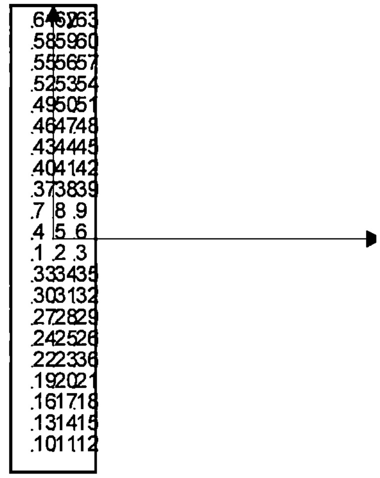
2 Load case/Resulting anchor forces



Anchor reactions [lb]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	0	5,225	0	5,225
2	0	5,225	0	5,225
3	0	5,225	0	5,225
4	0	5,225	0	5,225
5	0	5,225	0	5,225
6	0	5,225	0	5,225
7	0	5,225	0	5,225
8	0	5,225	0	5,225
9	0	5,225	0	5,225
10	0	5,225	0	5,225
11	0	5,225	0	5,225
12	0	5,225	0	5,225
13	0	5,225	0	5,225
14	0	5,225	0	5,225
15	0	5,225	0	5,225
16	0	5,225	0	5,225
17	0	5,225	0	5,225
18	0	5,225	0	5,225
19	0	5,225	0	5,225
20	0	5,225	0	5,225
21	0	5,225	0	5,225
22	0	5,225	0	5,225
23	0	5,225	0	5,225
24	0	5,225	0	5,225
25	0	5,225	0	5,225
26	0	5,225	0	5,225
27	0	5,225	0	5,225
28	0	5,225	0	5,225
29	0	5,225	0	5,225
30	0	5,225	0	5,225
31	0	5,225	0	5,225
32	0	5,225	0	5,225
33	0	5,225	0	5,225
34	0	5,225	0	5,225
35	0	5,225	0	5,225
36	0	5,225	0	5,225
37	0	5,225	0	5,225
38	0	5,225	0	5,225

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Fastening point:			

Anchor	Tension force	Shear force	Shear force x	Shear force y
39	0	5,225	0	5,225
40	0	5,225	0	5,225
41	0	5,225	0	5,225
42	0	5,225	0	5,225
43	0	5,225	0	5,225
44	0	5,225	0	5,225
45	0	5,225	0	5,225
46	0	5,225	0	5,225
47	0	5,225	0	5,225
48	0	5,225	0	5,225
49	0	5,225	0	5,225
50	0	5,225	0	5,225
51	0	5,225	0	5,225
52	0	5,225	0	5,225
53	0	5,225	0	5,225
54	0	5,225	0	5,225
55	0	5,225	0	5,225
56	0	5,225	0	5,225
57	0	5,225	0	5,225
58	0	5,225	0	5,225
59	0	5,225	0	5,225
60	0	5,225	0	5,225
61	0	5,225	0	5,225
62	0	5,225	0	5,225
63	0	5,225	0	5,225

max. concrete compressive strain: - [‰]
max. concrete compressive stress: - [psi]
resulting tension force in (x/y)=(0.000/0.000): 0 [lb]
resulting compression force in (x/y)=(0.000/0.000): 0 [lb]

Anchor forces are calculated based on the assumption of a rigid anchor plate.

3 Tension load

	Load N_{ua} [lb]	Capacity ϕ N_n [lb]	Utilization $\beta_N = N_{ua}/\phi$ N_n	Status
Steel Strength*	N/A	N/A	N/A	N/A
Bond Strength**	N/A	N/A	N/A	N/A
Sustained Tension Load Bond Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Failure**	N/A	N/A	N/A	N/A

* highest loaded anchor **anchor group (anchors in tension)

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4 Shear load

	Load V_{ua} [lb]	Capacity ϕ V_n [lb]	Utilization $\beta_V = V_{ua}/\phi\ V_n$	Status
Steel Strength*	5,225	4,536	116	not recommended
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength (Concrete Breakout Strength controls)**	329,184	250,821	132	not recommended
Concrete edge failure in direction x-**	329,184	86,968	379	not recommended

* highest loaded anchor **anchor group (relevant anchors)

4.1 Steel Strength

$V_{sa,eq}$ = ESR value	refer to ICC-ES ESR-3814
$\phi\ V_{steel} \geq V_{ua}$	ACI 318-14 Table 17.3.1.1

Variables

$A_{se,V}$ [in.^{2}]	f_{uta} [psi]	$\alpha_{V,seis}$
0.20	90,000	0.700

Calculations

$V_{sa,eq}$ [lb]
7,560

Results

$V_{sa,eq}$ [lb]	ϕ_{steel}	$\phi\ V_{sa,eq}$ [lb]	V_{ua} [lb]
7,560	0.600	4,536	5,225

NOMINAL
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4.2 Pryout Strength (Concrete Breakout Strength controls)

$V_{cpg} = k_{cp} \left[\left(\frac{A_{Nc}}{A_{Nc0}}\right) \psi_{ec,N}\ \psi_{ed,N}\ \psi_{c,N}\ \psi_{cp,N}\ N_b\right]$ ACI 318-14 Eq. (17.5.3.1b)

$\phi\ V_{cpg} \geq V_{ua}$ ACI 318-14 Table 17.3.1.1

A_{Nc} see ACI 318-14, Section 17.4.2.1, Fig. R 17.4.2.1(b)

$A_{Nc0} = 9\ h_{ef}^2$ ACI 318-14 Eq. (17.4.2.1c)

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\ e_N}{3\ h_{ef}}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.4)

$\psi_{ed,N} = 0.7 + 0.3\left(\frac{c_{a,min}}{1.5 h_{ef}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.5b)

$\psi_{cp,N} = \mathrm{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5 h_{ef}}{c_{ac}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.7b)

$N_b = k_c\ \lambda_a\ \sqrt{f'_c}\ h_{ef}^{1.5}$ ACI 318-14 Eq. (17.4.2.2a)

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	9.000	0.000	0.000	9.000

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ_a	f'_c [psi]
1.000	24.580	17	0.600	5,000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
7,452.00	729.00	1.000	1.000	0.900	1.000	19,474

Results

V_{cpg} [lb]	$\phi_{concrete}$	$\phi_{seismic}$	$\phi_{nonductile}$	$\phi\ V_{cpg}$ [lb]	V_{ua} [lb]
358,316	0.700	1.000	1.000	250,821	329,184

NOMINAL
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ANCHOR GROUP

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4.3 Concrete edge failure in direction x-

$V_{cbg} = \left(\frac{A_{Vc}}{A_{Vc0}}\right) \psi_{ec,V}\ \psi_{ed,V}\ \psi_{c,V}\ \psi_{h,V}\ \psi_{parallel,V}\ V_b$ ACI 318-14 Eq. (17.5.2.1b)

$\phi\ V_{cbg} \geq V_{ua}$ ACI 318-14 Table 17.3.1.1

A_{Vc} see ACI 318-14, Section 17.5.2.1, Fig. R 17.5.2.1(b)

$A_{Vc0} = 4.5\ c_{a1}^2$ ACI 318-14 Eq. (17.5.2.1c)

$\psi_{ec,V} = \left(\frac{1}{1 + \frac{2e_V}{3c_{a1}}}\right) \leq 1.0$ ACI 318-14 Eq. (17.5.2.5)

$\psi_{ed,V} = 0.7 + 0.3\left(\frac{c_{a2}}{1.5c_{a1}}\right) \leq 1.0$ ACI 318-14 Eq. (17.5.2.6b)

$\psi_{h,V} = \sqrt{\frac{1.5c_{a1}}{h_a}} \geq 1.0$ ACI 318-14 Eq. (17.5.2.8)

$V_b = \left(7\left(\frac{l_e}{d_a}\right)^{0.2} \sqrt{d_a}\right) \lambda_a \sqrt{f'_c}\, c_{a1}^{1.5}$ ACI 318-14 Eq. (17.5.2.2a)

DUE TO THE LONGITUDINAL BARS IN THE BEAM A SHEAR BREAOUT FAILURE WILL NOT OCCUR. FAILURE MECHANISM WILL NOT GOVERN.

Variables

c_{a1} [in.]	c_{a2} [in.]	e_{cV} [in.]	$\psi_{c,V}$	h_a [in.]
9.000	-	0.000	1.000	12.000

l_e [in.]	λ_a	d_a [in.]	f'_c [psi]	$\psi_{parallel,V}$
4.000	0.600	0.500	5,000	2.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [lb]
2,484.00	364.50	1.000	1.000	1.061	8,594

Results

V_{cbg} [lb]	$\phi_{concrete}$	$\phi_{seismic}$	$\phi_{nonductile}$	$\phi\ V_{cbg}$ [lb]	V_{ua} [lb]
124,240	0.700	1.000	1.000	86,968	329,184

B.3 - Fluid Viscous Damper Design

Executive Summary

The following sections present the design of the viscous dampers at the library building. Damper properties were varied +/- 15% per the calculations presented in Section 8 of the Volume 1 calculations and the envelope of the results are used to assess the existing condition and design all new elements.

B.3.a - Summary of Damper Properties and Results

Executive Summary

The following section presents a summary of damper design properties and results. Below is a summary of the damping coefficients used at each story for each model and a summary of design damper values obtained from the analysis.

COI Library Summary of Damping Coefficients			
Floor Level	Damping Coefficient (kip-sec/in)		
	$C_{nominal}$	$C_{Lower\ Bound}$	$C_{Upper\ Bound}$
4	70	59.5	80.5
3	106.5	90.525	122.475
2	141	119.85	162.15

COI Library Damper Design Properties Both Directions									
Floor Level	Damping Coefficient	Number of Dampers	Velocity Exponent	BSE-2E Damper Demands					
	C (kip-sec/in)	n	α	Nominal Damper Force (k)[1]	Max Damper Design Force (k)[2]	Nominal Damper Velocity (in/sec)[3]	Max Damper Design Velocity (k)[4]	Nominal Damper Stroke (+/-) (in)[5]	Max Damper Design Stroke (in)[6]
4	70	16	0.4	161.64	206.45	8.10	11.85	1.51	2.18
3	106.5	16	0.4	254.31	324.82	8.81	12.60	1.46	2.19
2	141	16	0.4	328.02	418.96	8.25	11.69	1.39	2.02

Notes:

1. Nominal Damper Force is the max average force obtained from a model with nominal Damper Properties.
2. $P = 1.15 * P_{Nominal} * 1.3^{0.4}$
3. Nominal Damper Velocity is the max average velocity obtained from a model with nominal Damper Properties.
4. $V_{design} = V_{LB} * 1.3$; V_{LB} obtained as max average velocity from a model with Lower Bound Damper Properties.
5. Nominal Damper stroke is the max average stroke obtained from a model with nominal Damper Properties.
6. $S_{design} = S_{LB} * 1.3$; S_{LB} obtained as max average stroke from a model with Lower Bound Damper Properties.

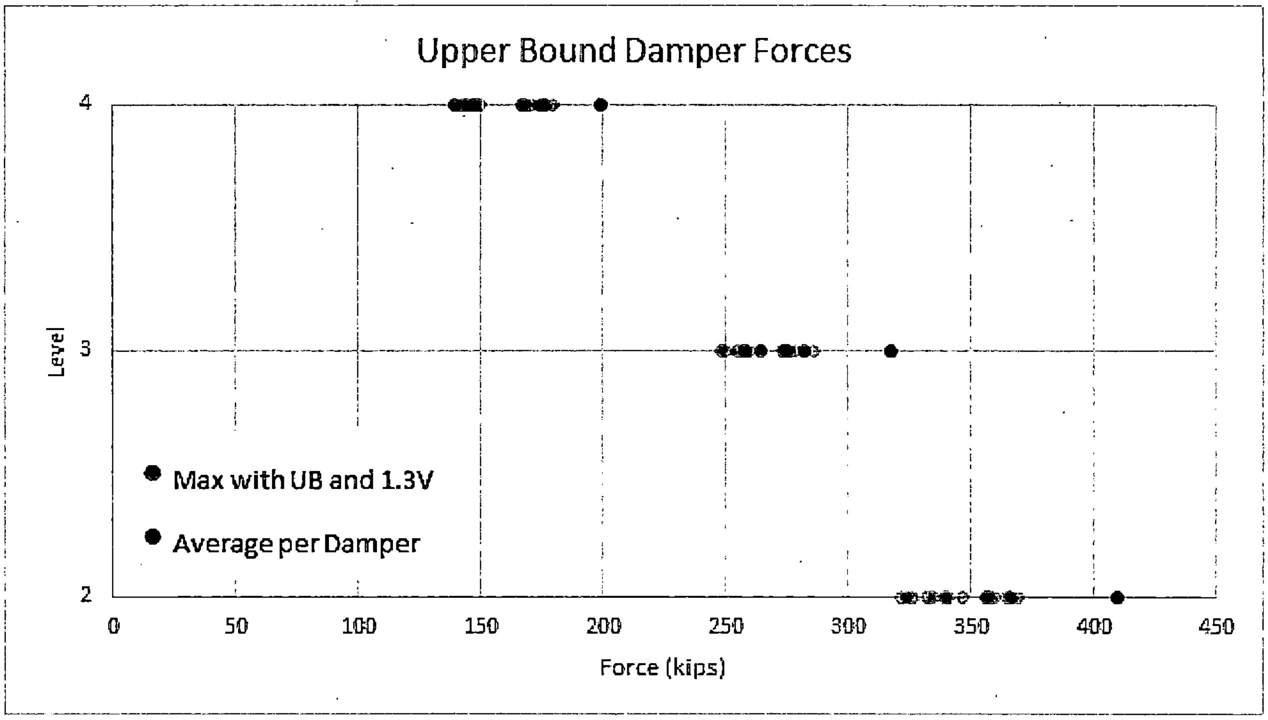

Figure B.3.a-1 Upper Bound Damper Forces. Forces are the average of the 11 ground motions Damper, and the shown maximum is the maximum Average value amplified by 130% Velocity.

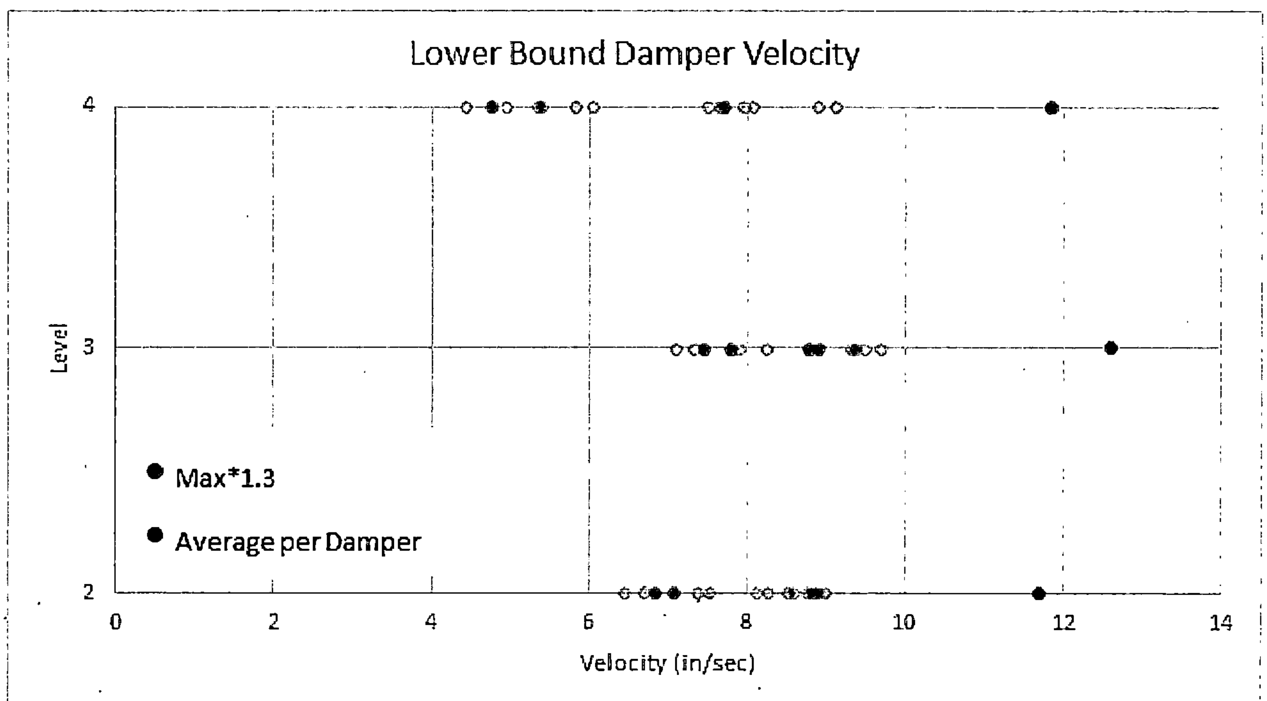

Figure B.3.a-2 Lower Bound Damper Velocities. Velocities are the average of the 11 ground motions per Damper, and the shown maximum is the maximum Average value amplified by 130%.

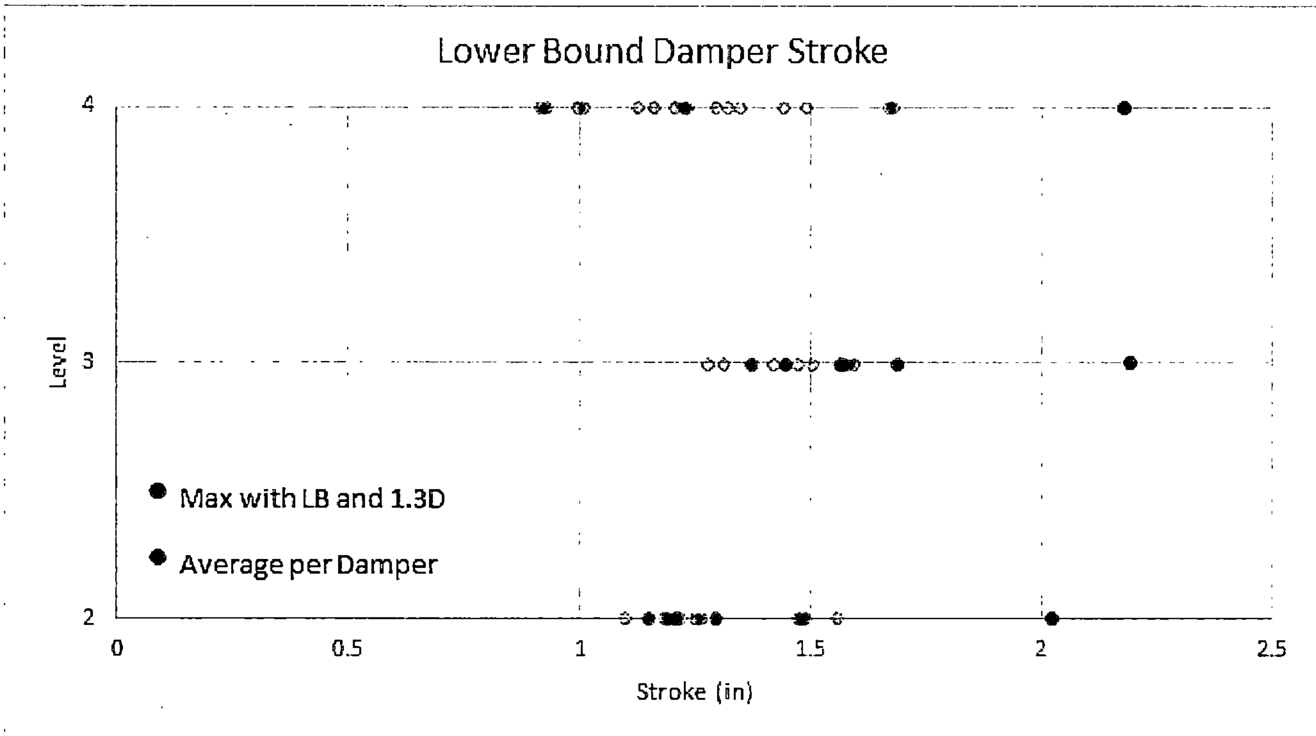

Figure B.3.a-3 Lower Bound Damper Stroke. Stroke values are the average of the 11 ground motions per Damper, and the shown maximum is the maximum Average value amplified by 130%.

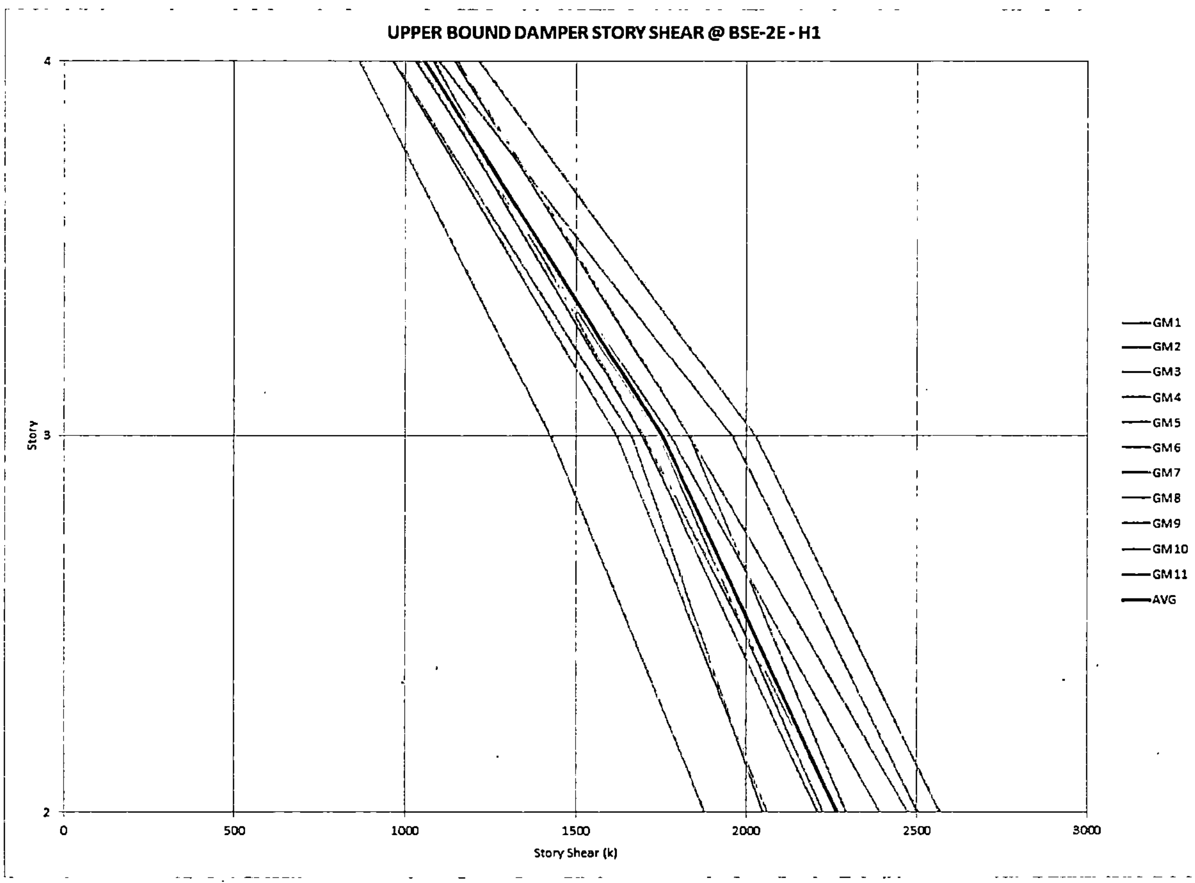

Figure B.3.a-4 Upper Bound Peak Average Damper Story Shear in the H1 Direction under the BSE-2E Hazard Level.

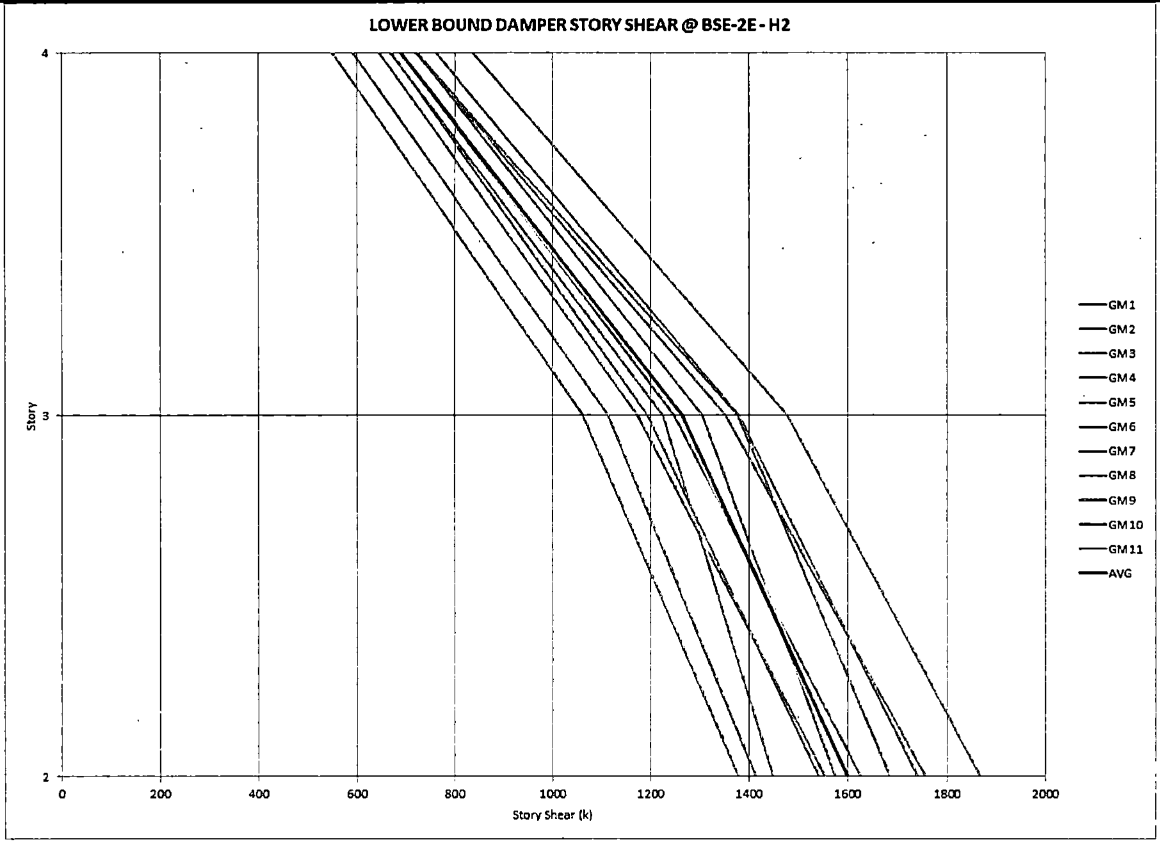

Figure B.3.a-5 Upper Bound Peak Average Damper Story Shear in the H2 Direction under the BSE-2E Hazard Level.

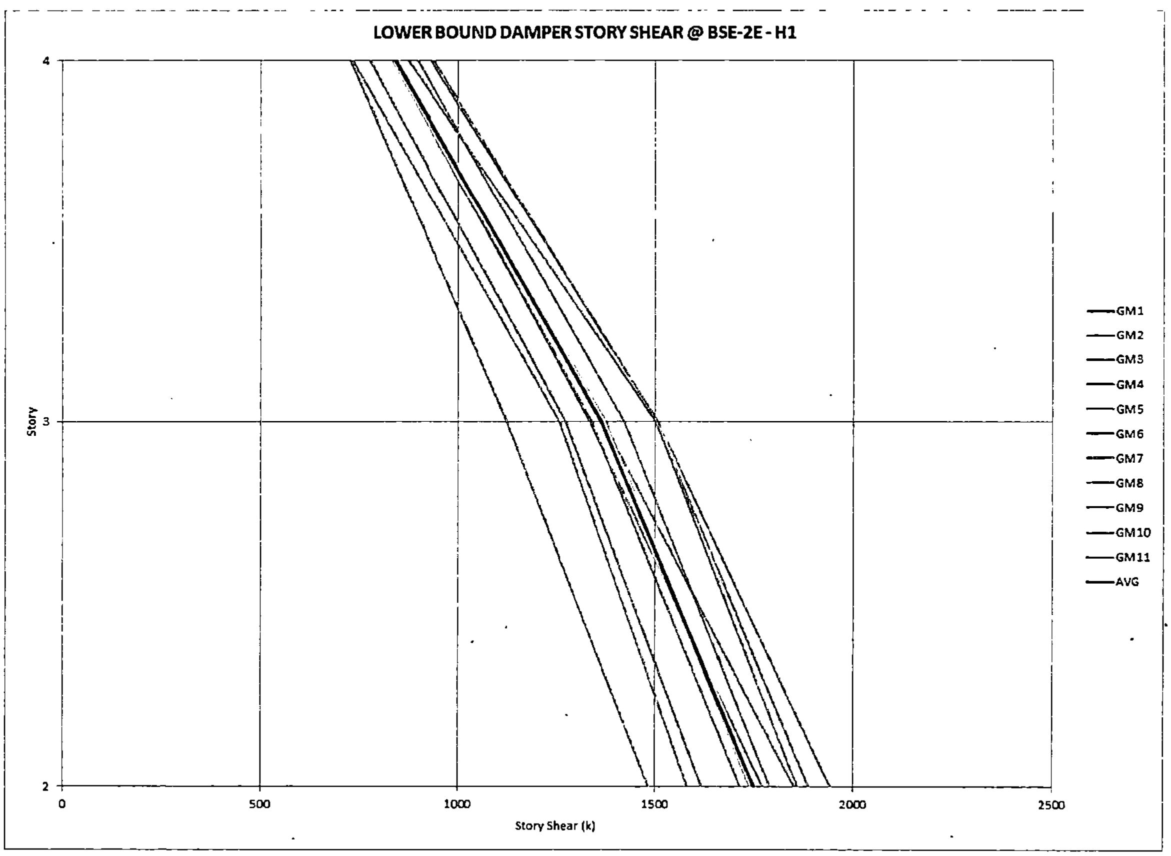

Figure B.3.a-6 Lower Bound Peak Average Damper Story Shear in the H1 Direction under the BSE-2E Hazard Level.

kpff	project City of Inglewood - Library	by JL	sheet no. B.3.a-6
	location Inglewood, CA	date 10/20/21	
	client	job no. 2000362	
	Fluid Viscous Dampers		

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Los Angeles, CA 90017
(213) 418-0201

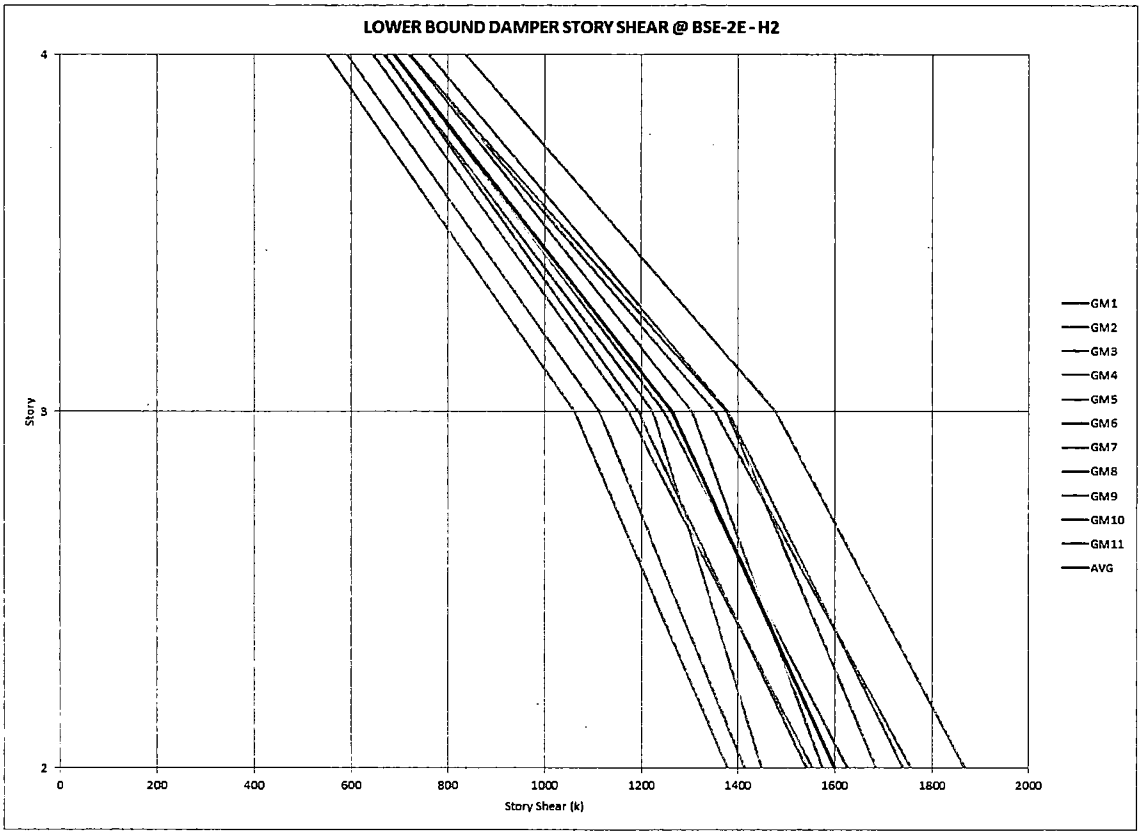

Figure B.3.a-7 Lower Bound Peak Average Damper Story Shear in the H2 Direction under the BSE-2E Hazard Level.

Figures B.3.a-4 through B.3.a-7 were used to establish the damper force relationship used in Section A.3.c to distribute forces to dampers above and below a level. The tables below summarize the story shears used to establish a story force relationship at each level. The Upper Bound values were used to favor higher forces to the level below to produce a higher change in collector force.

Upper Bound Damper Story Force Relationship Summary			
Level	Direction	Shear (k)	Ratio (Story Above/Story Below)
Roof	H1	1054.30	0.00
3rd	H1	1752.12	0.60
2nd	H1	2266.32	0.77
Roof	H2	873.68	0.00
3rd	H2	1609.97	0.54
2nd	H2	2072.91	0.78

Lower Bound Damper Story Force Relationship Summary			
Level	Direction	Shear (k)	Ratio (Story Above/Story Below)
Roof	H1	839.56	0.00
3rd	H1	1364.25	0.62
2nd	H1	1749.40	0.78
Roof	H2	688.83	0.00
3rd	H2	1263.74	0.55
2nd	H2	1599.03	0.79

B.3.b - Connection Design

Executive Summary

The following section presents the calculations for the gusset plate connections at the Beam-Column joints and the top chevron brace connection to the bottom of the beam. Gusset plate connections for a single in-framing damper were sized using the Uniform force method. Due to the chevron brace connection being a statically determinate system the internal forces used to design the gusset plate were determined using statics in lieu of the uniform force method.

Typical Bottom Connection

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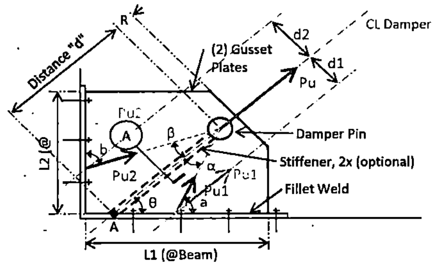
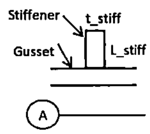
(213) 418-0201

project:	COI Library	by:	JL
location:	Inglewood, CA	date:	10/15/2021
client:	City of Inglewood	job no:	2000362

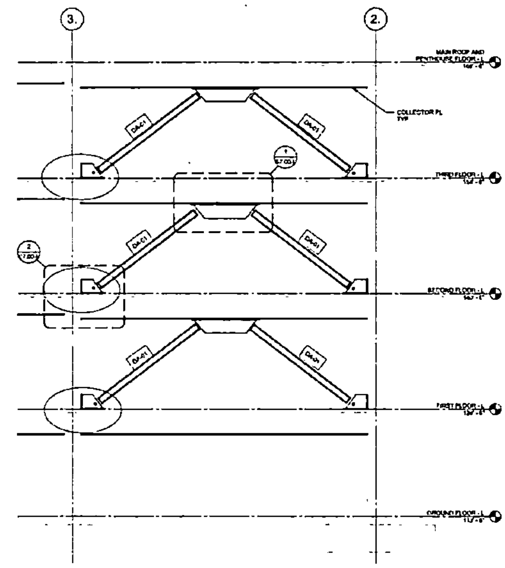
DESIGN OF GUSSET PLATES: Covered, Typical Single Connection





SUMMARY:

Check 1:	Gusset Plate Yielding at Gross Section	D/C =	0.30	; OK
Check 2:	Gusset Plate Fracture at Net Section	D/C =	0.44	; OK
Check 3:	Bearing of Pin Damper at Gusset Plate	D/C =	0.73	; OK
Check 4:	Buckling of Gusset Plate:	D/C =	0.98	; OK
Check 5:	Fillet Weld at Gusset to Plate Support	D/C =	0.14	; OK
Check 6a:	High-Strength Bolts @ L1 (Horizontal)	D/C =	0.83	; OK
Check 6b:	High-Strength Bolts @ L2 (Vertical)	D/C =	0.59	; OK
Check 7a:	Bearing of (N) Bolts on (E) Conc Beam	D/C =	0.63	; OK
Check 7b:	Bearing of (N) Bolts on (E) Conc Column	D/C =	0.56	; OK
Check 8a:	Vertical Shear Friction at Beam-Joint Interface	D/C =	0.53	; OK
Check 8b:	Horizontal Shear Friction at Column-Joint Interface	D/C =	0.13	; OK



INPUT:

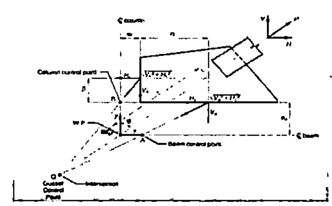
t =	1.50	in	; gusset plate thickness (1 plate)
d =	20.0	in	; distance along damper CL from "damper pin" to "frame"
R =	5	in	; R = 7-1/2" max for 440-kip damper (verify w/ manuf)
L1 =	46.0	in	; length of gusset plate horizontal support, see diagram above
L2 =	24.4	in	; length of gusset plate vertical support, see diagram above
w =	0.50	in	; fillet weld size
t_stiff =	0.00	in	; stiffener thickness (optional), see diagram above
L_stiff =	0.00	in	; stiffener length (optional), see diagram above
ϕ_pin =	3.5	in	; diameter of damper pin = 3.5" for 440-kip damper (verify w/ manuf)
θ =	38	degrees	; angle, per diagram above
α_{UFM} =	23.0	in	; distance from face of col to centroid of gusset cxn, UFM
β_{UFM} =	12.2	in	; distance from face of beam to centroid of gusset cxn, UFM
e_b =	15.0	in	; one half depth of the beam, Uniform Force Method
e_c =	12.0	in	; one half depth of the beam, Uniform Force Method
# of H Bolts =	8	bolts	; number of anchors engaged at horizontal plate support (L1)
H Bolt Dia =	1.00	in	; bolt diameter at horizontal plate support
# of V Bolts =	6	bolts	; number of anchors engaged at vertical plate support (L2)
V Bolt Dia =	1.00	in	;Bolt Diameter at vertical plate support
(E) Bm Depth =	30.0	in	; depth of (E) beam
(E) Col Depth =	24.0	in	; depth of (E) column
(E) Bm Width =	24.0	in	; width of (E) beam
(E) Col Width =	24.0	in	; width of (E) column
Pu =	408	kip	; gusset plate demand (max damper force including 130% Velocity)
Pu,vf =	367	kip	; UB Damper Force (100% V) Used for shear friciton
Fy =	50	ksi	; gusset plate steel material strength
Fu =	65	ksi	; gusset plate steel material strength
Fnt =	90	ksi	; high-strength A449 bolt tensile strength
Fnv =	54	ksi	; high-strength A449 bolt shear strength
FEXX =	70	ksi	; weld material strength
E =	29000	ksi	; steel Young's modulus
f'c =	5.042	ksi	; concrete strength of (E) beam and column
Col Rebar Size =	11		; Conservatively, smallest column bar size
Col Rebar Count =	8		
Bm Rebar Size =	10		; Conservatively, using worst case Top and Bottom Bars
Bm Rebar Count =	5		; Conservatively, (2) Bottom #10's, and (3) Top #10's
$V_{pr,Bm}$ =	125	kip	; Conservatively, use worst case Vpr from any Beam

CALCULATIONS:

Uniform Force Method

$r = \sqrt{(\alpha+e_c)^2 + (\beta+e_b)^2}$

r = 44 in



$Pub,x = P\alpha/r$
Pub,x = 211 kip

$Puc,x = Pe_c/r$
Puc,x = 110 kip

$Pub,y = Pe_b/r$
Pub,y = 138 kip

$Puc,y = P\beta/r$
Puc,y = 112 kip

Check 1: Gusset Plate Yielding at Gross Section
ϕPn = ϕ 2t L Fy ; conservatively assume L = 2R
ϕPn = 1350 kip
D/C = 0.30 ; OK

Check 2: Gusset Plate Fracture at Net Section
ϕPn = ϕ 2t (L - ϕ_pin - 1/8") Fu
ϕPn = 932 kip
D/C = 0.44 ; OK

Check 3: Bearing of Pin Damper at Gusset Plate
$\phi Rn = \phi\ 1.2Lc\ 2t\ Fu \le \phi\ 2.4\phi\_pin\ 2t\ Fu$
ϕRn = 559 kip
D/C = 0.73 ; OK

Typical Bottom Connection

Check 4: Bucking of Gusset Plate: (2) t × ϕ_pin Column Strips

kL/r =	42.0		; for (1) column strip
Fe =	162	ksi	; Euler stress
ϕPn =	415	kip	
D/C =	0.98	; OK	

Buckling of Gusset Plate w/ Stiffener:

A =	5.3	in^2	; for (1) T-section column strip per section A
YCG =	0.8	in	
I =	1.0	in^4	
r =	0.4	in	
kL/r =	42.0		
Fe =	162	ksi	; Euler stress
ϕPn =	415	kip	
D/C =	0.98	; OK	; very conservative approach

Check 5: Fillet Weld at Gusset to Plate Support

ϕRn = 2 × ϕ 0.707w 2L1 Fw ; horizontal plate support

ϕRn =	2049	kip
D/C =	0.12	; OK

ϕRn = 2 × ϕ 0.707w 2L2 Fw ; vertical plate support

ϕRn =	1089	kip
D/C =	0.14	; OK

Check 6a: High-Strength Bolts @ L1 (Horizontal)

frv = Pu1x / [Ab × (No of Bolts)]

frv =	34	ksi	; shear stress demand in bolts
D/C =	0.83		

F'nt = 1.3Fnt - Fnt/ϕFnv × frv ≤ Fnt

F'nt =	42	ksi	; tensile strength including shear stress effects

ϕRn = 0.75 × As F'nt × (No of Bolts)

ϕRn =	199	kip
D/C =	0.69	; OK

Check 6b: High-Strength Bolts @ L2 (Vertical)

frv = Pu1x / [Ab × (No of Bolts)]

frv =	24	ksi	; shear stress demand in bolts
D/C =	0.59		

F'nt =	64	ksi
ϕRn =	226	kip
D/C =	0.49	; OK

Check 7a: Bearing of (N) Bolts on (E) Conc Beam

Assume a triangular bearing pressure distribution (1/2 factor):

ϕBn = ϕ 0.85 f'c A1 × 1/2 ; A1 = Beam Depth × Bolt ϕ

ϕBn =	42	kip	; per bolt
D/C =	0.63	; OK	

Check 7b: Bearing of (N) Bolts on (E) Conc Column

ϕBn = ϕ 0.85 f'c A1 × 1/2 ; A1 = Column Depth × Bolt ϕ

ϕBn =	33	kip	; per bolt
D/C =	0.56	; OK	

Check 8a: Vertical Shear Friction at Beam-Joint Interface

Using Mattocks Eq and worst case Beam Top and Bottom bars at joint face

V_u = Pub,y/(1.3^0.4) + $V_{pr,\,Bm}$; removes 130% amplification from Damper demand

V_u = 249 kip

$V_n = 0.8A_{vf}f_{yL} + A_cK_1$

V_n = 474 kip

D/C = 0.53 ; OK

Check 8b: Horizontal Shear Friction at Column-Joint Interface

Using Mattocks Eq and only the bottom bars, This is very conservative because dampers act out of phase and we are only using the bottom bar

V_u = Puc,x/(1.3^0.4) ; removes 130% amplification from Damper demand

V_u = 99 kip

$V_n = 0.8A_{vf}f_{yL} + A_cK_1$

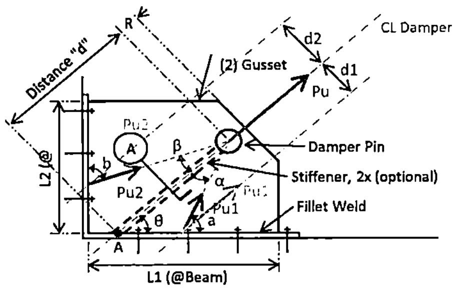
V_n = 764 kip

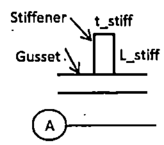
D/C = 0.13 ; OK

Typical Top Connection

kpff 700 S. Flower St, Suite 2100 Los Angeles, CA 90017 (213) 418-0201	project: COI Library location: Inglewood, CA client: City of Inglewood	by: JL date: 10/15/2021 job no: 2000362

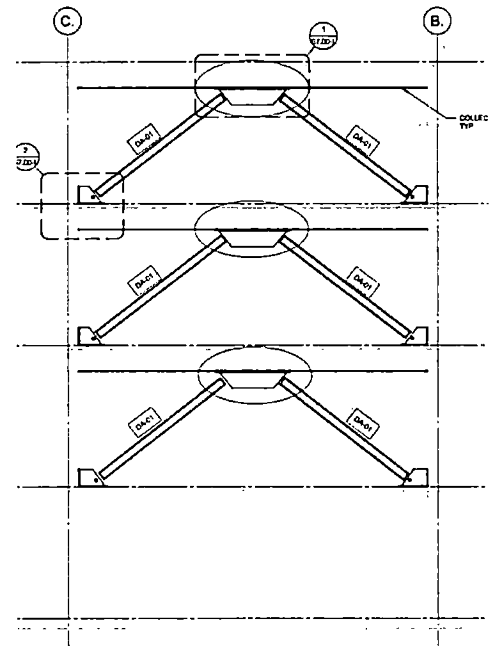
DESIGN OF GUSSET PLATES: Exposed, Elev Grid B, Typical





SUMMARY:

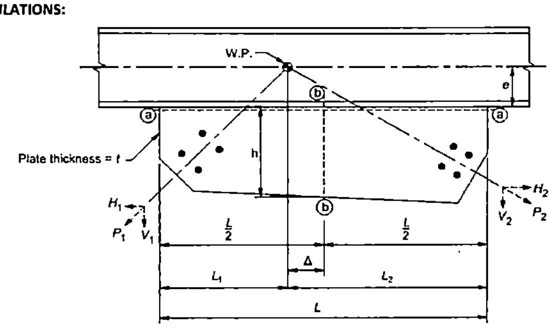
Check 1:	Gusset Plate Yielding at Gross Section	D/C =	0.30	; OK
Check 2:	Gusset Plate Fracture at Net Section	D/C =	0.44	; OK
Check 3:	Bearing of Pin Damper at Gusset Plate	D/C =	0.73	; OK
Check 4:	Bucking of Gusset Plate:	D/C =	0.98	; OK
Check 5:	Fillet Weld at Gusset to Plate Support	D/C =	0.12	; OK
Check 6:	Shear yielding along a-a	D/C =	0.09	; OK
Check 7:	Tensile yielding along a-a	D/C =	0.04	; OK
Check 8:	Shear yielding along b-b	D/C =	0.00	; OK
Check 9a:	High-Strength Bolts @ L1 (Horizontal)	D/C =	0.92	; OK
Check 9b:	High-Strength Bolts @ L2 (Vertical)	D/C =	0.00	; OK
Check 10a:	Bearing of (N) Bolts on (E) Conc Beam	D/C =	0.87	; OK
Check 10b:	Bearing of (N) Bolts on (E) Conc Column	D/C =	N/A	



INPUT:

t =	1.50	in	; gusset plate thickness (1 plate)
d =	20.0	in	; distance along damper CL from "damper pin" to "frame"
R =	5	in	; R = 6-3/8" max for 330-kip damper (verify w/ manuf)
L1 =	78.0	in	; length of gusset plate horizontal support, see diagram above
L2 =	21.0	in	; length of gusset plate vertical support, see diagram above
w =	0.50	in	; fillet weld size
t_stiff =	0.00	in	; stiffener thickness (optional), see diagram above
L_stiff =	0.00	in	; stiffener length (optional), see diagram above
ϕ_pin =	3.5	in	; diameter of damper pin = 3.5" for 440-kip damper (verify w/ manuf)
α =	5	degrees	; angle, per diagram above
β =	0	degrees	; angle, per diagram above
θ =	38	degrees	; angle, per diagram above
a =	27	degrees	; angle, per diagram above
b =	0	degrees	; angle, per diagram above
d1 =	1.6	in	; distance from Pu to Pu1 force, see diagram above
d2 =	0.0	in	; distance from Pu to Pu2 force, see diagram above
# of H Bolts =	14	bolts	; number of anchors engaged at horizontal plate support (L1)
H Bolt Dia =	1.25	in	; bolt diameter at horizontal plate support
# of V Bolts =	0	bolts	; number of anchors engaged at vertical plate support (L2)
V Bolt Dia =	1.00	in	; rebar size at vertical plate support
(E) Bm Depth =	30.0	in	; depth of (E) beam
(E) Col Depth =	24.0	in	; depth of (E) column
Pu =	408	kip	; gusset plate demand (max damper force including 130% Velocity)
Pu,vf =	367	kip	; UB Damper Force (100% V) Used for shear friciton, Single Damper
Fy =	50	ksi	; gusset plate steel material strength
Fu =	65	ksi	; gusset plate steel material strength
Fnt =	90	ksi	; high-strength (Group A) bolt tensile strength
Fnv =	54	ksi	; high-strength (Group A) bolt shear strength
FEXX =	70	ksi	; weld material strength
E =	29000	ksi	; steel Young's modulus
f'c =	5.042	ksi	; concrete strength of (E) beam and column

CALCULATIONS:



Sign convention

P_1, P_2 + for tension, - for compression

If P_1 is +, V_1 and H_1 are + also

If P_1 is -, V_1 and H_1 are - also

Same for P_2 (V_2, H_2)

$\Delta = \frac{1}{2}(L_2 - L_1)$ Note Δ is negative if $L_2 < L_1$

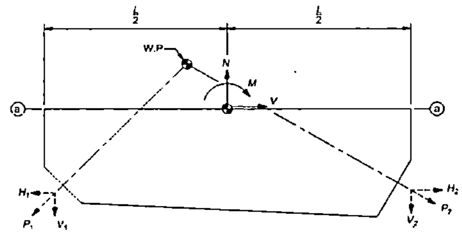
$M_1 = H_1 e + V_1 \Delta$

$M_2 = H_2 e - V_2 \Delta$

$M_1' = \frac{1}{8}V_1 L - \frac{1}{4}H_1 h - \frac{1}{2}M_1$

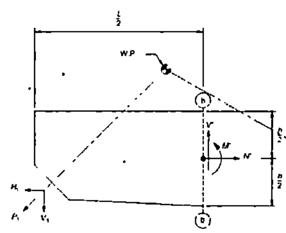
$M_2' = \frac{1}{8}V_2 L - \frac{1}{4}H_2 h - \frac{1}{2}M_2$

Fig. 4-5. Chevron brace gusset forces.



Forces on Section a-a:
Axial: $N = V_1 + V_2$
Shear: $V = H_1 - H_2$
Moment: $M = M_1 - M_2$

Fig. 4-6. Forces on Section a-a (positive directions shown).



Forces on Section b-b
Axial: $N' = \frac{1}{2}(H_1 + H_2)$
Shear: $V' = \frac{1}{2}(V_1 - V_2) - \frac{2}{L}(M)$
Moment: $M' = M_1' + M_2'$

Fig. 4-7. Forces on Section b-b (positive directions shown).

Figures from AISC Design Guide 29

Typical Top Connection

Obtain Demands on Gusset

Assume one damper is in tension and the other in compression.
Brace 1 is in tension.
Brace 2 is in compression.

Pu1 =	408	kip	Pu2 =	-408	kip
Hu1 = Pu1 × cos(θ)			Hu2 = Pu2 × cos(θ)		
Hu1 =	320	kip	Hu2 =	-320	kip
Vu1 = Pu1 × sin(θ)			Vu2 = Pu2 × sin(θ)		
Vu1 =	253	kip	Vu2 =	-253	kip

e = Bm Depth/2
e = 15 in

Δ = 0 in ; Gusset plate geometry is symmetric

Mu1 = Hu1*e + Vu1*Δ			Mu2 = Hu2*e - Vu2*Δ		
Mu1 =	4794	k-in	Mu2 =	-4794	k-in
Mu1' = (1/8)Vu1*L - (1/4)Hu1*h - (1/2)Mu1			Mu2' = (1/8)Vu2*L - (1/4)Hu2*h - (1/2)Mu2		
Mu1' =	-1608	k-in	Mu2' =	1608	k-in

Forces along section a-a

Nu = Vu1 + Vu2
Nu = 0 kip

Vu = Hu1-Hu2
Vu = 639 kip

Mu = Mu1 - Mu2
Mu = 9588 k-in

Forces along section b-b

Nu' = 0.5*(Hu1 + Hu2)
Nu' = 0 kip

Vu' = 0.5*(Vu1 - Vu2) - (2Mu/L)
Vu' = 7 kip

Mu' = Mu1' + Mu2'
Vu' = 0 kip

Check 1: Gusset Plate Yielding at Gross Section
ϕPn = ϕ 2t L Fy ; conservatively assume L = 2R
ϕPn = 1350 kip
D/C = 0.30 ; OK

Check 2: Gusset Plate Fracture at Net Section
ϕPn = ϕ 2t (L - ϕ_pin - 1/8") Fu
ϕPn = 932 kip
D/C = 0.44 ; OK

Check 3: Bearing of Pin Damper at Gusset Plate
ϕRn = ϕ 1.2Lc 2t Fu ≤ ϕ 2.4ϕ_pin 2t Fu
ϕRn = 559 kip
D/C = 0.73 ; OK

Check 4: Bucking of Gusset Plate: (2) t × ϕ_pin Column Strips
kL/r = 42.0 ; for (1) column strip
Fe = 162 ksi ; Euler stress
ϕPn = 415 kip
D/C = 0.98 ; OK

Buckling of Gusset Plate w/ Stiffener:
A = 5.3 in^2 ; for (1) T-section column strip per section A
YCG = 0.8 in
I = 1.0 in^4
r = 0.4 in
kL/r = 42.0
Fe = 162 ksi ; Euler stress
ϕPn = 415 kip
D/C = 0.98 ; OK ; very conservative approach

Check 5: Fillet Weld at Gusset to Plate Support
ϕRn = 2 × ϕ 0.707w 2L1 Fw ; horizontal plate support
ϕRn = 3474 kip
D/C = 0.12 ; OK

ϕRn = 2 × ϕ 0.707w 2L2 Fw ; vertical plate support
ϕRn = 935 kip
D/C = N/A ; NG

Check 6: Shear yielding along a-a
fuv = (0.5*Vu)/Ag ; Shear Stress on 1 gusset plate
fuv = 3 ksi
fvn = 0.6*Fy

fvn = 30 ksi
D/C = 0.09 ; OK

Check 7: Tensile yielding along a-a
fua = (0.5*Nu)/Ag ; Normal Stress on 1 gusset plate due to axial demand
fua = 0 ksi

fub = (0.5*Mu)/Z ; Normal Stress on 1 gusset plate due to moment demand
fub = 2 ksi

fun = fua + fub
fun = 2
fn = Fy
fn = 50 ksi
D/C = 0.04 ; OK

Check 8: Shear yielding along b-b
fuv = (0.5*Vu)/Ag ; Shear Stress on 1 gusset plate
fuv = 0 ksi
fvn = 0.6*Fy
fvn = 30 ksi
D/C = 0.00 ; OK

Check 9a: High-Strength Bolts @ L1 (Horizontal)
frv = Pu1x / [Ab × (No of Bolts)]
frv = 37 ksi ; shear stress demand in bolts
D/C = 0.92

F'nt = 1.3Fnt - Fnt/ϕFnv × frv ≤ Fnt
F'nt = 55 ksi ; tensile strength including shear stress effects
ϕRn = 1.0 × As F'nt
ϕRn = 67 kip/bolt
Tu = Mu/(L1/2)/(0.5* No of Bolts) ; half of bolts resist tension
Tu = 35 kip/bolt
D/C = 0.52 ; OK

Check 9b: High-Strength Bolts @ L2 (Vertical)
frv = Pu1x / [Ab × (No of Bolts)]
frv = #DIV/0! ksi ; shear stress demand in bolts
D/C = N/A

F'nt = #DIV/0! ksi
ϕRn = #DIV/0! kip
D/C = N/A ; NG

Check 10a: Bearing of (N) Bolts on (E) Conc Beam
Assume a triangular bearing pressure distribution (1/2 factor):
ϕBn = ϕ 0.85 f'c A1 × 1/2 ; A1 = Beam Depth × Bolt ϕ
ϕBn = 52 kip ; per bolt
D/C = 0.87 ; OK

Check 10b: Bearing of (N) Bolts on (E) Conc Column
ϕBn = ϕ 0.85 f'c A1 × 1/2 ; A1 = Column Depth × Bolt ϕ
ϕBn = 33 kip ; per bolt
D/C = N/A ; NG

B.3.c - Driver Brace Design

Executive Summary

The following section presents the calculations for the HSS driver brace attached to the dampers along with the design of the connections of the brace to the damper and to the gusset plate.

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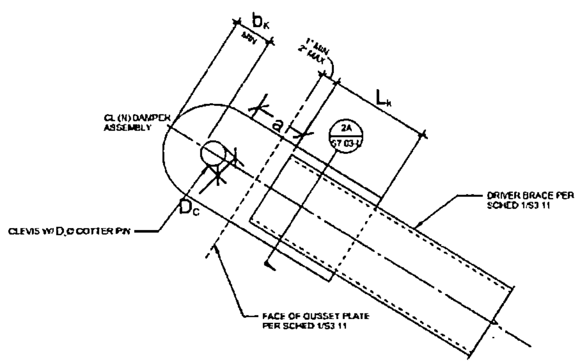
Driver Brace & Connection Design

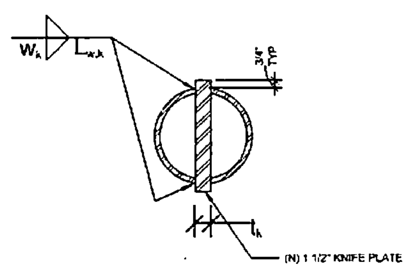
Summary:

Check 1:	**DCR =**	**0.74**	OK
Check 2a:	**DCR =**	**0.56**	OK
Check 2b:	**DCR =**	**0.64**	OK
Check 3:	**DCR =**	**0.60**	OK
Check 4:	**DCR =**	**0.62**	OK
Check 5:	**DCR =**	**0.68**	OK
Check 6:	**DCR =**	**0.78**	OK
Check 7:	**DCR =**	**0.65**	OK
Check 8a:	**DCR =**	**0.52**	OK
Check 8b:	**DCR =**	**0.48**	OK
Check 9:	**DCR =**	**0.75**	OK
Check 10:	**DCR =**	**0.87**	OK
Check 11:	**DCR =**	**0.15**	OK
Check 12:	**DCR =**	**0.79**	OK

HSS Size =	HSS10X.625		
L_u =	18.54	ft	Unbraced Length
A =	17.2	in^2	Area of HSS
D =	10	in	
D/t =	17.2		Effective Length Factor
$t_{HSS, Design}$ =	0.581	in	
r =	3.34	in	UB Damper Force (100% V)
k =	1		UB Damper Force (130% V)
t_K =	2	in	Thickness of Knife PL
L_k =	12	in	Length of Knife PL Connection
w_k =	0.4375	in	Fillet weld size at Knife PL
$L_{w,k}$ =	12	in	Length of Fillet weld, one side
b_k =	3	in	Edge distance to Cotter Pin Hole
a =	4	in	Distance from Cotter Pin Hole to HSS
D_c =	3	in	Diameter of cotter Pin
t_B =	2	in	Thickness of Base PL
B_B =	12	in	Width of Base PL
d_B =	1.25	in	Diameter of Bolts at Base PL
n_B =	6		No. of Bolts
w_B =	0.5625	in	Fillet weld size at Base PL
L_c =	4	in	Cantilever Distance for Bending in Base PL
b =	2	in	Distance from face of HSS to center of Bolt
L_e =	2	in	Edge distance to Center of Bolt
Pu,vf =	367	kip	
Pu =	408	kip	
Fy_{HSS} =	42	ksi	
Fu_{HSS} =	58	ksi	
Fy_{PL} =	50	ksi	
Fu_{PL} =	65	ksi	
E =	29000	ksi	
F_{nt} =	90	ksi	
FEXX =	70	ksi	



ELEVATION



2A SECTION

Check 1: Check HSS Brace in Compression per AISC 360-16 E3

Check if HSS is Slender for Compression per AISC 360-16 B.4.1

If $D/t \le \lambda_r$ → Nonslender
If $D/t > \lambda_r$ → Slender

$\lambda_r = 0.11*E/Fy$
$\lambda_r =$ 75.95

Therefore HSS is Nonslender **OK**

Check Compression
KL/r = 66.62

$Fe = \pi^2 E/(KL/r)^2$ AISC 360-16 EQ. E3-4
Fe = 64.50 ksi

$4.71*\sqrt{(E/Fy)}$ = 123.76

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If $KL/r \le 4.71*\sqrt{(E/Fy)}$

$F_{cr} = (0.658^{Fy/Fe})Fy$ AISC 360-16 EQ. E3-2

If $KL/r > 4.71*\sqrt{(E/Fy)}$

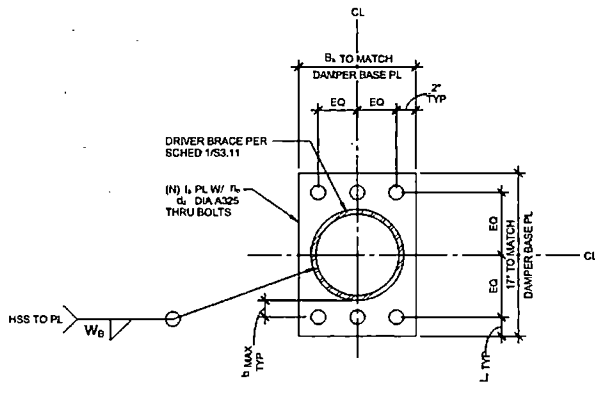
$F_{cr} = 0.877Fe$ AISC 360-16 E3-3

$F_{cr} =$ 31.98 AISC 360-16 EQ. E3-2 or E3-3

$P_n = F_{cr}A_g$

$P_n =$ 550.06 k

DCR = 0.74 **OK**



(1A) BASE PLATE

Check 2a: Check HSS Brace For Tensile Yielding per AISC 360-16 D.2.a

$P_n = FyA_g$ AISC 360-16 EQ. D2-1

$P_n =$ 722.40 k

DCR = 0.56 **OK**

Check 2b: Check HSS Brace For Tensile Rupture per AISC 360-16 D.2.b

$A_n = A_g - 2*(t_{HSS,\ Design} * t_k)$

$A_n =$ 14.88 in^2

Shear Lag Factor U, per Table D3.1

if $L_k \ge 1.3D$ → $U = 1.0$

if $D \le L_k < 1.3D$ → $U = 1-X/L_k$

$X = D/\pi$

$U =$ 0.73

$A_e = A_nU$ AISC 360-16 EQ. D3-1

$A_e =$ 10.93 in^2

$P_n = F_uA_e$ AISC 360-16 EQ. D2-2

$P_n =$ 633.94 k

DCR = 0.64 **OK**

Check 3: Check Prying @ Base Plate

$t_{min} = \sqrt{(4*T*b'/(p*Fu))}$ AISC SCM Eq. 9-20a

$b' = b-d_B/2$ AISC SCM Eq. 9-21

$b' =$ 1.38 in

$p = 2b$

$p =$ 4.00 in

$T = Pu/n_b$

$T =$ 67.93 k/bolt

$t_{min} =$ 1.20 in

DCR = 0.60 **OK**

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Check 4: Tension in Bolts per AISC 360-16 J3.6

$Tu = Pu/n_b$
Tu = 67.93 k/bolt

$Tn = F_{nt}*A_b$ AISC 360-16 EQ. J3-1
Tn = 110.45 k/bolt

DCR = 0.62 **OK**

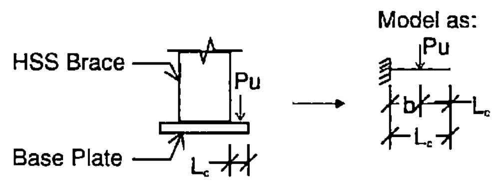
Check 5: Check Bending in Base PL per AISC 360-16 F2.1

Pu = Pu/2 Bolt Groups
Pu = 203.80 k/group

Mu = Pu*b
Mu = 407.61 k-in

Mn = Fy*Z AISC 360-16 EQ. F2-1
Mn = 600.00 k-in

DCR = 0.68 **OK**



Check 6: Check Weld at Base PL

$l = \pi D$ length of weld
l = 31.42 in

$Rn = 0.6*FEXX*0.707*w_B*l$ AISC SCM Eq. 8-1
Rn = 524.82 k

DCR = 0.78 **OK**

Check 7: Check Weld at Knife PL

$Rn = 0.6*FEXX*0.707*w_B*L_{w,k}$ AISC SCM Eq. 8-1
Rn = 623.67 k

DCR = 0.65 **OK**

Check 8a: Tensile Rupture of Pin Connection per AISC 360-16 D.5.1a

$b_e = 2t_k+0.63 <= b_c$
b_e = 3.00 in

$Pn = F_u*(2*t*b_e)$ AISC 360-16 EQ. D5-1
Pn = 780.00 k

DCR = 0.52 **OK**

Check 8b: Shear Rupture of Pin Connection per AISC 360-16 D.5.1b

$A_{sf} = 2t_k(a+D_c/2)$
A_{sf} = 22.00 in^2

$Pn = 0.6F_uA_{sf}$ AISC 360-16 EQ. D5-2
Pn = 858.00 k

DCR = 0.48 **OK**

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Check 9: Check bearing on Cotter Pin per AISC 360-16 J.7.a

$A_{pb} = D_c*t_k$
$A_{pb} =$ 6 in^2

$Pn = 1.8*Fy*A_{pb}$ AISC 360-16 EQ. J7-1
Pn = 540.00 k

DCR = 0.75 **OK**

Check 10: Check bearing on Cotter Pin Hole per AISC 360-16 J.3.10a

$Rn = 1.2*b_k*t_k*F_u \le 2.4*D_C*t_k*F_u$
Rn = 468.00 k

DCR = 0.87 **OK**

Check 11: Check block shear on Knife PL per AISC 360-16 J.4.3

$A_{nv} = A_{gv} = 2*L_k*t_k$
$A_{nv} = A_{gv} =$ 48 in^2

$A_{nt} = t_k*D$
$A_{nt} =$ 20 in^2

$U_{bs} =$ 1 Tension stress is uniform

$Rn = 0.6*F_uA_{nv} + U_{bs}F_uA_{nt} \le 0.6*F_yA_{gv} + U_{bs}F_uA_{nt}$
Rn = 2740 k

DCR = 0.15 **OK**

Check 12: Check shear on Cotter per AISC 360-16 J.4.3

$F_{nv} = 0.563F_u$ Per Table J3.2, For A572 Bolts when threads are not included
$F_{nv} =$ 36.60 ksi

$Rn = F_{nv}*A_b$ AISC 360-16 EQ. J3-1
Rn = 517.35 k Cotter Pin is in Double Shear Condition

DCR = 0.79 **OK**

B.3.d - Collector Plate Design

Executive Summary

The following section presents the calculations for the collector plates attached to the underside of beams at the damper frame lines.

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	client	job no. 2000362	
	Collector Plate Design		

Demands and Assumptions:

Per collector diagrams maximum axial force seen in the collector plates is Pu = 833.7k, see section A.3.c.
Plates will be anchored every 12", providing an unbraced length of 12". Conservatively all plates will be designed for the maximum collector force.

Check Compression Capacity:

Assume 7/8" thick plate
$A = 24*0.875 = 21in^2$
$Ix = (1/12)(0.875)(24^3) = 1008in^4$
$Iy = (1/12)(24)(0.875^3) = 1.34in^4$

$r_x = \sqrt{(I_x/A)} = 6.93in$
$r_y = \sqrt{(I_y/A)} = 0.253in$

Assume pin-pin condition, K = 1.0
Unbraced Length in either axis, L = 1'
$KL/r_x = 1.73$
$KL/r_y = 47.43$

$4.71*\sqrt{(E/Fy)} = 4.71*\sqrt{(29000ksi/50ksi)} = 113.43$

Both KL/r values are less than $4.71*\sqrt{(E/Fy)}$ therefore use Equation E3-2 per AISC 360-16

$Fe = \pi^2E/(KL/r)^2 = 127.23ksi$
Fy/Fe = 50ksi/127.23ksi = 0.39

$Fcr = (0.658^{Fy/Fe})Fy = 42.47ksi$

$Pn = 42.47ksi*21in^2 = 891.9k$

DCR = 833.7/891.9 = 0.94

Therefore use 7/8" Collector Plate for compression.

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	Collector Plate Design		

Check Tension Capacity:

Check tensile yielding per AISC 360-16 D2.a:
Use 7/8" thick plate
$A = 24*0.875 = 21in^2$
$Tn = Fy*A = 50ksi*21in^2 = 1050k$ per EQ. D2-1
DCR = 833.7/1050 = 0.79

Therefore 7/8" Thick PL is adequate for tensile yielding.

Check Tensile Rupture per AISC 360-16 D2.b:
Assume anchor bolts are 1" DIA and Standard Holes.
Hole DIA = 1.0625"

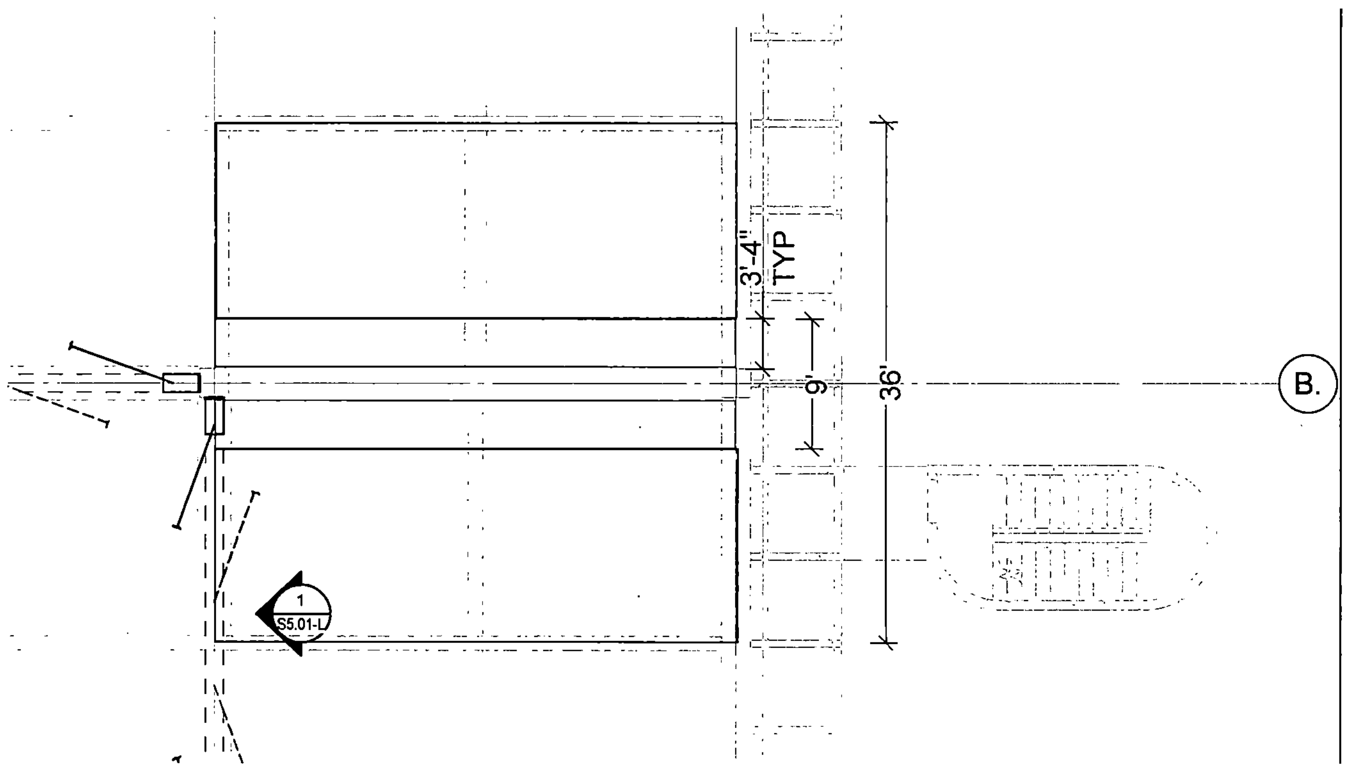
$Ae = An - A_{Holes} = 21in^2 - 2*(1.0625"*0.875") = 19.14in^2$
Fu = 65ksi
$Tn = Fu*Ae = 65ksi*19.14in^2 = 1244.1k$ per EQ. D2-2

DCR = 833.7/1244.1 = 0.67

Therefore 7/8" Thick PL is adequate for tensile rupture.

Extents of Plate Length:

Collector plates will be provided at all bays with a damper frame however the extents of the plates beyond the bays that contain the dampers will be determined by the axial demands in the collector diagrams and the axial capacity of the slab to resist the collector demands. Per the time history analysis, most beams frame girders yield, it is assumed that the axial load in the collector formed by the beam and slab will be taken by the slab only.



The typical width of a collector can be seen above. Typically a collector will be 36' wide however only the areas highlighted in blue will be able to resist axial demands. It is assumed that due to beam yielding the effective flange of the beams will not be used to resist axial demands. The effective flange of the beam can be seen in red. Each beam flange is 40" on either side of the beam web therefore at the worst case only 27' of slab will be used to resist axial demands.

The bars in the slab used to resist the axial demands will be the slab top bars #4's @ 10" OC reduced by gravity demands and the slab bottom bars #4's @28" OC. Per calculations presented in the diaphragm section 34% of the slab top bars can be used to resist seismic forces. Only negative moment demand is expected over the beam support of a slab therefore 100% of the bottom bars will be used to resist seismic forces.

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location Inglewood, CA	date 10/14/21	
client	job no. 2000362	
Collector Plate Design		

Extents of Plate Length:

Governing capacity of slab will be tensile capacity.
Total capacity of the slab bars:
$A_{s,Top}$ = 0.2in^2 (12/10)*0.34 = 0.082in^2/ft
$A_{s, Bot}$ = 0.2in^2(12/28) = 0.086in^2/ft
$A_{s, Total}$ = 0.082+0.086 = 0.168in^2/ft

Tn$_{slab}$ = 0.168in^2/ft*27'*73ksi = **331.13k**

Special Case @ Grid B between Grids 4 and 5, on Grid 4 between Grids A and B, on Grid D between Grids 3 and 4, and on Grid 2 between grids C and D on floors 2, and 3. Only half of the slab is available to resist collector demands therefore:
Tn$_{slab}$ = 331.13/2 = **165.6k**

Collector diagrams are recreated in the following pages to show DCR's at locations outside of damper frame bays.

Check Unit Shear can be resisted by Shear Friction at Slab and Beam interfaces:

Per previous shear friction calculations in diaphragm calculations #4s@10" OC with 34% effective in resisting seismic demands result in a capacity of vn = 8.6 k/ft.

At the worst case vu = 7.45k/ft / 2 shear friction planes = 3.73 k/ft

DCR = 0.43

Therefore existing slab bars are adequate to resist unit shear in shear friction.

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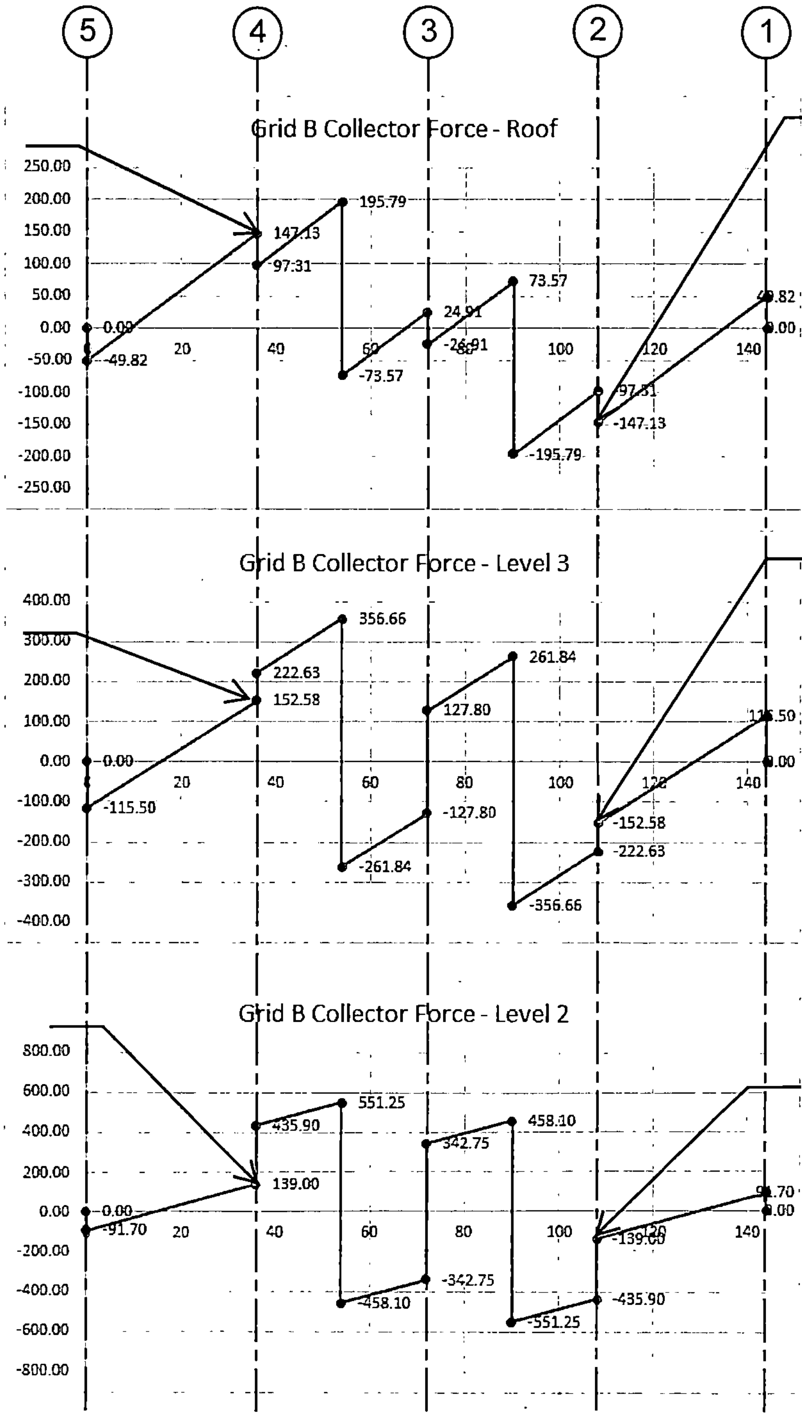
	Collector Plate Design		

Grid B Collector Plate Extent

Max Force @ Slab Only = 147.13k
Slab on Both sides
Pn = 331.13k
DCR = 0.44

Max Force @ Slab Only = 147.13k
Slab on Both sides
Pn = 331.13k
DCR = 0.44



Max Force @ Slab Only = 152.58k
Slab on one side
Pn = 165.6k
DCR = 0.92

Max Force @ Slab Only = 152.58k
Slab on Both sides
Pn = 331.13k
DCR = 0.46

Max Force @ Slab Only = 139k
Slab on one side
Pn = 165.6k
DCR = 0.84

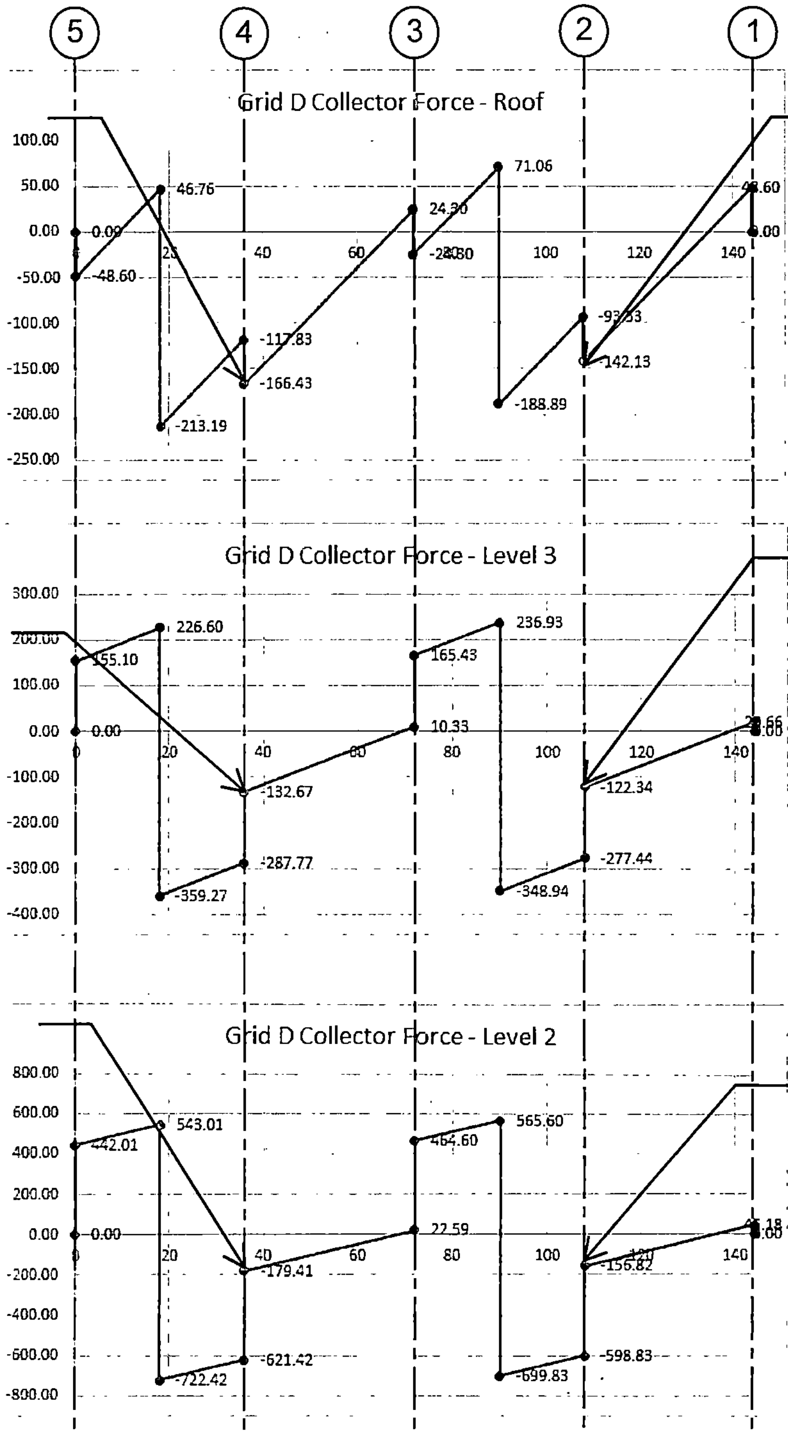
Max Force @ Slab Only = 139k
Slab on Both sides
Pn = 331.13k
DCR = 0.42

DCR's of slab only are under 1 therefore plates are not required outside of damper bays.

Grid D Collector Plate Extent

Max Force @ Slab Only = 166.4k
Slab on Both sides
Pn = 331.13k
DCR = 0.50

Max Force @ Slab Only = 142.13k
Slab on Both sides
Pn = 331.13k
DCR = 0.43



Max Force @ Slab Only = 132.67k
Slab on Both sides
Pn = 331.13k
DCR = 0.4

Max Force @ Slab Only = 122.34k
Slab on Both sides
Pn = 331.13k
DCR = 0.67

Max Force @ Slab Only = 179.41k
Slab on Both Sides
Pn = 331.13k
DCR = 0.54

Max Force @ Slab Only = 152.82k
Slab on Both sides
Pn = 331.13k
DCR = 0.46

DCR's of slab only are under 1 therefore plates are not required outside of damper bays.

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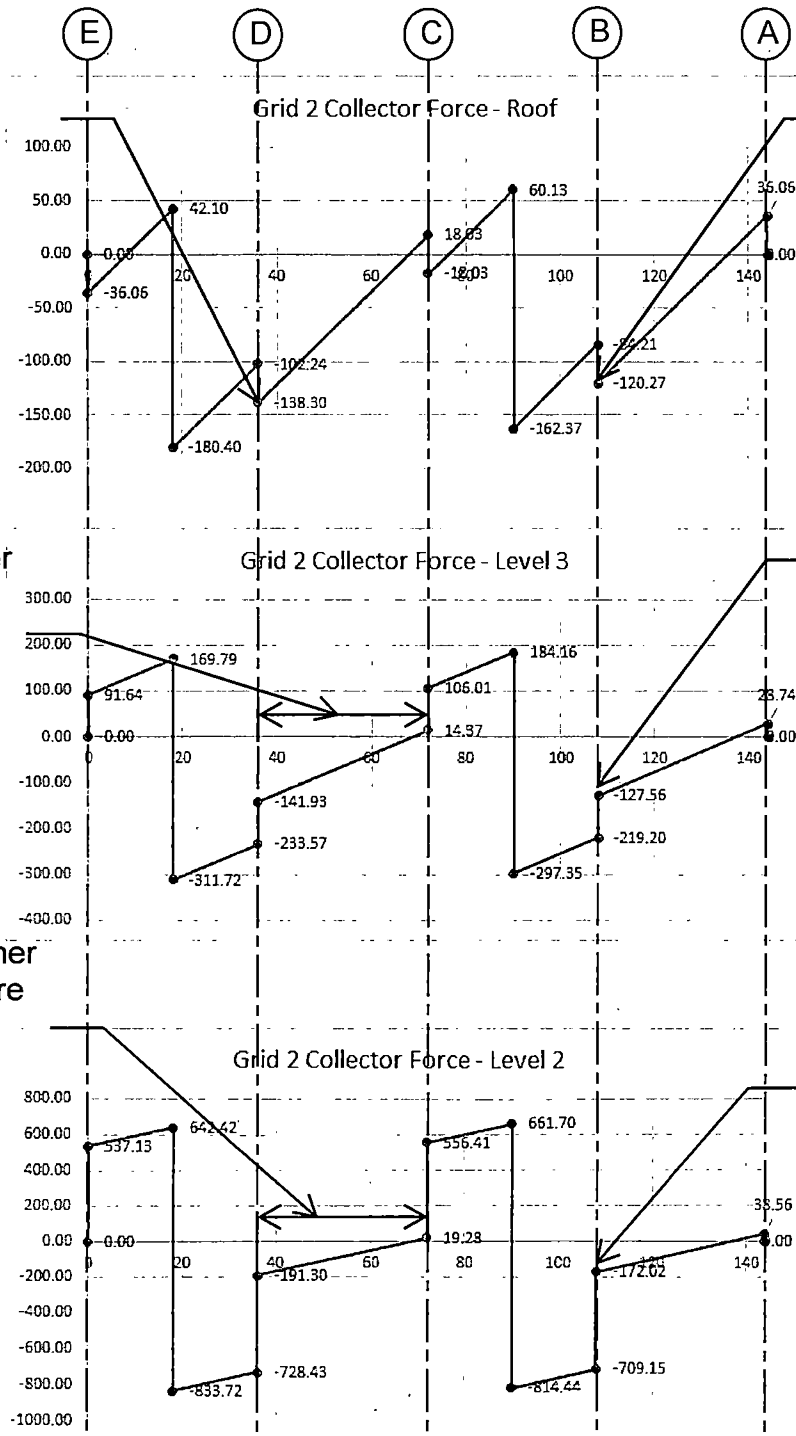
Collector Plate Design		

Grid 2 Collector Plate Extent

Max Force @ Slab Only = 138.3k
Slab on One side
Pn = 165.6k
DCR = 0.84

Max Force @ Slab Only = 120.27k
Slab on Both sides
Pn = 331.13k
DCR = 0.36



Max Force @ Slab Only = 127.56k
Slab on Both sides
Pn = 331.13k
DCR = 0.39

(3) openings on either side of slab therefore conservatively provide plate.

(3) openings on either side of slab therefore conservatively provide plate.

Max Force @ Slab Only = 172.02k
Slab on Both sides
Pn = 331.13k
DCR = 0.52

Provide plates from Grid E to B on Levels 2 and 3. At roof no plates are required outside of damper bays.

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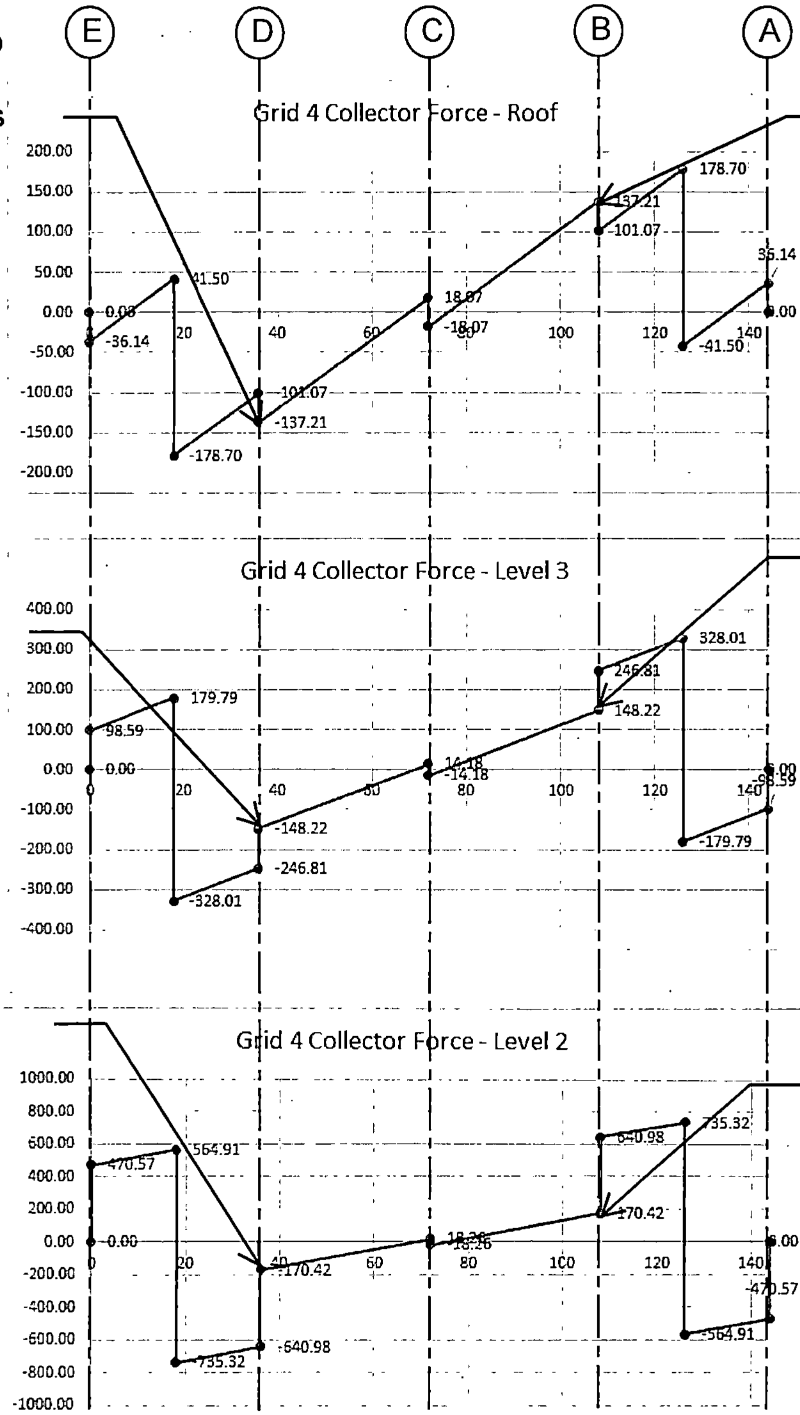
	client	job no. 2000362	
	Collector Plate Design		

Grid 4 Collector Plate Extent

Max Force @ Slab Only = 137.21k
Slab on Both sides
Pn = 331.13k
DCR = 0.41

Max Force @ Slab Only = 137.21k
Slab on One side
Pn = 165.6k
DCR = 0.83



Max Force @ Slab Only = 148.22k
Slab on Both sides
Pn = 331.13k
DCR = 0.45

Max Force @ Slab Only = 148.22k
Slab on Both sides
Pn = 331.13k
DCR = 0.45

Max Force @ Slab Only = 170.42k
Slab on Both sides
Pn = 331.13k
DCR = 0.51

Max Force @ Slab Only = 170.42k
Slab on Both sides
Pn = 331.13k
DCR = 0.51

DCR's of slab only are under 1 therefore plates are not required outside of damper bays.

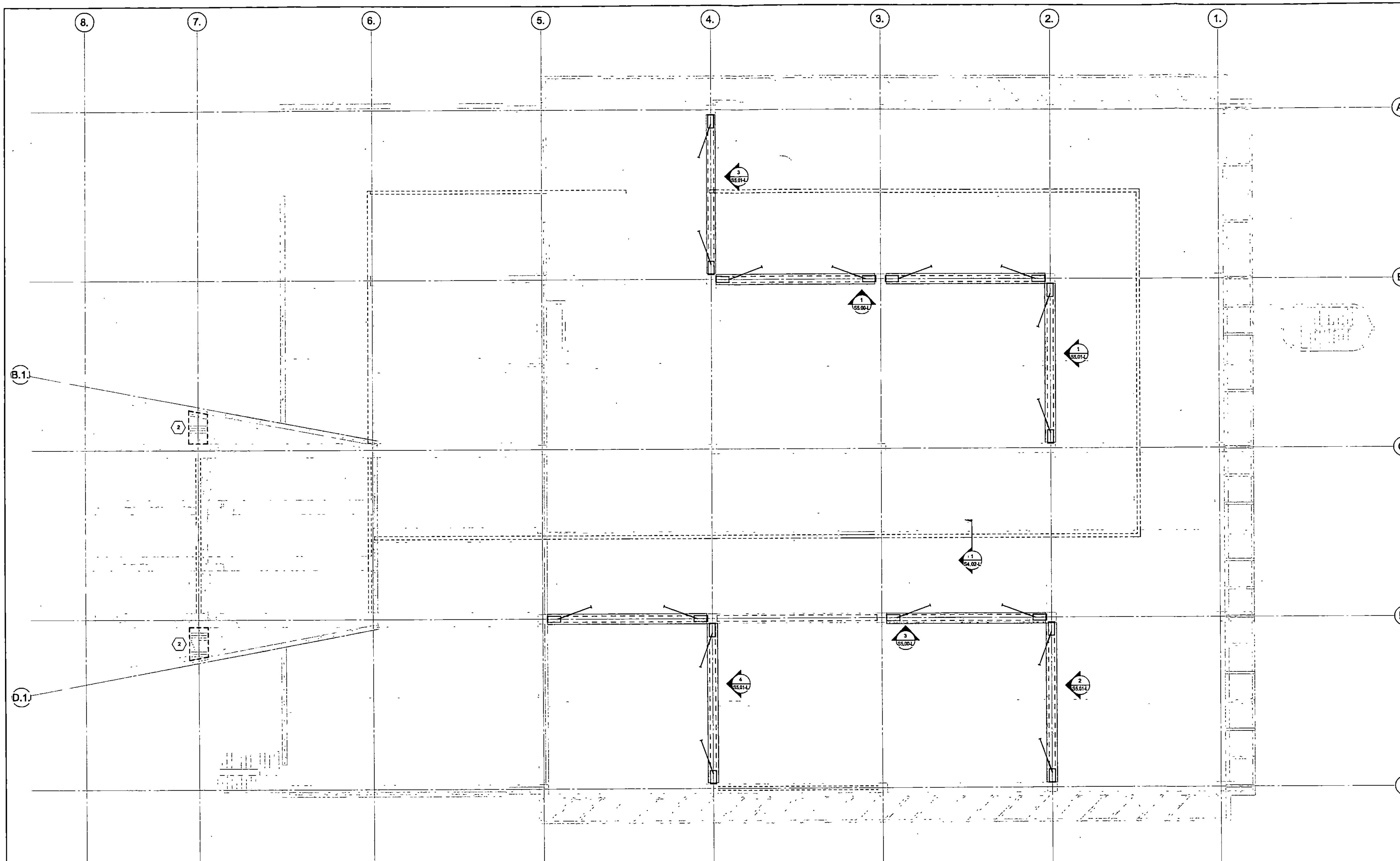
Extents of Plate Length:

At the first floor, since dampers are transferring to the walls below, the collector plates are acting as force distributors. The plates will be placed underneath damper frame bays only. Plate anchorage will be designed to take the shear reaction from both dampers at each bay.

Max average reaction over 4 dampers: Vu = 1148.33k/2 bays/36' bay length = 15.95k/ft

Plate extents on plan are summarized in the following pages.

B.3.d-12



1 FIRST FLOOR - L
SCALE : 1/8" = 1'-0"

PLAN NOTES:

1. SEE SHEET S0.02 FOR GENERAL NOTES.
2. SEE SHEET S2.01 THROUGH S2.08 FOR VISCOUS DAMPER FRAME ELEVATIONS.
3. SEE ARCH DRAWINGS FOR DIMENSIONS NOT SHOWN.
4. CONTRACTOR TO VERIFY ALL EXISTING CONDITIONS, DIMENSIONS AND ELEVATIONS PRIOR TO FABRICATION AND ERECTION AND NOTIFY ARCHITECT OF ANY SIGNIFICANT DISCREPANCIES FROM THAT SHOWN ON THE DRAWINGS.
5. CONTRACTOR TO SHORE ALL EXISTING FRAMING AS REQUIRED FOR DEMOLITION AND REFRAMING WORK.

LEGEND:

XXX'-XXX"	INDICATES TOP OF (E) CONCRETE SLAB ELEVATION.
(E)	INDICATES EXISTING.
	INDICATES EXISTING STRUCTURE.
(N)	INDICATES NEW.
	INDICATES NEW CONSTRUCTION.
	INDICATES PORTION OF BUILDING TO BE DEMOLISHED.
STEEL CONNECTOR PLATE BELOW BEAM	INDICATES DAMPER ASSEMBLY ABOVE FLOOR LEVEL PER ELEVATIONS S5.00 THRU S5.01.
	INDICATES DAMPER ASSEMBLY BELOW FLOOR LEVEL PER ELEVATIONS S5.00 THRU S5.01.
#	INDICATES U-WRAP FRP OF BEAM PER DETAIL 1/S6.01 OR 2/S6.01 # INDICATES NUMBER OF FRP LAYERS
	INDICATES FRP STRENGTHENING BELOW THE SLAB.

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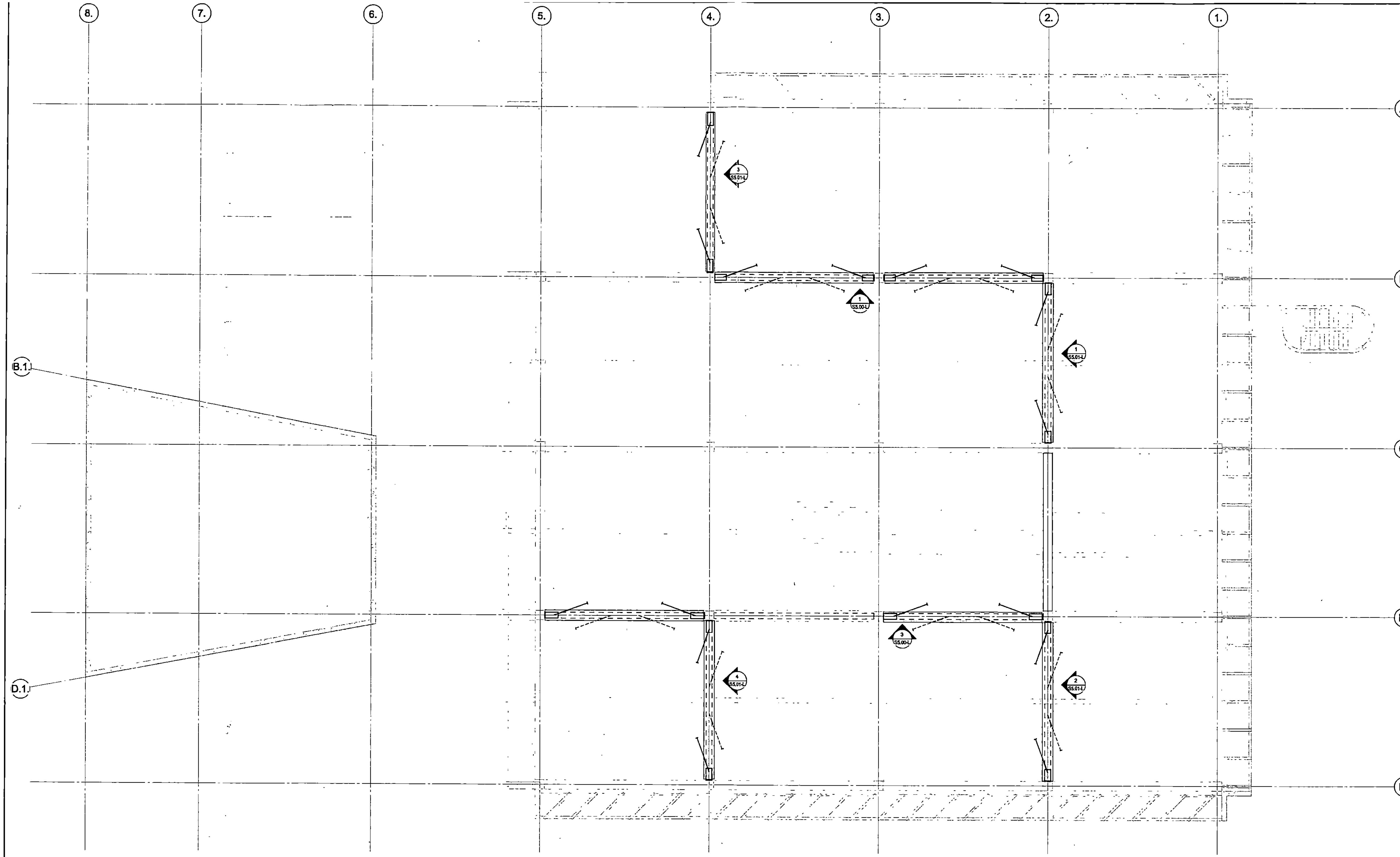
SEPTEMBER 10, 2021

LIBRARY - 1ST FLOOR PLAN

Drawn By:	Author
Designed By:	Designer
Project No:	2000362
Date:	04/21/2021
Scale:	As indicated

Drawing No:
S2.01-L



1 SECOND FLOOR - L
SCALE : 1/8" = 1'-0"

PLAN NOTES:

1. SEE SHEET S0.02 FOR GENERAL NOTES.
2. SEE SHEET S2.01 THROUGH S2.08 FOR VISCOUS DAMPER FRAME ELEVATIONS.
3. SEE ARCH DRAWINGS FOR DIMENSIONS NOT SHOWN.
4. CONTRACTOR TO VERIFY ALL EXISTING CONDITIONS, DIMENSIONS AND ELEVATIONS PRIOR TO FABRICATION AND ERECTION AND NOTIFY ARCHITECT OF ANY SIGNIFICANT DISCREPANCIES FROM THAT SHOWN ON THE DRAWINGS.
5. CONTRACTOR TO SHORE ALL EXISTING FRAMING AS REQUIRED FOR DEMOLITION AND REFRAMING WORK.

LEGEND:

XXX'-XXX"	INDICATES TOP OF (E) CONCRETE SLAB ELEVATION.
(E)	INDICATES EXISTING.
	INDICATES EXISTING STRUCTURE.
(N)	INDICATES NEW.
	INDICATES NEW CONSTRUCTION.
	INDICATES PORTION OF BUILDING TO BE DEMOLISHED.
STEEL CONNECTOR PLATE BELOW BEAM	INDICATES DAMPER ASSEMBLY ABOVE FLOOR LEVEL PER ELEVATIONS S5.00 THRU S5.01.
	INDICATES DAMPER ASSEMBLY BELOW FLOOR LEVEL PER ELEVATIONS S5.00 THRU S5.01.
#	INDICATES U-WRAP FRP OF BEAM PER DETAIL 1/S6.01 OR 2/S6.01 # INDICATES NUMBER OF FRP LAYERS
	INDICATES FRP STRENGTHENING BELOW THE SLAB.

kpff
700 S. Flower St., Suite 2100
Los Angeles, CA 90017
O: 213.418.0201
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CITY OF INGLEWOOD CIVIC CENTER - LIBRARY
VOLUNTARY SEISMIC IMPROVEMENTS

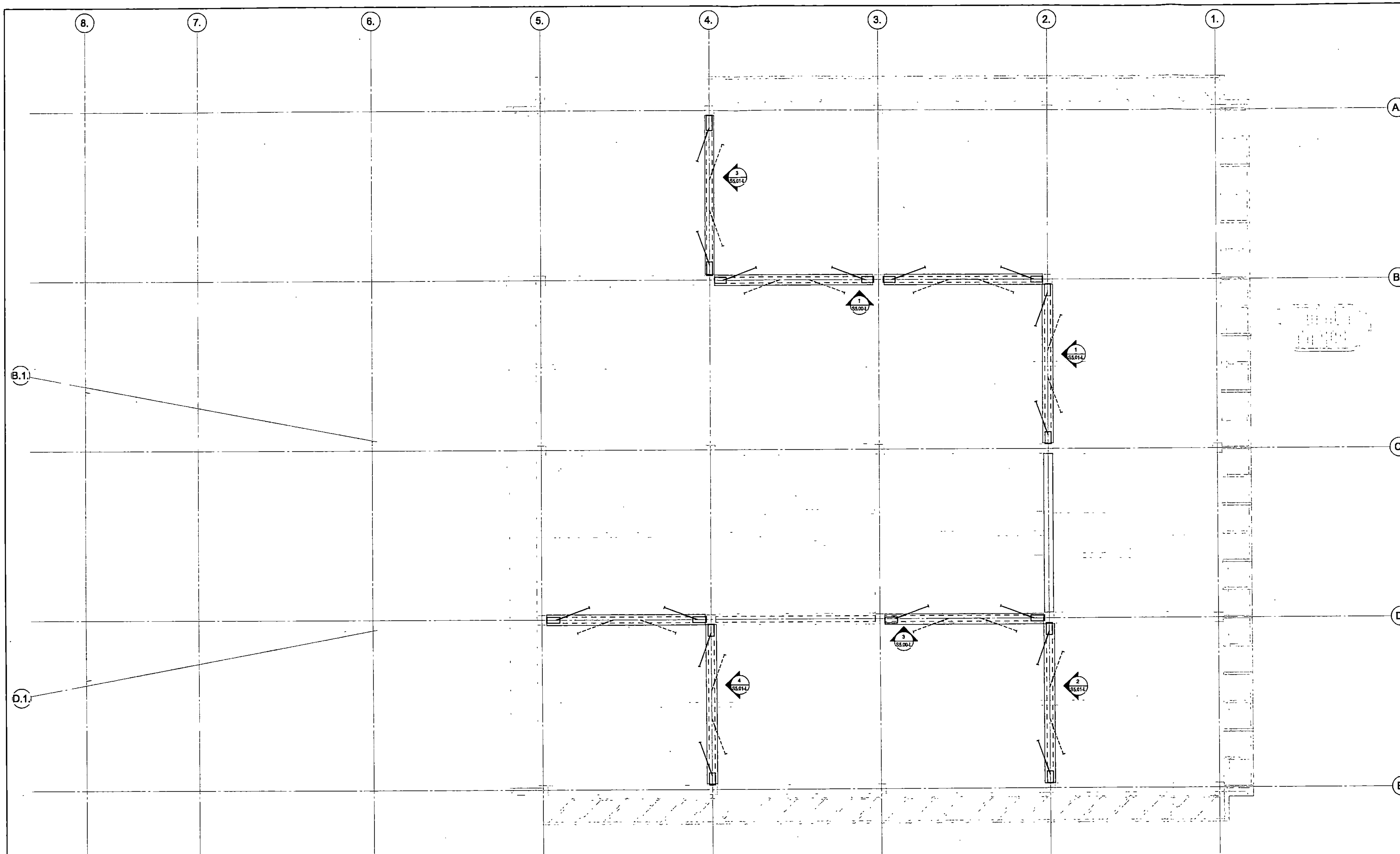
DESIGN DEVELOPMENT
KPFF PROJECT # 10012000362
SEPTEMBER 10, 2021

LIBRARY - 2ND FLOOR PLAN

Drawn By:	Author
Designed By:	Designer
Project No:	2000362
Date:	04/21/2021
Scale:	As indicated

Drawing No:

S2.02-L



PLAN NOTES:

1. SEE SHEET S0.02 FOR GENERAL NOTES.
2. SEE SHEET S2.01 THROUGH S2.08 FOR VISCOUS DAMPER FRAME ELEVATIONS.
3. SEE ARCH DRAWINGS FOR DIMENSIONS NOT SHOWN.
4. CONTRACTOR TO VERIFY ALL EXISTING CONDITIONS, DIMENSIONS AND ELEVATIONS PRIOR TO FABRICATION AND ERECTION AND NOTIFY ARCHITECT OF ANY SIGNIFICANT DISCREPANCIES FROM THAT SHOWN ON THE DRAWINGS.
5. CONTRACTOR TO SHORE ALL EXISTING FRAMING AS REQUIRED FOR DEMOLITION AND REFRAMING WORK.

LEGEND:

XXX'-XXX"	INDICATES TOP OF (E) CONCRETE SLAB ELEVATION.
(E)	INDICATES EXISTING.
	INDICATES EXISTING STRUCTURE.
(N)	INDICATES NEW.
	INDICATES NEW CONSTRUCTION.
	INDICATES PORTION OF BUILDING TO BE DEMOLISHED.
	INDICATES DAMPER ASSEMBLY ABOVE FLOOR LEVEL PER ELEVATIONS S5.00 THRU S5.01.
STEEL CONNECTOR PLATE BELOW BEAM	INDICATES DAMPER ASSEMBLY BELOW FLOOR LEVEL PER ELEVATIONS S5.00 THRU S5.01.
#	INDICATES U-WRAP FRP OF BEAM PER DETAIL 1/S6.01 OR 2/S6.01 # INDICATES NUMBER OF FRP LAYERS
	INDICATES FRP STRENGTHENING BELOW THE SLAB.

1 THIRD FLOOR - L
SCALE: 1/8" = 1'-0"

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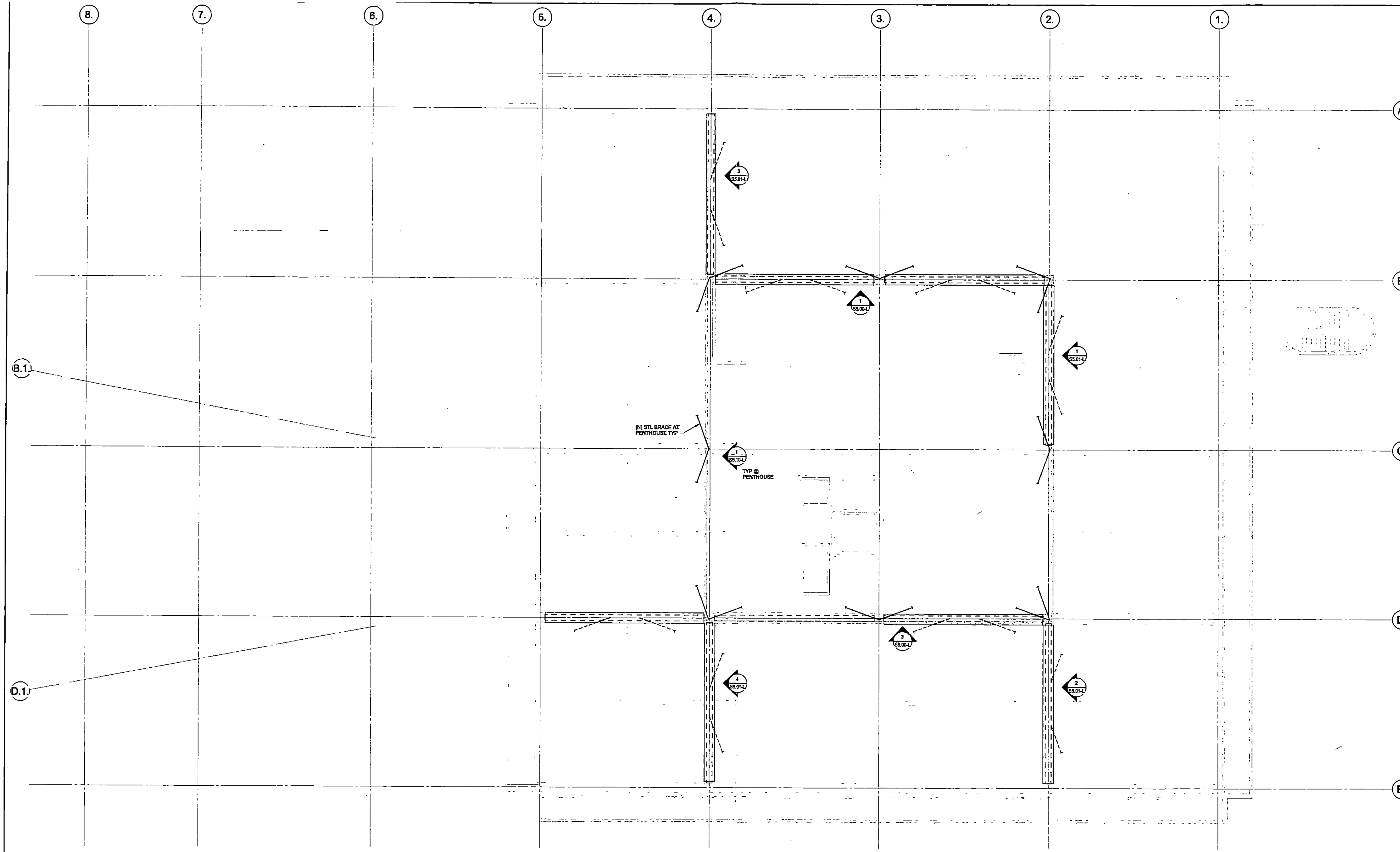
DESIGN DEVELOPMENT
KPFF PROJECT # 10012000362
SEPTEMBER 10, 2021

LIBRARY - 3RD FLOOR PLAN

Drawn By:	Author
Designed By:	Designer
Project No:	2000362
Date:	04/21/2021
Scale:	As Indicated

Drawing No:
S2.03-L



1 MAIN ROOF AND PENTHOUSE FLOOR - L
SCALE: 1/8" = 1'-0"

PLAN NOTES:

1. SEE SHEET S0.02 FOR GENERAL NOTES.
2. SEE SHEET S2.01 THROUGH S2.08 FOR VISCOUS DAMPER FRAME ELEVATIONS.
3. SEE ARCH DRAWINGS FOR DIMENSIONS NOT SHOWN.
4. CONTRACTOR TO VERIFY ALL EXISTING CONDITIONS, DIMENSIONS AND ELEVATIONS PRIOR TO FABRICATION AND ERECTION AND NOTIFY ARCHITECT OF ANY SIGNIFICANT DISCREPANCIES FROM THAT SHOWN ON THE DRAWINGS.
5. CONTRACTOR TO SHORE ALL EXISTING FRAMING AS REQUIRED FOR DEMOLITION AND REFRAMING WORK.

LEGEND:

XXX'-XXX"	INDICATES TOP OF (E) CONCRETE SLAB ELEVATION.
(E)	INDICATES EXISTING.
	INDICATES EXISTING STRUCTURE.
(N)	INDICATES NEW.
	INDICATES NEW CONSTRUCTION.
	INDICATES PORTION OF BUILDING TO BE DEMOLISHED.
	INDICATES DAMPER ASSEMBLY ABOVE FLOOR LEVEL PER ELEVATIONS S5.00 THRU S5.01.
STEEL CONNECTOR PLATE BELOW BEAM	INDICATES DAMPER ASSEMBLY BELOW FLOOR LEVEL PER ELEVATIONS S5.00 THRU S5.01.
#	INDICATES U-WRAP FRP OF BEAM PER DETAIL 1/S8.01 OR 2/S8.01 # INDICATES NUMBER OF FRP LAYERS
	INDICATES FRP STRENGTHENING BELOW THE SLAB.

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CITY OF INGLEWOOD CIVIC CENTER - LIBRARY VOLUNTARY SEISMIC IMPROVEMENTS

DESIGN DEVELOPMENT
KPFF PROJECT # 10012000362
SEPTEMBER 10, 2021

LIBRARY - MAIN ROOF AND PENTHOUSE FLOOR - L

Drawn By:	Author
Designed By:	Designer
Project No:	2000362
Date:	04/21/2021
Scale:	As indicated

Drawing No:
S2.04-L

kpff

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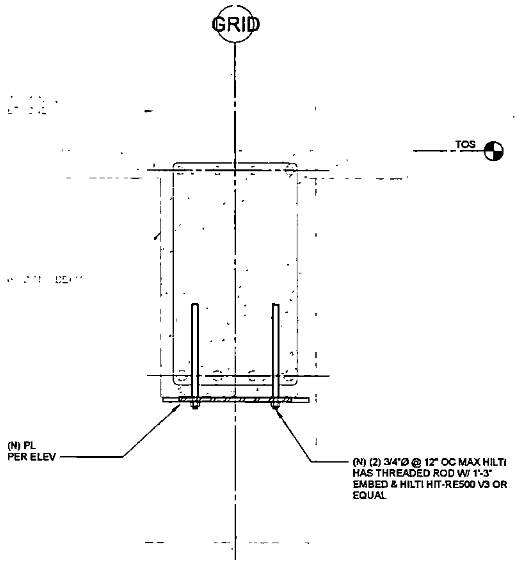
project City of Inglewood - Library	by JL	sheet no. B.3.d-16
location Inglewood, CA	date 10/14/21	
client	job no. 2000362	
Collector Plate Design		

Check Anchorage of Plates to Beams above:



Anchors will be designed for the worst case unit shear at any level.
$vu = 7.45k/ft$ and $vu_{@1st\ Floor} = 15.95k/ft$

Anchorage will be checked using Hilti Profis.

Due to the longitudinal bars in the beam a shear breakout failure should not occur. Hilti profis does not allow the user to remove failure mechanisms therefore only steel shear failure or shear pryout will be used to determine the capacity of the anchorage. Setting phi = 1.0 is not possible to do in Hilti Profis. Nominal capacities will be obtained through the generated reports in Hilti Profis.

Per profis results governing capacity is steel shear strength.
Vn = 25.296k/ft

DCR = 7.45/25.296 = 0.29 @ Upper Levels
DCR = 15.95/25.296 = 0.63 @ 1st floor

Therefore (2) 1" DIA epoxied threaded rods @ 12" OC is adequate to resist shear transfer.

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Company:		Page:	1
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	Collector Plate Dowels - Levels 2 To Roof	Date:	10/15/2021
Fastening point:			

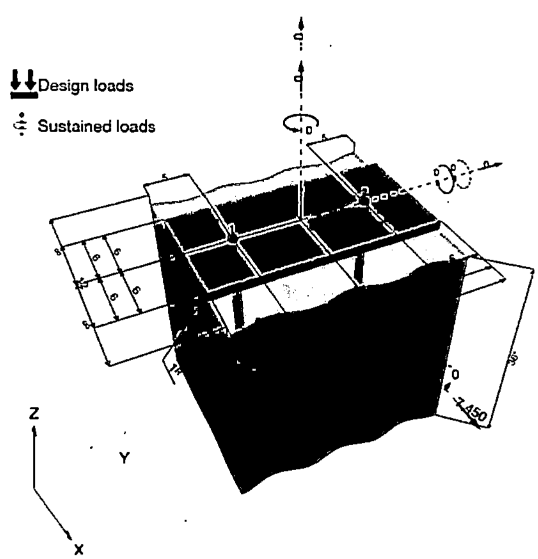
Specifier's comments:

1 Input data

Anchor type and diameter:	**HIT-RE 500 V3 + HAS-V-36 (ASTM F1554 Gr.36) 1**
Item number:	not available (element) / 2123401 HIT-RE 500 V3 (adhesive)
Effective embedment depth:	$h_{ef,act}$ = 15.000 in. ($h_{ef,limit}$ = - in.)
Material:	ASTM A 1554 Grade 36
Evaluation Service Report:	ESR-3814
Issued I Valid:	3/1/2021 | 1/1/2023
Proof:	Design Method ACI 318-14 / Chem
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 1.000 in.
Anchor plate^R :	l_x x l_y x t = 12.000 in. x 24.000 in. x 1.000 in.; (Recommended plate thickness: not calculated)
Profile:	no profile
Base material:	cracked lightweight concrete, 5000, f_c' = 5,000 psi; h = 36.000 in., Temp. short/long: 32/32 °F
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	tension: condition B, shear: condition B; no supplemental splitting reinforcement present edge reinforcement: none or < No. 4 bar
Seismic loads (cat. C, D, E, or F)	Tension load: yes (17.2.3.4.3 (d)) Shear load: yes (17.2.3.5.3 (c))

^{R} - The anchor calculation is based on a rigid anchor plate assumption.

Geometry [in.] & Loading [lb, in.lb]



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Address:		Specifier:	
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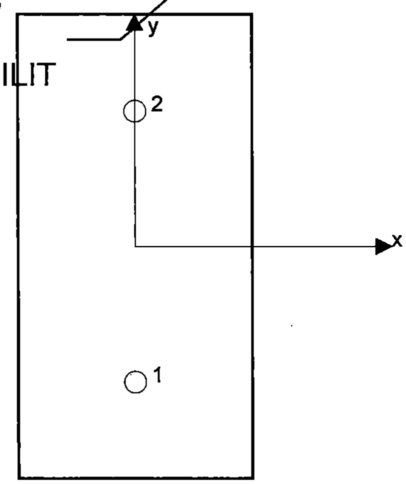
Design:	Collector Plate Dowels - Levels 2 To Roof	Date:	10/15/2021
Fastening point:			

1.1 Design results

Case	Description	Forces [lb] / Moments [in.lb]	Seismic	Max. Util. Anchor [%]
1	Combination 1	$N = 0$; $V_x = 7{,}450$; $V_y = 0$; $M_x = 0$; $M_y = 0$; $M_z = 0$; $N_{sus} = 0$; $M_{x,sus} = 0$; $M_{y,sus} = 0$;	yes	125

HILTI AUTOMATICALLY INCLUDES PHI WITHIN ALL CALCULATIONS SEE NOMINAL CAPACITIES IN SECTIONS 4.1, 4.2 AND 4.3 OF HILIT REPORT

2 Load case/Resulting anchor forces



Anchor reactions [lb]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	0	3,725	3,725	0
2	0	3,725	3,725	0

max. concrete compressive strain: - [‰]
max. concrete compressive stress: - [psi]
resulting tension force in (x/y)=(0.000/0.000): 0 [lb]
resulting compression force in (x/y)=(0.000/0.000): 0 [lb]

Anchor forces are calculated based on the assumption of a rigid anchor plate.

3 Tension load

	Load N_{ua} [lb]	Capacity ϕ N_n [lb]	Utilization $\beta_N = N_{ua}/\phi$ N_n	Status
Steel Strength*	N/A	N/A	N/A	N/A
Bond Strength**	N/A	N/A	N/A	N/A
Sustained Tension Load Bond Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Failure**	N/A	N/A	N/A	N/A

* highest loaded anchor **anchor group (anchors in tension)

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Company:		Page:	3
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Phone I Fax:	|	E-Mail:	
Design:	Collector Plate Dowels - Levels 2 To Roof	Date:	10/15/2021
Fastening point:			

4 Shear load

	Load V_{ua} [lb]	Capacity ϕ V_n [lb]	Utilization $\beta_V = V_{ua}/\phi$ V_n	Status
Steel Strength*	3,725	8,221	46	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength (Concrete Breakout Strength controls)**	7,450	23,986	32	OK
Concrete edge failure in direction y+**	7,450	5,977	125	not recommended

* highest loaded anchor **anchor group (relevant anchors)

4.1 Steel Strength

$V_{sa,eq}$ = ESR value refer to ICC-ES ESR-3814
$\phi\ V_{steel} \geq V_{ua}$ ACI 318-14 Table 17.3.1.1

Variables

$A_{se,V}$ [in.^{2}]	f_{uta} [psi]	$\alpha_{V,seis}$
0.61	58,000	0.600

Calculations

$V_{sa,eq}$ [lb]
12,648

Results

$V_{sa,eq}$ [lb]	ϕ_{steel}	$\phi\ V_{sa,eq}$ [lb]	V_{ua} [lb]
12,648	0.650	8,221	3,725

NOMINAL CAPACITY OF A
SINGLE ANCHOR
CAPACITY OF BOTH ANCHORS
Vn = 12648#*2 = 25296#

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Company:		Page:	4
Address:		Specifier:	
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Design:	Collector Plate Dowels - Levels 2 To Roof	Date:	10/15/2021
Fastening point:			

4.2 Pryout Strength (Concrete Breakout Strength controls)

$V_{cpg} = k_{cp} \left[\left(\frac{A_{Nc}}{A_{Nc0}}\right) \psi_{ec,N}\ \psi_{ed,N}\ \psi_{c,N}\ \psi_{cp,N}\ N_b\right]$ ACI 318-14 Eq. (17.5.3.1b)

$\phi\ V_{cpg} \geq V_{ua}$ ACI 318-14 Table 17.3.1.1

A_{Nc} see ACI 318-14, Section 17.4.2.1, Fig. R 17.4.2.1(b)

$A_{Nc0} = 9\ h_{ef}^2$ ACI 318-14 Eq. (17.4.2.1c)

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\ e_N}{3\ h_{ef}}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.4)

$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5 h_{ef}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.5b)

$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5 h_{ef}}{c_{ac}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.7b)

$N_b = k_c\ \lambda_a\ \sqrt{f'_c}\ h_{ef}^{1.5}$ ACI 318-14 Eq. (17.4.2.2a)

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	15.000	0.000	0.000	5.000

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ_a	f'_c [psi]
1.000	26.967	17	0.600	5,000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
1,080.00	2,025.00	1.000	1.000	0.767	1.000	41,901

Results

V_{cpg} [lb]	$\phi_{concrete}$	$\phi_{seismic}$	$\phi_{nonductile}$	$\phi\ V_{cpg}$ [lb]	V_{ua} [lb]
34,266	0.700	1.000	1.000	23,986	7,450

NOMINAL
CAPACITY OF
BOTH ANCHORS

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Design:	Collector Plate Dowels - Levels 2 To Roof	Date:	10/15/2021
Fastening point:			

4.3 Concrete edge failure in direction y+

$V_{cb} = \left(\frac{A_{Vc}}{A_{Vc0}}\right) \psi_{ed,V}\ \psi_{c,V}\ \psi_{h,V}\ \psi_{parallel,V}\ V_b$ ACI 318-14 Eq. (17.5.2.1a)

$\phi\ V_{cb} \geq V_{ua}$ ACI 318-14 Table 17.3.1.1

A_{Vc} see ACI 318-14, Section 17.5.2.1, Fig. R 17.5.2.1(b)

$A_{Vc0} = 4.5\ c_{a1}^2$ ACI 318-14 Eq. (17.5.2.1c)

$\psi_{ed,V} = 0.7 + 0.3\left(\frac{c_{a2}}{1.5c_{a1}}\right) \leq 1.0$ ACI 318-14 Eq. (17.5.2.6b)

$\psi_{h,V} = \sqrt{\frac{1.5c_{a1}}{h_a}} \geq 1.0$ ACI 318-14 Eq. (17.5.2.8)

$V_b = 9\ \lambda_a\ \sqrt{f'_c}\ c_{a1}^{1.5}$ ACI 318-14 Eq. (17.5.2.2b)

DUE TO THE LONGITUDINAL BARS IN THE BEAM A SHEAR BREAOUT FAILURE WILL NOT OCCUR. FAILURE MECHANISM WILL NOT GOVERN.

Variables

c_{a1} [in.]	c_{a2} [in.]	$\psi_{c,V}$	h_a [in.]	l_e [in.]
5.000	-	1.000	36.000	8.000

λ_a	d_a [in.]	f'_c [psi]	$\psi_{parallel,V}$
0.600	1.000	5,000	2.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [lb]
112.50	112.50	1.000	1.000	4,269

Results

V_{cb} [lb]	$\phi_{concrete}$	$\phi_{seismic}$	$\phi_{nonductile}$	$\phi\ V_{cb}$ [lb]	V_{ua} [lb]
8,538	0.700	1.000	1.000	5,977	7,450

C - Miscellaneous

C.1 - Accidental Torsion Study

Executive Summary

The following section presents the calculations for the accidental torsion parametric study per Section 4.2.3.2 of the basis of design. The torsion parametric study was done on a model with nominal damper properties and at the BSE-2E hazard level.

The accidental torsion parametric study compares results from drift definitions at the corners of the building measured at the lateral elements (in Upper floors at the corners of the moment frames, at the bottom story at the corner of the walls) and section cut shear results at the exterior frame lines (at the bottom story the results are at the walls only). The results at the drift definitions and section cuts from a model with a shifted center of mass(COM) are compared to the results of a model with the original COM calculated using the ETABS model.

Ratios of the results are created:
η = (result from shifted COM Model)/(result from Original COM model)

If the η values are greater than 1.1 then the analysis results will be amplified by the governing value. η values from the drift results will be used to amplify deformation results and η values from the section cut shears will be used to amplify force results.

Per the results of the study torsion amplification factors will be applied at the 1st story for deformation demands but force demands will not be amplified. Deformation and force demands at the upper stories will also not be amplified.

(4) cases were run for the accidental torsion study. Each case involves moving the center of mass 5% in a given direction. The tables below summarize each case and the location of the center of mas in each case. The center of mass was obtained per the ETABS model submitted in Volume 1 calculation package. The center of mass can be seen in Plan in the following pages. A summary of η values calculated at each can be seen following the plan sheets.

Accidental Torsion Case 1: 5% West

Story	XCM	YCM	LE/W	LN/S	Δx	Δy	XCM'	YCM'
	ft	ft	ft	ft	ft	ft	ft	ft
Roof	144.90	72.84	144.00	144.00	-7.20	0.00	137.70	72.84
Level 3	151.88	67.47	144.00	144.00	-7.20	0.00	144.68	67.47
Level 2	151.88	67.47	144.00	144.00	-7.20	0.00	144.68	67.47
Level 1	105.64	71.58	241.00	144.00	-12.05	0.00	93.59	71.58
Lecture Hall Roof	4.83	54.00	61.00	63.33	-3.05	0.00	1.78	54.00

Accidental Torsion Case 2: 5% East

Story	XCM	YCM	LE/W	LN/S	Δx	Δy	XCM'	YCM'
	ft	ft	ft	ft	ft	ft	ft	ft
Roof	144.90	72.84	144.00	144.00	7.20	0.00	152.10	72.84
Level 3	151.88	67.47	144.00	144.00	7.20	0.00	159.08	67.47
Level 2	151.88	67.47	144.00	144.00	7.20	0.00	159.08	67.47
Level 1	105.64	71.58	241.00	144.00	12.05	0.00	117.69	71.58
Lecture Hall Roof	4.83	54.00	61.00	63.33	3.05	0.00	7.88	54.00

Accidental Torsion Case 3: 5% North

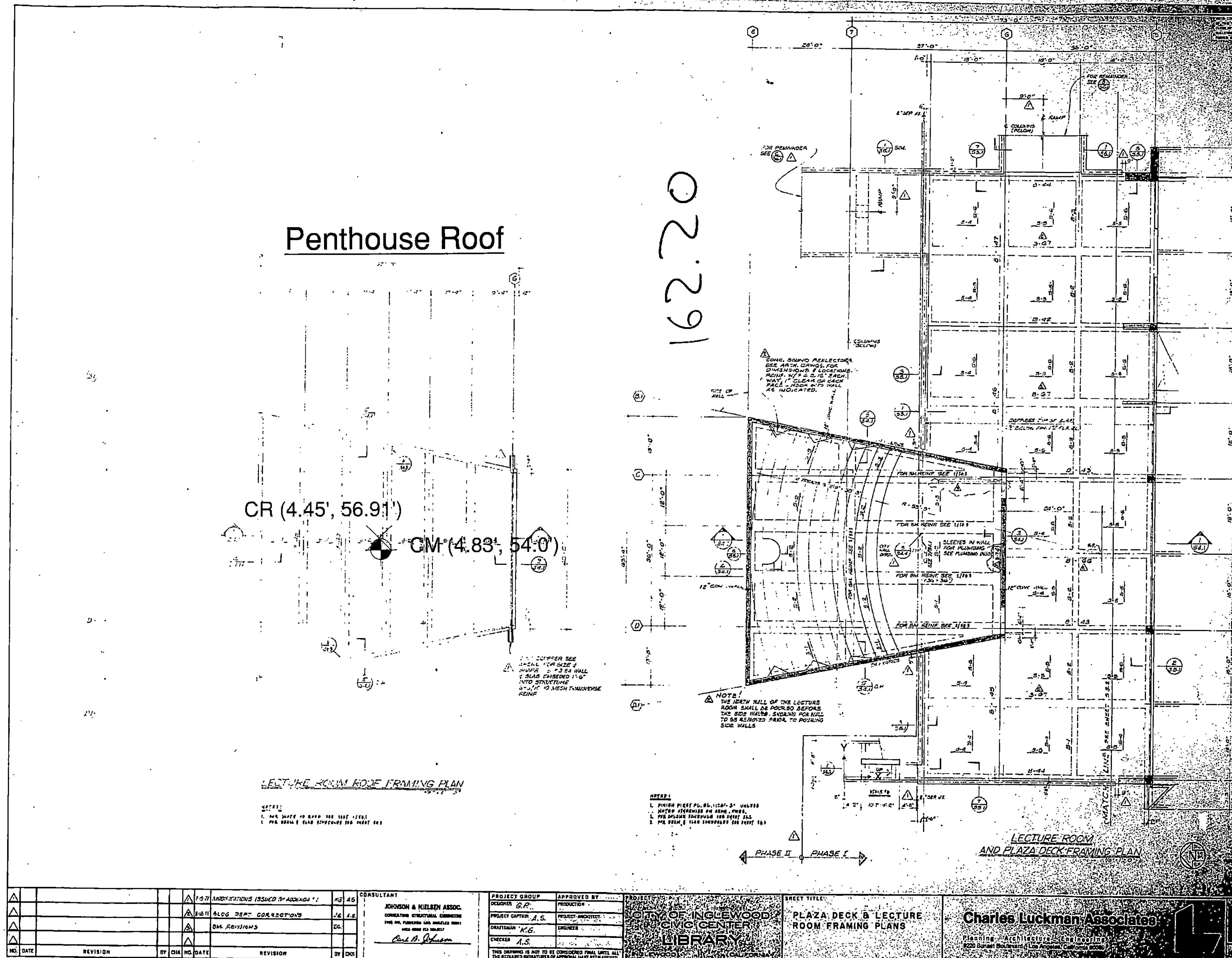
Story	XCM	YCM	LE/W	LN/S	Δx	Δy	XCM'	YCM'
	ft	ft	ft	ft	ft	ft	ft	ft
Roof	144.90	72.84	144.00	144.00	0.00	7.20	144.90	80.04
Level 3	151.88	67.47	144.00	144.00	0.00	7.20	151.88	74.67
Level 2	151.88	67.47	144.00	144.00	0.00	7.20	151.88	74.67
Level 1	105.64	71.58	241.00	144.00	0.00	7.20	105.64	78.78
Lecture Hall Roof	4.83	54.00	61.00	63.33	0.00	3.17	4.83	57.17

Accidental Torsion Case 4: 5% South

Story	XCM	YCM	LE/W	LN/S	Δx	Δy	XCM'	YCM'
	ft	ft	ft	ft	ft	ft	ft	ft
Roof	144.90	72.84	144.00	144.00	0.00	-7.20	144.90	65.64
Level 3	151.88	67.47	144.00	144.00	0.00	-7.20	151.88	60.27
Level 2	151.88	67.47	144.00	144.00	0.00	-7.20	151.88	60.27
Level 1	105.64	71.58	241.00	144.00	0.00	-7.20	105.64	64.38
Lecture Hall Roof	4.83	54.00	61.00	63.33	0.00	-3.17	4.83	50.83

NOTES:

1) XCM: Location of center of mass in the X direction
2) YCM: Location of center of mass in the Y direction
3) $L_{E/W}$: Length of diaphragm in the East/West direction
4) $L_{N/S}$: Length of diaphragm in the North/South direction
5) Δ_x: Calculated eccentricity in the X direction
6) Δ_y: Calculated eccentricity in the Y direction
7) XCM': Modified location of the center of mass in the X direction
8) YCM': Modified location of the center of mass in the Y direction



OPERATOR'S CERTIFICATION

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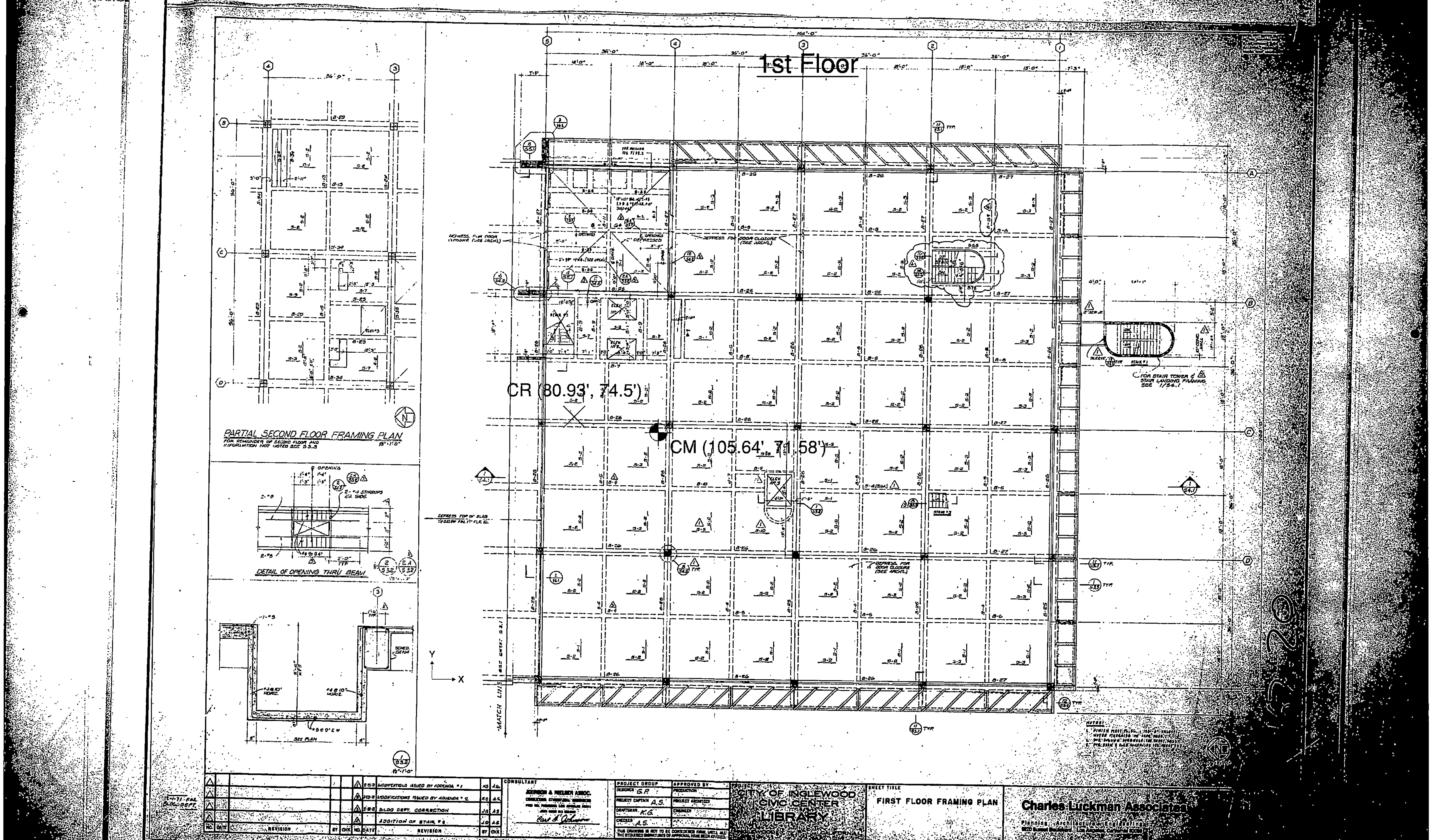
Signed: M. Netzeband Date 3-7-87



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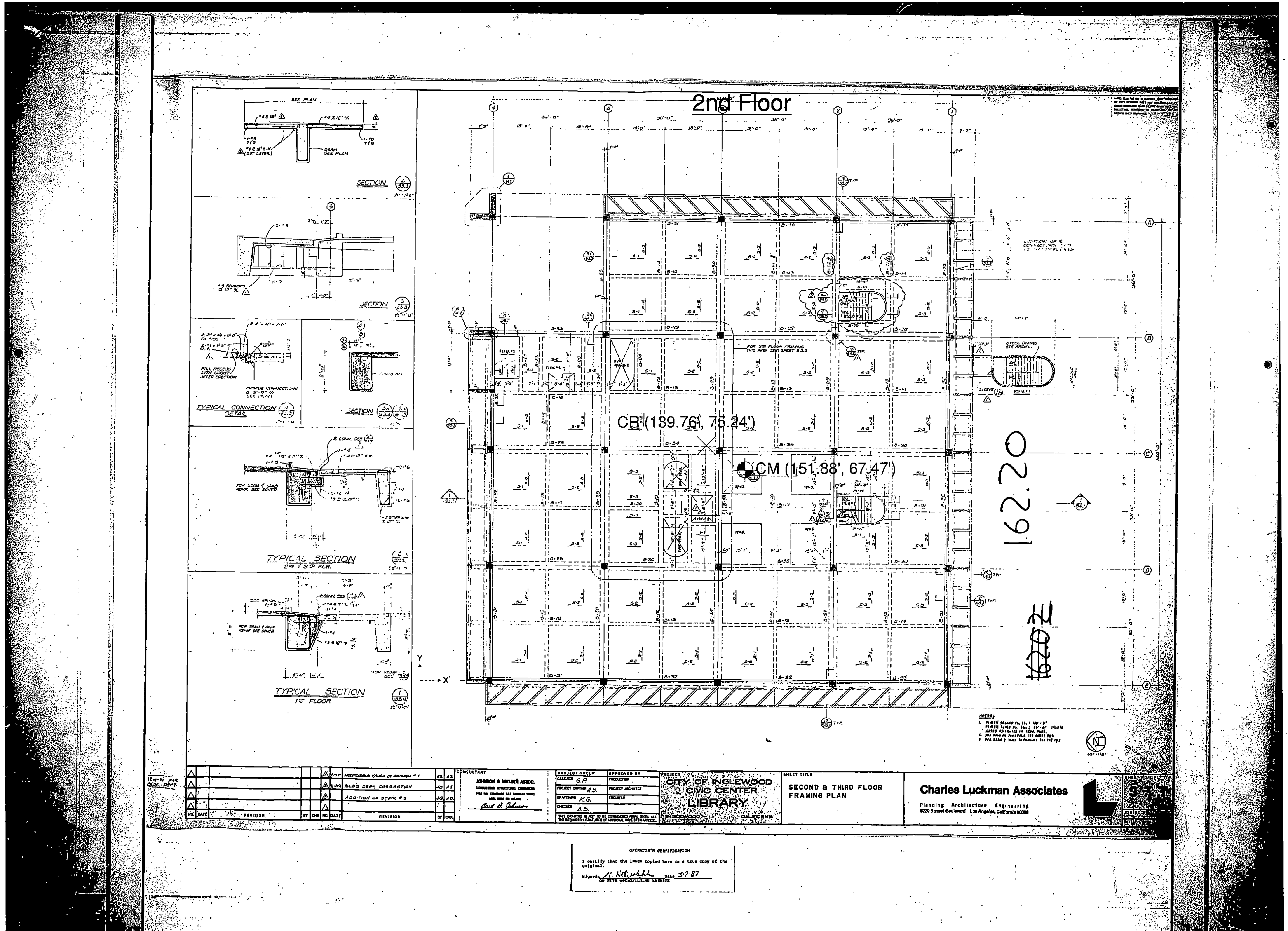
Signed: M. Netzold Date 3-7-87


2nd Floor
CR (139.76', 75.24')
CM (151.88', 67.47')
162.20
SECTION
TYPICAL CONNECTION DETAIL
TYPICAL SECTION
TYPICAL SECTION
1ST FLOOR
Y
X
JOHNSON & NIELSEN ASSOC.
CITY OF INGLEWOOD
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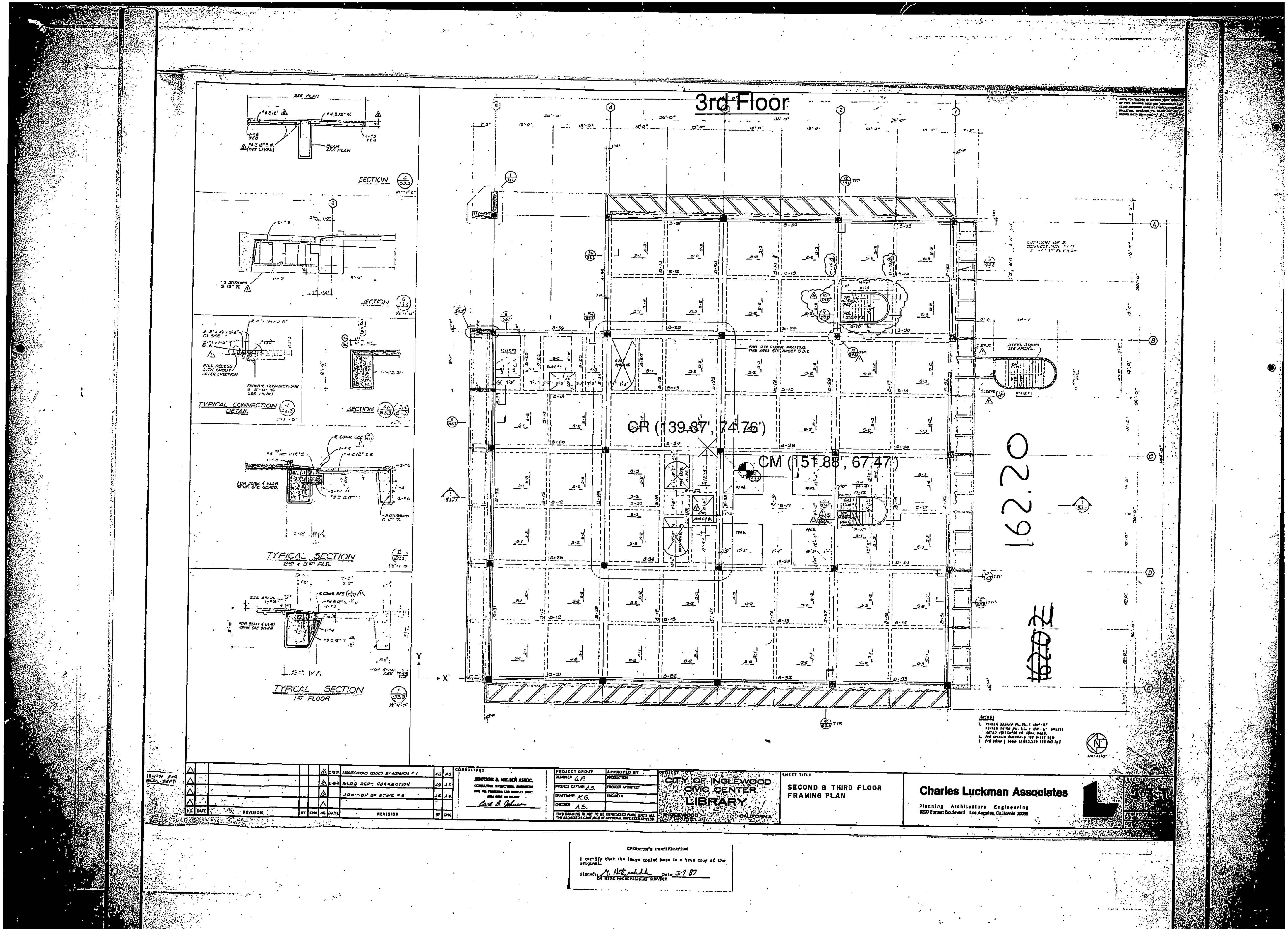
3rd Floor
CR (139.87', 74.76')
CM (151.88', 67.47')
162.20
SECTION
TYPICAL CONNECTION DETAIL
TYPICAL SECTION
2ND & 3RD FLR.
TYPICAL SECTION
1ST FLOOR
CITY OF INGLEWOOD
CIVIC CENTER
LIBRARY
SECOND & THIRD FLOOR
FRAMING PLAN
Charles Luckman Associates
Planning Architecture Engineering
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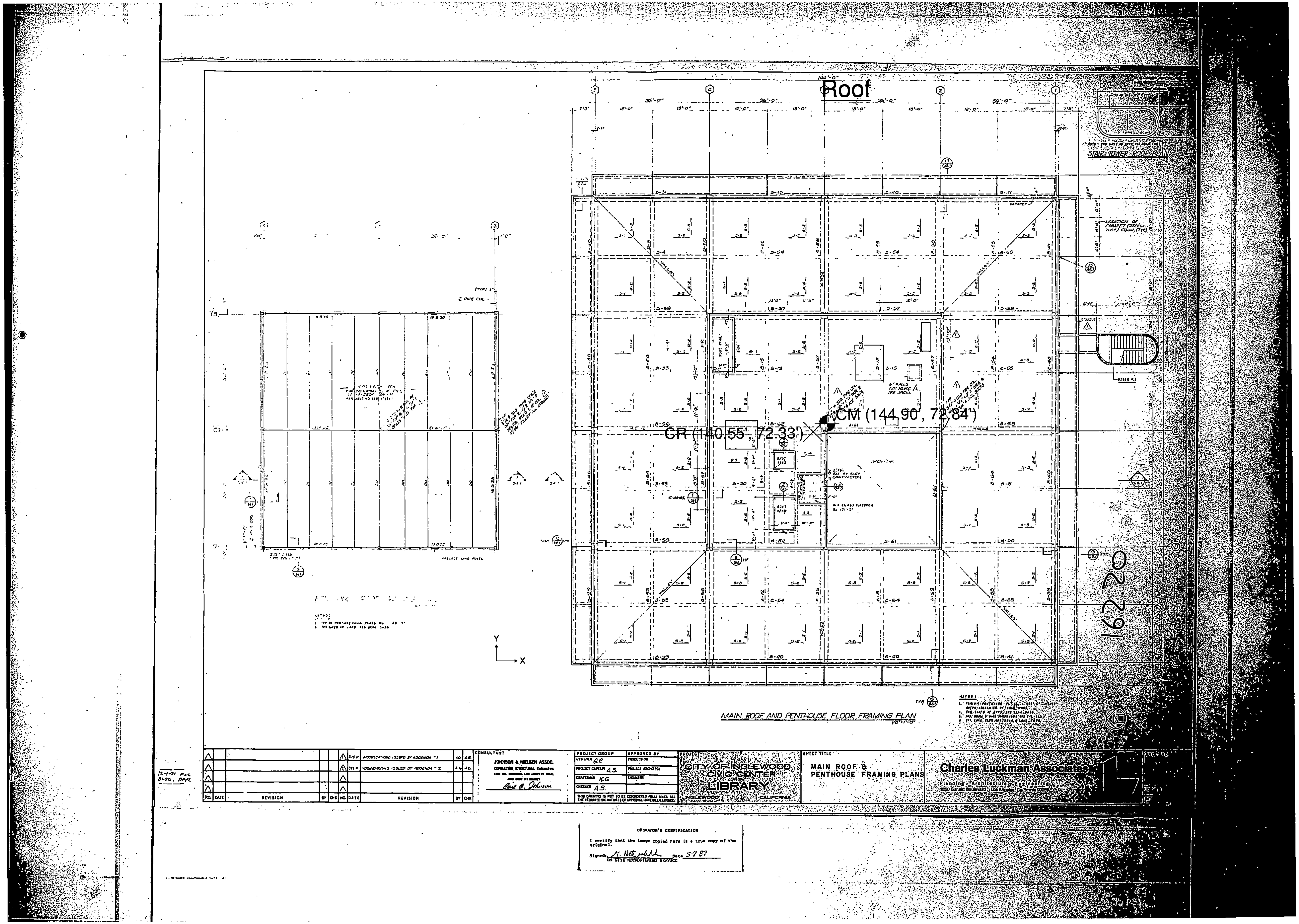
Roof
CM (144.90', 72.84')
CR (140.55', 72.33')
Y
X
STAIR TOWER ROOF PLAN
MAIN ROOF AND PENTHOUSE FLOOR FRAMING PLAN
CONSULTANT
JOHNSON & NIELSEN ASSOC.
CONSULTING STRUCTURAL ENGINEERS
PROJECT GROUP
DESIGNER G.P.
PROJECT CAPTAIN A.S.
DRAFTSMAN K.G.
CHECKER A.S.
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PRODUCTION
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ENGINEER
PROJECT
CITY OF INGLEWOOD
CIVIC CENTER
LIBRARY
INGLEWOOD
CALIFORNIA
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PENTHOUSE FRAMING PLANS
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Los Angeles, CA 90017
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project City of Inglewood - Library	by JL	sheet no. C.1-9
location	date 10/19/21	
client	job no. 2000362	

Calculation of η for Drift - H1 Direction									
Drift Definition	COI Lib_19	COI Lib_19T1		COI Lib_19T2		COI Lib_19T3		COI Lib_19T4	
	Drift Ratio	Drift Ratio	η	Drift Ratio	η	Drift Ratio	η	Drift Ratio	η
H1_NES04	0.0107	0.0104	0.97	0.0113	1.06	0.0117	1.09	0.0095	0.88
H1_NES03	0.0114	0.0111	0.97	0.0121	1.07	0.0000	0.00	0.0100	0.88
H1_NES02	0.0099	0.0097	0.97	0.0105	1.06	0.0110	1.11	0.0089	0.89
H1_NWS04	0.0105	0.0103	0.98	0.01116	1.06	0.01175	1.12	0.0092	0.88
H1_NWS03	0.0105	0.0103	0.98	0.01110	1.06	0.01169	1.12	0.0092	0.88
H1_NWS02	0.0102	0.0100	0.98	0.01067	1.05	0.01123	1.10	0.0091	0.89
H1_SWS04	0.0099	0.0103	1.04	0.01001	1.01	0.00885	0.89	0.0108	1.09
H1_SWS03	0.0130	0.0135	1.04	0.01308	1.00	0.01140	0.88	0.0146	1.12
H1_SWS02	0.0106	0.0110	1.03	0.01063	1.00	0.00955	0.90	0.0118	1.11
H1_SES04	0.0099	0.0103	1.04	0.01001	1.01	0.00885	0.89	0.0108	1.09
H1_SES03	0.0130	0.0135	1.04	0.01308	1.00	0.01140	0.88	0.0146	1.12
H1_SES02	0.0106	0.0110	1.03	0.01063	1.00	0.00955	0.90	0.0118	1.11
H1_NES01_Walls	0.00021	0.00018	0.87	0.00024	1.16	0.00022	1.04	0.0002	0.97
H1_NWS01_Walls	0.00021	0.00018	0.87	0.00024	1.16	0.00022	1.04	0.0002	0.97
H1_SES01_Walls	0.00026	0.00023	0.89	0.00029	1.12	0.00025	0.95	0.0003	1.04

Values of 1.11 and 1.12 are within 1% of the limit and will be seen as acceptable to provide no amplification, TYP.

Values of 1.16 will be applied to all deformation demands at the 1st story.

Calculation of η for Drift - H2 Direction									
Drift Definition	COI Lib_19	COI Lib_19T1		COI Lib_19T2		COI Lib_19T3		COI Lib_19T4	
	Drift Ratio	Drift Ratio	η	Drift Ratio	η	Drift Ratio	η	Drift Ratio	η
H2_NES04	0.0088	0.0076	0.87	0.0096	1.09	0.0084	0.96	0.0092	1.05
H2_NES03	0.0115	0.0104	0.90	0.0127	1.10	0.0112	0.97	0.0125	1.08
H2_NES02	0.0098	0.0089	0.91	0.0107	1.09	0.0096	0.98	0.0104	1.06
H2_NWS04	0.0085	0.0091	1.08	0.0076	0.89	0.0088	1.04	0.0086	1.02
H2_NWS03	0.0085	0.0092	1.08	0.0076	0.89	0.0089	1.04	0.0086	1.02
H2_NWS02	0.0085	0.0091	1.08	0.0075	0.89	0.0088	1.04	0.0086	1.01
H2_SWS04	0.0078	0.0081	1.04	0.0070	0.90	0.0079	1.02	0.0078	1.00
H2_SWS03	0.0100	0.0110	1.09	0.0089	0.89	0.0106	1.05	0.0102	1.01
H2_SWS02	0.0084	0.0092	1.10	0.0076	0.91	0.0088	1.04	0.0086	1.03
H2_SES04	0.0088	0.0076	0.87	0.0096	1.09	0.0084	0.96	0.0092	1.05
H2_SES03	0.0115	0.0104	0.90	0.0127	1.10	0.0112	0.97	0.0125	1.08
H2_SES02	0.0098	0.0089	0.91	0.0107	1.09	0.0096	0.98	0.0104	1.06
H2_NES01_Walls	0.0009	0.0008	0.91	0.0010	1.10	0.0009	0.99	0.0009	1.00
H2_NWS01_Walls	0.0005	0.0005	1.02	0.0005	0.96	0.0005	0.99	0.0005	0.99
H2_SES01_Walls	0.0008	0.0007	0.94	0.0008	1.08	0.0008	0.99	0.0008	1.00

Calculation of η for Story Shear - H1 Direction

Section Cut	COI Lib_19	COI Lib_19T1		COI Lib_19T2		COI Lib_19T3		COI Lib_19T4	
	V (k)	V (k)	η	V (k)	η	V (k)	η	V (k)	η
P7S01_Bot	5.10	5.17	1.01	5.03	0.99	5.11	1.00	5.12	1.00
PES01_Bot	1010.59	943.36	0.93	1067.32	1.06	1004.27	0.99	1037.39	1.03
P6S01_Bot	9.89	9.85	1.00	10.07	1.02	10.29	1.04	9.40	0.95
P1.5S01_Bot	0.03	0.02	0.86	0.03	1.08	0.03	1.02	0.02	0.97
PC.5S01_Bot	3393.28	3307.76	0.97	3507.86	1.03	3363.42	0.99	3473.06	1.02
Grid A_S04 - Col Only	265.86	265.63	1.00	269.21	1.01	271.19	1.02	260.86	0.98
Grid A_S03 - Col Only	206.49	202.65	0.98	217.55	1.05	212.07	1.03	208.07	1.01
Grid A_S02 - Col Only	347.17	347.41	1.00	351.08	1.01	364.60	1.05	335.48	0.97
Grid E_S04 - Col Only	264.13	268.32	1.02	261.71	0.99	254.78	0.96	271.50	1.03
Grid E_S03 - Col Only	320.70	330.07	1.03	323.49	1.01	312.84	0.98	340.91	1.06
Grid E_S02 - Col Only	469.46	471.02	1.00	465.53	0.99	458.13	0.98	474.88	1.01
Grid 5_S04 - Col Only	154.80	157.53	1.02	155.63	1.01	153.12	0.99	157.38	1.02
Grid 5_S03 - Col Only	145.44	146.69	1.01	145.21	1.00	145.50	1.00	146.22	1.01
Grid 5_S02 - Col Only	239.66	236.89	0.99	236.34	0.99	235.47	0.98	237.09	0.99
Grid 1_S04 - Col Only	276.78	273.66	0.99	275.69	1.00	275.16	0.99	270.65	0.98
Grid 1_S03 - Col Only	238.80	235.35	0.99	233.69	0.98	235.39	0.99	233.97	0.98
Grid 1_S02 - Col Only	381.37	383.05	1.00	379.78	1.00	382.56	1.00	376.81	0.99
PA.5S01_Bot	3342.12	3154.44	0.94	3490.80	1.04	3360.40	1.01	3320.12	0.99

Calculation of η for Story Shear - H2 Direction

Section Cut	COI Lib_19	COI Lib_19T1		COI Lib_19T2		COI Lib_19T3		COI Lib_19T4	
	V (k)	V (k)	η	V (k)	η	V (k)	η	V (k)	η
P7S01_Bot	1155.24	1202.15	1.04	1096.23	0.95	1149.52	1.00	1165.41	1.01
PES01_Bot	19.66	20.06	1.02	18.95	0.96	19.75	1.00	19.65	1.00
P6S01_Bot	2326.39	2312.35	0.99	2313.98	0.99	2323.33	1.00	2309.76	0.99
P1.5S01_Bot	2153.40	2115.98	0.98	2177.67	1.01	2155.47	1.00	2143.15	1.00
PC.5S01_Bot	0.18	0.16	0.94	0.18	1.05	0.17	0.99	0.17	1.00
Grid A_S04 - Col Only	214.71	218.86	1.02	216.70	1.01	216.25	1.01	206.49	0.96
Grid A_S03 - Col Only	202.60	203.24	1.00	200.88	0.99	204.06	1.01	200.12	0.99
Grid A_S02 - Col Only	316.42	316.92	1.00	312.04	0.99	314.31	0.99	310.24	0.98
Grid E_S04 - Col Only	246.53	249.43	1.01	238.68	0.97	252.98	1.03	237.36	0.96
Grid E_S03 - Col Only	267.28	265.74	0.99	264.32	0.99	266.33	1.00	260.29	0.97
Grid E_S02 - Col Only	347.59	354.08	1.02	341.42	0.98	352.75	1.01	343.57	0.99
Grid 5_S04 - Col Only	148.38	161.72	1.09	138.65	0.93	165.47	[redacted]	144.44	0.97
Grid 5_S03 - Col Only	207.06	215.28	1.04	205.29	0.99	215.34	1.04	215.77	1.04
Grid 5_S02 - Col Only	268.52	275.08	1.02	256.66	0.96	274.15	1.02	267.80	1.00
Grid 1_S04 - Col Only	200.23	190.74	0.95	221.77	[redacted]	206.75	1.03	220.97	[redacted]
Grid 1_S03 - Col Only	338.82	333.58	0.98	348.12	1.03	326.35	0.96	355.25	1.05
Grid 1_S02 - Col Only	408.19	395.91	0.97	423.36	1.04	409.35	1.00	414.18	1.01
PA.5S01_Bot	0.21	0.20	0.95	0.22	1.05	0.21	0.99	0.21	0.99

Values of 1.11 and 1.12 are within 1% of the limit and will be seen as acceptable to provide no amplification, TYP.

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C.2 - Penthouse Evaluation and Retrofit

kpff 700 South Flower Street, Suite 2100 Los Angeles, CA 90017 (213) 418-0201	project City of Inglewood - Library	by JL	sheet no. C.2-2
	location Inglewood, CA	date 10/20/21	
	client	job no. 2000362	
	Penthouse Evaluation and Retrofit		

Executive Summary

The following section presents the calculations for the evaluation and retrofit of the penthouse. The penthouse demands were determined using the average spectral acceleration from response spectra developed at the library roof center of mass node for each ground motion in each direction.

The penthouse strengthening involves strengthening the existing connections to use the existing precast panels as shear walls.

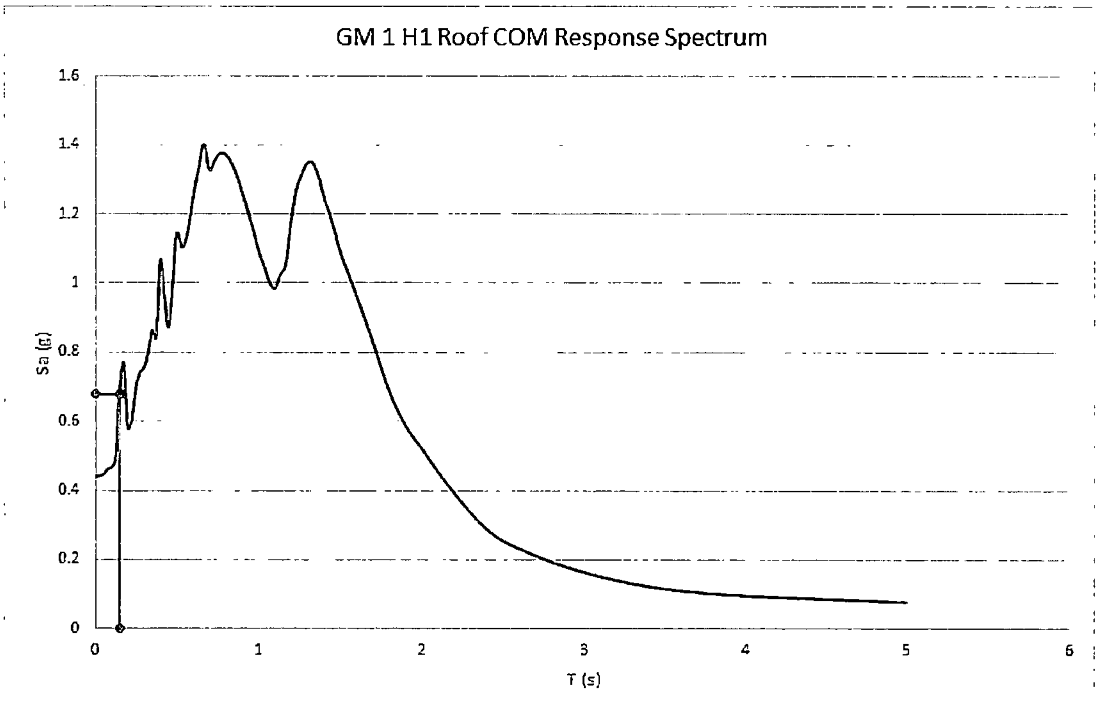
Since the roof of the library penthouse is not explicitly modeled the acceleration demands at the penthouse roof will be obtained by creating a response spectrum of the library roof using the center of mass node in the PERFORM-3D model for every ground motion. The period of the penthouse will be determined per ASCE 41-17 7.4.1.2.2. With the period of the penthouse the demand at the penthouse will be determined as the average spectral acceleration from each ground motion response spectrum.

Period of the Penthouse:

$T = C_t h_n^{\beta}$
$C_t = 0.02$
$h_n = 14.5'$
$\beta = 0.75$

$T = 0.149s$

Example of Roof Response spectrum:



$Sa_{@\,T=0.149s} = 0.68g$

These spectral acceleration values are found for every ground motion in each direction and averaged.

The final spectral acceleration values are as follows:
Average $Sa_{H1} = 0.56g$
Average $Sa_{H2} = 0.49g$

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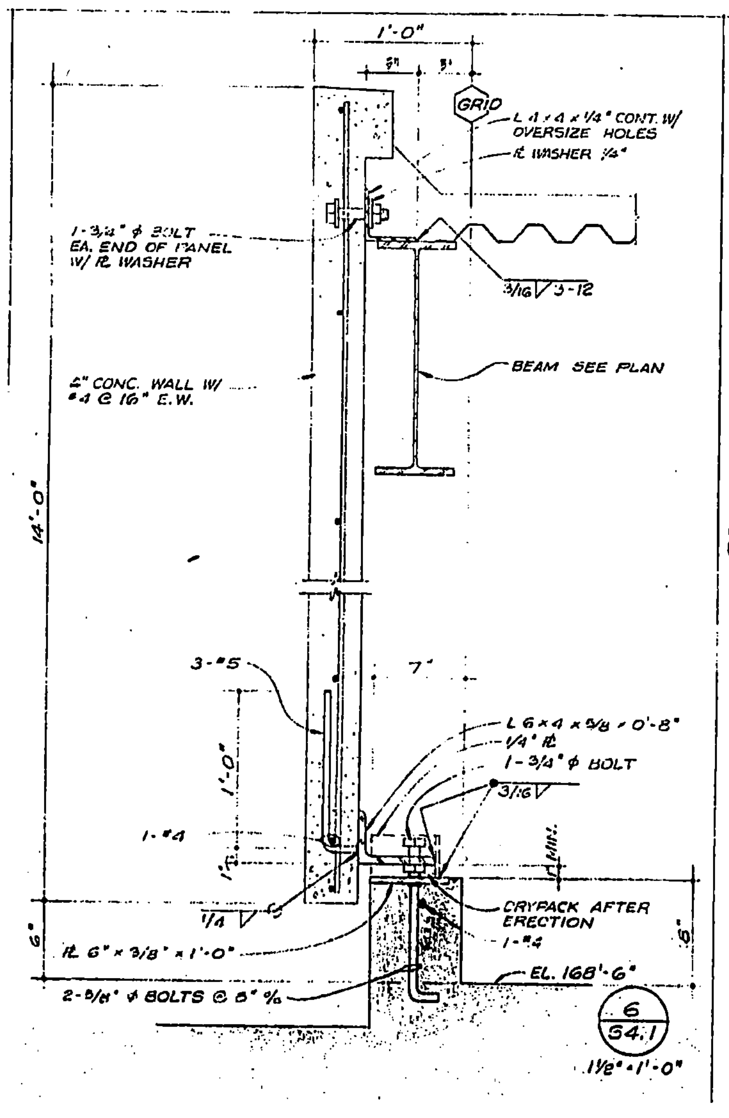
project COI Library	by IK	sheet no. C.2-4
location Inglewood, CA	date 10/19/2021	
client City of Inglewood	job no. 2000362	
Penthouse Study		

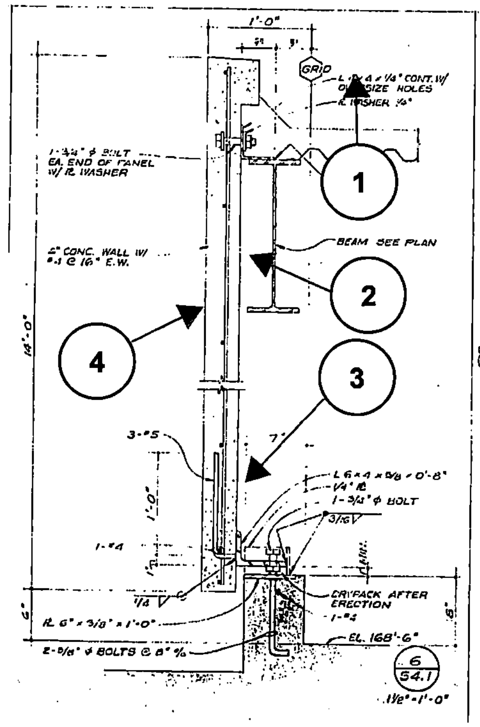
Check existing pre-cast concrete panels and associated connections to resist lateral force at penthouse framing

As-built drawings 6/S4.1



All connections in the load path are checked to enable the concrete panels to act as concrete shear walls. Gravity connections are assumed adequate since no modifications are made. New connections are added for shear load, where load path is not sufficient.

1 SEISMIC DEMAND CALCULATION



Acceleration at Penthouse Level = 0.56g

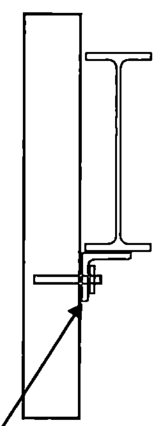
High Roof Contribution:
High roof mass = 64.85 psf
Total seismic load 64.85*0.56 = 36 psf
Total load per side = 36 psf * 72ft * 72ft / 2 = 94 kips

Concrete Panel Contribution:
Worst case loading is at Western wall.
There are 8 total full size pre-cast panels, and 4 partial height louvered panels.
6 pre-cast panels available to resist shear - other panels are obstructed by ducts or equipment.

Full size Precast panel = 6' wide by 14' tall by 4" thick
Louvered Precast panel = 6' wide by 11' tall by 4" thick
Full size panel seismic mass = 2.3 kip
Louvered panel seismic mass = 1.8 kip

Total lateral load resisted by a wall panel =
((8+(6+3.5)/2)*2.3+(4+2.5/2)*1.8+94+)/6 = 22.2k per panel
(Includes upper 1/2 half of perpendicular walls and upper 1/2 half of louvered panels)

2 PANEL TOP CONNECTION CHECK



Added angle with epoxy anchor

Lateral load to transfer = 22k
Use 1/2" Ø Gr. 105 Threaded rods with Hilti HIT-HY 200 w/ 2 3/4" min eff embed (ICC ESR-3187). Anchor capacity per Hilti Profis output = 3.75k.

n_anchors required = 22k/3.75k = 6 Anchors
DCR = 0.78 < 1.0 per anchor

Attach anchors to bottom of Steel beam w/ continuous L4x4x3/8 over panel width.
Weld to beam w/ 3/16" fillet weld 3" long @ 12" OC

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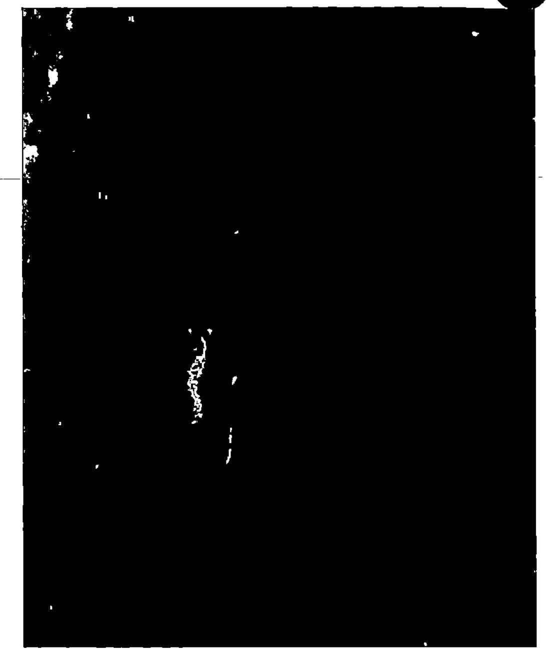
project COI Library	by RS	sheet no. C.2-6
location Inglewood, CA	date 07/29/2021	
client City of Inglewood	job no. 2000362	
Penthouse Study		

(3) PANNEL BOTTOM CONNECTION CHECK



Existing conditions differ from as-built drawings.
See photo.
It is assumed that existing connections support gravity loads only.

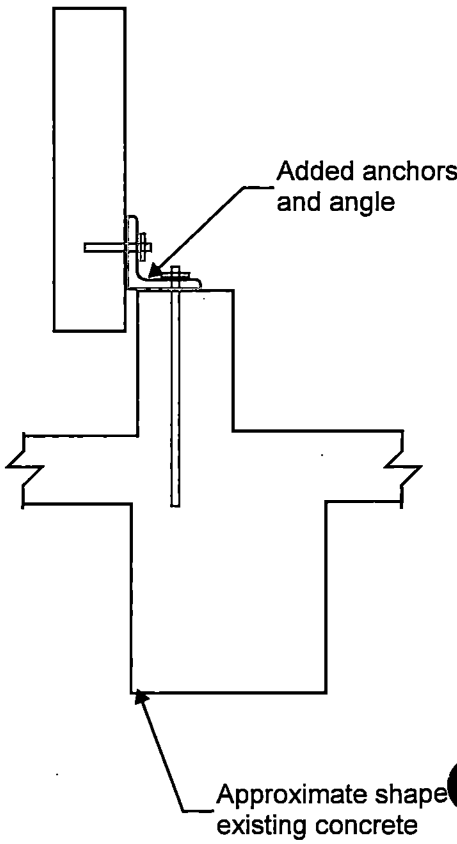
For seismic load transfer, provide L6x6x3/8 w/ anchors to beam/slab below curb and anchors to wall panel.
See attached Hilti Profis calculation for bottom connection.

For bottom connection to panel use (6) 1/2" Ø Gr. 105 threaded rods with Hilti HIT-HY 200 w/ 2 3/4" effective embed.

Shear load to transfer = 22k
Shear load per anchor = 22/6=3.75k
DCR = 0.78 < 1.0 per Anchor

Connection to structure below using (6) 3/4" Ø Gr. 55 Threaded rods with Hilti HIT-HY 200 w/ 8" eff embed extending into beam below curb.

DCR = 0.99 < 1.0 w/ only the embed in to beam being considered.



(4) PRE CAST PANEL SHEAR STRENGTH

ΦVc=Φ*2*L*sqrt(fc')*bw*d
= 0.65*2*1.0*sqrt(3000)*4"*71" = 20.2 kip

#4 bars @16" OC Each Way, approx (4) bars total for shear

ΦVs=Φ*Av*Fy (ACI 318-14 §22.5.10.6.2a)
=0.65*4*0.2*40ksi = 20.4 kip

ΦV=ΦVs+ΦVc = 40.6 kip

DCR = 22k/40.6k = 0.542 < 1.0 OKAY

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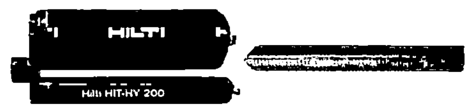
Address:	700 S Flower Street, Suite 2000	Specifier:	Raivyno Sutrisno
Phone I Fax:	2134180201 |	E-Mail:	raivyno.sutrisno@kpff.com
Design:	COI Bottom to Panel	Date:	10/13/2021
Fastening point:			

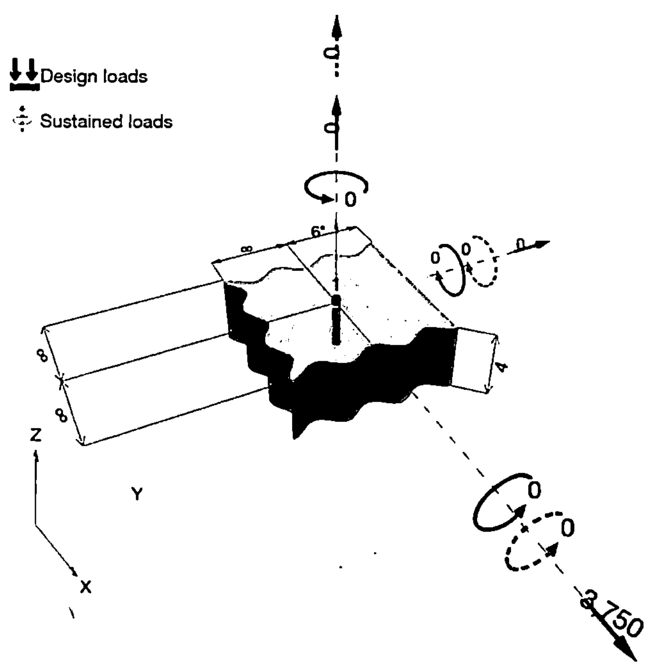
Specifier's comments:

1 Input data



Anchor type and diameter:	**HIT-HY 200 + HAS-B-105 (ASTM F1554 Gr.105) 1/2**
Item number:	2197961 HAS-B-105 1/2"x6 1/2" (element) / 2022793 HIT-HY 200-R (adhesive)
Effective embedment depth:	$h_{ef,opti}$ = 2.750 in. ($h_{ef,limit}$ = 2.750 in.)
Material:	ASTM A 1554 Grade 105
Evaluation Service Report:	ESR-3187
Issued I Valid:	5/1/2021 | 3/1/2022
Proof:	Design Method ACI 318-14 / Chem
Stand-off installation:	
Profile:	
Base material:	cracked concrete, 3000, f_c' = 3,000 psi; h = 4.000 in., Temp. short/long: 32/32 °F
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	tension: condition B, shear: condition B; no supplemental splitting reinforcement present edge reinforcement: none or < No. 4 bar
Seismic loads (cat. C, D, E, or F)	Tension load: yes (17.2.3.4.3 (d)) Shear load: yes (17.2.3.5.3 (c))

Geometry [in.] & Loading [lb, in.lb]



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Phone I Fax:	2134180201 |	E-Mail:	raivyno.sutrisno@kpff.com
Design:	COI Bottom to Panel	Date:	10/13/2021
Fastening point:			

1.1 Design results

Case	Description	Forces [lb] / Moments [in.lb]	Seismic	Max. Util. Anchor [%]
1	Combination 1	$N = 0; V_x = 3{,}750; V_y = 0;$ $M_x = 0; M_y = 0; M_z = 0;$ $N_{sus} = 0; M_{x,sus} = 0; M_{y,sus} = 0;$	yes	78

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Design:	COI Bottom to Panel	Date:	10/13/2021
Fastening point:			

2 Proof I Utilization (Governing Cases)

		Design values [lb]		Utilization	
Loading	Proof	Load	Capacity	β_N / β_V [%]	Status
Tension	-	-	-	- / -	N/A
Shear	Steel Strength	3,750	4,843	- / 78	OK

Loading	β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
Combined tension and shear loads	-	-	-	-	N/A

3 Warnings

- Please consider all details and hints/warnings given in the detailed report!

Fastening meets the design criteria!

Company:	KPFF Consulting Engineers	Page:	4
Address:	700 S Flower Street, Suite 2000	Specifier:	Raivyno Sutrisno
Phone I Fax:	2134180201 |	E-Mail:	raivyno.sutrisno@kpff.com
Design:	COI Bottom to Panel	Date:	10/13/2021
Fastening point:			

4 Remarks; Your Cooperation Duties

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Company:	KPFF Consulting Engineers	Page:	1
Address:	700 S Flower Street, Suite 2000	Specifier:	Raivyno Sutrisno
Phone I Fax:	2134180201 |	E-Mail:	raivyno.sutrisno@kpff.com
Design:	COI Bottom to Curb	Date:	10/13/2021
Fastening point:			

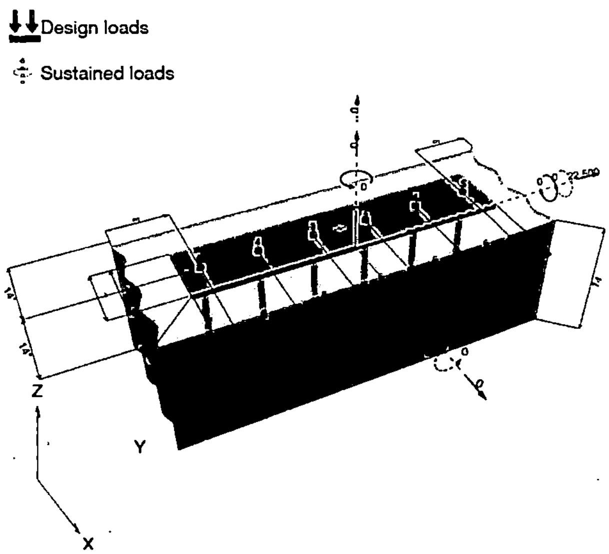
Specifier's comments:

1 Input data

Anchor type and diameter:	**HIT-HY 200 + HAS-E-55 (ASTM F1554 Gr.55) 3/4**
Item number:	2197999 HAS-E-55 3/4"x10" (element) / 2022793 HIT-HY 200-R (adhesive)
Effective embedment depth:	$h_{ef,act}$ = 8.000 in. ($h_{ef,limit}$ = - in.)
Material:	ASTM A 1554 Grade 55
Evaluation Service Report:	ESR-3187
Issued I Valid:	5/1/2021 | 3/1/2022
Proof:	Design Method ACI 318-14 / Chem
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.500 in.
Anchor plate[R] :	l_x x l_y x t = 7.000 in. x 34.000 in. x 0.500 in.; (Recommended plate thickness: not calculated)
Profile:	no profile
Base material:	cracked concrete, 4000, f_c' = 4,000 psi; h = 14.000 in., Temp. short/long: 32/32 °F
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	tension: condition B, shear: condition B; no supplemental splitting reinforcement present
	edge reinforcement: none or < No. 4 bar
Seismic loads (cat. C, D, E, or F)	Tension load: yes (17.2.3.4.3 (d))
	Shear load: yes (17.2.3.5.3 (c))

[R] - The anchor calculation is based on a rigid anchor plate assumption.

Geometry [in.] & Loading [lb, in.lb]



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Fastening point:			

1.1 Design results

Case	Description	Forces [lb] / Moments [in.lb]	Seismic	Max. Util. Anchor [%]
1	Combination 1	$N = 0$; $V_x = 0$; $V_y = 22{,}500$; $M_x = 160{,}000$; $M_y = 0$; $M_z = 0$; $N_{sus} = 0$; $M_{x,sus} = 0$; $M_{y,sus} = 0$;	yes	99

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2 Proof I Utilization (Governing Cases)

		Design values [lb]		Utilization	
Loading	Proof	Load	Capacity	β_N / β_V [%]	Status
Tension	Concrete Breakout Failure	6,906	16,404	43 / -	OK
Shear	Concrete edge failure in direction x+	22,752	26,990	- / 85	OK

Loading	β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
Combined tension and shear loads	0.421	0.843	5/3	99	OK

3 Warnings

- Please consider all details and hints/warnings given in the detailed report!

Fastening meets the design criteria!

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- You must take all necessary and reasonable steps to prevent or limit damage caused by the Software. In particular, you must arrange for the regular backup of programs and data and, if applicable, carry out the updates of the Software offered by Hilti on a regular basis. If you do not use the AutoUpdate function of the Software, you must ensure that you are using the current and thus up-to-date version of the Software in each case by carrying out manual updates via the Hilti Website. Hilti will not be liable for consequences, such as the recovery of lost or damaged data or programs, arising from a culpable breach of duty by you.

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DIVISION I

SPECIAL PROVISIONS

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DIVISION I

SPECIAL PROVISIONS

Except as otherwise provided in the Special Provisions, Technical/Special Specifications, or as modified herein, the work embraced herein shall be done in accordance with the appropriate provisions of the Standard Specifications for Public Works Construction, Latest Edition, which are hereinafter referred to as the Standard Specifications.

The intention of the Contract Documents is to include all plant labor, services, materials, tools, equipment, supplies, transportation, utilities, and all other items and facilities necessary therefore, as provided in the contract documents for the proper execution and completion of the work on the project in strict accordance with the plans and specifications.

Section 1. DEFINITIONS

Whenever in the contract documents the following terms are used, they shall be understood to mean and refer to the following:

AGENCY means the City of Inglewood.

ALLOWABLE COSTS means those costs, listed in Article 22 of this Contract for Work not covered by agreed unit prices, which are to be used in calculating adjustments to the Contract Sum and that do not include any costs listed as not allowed in Article 22 of this Contract.

ALLOWABLE MARKUPS means the percentage of markups specified in Article 22 of this Contract for Work not covered by agree unit prices, which are to be used in calculating adjustments to the Contract Sum.

APPLICABLE LAWS means all applicable federal, state and municipal laws (legal and equitable), statutes, building codes, ordinances, regulations and lawful orders (including, without limitation, the City acting in its regulatory capacity) having jurisdiction over the Project, Work, Site, City, or Contractor (including, without limitation, Environmental Laws) and all ordinances, rules and regulations enacted by City. In the event of a conflict between or among Applicable Laws governing Contractor's performance of the Work, the more stringent shall apply.

APPLICATION FOR PAYMENT means Contractor's certified application for payment for Work in accordance with Contract Documents.

ARCHITECT means the individual or firm under contract with City primarily responsible to provide design, engineering and related construction administration for the Project.

BOARD: CITY COUNCIL of the CITY OF INGLEWOOD

BIDDING DOCUMENTS means the following collection of documents prepared and issued for the purpose of soliciting Bids for the Work: (1) Invitation to Submit Bids, (2) Instructions to Bidders, (3) Bid Forms, (4) Construction Contract, (5) Technical Specifications, (6) Drawings and Schedules, (7) Details, (8) Addenda(s), and (9) those documents, or those portions or provisions of documents that, although not listed among the documents described in Clauses (1) through (8) hereinabove, are expressly cross- referenced therein or attached thereto.

CERTIFICATE FOR PAYMENT means the statement from the Engineer certifying both the undisputed amount of money due to Contractor and the amount of money, if any, that are disputed upon an Application for Payment.

CHANGE means a modification, change, addition, substitution or deletion in the Work or in

Contractor's means, methods, manner, time or sequence of performing the Work arising from any cause or circumstances, including, without limitation, either directly at the request of City or constructively by reason of other circumstances. Use of the term "Change," in any context, in the Contract Documents shall not be interpreted as implying that Contractor is entitled to an adjustment increasing the Contract Sum or extending the Contract Time on any basis other than for Compensable Change or Compensable Delay.

CHANGE ORDER means a written instrument, signed by City and Contractor in accordance with the requirements of the General Conditions, designating any work that is a change of scope requiring additional expenditure of materials and labor and/or requiring additional time to complete. Its purpose is to establish the terms of City's and Contractor's mutual agreement to an adjustment of the Contract Sum or Contract Time on account of Compensable Change, Deleted Work, Compensable Delay or Excusable Delay.

CHANGE ORDER REQUEST means Contractor's written request for an adjustment in the Contract Sum and/or Contract Time due to a Compensable Change, Compensable Delay or Deleted Work.

CITY means the City of Inglewood, a municipal corporation organized under the laws of the State of California, acting through the City Council or other representatives duly authorized by the City Council to act on City's behalf.

CITY CONSULTANT means the designated Consultant, other than Architect, engaged by City (or engaged as a sub-consultant to the Architect or Consultant) to provide professional advice with respect to the design, construction or management of the Project.

CITY COUNCIL means the City Council of the City of Inglewood.

CLAIM means a written demand or assertion by City or Contractor seeking, as a matter of right, an interpretation of contract, payment of money, recovery of damages or other relief. A CLAIM does not include the following: (1) a tort claims for personal injury or death, (2) stop notice claims, (3) the right of City to specific performance or injunctive relief to compel performance, or (4) any rights remedies, administrative action, and/or penalties that the City has under applicable law.

CLOSE-OUT DOCUMENTS means the warranties, guarantees, maintenance and operations manuals that, along with electronic versions, are required to be delivered by Contractor to the City upon Final Completion of the Project Work.

COMPENSABLE CHANGE means Extra Work: (1) that is the result of (a) Differing Site Conditions, or (b) revisions in Applicable Laws enacted after the execution of the Construction Contract by City and Contractor, (c) a Change requested in a writing signed by Engineer, or (d) other circumstances involving a Change in the Work or which Contractor is given under the Contract Documents a specific and express right to adjustment of the Contract sum; and (2) that is not caused, in whole or part, by the negligence or willful misconduct of Contractor or a Subcontractor of any Tier or a failure to comply with Contractor's obligations under the Contract Documents; and (3) for which an adjustment to the Contract Sum is not prohibited by nor waived under the terms of the Contract Documents; and (4) that if performed would require Contractor to incur additional and unforeseeable Allowable Costs that would not have been required to be incurred in the absence of such Extra Work.

COMPENSABLE DELAY means a Delay to the critical path of activities affecting Contractor's ability to achieve Final Completion of the Project Work within the Contract Time, not caused, in whole or in part, by the negligence or willful misconduct of Contractor or a Subcontractor or any Tier or a failure to comply with Contractor's obligations under the Contract Documents, and that is caused solely by any of the following: (1) a Compensable Change, (2) the active negligence of City, Engineer, Architect, City Consultant or a Separate Contractor, or (3) other circumstances involving Delay for which Contractor is given under the Contract Documents a specific and express right to both an adjustment of the Contract Sum and/or Contract Time.

COMPLETION PUNCH LIST means the list of items of Work to be completed or corrected by Contractor for Final Completion of the Project Work.

CONSEQUENTIAL DAMAGES means damages incurred by either City or Contractor for loss of use, loss of profit or income, lost of revenue, lost opportunity, additional or unabsorbed overhead, loss of management or services, loss of productivity, loss of financing or funding, loss of business reputation, loss of bonding and all similar indirect, economic damages that are caused as a result of either Delay or that result from a termination or suspension (for default or convenience) of all or any portion of the Construction Contract or the Work. Consequential Damages do not include direct or indirect damage or injury to persons or tangible property, including without limitation, the repair or replacement of tangible property damaged or lost.

CONSTRUCTION CONTRACT means the written contract contained in the Bidding Documents and executed between City and Contractor for the Work.

CONTRACT DOCUMENTS means the following collection of documents governing Contractor's performance of the Work: (1) the Bidding Documents, (2) the Construction Contract between City and Contractor, other terms, conditions and requirements applicable to the performance of the Construction Contract and Work (including General Conditions, any supplemental and Special Conditions and the General Requirements), Drawings, Specifications, Addenda issued prior to execution of the Construction Contract and other documents listed in the Construction Contract and Modifications issued after execution of the Construction Contract, (3) a Change Order signed by both City and Contractor and/or such others, if any, as required by the General Conditions, (4) a Unilateral Change Order signed by City and/or such others, if any, as required by the General Conditions, (5) a Field Order signed by City and/or such others, if any, as required by the General Conditions, (6) a written order for a Minor Change in the Work issued by the Engineer, and (7) the Declaration of Sufficiency of Funds completed and signed by Contractor.

CONTRACT SUM means the total amount of compensation stated in the Construction Contract, including adjustments authorized by Change Orders or Unilateral Change Orders, that is payable to Contractor for the performance of the Work in accordance with the Contract Documents.

CONTRACT TIME means the total number of Days set forth in the Construction Contract within which Contractor is obligated to submit Materials Confirmations and achieve Completion and Final Completion of the Project Work and/or Project Work, as adjusted for extensions of time permitted under the terms of the Contract Documents and approved by City.

CONTRACTOR means the person or entity under contract with City pursuant to the Construction Contract to serve as the general contractor for construction of the Work.

DAY, whether capitalized or not, and unless otherwise specifically provided, means Monday, Tuesday, Wednesday, Thursday, and Fridays, and does not include weekends or City recognized legal holidays.

DEFECTIVE WORK means Work by Contractor or a Subcontractor that is unsatisfactory, faulty, omitted, incomplete, deficient or does not conform to Applicable laws, the Contract Documents or the requirements of any inspection, reference standard, test, code or approval specified in the Contract Documents.

DELAY, whether capitalized or not, means any circumstances involving delay, disruption, hindrance or interference in the performance of the Work.

DELETED WORK means work that is eliminated due to a Change requested by City. DESIGN DOCUMENTS means all plans, drawings, tracings, specifications, programs, reports, calculations, models, presentation materials and other materials or documents containing designs, specifications or engineering information prepared by the Architect, City Consultants, Contractor, Separate Contractors or Subcontractors including, without limitation, computer aided design materials, electronic data files and paper copies. The term "Design Documents" includes, without limitation, all building and other designs depicted therein, as well as the written documents themselves.

DIFFERING SITE CONDITION means an unforeseen condition at a Site or in Existing improvements at a Site. Specifically they are those conditions, located at a Site or in Existing Improvements, not otherwise ascertainable by Contractor through the exercise of thorough care and diligence in its inspection of the Sites and Bidding Documents, that constitute: (1) hazardous materials that constitute hazardous waste, as defined in California Health and Safety Code Section 25117, that is required to be removed to a Class I, Class II, or Class III disposal site in accordance with provisions of Applicable Laws; or (2) subsurface or concealed conditions at the Sites or concealed conditions in Existing Improvements which differ materially from those indicated by the Contract Documentsor other information available to Contractor prior to submission of the Bid; or (3) unknown physical conditions at the Sites or concealed conditions in Existing improvements of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in the Work of the character provided for in the Contract Documents.

DISCOVERY DATE, used in reference to Contractor's obligation to give written notice of certain facts, conditions or circumstances, means the earlier of the dates the Contractor either: (1) discovered such facts, conditions or circumstances, or (2) should have discovered such facts, conditions or circumstances in the exercise of reasonable care practiced by the general contractors performing public works construction projects in the Southern California area.

DRAWINGS means the graphic and pictorial portions of the Contract Documents prepared by the Architect or a City Consultant showing the design, location and dimensions of the Work, including plans, elevations, details, schedules and diagrams. The term "Drawings" is used interchangeably with "Plans."

ENGINEER means the City Engineer/Public Works Director, City of Inglewood acting either directly or through properly authorized agents, acting within the scope of the particular duties entrusted to them.

EXCUSABLE DELAY means a Delay, other than a Compensable Delay, to Contractor's ability to perform within the Contract Time that is (1) not caused, in whole or in part, by the negligence or willful misconduct of Contractor or a Subcontractor of any Tier or a failure to comply with the obligations of Contractor under the Contract Documents; and
(2) is unforeseeable, unavoidable and beyond the control of Contractor and the Subcontractor, of any Tier; and (3) the result of a Force Majeure Event. Without limitation to the foregoing, neither the bankruptcy, insolvency nor financial inability of Contractor or any Subcontractor, nor any failure by a Subcontractor to perform any obligation imposed by contract or Applicable Laws, shall constitute a grounds for Excusable Delay.

EXTRA WORK means Work (other than Work that is either a logical evolution of the Engineer's detailing, refinement and clarification of the Drawings and Specifications that are part of the Contract Documents or that is reasonably inferable as necessary to satisfy the design intent for a completed and fully operational system, facility or structure) that is not indicated by the Contract Documents, the performance of which requires the expenditure by Contractor of additional and unforeseen Allowable Costs. Reference to Extra Work shall not be interpreted to mean or imply that Contractor is entitled to an adjustment to the Contract Sum or Contract Time unless such Extra Work constitutes a Compensable Change.

FIELD ORDER means a written directive signed by the City and Contractor that: (1) directs the performance of a Minor Change, (2) directs performance of Work or a Change with respect to which there exists a dispute or question regarding adjustment of the Contract Sum or Contract Time, or (3) establishes a mutually agreed basis for compensation to Contractor for a Compensable Change or Deleted Work under circumstances where performance needs to proceed in advance of the Contractor having completed its substantiation and evaluation of the impact thereof on the Contract Sum or Contract Time.

FINAL COMPLETION, FINALLY COMPLETE means (1) with respect to Project Work, the point at which the following conditions have occurred with respect to such Work:
(a) the entirety of such Work is fully completed, including all minor corrective, or "punch list," items, (b) a permanent and unconditional waiver for the entirety of such Work has been delivered to City, (c) all documents required to be submitted, including without limitation, warranties, guaranties and other Close-Out Documents, (d) such Work and the related portions of the Site have been thoroughly cleared of all construction debris and cleaned in accordance with the requirements of the Contract Documents, including, but not necessarily limited to where applicable, the following: removal of temporary protections; removal of marks, stains, fingerprints and other soil and dirt from painted, decorated and natural-finished woodwork; removal of spots, plaster, soil and paint from ceramic tile, marble and other finished materials; all surfaces, fixtures, cabinet work and equipment are wiped in accordance with recommendations of the manufacturer; and all stone, tile and resilient floors are cleaned thoroughly in accordance with manufactures recommendations and buff dried by machine to bring the surfaces to sheen, and (d) all conditions set forth in the Contract Documents for completion of such Work have been, and continue to be, fully satisfied; and (2) with respect to the Project Work, the point at which: (a) all of the conditions set forth in Clause (1) of the Paragraph have occurred for each and every Home comprising the Project; and (b) all contractors and subcontractors have been paid and there are no outstanding stop orders claims or claims of any kind that may delay the payment by the City of its ten-percent self-retention monies.

FORCE MAJEURE EVENT means, and is restricted to, any of the following: (1) Acts of God, (2) terrorism or other acts of public enemy, (3) acts or omissions of Governmental Authorities beyond the reasonable foreseeability and control of Contractor, (4) epidemics or quarantine restrictions, (5) strikes, other than those resulting from a violation by Contractor or a Subcontractor of Applicable Laws or applicable collective bargaining agreements, resulting in the unavailability of workers or replacement workers, (6) acts or omissions of the Homeowner that Delay access to a Home or performance of the Work, or (7) unusual shortages in materials that are supported by documented proof that (a) Contractor made every effort to obtain such materials from all available sources located within a reasonable distance of the Site where those materials are to be used in performing the Work, (b) such shortage is due to the fact that such materials are not physically available or could not have been obtained only at exorbitant prices entirely inconsistent with current rates taking into account the quantities involved and the usual industry practices in obtaining such quantities, and (c) such shortages and the difficulties in obtaining alternate sources of materials could not have been known or anticipated at the timed the Construction Contract was entered into.

GENERAL CONDITIONS means the herein set forth general terms and conditions.

HAZARDOUS SUBSTANCE means: (1) any chemical, material or other substance defined as or included within the definition of "hazardous substances," "hazardous wastes", "extremely hazardous substances," "toxic substances", "toxic material", "restricted hazardous waste", "special waste", "contamination", or words of similar import under any Environmental Law, including without limitation, the following: petroleum (including crude oil or any fraction thereof), asbestos, asbestos-containing materials, polychlorinated biphenyls ("PCB:") and PCB-containing materials, whether or not occurring naturally; (2) lead paint, or
(3) any substance that because of its quantity, concentration or physical or chemical characteristics poses a significant present or potential hazard to human health and safety or to the environment, and which has been determined by any Governmental Authority to be a hazardous waste or hazardous substance.

INSPECTOR OF RECORD means the Building Official for the City of Inglewood responsible, among others, for conducting inspections of Project Work.

LABORATORY means the designated laboratory authorized by the Engineer to test materials and work involved in the contract.

LOSS, LOSSES mean any and all economic and non-economic injuries, losses, costs, liabilities, claims, damages, actions, judgments, settlements, expenses, fines and penalties. "Losses" do not include attorney's fees or court costs, whether arising as an expense or cost or legal proceeding to which Contractor is a party or as a consequential damage claimed against Contractor by any third person.

MINOR CHANGE means a Change in the Work that does not involve either performance of Extra Work or an adjustment to the Contract Sum or Contract.

MODIFICATION means a written agreement of City and Contractor that amends, adds to or revises the provisions of the Construction Contract or other Contract Documents.

NOTICE OF COMPLETION means the written notice by Engineer confirming the date that the Project Work is Finally Completed.

NOTICE TO PROCEED means the written notice issued by City to Contractor to begin the Project Work.

PLANS means the graphic and pictorial portions of the Contract Documents prepared by the Engineer or a City Consultant showing the design, location and dimensions of the Work, including plans, elevations, details, schedules and diagrams. The term "Plans" is used interchangeably with "Drawings."

PROGRESS PAYMENTS means a monthly payment of a portion of the Contract Sum based on Contractor's progress in the performance of the Work.

PROJECT COMPLETION DATE means the point at which the Project Work is: (1) sufficiently and entirely complete in accordance with Contract Documents so that such Work can be utilized for its intended purpose, (2) receipt by City of all permits and certificates by Governmental Authorities, if any, required to occupy and use such Work, and
(3) all systems included in the Work are operational as specified, all designated or required inspections and certifications by Governmental Authorities have been made and posted and has been completed.

PROJECT OR PROJECT WORK means the totality of the Work to be performed by Contractor under the terms of the Contract Documents covered by the Project Contract.

REQUEST FOR EXTENSION means a formal written request required to be submitted by Contractor pursuant to Article 23 of this Contract setting forth the justification and support for Contractor's request for adjustment in the Contract Time due to an Excusable Delay or Compensable Delay.

REQUEST FOR INFORMATION means a written request by Contractor for clarification of what it perceives to be discrepancies in the Contract Documents, including, without limitation, information in the Contract Documents constituting errors, omissions, conflicts, ambiguities, lack of coordination, noncompliance with Applicable Laws or variances between the information in the Contract Documents and field conditions.

SPECIFICATIONS mean the portion of the Bidding Documents consisting of the written requirements for materials, equipment, standards and workmanship for the Work and performance of related services.

SUBCONTRACTOR means a person or entity that has a contract to perform a portion of the Work, including without limitation, subcontractors, sub-subcontractors, suppliers and vendors, of any and every Tier.

SURETY means Contractor's surety issuing the Bid, Performance and/or Labor and Material

Bonds.

TIER means the contractual level of a Subcontractor with respect to Contractor. For example, a "first-tier" Subcontractor is under contract with Contractor. A sub-subcontractor under contract with a first-tier Subcontractor is in the "second tier," and so on. Use ofthe

phrase "of every tier", or similar phraseology, in the Contract Documents shall not be interpreted as implying that other provisions of the Contract Documents, where such phases are not used, are intended to be limited application to only the first Tier or to only certain Tiers of Subcontractors.

UNEXCUSED DELAY means any Delay that is not a Compensable Delay or Excusable Delay, including, without limitation, the following: (1) Delay caused by Contractor's failure to comply with the Contractor's Documents, (2) Delay for which Contractor has failed to provide timely and complete Request for Extension, or (3) Delay associated with any circumstances where costs or risk associated with such circumstances are designated in the Contract Documents as being at Contractor's risk or Contractor's Own Expense.

UNILATERAL CHANGE ORDER means a writing signed by City in accordance with the General Conditions, in which City unilaterally sets forth its determination of the amount of adjustments to the Contract Sum or Contract Time due to a Compensable Change, Compensable Delay or Deleted Work.

WORK means the labor, materials, equipment, services, permits, licenses and taxes and all other things necessary for Contractor to perform its obligations under the Contract Documents, including, without limitation, any Changes requested by City.

WORK DAY means Mondays, Tuesdays, Wednesday, Thursdays, and Fridays. It does not include Saturdays, Sundays, or Holidays recognized by the City of Inglewood.

Other terms appearing in the Standard Specifications shall have the intent and meaning specified therein.

Section 2. CONTRACT DOCUMENTS

The Contract Documents are comprised of the following, including all additions, deletions, modifications, appendices, and all addenda as prepared prior to the date of bid opening setting forth modifications or interpretations of any of said Documents:

The Notice Inviting Bids, the Instructions to Bidders, the accepted Proposal, the List of Subcontractors, the Bid Security Forms, the Agreement, the Faithful Performance Bond, the Labor & Material Bond, the Plans, Technical/Special Specifications, Special Provisions, the Disadvantaged Business Enterprise (DBE) Requirements and the Standard Specifications.

Section 3. PICKUP OF PLANS AND SPECIFICATIONS

The Plans and Specifications and all other Documents comprising the pertinent Contract Documents, may be obtained at the Public Works Department on the Third Floor of Inglewood City Hall, One Manchester Boulevard, Inglewood, CA, 90301. Each set of Specifications may be purchased for a fee of $50.00 per hard copy; $25.00 fee per CD-ROM. All fees are non-refundable. If requested by mail, prospective bidder must pre-pay mailing charge of $15.00 per set requested.

Section 4. PRECEDENCE OF CONTRACT DOCUMENTS

The order of precedence of Documents shall be:

FIRST:	Requirements of law, including the Charter and Ordinances of the City.

SECOND:	Permits from other Agencies as may be required by law or Ordinance.
THIRD:	Permits from City Departments as may be required by law or Ordinance.
FOURTH:	Change Orders and/or Supplemental Agreements; whichever occurs last.
FIFTH:	Contract/Agreement.
SIXTH:	Addenda.
SEVENTH:	Bid/Proposal.
EIGHTH:	Special Provisions.
NINTH:	Plans.
TENTH:	Standard Plans.
ELEVENTH:	Standard Specifications.
TWELFTH:	Reference Specifications.

Detail drawings shall take precedence over general drawings.

Section 5. THE PROPOSAL

Proposals shall be submitted on the form provided by the City and shall be enclosed in a sealed envelope, marked, and addressed as hereinafter directed. The Bidder shall state in words and figures the specific sum for which he/she proposes to supply the labor, materials, supplies, or machinery, and perform the work required by the Plans and Specifications. In case words and figures do not agree, the words shall govern and the figures shall be disregarded. If the Proposal is made by an individual, it shall be signed and his/her full name and address shall be given; if it is made by a firm, it shall be signed with the co-partnership name by a member of the firm who shall also sign his/her own name and the name and address of each member shall be given; if it is made by a corporation, the name of the corporation shall be signed by its duly authorized officer or officers, attested by the corporate seal, and the names and titles of all officers of the corporation shall be given. No telegraphic proposal or telegraphic modification of the Proposal will be considered.

Blank spaces in the Proposal shall be properly filled. The phraseology of the Proposal must not be changed and no additions shall be made to the items mentioned therein. Unauthorized conditions, limitations, or provisions attached to the Proposal will render it informal and may cause its rejection. Alterations by erasure or inter-lineation must be explained or noted in the Proposal over the signature of the Bidder. Alternative proposals will not be considered unless specifically provided for in the Bidding Sheet. A bidder may withdraw their proposal before the hour fixed for opening bids without prejudice to themselves by submitting a written request to the City Clerk for its withdrawal and the Proposal will be returned to him/her unopened when reached in the procedure of opening bids. No proposals may be withdrawn after the hour fixed for opening bids without rendering the accompanying bidder's bond, or certified or cashier check, or cash guaranty subject to forfeiture or liquidated damages in like manner as in the case of failure to execute contract after award, as hereinafter provided. No proposal received after the time named or at any place other than the place stated in the Invitation to Submit Bids will be considered. All bids will be opened and declared publicly.

Bidders, their representatives, and others interested are invited to be present at the opening. The City reserves the right to waive an informality in any bid, to reject any or all proposals, to reject one part of a proposal and accept the other, except to the extent that bids are qualified by specific limitations, and to make awards to the lowest responsible bidder as the interest of the City may require.

Any proposal which is so unbalanced between the various contract items as to be detrimental to the interests of the City may also be rejected. Where bonds are required, the bidder shall name in his/her proposal the Surety or Sureties which have agreed to furnish said bonds.

The envelope enclosing the Proposal shall be sealed and addressed to the City Clerk, City of Inglewood, One Manchester Boulevard, Inglewood, CA, 90301. The envelope shall be plainly marked in the upper left-hand corner with the name and address of the bidder and bear the words "Proposal For..." followed by the name of the work and the date and hour of bid opening.

Section 6. LOWEST RESPONSIBLE BIDDER

Section 2-200 of the Inglewood Municipal Code states: "The expression 'lowest responsible bidder' as used in this article and the City's Bidding Documents shall be deemed to mean the lowest bidder whose offer best responds in quality, fitness, and capacity to the requirements of the proposed work or usage." In selecting the lowest responsible bidder, consideration will be given not only to the financial standing, but also to the general competence of the Bidder for the performance of the work covered by the Proposal. To receive favorable consideration, a bidder must present evidence that he/she has successfully performed similar work of comparable magnitude or submit other evidence satisfactory to the City that he/she or their associates are personally competent to manage the proposed undertaking and to carry it forward to a successful conclusion. Professional integrity and honesty of purpose shall be essential requirements.

A showing of adequate financial resources is required, but will not alone determine whether a bidder is competent to undertake the proposed work. Each bidder must furnish, if required, a record of past performance and experience and show that his/her organization, capital, and equipment are adequate for the successful prosecution of the required work and its completion within the time specified.

Section 7. BIDDER'S BOND

As a guaranty of good faith, each bidder shall submit with their proposal an unconditional Bidder's Bond or Certified or Cashier's Check, drawn on a solvent State or National bank, or cash in the sum stated in the Invitation to Submit Bids, payable to the "City of Inglewood," said Bidder's Bond or check to be held uncollected until it becomes subject to disposal as herein provided. Any condition or limitation placed upon said Bidder's Bond or check will render it informal and may, at the option of the City, result in the rejection of the Proposal under which such Bidder's Bond or check is submitted. If a bidder to whom an award is made fails or refuses to execute the Contract and furnish the required bonds, all within the time stated, said Bidder's Bond or check and the monies represented thereby, or the cash guaranty, shall be and remain the property of the City and shall be subject to deposit with the Treasurer of the City as other monies belonging to the City, the amount thereof being agreed to by the Bidder as liquidated damages due the City. Within fifteen (15) days after the award of the Contract, the City will return the Proposal guarantees accompanying such as the Proposals, which are not to be considered in making the award. All other proposal guarantees will be held until the Contract has been finally executed, after which they will be returned to the respective bidders whose proposal they accompany.

Section 8. CONSTRUCTION BOND

The Contractor agrees to at all times during the performance of the agreement obtain, keep, and maintain a Faithful Performance Bond in the amount of the Contract Sum, and a Contractor's

Labor and Material Bond in the amount of the Contract Sum. Said bonds shall be in the form approved by the City Attorney and Surety on all bonds furnished must be satisfactory to the City.

Section 9. INGLEWOOD BUSINESS LICENSE

The Contractor/Consultant agrees to at all times during the performance of the Agreement, obtain and maintain a City of Inglewood Business License. A copy of said license must be forwarded to the City Clerk and Public Works Department prior to issuing Notice To Proceed (NTP).

Section 10. LIABILITY INSURANCE

The Contractor shall furnish the City with Comprehensive General Liability Insurance including automobile, contractual liability, products, and completed operations, owner's protective and personal injury coverage, in which the City is named as an additional insured, with the Contractor's insurance to be primary.

Any insurance in effect protecting the City shall be excess and shall be effective only upon exhaustion of Contractor's insurance. The Policy shall insure the City, its officers, employees and volunteers, while acting within the scope of their duties, against all claims arising out of or in connection with the work, except as provided for in Section 25 of these Special Provisions. The Policy or endorsement shall state clearly that the City shall be notified by registered mail at least thirty (30) days prior to cancellation of the Policy for any reason.

Minimum Scope of Insurance

Coverage shall be at least as broad as indicated below:

1. Insurance Services Office Commercial General Liability Coverage (occurrence Form CG 00 01 11 85 or 11 88).
2. Insurance Services Office Form Number CA 00 01 06 92 covering Automobile Liability, Code 1 (any auto).
3. Workers' Compensation Insurance as required by the State of California and Employer's Liability Insurance.

Minimum Limits of Insurance

The Contractor shall maintain these policies and shall cause all parties supplying services, labor, or materials to maintain the following insurance in amounts not less than those specified below:

1.	General Liability: $1,500,000 (including operations, products, and completed operations)	per occurrence for bodily injury, personal injury, and property damage. If Commercial General Liability Insurance or other form with a general aggregate limit is used, either the general aggregate limit shall apply separately to the Project/location or the general aggregate limit shall be twice the required occurrence limit.
2.	Automobile Liability: $1,500,000	per accident for bodily injury and property damage.
3.	Employer's Liability: $1,500,000	per accident for bodily injury or disease.

Deductibles and Self-Insurance Retentions

Any deductibles or self-insured retentions must be declared to and approved by the City Attorney. At the option of the City, either: the Insurer shall reduce or eliminate such deductibles or self-insured retentions as respects the City, its officials, employees, and volunteers; or the Contractor shall provide a financial guarantee satisfactory to the City Attorney guaranteeing payment of losses and related investigations, claims administration, and defense expenses.

Other Insurance Provisions

The Commercial General Liability and Automobile Liability policies are to contain, or be **endorsed** to contain, the following provisions:

1. The City, its officials, employees, and volunteers are to be covered as insured with respect to liability arising out of automobile owned, leased, hired, or borrowed by, or on behalf of, the Contractor: and with respect to liability arising out of work or operations performed by, or on behalf of, the Contractor, including materials, parts, or equipment furnished in connection with such work or operations. General liability coverage can be provided in the form of an endorsement to the Contractor's insurance, or as a separate owner's policy (CG 20 10 11 85).

2. For any claims related to this project, except as provided in Section 19 of the Special Provisions, the Contractor's insurance coverage shall be primary insurance as respects the City, its officers, officials, employees, and volunteers. Any insurance or self-insurance maintained by the City, its officers, officials, employees, or volunteers shall be excess of the Contractor's insurance and shall not contribute with it.

3. Each insurance policy required by this clause shall be endorsed to state that coverage shall not be canceled by either party, except after thirty (30) days prior written notice by Certified Mail, return receipt requested, has been given to the City.

4. Coverage shall not extend to any indemnity coverage for the active negligence of the additional insured in any case where an agreement to indemnify the additional insured would be invalid under Subdivision (b) of Section 2782 of the Civil Code.

Acceptability of Insurers
Insurance is to be placed with insurers with insurance in California or placed by a non- admitted insurer on California's List of Eligible Surplus Lines Insurers (LESLI). Any insurer, whether admitted or non-admitted, shall have a current A.M. Best's rating of not less than A:VII.

Verification of Coverage

The Contractor shall furnish the City with original certificates and amendatory endorsements effecting coverage required to conform to the insurance requirements. All certificates and endorsements are to be received and approved by the City Attorney's office before work commences. The City reserves the right to require complete, certified copies of all required insurance policies, including endorsements affecting the coverage required by these Special Specifications at any time. The Contractor shall include all subcontractors as insured under its policies or shall furnish separate certificates and endorsements for each subcontractor. All coverage for subcontractors shall be subject to all of the requirements stated herein.

The Contractor shall hold harmless the City, its officers and employees from any and all liability from personal injuries, property damage, cost of litigation, legal expenses or any other claim or action arising out of the performance of the services required by the Contractor pursuant to these specifications.

Section 11. INDEMNIFICATION

The Contractor shall indemnify and hold harmless the City and its officers, employees, and volunteers from and against all claims, damages, losses, and expenses, including attorney fees arising out of the performance of the work described herein, caused in whole or part by any negligent act or omission of the Contractor, any subcontractor, anyone directly or indirectly employed by any of them, or anyone for whose acts any of them may be liable, except where caused by the active, sole negligence, or willful misconduct of the City.

If any action or proceeding is brought against Indemnities by reason of any act of the matters against which the Consultant has agreed to indemnify Indemnities as provided above, the Contractor, upon notice from the City, shall defend Indemnities at the Contractor's expense by counsel acceptable to the City, such acceptance not to be unreasonably withheld. Indemnities need not have first paid for any of the matters to which Indemnities are entitled to indemnification in order to be indemnified. The insurance required to be maintained by the Contractor under this Article shall ensure the Contractor's obligations under this Section, but the limits of such insurance shall not limit the liability of the Contractor hereunder. The provisions of this Article shall survive the expiration or earlier termination of this Agreement.

Section 12. EXCERPTS FROM THE CALIFORNIA LABOR CODE RELATING TO APPRENTICES ON PUBLIC WORKS

Labor Code § 1773.3: Contract Awards; Copy to Division; Notice to Local Committee; Discrepancy in Ratio.

"An awarding Agency whose public works contract falls within the jurisdiction of Section 1777.5 shall, within five (5) days of the Award send a copy of the Award to the Division of Apprenticeship Standards."
When specifically requested by a Local Joint Apprenticeship Committee, the Division of Apprenticeship Standards shall notify the Local Joint Apprenticeship Committee regarding all such awards applicable to the Joint Apprenticeship Committee making the request. Within five (5) days of a finding of any discrepancy regarding the ratio of apprentices to journeymen, the pursuant to the certified fixed number of apprentices to journeymen, the awarding Agency shall notify the Division of Apprenticeship Standards.

Labor Code § 1777.5: Employment of Registered Apprentices; Wages; Standards; Number; Apprenticeable Craft or Trade; Exemptions; Contributions.

Every such apprentice shall be paid the standard wage paid to apprentices under the regulations of the craft or trade at which he/she is employed, and shall be employed only at the work of the craft or trade to which he/she is registered.

Only apprentices, as defined in Section 3077, who are in training under apprenticeship standards and written apprentice agreements under Chapter 4 (commencing with Section 3070), Division 3 of the Labor Code are eligible to be employed on public works. The employment and training of each apprentice shall be in accordance with the provisions of the apprenticeship standards and apprentice agreements under which he/she is training.

When the Contractor to whom the Contract is awarded by the State or any political subdivision, or any subcontractor under him/her, in performing any of the work under the Contract or subcontract, employs workers in any apprenticeable craft or trade, the Contractor and subcontractor shall apply to the Joint Apprenticeship Committee administering the apprenticeship standards of the craft or trade in the area of the site of the public work for a certificate approving the Contractor or subcontractor under the apprenticeship standards for the employment and training of apprentices in the area of the site of the public work. However, approval as established by the Joint Apprenticeship Committee or committees shall be subject to the approval of the Administrator of Apprenticeship. The Joint Apprenticeship Committee or committees, subsequent to the approving the subject Contractor or subcontractor, shall arrange for the dispatch of apprentices to the

Contractor or subcontractor in order to comply with this Section.

Every contractor and subcontractor shall submit contract award information to the applicable Joint Apprenticeship Committee, which shall include an estimate of journeyman hours to be performed under the Contract, the number of apprentices to be employed, and the approximate dates the apprentices will be employed. There shall be an affirmative duty upon the Joint Apprenticeship Committee or committees administering the apprenticeship standards of the craft or trade in the area of the site of the public work to ensure equal employment and affirmative action in apprenticeship for woman and minorities. Contractors or subcontractors shall not be required to submit individual applications for approval to local Joint Apprenticeship Committees provided they are already covered by the local apprenticeship standards.

The ratio of work performed by apprentices to journeymen who shall be employed in the craft or trade on the public work may be the ratio stipulated in the apprenticeship standards under which the Joint Apprenticeship Committee operates, but, except as otherwise provided in this Section, in no case shall the ratio be less than one (1) hour of apprentice work for every five (5) hours of labor performed by a journeymen.

Any ratio shall apply during any day or portion of a day when any journeyman or the higher standard stipulated by the Joint Apprenticeship Committee, is employed at the job site and shall be computed on the basis of the hours worked during the day by journeymen so employed, except for the land surveyor classification. The Contractor shall employ apprentices for the number of hours computed as above before the end of the Contract. However, the Contractor shall endeavor, to the greatest extent possible, to employ apprentices during the same time period that the journeymen in the same craft or trade are employed at the job site. Where an hourly apprenticeship is not feasible for a particular craft or trade, the Division of Apprenticeship Standards, upon application of a Joint Apprenticeship Committee, may order a minimum ratio of not less than one (1) apprentice for each five (5) journeymen in a craft or trade classification.

The Contractor or subcontractor, if he/she is covered by this Section, upon the issuance of the approval certificate, or if he/she has been previously approved in the craft or trade, shall employ the number of apprentices or the ratio of apprentices to journeymen stipulated in the apprenticeship standards. Upon proper showing by the Contractor that he/she employs apprentices in the craft or trade in the State on all of his/her contracts on an annual average of not less than one (1) hour of apprentice work for every five (5) hours of labor performed by a journeyman, or in the land surveyor classification, one (1) apprentice for each five (5) journeymen, the Division of Apprenticeship Standards may grant a certificate exempting the Contractor from the 1-to-5 hourly ratio as set forth in this Section. This Section shall not apply to contracts of general contractors or to contracts of specialty contractors not bidding for work through a general or prime contractor, when the contracts of general contractors or those specialty contractors involve less than thirty thousand dollars ($30,000) or twenty (20) working days. Any work performed by a journeyman in excess of eight (8) hours per day or forty (40) hours per week, shall not be used to calculate the hourly ratio required by this Section.

"Apprenticeable craft or trade," as used in this Section, means a craft or trade determined as an apprenticeable occupation in accordance with rules and regulations prescribed by the Apprenticeship Council. The Joint Apprenticeship Committee shall have the discretion to grant a certificate, which shall be subject to approval of the Administrator of Apprenticeship, exempting a contractor from the 1-to-5 ratio set forth in this Section when it finds that any one of the following conditions is met:

(a.) Unemployment for the previous three (3) month period in the area exceeds an average of fifteen percent (15%).

(b.) The number of apprentices in training in such area exceeds a ratio of 1 to 5.

(c.) There is a showing that the apprenticeable craft or trade is replacing at least one- thirtieth (1/30) of its journeymen annually through apprenticeship training, either on a statewide basis, or on a local basis.

(d.) Assignment of an apprentice to any work performed under a public works contract would create a condition which would jeopardize his/her life, safety, or property of fellow employees, or the public at large, or if the specific task to which the apprentice is to be assigned is of such a nature that training cannot be provided by a journeyman.

When exemptions are granted to an organization, which represents contractors in a specific trade from a 1-to-5 ratio on a local or statewide basis, the member contractors will not be required to submit individual applications for approval to local Joint Apprenticeship Committees, if they are already covered by the local apprenticeship standards.

The Contractor to whom the Contract is awarded, or any subcontractor under him/her, who, in performing any of the work under the Contract, employs journeymen or apprentices in any apprenticeable craft or trade, and who is not contributing to a fund or funds to administer and conduct the apprenticeship program in any such craft or trade in the area of the site of the public work, to which fund or funds other contractors in the area of the site of the public work are contributing, shall contribute to the fund or funds in each craft or trade in which he/she employs journeymen or apprentices on the public work in the same amount or upon the same basis and in the same manner as the other contractors do, but where the trust fund administrators are unable to accept the funds, contractors not signatory to the trust agreement shall pay a like amount to the California Apprenticeship Council. The Contractor or subcontractor may add the amount of the contributions in computing his/her bid for the Contract. The Division of Labor Standards Enforcement is authorized to enforce the payment of the contributions to the fund or funds as set forth in Section 227.

<u>Labor Codes §1777.7; Noncompliance with §1777.5 Denial of Right to Bid on Contracts; Civil Penalty; Procedure.</u>

The body awarding the Contract shall cause to be inserted in the Contract stipulations to effectuate this Section. The stipulations shall fix the responsibility of compliance with the Section for all apprenticeable occupations with the prime contractor. All decisions of the Joint Apprenticeship Committee under this Section are subject to Section 3081:

(a.) In the event a contractor or subcontractor willfully fails to comply with Section 1777.5, the Director of Industrial Relations shall deny to the Contractor or subcontractor both individually and in the name of the business entity under which the Contractor or subcontractor is doing business, the right to bid on, or to receive, any public works contract for a period of up to one (1) year for the first violation and for a period of up to three (3) years for the second and subsequent violations. Each period of debarment shall run from the date the determination of noncompliance by the Administrator of Apprenticeship becomes an order of the California Apprenticeship Council.

(b.) A contractor or subcontractor who violates Section 1777.5 shall forfeit as a civil penalty the sum of fifty dollars ($50) for each calendar day of noncompliance. Notwithstanding Section 1727, upon receipt of a determination that a civil penalty has been imposed, the awarding body shall withhold the amount of the civil penalty from the Contract progress payments then due or to become due.

(c.) In lieu of the penalty provided for in Subdivision (a) or (b), the Director may for a first time violation and with the concurrence of the Joint Apprenticeship Committee, order the Contractor or subcontractor to provide apprentice employment equivalent to the work hours that would have been provided for apprentices during the period of noncompliance.

(d.) Any funds withheld by the awarding body pursuant to this Section shall be deposited in the General Fund if the awarding body is a State entity, or in the equivalent fund or an awarding if the awarding body is an entity other than the State.

(e.) The interpretation and enforcement of Section 1777.5 and this Section shall be in accordance and the rules and procedures of the California Apprenticeship Council.

Government Code §4552. Submission of Bids to Public Purchasing Body; Agreement to Assign.

In submitting a bid to a public purchasing body, the Bidder offers and agrees that if the Bid is accepted, it will assign to the purchasing body all rights, title, and interest in and to all causes of action it may have under Section 4 of the Clayton Act (15 U.S.C. Sec. 15) or under the Cartwright Act (Chapter 2, commencing with Section 16700, of Part 2 of Division 7 of the Business and Professions Code), arising from purchases of goods, materials, or services by the Bidder for sale to the purchasing body pursuant to the Bid. Such assignment shall be made and become effective at the time the purchasing body tenders final payment to the Bidder.

The preceding provisions of this Section shall be included in full in any specifications for the general public purchase and shall be included in full in the Bid Agreement or general provisions incorporated into the Bid Agreement.

Federal Labor Standards:

This is federally assisted construction contract. Pursuant to Section 1773 of the Labor Code, the State prevailing wage rates for this project have been determined by the Director of the California Department of Industrial Relations (DIR) and are set fort on the DIR website: http://www.dir.ca.gov/DLSR/PWD and are printed in the Specifications.
The Federal prevailing wage rates for this project are also set forth in the Specifications, and addenda to modify the Federal and State wage rates, if necessary, will be issued to holders of the Specifications. If there is a difference between the State wage rates and Federal wage rates for similar classification of labor, Contractor and subcontractors shall pay not less than the higher of two. Lower State wage rates for classifications not specifically listed in the Federal wage determination will not be accepted; this includes "helper" (or other classifications based on hours of experience) or any other classification not appearing in the Federal wage determination.
This project is subject to the "Buy America" provisions of the Surface Transportation Assistance Act of 1982 as amended by the Intermodal Surface Transportation Efficiency Act of 1991.

The U.S. Department of Transportation (DOT) provides a toll-free hotline service to report bid rigging, bidder collusion, or other fraudulent activities. The hotline is available Mondays through Fridays between 8:00 a.m. and 5:00 p.m. eastern time, at (800) 424 9071. The hotline is part of the DOT's continuing effort to identify and investigate highway construction contract fraud and abuse and is operated under the direction of the DOT Inspector General. All information will be treated confidentially, and caller anonymity will be respected.

Section 13. PAYMENT OF PREVAILING WAGE RATES AND PAYROLL RECORDS

The Contractor's attention is directed to the following provisions of the Labor Code. The Contractor shall be responsible for the compliance with these provisions by his/her subcontractors.
Copies of the prevailing rate of per diem wage determinations are on file in the City Clerk's Office and are available to any interested party on request.

Labor Code § 1725.5:

1. No contractor or subcontractor may be listed on a bid proposal for a public works project (submitted on or after March 1, 2015) unless registered with the Department of Industrial Relations (with limited expectations for this requirement for bid purposes only under Labor Code Section 1771.1a)
2. No contractor or subcontractor may be awarded a contract for public work on a public works project (awarded on or after April 1, 2015) unless registered with the Department of

Industrial Relations.

3. All contractors and subcontractors must furnish electronic certified payroll records to the Labor Commissioner for all new projects awarded on or after April 1, 2015. The Labor Commissioner may excuse contractors and subcontractors on a project that is under the jurisdiction of one of the four legacy DIR-approved labor compliance programs (Caltrans, City of Los Angeles, Los Angeles Unified School District and County of Sacramento) or that is covered by a qualified project labor agreement.
4. This project is subject to compliance monitoring and enforcement by the Department of Industrial Relations.

Labor Code § 1771: Payment of General Prevailing Rate.

Except for public works projects of one thousand dollars ($1,000) or less, not less than the general prevailing rate of per diem wages for work of a similar character in the locality in which the public work is performed, and not less than the general per diem wages for holiday and overtime work fixed as provided in this Section, shall be paid to all workers employed on public works.

Labor Code § 1772: Employees of Contractors and Subcontractors.

Workmen employed by contractors or subcontractors in the execution of any contract for public works are deemed to be employed upon public work.

Labor Code § 1774: Payment of General Prevailing Rate.

The Contractor to whom the Contract is awarded, and any subcontractor under him/her, shall pay no less than the specified prevailing rates of wages to all workmen employed in the execution of the Contract. If the Contractor is making more than one wage determination, the Contractor shall ensure the higher wage rate is applied.

Labor Code §1775: Penalties for Violations; Action Against Contractor to Recover Penalties.

The Contractor shall, as a penalty to the State or political subdivision on whose behalf the Contract is made or awarded, forfeit not more than fifty dollars ($50) for each calendar day, or portion thereof, for each worker paid less than the prevailing rates, as determined by the Director for the work or craft in which the worker is employed for any public work done under the Contract by him/her or by any subcontractor under him/her. The amount of this penalty shall be determined by the Labor Commissioner and shall be based on consideration of the Contractor's mistake, inadvertence, or neglect in failing to pay the correct rate of prevailing wages, or the previous record of the Contractor in meeting his/her prevailing wage obligations, or the Contractor's willful failure to pay the correct rates of prevailing wages. A mistake, inadvertence, or neglect in failing to pay the correct rate of prevailing wages is not excusable if the Contractor had knowledge of his/her obligations under this part. The difference between the prevailing wages rates and the amount paid to each worker for each calendar day or portion thereof for which each worker was paid less than the prevailing wage rate shall be paid to each worker by the Contractor, and the body awarding the Contract shall cause to be inserted in the Contract a stipulation that this Section will be complied with. To the extent that there is insufficient money due the Contractor to cover all penalties and amounts due in accordance with this Section, or in accordance with Section 1813, and in all cases where the Contract does not provide for a money payment by the awarding body to the Contractor, the awarding body shall notify the Division of Labor Standards Enforcement of the violation and the Division of Labor Standards Enforcement, if necessary, with the assistance of the awarding body, may maintain an action in any court of competent jurisdiction to recover the penalties and the amounts due provided in this Section. This action shall be commenced not later than ninety (90) days after the filing of a valid Notice of Completion in the Office of the County Recorder in each County in which the public work or some part thereof was performed, or not later than ninety (90) days after acceptance of public work, whichever last occurs. No issue other than that of the liability of the Contractor for the penalties allegedly forfeited and amounts due shall be determined in the action, and the burden shall be upon the Contractor to establish that the penalties and amounts demanded in the action are not due.

Out of any money withheld, recovered, or both, there shall first be paid the amount due each worker, and if insufficient funds are withheld, recovered, or both, to pay each worker in full, the money shall be prorated among all workers.

Labor Code § 1776: Payroll Records; Retention; Inspection; Noncompliance Penalties; Rules and Regulations.

(a.) Each contractor and subcontractor shall keep an accurate payroll record, showing the name, address, social security number, work classification, and straight time and overtime hours worked each day and week, and the actual per diem wages paid to each journeyman, apprentice, worker, or other employee employed by him/her in connection with the public work.

(b.) The payroll records enumerated under Subdivision (a) shall be certified and shall be available for inspection at all reasonable hours at the principal office of the Contractor on the following basis:

(1) A certified copy of an employee's payroll record shall be made available for inspection or furnished to the employee or his/her authorized representative on request.

(2) A certified copy of all payroll records enumerated in Subdivision (a) shall be made available for inspection or furnished upon request to a representative of the body awarding the Contract, the Division of Labor Standards Enforcement, and the Division of Apprenticeship Standards of the Department of Industrial Relations.

(3) A certified copy of all payroll records enumerated in Subdivision (a) shall be made available upon request by the public for inspection or for copies thereof. However, a request by the public shall be made through either the body awarding the Contract, the Division of Apprenticeship Standards, or the Division of Labor Standards Enforcement. If the requested payroll records have not been provided pursuant to paragraph (2), the requesting party shall, prior to being provided the records, reimburse the costs of preparation by the Contractor, subcontractors, and the entity through which the request was made. The public shall not be given access to the records at the principal office of the Contractor.

(c.) The certified payroll records shall be on forms provided by the Division of Labor Standard Enforcement or shall contain the same information as the forms provided by the Division.

(d.) Each contractor shall file a certified copy of the records enumerated in Subdivision (a) with the entity that requested the records within ten (10) days after receipt of a written request.

(e.) Any copy of records made available for inspection as copies and furnished upon request to the public or any public agency by the awarding body, the Division of Apprenticeship Standards, or the Division of Labor Standards Enforcement, shall be marked or obliterated in such a manner as to prevent disclosure of an individual's name, address, and social security number. The name and address of the Contractor awarded the Contract or performing the Contract shall not be marked or obliterated.

(f.) The Contractor shall inform the body awarding the Contract of the location of the records enumerated under Subdivision (a) including the street address, City and County, and shall, within five (5) working days, provide a notice of a change of location and address.

(g.) The Contractor shall have ten (10) days in which to comply subsequent to receipt of written notice specifying in what respects the Contractor must comply with this Section. In the event that the Contractor fails to comply with the ten (10) day period, he/she shall, as a penalty to the State or political subdivision on whose behalf the Contract is made or awarded, forfeit twenty-five dollars ($25) for each calendar day, or portion thereof, for each worker, until strict compliance is effectuated. Upon the request of the Division of Apprenticeship Standards or the Division of Labor Standards Enforcement, these penalties shall be withheld from progress payments then due.

(h.) The body awarding the Contract shall cause to be inserted in the Contract stipulations to effectuate this Section. These stipulations shall fix the responsibility for compliance with this Section on the prime contractor.

(i.) The Director shall adopt rules consistent with the California Public Records Act, (Chapter 3.5, commencing with Section 6250, of Division 7, Title 1, Government Code) and the Information Practices Act of 1977, (Title 1.8, commencing with Section 1798, Part 4, Division 3, Civil Code) governing the release of these records, including the establishment of reasonable fees to be charged for producing copies of records required by this Section.

Section 14. NON-DISCRIMINATION

Labor Code § 1735: Discrimination in employment because of race, color, etc.

No discrimination shall be made in the employment of persons upon public works because of the race, religious creed, color, national origin or ancestry, physical disability, medical condition, marital status, or sex of such persons except as provided in Section 12940 of the Government Code, and every contractor for public works violating this Section is subject to all the penalties imposed for a violation of this Chapter.

Section 15. SUBCONTRACTS

The Engineer shall have the authority to approve changes of, or additions of, subcontractors. Such permission shall be requested in writing and must be approved in writing. Nothing contained in the Contract Documents shall be held to create a direct contractual relationship between any subcontractor and the City.

No subcontractor will be recognized as such; all persons engaged in the work of construction will be considered as employees of the Contractor, and the Contractor will be held responsible for their work, which shall be subject to all the Provisions of the Contract Documents.

Section 16. AUTHORITY OF THE ENGINEER

All work of the Contract will be supervised by the Engineer. References to "Engineer" in Division I which concern administrative aspects of the Contract including provisions for time for commencing and completing work and extension of time shall be understood literally as meaning the Engineer or an authorized representative.

The Engineer shall have the authority to give such general directions and exercise such control as may be necessary to ensure that work on the Project is in strict compliance with the Contract Documents. The Engineer shall determine the adequacy of the Contractor's methods, plant, and equipment, and may issue such directions relative to the sufficiency of forces as may be reasonably necessary to ensure proper and continuous execution of the work. The Engineer shall have the authority to stop the work, if necessary, to prevent its improper execution and shall determine the amount, quality, and fitness of the several kinds of work. The Engineer shall have the authority to reject all work which does not conform to the requirements of the Contract and shall have power to make such other decisions as provided in these Specifications. All instructions, rulings, and decisions of the Engineer shall be final and binding unless formal protest is made under the Provisions for "Claims and Protests" in Section 42 of these Specifications.

The Engineer shall have executive authority to enforce such decisions and orders, which the Contractor shall carry out promptly. The Engineer shall have the authority to issue change orders not to exceed fifteen percent (15%) of the Contract amount, and time extensions as he/she deems necessary to best serve the City's interests.

Section 17. CHANGE ORDERS

General

All administrative aspects involving change orders shall be authorized by the Public Works Director/Engineer or designee. Changes in the Work, whether ordered by City or otherwise arising, are permitted, reasonably foreseeable and, regardless of their number, size, scope or complexity, shall not invalidate the Construction Contract or give rise to any right on the part of Contractor to seek recovery of any Loss from City other than pursuant to the contractual processes for adjustment of Contract Sum and Contract Time that are expressly provided for by the Contract Documents.

Contract Allowances and Adjustments

The Contract shall include in the Contract Sum all allowances stated in the Contract Documents. Allowances shall cover all costs for materials and labor necessary to do the work specified. Whenever the actual costs are more or less than the allowances, the Contract Sum shall be adjusted by Change Order. Contractors' costs for overhead and profit on the allowances shall be shown where indicated on the Bidders Proposal and Statement and not in the allowance amounts. An accounting of all materials and labor costs for work covered by allowances shall be submitted before materials and labor are expensed. If an allowance is not adequate, the City shall be provided with a cost quote (complete with back-up data) before work is started.

Adjustments to the Contract Sum or Contract Time shall only be permitted as follows: (1) The Contract Sum shall only be adjusted pursuant to this Article by means of a Change Order or Unilateral Change Order for Compensable Change, Deleted Work or Compensable Delay; and (2) the Contract Time shall only be adjusted for pursuant to this Article by means of a Change Order or Unilateral Change Order for Compensable Delay, Excusable Delay or Deleted Work authorizing an extension or contraction of the Contract Time as provided in Article 23, below.

Contractors Own Expense

Without Limitation to any other provisions of the Contract Documents expressly or impliedly requiring performance of Work at Contractor's Own Expense, any Change performed by Contractor pursuant to any direction other than a duly authorized and executed Change Order, Unilateral Change Order or Field Order shall be deemed performed at Contractor's Own Expense.

Prompt Performance

Subject to the procedures set forth this section and elsewhere in the Contract Documents, all Changes shall be performed promptly and without Delay.

Change Order Defined

A Change Order is a written instrument as defined in Section 1 - Definitions.

Change Order Request

With respect to any matter that Contractor believes may involve or require an adjustment to the Contract Sum due to Compensable Change, Contractor shall, within forty-eight (48) Hours after the Discovery Date of the circumstances giving rise to the Compensable Change, submit to Engineer a Change Order Request. With respect to Deleted Work, Contractor shall submit a Change Order Request no later than forty-eight
(48) Hours after receipt of a request for pricing of such Deleted Work.

Form

Change Order Request shall be provided using forms furnished by City. Failure by City to provide or approve a particular form, however, shall not relieve Contractor or its obligation to provide Change Order Request in written form that complies with Content Requirements set forth below.

Content Requirements

Each Change Order Request shall include:

1. A detailed description of the circumstances for the Compensable Change, Deleted Work or Compensable Delay and a detailed estimate, which in the case of a Compensable Change shall be based on definitive Subcontractor pricing where available, of the proposed adjustment of the Contract Sum.

2. A complete, itemized cost breakdown of all Contractor and Subcontractor costs, quantifies, hours, unit prices, rates and markups (additive and deductive); provided, however, that, unless otherwise agreed to by City in writing, under no circumstances shall any Change Order Request include or be based upon any costs, expenses or markups (on behalf of Contractor or any Subcontractor) other than either: (1) a unit price set forth in the Construction Contract, or (2) Allowable Costs and Allowable Markups. If the Change Order Request involves the performance of Work by the Subcontractor, Contractor must include an estimate or bid from the Subcontractor containing the same detailed information as required herein of Contractor; and

3. If such circumstances involve a right to adjustment of the Contract Time due to Compensable Delay or Excusable Delay that has not been waived, Contractor shall include, if not previously provided, a complete and timely Request for Extension.

Waiver by Contractor

Failure by Contractor to provide a timely and complete Change Order Request under circumstances where a Change Order Request is required by this Section shall constitute a waiver by Contractor of the right to any adjustment to the Contractor Sum on account of such circumstances.

Unilateral Change Orders

If, after receipt by City of a Change Order Request properly prepared and submitted by Contractor, the parties are unable to agree upon the amount of any adjustment to the Contract Sum or Contract Time to be included in a Change Order or if the amount of such adjustment after performance is otherwise disputed, then City may, in its sole discretion, issue a Unilateral Change Order setting forth its unilateral determination of the appropriate adjustment to the Contract Sum or Contract Time. City's Determination in a Unilateral Change Order shall be based upon City's good faith estimate of an appropriate and reasonable adjustment to the Contract Sum and Contract Time. City's Unilateral determination of an adjustment to the Contract Sum or Contract Time shall become final and binding upon Contractor if Contractor fails to submit a Claim in writing to City disputing the terms of such Unilateral Change Order within thirty (30) Days of the issuance of the Unilateral Change Order.

Field Orders Defined

A Field Order is a written directive as defined in Article 2 of this Agreement.

Adjustment Estimate

Each Field Order involving a Compensable Change or Deleted Work shall include an estimate prepared by Contractor of the probable amount of the adjustment to the Contract Sum and Contract Time based on Allowable Costs and Allowable Markups.

Authorization

A Field Order confers no rights upon Contractor for adjustments of the Contract Sum or Contract Time unless it is signed by Engineer. A Field Order for a Minor Change or for the performance of Work that is not a Change to the Work and therefore does not involve an adjustment to the Contract Sum or Contract Time may be authorized by either Engineer or Architect.

Disputed Work

In the event there arises a dispute over whether Work directed to be performed by Field Orders constitutes a Compensable Change, Contractor shall, if requested in a Field Order signed by the Engineer, nonetheless proceed with performance of the Work (including, without limitation any Change) as directed by such Field Order.

If Contractor contends that such disputed work is an extra, then Contractor shall proceed as otherwise required by the Contract Document requirements set forth elsewhere herein. At a minimum, Contractor shall keep daily time and material records for all such disputed work and turn same into the Inspector at the end of each day that any such work takes place on. The time and material records must specifically identify the names of the workmen performing such work, specifically describe the type of work each man/woman was doing and the respective durations thereof. The time and material cards must also specifically identify all equipment, materials, apparatus or the like that the Contractor contends went into the work of improvement that day. Any and all other cost items that Contractor contends are associated with such disputed work must also be set forth on the time and material cards.

Failure to include any items on the time and material cards, or the failure to submit time and material cards daily for such disputed work shall be an absolute admission and waiver by Contractor that he/she has incurred no extra costs and shall seek no extra costs or time from the City.

No Implied Obligation

In recognition of the fact that Field Orders may be issued under circumstances in which the City may not have had the time and opportunity to fully evaluate the circumstances giving rise to a Change, it is agreed that neither the issuance nor execution of, nor any statement contained in, nor any course of conduct in connection with, a Field Order shall be interpreted as creating or implying on the part of City to increase the Contract Sum or extend the Contract Time on account of any Change described in the Field Order that upon further investigation is found in fact to not constitute a valid basis for adjustment of the Contract Sum or Contract Time.

Waiver by Contractor

The following shall be deemed performed by Contractor at Contractor's Own Expense: (1) any Changes or Extra Work performed by Contractor, before or after issuance by Contractor of a Change Order Request, without Contractor having first obtained a Field Order that has been duly authorized directing such performance to proceed; and (2) any Changes or Extra Work performed in response to a directive set forth in a Field Order prior to the receipt by Engineer of a Change Order Request in accordance with the appropriate Change Order requirements of this Section.

Additional Work

Additional work requested by the Building Owner or occupant shall not be performed without written permission from the City or its designated representative. Such requests may be approved if the additional work will not delay progress of the project or cause additional project cost.

Written Authorization of Essence

It is the essence to this agreement between Contractor and City that all adjustments to the Contract Sum or Contract Time must be authorized in advance, in writing, before the

additional work is performed. Approval will be contingent upon cost data submittal. Any additional days needed to complete change order work will NOT be approved up-front. The City or its designated representative will assess the need for additional days at the end of the contract. Contractors must make a good faith effort to include change order work in the original construction schedule (with in 10 days per unit). Accordingly, no verbal directions, course of conduct between the parties, or express or implied acceptance of changes or of the work, and no claim that City has been unjustly enriched (whether or not there has been such enrichment) shall be the basis for an adjustment to the contract sum or contract time if contractor has not obtained advance written authorization in the manner required by this Article 22.

Formal Notice of Essence

Contractor recognizes and acknowledges that timely submission of a formal Change Order Request, whether or not the circumstances of the Change may be know to City or Engineer or available to City through other means, is not a mere formality but is of crucial importance to the ability of City to promptly identify, prioritize, evaluate and mitigate the potential effects of Changes. Any form of informal notice, whether verbal of written (including, without limitation statements at regular job meetings or entries on monthly reports, daily logs or job meeting minutes), that does not strictly comply with the formal requirements of this Article 22 shall accordingly be deemed insufficient.

Allowable Costs

The term "Allowable Costs" means, and is limited to, the costs set forth in this paragraph and that are not prohibited under the next succeeding paragraph. Allowable costs are as follows: (1) labor and benefits – straight-time wages, salaries, benefits, and overtime wages, salaries and benefits specifically authorized by City or Engineer in writing, for employees employed at a site in the direct performance of the Extra Work or that would have been incurred in the direct performance of the Deleted Works; (2) materials and consumable items (and sales taxes derived thereof) furnished or incorporated in the work at the lowest competitive price available to Contractor in the general vicinity of the site; (3) reasonable rental charges for necessary machinery and equipment as authorized by City or Engineer, exclusive of hand tools; (4) additional or saved costs of permits, and additional or saved costs of insurance or bond premiums.

Costs not Allowed

Allowable costs shall not include any of the following: (1) additional costs for labor, salaries or benefits incurred by such positions as superintendents, assistant superintendents, project directors, project managers, schedulers, or estimators; (2) drafting or detailing, (3) vehicles not dedicated solely to the performance of the Work, (4) small tools with a replacement value not exceeding One Hundred Dollars ($100); (5) office expenses, including staff, materials and supplies, (6) on-site and off-site trailer and storage rental and expenses; (7) site fencing not added solely due to the performance of Extra Work; (8) utilities, including gas, electric, sewer, water, telephone, telefax and copier equipment; (9) computer and data-processing personnel, equipment and software; (10) federal, state or local business income and franchise taxes, (11) costs (other than liquidated damages for Compensable Delay permitted by Article 13 of this Contract arising from or related to Delay or acceleration to overcome Delay, whether incurred by Contractor or the Subcontractor, of any Tier; and (12) costs and expenses of any kind or item not specifically included in the Allowable Costs set forth above.

Allowable Markups

Allowable markups consists of a reasonable percentage of the Contract Sum based upon the Change of Work to cover the following: (1) direct and indirect overhead, consumables, small tools, cleanup and profit of Contractor, (2) direct and indirect overhead, consumables, small tools, cleanup and profit of the Subcontractor, of every Tier, and (3) all costs that are not reimbursable to Contractor under Costs Not Allowed set forth above.

Final Payment

No claim by Contractor for adjustment to the Contract Sum relating to any Project Work for a Home shall be allowed if asserted after Residence Final Payment for such Project Work has been made by City.

Continuous Performance

No dispute or disagreement with respect to any Changes or Delay, including, without limitation, disputes over Contractor's right to or the amount of any adjustment to the Contract Sum or Contract Time, shall relieve or excuse Contractor from the obligation to proceed with and maintain continuous, expeditious and uninterrupted performance of the Work, including performance of any disputed Changes.

Section 17a. CONTRACT TIME AND DELAYS

Except as set forth in this section or otherwise in the Contract Documents, the Contractor shall complete the work within the time specified in the proposal beginning with the date of the Notice to Proceed.

Commencement

The Date of Commencement shall not be postponed by the failure to act of Contractor or of persons or entities for whom Contractor is responsible. Contractor shall not knowingly, except by agreement or instruction of City in writing, prematurely commence operations on a Site or elsewhere prior to the effective date of insurance required by Section 10 of this Division to be furnished by Contractor. The Date of Commencement of the Work shall not be changed by the effective date of such insurance.

Contract Time

Contractor shall proceed expeditiously with adequate forces and shall perform the Work within the Contract Time, as adjusted for extensions of time duly permitted, authorized and noticed pursuant to the provisions of this section..

Adjustments in Contract Time

Subject to the limitations set forth in this Section and elsewhere in the Contract Documents, the Contract Time shall be extended for Compensable Delays and Excusable Delays and shall be contracted for Changes involving Deleted Work.

Early Completion

Nothing stated in these General Conditions or elsewhere in the Contract Documents shall be interpreted as creating any contractual right, express or implied, on the part of Contractor to complete the Work earlier than the Contract Time. Contractor has included in its Contract Sum the costs of all Contractor's and Subcontractor's direct and indirect overhead, including but not limited to all Project staff, temporary facilities, temporary utilities and home office overhead for the entire duration of the Contract Time. The above costs have been included in the Contract Sum notwithstanding Contractor's possible anticipation of completion in fewer Days than established by the Contract Time. Under no circumstances shall City be liable to Contractor for any Losses, of any kind, due to the inability of Contractor to complete Work earlier than the Contract Time, regardless of the cause, including, without limitation, Delays due to acts or omissions (intentional or negligent) of City, Architect, Engineer, City Consultant or others. No reduction in the Contract Sum shall be made nor will Contractor be required to remain on a Site if the Project Work Site if Finally Completed before expiration of the Contract Time.

Delays and Extensions of Time

Provided that Contractor has complied with the provisions of this Article 23, including without limitation, the requirements pertaining to timely delivery of a complete Request for Extension, if Contractor is delayed by an Excusable Delay or Compensable Delay to the path(s) of activities critical to performance of the Work by one or more of the deadlines comprising the Contract Time, then the applicable deadline in the Contract Time shall be changed either by Change Order or Unilateral Change Order, for such reasonable time as Engineer may determine. The Contract shall not be adjusted for Unexcused Delays.

Request for Extension

1. *Submission.* With respect to any matter that Contractor believes may involve or require an adjustment extending or contracting the Contract Time, Contractor shall within the earlier of: (1) 48 hours after the Discovery Date of the circumstances causing a Compensable or Excusable Delay; or (2) in the case of a Delay caused by Compensable Change, within the period of time set forth for submission of Change Order Requests, submit to Engineer a written Request for Extension.

2. *Form.* Request for Extension shall be provided using forms furnished by Engineer. However, failure by Engineer to provide a particular form shall not relieve Contractor of its obligation to provide Request for Extension in a written form that complies with the requirements set forth below.

3. *Content.* Each Request for Extension in order to be considered complete shall include: (1) a detailed description of the circumstances for the Compensable Delay and Excusable Delay; and (2) if such circumstances involve a right to an adjustment of the Contract Sum for Compensable Change that has not been waived by Contractor, Contractor shall include, if not previously provided, a complete and timely Change Order Request.

4. *Waiver by Contractor.* Failure by Contractor to provide a timely and complete request for extension in accordance with this section under circumstances where a Request for Extension is required by this paragraph shall constitute a waiver by Contractor of the right to any adjustment in the Contract Time or Contract Sum on account of such circumstances.

5. *Response by City.* Engineer shall thereafter investigate the facts concerning the cause and extent of such delay and, depending on whether the Request for Extension is justified, will notify Contractor of its approval or disapproval of all or a portion of Contractor's request. Extensions of time approved by Engineer shall apply only to that portion of the Work affected by the Delay, and shall not apply to other portions of Work not affected.

6. *Formal Notice of Essence.* Contractor recognizes and acknowledges that time submission of formal Request for Extension, whether or not circumstances of a Delay may be known to City or Engineer or available through other means, is not a mere formality but is of crucial importance to the ability of City to promptly identify, prioritize, evaluate and mitigate the potential effects of Delay. Any form of informal notice, whether verbal or written (including, without limitation, statements at

regular job meetings or entries on monthly reports, daily logs or job meetings), that does not strictly comply with the formal notice requirements set forth above, shall accordingly be deemed insufficient.

Compensation for Delay

1. *Compensable Delay.* Contractor agrees to accept compensation based upon a reasonable calculation of the City for Compensable Delay in lieu of any other right that may exist under Applicable Law or in equity for recovery of Losses, whether incurred by Contractor or the Subcontractors of any Tier, due to Delay, including, without limitation, the following: extended or extraordinary (direct and indirect) overhead; lost of productivity; labor, wage and material costs escalators; inefficiency; direct and indirect costs associated with the cumulative impact of multiple Changes or Delays; legal expenses; consultant costs; interest; lost profits or revenue; bond and insurance costs; and changes in taxes.

2. *Deleted Work.* Adjustments reducing the Contract Sum for contractions of the Contract Time due to Deleted Work shall be based, without duplication to any other adjustments to the Contract Sum, upon a reasonable calculation of the City for such delay.

Acceleration of the Work

1. *Due to Unexcused Delay.* If Engineer determines that due to Unexcused Delay Contractor will not perform the Work within the Contract Time, then Contractor shall immediately take, at Contractor's Own Expense, all measures necessary to accelerate performance.

2. *Due to Excusable Delay.* Acceleration, whether performed at the request of City or otherwise, to overcome Excusable Delay shall be deemed a voluntary acceleration performed at Contractor's Own Expense.

3. *Due to Compensable Delay.* City shall have the right, exercised in its sole discretion, in lieu of granting an adjustment to the Contract Time and Contract Sum for Compensable Delay to direct in writing the acceleration of the Work by Contractor in order to recapture time lost due to Compensable Delay. Any adjustment in the Contract Sum on account of such shall be limited to costs incurred and paid for the premium time portion of overtime only.

Concurrent Delays

Contractor's right to adjustment to the Contract Time for Excusable Delay and its right to adjustment to the Contract Sum and Contract Time for Compensable Delay shall, in case of concurrency of Delays, be calculated as follows:

1. If an Excusable Delay and a Compensable Delay occur concurrently, the maximum extension of the Contract Time shall be the number of days from the commencement of the first Delay to the cessation of the Delay which ends lasts.
2. If an Unexcused Delay occurs concurrently with either an Excusable Delay or a Compensable Delay, the maximum extension of the Contract Time shall be the number of Days, if any, by which such Excusable Delay or Compensable Delay exceeds the number of Days of such Unexcused Delay.
3. If an Unexcused Delay occurs concurrently with both Excusable Delay and Compensable Delay, the maximum extension of the Contract Time shall be the number of days if any, by which such Excusable Delay and Compensable Delay exceeds the number of Days of such Unexcused Delays.

Delay Claims

Claims relating to disputed adjustments of the Contract Time or adjustments to the Contract Sum to Delay shall be made in accordance with applicable provisions of this Article, above.

Exercise of City Rights

Notwithstanding any other provisions of the Contract Documents to the contrary, any Delay to Contractor's performance of the Work that is the result of City's exercise of its rights or remedies under the Contract Documents or Applicable Laws in response to a failure by Contractor or any Subcontractor to comply with the Contract Documents shall be deemed an Unexcused Delay and shall not, under any circumstances, entitle Contractor to an adjustment to the Contract Time or Contract Sum.

City-Furnished Information

Information included as part of the Contract Documents and furnished by City's equipment vendors including the expected shipping dates, weights, handling instructions, erection information and all other such data is furnished in good faith, but no warranty of accuracy, sufficiency or completeness is given or implied.

Section 17b. COMPLETION, CLOSE-OUT AND ACCEPTANCE OF WORK

Close-out Requirements Included

Contractor shall comply with requirements stated in Conditions of the Contract.

Final Inspection

It shall be within the area of responsibility of the Engineer or his designee to make the final inspection of the work and to accept the completed work on behalf of the City.

1. When Contractor considers the work is complete and all items per contract documents have been installed, Contractor shall submit to the City a written notice that the Work, or designated portion thereof for a project building, is complete and ready for "punch" inspection.

2. Within five (5) working days after receipt of such notice, the City will make an inspection to determine the status of completion.

3. Should the City determine that the work is not complete:
   a. The City will notify the Contractor in writing, giving reasons thereof.
   b. Contractor shall remedy the deficiencies in the Work, and send a second written notice of completion to the City.
   c. The City will re-inspect the work.

Contractor's Close-Out Submittals and Requirements

All documents should be packaged in a per unit basis. Documents should be specific to each unit and should include literature addressing only those items installed at that particular address.

1. Bonds, including the guaranty bond.

2. Evidence of Payment and Release of Liens.

3. List of subcontractors, service organizations, and principal vendors, including names, addresses, and telephone numbers where they can be reached for emergency service at all times including nights, weekends, and holidays.

4. As-built drawings.

5. Copy of building permits with complete signatures.

Final Adjustment of Accounts

1. Submit final statements of accounting to the Contract Sum.

2. Statement shall reflect all adjustments resulting from:
   a. The original Contract Sum.
   b. Additions and deductions resulting from:
      (1) Previous Change Orders
      (2) Allowances
      (3) Unit Prices
      (4) Deductions for uncorrected work
      (5) Penalties
      (6) Deductions for Liquidated Damages
      (7) Deductions for re-inspected Payments
      (8) Other adjustments
   c. Total Contract Sum, as adjusted.
   d. Previous payments.
   e. Sum remaining due.

Notice of Completion

The City of Inglewood will prepare and file the Notice of Completion.

Final Application for Payment

Contractor shall submit the final Application for Payment in accordance with procedures and requirements stated in the Conditions of the Contract.

Section 18. SERVICE OF NOTICE

The delivering of any notice, instruction, claim, protest, or other written communication, personally to the Contractor or a representative on the Project, to the Engineer or a representative on the Project, or to the City or its representative at his/her office or legal place of business, shall constitute service thereof upon the Contractor, the Engineer, or the City, respectively.

The depositing in a post-paid wrapper directed to the official address of the Contractor, the Engineer, or the City, in any post office box regularly maintained by the protestor, or other written communication, shall be deemed sufficient service thereof upon the Contractor, the Engineer, or the City, respectively, and the date of such service shall be considered to be the day following the date of such mailing.

The official address of the Contractor shall be the address given in the accepted Proposal or such other address as the Contractor may subsequently designate in writing to the Engineer and the City. The official address of the City shall be: City of Inglewood; City Clerk's Office; One Manchester Boulevard; Inglewood, CA, 90301.

Section 19. WORK DONE BY OTHERS

The City reserves the right to do other work and to let other contracts for work contiguous to the work set forth in the Contract Documents.

In the event that work is done by the City or by other contractors contiguous to the work covered by this contract, the respective rights of the various interest involved shall be established by the

Engineer. The Contractor shall afford the City and other contractors reasonable opportunity for the introduction and storage of their materials and for the execution of their work, and shall properly conduct and coordinate work with all other parties.

If any part of the work under this contract depends for proper execution or result upon any other contiguous work, the Contractor shall inspect such work and promptly report to the Engineer any condition which may adversely affect the work under this contract. The Contractor's failure to inspect and report same shall constitute an acceptance of said other contiguous work as fit and proper for the reception of the work under this contract, except as to deficiencies which may develop in said other work after the execution of the work covered under this contract.

Section 20. PERMITS AND INSPECTION COSTS

Wherever the property of the Federal Government, the State of California, the County of Los Angeles, the City of Inglewood, any local utilities, or of any other agency affected by the work included in this contract, the Contractor shall bear the cost of all permits and inspection lawfully exacted by said Government, State, County, City, District, Department, or other agency during the time of performing the work affecting said property; also, the Contractor shall bear all cost of traffic regulation and traffic control devices lawfully exacted by said State, County, City, or other agency during the time of performing the work affecting said property.

When working within the Railroad's right of way, the Contractor shall contact Burlington Northern Santa Fe (BNSF) and/or Metro Transportation Agency (MTA) and bear all cost of traffic regulation and traffic control during the time performing the work affecting said property.

Where required under the terms of the permits, the Contractor shall obtain liability insurance acceptable to and in an amount required by the public agency having jurisdiction. The policy shall insure said agency against all claims arising out of or in connection with the work to be performed and shall remain in full force and effect until the work is accepted by the City. The Contractor shall furnish to each such agency a certificate of protective liability insurance showing the protection afforded and the amount thereof.

Neither the terms hereof nor anything shown on the Drawings in connection with rights- of-way provided by the City shall be construed to entitle the Contractor to conduct operations in said rights-of-way in violation of existing regulations restricting interference with watercourses and drainage channels. The Contractor shall take adequate precautions against obstructing storm water flow in any affected watercourse or channel, and shall not deposit excavated materials in any area where they might interfere with or be subject to erosion from such flow.

Section 21. LOCAL CONDITIONS

Bidders shall read the Specifications, examine the Drawings, and make their own estimates of the existing facilities and the difficulties, which will attend the execution of the work called for by the proposed contract, including local conditions, uncertainty of weather, and all other contingencies. Bidders shall satisfy themselves by personal examination of the location of the proposed work and by such other means as they may choose so as to determine the actual conditions and requirements. Information derived from the maps, profiles, Plans and Specifications, Drawings, City Personnel, the Consultant, or his/her assistants, shall not relieve the Bidder of this responsibility.

Section 22. "OR EQUAL" CLAUSE

Whenever a material, article, or piece of equipment is identified on the Plans or in the Specifications by reference to manufacturers' or vendors' names, trade names, catalogue numbers, etc., it is intended merely to establish a standard; and any material, article, or equipment of other manufacturers' and vendors' which will perform adequately the duties imposed by the general design, shall be considered equally acceptable provided the material, article, or equipment so proposed is, in the opinion of the Engineer, of equal substance and function. Said materials, articles, or equipment shall not be purchased or installed by the Contractor without the Engineer's written approval.

Section 23. SCOPE OF WORK

The work to be performed under this contract shall consist of furnishing all plant, tools, equipment, materials, supplies, and manufactured articles, and for furnishing all transportation and services, including fuel, power, water, and essential communications, and for the performance of all labor, work, or other operations required for the fulfillment of the Contract in strict accordance with the Specifications, Drawings, schedules, and

other Contract Documents, as herein before defined, all of which are made a part hereof, and including such detail sketches as may be furnished by the Engineer from time to time during construction in explanation of said Drawings. The work shall be complete, and all work, materials, and services not expressly called for in the Specifications or not shown on the Drawings, which may be necessary for the complete and proper construction of the work, in good faith shall be performed, furnished, and installed by the Contractor as though originally so specified or shown, at no increase in cost to the City.

The Contractor shall check all dimensions and quantities on the Drawings or schedules herein contained or given by the Engineer, and shall notify the Engineer of all errors therein which may be discovered by examining and checking the Drawings. The Contractor shall not take advantage of any error or omission in these Specifications, or in the Drawings or schedules, but should such error or omission be discovered, the Contractor shall obtain instructions from the Engineer and the Contractor shall carry out such instructions as if originally specified.

The Contractor shall verify all dimensions in the field and shall check field conditions continuously during construction. The Contractor shall be solely responsible for any inaccuracies built into the work.

The Contractor shall inspect related and appurtenant work and shall report in writing to the Engineer any conditions, which will prevent proper completion of the work. Any required removal, repair, or replacement caused by unsuitable conditions shall be done by the Contractor at his/her sole cost and expense.

Section 24. RIGHTS-OF-WAY

Rights-of-way or easements as required for the prosecution of the work will be provided by the City. The Contractor shall be responsible for making their own arrangements for parking facilities, storage areas, and staging areas; the Contractor shall obtain written permission from the owners of the affected property for such use, and a copy of each such written permit shall be furnished to the City and property owners for their protection and records.

The Contractor shall indemnify and hold the City harmless from all claims for damages occasioned by such actions.

Section 25. USE OF IMPROVEMENT DURING CONSTRUCTION

The City reserves the right to take over and utilize all or parts of any completed facility or appurtenance. Such action by the City will relieve the Contractor of responsibility for injury or damage to said completed portions of the improvement resulting from use by public traffic or from the action of the elements or from any other cause except injury or damage resulting from the Contractor's operations or negligence. The Contractor will not be required to re-clean said utilized portions of the improvement before field acceptance, except for cleanup made necessary by their operations. Nothing in this Section shall be construed as relieving the Contractor from full responsibility for correcting defective work or materials.

In the event the City exercises its right to place into service and utilize all or part of any completed facility or appurtenance, the City shall assume any responsibility and liability for injury to persons or property arising out of or resulting from the utilization of the facility or appurtenance so placed into service except for any such injury to person or property caused by any willful or negligent act or omission of the Contractor, subcontractor, their officers, employees, or agents.

Notwithstanding the above, the City reserves all rights to use and maintain the public rights-of-way for pedestrian and vehicular traffic, except as may otherwise be provided in the Special Provisions. Such use of the public rights-of-way does not relieve the Contractor of any liability for damages to the improvements caused in whole or in part by the Contractor, any of his agents or subcontractors, or any other third party.
Furthermore, such use of the public rights-of-way by City in no way constitutes acceptance of the work in whole or in part.

The right is reserved to the City and to the owners of public utilities and franchises to enter at any time upon any public street, alley, right-of-way, or easement for the purpose of making changes in their property made necessary by the work of this contract.

Nothing herein shall be construed to entitle the Contractor to the exclusive use of any public street, alley, way, or parking area during the performance of the work hereunder and he shall so conduct his operations as not to interfere unnecessarily with the authorized work of utility companies or other agencies in such streets, alleys, ways, or parking areas.

Section 26. EXECUTION OF CONTRACT

A bidder to whom award is made shall execute a written contract with the City and furnish good and approved bonds, if required in the Special Provisions all in accordance with the Provisions hereof and within the time stated in the Proposal. If a bidder to whom an award is made fails or refuses to enter into the Contract as herein provided or to conform to any of the stipulated requirements in connection therewith, the bid bond, check or cash guaranty shall become the property of the City as provided in Section 7 hereof, the award will be annulled and, in the discretion of the City, an award may be made to the Bidder whose proposal is next most acceptable to the City. Such bidder shall fulfill every stipulation embraced herein as if he/she were the party to whom the first award was made. A corporation to which an award is made will be required, before the Contract is finally executed, to furnish evidence of its corporate existence, of its rights to do business in California and of the authority of the officer signing the Contract and bonds for the corporation to so sign.

Section 27. CONSTRUCTION SCHEDULE

The Contractor shall prepare and submit a complete construction schedule in a suitable form (refer to Division II) indicating starting time and completion of each subdivision of trade or work in the Project prior to start of work. The construction schedule shall be approved by the Engineer prior to commencement of construction.

Holidays and alternating Fridays (Fridays City is closed due to its 9/80 schedule) are "non-workdays." Every other day is a workday. Contractor will be provided a list of closed Fridays and City Holidays. Contractor must receive prior approval before working on a "non-workday." If work needs to be done on a non-workday, Contractor must submit a written request, to the Project Manager, at least 48 hours before the start of the work.

All work shall start after 7:00 a.m. and stop by 5:00 p.m. on regular working days.

Section 28. COMPLETION AND ACCEPTANCE

It shall be within the area of responsibility of the Engineer to make the final inspection of the work and to accept the completed work on behalf of the City.

Section 29. TERMINATION OF CONTRACT

The City may terminate the Contract at its own discretion or when conditions encountered during the work make it impossible or impracticable to proceed, or when the Agency is prevented from proceeding with the Contract by law, or by official action of a public authority.

Section 30. TIME OF COMPLETION

The Contractor shall complete the work within the time specified in the Proposal beginning with the date of the Notice to Proceed.

Section 31. LIQUIDATED DAMAGES

It is agreed to by the parties to the Contract that in case all the work called for under the Contract is not completed before or upon the expiration of the time limit as set forth in these Specifications, damage will be sustained by the City, and that it is, and will be impracticable to determine the actual damage which the City will sustain in the event of and by reason of such delay; and it is, therefore, agreed that the Contractor will pay to the City the sum of one thousand dollars ($4,000) per day for each and every day's delay beyond the time prescribed to complete the work; and the Contractor agrees to pay such liquidated damages as herein provided, and in case the same are not paid, agrees that the City may deduct the amount thereof from any money due or that may become due the Contractor under the Contract.

Section 32. NOTIFICATION OF START OF WORK

The Contractor shall notify the City of Inglewood Public Works Department Permit Section at (310) 412-5333, at least 48 hours prior to starting any construction within the street rights-of-way. The Contractor shall notify the Communications Center of the City at (310) 412-5251, at least 24 hours before commencing work. The Contractor shall formally notify, in writing, all residents and businesses that are located within a ½ mile radius from the construction site and/or are impacted by the construction work at least 48 hours before commencing work. Any and all correspondence to City Constituents shall be submitted no later than ten (10) working days for City Administrator's approval prior to distribution. The Contractor shall also produce door knob hang tags containing general information related to the construction no later than ten (10) working days after receiving the Contract for City Administrator's approval. A sample shall be provided by the City.

Section 33. RECORD DRAWINGS

The Contractor shall maintain at the job site a set of Plans and Specifications available at all times for inspection by the City, exclusively, and so marked for recording all changes in the work. The Contractor shall be responsible for seeing that any and all changes are recorded on this set each day.

Section 34. SUPERINTENDENTS

The Contractor shall assign and designate a Project Superintendent responsible for the Project who will be on the site full-time and will be in charge of all subcontract work supplied.

Section 35. NOISE ABATEMENT

The Contractor shall conform to the regulations set forth in Chapter 6 of the Inglewood Municipal Code. All equipment used in the Project must be the quietest available for this type of work, said equipment shall not exceed 90 dba measured at an unobstructed distance of 25 feet, unless a permit and variance has been obtained from the City.

Section 36. CLEANUP AND DUST CONTROL

Throughout all phases of construction, including suspension of work, and until final acceptance of the Project, the Contractor shall keep the work site clean and free from rubbish and debris. The Contractor shall also abate dust nuisance by cleaning and sweeping, water trucks, or other means, as necessary.

Materials and equipment shall be removed from the site as soon as they are no longer necessary; and upon completion of the work and before final inspection, the entire worksite shall be cleared of equipment, unused materials, and rubbish so as to present a satisfactory clean and neat appearance. All cleanup costs shall be included in the Contractor's Bid Items.

Earth dams will not be permitted at catch basin openings, local depressions, or elsewhere, except in time of emergency. Temporary dams of sand bags, asphaltic concrete, or other acceptable material, may be permitted when necessary to protect the work, provided their use does not create a hazard or nuisance to the public. Such dams shall be removed from the site as soon as their use is no longer necessary.

Failure of the Contractor to comply with the Engineer's cleanup orders may result in an order to suspend work until the condition is corrected. No additional compensation or extension of contract completion time will be allowed as a result of such suspension.

After completion of all other work on the Project, and before making application for acceptance of the work, the Contractor shall clean the site of their operations, including all areas under the control of the City that have been used by the Contractor in connection with the work on the Project, and shall remove all debris, surplus material, and equipment of whatever nature, unless otherwise approved by the City. Final acceptance of the work by the City will be withheld until the Contractor has satisfactorily complied with the foregoing requirements for final cleanup of the Project site.

Section 37. WATER FOR CONSTRUCTION

The City will provide a water meter, eddy valve, and construction water at a cost to the Contractor. The Contractor shall provide facilities for conveying the water from the fire hydrant or source designated by the City to points of use.

The Contractor shall complete an application for a Construction Water Meter available at the Public Works Department with a deposit a check in the amount of one thousand dollars ($1000.00) payable to the "City of Inglewood". The City shall install/relocate the water meter and eddy valve as requested by the Contractor. The Contractor shall provide notice at least forty-eight (48) hours in advance.

The following fees shall be deducted from the deposit:

Meter Installation/Removal	$100.00
Monthly Service Charge	$ 50.00
Meter Relocation	$ 50.00
Commodity Charge	$ 4.50 per HCF

Section 38. EXISTING UTILITY LINES

Those agencies that are known to have utilities located within the boundaries of the Project are listed in the Construction Plans. The City has diligently attempted to correctly locate and show all existing pipelines and other substructures in the vicinity of the work, but the City does not guarantee that there are no other substructures. Known underground utilities are identified in the Specifications and/or on the Plans and will be marked on the Project site prior to construction in accordance with the requirements of Section 4214 of the Government Code. The Contractor shall protect all utilities and other improvements, which may be encountered during construction operations. It shall be the Contractor's responsibility to ascertain the actual location of all existing utilities an other improvements indicated on the Drawings or marked in the field, which may be encountered during construction operations, and to see that such utilities or other improvements are adequately protected from damage due to such operations.

Because of the organization and incompleteness of some utility records, all underground interference may not be shown on the Plans and any underground facilities shown are not necessarily at the exact location and elevation indicated.

The Contractor shall endeavor to take all possible precautions for the uninterrupted service of all utilities, and to provide such special protection as may be directed by the Engineer.

Existing utility lines that are shown on the Drawings or the locations of which are made known to the Contractor prior to excavation and that are to be retained, and all utility lines that are encountered during excavation operations shall be protected and if damaged, shall be immediately repaired by the Contractor at his/her expense.

The Contractor will not be assessed liquidated damages for delay in completion of the Project, when such delay is caused by failure or relocation of existing utility facilities. Notwithstanding any of the Provisions in Subsections 5-5 and 6-6.3 of the Standard Specifications relative to payment to the Contractor for actual loss due to utility delay; the Contractor will be entitled to an extension of time as provided in Subsection 6-6 but will not be entitled to any other compensation for such delay.

The Contractor shall notify the following utility companies, as applicable, at least five (5) days in advance of his/her intention to excavate or work in the vicinity of the facilities of these utilities:

UTILITY COMPANY	TELEPHONE
AT&T	510-645-2929
City of Inglewood Public Works Department	310-412-5333
Crown Castle	724-416-2193
Golden State Water Company	310-767-8200
Los Angeles County Sanitation District	562-908-4288
Los Angeles Department of Water & Power	213-367-2659
Metro – LACMTA	213-922-7255
Southern California Edison	310-713-9156
Southern California Edison	310-767-8200
Southern California Gas Co.	310-687-2055
Tesoro	714-880-1655
Verizon	469-886-4238
West Basin Metropolitan Water District	310-660-6255
Wilshire Connection LLC	213-550-5240

After completion of project, the contractor shall remove all pavement markings placed through Underground Service Alert (USA) Dig-Alert.

Section 39. TRAFFIC AND ACCESS

The Contractor shall personally inspect the site to familiarize himself/herself with the parking and traffic control problems and other special conditions relating to the Project, prior to submitting his/her bid.

The Contractor shall at all times conduct his/her work so as to insure the least possible obstruction to parking areas and to the general public, and shall provide adequate protection of persons and property in the vicinity of the work.

The Contractor will be required to maintain the pavement within construction areas. Any pavement damaged by the Contractor or subcontractors and all pavement constructed by the Contractor which becomes damaged shall be repaired or replaced, as directed by the Engineer, at no additional cost to the City. Specific requirements for traffic control and access in the vicinity of the Project are detailed in Division II,
Technical/Special Specifications. All traffic control plan submittals shall comply with the latest edition of the Work Area Traffic Control Handbook (WATCH) and approved by the Engineer.

Section 40. REQUESTS FOR PAYMENT

City Retention of 5%

The City shall retain 5% of the Contract Sum until final completion of the project as defined below.

Securities in Lieu of Retention

Provisions of California Public Contract Code Section 22300 et. seq. substitution of eligible and equivalent securities for retention held by City to ensure Contractors performance under the Contract will be permitted at the request and expense of the Contractor and in conformity with California Section 22300. The foregoing notwithstanding, the Contractor shall have ten (10) days following action by the City to award the Agreement to the Contractor to submit its written request to the City to permit the substitution of securities for retention under California Public Contract Code Section 22300. The failure of such Contractor to make such a written request for the City within said ten (10) day period shall be deemed a waiver of the Contractor's right under California Public Contract Code Section 22300.

In the event the Contractor wishes to choose to exercise its rights under California Public Contract Code Section 22300, the Contractor shall enter into an escrow agreement with the City, and the escrow agent, a state or federally chartered bank in California with a current A.M. Best Rating of not less than "A," in the form specified by said Section 22300. Contractor shall have the obligation of ensuring that such securities deposited are sufficient to maintain it total fair market value an amount equal to the cash amount of the sums to be withheld under the Agreement. If upon written notice from the City or from the appropriate escrow agent, indicating that the fair market value of the securities has dropped below the dollar amount of monies to be withheld by the City to ensure performance, Contractor shall, within five (5) days of the date of such notice, post additional securities as necessary to ensure that the total fair market value of all such securities held by the City, or in escrow, is equivalent to the amount of money to be withheld by the City under the Agreement.

Application for Progress Payment

On the tenth (10th) Day of each month, Contractor shall submit an Application for Progress Payment with the Engineer using such forms as required by Engineer, indicating the percentage of work completed and detailing the work performed. Engineer shall promptly review said application and if no inaccuracy is discovered he shall submit the Application to the City for prompt payment.

Decisions to Withhold Progress Payments

The Engineer may withhold or nullify the requested Progress Payments in whole or in part due to the Contractor to such extent as may be necessary to protect the City from loss as a result of because of any of the circumstances listed below:

1. Defective work not remedied in accordance with provisions of the Contract Documents;

2. Third party claims, liens or stop notices filed or reasonable evidence indicating probable filing of such claims, liens or stop notices;

3. Failure of the Contractor to make payments properly for labor, services, materials, equipment, or other facilities or to subcontractor;

4. A reasonable doubt that the work can be completed for the unpaid balance of the Contract Sum;

5. A reasonable doubt that the Contractor will complete the work within the agreed Contract Time;

6. Costs to the Owner resulting from failure of the Contractor to complete the work within the stipulated time, or in accordance with the terms of the contract;

7. Damage to other work or property;

8. Failure to fulfill all the requirements of the Contract Documents;

9. When there is pending litigation against the City related to this contract or reasonable anticipation thereof;

10. Failure of the contractor to maintain all records as required; to submit progress schedules, weekly payroll records, minority enterprise utilization reports and forms and any other such item required by these specifications;

11. Failure to pay laborers and mechanics employed by the contractor or any subcontractor on the work the full amount of wages required by this contract, after written notice to the contractor.

12. Failure of Contractor of the subcontractors to comply with applicable laws;

13. Any reason specified elsewhere in the Contract Documents as grounds for a withholding, offset or setoff or that would legally entitle City to a setoff or recoupment;

14. Additional professional, consultant or inspection services required due to Contractor's failure to comply with Contract Documents;

15. Liquidated damages payable to City;

16. Materials ordered or paid by City on behalf of Contractor;

17. Damage loss caused to City, a separate contractor, homeowner contractor or any other person or entity due to the actions of the Contractor;

18. Cleanup performed by City and chargeable to Contractor;

19. Failure of Contractor to pay contributions due and owing to employee benefits funds pursuant to applicable collective bargaining agreements or trust agreements;

20. Failure of Contractor or any Subcontractor to properly pay prevailing wages as

defined in California Labor Code Section 1720 et/ seq.;

21. A breach by Contractor of any obligation or provision of the Contract Documents.

22. Whenever the City shall, in accordance herewith, withhold any monies otherwise due the Contractor, written notice of the amount withheld and the reasons therefore shall be given the Contractor, and, when the Contractor shall remove the grounds for such withholding, the City will pay to the Contractor, within 35 calendar days, the amount so withheld.

Application of Withholding

Sums properly withheld in good faith may be used by City without a prior judicial determination of City's actual rights with respect to recovery of any Loss on which such withholding is based. Contractor agrees and hereby designates City as its agent in for such purposes, and agrees that such payments shall be considered as payments made under the Construction Contract by City to Contractor. City shall submit to Contractor an accounting of such funds disbursed on behalf of Contractor. As an alternative to such payment, City may, in its sole discretion, elect to exercise its rights to adjust the Contract Sum.

Payment by City

After an Application for Progress Payment has been made, the City shall make payment in a timely manner unless there is a good faith reason for withholding the payments in accordance with the provisions of the Contract Documents or Applicable Law.

Payment to Subcontractors

Upon receipt of payment from City, Contractor shall pay the Subcontractors performing the Work, out of the amount paid to Contractor on account of such Subcontractor's portion of the work, the amount of which said Subcontractor is entitled in accordance with the terms of its contract with Contractor and Applicable Laws, including, without limitation, California Public Contract Code Section 7107. Contractor shall remain responsible, notwithstanding a withholding by City pursuant to the terms of these General Conditions, to promptly satisfy from its own funds sums due to all Subcontractors who have performed the Work that is included in Contractor's Application for Payment. Contractor shall, by appropriate agreement, require each Subcontractor to make payments to its sub- contractors and suppliers in similar manner. City shall have no obligation to pay or be responsible in any way for payments to Subcontractors, of any Tier.

Direct Negotiation of Stop Notices

City shall have the right to directly discuss, negotiate, settle or pay, without notice to or participation by Contractor, any stop notice claims asserted by the Subcontractors, of any Tier, and to deduct such sums paid from sums due to Contractor.

Release of Stop Notices

Except to the extent of any payments that City fails to make to Contractor under circumstances that constitute a breach by City of its payment obligations under the Contract Documents, if any stop notice, whether invalid or valid, is made, filed with, served upon or asserted against City or a Homeowner by any of the Subcontractors, of any Tier, or their agent or employee, for money claimed due for Work of any kind provided, then Contractor shall within five (5) Days after written notice by City and at Contractor's Own Expense, procure, furnish and record appropriate releases or other instruments which under Applicable Laws will full release, extinguish and removed such stop notice. Unless and until such stop notice is fully released as afore-stated, City shall have the right to retain from any payments then due, or thereafter to become due, an amount equal to one hundred and fifty percent (150%) of the amount necessary to satisfy, discharge and defend against any such stop notice and any action or proceeding thereon which may be brought to judgment or award. If the amount to be paid, or the amount retained thereon, is insufficient to satisfy, discharge or defend against such stop notice and any action of proceeding thereon, then Contractor shall be liable for the difference and upon written demand shall immediately deposit the same with City. The provisions in this paragraph are in addition to such other rights as City may have against Contractor under the Contract Documents or Applicable Laws.

Failure of Payment by City

If, through no fault of Contractor or failure by Contractor to comply with its obligations under the Contract Documents, Payment is not issued within thirty (30) Days after receipt of an undisputed and properly prepared and submitted Application for Payment then Contractor may, upon fourteen (14) additional Days' written notice to City, stop the Project Work for which such Application for Payment is received until payment is received as to any undisputed and owing work. Any resulting Delay associated with the shut down andstart up of the Project Work of ~~a Home~~ as a result of Contractor's proper exercise of its rights under this paragraph shall constitute a Compensable Delay.

Disputed Payments, Continuous Work

No dispute or disagreement with respect to the amount of any payment claimed due by Contractor shall relieve or excuse Contractor from the obligation to proceed with and maintain continuous, expeditious and uninterrupted performance of the Work.

Completion. Inspection. Punch List. Re-Inspection

A Contractor-generated punch list must be provided to the City or its representative prior to the request for final inspection. It will be the discretion of the City or its representative to grant the final inspection based on the Contractor generated punch list. Contractor shall achieve Completion of the Project Work in accordance with the requirements of the Contract Time and other provisions of the Contract Documents. Contractor shall notify Engineer when Contractor believes that the Project Work is Complete.

Unless Engineer determines that the Project Work for Home is not sufficiently complete to warrant an inspection to determine Compliance, Engineer, accompanied by Inspector of Record and any others deemed appropriate by Engineer, will inspect Project Work performed. Contractor, along with such Subcontractors and others as Engineer deems necessary shall participate in the inspection. If the Project Work is found to be Complete, then Engineer shall proceed to issue a written completion notice as provided hereinafter.

Any items necessary for Compliance that are found missing, incomplete or requiring correction shall be summarized by Contractor in a Completion Punch List and promptly signed by Contractor and delivered to Engineer. Contractor shall proceed within forty-eight (48) hours after signing the Completion Punch List to commence correction and completion of the items listed.

Contractor shall notify Engineer when the items listed are completed at which time a re-inspection shall be scheduled in the same manner as the original inspection. If said inspection discloses any item, whether or not included on the original Punch List, which is found missing, incomplete, or requiring correction said item shall be corrected before a Notice of Completion shall be issued.

The City shall be reimbursed or at its option shall withhold from Contractor's payments, amounts incurred by City to conduct more than two (2) inspections to determine Compliance of the Project Work for any Home. A Notice of Completion shall be issued by the Engineer when he determines that Compliance of the Project Work has occurred.

Final Completion

Contractor shall expeditiously and diligently perform all items of Project Work on the Final Completion Punch List so as to achieve Final Completion of the Project Work within the requirements of the Contract Time for Final Completion of the Project Work. Contractor shall forward to Engineer a written notice when Contractor believes that it has completed all of the items on the Final Completion Punch List and is read for a Final Completion Inspection. Unless Engineer determines that the Project Work is not sufficiently complete to warrant an inspection to determine Final Completion, Engineer, accompanied by Inspector of Record and any others deemed appropriate by Engineer, will inspect Project Work performed. If the Project Work is found to be Finally Complete, then Engineer shall proceed to issue a Notice of Final Completion as provided hereinafter.

If said inspection discloses any item, whether or not included on the Final Completion Punch List, which is found missing, incomplete, or requiring correction said item shall be corrected before a Notice of Final Completion shall be issued. The City shall be reimbursed or at its option shall withhold from Contractor's payments, amounts incurred by City to conduct more than two (2) inspections to determine Final Compliance of the Project Work for any Home. A Notice of Final Completion shall be issued by the Engineer when he determines that Final Compliance of the Project Work has occurred.

Concluding Payment

Upon issuance by Engineer of the Notice of Final Completion for the Project Work Contractor shall submit to Engineer its Application for Payment requesting payment for completion. Without limitations to any other conditions to payment set forth elsewhere in the Contract Documents, the following shall be conditions precedent to a proper submission, and to Engineer's approval, of Contractor's Application for Final Payment:

1. Submission of an affidavit that payrolls, bills for materials and equipment, and other indebtedness connected with the Project Work for which City or City's or Homeowner's property or funds might be liable have been paid or otherwise satisfied;

2. Submission of consent of Surety, if any, to Completion Payment;

3. Submission of a certificate evidencing that the insurance required by the Contract Documents is in force;

4. Submission of conditional releases and waivers of stop notice and bond rights upon final payment in the form required by California Code Section 3262(d)(3) executed by Contractor and by all Subcontractors, of every Tier, performing any portion of the Project Work;

5. Submission of all Close-Out Documents for the Project Work;

6. Submission of adequate and complete certified payroll records as required by the Contract Documents for any time period that Project Work was performed, which have not been submitted by Contractor in connection with its previous Applications for Payments.

7. Proper payment of prevailing wages as defined in California Labor Code Section 1720, et seq for the Project Work.

8. Submission of certificates by Contractor and each Subcontractor, as required by any applicable collective bargaining agreement or trust agreement or Applicable Laws, certifying that all employees benefits relating to the Project Work due and owing having been paid in full;

9. and Submission of any other documents or information required by the Contract Documents as a condition of Final Payment or Final Completion of the Project Work.

Section 41. FINAL PAYMENT OF UNDISPUTED AMOUNT

Final payment by the City of undisputed amounts is contingent upon the Contractor furnishing the City with a release of all claims against the City arising by virtue of those amounts. Disputed contract claims in stated amounts may be specifically excluded by the Contractor from the operation of the release pursuant to Section 7100 of the Public Contract Code.

Section 42. RIGHTS AND REMEDIES: CLAIMS AND PROTESTS

General

Duties and obligations imposed by the Contract Documents and rights and remedies available hereunder shall be in addition to and not a limitation of duties, obligations, rights and remedies otherwise imposed or available by Applicable Law.

If the Contractor considers any work demanded of them to be outside the requirements of the contract, or considers any instruction, ruling, or decision of the Engineer to be unfair, the Contractor shall within 10 working days after any such demand is made, or any such instruction, ruling, or decision is given, file a written protest with the Engineer stating the nature of the protest and the reasons therefore.

Except for such protests and objections as are made of record in the manner and within the time above stated, the Contractor shall be deemed to have waived and does hereby waive all claims for any extra work, damages, and extensions of time on account of such demands, instructions, rulings, and decisions of the Engineer.

Upon receipt of any such protest from the Contractor, the Engineer will review the demand, instruction, ruling, or decision objected to and will, within 30 calendar days, advise the Contractor, in writing, of his/her final decision, which shall be binding upon all parties unless, within 10 working days after the date of said final decision, the Contractor shall file with the Council formal protest against said final decision of the Engineer. The Council will then consider and render its final decision on any such protest within 30 calendar days after receipt of such protest. The decision of the City Council shall be final and binding upon all parties to the dispute.

It shall be understood and agreed that if a claim or protest is made in accordance with the foregoing provisions, and the Contractor refuses to accept the decision of the Council as final, the dispute shall then be settled by arbitration in accordance with Statutory Provisions of the State of California then prevailing.

If in conformity with the requirements of law at the time applicable, the following shall apply: Any controversy or claim arising out of or relating to the Contract or the breach thereof shall be settled by arbitration in accordance with the Construction Industry Arbitration Association, and judgment upon the award rendered by the Arbitrator or Arbitrators may be entered in any court having jurisdiction thereof.

Claims Based on Differing Site Conditions.

Save and except as provided in this paragraph, Contractor agrees to solely bear the risk of Loss and Delay due to concealed or unknown conditions, surface or subsurface, at a Site or in Existing Improvements at the Site, without adjustments to the Contract Sum or Contract Time. If Contractor encounters conditions it believes constitutes Differing Site Conditions, then notice of such conditions shall, before such conditions are disturbed, be promptly reported to Engineer within twenty-four (24) hours by a written notice stating a detailed description of the condition encountered. Failure to submit a timely written notice to the Engineer shall be deemed a waiver of any right by Contractor for an adjustment to the Contract Sum or Contract Time by reason of such conditions. The City shall treat any time written notice as a claim for damages and shall be resolved in accordance with this Article 55 of the Contract.

Section 43. GUARANTEE

All work shall be guaranteed one (1) year for defective materials and workmanship, commencing at final acceptance. Work found to be defective or not in accordance with the contract Documents shall be corrected by the Contractor promptly after receipt of a written notice from the City.

If the Contractor fails to make such repairs or replacements promptly, the City reserves the right to do the work and the Contractor and Surety company shall be liable to the City for the costs thereof.

Section 44. ADDITIONAL REFERENCES

Conformance with the Provisions for safety practices set forth in the "Manual of Accident Prevention in Construction", published by the A.G.C.A., and in the "Construction Safety Orders", published by the State of California, Department of Industrial Relations, Division of Industrial Safety, shall take precedence over any requirements of these Specifications.

Whenever in these Specifications references are made to published specifications, standards, or other requirements, it shall be understood that the latest specifications, standards, or requirements of the respective issuing agencies, which have published as of the date that the work is advertised for bids, shall apply; except as otherwise specified herein, and except to the extent that said standards or requirements may be in conflict with applicable laws, ordinances, or governing codes.

No requirements set forth herein or shown on the Drawings shall be waived because of any provision of, or omission from, said standards or requirements.
References in these specifications to "Standard Specifications" shall mean the Standard Specifications for Public Works Construction, Latest Edition of the Joint Committee of APWA-AGC, including all current supplements, addenda, and revisions thereof.

References herein to "Standard Drawings" shall mean the various City of Inglewood Public Works Department Standards, which are hereby incorporated in and made a part of these Specifications.

References herein to "OSHA Safety and Health Regulations for Construction" shall mean Title 29, Part 1926, Construction Safety and Health Regulations, Code of Federal Regulations (OSHA), including all changes and amendments thereto.

References herein to "OSHA" Safety and Health Standards" shall mean Title 29, Part 1910, Occupational Safety and Health Standards, Code of Federal Regulations (OSHA), including all changes and amendments thereto.

References herein to "Building Code" shall mean the California Building Code, 2001 Edition, as published by the International Conference of Building Officials, which Code is hereby incorporated in and made a part of these Specifications to the extent of the applicable references thereto.
Reference herein to "California Code of Regulation (CCR), Title 24", also known as the "California Building Standards Code", which Code is hereby incorporated in and made a part of these Specifications to the extent of the applicable references thereto.

Reference is also made to the Standards of the American Water Works Association, which shall serve as materials and equipment specifications for water system construction, except as herein modified, and any other reference cited in the Special Provisions, such as American National Standards Institute.

Section 45. SURVEY WORK AND PRESERVATION OF SURVEY MONUMENTS

The Contractor shall be responsible for the protection and preservation of existing permanent survey monuments, benchmarks, and centerline ties during construction. Damaged or lost monuments, benchmarks, and centerline ties shall be restored to existing condition by a Land Surveyor licensed by the State of California, at no cost to the City.

The Contractor, at own expense, shall employ a qualified surveyor to perform all survey work required for the completion of the Project as specified in the Plans and Specifications, comply with the requirements of Section 8771 of the Land Surveyors Act as amended, and submit documentation from the County Surveyor as proof of compliance to the City of Inglewood. Payment for survey services shall be included in other items of work, and no additional compensation will be made thereof.

Section 46. KEY POLICY FOR CITY FACILITIES

When performance of the work requires access to City of Inglewood facilities, which are secured by the City's keying system, and it is determined to be in the best interests of the City, keys may be requested from the Facilities Division of Public Works. The distribution of City keys to non-employees shall be at the discretion of the City's Project Engineer and the Facilities Manager. Each non-employee who is issued keys to any City facility shall review and sign a document, which is an acceptance of liability associated with loss of or damage to such keys. The original notice of acceptance of liability shall be maintained by the Facilities Division of Public Works.

The Contractors whose services necessitate keys to access City facilities be provided, shall be supplied with a minimum number of keys, for which they are responsible. The Contractor may incur liability if the keys are lost, loaned, mislaid, misplaced, or abused.

The Contractor is prohibited from duplicating or causing the duplication of City keys, notwithstanding whether the keys may be stamped with a statement prohibiting duplication.

The Contractor is prohibited from loaning City keys to anyone not specifically authorized to have a City key in his/her possession.

The issuance of a City key does not convey rights or authority beyond that of permitting the Contractor to whom the key is issued to enter the City facility to perform the contracted work, and only during specified hours.

The City may demand the return of any issued key and all duplicates, notwithstanding whether a duplicate was authorized by City, at any time, for any reason.

The Contractor shall deposit two hundred dollars ($200.00) per key received. The deposit shall be paid by a certified check, payable to the "City of Inglewood" and the Contractor shall be given a receipt for said deposit. Deposits are refundable upon return of the key(s). In no event shall any interest be paid to any contractor as a result of the $200.00 per key deposit.

The Contractor is hereby advised that, in the event re-keying of any City facility is necessary as a result of lost, loaned, mislaid, misplaced, or abused keys, the $200.00 deposit may not cover the cost of re-keying the locks and/or any liability associated with the loss of keys. The City shall seek to recover all additional costs from the Contractor by all available legal means, including litigation, if necessary.

Section 47. CONSTRUCTION WASTE DISPOSAL CONTAINER

The Contractor shall provide a waste disposal container at the construction site for the duration of the construction. The Contractor shall contact Consolidated Disposal. Please contact Angela Williams of the City's Environmental Services Division at (310) 412-8722 for a waste container.

Section 48. CLEAN WATER ACT COMPLIANCE

The Contractor shall be responsible for complying with all regulations of the Clean Water Act including those associated with the National Pollutant Elimination Discharge System (NPEDS) Permit. The Contractor shall comply with the regulations set forth in the Inglewood Municipal code, and any other state and federal programs targeted at preventing and eliminating storm water and urban runoff pollution and shall abide to those regulations throughout all phases of the Project.

Section 49. CONSTRUCTION & DEMOLITION DIVERSION PROGRAM PERMIT AND REPORTS

The Contractor shall obtain a Construction & Demolition Diversion Program Permit Application (attached) prior to removing any waste and other materials from job sites. If any material will be reused on site, the Contractor shall indicate the material and estimated quantity (in yards and/or tons).

Upon completion of the job, the Contractor shall complete and submit a Construction & Demolition Diversion Program Final Compliance Disposal Report (attached) and provide the Engineer all disposal/recycle tickets for all material transported. The Contractor shall reproduce the forms as needed.

Section 50. STAGING AREAS FOR CONSTRUCTION

When possible, the City will consider providing City-owned vacant lots to the Contractor for use as staging areas for construction.

The Contractor shall be responsible for all costs for permits and fees associated with the use of the City-owned vacant lots.
The Contractor shall assume sole and complete responsibility for the lot condition during the course of construction of the Project, including safety of all persons and properties. This requirement shall be maintained continuously and not be limited to normal working hours.

The Contractor shall assume sole and complete responsibility for all items stored within the lots. All the items stored within the lots shall be properly stored in accordance with all current requirements of most stringent codes, regulations, and ordinances.

The Contractor shall at all times keep the premises free from accumulation of waste materials or rubbish caused by his/her work. At the completion of the work, the Contractor shall remove all rubbish, tools, scaffolding, and surplus materials. The Contractor shall leave the lots broom-clean and at the pre-existing conditions.
The Contractor shall be responsible for any damage to adjoining properties, public and private, caused by his/her employees, equipment, and materials. All repairs shall be done as necessary to restore the damaged areas to a condition equal to and matching the condition existing prior to damage. All repairs shall be made at the expense of the Contractor.

DIVISION II

TECHNICAL SPECIFICATIONS

SECTION 028213

ASBESTOS ABATEMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. Remove and properly dispose of asbestos-containing materials from Project site as herein specified. Contractor is responsible for verifying actual quantities. Contractor shall provide all labor, materials, services, insurance (specifically covering the handling and transportation of asbestos material), and equipment which is specified, shown or reasonably implied for the following asbestos abatement activities:

1.	1' x 1' Ceiling Tiles	7,455 Square Feet
2.	Vinyl Floor Tile (Various Sizes)	525 Square Feet
3.	Floor Tile Mastic	525 Square Feet
4.	Pipe and Pipe Fitting Insulation (Various Sizes)	200 Linear Feet
5.	Exterior Stucco (Window Inserts)	1,300 Square Feet
6.	Ceiling Plaster	50 Square Feet

B. General:
1. The work specified herein covers the preparation of the Project site, removal and encapsulation of building structures and components and the removal of materials that have been determined to contain, or to be contaminated by, asbestos.
2. The work shall be supervised by experienced persons trained, knowledgeable and qualified in the techniques of asbestos abatement, handling and disposal of asbestos-containing, and asbestos contaminated, materials and the subsequent cleaning of contaminated areas.
3. Damages caused during the performance of abatement activities shall be repaired by Contractor (e.g. paint peeled off by barrier tape, nail holes, water damage, broken glass) at no additional expense to City of Inglewood. Contractor is responsible for restoring the work area and auxiliary areas, used in the abatement work, to conditions equal or better than original.

1.2 DEFINITIONS

A. The following definitions and acronyms are used throughout the specifications and drawings in reference to Asbestos Abatement:
1. Abatement: Procedures to control fiber release from Asbestos Containing Materials. Includes Demolition, Encapsulation and Removal.
2. AHERA: Asbestos Hazard Emergency Response Act, 40 CFR, Part 763, Subpart E, and subsequent amendments.
3. Amended Water: Water to which a surfactant (wetting agent) has been added.
4. Asbestos Containing Material (ACM): Means any material containing more than one-percent (1%) Asbestos.
5. Class I, II, III, and IV asbestos work has the meaning as defined in California Code of Regulations Title 8, Section 1529.
6. Clean Room: An uncontaminated area or room, which is a part of the worker Decontamination Enclosure System with provisions for storage of worker's street clothes and clean protective equipment.
7. Controlled Disturbance: An activity by which a contractor disturbs an asbestos containing material or an asbestos containing construction material using the work practices allowed for in this specification and in compliance with regulatory limitations.
8. Curtained Doorway: A device to allow ingress and egress from one room to another while permitting minimal air movement between the rooms, typically constructed by placing two overlapping sheets of plastic over an existing or temporarily framed doorway, securing each along the top of the doorway, securing the vertical edge of one sheet along one vertical side of the

doorway and securing the vertical edge of the other sheet along the opposite vertical side of the doorway. Other effective designs may be submitted for review.

9. Decontamination: The process of eliminating Asbestos contamination from building surfaces, objects, and property, by cloths, mops, or other utensils dampened with water and disposed of afterwards as Asbestos contaminated waste.
10. Decontamination Enclosure System: Means an enclosed area, which is adjacent and connected to the Regulated Area, consisting of an Equipment Room, Shower Room, and Clean Room for the Decontamination of workers, materials, and equipment contaminated with Asbestos.
11. Demolition: The wrecking or taking out of any load supporting structural member of a facility together with any related handling operations.
12. DOSH: Division of Occupational Safety & Health or Cal/OSHA
13. DOT: Department of Transportation
14. DTSC: Department of Toxic Substances Control
15. Encapsulating Material: A liquid material applied to Asbestos Containing Materials which controls the possible release of Asbestos fibers from the material either by creating a membrane over the surface (bridging agent) or by penetrating into the material and binding its components together (penetrating Encapsulating Material).
16. Encapsulation: The application of an Encapsulating Material to Asbestos Containing Materials to prevent the release of Asbestos fibers into the air.
17. Enclosure: The construction or application of an airtight, impermeable, permanent barrier around Asbestos Containing Material to control the release of Asbestos fibers into the air.
18. Friable Asbestos: Asbestos Containing Material which, when dry, can be crumbled, pulverized or reduced to a powder by hand pressure or as defined by current regulations.
19. Glove Bag Technique: A method with limited applications for removing small amounts of Asbestos Containing Material from short piping runs, valves, joints, elbows, and other non-planar surfaces in a Work area. The glove bag assembly is a manufactured or fabricated device consisting of a glove bag (typically constructed of 6 mil transparent polyethylene or polyvinyl chloride plastic), two inward projecting long sleeves gloves, an internal tool pouch, and labeled for Asbestos waste. The glove bag is constructed and installed in such a manner that it surrounds the object or material to be removed and contains all Asbestos fibers released during the process. All workers who are permitted to perform the Glove Bag Technique shall be thoroughly trained, experienced, and skilled in this method.
20. HEPA Filter: Means a filtering system capable of trapping and retaining at least 99.97% of all mono-dispersed particles 0.3 microns in diameter or larger. For respirators this shall include NIOSH rated P-100 cartridges only.
21. HEPA Vacuum: A vacuum system furnished with HEPA filtration.
22. Lockdown Coat: A material applied to surfaces where Asbestos has been completely removed. The manufacturer shall determine the concentration of this material.
23. NESHAP: National Emission Standards for Hazardous Air Pollutants (40 CFR Part 61)
24. NIOSH: National Institute for Occupational Safety and Health
25. PCM: Phase Contrast Microscopy as it relates to clearance air, personnel exposure assessment, and ambient air monitoring. This procedure must follow the NIOSH Method 7400, Asbestos Fibers by PCM.
26. PLM: Polarized Light Microscopy used for bulk sample analysis with dispersion staining for the determination and quantifying of Asbestos in Bulk Samples building materials.
27. SCAQMD: South Coast Air Quality Management District
28. Shower Room: A room between the Clean Room and the Equipment Room in the worker Decontamination Enclosure System furnished with hot and cold running water controllable at the tap, and suitably arranged for complete showering during Decontamination.
29. Staging Area: Areas near the Waste Transfer Airlock where containerized Asbestos waste is temporarily placed prior to permanent removal from the Work area.
30. Surfactant: A chemical wetting agent added to water.
31. TEM: Transmission Electron Microscopy as defined for Asbestos clearance air monitoring within AHERA. This procedure must follow the NIOSH Method 7402, Asbestos Fibers by TEM.
32. TSDF: Treatment Storage Disposal Facility.

33. TSI: Thermal System Insulation as defined in AHERA.
34. USEPA or EPA: United States Environmental Protection Agency
35. Waste Transfer Airlock: A Decontamination system provided for transferring containerized waste from inside to outside of the Work area.

1.3 PROCEDURES

A. Contractor shall perform all Work in compliance with all Applicable Code Requirements and any other trade done in conjunction with the abatement.

B. The most recent edition of any relevant regulation, standard, document or code shall be in effect.

C. In addition to the codes and regulations specified in Section 01 4100, REGULATORY REQUIREMENTS, Contractor shall comply, without limitation, with the following:
   1. Code of Federal Regulations (CFR).
      a. 29 CFR §1910.134 Respiratory Protection
      b. 29 CFR §1910.145 Specifications for Accident Prevention Signs and Tags
      c. 29 CFR §1926.1101 Construction Standard for Asbestos, Tremolite, Anthophylite and Actinolite
      d. 29 CFR §1926.050 Stairways and Ladders
      e. 29 CFR §1926.59 Hazard Communication – Construction
      f. 29 CFR §1926.450-454 Scaffolds and Training
      g. 40 CFR 61 Subpart A General Provisions
      h. 40 CFR 61 Subpart M National Emissions Standard for Hazardous Air Pollutants (NESHAP)
      i. 40 CFR Part 763 Subpart E, EPA AHERA Regulations
      j. 49 CFR 171 through 180 U.S. Department of Transportation
   2. California Code of Regulations (CCR).
      a. Title 8 §341.6 Registration, Asbestos Related Work
      b. Title 8 §1529 Construction Industry Safety Orders
      c. Title 8 §3203 Injury and Illness Prevention Program
      d. Title 8 §5144 Respiratory Protective Equipment
      e. Title 8 §5194 Hazard Communication
      f. Title 8 §5208 General Industry Safety Orders (GISO), asbestos
      g. Title 22 Hazardous Waste Handling
      h. Title 24, Part 9, Chapter 26, California Fire Code 2016
   3. American National Standards Institute (ANSI) Publications.
      a. Z9.2-79 Fundamentals Governing the Design and Operation of Local Exhaust Systems
      b. Z88.2-80 Practice for Respiratory Protection
   4. American Society for Testing and Material (ASTM) Publication.
      a. E 1368-14 Standard Practice for Visual Inspection of Asbestos Abatement Projects
   5. Underwriters' Laboratories, Inc. (UL) Publication.
      a. 586-85 High Efficiency, Particulate, Air (HEPA) Filter Units
      b. Cal. Lab, Code Sections 6501.5, 6501.8, and 6503.5.
   6. South Coast Air Quality Management District (SCAQMD).
      a. Rule 1403
   7. Los Angeles City Fire Department (LAFD).
      a. Rule 68 Note: Contractor is exempt from paying permit fees.
   8. Any guidelines established by City of Inglewood Environmental Services.

D. Transportation:
   1. Regulations pertaining to the transport and disposal of hazardous substances/materials include, but are not limited to, the following:
      a. Department of Transportation 49 CFR 171 through 180.
      b. Department of Transportation 49 CFR 387 (46 FR 30974, 47073).
      c. Department of Transportation DOT-E 8876.

d. Environmental Protection Agency 40 CFR 136 (41 FR 52779).
e. Environmental Protection Agency 40 CFR 261, 262 and 761.
f. Resource Conservation and Recovery Act (RCRA).
g. California Vehicle Code, CHP Regulations (Cal.Code Regs., tit. 13).
h. California State Fire Marshal Regulations (Cal. Code Regs., tit. 19).

2. Any transporter of hazardous substances shall be licensed in the state in which handling and transportation will take place in accordance with all Applicable Code Requirements..
3. Comply with OSHA (Occupational Safety and Health Administration) Standards and Regulations contained in Title 29 Code of Federal Regulations, Part 1910.120 "Hazardous Waste Operations and Emergency Response."
4. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.4 SUBMITTALS

A. Refer to Section 01 3323, SHOP DRAWINGS, PRODUCT DATA & SAMPLES, for procedures.

B. Contractor shall submit to City of Inglewood's Representative at least one (1) copy in a pdf, OCR (Optical Character Recognition), format the following documentation prior to the start of work:

1. Written notification to the following regulatory agencies:
   a. California Division of Occupational Safety and Health (DOSH)
   b. South Coast Air Quality Management District (SCAQMD)
   c. Los Angeles City Fire Department (LAFD) – Rule 68 Note: Contractor is exempt from paying permit fees.
2. Registration with the Division of Occupational Safety and Health (DOSH) as an asbestos abatement Contractor per the requirements in 8 CCR §341.6 through 361.14.
3. A marked-up, site-specific set of floor plans showing locations and lay-out of work area enclosures, decontamination units, air filtration devices, temporary fire protection, waste containers, utility (e.g., water, electrical sources), staging areas, and emergency exiting from the building.
4. SCAQMD Permits for all HEPA vacuums and negative air machines brought to or used on the Project site.
5. Documentation that Contractor's employees, including foreman, supervisor and any other company personnel or agents who may be exposed to airborne asbestos fibers or who may be responsible for any aspects of abatement activities have received training as required by CCR Title 8, Section 1529. All training certificates shall be current within one year.
6. Documentation of respirator fit-testing for all Contractor employees and agents who must enter the work area. All respirator fit-testing certificates shall be current within one year.
7. Documentation that Contractor's employees, including foreman, supervisor and any other company personnel or agents who may be exposed to airborne asbestos fibers have successfully passed a medical examination and are medically qualified to wear respiratory protection. All medical exam documentation shall be current within one year.
8. Safety Data Sheets (SDS) for neutralizers, solvents, encapsulants, wetting agents and replacement materials, as necessary.
9. An emergency preparedness plan as specified in Paragraph 1.7 herein.
10. Carbon Monoxide (CO) Health & Safety Plan (HASP) prior to use of propane-powered or combustion engine equipment inside enclosed and/or regulated area. HASP must include the following key elements:
    a. Scope
    b. Project personnel
    c. Description of hazards
    d. Responsibilities
    e. Hazard control procedures
    f. Hazard communication
    g. Details regarding monitoring equipment and procedures
    h. Emergency planning and response.

C. Contractor shall submit the following information to City of Inglewood's Representative at least one (1) copy in a pdf, OCR (Optical Character Recognition), format the following documentation on a daily basis or whenever requested during progression of the work:
   1. Copies of Contractor's respiratory protection program, and injury and illness protection program.
   2. Copies of daily Project site entry logbooks with information on worker and visitor access.
   3. Initial air monitoring results for HEPA negative air filter unit exhaust as required by SCAQMD. Collect air samples on the first day of abatement activities.
   4. Logs documenting filter changes on respirators, HEPA vacuums, differential pressure air filtration devices, and other engineering controls.
   5. Copies of all original laboratory analytical reports for Contractor employee's personal air sampling exposure data.

      City of Inglewood - Division of Environmental Services

      1 Manchester Boulevard, Inglewood, CA 90301

   6. Copies of all transport manifests, trip tickets and disposal receipts for all hazardous materials removed from the work area within 24 hours of the transport. Send to:

      City of Inglewood - Division of Environmental Services
      1 Manchester Boulevard, Inglewood, CA 90301

D. Contractor shall submit at least one (1) copy in a pdf, OCR (Optical Character Recognition), format the following close-out information to City of Inglewood's Representative following completion of the Project:
   1. Copies of Project Log Book including Worker submittals, Project daily logs, air sample reports and manifests.
   2. Asbestos Work Description Form (attached at the end of this Section 02 8213).

1.5 NOTICES

A. Post in the clean room area of the worker decontamination enclosure the following:
   1. Copies of written notification to the regulatory agencies listed in Paragraph 1.4 herein.
   2. Employee Daily Sign-in Log.
   3. Visitor Entry and Exit Log.
   4. Emergency telephone numbers for Contractor and City of Inglewood's Representative including Construction Project Manager, Asbestos Coordinator and Environmental Consultant.

1.6 SITE SECURITY

A. The work area shall be restricted only to authorized, trained and protected personnel, including Contractor, Contractor's employees, City of Inglewood employees and representatives, State and Local inspectors.

B. A list of authorized personnel shall be posted at the entrance of the Regulated Area. Entry into the work area by unauthorized individuals shall be reported immediately to City of Inglewood's Representative.

C. A logbook shall be maintained at the entrance of the Regulated Area. All persons entering the Regulated area shall record their name, company affiliation, time in, and time out for each entry and exit.

D. Access to the work area shall be through a worker de-contamination system located at the designated entrance to the area. All other means of access shall be locked or blocked by the erection of plywood or particle board barriers so as to prevent entry to or exit from the work area, except for emergency exits which shall not be locked from the inside but shall be sealed with polyethylene sheeting and tape until needed.

E. Contractor shall be responsible for Project site security during abatement operations in order to protect work efforts and equipment.

1.7 EMERGENCY PLANNING

A. Emergency planning and procedures shall be developed by Contractor prior to abatement initiation.

B. Emergency procedures shall be in written form and prominently posted. Contractor shall ensure that all persons entering the work area read these procedures and understand the Project site layout, location of emergency exits and emergency procedures.

C. Emergency planning shall include considerations of fire, explosion, electrical hazards, slips, trips and falls, confined spaces, and heat related injury. Written procedures shall be developed and employee training in procedures shall be furnished by Contractor.

D. Employees shall be trained in evacuation procedures in the event of work place emergencies.
   1. For non-life-threatening situations, employees injured or otherwise incapacitated shall decontaminate following normal procedures with assistance from fellow workers, if necessary, before exiting the work place to obtain proper medical treatment.
   2. For life-threatening injury or illness, worker decontamination shall take least priority. After measures to stabilize the injured worker, remove him from the work place and secure proper medical treatment.
   3. Telephone numbers of all emergency response personnel shall be prominently posted in the clean and equipment rooms.

1.8 RESTRICTED HOURS OF WORK AND ACCESS

A. Refer to Section 01 1400, WORK RESTRICTIONS.

1.9 ACTIVITIES AND QUALIFICATIONS

A. Qualifications:
   1. Comply with the provisions of the California Labor Code, Division 5, Part 1, as it pertains to safety in employment and the applicable provisions of Title 8, Chapter 4, Subchapters 1 through 21, California Code of Regulations (CCR) as it pertains to Occupational Safety and Health, and Subchapter 7, Section 5208 Article 4, and Section 1529, Asbestos regulations.

B. Abatement Activities:
   1. The Asbestos Abatement work shall be performed by persons who comply with all Applicable Code Requirements. including AHERA certified training.
   2. Provide all labor, materials, services, insurance, permits, and equipment necessary to perform the Work in accordance with all Applicable Code Requirements. and this Specification.
   3. For Class I asbestos work, collect pre-Abatement air samples. Results shall be submitted prior to commencement of the Work of this section. Include location of Samples, name of air sampling professional, equipment, and methods utilized for sampling and analysis.
   4. Submit weekly job progress reports detailing Abatement activities for Projects with schedules that exceed thirty days of Abatement work. Include review of progress with respect to previously established Milestones and schedules, major problems and action taken, injury reports, equipment breakdown, and air sampling results.

5. Within five (5) workdays of transport and/or disposal, submit copies of all transport manifests, disposal receipts, and weight certificates for all Asbestos waste removed from the Work area during the Abatement process. Weight certificates shall indicate in pounds the net weight of waste disposed from the Project site as indicated on the manifest.
6. Submit copies on a daily basis of the Work site entry logbooks.
7. Submit logs on a weekly basis documenting filter changes on respirators, HEPA Vacuums, HEPA Filtered ventilation units, water filtration units, and other approved engineering controls.
8. Submit results of materials testing conducted during Asbestos Abatement work for purposes of utilization during such activities. (i.e., depth test, substitution materials, etc.)
9. Where Decontamination Enclosure System is required, post at the entrance a list containing the names, addresses, and telephone numbers of the entity performing the Work of this section, designated Supervisor, City of Inglewood's Representative, the testing laboratory and any other personnel who may be required to access the Work area or perform services during the Abatement Work.

C. Asbestos Related Disturbance:
   1. The Asbestos Related Disturbance Work shall be performed by persons who comply with all applicable Federal, State, and local regulations including AHERA certified training.
   2. Within ten (10) days of analysis, submit results of air sampling data collected for Cal/OSHA compliance air monitoring during the course of the Asbestos Related Disturbance (Class III asbestos work). If this data is used to discontinue use of employee protective equipment then the data shall be provided before discontinuing use of protective equipment.

1.10 FIRE PROTECTION

A. All plastic, spray-on strippable coatings and structural materials used in the asbestos abatement process shall be UL approved and certified as fire retardant or noncombustible.

B. All combustible rubbish and debris, including properly bagged asbestos shall be properly disposed of at the end of each working day.

C. A minimum of one (1) 4A/60BC dry-chemical extinguisher shall be maintained at each of the following locations:
   1. At each corner of the work area. Where no clear corners exist, four (4) extinguishers shall be placed around the exterior wall of the work area so that they are approximately 25 percent of the total distance apart.
      a. Exception: Where the total abatement containment area is less than 1,000 square feet, two (2) 4A/60BC extinguishers shall be provided. All extinguishers shall be clearly identified with red tape.
   2. Contractor shall ensure that on site personnel are aware of the location and proper use of all extinguishers and other fire/life safety equipment.

D. Maintain a fire watch for a minimum of thirty (30) minutes after the cessation of work.

E. Maintain fire/life safety information in the project log.

F. A statement shall be prepared at the conclusion of each work day, signed by Contractor, confirming that a survey of the work site has been made and that any unsafe fire/life safety conditions have been rectified.

G. In the absence of a functioning automatic fire detection system connecting the building's central alarm system in the area undergoing abatement or respray, a fire watch shall be maintained on a 24-hour basis until:
   1. The final clean air certificate is issued.
   2. All respray is completed in buildings where fire protective coatings have been removed.

H. Any work requiring welding, cutting, open torches and other hot work operations and equipment shall comply with California Fire Code 2016.

I. All existing fire detection, alarm systems, connections and standpipes shall remain in place, active and unobstructed. Any alteration to this equipment shall be approved by City of Inglewood's Representative.

J. Existing fire alarm manual pull boxes, fire department communication jacks, and signaling systems shall be maintained in place and active. The foregoing items shall be clearly marked with signs containing lettering which is a minimum of 3" X 1/2" wide on a contrasting background. If the foregoing items are covered by plastic, each device shall be surrounded by a square of red duct type tape. In addition, a cutting device, also surrounded by red tape, shall be kept immediately adjacent to the device.

K. All existing sprinkler systems shall remain active. Sprinkler heads may be covered with a thin, .003" or less, plastic bag during abatement only so as to avoid their contamination.

L. Fire rated partitions, doors, and other fire cutoffs shall not be temporarily or permanently modified without the approval of City of Inglewood's Representative.

M. A single switch or set of switches shall be provided for the emergency shutdown of all negative air equipment located in the containment area. This switch or set of switches shall be for emergency use by the fire department personnel. The switches shall be located in a non-contaminated area near the clean exit of the decontamination station, and shall be clearly identified using a sign with minimum 3" X 1/2" lettering on a contrasting background. The sign shall read as follows: "NEGATIVE AIR MASTER SHUT OFF."

N. The asbestos abatement process shall not cause a building to have an amount of exiting less than that required for the existing occupant load. In all cases where the required exiting must be obstructed, an alternate means of exiting shall be provided as approved by City of Inglewood's Representative. A minimum of two (2) clearly marked exits shall be maintained from each floor during the abatement process. The second exit from a containment area may be covered with plastic upon City of Inglewood's Representative's approval. If this occurs, the covered exit shall be outlined with red duct type tape, and a cutting device shall be kept immediately adjacent to the door in an obvious and readily accessible location. The cutting device shall also be surrounded by a square of red tape as described above.

O. The following shall apply in containment areas greater than 1,000 square feet:
   1. Five (5) "Tyvek" type protective entry suits, or equal, rated for use in an asbestos containment area, shall be provided for each containment site. All suits shall be extra-large and shall be kept in a separate, clearly identified, readily accessible container near the clean exit from the decontamination area. These suits shall be for the exclusive use of emergency personnel.

1.11 QUALITY ASSURANCE

A. The Work of this Section shall be performed by an entity possessing the following minimum qualifications:
   1. A Comprehensive Quality Assurance Plan on file with the California Environmental Protection Agency.
   2. All Project site personnel shall wear personal protective equipment and protective clothing consistent with the levels of protection required for this Work as specified by CCR Title 8 §1529 Construction Industry Safety Orders.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General:
1. All plastic, spray-on strippable coatings and structural materials used shall be UL certified as fire retardant or non-combustible. Safety Data Sheets (SDS) for fire retardant materials shall be made available upon request.
2. Wood shall be pressure impregnable and certified as fire retardant.
3. Polyethylene sheeting utilized for worker decontamination and barriers shall be black in color and shall be a minimum of 6 mils thick.
4. Disposal bags shall be of clear 6-mil polyethylene, pre-printed with labels as required by Environmental Protection Agency (EPA) regulation 40 CFR 61.152 (b) (i) (iv) or applicable Cal/OSHA requirements.
5. Disposal drums shall be metal, fiberglass or plastic with locking ring tops.
6. Stick-on labels as per EPA or Cal/OSHA
7. Warning signs as required by Cal/OSHA shall be utilized.
8. Deliver all materials in the original sealed packages, containers, or bundles bearing the name of the manufacturer and brand name.
9. Store all materials subject to damage off the ground, away from wet or damp surfaces, and under cover sufficient enough to prevent damage or contamination. Replacement materials shall be stored outside of the Abatement Work area until area is cleared for normal occupancy.
10. Damaged, deteriorating or previously used materials shall not be used and shall be removed from the Project site.

B. Removal, Encapsulation and Replacement:
1. Surfactant (wetting agent) shall be a 50/50 mixture of polyoxyethylene ether and polyoxyethylene ester, or equivalent, mixed with water in accordance with manufacturer's printed instructions.
2. The encapsulating agent to be applied shall adhere to the substrate surfaces from which asbestos-containing material has been stripped.
3. Encapsulants shall not be flammable.
4. Solvents used to remove mastic shall be low odor, non-noxious and an SDS shall be submitted.
5. A sufficient supply of transparent 6-mil polyethylene glove bags, pre-labeled with the prescribed Cal/OSHA and EPA warnings.
6. Encapsulating agent applied to areas to be resprayed with fireproofing shall neither affect the resprayed fireproofing ability to bond to the substrate, nor reduce the UL rating of the fireproofing.
7. Replacement sprayed-on or trowel applied fireproofing shall meet required specifications and be non-asbestos-containing.
8. Replacement acoustical materials shall meet or exceed original materials and be non-asbestos-containing.

2.2 EQUIPMENT

A. General:
1. A sufficient quantity of differential pressure air filtration devices equipped with HEPA filtration and operated in accordance with ANSI Z9.2-79 (local exhaust ventilation requirements) and EPA guidance document EPA 560/5-83-002 Guidance for Controlling Friable Asbestos-Containing Materials in Buildings. To calculate total air flow requirement:

$$\text{Total ft}^3/\text{min} = \frac{\text{Vol. of work area (in ft}^3)}{15 \text{ min}}$$

To calculate the number of units needed for the abatement:

$$\text{Number of units needed} = \frac{[\text{total ft}^3/\text{min}]}{[\text{capacity of unit in ft}^3 \text{ min /}]}$$

If air-supplied respirators are utilized, estimate the volume of supplied air and add to work place air volume when calculating filtration requirement. For small enclosures and glove bags, a HEPA filtered vacuum system shall be utilized to provide differential air pressure.

2. A manometer shall be used to continuously monitor pressure differential within removal area to ensure that an adequate level is maintained.
3. Half-face air purifying respirators with P-100 (HEPA) filters at a minimum shall be utilized during removal tasks for this project.
4. Type "B" powered purifying respirators shall be utilized during removal tasks involving friable materials or in environments requiring eye protection. Contractor shall be responsible for assessing the proper protection factor and personal protective equipment necessary to protect employees relative to airborne contaminant concentration and permissible exposure limits.
5. Respirators shall be furnished to the abatement workers by Contractor. The respirators shall have been tested and approved by National Institute of Occupational Safety and Health (NIOSH) for use in asbestos contaminated atmospheres.
6. Full body disposable protective clothing, including head, body, and foot coverings shall be furnished to visitors in sizes adequate to accommodate movement without tearing.
7. Additional safety equipment (e.g. hard hats meeting the requirements of ANSI Standard Z89.1-1981, eye protection meeting the requirements of ANSI Standard Z87.1-1979, safety shoes meeting the requirements of ANSI Standard Z41.1-1967, disposable gloves), as necessary, shall be furnished to all workers and authorized visitors.
8. Non-skid footwear shall be furnished to all abatement workers. Disposable clothing shall be adequately sealed to the footwear to prevent body contamination
9. Provide respirator cartridges capable of filtering both asbestos and other organic vapors.
10. All equipment delivered to the Project site shall be free of all Asbestos and/or fibrous debris. No equipment with Asbestos and/or fibrous debris in or on it is permitted on City of Inglewood properties.
11. A sufficient supply of scaffolds, ladders, lifts, and hand tools (e.g., scrapers, wire cutters, brushes, utility knives, wire saws, etc.) shall be furnished as needed.
12. Furnish a sufficient supply of disposable mops, rags, and sponges for work area decontamination.

B. Removal:
1. Sprayers are required with pumps capable of providing 500 pounds per square inch (PSI) at the nozzle tip at a flow rate of 2 gallons per minute for spraying amended water.
2. Rubber dustpans and rubber squeegees shall be furnished for cleanup.
3. Brushes utilized for removing loose asbestos-containing material shall have nylon or fiber bristles, not metal.
4. A sufficient supply of HEPA filtered vacuum systems shall be furnished during cleanup.
5. Contractor to provide direct reading instrumentation capable of simultaneously measuring Carbon Monoxide (CO), Oxygen and % Lower Explosive Limit (LEL) concentrations if using propane-powered or combustion engine equipment inside enclosed and/or regulated areas.

C. Encapsulation: Encapsulants shall be sprayed using airless spray equipment. Nozzle pressure shall be adjustable to within the 400 to 500 psi range.

PART 3 - EXECUTION

3.1 WORK AREA PREPARATION

A. General:
1. Post warning signs meeting the specifications of Cal/OSHA General Industry Safety Order Section 5208 and 29 CFR 1926.1101 at any location and approaches to a location where airborne concentration of asbestos fibers may exceed ambient background levels. Signs shall be posted at a distance sufficiently far enough away from a work area to permit a person to read the sign and take necessary protective measures to avoid exposure. Additional signs may need to be posted following construction of work place enclosure barriers.
2. Obtain City of Inglewood's Representative's approval prior to any utility shut-down in accordance with Section 01 1400, WORK RESTRICTIONS.
3. Temporary Electrical Service: Refer to Section 01 5100, TEMPORARY UTILITIES.
   a. Provide and maintain all necessary temporary electrical equipment, connections, etc., as necessary for the Work. Before final acceptance, all temporary equipment and connections installed by Contractor shall be removed in a manner approved by City of Inglewood's Representative. Electric power will be provided by City of Inglewood at no cost to Contractor. See Section 01 5100.
   b. Comply with CCR, Title 24, Part 3, California Electrical Code (2011 NEC with 2013 California Amendments), and Cal/OSHA requirements for temporary electrical systems. Refer to Section 01 4100, REGULATORY REQUIREMENTS.
4. All intake and exhaust vents leading to and from the work area shall be sealed with two (2) layers of 6-mil polyethylene sheeting and duct tape. Also seal any seams in HVAC system components that pass through the work area. HVAC system preparation for abatement shall be as approved by City of Inglewood's Representative.
5. City of Inglewood will furnish sanitary facilities for abatement personnel outside of the enclosed work area and maintain them in a clean and sanitary condition throughout the project.
6. City of Inglewood will furnish water for construction purposes. Contractor shall connect to existing system.
7. Seal off all windows, doorways, corridor entrances, drains, ducts, grills, grates, diffusers, skylights and any other openings with two (2) layers of 6-mil polyethylene sheeting and tape. All glass windows and doors leading to the outside shall be covered with black polyethylene sheeting.
8. Pre-clean all movable objects within the work area using a HEPA-filtered vacuum and/or wet cleaning method as appropriate. After cleaning, these objects shall be removed from the work area and carefully stored in an uncontaminated location.
9. Pre-clean all fixed objects, including machinery, grilles, diffusers, and horizontal surfaces such as pipes and ducts to remove spray applied-fireproofing overspray in the work area using HEPA-filtered vacuum systems and/or wet cleaning methods as appropriate. All cleaned fixed objects shall be covered with one (1) layer of 6-mil polyethylene sheeting and sealed with tape. This shall include items such as fiberglass and canvas-wrapped duct insulation and pipe insulation not removed as a part of the scope of work.
10. Preparation of Elevator: A minimum of two (2) layers of 6-mil polyethylene sheeting shall be adhered to the walls and floors of the elevator in such a manner as to prevent loosening during the course of abatement.
11. Elevators that pass through an asbestos work area shall be addressed in the following manner:
   a. Elevator service to floor that is under containment shall be locked out and prevented from opening onto work area. Elevator door opening shall first be sealed with two (2) layers of 6-mil polyethylene securely fastened with duct tape. A hard-board barrier of 1/2" plywood shall then be provided. All seams shall be caulked and made air-tight. Two (2) additional layers of 6-mil polyethylene shall then be securely fastened over the hard-board barrier.

B. Preparation for removal of asbestos-containing or asbestos-contaminated floor tile, floor tile mastic, resilient sheet flooring, floor leveling compounds, and carpeting, (including removal of flooring materials using non-mechanical means):

1. Walls shall be protected with a minimum of one (1) layer of 6-mil fire resistant polyethylene sheeting splash guarding a minimum of 72" in height.
2. Contractor shall isolate all heating, ventilation and air conditioning (HVAC) vents and all other critical openings such as windows, doors or holes with two (2) layers of 6-mil fire resistant polyethylene sheeting.
3. Contractor shall protect in place or remove where possible all door stops, electrical floor outlet plates or electrical floor monuments.
4. Contractor shall seal all floor penetrations with a minimum of two (2) layers of 6-mil fire resistant polyethylene sheeting or equivalent barrier to prevent water or solvent leakage to areas below.
5. All mastic remover/stripper or material contaminated with mastic remover/stripper shall be packaged separately from non-contaminated asbestos waste. Refer to waste disposal requirements in Paragraph 3.13 herein.

C. Preparation for removal of asbestos-containing material using glove bags:
1. Contractor shall isolate all heating, ventilation and air conditioning (HVAC) vents and all other critical openings such as windows, doors or holes with two (2) layers of 6-mil. fire-resistant polyethylene sheeting.
2. Surfaces beneath glove bag work shall be covered with a minimum of one (1) layer of 6-mil. fire-resistant polyethylene sheeting.
3. Saturate asbestos material to be removed with wetting agent prior to removal.
4. Each glove bag shall be installed so that it completely covers the circumference of pipe or other structure where the work is to be performed.
5. Glove bags shall be designed to enclose components without modification.
6. Glove bags may be used only once and may not be moved.
7. Glove bags shall be smoke tested for leaks and any leaks shall be sealed prior to use.
8. Provide a HEPA vacuum to remove air from glove bags prior to removing the bag from the pipe or structure.
9. Glove bags shall not be used on surfaces whose temperature exceeds 150°F.

D. Preparation for removal of asbestos-containing material using full containment (including removal of flooring materials using mechanical means):
1. Contractor shall coordinate the arrest of the heating, ventilation and air conditioning (HVAC) system with City of Inglewood's Representative which shall remain off during the duration of the abatement Project prior to isolating HVAC vents and all other critical openings such as windows, doors or holes with 2 layers of 6-mil. fire-resistant polyethylene sheeting.
2. Contractor shall coordinate the arrest of all electricity from the work area prior to supplying temporary power on ground fault circuit interrupters (GFCI) for all electrical equipment in the work area.
3. Walls, ceilings and floors shall be covered with a minimum of two (2) layers of 6-mil. fire-resistant polyethylene sheeting.
4. Contractor shall provide two layers of 6-mil polyethylene sheeting "pony walls" between the suspended ceilings and the decking where ceiling tiles are to be removed. Secure polyethylene sheeting so as to prevent it from falling away from walls. This may require additional support/attachments when negative pressure ventilation systems are turned on. Tightly seal polyethylene sheeting at both the decking and the ceiling line.
5. Plastic shall be sized to minimize seams.
6. Emergency exits shall be demarcated showing location of and direction towards with bright colored arrows located approximately 30" from the floor.
7. Contractor shall provide sufficient viewing ports to allow persons outside the containment to view all of the work area.
8. The work area shall be maintained under a static pressure differential of -0.02 inches of water across any barrier at all times. This static pressure differential shall be continuously measured.
9. Contractor shall furnish and install at least 2 airless sprayers. Contractor shall demonstrate the ability to supply copious quantities of water to all areas of the work area prior to any work activity.

Hudson- type or garden-type hand sprayers may be used in addition to but not in place of these specified wetting devices.

E. Preparation for removal of asbestos-containing Exterior Window Inserts and Ceiling Plaster (Spot Abatement):
   1. Construct mini-containments for spot abatements not located within containment areas.
   2. Constructed mini-containments or moveable containments with, at minimum, one layer of 6-mil polyethylene sheeting supported by scaffolding and bailing wire, PVC tubing, or other rigid material.
   3. Secure walls and ceilings to one another using tape and spray-adhesives. Mini-containments shall be rendered air-tight to the extent feasible.
   4. Construct worker decontamination enclosure systems as described in 3.2. Post asbestos warning signs as per 3.1(A) on the outside of the flaps to each work area.
   5. Provide and initiate local HEPA-equipped air filtration devices using HEPA vacuum.

F. After installation and operation of critical barriers, decontamination enclosure system, and HEPA filtration devices, request, receive, and pass a visual inspection as arranged by the City of Inglewood's Representative prior to initiation of abatement activities.

G. Remove, clean and enclose in polyethylene the ceiling mounted objects such as light fixtures and other items that may interfere with the abatement process and were not previously cleaned and sealed. Utilize localized spraying of amended water and/or HEPA vacuums to reduce fiber dispersal during the removal of these fixtures.

H. Commencement of work shall not occur until City of Inglewood's Representative has verified and approved the following:
   1. Enclosure systems have been constructed and inspected.
   2. Differential pressure air filtration devices are functioning adequately.
   3. All pre-abatement submissions, notifications, postings and permits have been furnished and are satisfactory to City of Inglewood's Representative.
   4. All equipment for abatement, cleanup and disposal are on hand.
   5. All worker training and certification is completed.

3.2 WORKER DECONTAMINATION ENCLOSURE SYSTEMS

A. Worker decontamination enclosure systems shall be provided at all locations where workers will enter or exit the work area. As a minimum, one system at a single location is required.

B. Worker decontamination enclosure systems constructed at the Project site shall utilize 6-mil black polyethylene sheeting, or other approved materials for privacy.

C. The worker decontamination enclosure system shall consist of at least a clean room, a shower room, and an equipment room, each separated from the other and from the work area by airlocks.

D. Access between any two rooms in the decontamination enclosure system shall be through an airlock with at least three feet separating each curtained doorway.

E. Clean rooms shall be sized to adequately accommodate the work crew. Space for storing respirators shall be provided in this area. Lockers for storing street clothes and other personal items, clean work clothes, clean disposable clothing, replacement filters for respirators, towels and other necessary items shall be provided in adequate supply in the clean room. A location for posting notices shall also be provided in the area.

F. Shower room shall contain one or more showers as necessary to adequately accommodate workers. Each shower head shall be supplied with warm and cold water adjustable at the tap. The shower enclosure shall be constructed to ensure against leakage of any kind. An adequate supply of soap, shampoo and towels shall be supplied by Contractor and available at all times. Shower water shall be drained, collected and filtered through a system with at least 0.5-1.0 micron particle size collection capability.

G. The equipment room shall be used for storage of equipment and tools at the end of a shift after they have been decontaminated using a HEPA filtered vacuum and/or wet cleaning techniques as appropriate. Replacement filters (in sealed containers until used) for filtration equipment, extra tools, containers or surfactant and other materials and equipment that may be required during the abatement may also be stored here as needed.
   1. A walk-off pan (a small children's swimming pool or equivalent filled with water shall be located in the room for workers to clean off foot coverings after leaving the work area and prevent excessive contamination of the worker decontamination enclosure system.
   2. A drum lined with a labeled 6-mil polyethylene bag for collection of disposable clothing shall be located in this room. Contaminated footwear shall be stored in this area for reuse the following workday.

H. Emergency exits shall be established and clearly marked with duct tape arrows or other effective ways to permit easy location from anywhere within the work area. If duct tape arrows are utilized, the arrows shall be a different color from the tape used to secure the polyethylene sheeting. Red or yellow duct tape is preferred to mark emergency exits.

I. Emergency exits shall be secured to prevent access from uncontaminated areas and still permit emergency exiting. These exits shall be properly sealed with polyethylene sheeting which can be cut to permit exiting, if needed. A utility knife shall be taped close to the bottom of the exit for use in cutting the polyethylene sheeting in case of emergency.

J. Maintenance of Work Place Barriers and Worker Decontamination Enclosure Systems:
   1. After the construction of all polyethylene barriers and decontamination system enclosures are complete, allow sufficient settling time to insure that barriers will remain intact and secured to walls and fixtures before actual abatement activities.
   2. Inspect all polyethylene barriers inside the work place and worker decontamination enclosure systems constructed to isolate the work area at least twice daily, prior to the start of each day's abatement activities. Contractor shall document inspections and observations in the daily project log.
   3. Damage and defects in the enclosure system shall be repaired immediately upon discovery.
   4. Use smoke tubes to test the integrity of the barrier system at least once for each 24 hour period or when requested by City of Inglewood's Representative.
   5. At any time during the abatement activities after barriers have been erected, if visible asbestos-containing material is observed outside of the work area or if damage occurs to barriers, work shall immediately stop, repairs made to barriers and the debris or residue cleaned up using appropriate HEPA vacuuming and wet mopping.
   6. If air samples collected outside of the work area during abatement activities indicate airborne fiber concentrations greater than 0.01 f/cc or pre-measured background levels (whichever is higher) work shall immediately stop for inspection and repair of barriers. Cleanup of surfaces outside of the work area using HEPA vacuums or wet cleaning techniques will be required.
   7. Install and initiate operation of differential pressure air filtration equipment as needed to provide one air change in the work area at least every 15 minutes. Openings made in the enclosure system to accommodate these units shall be made airtight with tape and/or caulking as needed. Insure that adequate power supply is available to satisfy the requirements of the filtration devices. Differential pressure air filtration devices shall be exhausted to the outside of the building. These shall not be exhausted into occupied areas of the building. Careful installation, air monitoring and daily inspections shall be conducted to insure that the ducting does not release fibers into the uncontaminated building areas.

K. Once barriers are constructed, and the differential pressure air filtration devices are in operation, the containment shall be tested for leakage utilizing smoke tubes. Repair the barriers as needed.

L. Monitor negative pressure within removal area to ensure that an adequate level is maintained. Check readings, and record, 3 times each work shift; at the beginning, at mid-point, and end.

M. Remove, clean and enclose in polyethylene the ceiling mounted objects such as light fixtures and other items that may interfere with the abatement process and were not previously cleaned and sealed. Utilize localized spraying of amended water and/or HEPA vacuums to reduce fiber dispersal during the removal of these fixtures.

N. Commencement of work shall not occur until City of Inglewood's Representative has verified and approved the following:
   1. Enclosure systems have been constructed and inspected.
   2. Differential pressure air filtration devices are functioning adequately.
   3. All pre-abatement submissions, notifications, postings and permits have been provided and are satisfactory to City of Inglewood's Representative.
   4. All equipment for abatement, cleanup and disposal are on hand.
   5. All worker training and certification is completed.

3.3 ALTERNATIVE PROCEDURES

A. If specified procedures cannot be utilized, a request shall be made in writing to City of Inglewood's Representative providing details of the problem encountered and recommended alternatives.

B. Alternative procedures shall provide equivalent or greater protection than procedures that are replaced.

C. Any alternative procedure shall be approved in writing by City of Inglewood's Representative prior to the implementation of the procedure.

3.4 WASTE CONTAINER REMOVAL AIRLOCK

A. The waste container pass-out airlock shall be constructed away from the Decontamination Enclosure System. This airlock shall be in a location that provides direct access from Abatement Work area to the outside of the building if possible.

B. This system shall consist of an airlock, container Staging Area, and another airlock providing access to outside Abatement Work area.

C. The waste container airlock shall be constructed in similar fashion with similar materials as the Decontamination Enclosure System.

D. This airlock system shall not be used to enter or exit the Abatement Work area.

3.5 WORKPLACE ENTRY AND EXIT PROCEDURES

A. Personnel Entry and Exit:
   1. All workers and authorized personnel shall enter the work area through the worker decontamination enclosure system.
   2. Contractor shall ensure that all personnel who enter the work area sign the entry/exit log.
   3. Contractor shall ensure that all personnel, before entering the work area, read and are familiar with all posted regulations, personal protection requirements (including work place entry and exit procedures) and emergency procedures.
   4. All personnel shall proceed first to the clean room, remove all street clothes and appropriately don respiratory protection and disposable coveralls, head covering and foot covering. Hard hats, eye

protection and gloves shall also be utilized. Clean respirator and protective clothing shall be provided and utilized by each person for each separate entry into the work area.

5. Personnel wearing designated personal protective equipment shall proceed from the clean room through the shower room and equipment room to the main work area.
6. Before leaving the work area, all personnel shall remove gross contamination from the outside of respirators and protective clothing by brushing and/or wet wiping procedures (small HEPA vacuums with brush attachments may be utilized for this purpose). Each person shall clean bottom of protective footwear in the walk off pan prior to entering the equipment room.
7. Personnel shall proceed to the equipment room where they remove all protective equipment except respirators. Upon completion of abatement, protective equipment shall be properly cleaned for reuse or disposed of as asbestos contaminated waste.
8. Reusable, contaminated footwear shall be stored in equipment room when not in use in the work area. Upon completion of abatement, it shall be properly cleaned for reuse or disposed of as asbestos contaminated waste.
9. Still wearing respirators, personnel shall proceed to the shower area, clean the outside of the respirators and the exposed face area under running water prior to removal of respirator then shower and shampoo to remove residual asbestos contamination. Various types of respirators will require slight modification of these procedures. An airline respirator with a HEPA filtered disconnect protection may be disconnected in the equipment room and worn into the shower. A powered air purifying respirator face piece will have to be disconnected from the filter/power pack assemble which is not waterproof, upon entering the shower. A dual cartridge respirator may be worn into the shower. Cartridges shall be replaced for each new entry into the work area.
10. After showering and drying off, personnel shall proceed to the clean room and don clean disposable clothing if there will be later reentry into the work area or street clothes if it is the end of the work shift.

3.6 REMOVAL PROCEDURES

A. Wet all asbestos-containing and contaminated material with an amended water solution. The wetting agent will be mixed according to manufacturer's printed instructions and then applied using equipment capable of providing a fine spray mist, in order to reduce airborne fiber concentrations when the material is disturbed during removal and vacuuming. Saturate the asbestos-containing material; however, do not allow excessive water to accumulate. Keep all removed material wet enough to prevent fiber release until it can be containerized for disposal. Maintain high humidity in the work area by misting or spraying to assist in fiber settling and reduce airborne concentrations.

B. Saturated asbestos-containing material shall be removed in manageable sections. Removed material shall be containerized before moving to a new location for continuance of work. Loose floor tiles shall be containerized before moving to a new location for continuance of work. Surrounding areas shall be periodically sprayed and maintained in a wet condition until visible material is cleaned.

C. Material removed from building structures or components shall not be dropped or thrown to the floor. Material shall be removed as intact sections or components and carefully lowered to the floor.

D. Containers (double 6-mil polyethylene bags or drums) shall be sealed when full. Bags shall not be overfilled. They shall be securely sealed to prevent accidental opening and leakage by tying tops of bags in an overhand knot or by taping in gooseneck fashion. Do not seal bags with wire or cord. Bags shall be decontaminated on exterior surfaces by wet cleaning and HEPA vacuuming.

E. Generator name and address labels shall be affixed to waste containers prior to disposal.

F. Asbestos-containing waste with sharp-edged components (e.g., nails, screws, metal lath, tin sheeting) will tear the polyethylene bags and sheeting and shall be placed into drums for disposal.

G. After removal of the asbestos-containing material, surfaces from which asbestos-containing materials have been removed shall be wet brushed and sponged or cleaned by some equivalent method to remove all visible residues.

H. After the work area has been rendered free of visible residue, a thin coat of a satisfactory encapsulating agent shall be applied to all surfaces in the work area including structural members, building components and plastic sheeting on walls, floors, and covering non-removable items, to seal in non-visible residues.

3.7 CLEAN-UP PROCEDURES

A. Remove and containerize all visible accumulations of asbestos-containing material and asbestos contaminated debris utilizing rubber dust pans and rubber squeegees to move material around. Do not use metal shovels to pick up or move accumulated waste. Special care shall be taken to minimize damage to floor sheeting.

B. Wet clean all surfaces in the work area using rags, mops and sponges as appropriate.

C. Remove the cleaned secondary layer of plastic sheeting from walls and floors. Windows, doors, HVAC system vents and all other opening shall remain sealed. The differential pressure air filtration devices shall remain in continuous operation. Decontamination enclosure systems shall remain in place and be utilized.

D. After cleaning the work area, furnish a period of time to allow fibers to settle and HEPA vacuum and wet clean all objects and surfaces in the work area again.

E. Remove all containerized waste from the work area and waste container pass-out airlock.

F. Decontaminate all tools and equipment and remove at the appropriate time in the cleaning sequence.

G. City of Inglewood's Representative will inspect the work area for visible residues. If any accumulation of residue is observed, it will be assumed to be asbestos and a second settling period and cleaning cycle repeated at no additional cost to City of Inglewood.

H. The work area shall be cleaned until it is in compliance with Applicable Code Requirements and any requirements specified herein. The criteria shall be in the form of visual inspections and airborne fiber concentrations. Additional cleaning cycles shall be provided, as necessary, at no cost to City of Inglewood until these criteria have been met.

I. Following the satisfactory completion of clearance air monitoring, the remaining barriers may be removed and prepared for proper disposal. A final visual inspection by City of Inglewood's Representative will be performed. Unsatisfactory conditions may require additional cleaning and air monitoring at no additional cost to City of Inglewood.

3.8 ENCAPSULATION AND BRIDGING AGENTS

A. All lockdown and Encapsulating Material, and bridging agents shall be reviewed by City of Inglewood's Representative prior to the commencement of the Work of this section.

B. Encapsulating Material shall be sprayed applied with airless spray equipment. Nozzle pressure shall be adjustable within a range of 400 to 1500 PSI.

C. Lock down coat shall be spray applied with low pressure providing a continuous even coat.

D. Bridging agents shall be a palm or brush grade.

E. All colorless lock down materials, Encapsulating Material, and bridging agents shall be furnished with a compatible color additive. A different color shall be furnished for each separate coat of applied material.

F. Install penetrating type Encapsulating Material to penetrate existing sprayed applied Asbestos Containing Materials to a depth as required.

G. During installation of the penetrating type Encapsulating Material, remove selected random core samples of the Asbestos Containing Materials in the presence of the City of Inglewood's Consultant to verify depth of penetration.

H. Lock down coating and Encapsulating Material for installation on hot water, steam, or any other high temperature equipment shall be manufactured and recommended for installation on high temperature systems.

3.9 AIR MONITORING

A. Background Air Monitoring: Upon request from Contractor, City of Inglewood will conduct air monitoring to determine ambient baseline fiber levels prior to abatement. Ambient baseline fiber levels are presumed to be 0.01 f/cc or less in the event background air sampling is not performed.

B. Area Air Monitoring: City of Inglewood will conduct in-progress air monitoring daily to determine area fiber levels outside and inside of containment, within the decontamination unit and in air exhausted by negative air machines.

C. Personal Air Monitoring:
   1. At minimum, Contractor shall conduct representative (10% of crew) breathing zone personal air monitoring of its employees twice each shift and repeated daily.
   2. Monitoring shall be conducted by a qualified air professional experienced and knowledgeable about the methods of air monitoring and in accordance with 29 CFR 1926.1101.
   3. Monitoring results and appropriate laboratory analysis work shall be submitted to City of Inglewood's Representative within twenty-four (24) hours of the monitoring work.

D. Clearance Air Monitoring:
   1. Following the completion of clean-up operations, notify City of Inglewood's Representative that work areas are ready for clearance air monitoring.
   2. Following a successful visual inspection as specified in Paragraph 1.3 herein, City of Inglewood will collect sufficient air samples within the work are to determine airborne fiber levels.
   3. All samples at all locations shall indicate concentrations of airborne fibers of 0.01 f/cc or less for release of the work area.
   4. Areas exceeding this level shall be recleaned using procedures specified in Paragraph 3.7 herein, and retested at no additional cost to City of Inglewood until satisfactory levels are obtained.

E. The following shall apply for all air monitoring:
   1. All testing shall be conducted by individuals trained in the NIOSH 582 course on Sampling and Evaluation of Airborne Asbestos Dusts and proficient participant in the NIOSH Proficiency Analytical Testing program.
   2. All air tests shall utilize NIOSH Analytical Method 7400, Fibers (Phase Contrast Microscopy) unless Transmission Electron Microscopy is requested by City of Inglewood's Representative.

3.10 REESTABLISHMENT OF THE WORK AREAS AND SYSTEMS

A. Reestablishment of the work area shall only occur following the completion of clean-up procedures and after clearance air monitoring has been performed and documented to the satisfaction of City of Inglewood's Representative.

B. Polyethylene barriers shall be removed from walls, ceilings, and floors, maintaining decontamination enclosure systems and barriers over doors, window, etc. as required.

C. Contractor and City of Inglewood's Representative shall visually inspect the work area for any remaining visible residues. Evidence of contamination will necessitate additional cleaning and air sampling at no additional cost to City of Inglewood, until approved by City of Inglewood's Representative.

D. Following satisfactory clearance of the work area, remaining polyethylene barriers may be removed and disposed of as asbestos contaminated waste.

E. Repair all areas of damage that occurred as a result of abatement activities at no additional cost to City of Inglewood.

3.11 STOP WORK ORDER

A. City of Inglewood's Representative shall have the right to issue a Stop Work Order whenever Contractor's work, engineering controls, or air monitoring results are not in accordance with published regulations, contractual restrictions, or the abatement specifications. All costs resulting from the Stop Work Order shall be at Contractor's expense. Refer to General Conditions Article 2.3.1.

B. The Stop Work Order shall first be given verbally to Contractor by City of Inglewood's Representative, at which point all work shall cease. This shall be immediately followed by a written notification to stop work. If the situation is not corrected to City of Inglewood's Representatives satisfaction within forty-eight (48) hours, Contractor shall be considered to be in breach of the Contract and will be subject to termination in accordance with General Conditions Article 13.2.

3.12 TESTING AND TRANSPORT

A. Collect one composite sample from each media type (solid, liquid, or sludge) of potentially hazardous substance stored in drums, stockpiled, or otherwise identified at the Project site for the purposes of obtaining approvals for proper transport and disposal of the suspect materials. Submit all analytical results to City of Inglewood's Representative.

B. If required, over-pack any leaking or deteriorated drums to prevent leaks or spills, and pack small 5-gallon containers into larger new 55-gallon drums. Cover all solid waste materials and stockpiled soils with an HDPE liner to prevent stormwater runoff from contaminating surrounding areas.

C. Prepare manifests, material profiles, and submit lab analysis for all drums/containers and any other documentation required by the receiving facility for signature by City of Inglewood's Representative.

D. Coordinate waste sampling and analysis requirements with the disposal facility and properly complete all profiling and transport documents prior to loading and transport.

E. A State registered "Hazardous Waste Hauler" shall transport the waste to a lawfully permitted and City of Inglewood approved facility.

F. Prior to transport, a copy of the hazardous waste manifest shall be delivered or emailed to the address listed below.

City of Inglewood - Division of Environmental Services

1 Manchester Boulevard, Inglewood, CA 90301

The manifests shall list the generator's name and address, site address, Generator's EPA ID number, to include the waste profile number. Attach the land disposal restriction (LDR) form to the manifest prior to submission to the EH&S. All other copies of the manifest and LDR shall be submitted to the waste transporter. Generator address for all waste manifests:

City of Inglewood - Division of Environmental Services

1 Manchester Boulevard, Inglewood, CA 90301

G. Load, handle, and transport all 55-gallon drums and other waste containers to the appropriate disposal facility in accordance with Federal and State regulations.

H. All transport documentation from the receiving facility verifying acceptance and receipt of drums/containers at the facility and all sampling and associated test results shall be submitted to City of Inglewood's Representative, within fifteen (15) days following receipt of all hazardous substances to the disposal facility.

I. All materials identified as hazardous wastes under the EPA's Resource Conservation and Recovery Act (RCRA) are not permitted to remain at the Project site more than 30 days after being deemed to be a hazardous waste. During this period of Project site storage, provide all precautions to contain and prevent the release of hazardous or potentially hazardous materials to the environment.

3.13 DISPOSAL PROCEDURES

A. As work progresses, to prevent exceeding available storage capacity on site, sealed and labeled containers of asbestos-containing waste shall be removed and transported to an approved disposal location.

B. All hazardous materials and contaminated soils must be transported by a California licensed and insured company.

C. Disposal shall occur at an approved facility in accordance with regulatory requirements of NESHAP and Applicable Code Requirements, including the California State Department of Health Services, Toxic Substances Control Division.

D. Disposal Facilities:
   1. All asbestos waste shall be disposed of at one of the following approved facilities:

US Ecology, Inc.
P.O. Box 578
Beatty, NV 89003
Highway 95 – 12 Miles South of Beatty, Nevada
(800) 239-3943

Azusa Land Reclamation Co.
1201 West Gladstone St.
Azusa, CA 91702
(626) 334-0719

Clean Harbors
2500 West Lokern Road
Buttonwillow, CA 93206
(661) 762-6200

Simi Valley Landfill and Recycling Center-SVLRC
(Only Non-friable & Non-Hazardous)
2801 Madera Road, Simi Valley, CA 93065
(805) 522-7023

2. All mastic remover/stripper or material contaminated with mastic remover/stripper shall be packaged separately from asbestos waste. Unless waste analysis performed by a certified laboratory shows the waste to be within Land Disposal Restriction (LDR) limits, the required disposal method is incineration. Presently, the only approved facilities are:

   Crosby & Overton
   1630 West 17th Street
   Long Beach, CA 90813
   (562) 432-5445

   Clean Harbors
   1737 East Denni Street
   Wilmington, CA 90744
   (310) 835-9998

3. Other facilities may be used only if prior written approval is obtained from City of Inglewood's Division of Environment Services.

E. All non-hazardous asbestos-containing waste shall be adequately wet prior to being double bagged in clear 6-mil polyethylene disposal bags and sealed with duct tape. Non-hazardous waste shall be disposed of as non-hazardous waste and transported on a non-hazardous waste manifest. The outer bags or containers shall be labeled with the following description:

DANGER
CONTAINS ASBESTOS FIBERS
AVOID CREATING DUST
CANCER AND LUNG DISEASE HAZARD

F. All friable and hazardous asbestos-containing waste shall be adequately wet prior to being double bagged in clear 6-mil fire-resistant polyethylene disposal bags. Both the inner and outer bag shall have the air removed with a HEPA vacuum prior to sealing with duct tape using the gooseneck technique. All bags shall be printed with appropriate DOT labeling and have generator identification labels. All hazardous waste shall be shipped using the following information of shipping papers and manifests:

NA 2212, Asbestos, 9, PGIII, RQ, NAERG 171

G. All Waste Certification Forms attesting to the content of the generated waste shall be signed and completed by Contractor.

All dump receipts, trip tickets, transportation manifests or other documentation of disposal shall be delivered to City of Inglewood Environmental Services Division, 1 Manchester Boulevard, Inglewood, CA 90301. Record keeping format shall utilize a chain of custody form which includes the names and addresses of the Generator (City of Inglewood), Contractor, pick-up site, disposal site, estimated quantity of asbestos waste disposed and the type of container utilized. This form shall be signed by the Generator's Representative, Transporter and the Disposal Site Operator as the responsibility of the material changes hands. Secondary Transporters are not allowed unless approved in writing by City of Inglewood's Division of Environment Services.

H. All hazardous and non-hazardous asbestos waste manifests shall require minimum 48-hour advance notice as a request prior to waste removal from City of Inglewood to the following Division:

City of Inglewood - Division of Environmental Services

1 Manchester Boulevard, Inglewood, CA 90301

I. All waste transportation vehicles or containers shall be prepared as follows:
   1. Following removal from the project site, all asbestos waste shall be immediately loaded into an enclosed truck, bin or dumpster for transportation.
   2. Any debris or residue observed on waste containers or surfaces outside the work area resulting from clean-up or waste disposal activities shall be immediately cleaned up using HEPA vacuums and/or wet methods as appropriate.
   3. The enclosed cargo area of the truck, bin or dumpster shall be free of debris and lined with at least one (1) layer of 6-mil. fire-resistant polyethylene sheeting to prevent contamination from leaking containers.
   4. The enclosed cargo area of the truck, bin or dumpster shall have doors or tops that can be closed and locked to prevent vandalism or other disturbance of the packaged asbestos waste and wind dispersion of asbestos fibers. The door or top shall be secured and locked at all times with the exception of loading and unloading of asbestos waste.
   5. Asbestos waste shall be transported from the Project site to the truck, bin or dumpster using appropriate drum dollies or covered debris carts.
   6. Asbestos waste containers shall not contain loose, un-bagged material nor shall they contain non-asbestos waste.
   7. Bags shall be placed, not thrown into the waste containers to prevent splitting and the release of asbestos fibers.
   8. Drums or large structural components shall be placed on level surfaces in the cargo area and packed together to prevent shifting or tipping.

END OF SECTION

(Note: City of Inglewood - Asbestos Removal Worksheets on the following 2 pages.)

COI ______ ASBESTOS WORK

DESCRIPTION

Project Name: ____

Project #: ____________ Order #: ____________________ Completion Date: ______________

Base Contract Amount: $__________________ Change Order #: __________ Change Order Amount: $____________

Contractor Name: ____

Monitoring Consultant: ____

Building Name: ____

Location Within Building: ____

Contractor's description of work performed and methods used: ______________________________

____

____

____

____

____

____

____

____

____

Check all that apply:

- Scaffolding ☐
- Full Containment ☐
- Glove Bag ☐
- Mini Enclosure ☐
- Other Methods Employed: ______________________________

COMPLETE ALL INFORMATION ON NEXT PAGE

COI ______ ASBESTOS WORK
DESCRIPTION

Location of Work		Type of Work (state specific dollar amount)				Type and Amount of Material (list amount in square or lineal feet)		
		Encapsulation/ Repair	Removal	Replacement	Incidental Removal	Surface Treatment	Insulation	Misc.
Floors								
Roof								
Walls								
Ceilings								
Pipes								
Boilers								
Tanks								
Shaft/Plenum/ Ducts								
Other								

SECTION 028319.13

LEAD MATERIAL AND LEAD-BASED PAINT ABATEMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. Remove, segregate, characterize and dispose of lead-based paint (LBP), lead-containing paint (LCP), Presumed Lead-Based Paint (PLBP) coatings, shielding, glazes, dust and other materials from the Project site as herein specified. Contractor is responsible for verifying actual quantities. Contractor shall provide all labor, materials, services, insurance (specifically covering the handling and transportation of hazardous materials), and equipment which is specified, shown or reasonably implied for the following lead abatement activities:
   1. Remove and dispose of the following Lead-Based Paint/Components in accordance with Section 3.1.B herein:
      a. Wall, Ceramic Tile — 1,750 Square Feet
   2. Remove and dispose of Lead-Containing Paint/Components in accordance with Section 3.1.B, 3.1C. or 3.1.D herein.

B. General:
   1. The work specified herein covers: Preparation of the Project site; disposal procedures; removal of building components coated with lead-containing paint (LCP); and the removal of coatings that have been determined to contain lead.
   2. All work shall be supervised by persons experienced in lead remediation. During all phases of work Contractor shall have at least one supervisory employee per work area (individual building) currently certified by the California Department of Public Health as a Certified Lead Supervisor as specified in CCR Title 17, Section 35008. All work shall be performed by employees currently certified by California Department of Public Health as a Certified Lead Worker as specified in CCR Title 17, Section 35009.
   3. Damages caused during the performance of abatement activities shall be repaired by Contractor (e.g. paint peeled off by barrier tape, nail holes, water damage, broken glass) at no additional expense to City of Inglewood. Contractor is responsible for restoring the work area and auxiliary areas, used in the abatement work, to conditions equal or better than original.

1.2 DEFINITIONS

A. The following definitions and acronyms are used throughout the specifications and drawings in reference to Lead Abatement:
   1. AAS: Atomic Absorption Spectrophotometry used for lead paint chip and dust wipe sample analysis.
   2. Abatement: Any set of measures designed to reduce or eliminate lead hazards or Lead Based Paint for public and residential buildings, but does not include containment or cleaning.
   3. Action Level: Means the Action Level as defined in Title 8, California Code of Regulations, Section 1532.1.
   4. CDPH: California Department of Public Health
   5. CDPH-Approved Course: "CDPH-approved course" means any lead-related construction course that satisfies the requirements specified in sections 35056, 35057, 35061, 35065, 35066, or 35067 as determined by CDPH pursuant to sections 35076 and 35078.
   6. Certificate: Means the document issued by CDPH to an individual meeting the certification requirements as described in CCR Title 17, Sections 35083, 35085, 35087, 35089, or 35091.

7. Clean Room: An uncontaminated area or room which is a part of the worker Decontamination Enclosure System with provisions for storage of worker's street clothes and clean protective equipment.
8. Curtained doorway: A device to allow ingress and egress from one room to another while permitting minimal air movement between the rooms, typically constructed by placing two overlapping sheets of plastic over an existing or temporarily framed doorway, securing each along the top of the doorway, securing the vertical edge of one sheet along one vertical side of the doorway and securing the vertical edge of the other sheet along the opposite vertical side of the doorway. Other effective designs may be submitted for review.
9. Decontamination: The process of eliminating lead contamination from building surfaces, and property by cloths, mops, or other utensils dampened with water and disposed of as lead contaminated waste.
10. Decontamination Enclosure System: A minimum a two-stage Decontamination unit consisting of a compartment for Decontamination, and a Clean Room. Unless otherwise specified, it shall be adjacent to the Abatement area.
11. DOSH: California Division of Occupational Safety & Health or Cal/OSHA.
12. DOT: Department of Transportation
13. DTSC: California Department of Toxic Substances Control
14. Encapsulating Material: Are coatings or rigid materials adhesively applied to Lead Based Painted surfaces in the Encapsulation process.
15. Encapsulation: The application of an Encapsulating Material to Lead Based Paint to provide a barrier between the Lead Based Paint and the environment.
16. EPA: United States Environmental Protection Agency
17. HEPA Filter: Means a filtering system capable of trapping and retaining at least 99.97% of all mono-dispersed particles 0.3 micrometers in diameter or larger.
18. ICP-AES: Means Inductively Coupled Plasma-Atomic Emission Spectroscopy used for heavy metal analysis, including lead.
19. Lead Based Paint (LBP): Means paint or other surface coatings that contain an amount of lead equal to or greater than 0.7 milligrams per square centimeter (0.7 mg/cm2) or equal to or greater than 0.5% by weight or equal to or greater than 5,000 ppm.
20. Lead Containing Paint (LCP): Means paint or other surface coatings that contain lead in an amount less than 0.7 milligrams per square centimeter (0.7 mg/cm2) or less than 0.5% by weight or less than 5,000 parts per million (ppm).
21. Lead Contaminated Dust: Means dust that contains an amount of lead equal to, or greater than, forty micrograms per square foot (40 □g/ft2) for interior floor surfaces; two hundred and fifty micrograms per square foot (250 □g/ft2) for interior horizontal window surfaces; and four hundred micrograms per square foot (400 □g/ft2) for exterior floor and exterior horizontal window surfaces.
22. Lead Contaminated Soil: Means bare soil that contains an amount of lead equal to, or greater than, four hundred parts per million (400ppm) in children's play area and one thousand parts per million (1000 ppm) in all other areas.
23. Lead Inspection: Means a surface by surface investigation to determine the presence of Lead Based Paint as described in Chapter 7: Lead Based Paint Inspection, "Guidelines for the Evaluation and Control of Lead Based Paint Hazards in Housing," U.S. Department of Housing and Urban Development, Second Edition, July 2012.
24. Lead-Related Construction Work: Means any construction, alteration, painting, demolition, salvage, renovation, repair, or maintenance of any residential or public building, including preparation and cleanup that, by using or disturbing lead-containing material or soil, may result in significant exposure of adults or children to lead.
25. Lead Safe Schools Program: Means the training program for lead safe working practices as developed by the Labor Occupational Health Program at U.C. Berkley.
26. NESHAP: The National Emission Standards for Hazardous Air Pollutants (40 CFR Part 61)
27. NIOSH: The National Institute for Occupational Safety and Health
28. PEL: Means permissible exposure limits as defined in Title 8, California Code of Regulations, Section 1532.1.

29. Presumed Lead-Based Paint (PLBP): Means paint or surface coating affixed to a component in or on a structure constructed prior to January 1, 1978. "Presumed lead-based paint" does not include paint or surface coating that has been tested and found to contain an amount of lead less than one milligram per square centimeter (1.0 mg/cm2) or less than half of one percent (0.5%) by weight.
30. SCAQMD: South Coast Air Quality Management District.
31. STLC: Means Soluble Threshold Limit Concentration used in the State of California in conjunction with TTLC to determine lead hazardous waste limits. If the STLC result is equal to or exceeds 5 mg/L the waste is deemed to be hazardous.
32. Surfactant: A chemical wetting agent added to water.
33. TCLP: Means Toxicity Characteristic Leaching Procedure used to determine the federal Resources Conservation Recovery Act (RCRA) lead hazardous waste limits. If the results equal or exceed 5 mg/L the waste is deemed to be hazardous.
34. TSDF: Treatment Storage Disposal Facility
35. TTLC: Means Total Threshold Limit Concentration used in the State of California in conjunction with STLC to determine lead hazardous waste limits. If the results are equal to or exceeds 1000 mg/kg, the waste is deemed to be hazardous.
36. X-Ray Fluorescence (XRF) Analyzer: Means a direct reading instrument that determines the lead content of the surface coatings in milligrams per square centimeter (mg/cm2) using the principle of x-ray fluorescence.

1.3 PROCEDURES

A. Contractor shall perform all Work in compliance with all Applicable Code Requirements and any other trade work done in conjunction with the abatement.

B. The most recent edition of any relevant regulation, standard, document or code shall be in effect.

C. In addition to the codes and regulations specified in Section 01 4100, REGULATORY REQUIREMENTS, Contractor shall comply, without limitation, with the following:
1. Code of Federal Regulations (CFR).
   a. 49 CFR §171 through 180 U.S. Department of Transportation (USDOT)
   b. 40 CFR Part 745 Subpart E EPA Lead Renovation Regulation
   c. 29 CFR §1200 Hazard Communication – General Industry
   d. 29 CFR §1910.134 Respiratory Protection
   e. 29 CFR §1910.145 Accident Prevention Signs and Tags
   f. 29 CFR §1926.62 Lead in Construction
   g. 29 CFR §1926.050 Stairways and Ladders
   h. 29 CFR §1926.59 Hazard Communication – Construction
   i. 29 CFR §1926.450-454 Scaffolds and Training

2. California Code of Regulations (CCR).
   a. Title 8 §1532.1 Lead in Construction
   b. Title 8 §1536 Ventilation Requirements for Welding, Brazing, and Cutting
   c. Title 8 §1537 Welding, Cutting, and Heating of Coated Metals
   d. Title 8 §3203 Injury and Illness Prevention Program
   e. Title 8 §5144 Respiratory Protective Equipment
   f. Title 8 §5194 Hazard Communication
   g. Title 17 Division 1, Chapter 8, California Department of Public Health (CDPH) Accreditation, Certification and Work Practices for Lead-Based Paint and Lead Hazards
   h. Title 22 Cal/EPA Hazardous Waste Handling
   i. Title 24 California Air Resources Board Ambient Air Quality Standard
   j. Title 24 Part 9 Chapter 26 California Fire Code 2016

3. Los Angeles County Public Health Code (Chapter 11)

4. American National Standards Institute (ANSI) Publications.
    a. Z9.2-79 Fundamentals Governing the Design and Operation of Local Exhaust Systems
    b. Z88.2-80 Practice for Respiratory Protection

5. Department of Housing and Urban Development
    a. Title X Guidelines for the Evaluation & Control of Lead-Based Paint Hazards in Housing

6. Underwriters Laboratories, Inc. (UL) Publication:
    a. High Efficiency Particulate Air (HEPA) Air Filtration Units

7. Any guidelines established by City of Inglewood Environmental Services.

D. Transportation:
  1. Regulations pertaining to the transport and disposal of hazardous substances/materials include, but are not limited to, the following:
      a. Department of Transportation 49 CFR 171 through 180.
      b. Department of Transportation 49 CFR 387 (46 FR 30974, 47073).
      c. Department of Transportation DOT-E 8876.
      d. Environmental Protection Agency 40 CFR 136 (41 FR 52779).
      e. Environmental Protection Agency 40 CFR 261, 262 and 761.
      f. Resource Conservation and Recovery Act (RCRA).
      g. California Vehicle Code, CHP Regulations (Cal. Code Regs., tit. 13).
      h. California State Fire Marshal Regulations (Cal. Code Regs., tit. 19).

  2. Any transporter of hazardous substances shall be licensed in the state in which handling and transportation will take place in accordance with all applicable code requirements.
  3. Comply with OSHA (Occupational Safety and Health Administration) Standards and Regulations contained in Title 29 Code of Federal Regulations, Part 1910.120 "Hazardous Waste Operations and Emergency Response."
  4. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.4 SUBMITTALS

A. Refer to Section 01 3323, SHOP DRAWINGS, PRODUCT DATA & SAMPLES, for procedures.

B. Contractor shall submit to City of Inglewood's Representative at least one (1) copy in a pdf, OCR (Optical Character Recognition), format the following documentation prior to the start of work:
  1. Proof of worker training and certification. Include a copy of the most current initial or refresher training certificate as issued by a CDPH accredited training provider. Attach a copy of CDPH issued certificate for lead-related work.
  2. Documentation that Contractor's employees, including foreman, supervisor, and any other company personnel or agents who may be exposed to lead compounds, have attended and passed the appropriate CDPH-approved lead-related construction Course from a training provider accredited under CCR Title 17, Division 1, Chapter 8.
  3. Physicians written medical opinion Contractor employees can wear respiratory protection.
  4. Documentation of respirator fit-testing for all Contractor employees and agents who are required to wear a respirator. Fit-testing shall be current within one year.
  5. Documentation of medical surveillance required in CCR Title 8, Sec. 1532.1 (j)
  6. Written notification to the following regulatory agencies:
      a. California Division of Occupational Safety and Health (DOSH)
      b. California Department of Public Health (CDPH)

  7. Contractor shall notify the above-listed agencies upon receipt of Notice of Selection as Apparent Lowest Responsible Bidder.

8. Proof of SCAQMD permits for HEPA-filtered air filtration machines.
9. An emergency preparedness plan as specified in Paragraph 1.7 below.
10. Safety Data Sheets (SDS) for neutralizers, solvents, caustic stripping agents, paints, encapsulants, adhesives, detergents, and replacement materials, as necessary.
11. Carbon Monoxide (CO) Health & Safety Plan (HASP) prior to use of propane-powered or combustion engine equipment inside enclosed and/or regulated area. HASP must include the following key elements:
    a. Scope
    b. Project personnel
    c. Description of hazards
    d. Responsibilities
    e. Hazard control procedures
    f. Hazard communication
    g. Details regarding monitoring equipment and procedures
    h. Emergency planning and response.

12. A marked-up, site-specific set of floor plans showing locations and lay-out of work area enclosures, decontamination units, air filtration devices, temporary fire protection, waste containers, utility (e.g., water, electrical sources), staging areas, and emergency exiting from the building.
13. Proposed Exposure Assessment (EA) and Demolition Work Plan for each type of demolition and construction activity to be performed in accordance with Paragraph 3.1(D).

C. Contractor shall submit the following information to City of Inglewood's Representative at least one (1) copy in a pdf, OCR (Optical Character Recognition), format the following documentation on a daily basis or whenever requested during progression of the work:
1. Copies of all transport manifests, trip tickets and disposal receipts for all hazardous materials removed from the work area within 24 hours of the transport. Send to:

   City of Inglewood - Division of Environmental Services

   1 Manchester Boulevard, Inglewood, CA 90301

2. Copies of daily personal air sample logs and results of laboratory analysis for airborne lead dust. Contractor or Contractor's independent laboratory shall send these to the address listed above, or, by facsimile to (310) 825-7076.
3. Copies of daily Project site entry logbooks with information on worker and visitor access.
4. Logs documenting filter changes on respirators, HEPA vacuums, differential pressure air filtration devices, and other engineering controls.
5. Copies of Contractor's respiratory protection program and injury and illness protection program.

D. Contractor shall submit at least one (1) copy in a pdf, OCR (Optical Character Recognition), format the following close-out information to City of Inglewood's Representative following completion of the Project:
1. Copies of Project Log Book.
2. Any documentation listed in Paragraphs 1.4.B or 1.4.C above not collected by City of Inglewood's Representative during the Project.

1.5 NOTICES

A. Post in the clean room area of the worker decontamination enclosure a list containing the names, addresses, and telephone numbers of Contractor, City of Inglewood's Representative, and emergency medical services.

B. Additional postings shall include:
  1. Visitor Entry and Exit Log.
  2. Employee Daily Sign in Log.
  3. Entry and Exit Procedures.

1.6 SITE SECURITY

A. Access to the work area shall be limited to authorized, trained and properly equipped personnel, including Contractor, Contractor's employees, City of Inglewood employees and representatives, and regulatory agency inspectors.

B. A list of authorized personnel shall be posted at the entrance of the Regulated Area. Entry into the work area by unauthorized individuals shall be reported immediately to City of Inglewood's Representative.

C. A logbook shall be maintained at the entrance of the Regulated Area. All persons entering the Regulated area shall record their name, company affiliation, time in, and time out for each entry and exit.

D. Access to the lead abatement area shall be through a worker decontamination unit attached to the entrance to the area. All other means of access shall be locked or blocked by the erection of plywood or particle board barriers so as to prevent entry to or exit from the work area, except for emergency exits which shall not be locked from the inside but shall be sealed with polyethylene sheeting and tape until needed.

E. Contractor shall be responsible for Project site security during abatement operations in order to protect work efforts and equipment.

1.7 EMERGENCY PLANNING

A. Emergency planning and procedures shall be developed by Contractor prior to abatement initiation.

B. Emergency procedures shall be in written form and prominently posted. Contractor shall ensure that all persons entering the work area read these procedures and understand the Project site layout, location of emergency exits and emergency procedures.

C. Emergency planning shall include considerations of fire, explosion, electrical hazards, slips, trips and falls, confined spaces, and heat related injury. Written procedures shall be developed and employee training in procedures shall be furnished by Contractor.

D. Employees shall be trained in evacuation procedures in the event of work place emergencies.
  1. For minor injuries and illness, employees injured or otherwise incapacitated shall decontaminate following normal procedures with assistance from fellow workers, if necessary, before exiting the work area to obtain proper medical treatment.
  2. For serious injury or illness, worker decontamination shall take least priority. After stabilizing the injured worker, remove him from the work area and seek proper medical treatment.
  3. Telephone numbers of all emergency response personnel shall be prominently posted in the clean and equipment rooms.

1.8 RESTRICTED HOURS OF WORK AND ACCESS

A. Refer to Section 01 1400, WORK RESTRICTIONS.

1.9 FIRE PROTECTION

A. All plastic sheet and structural materials used in the lead abatement process shall be UL approved and certified as fire retardant or noncombustible.

B. All combustible rubbish and debris shall be properly disposed of at the end of each working day.

C. A minimum of (2) 4A/60BC dry-chemical fire extinguishers shall be kept in the work area. They shall be charged and maintained in good working order

D. Contractor shall ensure that on site personnel are aware of the location and proper use of all fire extinguishers and other fire/life safety equipment.

E. Maintain a fire watch for a minimum of (30) minutes after the cessation of work.

F. Maintain fire/life safety information in the project log.

G. A statement shall be prepared at the conclusion of each work day, signed by Contractor, confirming that a survey of the work site has been made and that any unsafe fire/life safety conditions have been rectified.

H. Any work requiring welding, cutting, open torches and other hot work operations and equipment shall comply with California Fire Code 2016.

I. All existing fire detection, alarm systems, connections and standpipes shall remain in place, active and unobstructed. Any alteration to this equipment shall be approved by City of Inglewood's Representative.

J. Existing fire alarm manual pull boxes, fire department communication jacks, and signaling systems shall be maintained in place and active. The foregoing items shall be clearly marked with signs containing

K. lettering which is a minimum of 3" X ½" wide on a contrasting background. If the foregoing items are covered by plastic, each device shall be surrounded by a square of red duct type tape. In addition, a cutting device, also surrounded by red tape, shall be kept immediately adjacent to the device.

L. The lead abatement process shall not cause a building to have an amount of exiting less than that required for the existing occupant load. In all cases where the required exiting must be obstructed, an alternate means of exiting shall be provided as approved by City of Inglewood's Representative. A minimum of (2) clearly marked exits shall be maintained from each floor during the abatement process. The second exit from a containment area may be covered with plastic upon City of Inglewood's Representative's approval. If this occurs, the covered exit shall be outlined with red duct type tape, and a cutting device shall be kept immediately adjacent to the door in an obvious and readily accessible location. The cutting device shall also be surrounded by a square of red tape as described above.

M. The following shall apply in containment areas greater than 1,000 square feet:
   1. Five (5) "Tyvek" brand, spun-bound polypropylene or equal full body disposable protective suits, rated for use in a lead-contaminated environment, shall be furnished for each contained work area. All suits shall be extra-large and shall be kept in a separate, clearly identified,

readily accessible container near the clean exit of the decontamination unit. These suits shall be for the exclusive use of emergency response personnel.

1.10 LICENSING

A. The Work of this section shall be performed by an entity duly licensed in the State of California in accordance with the provisions of Chapter 9 of Division 3 of the Business and Professions Code, as amended.

1.11 TRAINING

A. Lead Related Construction Work shall be performed by personnel with the following training, as applicable:
   1. The Lead Related Construction Work, specified herein, shall be performed by individuals trained and qualified in the techniques of lead-related construction, handling, disposal of lead-based and Lead Containing Paint, and the subsequent cleaning of contaminated areas. These individuals must comply with all Applicable Code Requirements including, but not limited to, CDPH accredited training and certification, and must be capable of and willing to perform the Work of this section.
   2. Training specific to the performance of Lead Related Construction Work shall be provided to employees prior to performing the Work of this section.
   3. Training specific to the operation and use of fire extinguishers.

1.12 EXPOSURE ASSESSMENT

A. Disturbance of Lead Containing Paint, as defined in this Specification, disturbed by tasks not included in Title 8, CCR Section 1532.1, Subsection (d)(2), shall require worker-exposure monitoring upon initiation of the Work. The workers performing these tasks shall be trained in accordance with the Hazard Communications Standard, Section 5194, including but not limited to, the requirements concerning warning signs and labels, Safety Data Sheets (SDS), and employee information and training.

B. Furnish an exposure assessment where the workers are performing Lead Related Construction Work. If historical data, collected within the 12 months prior to the Work performed, indicates worker exposure is below the P.E.L., and the Work being performed closely resembles the process, type of material, control methods, work practices, and environmental conditions, additional exposure assessment is not required.

C. For Lead Related Construction Work where there is objective data or an exposure assessment demonstrating that the Lead Based Paint, or a specific process, operation or activity other than Abatement involving lead cannot result in employee exposure to lead at or above the P.E.L. during the specific process or handling, employees trained as required by Title 8, CCR Section 1532.1, including the training topics of the Lead-Safe Schools Program, may perform the Lead Related Construction Work.

D. Where Work being performed indicates an exposure above maximum allowable levels, each employee is required to have current blood lead level and Zinc Protoporphorin testing, medical clearance for negative pressure respirator use, and respirator fit testing.

E. If there is no objective data or a negative exposure assessment fulfilling the above requirements, all Lead Related Construction Work identified as a trigger task by Title 8, CCR 1532.1 shall be performed by workers who have received training as required by Title 8 CCR, Section 1532.1. This training shall, at a minimum, include the training topics of the Lead Safe Schools Program. An exposure assessment is required to be performed upon initiation of Work.

F. The required exposure assessment shall not exceed 12 months from the date the samples were collected to the date the Lead Related Construction Work or disturbance of Lead Containing Paint is performed.

G. The submission and review by the City of Inglewood's Representative of the objective data or exposure assessment is required prior to performing Lead Related Construction Work.

1.13 QUALITY ASSURANCE

A. The Work of this Section shall be performed by an entity possessing the following minimum qualifications:
   1. A Comprehensive Quality Assurance Plan on file with the California Environmental Protection Agency.
   2. All Project site personnel shall wear personal protective equipment and protective clothing consistent with the levels of protection required for this Work as specified by CCR Title 8 §1532.1 Lead in Construction.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General:
   1. All plastic, spray-on strippable coatings and structural materials used shall be UL certified as fire retardant or non-combustible. SDS for fire retardant materials shall be made available upon request.
   2. Polyethylene sheeting utilized for worker decontamination units and barriers shall be black in color and shall be a minimum of 6 mils thick.
   3. For disposal of lead-contaminated waste, Contractor shall furnish DOT 17H/55-gallon, open-top, steel drums with polyethylene liners and locking ring lids.
   4. Stick-on hazardous waste labels as per EPA or Cal/OSHA
   5. Contractor shall supply and post warning signs as required by Cal/OSHA. Signs shall read:

WARNING
LEAD WORK AREA
POISON
NO SMOKING OR EATING

   6. Detergents (surfactants) used to remove lead contamination shall contain 5-10% tri-sodium phosphate.
   7. Encapsulants, primer, and paints used in this Project shall adhere well to the substrate from which the lead-containing coating has been stripped. Contractor shall not apply new coatings which contain more than 90 parts lead (by weight) per million parts of coating.
   8. Deliver all materials in the original sealed packages, containers, or bundles bearing the name of the manufacturer and brand name.
   9. Store all materials subject to damage off the ground, away from wet or damp surfaces, and under cover sufficient enough to prevent damage or contamination. Replacement materials shall be stored outside of the Abatement Work area until area is cleared for normal occupancy.
   10. Damaged, deteriorating or previously used materials shall not be used and shall be removed from the Project site.

2.2 EQUIPMENT

A. General:
   1. Respirators shall be furnished to the abatement workers by Contractor. The type of respirator to be furnished shall be determined by air sampling and Table I of CCR Title 8, Sec. 1532.1.

The respirators shall have been tested and approved by National Institute of Occupational Safety and Health (NIOSH) for use in lead-contaminated atmospheres.

2. Full body disposable protective clothing, including head, body, and foot coverings shall be furnished to workers and visitors in sizes adequate to accommodate movement without tearing.
3. Additional safety equipment (e.g. hard hats meeting the requirements of ANSI Standard Z89.1- 1981, eye protection meeting the requirements of ANSI Standard Z87.1-1979, safety shoes meeting the requirements of ANSI Standard Z41.1-1967, disposable gloves), as necessary, shall be furnished to all workers and authorized visitors.
4. Non-skid foot wear shall be furnished to all abatement workers. Disposable clothing shall be adequately sealed to the footwear to prevent body contamination
5. Provide NIOSH and Mine Safety and Health Administration (MSHA)-approved disposable respirator cartridges capable of filtering dusts, mists, and radionuclides.

B. Removal:

1. A sufficient supply of scaffolds, ladders, lifts and hand tools (e.g., scrapers, wire cutters, brushes, utility knives, chisels, etc.) shall be furnished as needed.
2. Disposal bags shall be of 6-mil polyethylene, pre-printed with labels as required by applicable Cal/OSHA and DOT requirements.
3. Provide labels as per DOT requirements for disposal containers.
4. Provide warning signs as required by Cal/OSHA.
5. Disposal containers shall meet requirements of Title 22, CCR.
6. Sprayers are required with pumps capable of providing 500 pounds per square inch (PSI) at the nozzle tip at a flow rate of 2 gallons per minute for spraying amended water.
7. Furnish a sufficient supply of detergent and disposable mops, rags, and sponges for work area decontamination.
8. A sufficient supply of HEPA filtered vacuum cleaning systems shall be furnished during cleanup.
9. When an enclosure requiring negative pressure is specified, a sufficient quantity of air-filtration ventilation units furnished with HEPA filtration and operated in accordance with ANSI Z9.2-79 and EPA guidance documents shall be utilized to provide one workplace air change every 15 minutes and creating a pressure differential of -0.02 inches of water everywhere within the enclosure when compared to the area outside the enclosure. A log documenting the filter change history of each unit shall be required before use, and any unit without this log shall have all filters changed and the unit decontaminated.
10. When rental equipment is to be used in Abatement areas or to transport lead contaminated waste, a written notification concerning the intended use of the rental equipment shall be furnished to the rental agency with a copy submitted to the City of Inglewood's Representative.
11. When performing chemical Removal, provide portable eyewash station(s) that meet ANSI standards and are accessible to workers within 10 seconds.
12. All equipment delivered to the Project site shall be free of all debris suspect of containing lead. No equipment with suspect debris in or on it shall be permitted on City of Inglewood properties and/or the Project site.

PART 3 - EXECUTION

3.1 WORK AREA PREPARATION

A. General:

1. Post warning signs meeting the specifications of Cal/OSHA Construction Safety Order Section 1532.1 at any location or approaches to a location where there is lead-related construction work. Signs shall be posted at a distance sufficiently far enough away from a work area to permit a person to read the sign and take necessary protective measures to avoid exposure. Additional signs may need to be posted following construction of work place enclosure barriers.

2. Obtain City of Inglewood's Representative's approval prior to any utility shut-down in accordance with Section 01 1400, WORK RESTRICTIONS.
3. Temporary Electrical Service: Refer to Section 01 5100, TEMPORARY UTILITIES.
    a. Provide and maintain all necessary temporary electrical equipment, connections, etc., as necessary for the Work.
    b. Refer to Section 01 4100, REGULATORY REQUIREMENTS.

4. City of Inglewood will provide sanitary facilities for abatement personnel outside of the enclosed work area and maintain them in a clean and sanitary condition throughout the project.
5. City of Inglewood will furnish water for construction purposes. Contractor shall connect to existing system.

B. Preparation for interior work area removal of lead-based paint, defective paint or related materials:
    1. Contractor shall coordinate the arrest of the heating, ventilation, and air conditioning (HVAC) system with City of Inglewood's Representative prior to isolating vents and other openings into the work area, including windows, doors, open ceilings or holes with at least one layer of 6-mil fire-resistant polyethylene sheeting.
    2. Contractor shall coordinate the arrest of all electricity from the work area prior to supplying temporary power on ground fault circuit interrupters (GFCI) for all electrical equipment in the work area.
    3. Contractor shall pre-clean work area floors using a lead-dedicated HEPA vacuum to remove paint chips, lead-containing dust or debris.
    4. Floors and horizontal surfaces shall be covered with one layer of 6-mil fire-resistant polyethylene sheeting at a minimum.
    5. Contractor shall provide sufficient 12" x 12" viewing ports made of clear Plexiglas to allow persons outside the containment to view all work areas.
    6. The work area shall be contiguous with a decontamination unit in accordance with Paragraph 3.3 herein.
    7. The work area shall be conspicuously demarcated with the following sign:

WARNING
LEAD WORK AREA
POISON
NO SMOKING OR EATING

C. Preparation for exterior work area removal of lead-containing paint, defective paint or related materials:
    1. Contractor shall pre-clean exterior work area a minimum of 10' from the building exterior using a lead-dedicated HEPA vacuum to remove paint chips, lead-containing dust or debris.
    2. Contractor shall isolate vents and other openings no less than 20' from the work area such as windows, doors, open ceilings or holes with at least one layer of 6-mil fire-resistant polyethylene sheeting.
    3. The ground immediately adjacent to the exterior wall shall be covered with at least one layer of 6- mil fire-resistant polyethylene sheeting extending 10' beyond the building perimeter at a minimum.
    4. Contractor shall construct a containment enclosure around the exterior building component to be abated. The frame of this enclosure shall be constructed of steel or wood and shall be sturdy enough to withstand moderate wind. The skin of the enclosure shall be constructed with at least one layer of 6-mil fire-resistant polyethylene sheeting.
    5. The work area shall be contiguous with a decontamination unit in accordance with Paragraph 3.3 herein.
        a. The work area shall be conspicuously demarcated with the following sign:

WARNING
LEAD WORK AREA
POISON

NO SMOKING OR EATING

D. Preparation for removal or demolition of lead-containing paint or related materials:
   1. Prepare and submit proposed EA workplan for each type of demolition and construction activity to be performed. Perform initial EAs and submit results of EAs to the City of Inglewood's Representative prior to performing any lead-related demolition or construction activity as required by Paragraph 1.4 SUBMITTALS.
   2. Provide lead dust control measures, lead waste and debris retention areas, worker protection, and decontamination areas in accordance with this Section, the Contractor's work plan, and lead EA data.
   3. Pre-Project Initial EA:
      a. Prior to performing any lead-related demolition work, perform initial EAs as described in 8 CCR §1532.1.
      b. During pre-project EA utilize Supervisors/Competent Persons who are certified as Lead-Related Construction Supervisors and Lead-Related Construction Workers in accordance with 17 CCR, Division 1, Chapter 8.
   4. Perform initial EAs in accordance with this Section and the Contractor's lead-related demolition work plan.
   5. Perform initial EAs for a minimum of 2 full days (two 8-hour shifts) and include all work practices and trigger tasks that the Contractor expects to encounter during lead-related demolition work.
   6. Collect personal air samples as part of the EAs utilizing third party consulting firm.
   7. If the results of the EA indicate that the Action Level (AL) shall not be exceeded during the work, the following lead-related worker protection, engineering controls, training and certification requirements shall be required. Refer to the appropriate sections of 8 CCR §1532.1 for a complete description of requirements.
      a. Respirator if requested by employee.
      b. Hand washing facilities.
      c. Housekeeping.
      d. An employee's right to access to records under 29 CFR §1910.1020.
      e. The contents and requirements of 29 CFR §1926.62 and 8 CCR §1532.1.
      f. The specific nature of the operation that could result in exposure to lead.
      g. The purpose, proper selection, fitting, use, and limitations of respirators.
      h. Purpose and description of the medical surveillance program and the medical removal protection program, including information concerning the adverse health effects associated with excessive exposure to lead (with particular attention to the adverse reproductive effects on both males and females and hazards to the fetus and additional precautions for employees who are pregnant).
      i. Relevant engineering controls and good work practices.
      j. The contents of any compliance plan in effect.
      k. Instructions that chelating agents should not routinely be used to remove lead from their bodies and should not be used at all except under the direction of a licensed physician.
   8. If the results of the EA indicate that the Action Level (AL) 30 micrograms per cubic meter (30 ug/m3) shall be exceeded but below the Permissible Exposure Limit (PEL) (50 ug/m3) during the work, the following lead-related worker protection, engineering controls, training and certification requirements, in addition to those listed in Paragraph (D)8 above shall be required. Refer to the appropriate sections of 8 CCR §1532.1 for a detailed description of requirements.
      a. Engineering controls and work practices.
      b. Written Compliance Program.
      c. Mechanical Ventilation.
      d. Administrative Controls.
      e. Respiratory Protection.
      f. Regulated Area.

g. Decontamination Facilities.
h. Changing Areas.
i. CDPH certified supervisors/worker.
j. Signs.

9. If the Contractor's means and methods for the EAs change from those presented in the lead-related demolition work plan and during the work, perform another EA to determine lead-related worker protection, engineering controls, training and certification requirements for the lead-related demolition workers.

3.2 ALTERNATIVE PROCEDURES

A. If specified procedures cannot be utilized, a request shall be made in writing to City of Inglewood's Representative providing details of the problem encountered and recommended alternatives.
B. Alternative procedures shall provide equivalent or greater protection than procedures that are replaced.
C. Any alternative procedure shall be approved in writing by City of Inglewood's Representative prior to the implementation of the procedure.

3.3 WORKER DECONTAMINATION UNITS

A. Worker decontamination units shall be provided at all locations where workers will enter or exit the work area. As a minimum, one decontamination unit at a single location is required.
B. Worker decontamination units constructed at the Project site shall utilize 6-mil fire-resistant polyethylene sheeting, or other approved materials for privacy.
C. The worker decontamination units shall consist of at least a clean room, a shower room, and an equipment room, each separated from the other and from the work area by airlocks.
D. The clean room shall be sized to adequately accommodate the work crew. Space for storing respirators shall be provided in this area. Lockers for storing street cloths and other personal items, clean work clothes, clean disposable clothing, replacement filters for respirators, towels and other necessary items shall be provided in adequate supply in the clean room. A location for posting notices shall be provided in the area.
E. The shower room shall contain one or more showers as necessary to adequately accommodate workers. Each shower head shall be supplied with warm and cold water adjustable at the tap. The shower enclosure shall be constructed to ensure against leakage of any kind. An adequate supply of soap, shampoo and towels shall be supplied by Contractor and available at all times. Shower water shall be drained, collected and filtered through a system with at least 0.5-1.0 micron particle size collection capability. Contractor shall not commence lead removal work until a shower is operational on the Project site.
F. The equipment room shall be used for storage of equipment and tools at the end of a shift after they have been decontaminated using a HEPA filtered vacuum or wet cleaning techniques as appropriate. A walk- off pan (a small children's swimming pool or equivalent filled with water shall be located in the room for workers to clean off foot coverings after leaving the work area and prevent excessive contamination of the worker decontamination unit. A drum lined with a labeled 6-mil polyethylene bag for collection of disposable clothing shall be located in this room. Contaminated footwear may be stored in this area for reuse the following workday.
G. Maintenance of Work Place Barriers and Worker Decontamination Enclosure Systems:
1. After the construction of the containment and decontamination units are complete, allow sufficient settling time to insure that construction barriers will remain intact and secured to walls and fixtures before actual abatement activities.
2. Inspect the containment and worker decontamination units at least twice daily, prior to the start of each day's abatement activities. Contractor shall document inspections and observations in the daily project log.

3. Damage and defects in the containment shall be repaired immediately upon discovery.
4. Use smoke tubes to test the integrity of the containment at least once for each 24 hour period or when requested by City of Inglewood's Representative.
5. At any time during the abatement activities after barriers have been erected, if visible lead-containing debris is observed outside of the containment or if damage occurs to barriers, work shall immediately stop, repairs shall be made to barriers, and the debris or residue shall be cleaned up by HEPA vacuuming and wet mopping.
6. If air samples collected outside of the work area during abatement activities indicate airborne lead dust concentrations greater than 30 micrograms per cubic meter or pre-measured background levels (whichever is greater), work shall immediately stop for inspection and repair of barriers. Cleaning of surfaces outside of the work area using HEPA vacuums or detergent solution may be required.
7. If wipe or soil samples collected outside of the work area by City of Inglewood's Representative during abatement activities indicate lead contamination greater than those listed below, or previously measured background levels (whichever is greater), work shall immediately stop for inspection and repair of barriers. Contractor shall clean lead-contaminated surfaces outside of the work area using HEPA vacuums, detergent solution or removal as required by City of Inglewood's Representative.
    a. 40 micrograms per square foot (µg/ft2) for interior floor surfaces
    b. 250 µg/ft2 for interior (non-floor) horizontal surfaces
    c. 400 µg/ft2 for exterior horizontal surfaces
    d. 1,000 parts per million (ppm) for soil

8. Install and initiate operation of differential pressure air filtration equipment as needed to provide one air change in the work area at least every 15 minutes. Openings made in the enclosure system to accommodate these units shall be made airtight. Insure that an adequate power supply is available to satisfy the requirements of the filtration devices. Differential pressure air filtration devices shall be exhausted to the outside of the building. Careful installation, air monitoring and daily inspections shall be conducted to ensure that lead contamination does not migrate from the negative pressure enclosure.

3.4 WASTE CONTAINER REMOVAL AIRLOCK

A. The waste container pass-out airlock shall be constructed away from the Decontamination Enclosure System. This airlock shall be in a location that provides direct access from Abatement Work area to the outside of the building if possible.
B. This system shall consist of an airlock, container Staging Area, and another airlock providing access to outside Abatement Work area.
C. The waste container airlock shall be constructed in similar fashion with similar materials as the Decontamination Enclosure System.
D. This airlock system shall not be used to enter or exit the Abatement Work area.

3.5 EMERGENCY EXIT

A. Emergency exits shall be established and clearly marked with duct tape arrows or other effective ways to permit easy location from anywhere within the work area. If duct tape arrows are utilized, the arrows shall be a different color from the tape used to secure the polyethylene sheeting. Red or yellow duct tape is preferred to mark emergency exits.
B. Emergency exits shall be secured to prevent access from uncontaminated areas and still permit emergency exiting. These exits shall be properly sealed with polyethylene sheeting which can be cut to permit exiting, if needed. A utility knife shall be taped close to the bottom of the exit for use in cutting the polyethylene sheeting in case of emergency.

3.6 WORKPLACE ENTRY AND EXIT PROCEDURES

A. Personnel Entry and Exit:
   1. All workers and authorized personnel shall enter the work area through the worker decontamination unit.
   2. Contractor shall ensure that all personnel who enter the work area sign the entry/exit log.
   3. Contractor shall ensure that all personnel, before entering the work area, read and are familiar with all posted regulations, personal protection requirements (including work place entry and exit procedures) and emergency procedures.
   4. All personnel shall proceed first to the clean room, remove all street clothes and don respirators, disposable coveralls, hard hats, and work boots. Face shields and gloves shall also be utilized. Clean respirators and protective clothing shall be furnished and utilized by each person for each separate entry into the work area.
   5. Personnel wearing designated personal protective equipment shall proceed from the clean room through the shower room and equipment room to the lead removal work area.
   6. Before leaving the work area, all personnel shall remove gross contamination from the outside of respirators and protective clothing by brushing or wet wiping (small HEPA vacuums with brush attachments may be utilized for this purpose). Each person shall clean bottom of protective footwear in the walk off pan prior to entering the equipment room.
   7. Personnel shall proceed to the equipment room to remove all protective equipment except respirators. Upon completion of abatement, all protective equipment shall be properly cleaned for reuse or disposed of as lead-contaminated waste.
   8. Reusable, contaminated footwear shall be stored in equipment room when not in use in the work area. Upon completion of abatement, it shall be properly cleaned for reuse or disposed of as asbestos contaminated waste.
   9. Still wearing respirators, personnel shall proceed to the shower area, clean the outside of the respirators and the exposed face area under running water prior to removal of respirator then shower and shampoo to remove residual lead contamination. Various types of respirators will require slight modification of these procedures. An airline respirator with a HEPA filtered disconnect protection may be disconnected in the equipment room and worn into the shower. A powered air purifying respirator face piece will have to be disconnected from the filter/power pack assembly, which is not waterproof, upon entering the shower. A dual cartridge respirator may be worn into the shower.
   10. After showering and drying off, personnel shall proceed to the clean room and don clean disposable clothing if there will be later reentry into the work area or street clothes if it is the end of the work shift.

3.7 REMOVAL PROCEDURES

A. Wet all lead-containing coatings and dust with an amended water solution. The wetting agent will be mixed according to manufacturer's printed instructions and then applied using equipment capable of providing a fine spray mist, in order to reduce airborne dust concentrations when the material is disturbed during removal. Keep the lead-containing material wet; however, do not allow excessive water to accumulate. Maintain high humidity in the work area by misting or spraying to assist in lead-dust settling and reduce airborne concentrations.

B. Lead-containing paint chips and debris shall be continually containerized as they are removed. Surrounding areas shall be maintained in a wet condition until all lead contamination has been cleaned up.

C. Lids shall be replaced on disposal drums when they are full. Drums shall be securely closed to prevent accidental opening and leakage by tightening the bolts on the ring lids. After packaging, drums shall be decontaminated by cleaning the exterior surfaces with detergent.

D. Generator name and address labels shall be affixed to waste containers prior to disposal.

E. After removal of all visible lead-containing coating, all surfaces inside the containment shall be scrubbed with tri-sodium phosphate solution, wiped down, and rinsed to remove all residue.

F. After the work area has been rendered free of visible residue, and after the wall has had time to dry, Contractor shall apply a thin coat of a satisfactory encapsulating agent (primer).

3.8 CLEAN-UP PROCEDURES

A. Remove and containerize all visible accumulations of lead-containing debris utilizing HEPA vacuums, dust pans, sponges, and disposable rags. Special care shall be taken to minimize damage to floor sheeting.

B. Use tri-sodium phosphate solution to clean all surfaces in the work area using rags, mops and sponges as appropriate.

C. Remove the cleaned secondary layer of plastic sheeting from the walls and ground. The differential pressure air filtration devices shall remain in continuous operation. Decontamination enclosure systems shall remain in place and be utilized.

D. After cleaning the work area, provide a period of time no less than (60) minutes to allow dust to settle. HEPA vacuum and wet clean all objects and surfaces in the work area again.

E. Remove all containerized waste from the work area and waste container pass-out airlock.

F. Decontaminate all tools and equipment and remove at the appropriate time in the cleaning sequence.

G. City of Inglewood's Representative will inspect the work area for visible residues. If any accumulation of residue is observed, it will be assumed to be lead and a second settling period and cleaning cycle will be repeated at no additional cost to City of Inglewood.

H. The work area shall be cleaned until it passes visual inspection and City of Inglewood's Representative finds that there is no more than 800 micrograms of lead per square foot on any surface inside the work area. Additional cleaning cycles shall be provided, as necessary, at no cost to City of Inglewood until these criteria have been met.

I. As soon as wipe sampling results indicate a clean work area, the remaining barriers may be removed and prepared for proper disposal. A final visual inspection by City of Inglewood's Representative will be performed. Unsatisfactory conditions may require additional cleaning and wipe sampling at no additional cost to City of Inglewood.

3.9 AIR AND WIPE SAMPLING

A. Background air and wipe sampling: Upon request of the Contractor, City of Inglewood's Representative will conduct pre-abatement air monitoring and wipe sampling to determine ambient lead levels prior to abatement.

B. In-Progress Environmental Air Monitoring: City of Inglewood's Representative may collect air samples at any time and location in or adjacent to the Project area to determine the concentration of airborne lead or other pollutants.

C. Personal Air Monitoring:
   1. At minimum, Contractor shall conduct representative (10% of crew) personal breathing zone air monitoring of its employees twice each shift and repeated daily.
   2. Contractor shall collect the air samples on 37-millimeter cellulose ester membrane filters in closed- face cassettes. Samples shall be analyzed by an accredited laboratory using NIOSH Method 7082 or 7105.
   3. Copies of daily personal air sample logs and results of laboratory analysis for airborne lead dust shall be submitted to City of Inglewood's Representative within (48) hours of the monitoring work.

D. Clearance Wipe Sampling:
   1. Following the completion of clean-up operations, notify City of Inglewood's Representative that work area is ready for clearance wipe sampling.

2. City of Inglewood's Representative will then collect wipe and/or soil samples in accordance with HUD guidelines.
3. All samples at all location shall indicate concentrations of the following, or less for the release of the work area:
   a. 40 micrograms per square foot (μg/ft2) for interior floor surfaces
   b. 250 μg/ft2 for interior (non-floor) horizontal surfaces
   c. 400 μg/ft2 for exterior horizontal surfaces
   d. 1,000 parts per million (ppm) for soil

4. Areas exceeding this level shall be re-cleaned using procedures specified in Part 3 above, and retested at no additional cost to City of Inglewood until satisfactory levels are obtained.

3.10 STOP WORK ORDER

A. City of Inglewood's Representative shall have the right to issue a Stop Work Order whenever Contractor's work, engineering controls, or air monitoring results are not in accordance with published regulations, contractual restrictions, or the abatement specifications. All costs resulting from the Stop Work Order shall be at Contractor's expense. Refer to General Conditions Article 2.3.1.
B. The Stop Work Order shall first be given verbally to Contractor by City of Inglewood's Representative, at which point all work shall cease. This shall be immediately followed by a written notification to stop work. If the situation is not corrected to City of Inglewood's or City of Inglewood's Representative's satisfaction within (48) hours, Contractor shall be considered to be in breach of the Contract and will be subject to termination in accordance with General Conditions Article 13.2.

3.11 TESTING AND TRANSPORT

A. Collect one composite sample from each media type (solid, liquid, or sludge) of potentially hazardous substance stored in drums, stockpiled, or otherwise identified at the Project site for the purposes of obtaining approvals for proper transport and disposal of the suspect materials. Submit all analytical results to the City of Inglewood's Representative.
B. If required, over-pack any leaking or deteriorated drums to prevent leaks or spills, and pack small 5-gallon containers into larger new 55-gallon drums. Cover all solid waste materials and stockpiled soils with an HDPE liner to prevent stormwater runoff from contaminating surrounding areas.
C. Prepare manifests, material profiles, and submit lab analysis for all drums/containers and any other documentation required by the receiving facility for signature by the City of Inglewood's Representative.
D. Coordinate waste sampling and analysis requirements with the disposal facility and properly complete all profiling and transport documents prior to loading and transport.
E. A State registered "Hazardous Waste Hauler" shall transport the waste to a lawfully permitted and City of Inglewood approved facility.
F. Prior to transport, a copy of the hazardous waste manifest shall be delivered or emailed to the address listed below. The manifests shall list the generator's name and address, site address, Generator's EPA ID number, to include the waste profile number. Attach the land disposal restriction (LDR) form to the manifest prior to submission to the EH&S. All other copies of the manifest and LDR shall be submitted to the waste transporter. Generator Address for all waste manifests:

   City of Inglewood - Division of Environmental Services

   1 Manchester Boulevard, Inglewood, CA 90301

G. Load, handle, and transport all 55-gallon drums and other waste containers to the appropriate disposal facility in accordance with Applicable Code Requirements.

H. All transport documentation from the receiving facility verifying acceptance and receipt of drums/containers at the facility and all sampling and associated test results shall be submitted to the City of Inglewood's Representative, within fifteen (15) days following receipt of all hazardous substances to the disposal facility.

I. All materials identified as hazardous wastes under the EPA's Resource Conservation and Recovery Act (RCRA) are not permitted to remain at the Project site more than 30 days after being deemed to be a hazardous waste. During this period of Project site storage, provide all precautions to contain and prevent the release of hazardous or potentially hazardous materials to the environment.

3.12 DISPOSAL PROCEDURES

A. As work progresses, to prevent exceeding available storage capacity on site, sealed and labeled containers of lead-containing waste shall be removed and transported to an approved disposal location.

B. All hazardous materials and contaminated soils must be transported by a California licensed and insured company.

C. Disposal shall occur at an approved facility in accordance with regulatory requirements of NESHAP and applicable code requirements, including the California State Department of Public Health, Toxic Substances Control Division.

D. Disposal Facilities

1. All lead-containing waste shall be disposed of at the following approved facility:

US Ecology, Inc.
P.O. Box 578
Beatty, NV 89003
Highway 95 – 12 Miles South of Beatty, Nevada
(800) 239-3943

Clean Harbors
2500 West Lokern Road
Buttonwillow, CA 93206
(661) 762-6200

2. All lead-containing waste contaminated with caustic paint stripper shall be packaged separately from non-contaminated waste. Unless waste analysis performed by a certified laboratory shows the waste to be within Land Disposal Restriction (LDR) limits, the required disposal method is incineration. Presently the only approved facility is:

Crosby & Overton
1630 West 17th Street
Long Beach, CA 90813
(562) 432-5445

Clean Harbors
2500 West Lokern Road
Buttonwillow, CA 93206
(661) 762-6200

3. Other facilities may be used only if prior written approval is obtained from City of Inglewood Division of Environment Services.

E. All lead waste shall be shipped using the following information on shipping papers and manifests: RQ Hazardous Waste Solid, NOS (Lead, 9, NA3077, PG III, NAERG# 171).

F. All water generated by the decontamination of either equipment, waste containers or persons shall be collected, filtered and disposed of properly.

G. Lead Contaminated Soils:

1. Soils shown to contain contaminants that exceed federal or CA hazardous waste criteria are to be transported using a Uniform Hazardous Waste Manifest (UHWM) to an EH&S approved waste disposal facility.
2. Receiving facility shall furnish a weight certificate.
3. Contaminated soils that do not meet hazardous waste criteria may be eligible for landfill disposal. These soils may be removed to a solid waste landfill after filing an appropriate application and receiving approval from the landfill operator. A copy of the approval letter will be furnished to EH&S prior to any export of soil or fill material. These soils are to be shipped under a Bill of Lading and may be signed by either the City of Inglewood Representative or by an EH&S representative

H. All Waste Certification Forms attesting to the content of the generated waste shall be signed and completed by the Contractor.

I. All dump receipts, trip tickets, transportation manifests or other documentation of disposal shall be delivered to City of Inglewood Division of Environment Services. Record keeping format shall utilize a chain of custody form which includes the names and addresses of the Generator (City of Inglewood), Contractor, pick-up site, disposal site, estimated quantity of lead-containing waste disposed and the type of container utilized. This form shall be signed by the Generator's Representative, Transporter and the Disposal Site Operator as the responsibility of the material changes hands. Secondary Transporters are not allowed unless approved in writing by City of Inglewood Division of Environment Services.

J. All waste manifests shall require a minimum of 24-hour advance notice as a request prior to waste removal from the City of Inglewood to the following Division:

City of Inglewood - Division of Environmental Services

1 Manchester Boulevard, Inglewood, CA 90301

K. All waste transportation vehicles or containers shall be prepared as follows:
1. Following removal from the project site, all lead-containing waste shall be immediately loaded into an enclosed truck, bin or dumpster for transportation.
2. Any debris or residue observed on waste containers or surfaces outside the work area resulting from clean-up or waste disposal activities shall be immediately cleaned up using HEPA vacuums and/or wet methods as appropriate.
3. The enclosed cargo area of the truck, bin or dumpster shall be free of debris and lined with at least
4. (1) layer of 6 mil. fire-resistant polyethylene sheeting to prevent contamination from leaking containers.
5. The enclosed cargo area of the truck, bin or dumpster shall have doors or tops that can be closed and locked to prevent vandalism or other disturbance of the packaged lead-containing waste and wind dispersion of lead dust. The door or top shall be secured and locked at all times with the exception of loading and unloading of lead-containing waste.
6. Lead-containing waste shall be transported from the project site to the truck, bin or dumpster using appropriate drum dollies or covered debris carts.
7. Lead-containing waste containers shall not contain loose, un-bagged material nor shall they contain non-lead waste.
8. Bags shall be placed, not thrown into the waste containers to prevent splitting and the release of lead dust.
9. Drums or large structural components shall be placed on level surfaces in the cargo area and packed together to prevent shifting or tipping.

3.13 REESTABLISHMENT OF THE WORK AREAS AND SYSTEMS

A. Reestablishment of the work area shall only occur following the completion of clean-up procedures and after clearance wipe sampling has been performed and documented to the satisfaction of City of Inglewood's Representative.

B. Polyethylene barriers shall be removed from walls, ceilings, and ground, maintaining decontamination units and barriers over doors, window, etc. as required.

C. Contractor and City of Inglewood's Representative shall visually inspect the work area for any remaining visible residues. Evidence of contamination will necessitate additional cleaning and air sampling at no additional cost to City of Inglewood, until approved by City of Inglewood's Representative.

D. Following satisfactory clearance of the work area, remaining polyethylene barriers may be removed and disposed of as construction waste.

E. Repair all damage that occurred as a result of abatement activities at no additional cost to City of Inglewood.

END OF SECTION

SECTION 028700

MISCELLANEOUS HAZARDOUS MATERIALS ABATEMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. Remove and properly dispose of any hazardous and/or universal waste from Project site as herein specified. Contractor is responsible for verifying actual quantities. Contractor shall provide all labor, materials, services, insurance (specifically covering the handling and transportation of hazardous material), and equipment which is specified, shown or reasonably implied for the following hazardous materials abatement activities:

1.	Fluorescent Light Fixtures Ballasts	736 Each
2.	Fluorescent Light Tubes	1,472 Each
3.	Thermostats, Fire Extinguishers, Smoke Alarms/Detectors, Exit Signs, Carbon Monoxide Detectors	330 Each

B. All solid and liquid hazardous waste including but not limited to:

1.	Fire Extinguishers	56 Each

C. General:
1. The work specified herein covers the preparation of the Project site, removal and encapsulation of building structures and components and the removal of materials that have been determined to contain or to be contaminated by hazardous materials and/or universal waste.
2. The work shall be supervised by experienced persons trained, knowledgeable and qualified in the techniques of hazardous materials abatement, handling and disposal of hazardous, and hazardous contaminated materials and the subsequent cleaning of contaminated areas.
3. Damages caused during the performance of abatement activities shall be repaired by Contractor (e.g. paint peeled off by barrier tape, nail holes, water damage, broken glass) at no additional expense to City of Inglewood. Contractor is responsible for restoring the work area and auxiliary areas, used in the abatement work, to conditions equal or better than original.

1.2 DEFINITIONS

A. The following definitions and acronyms are used throughout the specifications and drawings in reference to Hazardous Material Removal:
1. Abatement: Any set of measures designed to reduce or eliminate lead hazards or Lead Based Paint for public and residential buildings, but does not include containment or cleaning.
2. Amended Water: Water to which a surfactant (wetting agent) has been added.
3. Clean Room: An uncontaminated area or room which is a part of the worker Decontamination Enclosure System with provisions for storage of worker's street clothes and clean protective equipment.
4. Curtained Doorway: A device to allow ingress and egress from one room to another while permitting minimal air movement between the rooms, typically constructed by placing two overlapping sheets of plastic over an existing or temporarily framed doorway, securing each along the top of the doorway, securing the vertical edge of one sheet along one vertical side of the doorway and securing the vertical edge of the other sheet along the opposite vertical side of the doorway. Other effective designs may be submitted for review.

5. Decontamination: The process of eliminating lead contamination from building surfaces, and property by cloths, mops, or other utensils dampened with water and disposed of as lead contaminated waste.
6. Decontamination Enclosure System: A minimum a two-stage Decontamination unit consisting of a compartment for Decontamination, and a Clean Room. Unless otherwise specified, it shall be adjacent to the Abatement area.
7. Demolition: The wrecking or taking out of any load supporting structural member of a facility together with any related handling operations.
8. CDPH: California Department of Public Health.
9. DOSH: California Division of Occupational Safety & Health or Cal/OSHA.
10. DOT: Department of Transportation
11. DTSC: California Department of Toxic Substances Control
12. Encapsulating Material: Are coatings or rigid materials adhesively applied to surfaces in the Encapsulation process.
13. Encapsulation: The application of an Encapsulating Material to provide a barrier between the surface and the environment.
14. Enclosure: The construction or application of an airtight, impermeable, permanent barrier around hazardous material to control the release of hazardous substances into the air.
15. HEPA Filter: Means a filtering system capable of trapping and retaining at least 99.97% of all mono-dispersed particles 0.3 micrometers in diameter or larger.
16. NESHAP: The National Emission Standards for Hazardous Air Pollutants (40 CFR Part 50.12)
17. NIOSH: The National Institute for Occupational Safety and Health
18. PAH: Polycyclic Aromatic Hydrocarbon
19. PCB: Polychlorinated Biphenyl
20. PEL: Means permissible exposure limits as defined in Title 8, California Code of Regulations, Section 5144, Respiratory Protection.
21. RCRA: US EPA's Resource Conservation and Recovery Act.
22. SCAQMD: South Coast Air Quality Management District.
23. Shower Room: A room between the Clean Room and the Equipment Room in the worker Decontamination Enclosure System furnished with hot and cold running water controllable at the tap, and suitably arranged for complete showering during Decontamination.
24. Staging Area: Areas near the Waste Transfer Airlock where containerized hazardous waste is temporarily placed prior to permanent removal from the Work area.
25. Surfactant: A chemical wetting agent added to water.
26. TPH: Total Petroleum Hydrocarbon
27. TSCA: Toxic Substance Control Act
28. TSDF: Treatment Storage Disposal Facility
29. USEPA or EPA: United States Environmental Protection Agency
30. VOC: Volatile Organic Compounds
31. Waste Transfer Airlock: A Decontamination system provided for transferring containerized waste from inside to outside of the Work area.

1.3 PROCEDURES

A. Contractor shall perform all Work in compliance with all Applicable Code Requirements and any other trade work done in conjunction with the abatement.

B. The most recent edition of any relevant regulation, standard, document or code shall be in effect.

C. In addition to the codes and regulations specified in Section 01 4100, REGULATORY REQUIREMENTS Contractor shall comply, without limitation, with the following:
   1. Code of Federal Regulations (CFR).
      a. 29 CFR §1910.134 Respiratory Protection
      b. 29 CFR §1910.145 Specifications for Accident Prevention Signs and Tags
      c. 40 CFR §61 Subpart A General Provisions

d. 40 CFR §61 Subpart M National Emissions Standard for Hazardous Air Pollutants (NESHAP)
e. 49 CFR §171 through 180 U.S. Department of Transportation

2. California Code of Regulations (CCR).
   a. Title 8 §1536 Ventilation Requirements for Welding, Brazing, and Cutting
   b. Title 8 §1537 Welding, Cutting, and Heating of Coated Metals
   c. Title 8 §3203 Injury and Illness Prevention Program
   d. Title 8 §5144 Respiratory Protection
   e. Title 8 §5155 Airborne Contaminants
   f. Title 8 §5192 Hazardous Waste Operations and Emergency Response
   g. Title 8 §5194 Hazard Communication
   h. Title 22 Hazardous Waste Handling
   i. Title 22 Chapter 42 Requirements for Management of Fluorescent Light Ballasts which Contain Polychlorinated Biphenyls (PCBs)
   j. Title 24 Part 9 Chapter 26 California Fire Code 2016

3. American National Standards Institute (ANSI) Publications.
   a. Z9.2-79 Fundamentals Governing the Design and Operation of Local Exhaust Systems
   b. Z88.2-80 Practice for Respiratory Protection

4. Underwriters Laboratories, Inc. (UL) Publication.
   a. 586-85 High Efficiency, Particulate, Air (HEPA) Filter Units

5. South Coast Air Quality Management District (SCAQMD).
   a. Rule 1166 Volatile Organic Compound (VOC) Emissions from Decontamination of Soil
   b. Rule 1403 Asbestos Emissions from Demolition/Renovation Activities
   c. Rule 1415 Reduction of Refrigerant Emissions from Stationary Refrigeration and Air Conditioning Systems

6. Any guidelines established by City of Inglewood Environmental Services.

D. Transportation:
1. Regulations pertaining to the transport and disposal of hazardous substances/materials include, but are not limited to, the following:
   a. Department of Transportation 49 CFR 171 through 180.
   b. Department of Transportation 49 CFR 387 (46 FR 30974, 47073).
   c. Department of Transportation DOT-E 8876.
   d. Environmental Protection Agency 40 CFR 136 (41 FR 52779).
   e. Environmental Protection Agency 40 CFR 261, 262 and 761.
   f. Resource Conservation and Recovery Act (RCRA).
   g. California Vehicle Code, CHP Regulations (Cal. Code Regs., tit. 13).
   h. California State Fire Marshal Regulations (Cal. Code Regs., tit. 19).

2. Any transporter of hazardous substances shall be licensed in the state in which handling and transportation will take place.
3. Comply with OSHA (Occupational Safety and Health Administration) Standards and Regulations contained in Title 29 Code of Federal Regulations, Part 1910.120 "Hazardous Waste Operations and Emergency Response."
4. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.4 SUBMITTALS

A. Refer to Section 01 3323, SHOP DRAWINGS, PRODUCT DATA & SAMPLES, for procedures.

B. Contractor shall submit to City of Inglewood's Representative at least one (1) copy in a pdf, OCR (Optical Character Recognition), format the following documentation prior to the start of work:
   1. Written notification to the following regulatory agencies:
      a. California Division of Occupational Safety and Health (DOSH)
      b. South Coast Air Quality Management District (SCAQMD)

   2. SCAQMD Notification for excavation of known or suspected VOC storage and/or transfer equipment (includes diesel and waste oil tanks); or handling known or suspected VOC contaminated soil. Each project type requires a valid SCAQMD Mitigation Plan.
   3. SCAQMD Permits for all HEPA vacuums and negative air machines brought to or used on the Project site.
   4. Documentation that Contractor's employees, including foreman, supervisor and any other company personnel or agents who may be exposed to hazardous waste or who may be responsible for any aspects of abatement activities have received training as per 29 CFR 1910.120 (HAZWOPER) training. All training certificates shall be current within one year.
   5. Documentation of respirator fit-testing for all Contractor employees and agents who must enter the work area. All respirator fit-testing certificates shall be current within one year.
   6. Documentation that Contractor's employees, including foreman, supervisor and any other company personnel or agents who may be exposed have successfully passed a medical examination and are medically qualified to wear respiratory protection. All medical exam documentation shall be current within one year.
   7. Safety Data Sheets (SDS) for neutralizers, solvents, encapsulants, wetting agents and replacement materials, as necessary.
   8. An emergency preparedness plan as specified in Paragraph 1.7 herein.

C. Contractor shall submit the following information to City of Inglewood's Representative at least one (1) copy in a pdf, OCR (Optical Character Recognition), format the following documentation on a daily basis or whenever requested during progression of the work:
   1. Copies of daily Project site entry logbooks with information on worker and visitor access.
   2. Logs documenting filter changes on respirators, HEPA vacuums, differential pressure air filtration devices, and other engineering controls.
   3. Copies of all original laboratory analytical reports for Contractor employee's personal air sampling exposure data.

      City of Inglewood - Division of Environmental Services

      1 Manchester Boulevard, Inglewood, CA 90301

   4. Copies of all transport manifests, trip tickets and disposal receipts for all hazardous materials removed from the work area within 24 hours of the transport. Send to:

      City of Inglewood - Division of Environmental Services

      1 Manchester Boulevard, Inglewood, CA 90301

D. Contractor shall submit at least one (1) copy in a pdf, OCR (Optical Character Recognition), format the following close-out information to City of Inglewood's Representative following completion of the Project:
   1. Copies of Project Log Book including Worker submittals, Project daily logs, air sample reports and manifests.

1.5 NOTICES

A. Post in the clean room area of the worker decontamination enclosure the following:
   1. Copies of written notification to the regulatory agencies listed in Paragraph 1.4 herein.
   2. Employee Daily Sign-in Log.
   3. Visitor Entry and Exit Log.
   4. Emergency telephone numbers for Contractor and City of Inglewood's Representative including Construction Project Manager, EH&S representative and Environmental Consultant.

1.6 SITE SECURITY

A. The work area shall be restricted only to authorized, trained and protected personnel, including Contractor, Contractor's employees, City of Inglewood employees and representatives, State and Local inspectors.

B. Entry into the work area by unauthorized individuals shall be reported immediately to City of Inglewood's Representative.

C. Access to the work area shall be through a worker decontamination system located at the designated entrance to the area. All other means of access shall be locked or blocked by the erection of plywood or particle board barriers so as to prevent entry to or exit from the work area, except for emergency exits which shall not be locked from the inside but shall be sealed with polyethylene sheeting and tape until needed.

D. Contractor shall be responsible for Project site security during abatement operations in order to protect work efforts and equipment.

1.7 EMERGENCY PLANNING

A. Emergency planning and procedures shall be developed by Contractor prior to abatement initiation.

B. Emergency procedures shall be in written form and prominently posted. Contractor shall ensure that all persons entering the work area read these procedures and understand the Project site layout, location of emergency exits and emergency procedures.

C. Emergency planning shall include considerations of fire, explosion, electrical hazards, slips, trips and falls, confined spaces, and heat related injury. Written procedures shall be developed and employee training in procedures shall be provided by Contractor.

D. Employees shall be trained in evacuation procedures in the event of work place emergencies.
   1. For non-life-threatening situations, employees injured or otherwise incapacitated shall decontaminate following normal procedures with assistance from fellow workers, if necessary, before exiting the work place to obtain proper medical treatment.
   2. For life-threatening injury or illness, worker decontamination shall take least priority. After measures to stabilize the injured worker, remove him from the work place and secure proper medical treatment.
   3. Telephone numbers of all emergency response personnel shall be prominently posted in the clean and equipment rooms.

1.8 RESTRICTED HOURS OF WORK AND ACCESS

A. Refer to Section 01 1400, WORK RESTRICTIONS.

1.9 FIRE PROTECTION

A. All plastic, spray-on strippable coatings and structural materials used in the hazardous materials abatement process shall be UL approved and certified as fire retardant or noncombustible.

B. All combustible rubbish and debris, including properly bagged hazardous materials shall be properly disposed of at the end of each working day.

C. A minimum of one (1) 4A/60BC dry-chemical extinguisher shall be maintained at each of the following locations:
   1. At each corner of the work area. Where no clear corners exist, four (4) extinguishers shall be placed around the exterior wall of the work area so that they are approximately 25 percent of the total distance apart.
      a. Exception: Where the total abatement containment area is less than 1,000 square feet, two (2) 4A/60BC extinguishers shall be provided. All extinguishers shall be clearly identified with red tape.

   2. Contractor shall ensure that on site personnel are aware of the location and proper use of all extinguishers and other fire/life safety equipment.

D. Maintain a fire watch for a minimum of thirty (30) minutes after the cessation of work.

E. Maintain fire/life safety information in the project log.

F. A statement shall be prepared at the conclusion of each work day, signed by Contractor, confirming that a survey of the work site has been made and that any unsafe fire/life safety conditions have been rectified.

G. In the absence of a functioning automatic fire detection system connecting the building's central alarm system in the area undergoing abatement or respray, a fire watch shall be maintained on a 24-hour basis until:
   1. The final clean air certificate is issued.
   2. All respray is completed in buildings where fire protective coatings have been removed.

H. Any work requiring welding, cutting, open torches and other hot work operations and equipment shall comply with California Fire Code 2016.

I. All existing fire detection, alarm systems, connections and standpipes shall remain in place, active and unobstructed. Any alteration to this equipment shall be approved by City of Inglewood's Representative.

J. Existing fire alarm manual pull boxes, fire department communication jacks, and signaling systems shall be maintained in place and active. The foregoing items shall be clearly marked with signs containing lettering which is a minimum of 3" X 1/2" wide on a contrasting background. If the foregoing items are covered by plastic, each device shall be surrounded by a square of red duct type tape. In addition, a cutting device, also surrounded by red tape, shall be kept immediately adjacent to the device.

K. All existing sprinkler systems shall remain active. Sprinkler heads may be covered with a thin, .003" or less, plastic bag during abatement only so as to avoid their contamination.

L. Fire rated partitions, doors, and other fire cutoffs shall not be temporarily or permanently modified without the approval of City of Inglewood's Representative.

M. A single switch or set of switches shall be provided for the emergency shutdown of all negative air equipment located in the containment area. This switch or set of switches shall be for emergency use by the fire department personnel. The switches shall be located in a non-contaminated area near the clean exit of the decontamination station, and shall be clearly identified using a sign with minimum 3" X 1/2" lettering on a contrasting background. The sign shall read as follows: "NEGATIVE AIR MASTER SHUT OFF."

N. The hazardous materials abatement process shall not cause a building to have an amount of exiting less than that required for the existing occupant load. In all cases where the required exiting must be obstructed, an alternate means of exiting shall be provided as approved by City of Inglewood's Representative. A minimum of two (2) clearly marked exits shall be maintained from each floor during the abatement process. The second exit from a containment area may be covered with plastic upon City of Inglewood's Representative's approval. If this occurs, the covered exit shall be outlined with red duct type tape, and a cutting device shall be kept immediately adjacent to the door in an obvious and readily accessible location. The cutting device shall also be surrounded by a square of red tape as described above.

O. The following shall apply in containment areas greater than 1,000 square feet:
   1. Five (5) "tyvek" type protective entry suits, rated for use in a hazardous materials containment area, shall be provided for each containment site. All suits shall be extra-large and shall be kept in a separate, clearly identified, readily accessible container near the clean exit from the decontamination area. These suits shall be for the exclusive use of emergency personnel.

1.10 QUALITY ASSURANCE

A. The Work of this Section shall be performed by an entity possessing the following minimum qualifications:
   1. Hazardous Waste Operations and Emergency Response training and specific health and safety plan for General Site Workers and Workers engaged in Hazardous Substance removal activities as required, that is applicable to OSHA 29 CFR 1910.120..
   2. A Comprehensive Quality Assurance Plan on file with the California Environmental Protection Agency.
   3. All Project site personnel shall wear personal protective equipment and protective clothing consistent with the levels of protection required for this Work as specified by OSHA (29 CFR Part 1910.120).

PART 2 - PRODUCTS

2.1 MATERIALS

A. General:
   1. All plastic, spray-on strippable coatings and structural materials used shall be UL certified as fire retardant or non-combustible. Safety Data Sheets (SDS) for fire retardant materials shall be made available upon request.
   2. Wood shall be pressure impregnable and certified as fire retardant.
   3. Polyethylene sheeting utilized for worker decontamination and barriers shall be white in color and shall be a minimum of 6 mils thick.
   4. Disposal bags shall be of clear 6-mil polyethylene, pre-printed with labels as required by Environmental Protection Agency (EPA) regulation 40 CFR 61.152 (b) (i) (iv) or applicable Cal/OSHA requirements.
   5. Utilize "UN1A2" or 17C or 17H lockable "ring top" 55-gallon steel drums for solid (PCB Ballast) waste transport, storage, or disposal.
   6. Stick-on labels as per EPA or Cal/OSHA
   7. Warning signs as required by Cal/OSHA shall be utilized.
   8. All replacement materials shall be delivered in the original packages, containers, or bundles bearing the name of the manufacturer and brand name.
   9. Damaged, deteriorating or previously used materials shall not be used and shall be removed from the Project site.

B. Removal and Encapsulation:
   1. Surfactant (wetting agent) shall be a 50/50 mixture of polyoxyethylene ether and polyoxyethylene ester, or equivalent, mixed with water in accordance with manufacturer's printed instructions.
   2. The encapsulating agent to be applied shall adhere to the substrate surfaces from which hazardous material has been stripped.
   3. Encapsulants shall not be flammable.
   4. Replacement sprayed-on or trowel applied fireproofing shall meet required specifications and be non-hazardous.
   5. Replacement acoustical materials shall meet or exceed original materials and be non-hazardous.
   6. Solvents used to remove mastic shall be low odor, non-noxious and an SDS shall be submitted.

2. All components of cooling tower.
3. **<Insert components requiring extended warranty>**.
4. Warranty Period: **[Five]** <**Insert number**> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 OPEN-CIRCUIT, FORCED-DRAFT, COUNTERFLOW COOLING TOWERS

A. Products: Subject to compliance with requirements, [**provide the following**] [**provide one of the following**] [**available products that may be incorporated into the Work include, but are not limited to, the following**]:

1. Baltimore Aircoil Company; Models VTL, VTO, and VT1.
2. Delta Cooling Towers, Inc.; Model Pioneer.
3. Evapco Inc.; Models LRT and LSTA.

B. Basis-of-Design Product: Subject to compliance with requirements, provide Evapco comparable product by one of the following:

1. Baltimore Aircoil Company.
2. Delta Cooling Towers, Inc.
3. Evapco Inc.

C. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.

D. Cooling tower designed to resist wind load of [**30 lbf/sq. ft.**] <**Insert value**>.

E. Casing and Frame:

1. Casing and Frame Material: 304 - Stainless steel.
2. Frame Material: Stainless steel.
3. Fasteners: Stainless steel.
4. Joints and Seams: Sealed watertight.
5. Welded Connections: Continuous and watertight.

F. Collection Basin: Configure tower for installation with a field-constructed collection basin.

G. Collection Basin:

1. Material: Stainless steel.
2. Strainer: Removable stainless-steel strainer with openings smaller than nozzle orifices.
3. Overflow and drain connections.
4. Makeup water connection.
5. Basin Sweeper Distribution Piping and Nozzles:

   a. Pipe Material: PVC.
   b. Nozzle Material: Plastic.
   c. Configure piping and nozzles to minimize sediment from collecting in the collection basin.

H. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.

I. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil or fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.

1. Pipe Material: [PVC] Galvanized steel.
2. Spray Nozzle Material: **[Plastic]** **[Polypropylene]** **[PVC]** <**Insert material**>.
3. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.

J. Fill:

1. Materials: PVC, with maximum flame-spread index of 5 according to ASTM E 84.
2. Minimum Thickness: **[15 mils]** **[20 mils]** <**Insert value**>, before forming.
3. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
4. Fill Material Operating Temperature: Suitable for entering-water temperatures up through 120 deg F.

K. Drift Eliminator:

1. Material: **[FRP]** **[PVC]** **[FRP or PVC]** <**Insert material**>; with maximum flame-spread index of [**5**] [**25**] <**Insert value**> according to ASTM E 84.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.

L. Removable Air-Intake Screens: Stainless-steel wire mesh.

M. Centrifugal Fan: Double-width, double-inlet, forward-curved blades, and statically and dynamically balanced at the factory after assembly.

1. Number of Fans: Each cooling tower cell shall have a single fan or multiple fans connected to a common shaft.
2. Fan Wheel and Housing Materials: Galvanized steel.
3. Fan Shaft: Steel, coated to resist corrosion.
4. Protective Enclosure: Removable, 304 stainless steel, wire-mesh screens complying with OSHA regulations.
5. Fan Shaft Bearings: Self-aligning, grease-lubricated ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F. Bearings designed for an L-10 life of [**40,000**] [**50,000**] <**Insert value**> hours.
6. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.

N. Belt Drive:

1. Service Factor: [**1.5**] <**Insert value**> based on motor nameplate horsepower.
2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
3. Belt: Multiple V-belt design with a matched set of[**cogged**] belts.
4. Belt: One-piece, multigrooved, solid-back belt.
5. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
6. Belt-Drive Guard: Comply with OSHA regulations.

O. Fan Motor:

1. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Division 23 Section "Common Motor Requirements for HVAC Equipment" and not indicated below.
2. Motor Enclosure: Totally enclosed air over (TEAO), Totally enclosed fan cooled (TEFC), with epoxy or polyurethane finish.
3. Energy Efficiency: [**Comply with ASHRAE/IESNA 90.1**] [**NEMA Premium Efficient**].
4. Service Factor: 1.15.
5. Insulation: Class F, Class H.
6. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
7. Severe-duty rating with the following features:

    a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
    b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and 300 deg F.
    c. Internal heater automatically energized when motor is de-energized.

8. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.

P. Discharge Hoods with Sound Attenuator:

1. Hood Configuration Straight; totally surrounding drift eliminators and constructed of same material as casing; and having factory-installed insulation and access doors.

Q. Vibration Switch: For each fan drive.

1. Enclosure: NEMA 250, [**Type 4**] [**Type 4X**] <**Insert type**>.
2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
3. Provide switch[**with manual-reset button**] for [**field connection to a BMS and**]hardwired connection to fan motor electrical circuit.
4. Switch shall, on sensing excessive vibration,[**signal an alarm through the BMS and**] shut down the fan.

R. Controls: Comply with requirements in Division 23 Section "Instrumentation and Control for HVAC."

S. Control Package: Factory installed and wired, and functionally tested at factory before shipment.

1. NEMA 250, Type 3R enclosure with removable internally mount backplate.
2. Control-circuit transformer with primary and secondary side fuses.
3. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
4. Microprocessor-based controller for automatic control of fan based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
5. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
6. Factory-installed and -wired, collection basin electric/electronic level controller.
7. Collection basin electric/electronic level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" Paragraph.
8. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
9. Controls and wiring for "two-motor, single-fan drives" shall be same as two-speed, two-winding motor.

10. Single-point, field-power connection to a **[fused disconnect switch]** **[nonfused disconnect switch]** **[circuit breaker]** **[for each cooling tower cell]**.

    a. Branch power circuit to each motor and electric basin heater and to controls[**with a disconnect switch or circuit breaker**].
    b. NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.

11. Visual indication of status and alarm[**with momentary test push button**] for each motor.
12. Audible alarm and silence switch.
13. Visual indication of elapsed run time, graduated in hours for each motor.
14. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:

    a. Operational status of each motor.
    b. Position of dampers.
    c. Cooling tower leaving-fluid temperature.
    d. Fan vibration alarm.
    e. Collection basin **[high]** **[low]** **[high- and low]**-water-level alarms.
    f. **<Insert conditions to be monitored>**.

2.2 SOURCE QUALITY CONTROL

A. Verification of Performance: Test and certify cooling tower performance according to CTI STD 201, "Certification Standard for Commercial Water-Cooling Towers Thermal Performance."

B. Factory pressure test heat exchangers after fabrication and prove to be free of leaks.

PART 3 - EXECUTION

3.1 GENERAL

A. The cooling towers will be delivered to the designated rigger's yard. Contractor shall coordinate shipment, receive, inspect and accept responsibility for equipment. Any damage or deficiency shall be resolved by Contractor directly with manufacturer and/or hauler, with no recourse to the Owner.

B. Delivery and rigging of cooling towers will be stages based on the construction schedule. Contractor shall protect equipment, transport to the site, rig into place, install, pipe, wire and test equipment in accordance with drawings, specifications and manufacturer's recommendations. Contractor shall coordinate any requirements directly with the manufacturer.

C. Consult equipment supplier regarding rigging requirements. If disassembly is required, both disassembly and reassembly shall be done by the Contractor in strict compliance with the manufacturer's instructions, under supervision of cooling tower manufacturer's representative, and shall not void any warranties.

3.2 EXAMINATION

A. Before cooling tower installation, examine roughing-in for tower support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting tower performance, maintenance, and operation.

1. Cooling tower locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 INSTALLATION

A. Install cooling towers on support structure indicated.

B. Equipment Mounting: Install cooling tower on concrete bases using [**elastomeric pads**] [**elastomeric mounts**] [**restrained spring isolators**] <**Insert device**>. Comply with requirements in Division 03 Section "[**Cast-in-Place Concrete**] [**Miscellaneous Cast-in-Place Concrete**]." Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/2 inch**] [**1 inch**] [**2 inches**] [**3 inches**] <**Insert dimension**>.
2. Provide [**galvanized**] [**stainless**]-steel plate to equally distribute weight over elastomeric pad.
3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
4. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
5. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

C. Equipment Mounting: Install cooling tower using [**elastomeric pads**] [**elastomeric mounts**] [**restrained spring isolators**] <**Insert device**>. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/2 inch**] [**1 inch**] [**2 inches**] [**3 inches**] <**Insert dimension**>.
2. Provide [**galvanized**] [**stainless**]-steel plate to equally distribute weight over elastomeric pad.

D. Equipment Mounting: Install cooling tower on concrete bases. Comply with requirements in Division 03 Section "[**Cast-in-Place Concrete**] [**Miscellaneous Cast-in-Place Concrete**]."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

E. Install anchor bolts to elevations required for proper attachment to supported equipment.

F. Maintain manufacturer's recommended clearances for service and maintenance.

G. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to cooling towers to allow service and maintenance.

C. Install flexible pipe connectors at pipe connections of cooling towers mounted on vibration isolators.

D. Provide drain piping with valve at cooling tower drain connections and at low points in piping.

E. Connect cooling tower overflows and drains, and piping drains to sanitary sewage system.

F. Domestic Water Piping: Comply with applicable requirements in Division 22 Section "Domestic Water Piping." Connect to water-level control with shutoff valve and union, flange, or mechanical coupling at each connection.

G. Supply and Return Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping." Connect to entering cooling tower connections with shutoff valve, balancing valve, thermometer, plugged tee with pressure gage,[**flow meter,**] and drain connection with valve. Connect to leaving cooling tower connection with shutoff valve. Make connections to cooling tower with a [**union**] [**flange**] [**mechanical coupling**] [**union, flange, or mechanical coupling**].

H. Equalizer Piping: Piping requirements to match supply and return piping. Connect an equalizer pipe, full size of cooling tower connection, between tower cells. Connect to cooling tower with shutoff valve.

I. Hot-Water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping." Connect to supply and return basin heater with shutoff valve, strainer, control valve, and union or flange on supply connection and union or flange and balancing valve on return connection. Provide supply and return piping with pressure gage and thermometer.

J. Steam and Condensate Piping: Comply with applicable requirements in Division 23 Section "Steam and Condensate Heating Piping." Connect steam supply to basin heater with shutoff valve, strainer, control valve, and union or flange and condensate piping with union or flange, shutoff valve, strainer, and an appropriate steam trap.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: [**Owner will engage**] [**Engage**] a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform field tests and inspections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections: Comply with [**ASME PTC 23, "ASME Performance Test Codes - Code on Atmospheric Water Cooling Equipment**] [**CTI ATC 105, "Acceptance Test Code for Water Cooling Towers**]."

E. Cooling towers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. **[Engage a factory-authorized service representative to perform]** **[Perform]** startup service.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

C. Obtain performance data from manufacturer.

1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

    a. Clean entire unit including basins.
    b. Verify that accessories are properly installed.
    c. Verify clearances for airflow and for cooling tower servicing.
    d. Check for vibration isolation and structural support.
    e. Lubricate bearings.
    f. Verify fan rotation for correct direction and for vibration or binding and correct problems.
    g. Adjust belts to proper alignment and tension.
    h. Verify proper oil level in gear-drive housing. Fill with oil to proper level.
    i. Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.
    j. Check vibration switch setting. Verify operation.
    k. Verify water level in tower basin. Fill to proper startup level. Check makeup water-level control and valve.
    l. Verify operation of basin heater and control.
    m. Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.
    n. Replace defective and malfunctioning units.

D. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.

E. Prepare a written startup report that records the results of tests and inspections.

3.7 ADJUSTING

A. Set and balance water flow to each tower inlet.

B. Adjust water-level control for proper operating level.

3.8 DEMONSTRATION

A. **[Engage a factory-authorized service representative to train]** **[Train]** Owner's maintenance personnel to adjust, operate, and maintain cooling towers.

END OF SECTION 23 6500

SECTION 23 8219

FAN COIL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

1.2 SUMMARY

A. This Section includes fan-coil units and accessories.

1.3 DEFINITIONS

A. BAS: Building automation system.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. LEED Submittals:
   1. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment complies.
   2. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection and associated values.
   1. Wiring Diagrams: Power, signal, and control wiring.

D. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Ceiling suspension components.
   2. Structural members to which fan-coil units will be attached.
   3. Method of attaching hangers to building structure.
   4. Size and location of initial access modules for acoustical tile.
   5. Items penetrating finished ceiling, including the following:
      a. Lighting fixtures.
      b. Air outlets and inlets.
      c. Speakers.
      d. Sprinklers.
      e. Access panels.

6. Perimeter moldings for exposed or partially exposed cabinets.

E. Samples for Initial Selection: For units with factory-applied color finishes.

F. Samples for Verification: For each type of fan-coil unit indicated.

G. Manufacturer Seismic Qualification Certification: Submit certification that fan-coil units, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
   b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

H. Field quality-control test reports.

I. Operation and Maintenance Data: For fan-coil units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

J. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. ARI Compliance: Rated and tested in accordance with ARI Standard 440 “Room Fan Coil Units.”

E. UL listed and labeled in accordance with ANSI/UL Standard 880- “Safety Standard for Fan Coil Units.”

1.6 COORDINATION

A. Coordinate layout and installation of fan-coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate size and location of wall sleeves for outdoor-air intake.

C. Specific configuration of the supply and return ductwork and piping at each unit has been indicated on the drawings. If the configuration of the units furnished on the project differs from that indicated on the drawings (whether or not the units furnished are the specific units or an acceptable substitute), it shall be the contractor's responsibility to modify ductwork, piping, etc., as required to accommodate the actual the actual configuration of units furnished on the project.

1.7 WARRANTY

A. Warranty Period: [**Four**] years from date of Substantial Completion.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  1. Fan-Coil-Unit Filters: Furnish <**Insert number**> spare filters for each filter installed.
  2. Fan Belts: Furnish <**Insert number**> spare fan belts for each unit installed.

PART 2 - PRODUCTS

2.1 GENERAL

A. Manufacturer shall be responsible for examining applications of each type of unit to assure that each will operate properly in the intended application.

B. Unit sizes are shown as selected in accordance with the principles set worth in the ASHRAE Guide and Manufacturer's literature.

C. All items of a given type shall be the products of the same manufacturer.

2.2 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

B. In the Fan-Coil-Unit Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:
  1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.3 DUCTED FAN-COIL UNITS

A. Manufacturers:
  1. Carrier Corporation.
  2. Environmental Technologies, Inc.
  3. International Environmental Corporation.
  4. Trane.
  5. YORK International Corporation.

7. A sufficient supply of transparent 6-mil polyethylene glove bags, pre-labeled with the prescribed Cal/OSHA and EPA warnings.
8. Encapsulating agent applied to areas to be resprayed with fireproofing shall neither affect the resprayed fireproofing ability to bond to the substrate, nor reduce the UL rating of the fireproofing.

2.2 EQUIPMENT

A. General:
1. Contractor shall supply a sufficient number of High Efficiency Particulate Air (HEPA) filtered vacuums to detail clean and remove hazardous materials.
2. Eye protection shall be worn at all times in the form of eye goggles, face shield or full-face-piece respirator.
3. Boots with steel shank shall be utilized during any wood demolition activities.
4. Contractor shall furnish Self-Contained Breathing Apparatus (SCBA) or supplied line respirators for all operations involving torch cutting through components covered with lead-containing coatings and for operations involving Volatile Organic Compounds (VOC).
5. HEPA filtered respirators shall be used for all other demolition activities. Contractor shall furnish respirators to the abatement workers. The respirators shall have been tested and approved by National Institute of Occupational Safety and Health (NIOSH) for use in asbestos contaminated atmospheres.
6. Full body disposable protective clothing, including head and foot covering shall be worn at all times inside the demolition area.
7. Provide respirator cartridges capable of filtering all identified contaminants.
8. Additional safety equipment, as necessary, shall be furnished to all workers and authorized visitors:
   a. Hard hats meeting the requirements of ANSI Standard Z89.1-1981
   b. Eye protection meeting the requirements of ANSI Standard Z87.1-1979
   c. Safety shoes meeting the requirements of ANSI Standard Z41.1-1967
   d. Disposable gloves

B. Removal:
1. A sufficient supply of scaffolds, ladders, lifts and hand tools (e.g., scrapers, wire cutters, brushes, utility knives, wire saws, etc.) shall be furnished as needed.
2. Sprayers are required with pumps capable of providing 500 pounds per square inch (PSI) at the nozzle tip at a flow rate of 2 gallons per minute for spraying amended water.
3. Rubber dustpans and rubber squeegees shall be furnished for cleanup.
4. Brushes utilized for removing loose hazardous material shall have nylon or fiber bristles, not metal.
5. A sufficient supply of HEPA filtered vacuum systems shall be furnished during cleanup.

C. Encapsulation: Encapsulants shall be sprayed using airless spray equipment. Nozzle pressure shall be adjustable to within the 400 to 500 psi range.

PART 3 - EXECUTION

3.1 WORK AREA PREPARATION

A. General:
1. Post warning signs meeting the specifications of Cal/OSHA General Industry Safety Order Section 5208 and 29 CFR 1926.1101 at any location and approaches to a location where airborne concentration of hazardous materials may exceed ambient background levels. Signs shall be posted at a distance sufficiently far enough away from a work area to permit a person to read the sign and take necessary protective measures to avoid exposure. Additional signs may need to be posted following construction of work place enclosure barriers.

B. Description: Factory-packaged, completely assembled and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.

C. Coil Section Insulation: **[1/2-inch]** **[1-inch]** **<Insert thickness>** thick **[coated]** **[foil-faced]** glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
   1. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
   2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

D. Drain Pans: **[Stainless steel]**. Fabricate pans and drain connections to comply with ASHRAE 62.1-2004.

E. Chassis: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panels.

F. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.
   1. Supply-Air Plenum: Sheet metal plenum finished and insulated to match the chassis[**with mill-finish, aluminum, double-deflection grille**].
   2. Return-Air Plenum: Sheet metal plenum finished to match the chassis.
   3. Mixing Plenum: Sheet metal plenum finished and insulated to match the chassis with outdoor- and return-air, formed-steel dampers.
   4. Dampers: Galvanized steel with extruded-vinyl blade seals, flexible-metal jamb seals, and interlocking linkage.

G. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   1. Washable Foam: 70 percent arrestance and 3 MERV.
   2. Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.
   3. Pleated Cotton-Polyester Media: 90 percent arrestance and 7 MERV.

H. Hydronic Coils: **[3/8 in. (9.5 mm)]** **[1/2in. (12.7 mm)]** diameter copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.

I. Belt-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, single-speed motor installed on an adjustable fan base resiliently mounted in the cabinet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.
   1. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

J. Factory, Hydronic Piping Package: **[ASTM B 88, Type L]** **[ASTM B 88, Type M]** copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
   1. **[Two]** , **[two-position]** **[modulating]** control valve for chilled-water coil.
   2. **[Two]**, **[two-position]** **[modulating]** control valve for heating coil.
   3. Hose Kits: Minimum 400-psig working pressure, and operating temperatures from 33 to 211 deg F. Tag hose kits to equipment designations.
      a. Length: **[24 inches]** **[36 inches]** **<Insert dimension>**.
      b. Minimum Diameter: Equal to fan-coil-unit connection size.
   4. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig working pressure, 250 deg F maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
   5. Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig working pressure at 250 deg F; with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to

maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig.

6. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig working pressure, with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 hose-end, full-port, ball-type blowdown valve in drain connection.
7. Wrought-Copper Unions: ASME B16.22.

K. Remote condensing units are specified in Division 23 Section "Packaged Compressor and Condenser Units."

L. Control devices and operational sequence are specified in Division 23 Section "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."

M. Basic Unit Controls:
 1. Control voltage transformer.

N. **DDC** Terminal Controller:
 1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
 2. Unoccupied Period Override Operation: [**Two**] <**Insert number**> hours.
 3. Unit Supply-Air Fan Operation:
  a. Occupied Periods: Fan runs continuously.
  b. Unoccupied Periods: Fan cycles to maintain room setback temperature.
 4. Hydronic-Cooling-Coil Operation:
  a. Occupied Periods: [**Modulate**] control valve to maintain room temperature.
  b. Unoccupied Periods: Close control valve.
 5. Dual-Temperature Hydronic-Coil Operation:
  a. Occupied Periods: When chilled water is available, [**open**] [**modulate**] control valve if room temperature exceeds thermostat set point. When hot water is available, [**open**] [**modulate**] control valve if temperature falls below thermostat set point.
  b. Unoccupied Periods: When chilled water is available, close valve. When hot water is available, [**open**] [**modulate**] control valve if room temperature falls below thermostat setback temperature.
 6. Reheat-Coil Operation:
  a. Humidity Control for Occupied Periods: Humidistat [**opens control valve**] [**modulates control valve**] [**energizes electric-resistance coil**] to provide heating. As room temperature rises above the set point, cooling coil valve [**opens**] [**modulates**] to maintain room temperature.
  b. Humidity Control for Unoccupied Periods: [**Close control valve**] [**De-energize**].
  c. Occupied Periods:
   1) Heating Operations: [**Open control valve**] [**Modulate control valve**] [**Energize electric-resistance coil**] to provide heating if room temperature falls below thermostat set point.
   2) Humidity-Control Operations: Humidistat [**opens control valve**] [**modulates control valve**] [**energizes electric-resistance coil**] to provide heating. As room temperature rises above the set point, cooling coil valve [**opens**] [**modulates**] to maintain room temperature.
  d. Unoccupied Periods: Start fan and [**open control valve**] [**modulate control valve**] [**energize electric-resistance coil**] if room temperature falls below setback temperature. Humidity control is not available.
 7. Outdoor-Air Damper Operation:
  a. Occupied Periods: Open damper to fixed position for [**25**] <**Insert percent**> percent outdoor air.
  b. Unoccupied Periods: Close damper.
 8. Outdoor-Air Damper Operation:

a. Occupied Periods:
1) Outdoor-Air Temperature below Room Temperature: If room temperature is above room-temperature set point, modulate outdoor- and return-air dampers to maintain room-temperature set point (outdoor-air economizer). If room temperature is below set point, position damper to fixed minimum setting.
2) Outdoor-Air Temperature above Room Temperature: Position damper to fixed minimum position for **[25]** <**Insert percent**> percent outdoor air.
b. Unoccupied Periods: Close outdoor-air damper and open return-air damper.
9. Outdoor-Air Damper Operation:
a. Occupied Periods:
1) Outdoor-Air Enthalpy below Room Enthalpy: If room temperature is above room-temperature set point, modulate outdoor-air damper to maintain room temperature (outdoor-air economizer). If room temperature is below set point, position damper to fixed minimum position for **[25]** <**Insert percent**> percent outdoor air.
2) Outdoor-Air Enthalpy above Room Enthalpy: Position damper to fixed minimum position for [**25**] <**Insert percent**> percent outdoor air.
b. Unoccupied Periods: Close outdoor-air damper and open return-air damper.
10. Controller shall have volatile-memory backup.

O. BAS Interface Requirements:
1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at the central workstation.
3. Provide [**BACnet**] [**or**] [**LonWorks**] interface for central BAS workstation for the following functions:
a. Adjust set points.
b. Fan-coil-unit start, stop, and operating status.
c. Data inquiry including [**outdoor-air damper position,**]supply- and room-air temperature[**and humidity**].
d. Occupied and unoccupied schedules.

P. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive fan-coil units for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan-coil-unit installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 STORAGE AND HANDLING

A. Comply with manufacturer's installation instructions for rigging, unloading and transporting units.

B. All fan coil units shall be received and stored on the job site with the wooden shipping skids in place. Under no condition shall the units be stored on such a way that metal components are in direct contact with the ground.

C. Unit delivery shall be coordinated with building construction and units shall be delivered to the job site just prior to their installation. Cover air handling units stored on the job site with 6 mil polyethylene sheet, taped in place, to protect the units from damage and the weather. Units that receive water damage due to improper handling or storage shall be removed from the site and new ones furnished at no additional charge to the Owner.

3.3 INSTALLATION

A. Install fan-coil units level and plumb.

B. Install fan-coil units to comply with NFPA 90A.

C. Suspend fan-coil units from structure with elastomeric hangers and at least four 3/8 inch (7.5 mm) galvanized threaded support rods. Vibration isolators are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices [**48 inches**] [**60 inches**] <**Insert dimension**> above finished floor.

E. Install new filters in each fan-coil unit within two weeks after Substantial Completion.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
   1. Install piping adjacent to machine to allow service and maintenance.
   2. Connect piping to fan-coil-unit factory hydronic piping package. Install piping package if shipped loose.
   3. Connect condensate drain to full size but not less than 3/4 inch (19 mm) indirect waste.
      a. Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.

B. Connect supply and return ducts to fan-coil units with flexible duct connectors specified in Division 23 Section "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect[**, test, and adjust**] field-assembled components and equipment installation, including connections[**, and to assist in field testing**]. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   2. Operate electric heating elements through each stage to verify proper operation and electrical connections.

3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.6 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]** <**Insert number**> visits to Project during other than normal occupancy hours for this purpose.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fan-coil units. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 23 8219

SECTION 26 0500

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section covers and applies to all work specified in Division 26 (and 27 & 28).

B. Work Included: Materials, equipment, fabrication, installation and tests for fully operational and safe systems, including all necessary materials, appurtenances and features whether specified or shown on drawings or not, in conformity with applicable codes and authorities having jurisdiction for the following:

1. Electrical work specified in all sections within Division 26 (and 27 & 28) of these specifications, including, but not limited to:

    a. Short circuit analysis and protective device coordination study.
    b. Primary underground service ducts from the point of connection to the Serving Agency to the transformer vault, building main switchboard.
    c. Equipment for serving agency facilities shall be furnished and installed in accordance with the requirements of the Serving Utility. Transformers, primary cable, and utilization equipment will be furnished and installed by the Serving Agency.
    d. Lighting and power distribution facilities, including busways, main switchboard with metering, transformers, distribution boards, panelboards with feeders, motor control centers, branch circuit wiring, connections to outlets, and wiring devices.
    e. Lighting fixtures and lamps.
    f. Motor and other power-consuming equipment connections from motor control centers or distribution apparatus to equipment.
    g. Telephone conduit system, including underground service facilities, riser and lateral extension conduits, and facilities required in terminal room in accordance with the requirements of the Telephone Utility.
    h. Elevator and escalator feeders.
    i. Control, alarm and interlock wiring for mechanical equipment, where indicated.
    j. Electrical grounding system.
    k. Emergency power and lighting system, including engine-generator set complete with oil system and power transfer capability.
    l. Vibration and seismic controls for electrical systems.
    m. Life safety system including ADA requirements.
    n. Lightning protection.
    o. Cable tray system.
    p. Water leak detection.
    q. Low voltage system (PA, NC, MATV, CCTV, CATV, Security, etc.)
    r. Excavation, backfilling and compacting for the Electrical Work.
    s. Cutting and patching for the Electrical Work.
    t. Adjustment and testing of the Electrical Work.

u. Examine the drawings and specifications of other Divisions and provide electrical service for all equipment, devices and controls noted therein, unless work specifically is not included.
v. Lighting control system.
w. Dimming system.
x. Uninterruptable power supply (UPS) system.
y. Underfloor power and telephone/telecom distribution system.

1.3 DESCRIPTION OF BID DOCUMENTS

A. Specifications:

1. Specifications, in general, describe quality and character of materials and equipment.
2. Specifications are of simplified form and include incomplete sentences.
3. Words or phrases such as "The Contractor shall," "shall be," "furnish," provide," "a," "an," "the," and "all" etc. have been omitted for brevity.

B. Drawings:

1. Electrical layouts are generally diagrammatic and, although size and location of equipment is drawn to scale wherever possible, Contractor shall make use of all data in Contract Documents and verify this information at building site.
2. Locations of items on the drawings may be distorted for purposes of clearness and legibility. Actual locations of architectural and mechanical items are shown on architectural and mechanical drawings.
3. Contractor shall adjust locations of light fixtures in mechanical rooms to compensate for changes in duct routing, to provide reasonably uniform lighting in work areas.
4. Outlets shall be located in accordance with architectural design, and specific locations may be determined by Owner's representative at jobsite prior to installation.
5. Outlets located on architectural plans by dimension shall be held. Additional outlets may be shown on electrical plans and shall be installed as close as practical to the location shown.
6. Manufacturers' drawings and instructions shall be followed in all cases where the makers of devices and equipment furnish directions, where details are not shown on the drawings, or where described in the specifications.
7. Work installed in a manner contrary to that shown in the contract documents shall be removed and reinstalled when so directed by the Architect. Discrepancies and questionable points shall be immediately reported to the Architect for clarification.
8. The Owner and the Architect reserve the right to make reasonable changes in outlet locations in each area prior to roughing-in at no additional cost to the Owner.

C. If any part of specifications or drawings appears unclear or contradictory, apply to Architect for his interpretation and decision as early as possible, including during bidding period. Do not proceed with such work without Architect's decision.

1.4 JOB CONDITIONS

A. Examine all drawings and specifications in a manner to be fully cognizant of all work required under this Division.

B. Adjoining work of other Divisions shall be examined for interferences and conditions affecting this Division.

C. Examine site related work and surfaces before starting work of any Section.

1. Report to Architect, in writing, conditions which will prevent proper provision of this work.
2. Beginning work of any Section without reporting unsuitable conditions to Architect constitutes acceptance of conditions by Contractor.
3. Perform any required removal, repair or replacement of this work caused by unsuitable conditions at no additional cost to Owner.

D. Connections to existing work:
1. Verification of existing: Before submitting bid, become thoroughly familiar with actual existing conditions and systems at the building, and of the existing installations to which connections must be made, including any necessary alterations, and existing building engineering practices and requirements. The intent of the work is shown on the drawings and described herein, and no consideration will be granted by reason of lack of familiarity on the part of the contractor with actual physical conditions, requirements, and practices at the site.
2. Install new work and connect to existing work with minimum interference to existing facilities.
3. Temporary shutdowns of existing services: At times not to interfere with normal operation of existing facilities and only with written approval of the Owner, at no additional charges.
4. Maintain continuous operation of existing facilities as required with necessary temporary connections between new and existing work. Do not interrupt alarm and emergency systems.
5. Connect new work to existing work in neat and acceptable manner. Restore existing disturbed work to original condition including maintenance of wiring continuity as required.
6. Following work shall be performed only after regular working hours:
   a. Only for scope requested and approved by owner.

E. Removal and Relocation of Existing Work:
1. Disconnect, remove or relocate electrical material, equipment and other work noted and required by removal or changes in existing construction.
2. Provide new material and equipment required for relocated equipment.
3. Disconnect load and supply end of conductors feeding existing equipment.
4. Remove conductors from existing raceways to be rewired.
5. Tape both ends of abandoned conductors. Cap outlets and abandoned raceways.
6. Cut and cap abandoned floor raceways flush with concrete floor or behind walls and ceilings.
7. Dispose of removed raceways and wire.
8. Dispose of removed electrical equipment as directed.

F. If asbestos insulation is found when working in existing areas, immediately stop work and notify Architect. Do not restart work until advised in writing by Architect that it is safe to do so following abatement, encapsulation, etc.

1.5 DEFINITIONS

A. "Provide": To furnish, install and connect complete and ready for safe and regular operation of particular work referred to unless specifically otherwise noted.

B. "Install": To erect, mount and connect complete with related accessories.

C. "Furnish" or "Supply": To purchase, procure, acquire and deliver complete with related accessories.

D. "Work": Labor, materials, equipment, apparatus, controls, accessories and other items required for proper and complete installation.

E. "Wiring": Raceway, fittings, wire, boxes and related items.

F. "Concealed": Embedded in masonry or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces or in enclosures.

G. "Exposed": Not installed underground or "concealed" as defined above.

H. "Indicated" "Shown" or "Noted": As indicated, shown or noted on drawings or specifications.

I. "Equal": Equal in quality, workmanship, materials, weight, size, design and efficiency of specified product, conforming with "Manufacturers".

J. "Reviewed," "Satisfactory," "Accepted," or "Directed": As reviewed, satisfactory, accepted or directed by or to Architect.

K. "Motor Controllers": Manual or magnetic starters (with or without switches), individual pushbuttons, or hand-off-automatic (HOA) switches controlling the operation of motors.

L. "Control Devices": Automatic sensing and switching devices such as thermostats, pressure, float, electro-pneumatic switches and electrodes controlling operation of equipment.

1.6 UTILITY CONNECTIONS

A. Finalize electrical service arrangements including verification of locations and details with the Serving Agency.

B. Verify locations of facilities and details with the Telephone Utility.

   1. Final telephone service arrangements will be made by the Owner.

C. In addition to the requirements shown on the drawings and stated herein, the work shall comply with the following:

   1. Construction Standards and Service Requirements of the respective utilities including any supplementary drawings issued by the utilities.
   2. Be subjected to inspection approval of these utilities.

D. Electrical service facilities shall consist of furnishing and installing concrete encased primary conduits, transformer vault appurtenances and secondary service including utility meter in accordance with the arrangement, details, and locations shown on the drawings and described herein and as required by the utility company.

   1. Transformer vault: Furnish and install conduits and ducts with terminations, mounting inserts, lighting fixtures and wiring devices, conduits with outlets, wire with connections for lighting facilities, grounding conductors and fittings and other work as required by the Serving Agency.

1.7 ELECTRICAL SYSTEM CHARACTERISTICS

A. Service: 480/277 volts, 3 phase, 4 wire with grounded neutral.

B. High intensity discharge and fluorescent lighting: 277 volts.

C. Motors ½ horsepower and above: 480 volts, 3 phase.

D. Fractional horsepower motors less than ½ horsepower: 120 volts single phase.

E. Incandescent lighting and general receptacles will be supplied at 120 volts.

1.8 MOUNTING HEIGHTS

A. Mounting heights of devices and equipment shown on the architectural drawings shall govern, but in the absence of such indications, the following centerline heights above the finished floor shall be maintained.

1.	Wall switches	3 feet - 6 inches (or as directed by architect).
2.	Wall lights (interior)	7 feet - 0 inches (or as directed by architect).
3.	Pendant or chain hung fixture	10 feet - 0 inches (or as directed by architect).
4.	Convenience receptacles	1 foot - 6 inches except in Toilets and over cabinets or -counters where devices shall be mounted at 4 feet - 0 inches (9 inches above counter).
5.	Fire alarm stations	4 feet - 0 inches.
6.	Telephone and communication outlets	1 foot - 6 inches.
7.	Clock outlets	1 foot - 6 inches below finished ceiling.
8.	Panelboard cabinets	Shall be installed with the top 6 feet - 6 inches above the floor for cabinets more than 2 feet - 6 inches high and 6 feet - 0 inches for cabinets less than 2 feet - 6 inches high.
9.	Motor controllers	5 feet-0 inches.

1.9 SUBMITTALS

A. Submit shop drawings, product data, samples and certificates of compliance required by contract documents.

1. See Submittals paragraph in Division 1.

B. Submit no later than 30 days after signing of Contract:

2. Obtain City of Inglewood's Representative's approval prior to any utility shut-down in accordance with Section 01 1400, WORK RESTRICTIONS.
3. Temporary Electrical Service: Refer to Section 01 5100, TEMPORARY UTILITIES.
   a. Furnish, install and maintain all necessary temporary electrical equipment, connections, etc., as necessary for the Work. Before final acceptance, all temporary equipment and connections installed by Contractor shall be removed in a manner approved by City of Inglewood's Representative. Electric power will be provided by City of Inglewood at no cost to Contractor. See section 01 51 00.
   b. Comply with CCR, Title 24, Part 3, California Electrical Code (2011 NEC with 2013 California Amendments), and Cal/OSHA requirements for temporary electrical systems. Refer to Section 01 4100, REGULATORY REQUIREMENTS.

4. All intake and exhaust vents leading to and from the work area shall be sealed with two (2) layers of 6-mil polyethylene sheeting and duct tape. Also seal any seams in HVAC system components that pass through the work area. HVAC system preparation for abatement shall be as approved by City of Inglewood's Representative.
5. City of Inglewood will provide sanitary facilities for abatement personnel outside of the enclosed work area and maintain them in a clean and sanitary condition throughout the project.
6. City of Inglewood will furnish water for construction purposes. Contractor shall connect to existing system.
7. Seal off all windows, doorways, corridor entrances, drains, ducts, grills, grates, diffusers, skylights and any other openings with two (2) layers of 6-mil polyethylene sheeting and tape. All glass windows and doors leading to the outside shall be covered with white polyethylene sheeting.
8. Pre-clean all movable objects within the work area using a HEPA-filtered vacuum and/or wet cleaning method as appropriate. After cleaning, these objects shall be removed from the work area and carefully stored in an uncontaminated location.
9. Pre-clean all fixed objects, including machinery, grilles and diffusers in the work area using HEPA-filtered vacuum systems and/or wet cleaning methods as appropriate. All cleaned fixed objects shall be covered with one (1) layer of 6-mil polyethylene sheeting and sealed with tape.
10. Preparation of Elevator: A minimum of two (2) layers of 6-mil polyethylene sheeting shall be adhered to the walls and floors of the elevator in such a manner as to prevent loosening during the course of abatement.
11. Elevators that pass through a hazardous materials work area shall be addressed in the following manner:
    a. Elevator service to floor that is under containment shall be locked out and prevented from opening onto work area. Elevator door opening shall first be sealed with two (2) layers of 6- mil polyethylene securely fastened with duct tape. A hard-board barrier of 1/2" plywood shall then be provided. All seams shall be caulked and made air-tight. Two (2) additional layers of 6-mil polyethylene shall then be securely fastened over the hard-board barrier.

B. Preparation for the removal of fluids or oils:
   1. Contractor shall place 6-mil. fire-resistant polyethylene sheeting or other similar impermeable and fire-resistant tarp on ground extending a minimum of 10' beyond the work area.
   2. Contractor shall berm, dyke, or plug all drains and sewer openings with 50' of work area.
   3. Contractor shall have sufficient vermiculite or similar absorbent material available in the event a spill or leak occurs during oil/fluid transfer.
   4. Contractor shall perform fluid and/or oil removal in secondary containment such as a plastic tub, bucket or other leak-proof container.

C. Preparation for removal of fluorescent light tubes and other mercury universal waste:

1. Complete schedule of submittals for equipment and layout shop drawings.
2. Submittals schedule shall be in such sequence as to cause no delay in work or in work of any other division.

C. Corrections or comments made on the shop drawings during review do not relieve the Contractor from compliance with requirements of the drawings and specifications. Shop drawing checking by the Engineer is only for review of general conformance with the design concept of the project and general compliance with the information given in the contract documents. The Contractor is responsible for:

1. Confirming and correlating all quantities and dimensions.
2. Fabrication processes and techniques of construction.
3. Work with all other trades.
4. Work in a safe and satisfactory manner.
5. Equipment that can be installed in the available space with all code clearances, prior to ordering any equipment.

D. Quantity of Submittals Required:

1. Layout Shop Drawings:

a. Submit one reproducible transparency and one print.
b. Upon review, transparency will be annotated and returned. Print will be retained by Engineer.
c. Copies of this transparency will serve as record copies for Architect and Engineer.
d. Additional prints will not be reviewed nor returned.

2. Product data (brochures):

a. Submit six copies of product data.
b. Five copies will be returned.
c. If comments are required, comment sheet(s) will be returned with each copy.
d. One copy will be retained by the Engineer.

3. Samples:

a. Submit as directed by the architect and as required in each specification section.

E. Submittal Format:

1. Number each submittal in consecutive order.
2. Submit minimum one binder for each specific section. Different specification sections shall not be combined within same binder.
3. In each submittal include complete index with the following information:

a. Project title and number.
b. Submittal number.
c. Referenced specification DIVISION, Section, Title, paragraph and page number or drawing reference as applicable and flap each applicable item.

d. Date of submission.
e. Referenced addendum or change order number as applicable.
f. Names of Contractor, supplier and manufacturer.
g. Description of item.
h. Stamp with Contractor's initials or signed certifying:

1) Review of submittal.
2) Verification of products, field measurements and field construction criteria.
3) Coordination of shop drawing and/or information in submittal with requirements of work of this Division and other divisions of Contract Documents.

4. Nomenclature, legend, symbols and abbreviations on submitted material shall be same as used in contract documents.

F. Resubmission Requirements:

1. Make any corrections or change in submittals required. Resubmit only items required for resubmittal for review until no exceptions are taken or a resubmission is not required.

2. Shop Drawings and Product Data:

a. Revise initial drawings or data, and resubmit as specified for initial submittal.
b. Indicate any changes which have been made other than those requested.
c. Provide written response of all previous comments with the resubmittals.

3. Samples: Submit new samples as required for initial submittal.

4. Clearly identify resubmittal by original submittal date, number and revision number and-indicate all changes from previous submittal.

G. Substitutions:

1. In the event of conflict, the provisions of this paragraph shall override those contained in SUBMITTALS and SUBSTITUTIONS paragraphs in DIVISION 1.
2. As a general, substitutions are not acceptable except for hereafter condition:

a. Requests for substitutions shall be considered only in case of product unavailability. Product unavailability shall be verified in writing by manufacturer.
b. Submit separate request for each substitution at appropriate time thereafter in the event of non-availability of item included in bid. Support each request with:

1) Complete data substantiating compliance of proposed substitution with requirements stated in Contract documents.
2) Data relating to changes in construction schedule.
3) Any effect of substitution on other Work in this and other Divisions, and any other related contracts, and changes required in other work or products.

c. Contractor shall be responsible at no extra cost to Owner for any changes resulting from proposed substitutions which affect work of other Sections or Divisions, or related contracts.
d. Substitute products shall not be ordered or installed without prior acceptance by Architect.
e. Architect will have sole discretion to determine acceptability of proposed substitutions and reserves the right to reject any such substitution.
f. Approval of substitutions shall not relieve Contractor from full compliance with requirements of Contract documents.

H. Layout Shop Drawings Required:

1. Prepare and submit following coordinated layout shop drawings on 1/4" scale:

   a. Mechanical equipment rooms containing motor control center and/or transformers.
   b. All electrical rooms and closets with equipment dimensions.
   c. Areas requiring deviations from design documents. Such deviations shall be clearly identified.

2. Layout drawings not varying from design documents shall not be submitted and will not be reviewed.

I. Operating Instructions, Maintenance Manuals and Parts Lists.

1. Before requesting acceptance of work submit one set for review by Architect.
2. After review, furnish five printed and bound sets.
3. Include:

   a. Manufacturer's name, model number, service manual, spare-parts list, and descriptive literature for all components, cross referenced and numbered on Reference Drawings.
   b. Maintenance instructions.
   c. Listing of possible breakdown and repairs.
   d. Instruction for starting, operation and programming.
   e. Detailed and simplified one line and wiring diagrams.
   f. Field test report.
   g. Name, address and phone number of contractors, equipment suppliers and service agencies.
   h. Assemble manufacturer's equipment manuals in chronological order following the specification alpha-numeric system in heavy duty three-ring binders clearly titled on the spine and front cover.

J. Record Drawings:

1. Comply with requirements of Division 1 Section PROJECT RECORD DOCUMENTS.
2. Submit to Architect for review prior to final acceptance inspection, one complete marked-up set of reproducible drawings.
3. Submit to Architect for review prior to final acceptance inspection, one complete set of reproducible engineering design drawings on electronic files using ACAD and one vellum set.

a. Fully illustrate all revisions made by all trades.
b. Include all field changes, adjustments, variances, substitutions and deletions, including all changes made by Change Orders.
c. Exact location, type and function of all equipment.

4. These drawings shall be for record purposes for Owner's use and are not considered Shop Drawings.

1.10 COORDINATION

A. Coordinate arrangement, mounting, and support of electrical equipment:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
3. To allow right of way for piping and conduit installed at required slope.
4. So that connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping.".

1.11 COMPLETION

A. Before Final Review: The work hereunder will not be reviewed for final acceptance until Operating and Maintenance Data, Manufacturer's Literature, Identification, Warning Signs and Nameplates specified herein have been reviewed and/or properly posted in the building and final cleaning has been completed.

B. Before operating any equipment for demonstration or test, comply with manufacturer's preparation instructions.

C. Demonstration of Operations: When the installation is complete and required adjustments have been made, operate the systems for a period of one week. During this time demonstrate to the Owner's representative that systems are completed and operating and performing in conformance with these specifications.

1.12 PRELIMINARY OPERATION

A. The owner reserves the right to operate portions of the electrical system on a preliminary basis without voiding the guarantee or relieving the Contractor of his responsibilities.

PART 2 - PRODUCTS

2.1 EQUIPMENT AND MATERIALS

A. All equipment and materials installed shall be new, unless otherwise specified.

B. All major equipment components shall have manufacturer's name, address, model number and serial number permanently attached in a conspicuous location.

C. All equipment shall be UL listed and bear the UL label.

D. Where UL labeling is not available, provide certification by a Nationally Recognized Testing Laboratory (NRTL).

E. Use products of the same manufacture and type for each category of material and equipment.

2.2 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:

   a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
   b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.3 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Metraflex Co.
   d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
3. Pressure Plates: Carbon steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.4 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

F. Layout and installation of electrical work shall be coordinated with the overall construction schedule and work schedules of various trades, to prevent delay in completion of the Project.

1. Complete drawings and specifications for the entire project will be available at the Project site.

2. It shall be obligatory to thoroughly check these drawings before organizing the electrical work schedule, or installing material and equipment.

G. Dimensions and information regarding accurate locations of equipment, and structural limitations and finish shall be coordinated and verified with other Division of Work. Be prepared to promptly furnish dimensions and information regarding electrical Work to other trades and cooperate with them to secure harmony and the best progress of the Project.

H. The drawings do not show off-sets, bends, and special fittings, or junction or pull boxes necessary to meet job conditions. These items shall be provided as required at no additional cost to the Owner.

I. Accessibility and Clearance:

1. Electrical equipment, outlets, junction and pull boxes shall be installed in accessible locations, avoiding obstructions, preserving headroom, and keeping openings and passageways clear.
2. Minor adjustments in the locations of equipment shall be made where necessary, providing such adjustments do not adversely affect functioning of the equipment.

J. Scaffolds and staging for installation of electrical work shall be provided under the work of this Division.

3.2 LOCATIONS

A. Drawings are essentially diagrammatic, and although the size and locations of equipment are generally shown to scale, make use of data in Contract Documents, and informational documents, including shop drawings, and verify this information against field conditions.

B. Drawings indicate the required size and points of termination of conduits, and the number and size of wires and suggest proper routing of conduit. Install conduit with necessary offsets, junction boxes, and fittings to conform to the structure, avoid obstructions, preserve headroom, maintain required accessibility, and satisfy the requirements of the governing codes and the standards of good practice.

C. Architectural and structural drawings and specifications take precedence over the electrical drawings in the representation of the general construction work. Civil drawings take precedence in the representation of the site work. Refer to the drawings, specifications, and reviewed shop drawings for all work, in order to coordinate electrical work with other work of the project.

D. When changes in indicated locations or arrangements are necessary due to conditions in building construction, rearrangement of furnishings or equipment, or conflict in location, make such changes at no cost to Owner, provided that the change is ordered before conduit is installed and that the length of the conduit run is not revised by more than ten feet.

E. Bring discrepancies between different drawings, between drawings and actual field conditions, or between drawings and specifications, promptly to the attention of the Architect for decision, and stop pertinent work subject to resolution of the conflict.

F. Equipment in the mechanical/electrical and signal rooms, or spaces, has been laid out based on the requirements of the first named equipment listed in the specifications or on the drawings. All additional costs resulting from contractor submitted/selected equipment that differs in design, layout or locations from indicated first named equipment, shall be borne by the contractor. The contractor is responsible for fully coordinating all pad and curb sizes, dimensional, elevation, sectional, structural, penetrations, and systems compatibility issues; and shall bear all costs related to contractor selection of equipment other than what was first named.

G. Coordinate the location of the lighting fixtures and framing with the ceiling construction. Architectural reflected ceiling drawings, plans and details govern. Locate lighting fixtures in mechanical and equipment rooms to avoid ductwork, piping and equipment. Coordinate location with trade supplying equipment prior to lighting fixture installation.

H. The drawings do not include dimensional information for roughing-in electrical utilities. Locate conduit stub-ups, floor boxes, poke-thru devices, sleeves, wall outlets, wall and trench duct, and devices serving equipment, built-in millwork, casework, and appliances, in accordance with dimensions shown on the respective equipment installation shop drawings of the equipment supplier, or on the contract architectural plans and details. Request additional dimensioned layouts from the architect where shop drawings or architectural plans and details do not suffice.

I. Provide clarifying details where required by inspecting authority and obtain Architect's and Inspector's approval prior to installation.

3.3 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 2 inches above finished floor level.

G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants.".

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.4 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.5 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.6 WEATHERPROOF EQUIPMENT

A. Electrical devices or equipment located in damp, semi-exposed areas shall be weather-resistant. Enclosure shall comply with NEMA Type 3R requirements.

B. Surface mounted outlet boxes shall be cast metal with threaded hubs. Pull or junction boxes shall be cast metal with bolted and gasketed covers.

C. Outlet box covers shall be of a suitable weatherproof type with gaskets, packing glands, weatherproof doors, or other required means to prevent entry of moisture.

D. Lighting fixtures shall be installed with suitable gasket, and UL labeled for location.

3.7 HOUSEKEEPING PADS AND FOUNDATIONS

A. Concrete work required for housekeeping pads and foundations will be provided by General Construction Work. Comply with the requirement for concrete base specified in Division 03 section.
   1. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section CAST-IN-PLACE CONCRETE and MISCELLANEOUS CAST-IN-PLACE CONCRETE.
   2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
   3. Install epoxy-coated anchor bolts for anchoring equipment to the concrete base.
   4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   5. Bolt equipment to channel-iron sills embedded in concrete bases. Install sills level and grout flush with floor or base.
   6. Refinish damaged or scratched surfaces.
   7. Provide 24 inch wide insulating mat in front of operable electrical equipment and in front and rear of free standing ones.
   8. Tighten all bolted connections prior to energizing.
   9. Provide fuse cabinet with specified number of fuses of each type.
   10. Provide special tools as required for routing maintenance and inspection.

B. Furnish required dimensional drawings and specify locations. Minimum height of housekeeping pads shall be 4 inches and shall extend out 6 inches from the footprint of the equipment.

C. Furnish anchor bolts and sleeves, and verify accuracy of installation.

D. Provide for:

   1. Switchboards, switchgears, unit substation and floor mounted ATS.
   2. Standby power plants.
   3. Floor mounted transformers.
   4. Motor control centers.
   5. Outdoor light fixture standards.
   6. UPS.
   7. All other floor mounted equipment.

3.8 ELECTRICALLY OPERATED EQUIPMENT

A. Where electrically operated equipment is specified under other divisions of the specification, provide conduit, wiring and connections under this section, as required for proper operation, and in accordance with wiring diagrams furnished by equipment supplier.

B. Install controls furnished by equipment supplier, and provide disconnect switches within sight of controller.

C. Refer to equipment specification for coordination of work.

3.9 PROTECTION AND CLEANING

A. Materials and Equipment: Cover all substations, transformers, switchboards, motor control centers, panel boards, busways, lighting fixtures, etc., stored or installed on the site, with polyethylene sheets or approved equal, to protect equipment from moisture, plaster, cement, paint, or other work of other trades. Cover outlet boxes with cardboard or plastic closures. Plug or cap conduit ends until final connection. Protect conduit stubs, stub ups and risers from construction equipment.

B. Storage: Provide proper and adequate storage facilities. Store conductors, raceways and fittings, in dry, protected locations.

C. Damage: Replace damaged or defective work, materials or equipment. Install sensitive or delicate equipment after major construction work is completed.

D. Parts: Store and protect all portable and detachable parts or portions of the installation such as spare parts, fittings, fuses, keys, locks, adapters, locking clips and inserts until completion of the work. As a precondition for acceptance of the work, deliver to the Owner's representative and obtain itemized receipt. Include receipts with the Operating and Maintenance Instruction Manual(s) required under other paragraphs of the specifications.

E. Site Cleaning: Periodically remove waste and rubbish and maintain order.

F. Equipment Finish: Clean and polish finished metal surfaces. Clean and prepare prime coated gear for painting.

G. Light Fixtures: Remove dust and handprints from light fixture surfaces.

H. Electrical Equipment: Clean exterior and interior of equipment. Vacuum interiors--do not blow out. Apply permanent identification and remove temporary and unauthorized notations.

I. Acceptance: Remove debris, dirt, grease and oil from building surfaces, caused by work under this section. Clean out and vacuum electric rooms.

3.10 PAINTING

A. In Equipment and Utility Areas: Provide factory finished equipment including prime coat and medium dark gray finish over rust-inhibitor.

B. Outdoors and in Wet Locations: Provide additional factory coat of exterior lacquer for a two mils finish thickness. Indicate finish on shop drawings.

1. Contractor shall isolate all power to the light fixture or thermostat prior to inspection or removal of fluorescent tubes.
2. Contractor shall remove intact all fluorescent light tubes and/or thermostats from associated fixtures.
3. Contractor shall group light tubes in bundles not to exceed 64 tubes.
4. Contractor shall wrap bundles with cardboard and duct tape and protect from breakage as appropriate.

D. Preparation for removal of PCB and non-PCB containing ballasts:
   1. Contractor shall isolate all power to the light fixture prior to inspection or removal of ballasts.
   2. Contractor shall remove intact suspect PCB-containing ballasts from light fixtures using non-destructive methods.
   3. Contractor shall visually inspect each ballast and separate PCB and non-PCB ballasts into separate containers.
   4. Contractor shall place ballasts in 17H DOT-rated 55 gallon drums lined with a 6-mil liner.

E. Remove, clean and enclose in polyethylene the ceiling mounted objects such as light fixtures and other items that may interfere with the abatement process and were not previously cleaned and sealed. Utilize localized spraying of amended water and/or HEPA vacuums to reduce fiber dispersal during the removal of these fixtures.

F. Commencement of work shall not occur until City of Inglewood's Representative has verified and approved the following:
   1. Enclosure systems have been constructed and inspected.
   2. Differential pressure air filtration devices are functioning adequately.
   3. All pre-abatement submissions, notifications, postings and permits have been provided and are satisfactory to City of Inglewood's Representative.
   4. All equipment for abatement, cleanup and disposal are on hand.
   5. All worker training and certification is completed.

3.2 ALTERNATIVE PROCEDURES:

A. If specified procedures cannot be utilized, a request shall be made in writing to City of Inglewood's Representative providing details of the problem encountered and recommended alternatives.

B. Alternative procedures shall provide equivalent or greater protection than procedures that are replaced.

C. Any alternative procedure shall be approved in writing by City of Inglewood's Representative prior to the implementation of the procedure.

3.3 WORKER DECONTAMINATION ENCLOSURE SYSTEMS

A. Worker decontamination enclosure systems shall be provided at all locations where workers will enter or exit the work area. As a minimum, one system at a single location is required.

B. Worker decontamination enclosure systems constructed at the Project site shall utilize 6-mil black polyethylene sheeting, or other approved materials for privacy.

C. The worker decontamination enclosure system shall consist of at least a clean room, a shower room, and an equipment room, each separated from the other and from the work area by airlocks.

D. Access between rooms in the decontamination unit shall be through an airlock consisting of double "Z- flaps."

E. Clean rooms shall be sized to adequately accommodate the work crew. Space for storing respirators shall be provided in this area. Lockers for storing street clothes and other personal items, clean work clothes, clean disposable clothing, replacement filters for respirators, towels and other necessary items shall be provided in adequate supply in the clean room. A location for posting notices shall also be provided in the area.

C. In Public Areas: Field paint all conduit, boxes, hangers, supports and other electrical material in public areas and where exposed to view. Provide shop prime coat for equipment installed flush in painted walls. Finish painting is under Specification Section "Painting."

D. Touchup: Use factory supplied paint for touchup of marred or scratched surfaces. Replace marred or scratched plated finishes.

3.11 LICENSES, FEES AND PERMITS:

A. Arrange for required inspections and pay all license, permit and inspection fees. Furnish a certificate of final inspections and approvals from local authority having jurisdiction over electrical installation.

3.12 WORKMANSHIP AND CONTRACTOR'S QUALIFICATIONS

A. Only professional quality workmanship will be accepted. Haphazard or poor installation practice will be the cause for rejection of work.

B. Provide foreman in charge of this work at all times. Foreman for this work shall have had experience in installing not less than 5 such electrical systems of equal or greater complexity.

C. Where specifications call for an installation to be made in accordance with manufacturer's recommendations, a copy of such recommendations shall at all times be kept in job superintendent's office.

END OF SECTION 26 0500

SECTION 26 0519

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.
3. Sleeves and sleeve seals for cables.

B. Related Sections include the following:
1. Division 26 Section "Medium-Voltage Cables" for single-conductor and multiconductor cables, cable splices, and terminations for electrical distribution systems with 2001 to 35,000 V.
2. Division 26 Section "Undercarpet Electrical Power Cables" for flat cables for undercarpet installations.
3. Division 27 Section "Communications Horizontal Cabling" for cabling used for voice and data circuits.
4. Division 26 Section "Hangers and Supports for Electrical Systems."
5. Division 26 Section "Identification for Electrical Systems."
6. Division 7 Section "Joint Sealants."
7. Division 7 Section "Penetration Firestopping."

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Qualification Data: For testing agency.

C. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.6 COORDINATION

A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Alcad Stabiloy (Aluminum Conductor); Alcan Products Corporation; Alcan Cable Division.
2. American Insulated Wire Corp.; a Leviton Company.
3. Carol.
4. General Cable Corporation.
5. Pirelli Group.
6. Okonite Company, The.
7. Rome Wire Company.
8. Southwire Wire and Cable Company.
9. Southwest Wire and Cable.
10. Triangle copper conductors: Comply with NEMA WC70.

C. Copper Conductors: Comply with NEMA WC 70.

D. The design is based on copper conductors. Aluminum conductors may be considered for feeders as limited herein. If aluminum is proposed, then all conductors shall be upsized and all raceways shall be redesigned accordingly by the Contractor and shall meet requirements of the authority having jurisdiction. In the event that Contractor's design of aluminum use requires Engineer's review or approval, such work by the Engineer shall be considered as part of the Contractor's redesign cost. If aluminum is proposed, provide alternate cost.

E. Conductor Insulation: Comply with NEMA WC 70 for Types THW THHN-THWN and XHHW.

2.2 CONNECTORS AND SPLICES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AFC Cable Systems, Inc.
2. Hubbell Power Systems, Inc.
3. O-Z/Gedney; EGS Electrical Group LLC.
4. 3M; Electrical Products Division.
5. Tyco Electronics Corp.

C. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SLEEVES FOR CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.4 SLEEVE SEALS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide [**the product indicated on Drawings**] <**Insert manufacturer's name; product name or designation**> or a comparable product by one of the following:
1. Advance Products & Systems, Inc.
2. Calpico, Inc.
3. Metraflex Co.
4. Pipeline Seal and Insulator, Inc.

D. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
2. Pressure Plates: Carbon steel. Include two for each sealing element.
3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. Minimum size No. 12 AWG up to 100 feet at 120V; lengths exceeding 100 feet, use No. 10. For 277V, over 220 feet, use No. 10 minimum.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN-THWN, single conductors in raceway.

B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-THWN, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

E. Feeders Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway.

F. Feeders in Cable Tray: Type THHN-THWN, single conductors in raceway.

G. Exposed Branch Circuits, Including in Crawlspaces: Type THHN-THWN, single conductors in raceway.

H. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.

I. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

J. Branch Circuits Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway.

K. Branch Circuits in Cable Tray: Type THHN-THWN, single conductors in raceway.

L. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

M. Class 1 Control Circuits: Type THHN-THWN, in raceway.

N. Class 2 Control Circuits: Type THHN-THWN, in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."

F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

G. Not more than three lighting or convenience outlet circuits in one conduit unless otherwise indicated.

H. Pull no thermoplastic wires at temperatures lower than 32°F.

I. Unless specifically indicated, separate raceways for conductors of 120/208 and 277/480 volt systems, except 480 volt motor branch circuit wiring and related 120 volt control wiring. Separate raceways for emergency system conductors.

J. Individual raceways for two pole ungrounded circuits.

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

B. Terminations, splices and taps:
   1. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation rating than unspliced conductor.
   2. Copper conductors No. 10 and smaller: Compression type or twist-on spring loaded connectors and clear nylon insulated covering.
   3. Copper conductors No. 8 and larger: Mechanical bolted pressure or hydraulic compression type using manufacturers recommended tooling.
   4. Cable lugs and connectors: Compression type of same metal as conductor to match cables with marking indicating size and type.
   5. For copper lug connection to bus bars provide anti-seize compound.
   6. Aluminum conductors:
      a. Hydraulic compression AL-CU type with factory pre-filled joint compound, meeting UL 486 requirements and also meeting 500 cycle heating and current tests. Two bolt type for No. 4 and larger cables.
      b. Joint compound non-flowing in minus 60°F to 500°F temperature range with zinc particles, Thomas & Betts No. 21059 or equal.
      c. Bus bar connections: Tin plated lugs and compression type washers ("Belleville").
      d. Use oxide inhibitor in each splice and tap.

C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inchesof slack.

3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls. Comply with requirements in Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling".

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Rectangular Sleeve Minimum Metal Thickness:
   1. For sleeve rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.
   2. For sleeve rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 0.138 inch.

E. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

F. Cut sleeves to length for mounting flush with both wall surfaces.

G. Extend sleeves installed in floors 2 inches above finished floor level.

H. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and cable unless sleeve seal is to be installed[**or unless seismic criteria require different clearance**].

I. Seal space outside of sleeves with grout for penetrations of concrete and masonry[**and with approved joint compound for gypsum board assemblies**].

J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants."

K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 07 Section "Penetration Firestopping."

L. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work. Obtain written approval from roofing contractor for actual materials being used and methods of installation.

M. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

N. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.6 SLEEVE-SEAL INSTALLATION

A. Install to seal underground exterior-wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Perform tests and inspections and prepare test reports.

C. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

D. Test Reports: Prepare a written report to record the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

E. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 26 0519

SECTION 26 0526

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes methods and materials for grounding systems and equipment:
1. Overhead-lines grounding.
2. Underground distribution grounding.
3. Common ground bonding with lightning protection system.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in Part 3 "Field Quality Control" Article, including the following:
1. Test wells.
2. Ground rods.
3. Ground rings.
4. Grounding arrangements and connections for separately derived systems.
5. Grounding for sensitive electronic equipment.

C. Qualification Data: For testing agency and testing agency's field supervisor.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For grounding to include the following in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Instructions for periodic testing and inspection of grounding features at test wells grounding connections for separately derived systems based on NFPA 70B.
   a. Tests shall be to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.
   b. Include recommended testing intervals.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association to supervise on-site testing specified in Part 3.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:
1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned conductor: ASTM B33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Bare Grounding Conductor and Conductor Protector for Wood Poles:
1. No. 4 AWG minimum, soft-drawn copper.
2. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir or cypress or cedar.

D. Grounding Bus: Rectangular bars of annealed copper, 1/4 by 4 inches in cross section, drilled and tapped with 3/8" coarse thread (2 rows at 2" [50 mm] centers), unless otherwise indicated; with insulators. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600V. Lexan or PVC, impulse tested at 5000V.

2.2 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors to Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Bus-bar Connectors: Mechanical type, cast silicon bronze solderless [**compression**] [**exothermic**]-type wire terminals and long-barrel two-bolt connection to ground bus-bar.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper- clad steel, suitable for adding multiple sections, minimum 10 feet (3 M) long, ¾ inch (19 mm) diameter.

B. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.
   1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches long.
   2. Backfill Material: Electrode manufacturer's recommended material.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.
   1. Bury at least 24 inches below grade.
   2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation. For concrete encased duct banks, provide #4/0 bare copper conductor in concrete 1" above top duct.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Grounding Bus: Install in electrical and telephone/telecommunication equipment rooms, in rooms housing service equipment, and all other low-voltage equipment rooms and elsewhere as indicated.
   1. Install bus on insulated spacers 1 inch, minimum, from wall 6 inches above finished floor, unless otherwise indicated.
   2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and connect to horizontal bus.

E. Conductor Terminations and Connections:
   1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
   2. Underground Connections: Welded connectors, except at test wells and as otherwise indicated.
   3. Connections to Ground Rods at Test Wells: Bolted connectors.
   4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING OVERHEAD LINES

A. Comply with IEEE C2 grounding requirements.

B. Install 2 parallel ground rods at least "length of rod" distance apart and connected by 4/0 cable if resistance to ground by a single, ground-rod electrode exceeds 25 ohms.

C. Drive ground rods until tops are 12 inches below finished grade in undisturbed earth.

D. Ground-Rod Connections: Install welded connections for underground connections and connections to rods.

E. Lightning Arrester Grounding Conductors: Separate from other grounding conductors. Bond the lightning arrestor ground system to the electrical safety ground system at a minimum of one location underground.

F. Secondary Neutral and Transformer Enclosure: Interconnect and connect to grounding conductor.

G. Protect grounding conductors running on surface of wood poles with molding extended from grade level up to and through communication service and transformer spaces.

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended in written instructions by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.4 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.
8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
9. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.

10. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.

C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

E. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Electrically isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

F. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Electrically isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

G. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J-STD-607-A.
1. For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
2. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-4-by-36-inch grounding bus.
3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

3.5 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade, unless otherwise indicated.
1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Division 26 Section "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.
   1. Test Wells: Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
   1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
   2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
   3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

F. Grounding and Bonding for Piping:
   1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to street side ahead of the water meter main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
   2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
   3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install [**tinned**]bonding jumper to bond across flexible duct connections to achieve continuity.

H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of the building.
   1. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
   2. Bury ground ring not less than 24 inches from building foundation.
   3. Where roof drip line varies from above locations, install conductor at roofing drip lines.

J. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, using a minimum of 20 feetof bare copper conductor not smaller than No. 4 AWG.
   1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
   2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to grounding electrode external to concrete.

K. Exothermic Connectors: Welds shall be made in accordance with kit recommendations. Damp materials shall not be used. Puffed up or connections that are not fully formed or where material is missing, shall be replaced.

3.6 LABELING

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems" Article for instruction signs. The label or its text shall be green.

B. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.
   1. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

E. Perform the following tests and inspections and prepare test reports:
   1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
   2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
   3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.
      a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
      b. Perform tests by fall-of-potential method according to IEEE 81.
   4. Prepare dimensioned drawings locating each test well, ground rod and ground rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

F. Grounding system will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

H. Report to Engineer, in a separate document, measured ground resistances that exceed the following values:
   1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.
   2. Substations and Pad-Mounted Equipment: 5 ohms.
   3. Manhole Grounds: 10 ohms.

I. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 26 0526

SECTION 26 0529

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

B. Related Sections include the following:

1. Division 26 Section "Vibration And Seismic Controls For Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Contractor shall provide all required support, seismic bracing (based on structural assigned zone) and anchor bolts. Drawings signed by a registered structural engineer to be retained by the Contractor. Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Steel slotted support systems.
2. Nonmetallic slotted support systems.
3. Hanger rods.
4. Steel channels.
5. Brackets and clamps.
6. Anchors and inserts.
7. The drawings provided by the contractor shall be submitted in a shop drawing format for project structural engineer for review and comment.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:

1. Trapeze hangers. Include Product Data for components.
2. Steel slotted channel systems. Include Product Data for components.
3. Nonmetallic slotted channel systems. Include Product Data for components.
4. Equipment supports.

C. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Comply with NFPA 70.

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Allied Tube & Conduit.
   b. Cooper B-Line, Inc.; a division of Cooper Industries.
   c. ERICO International Corporation.

d. GS Metals Corp.
e. Thomas & Betts Corporation.
f. Unistrut; Tyco International, Ltd.
g. Wesanco, Inc.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
5. Channel Dimensions: Selected for applicable load criteria.

B. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch-diameter holes at a maximum of 8 inches o.c., in at least 1 surface.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Allied Tube & Conduit.
b. Cooper B-Line, Inc.; a division of Cooper Industries.
c. Fabco Plastics Wholesale Limited.
d. Seasafe, Inc.

2. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
3. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.
4. Rated Strength: Selected to suit applicable load criteria.

C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

D. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

F. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Hilti Inc.

2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
3) MKT Fastening, LLC.
4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Cooper B-Line, Inc.; a division of Cooper Industries.
2) Empire Tool and Manufacturing Co., Inc.
3) Hilti Inc.
4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

F. Shower room shall contain one or more showers as necessary to adequately accommodate workers. Each shower head shall be supplied with warm and cold water adjustable at the tap. The shower enclosure shall be constructed to ensure against leakage of any kind. An adequate supply of soap, shampoo and towels shall be supplied by Contractor and available at all times. Shower water shall be drained, collected and filtered through a system with at least 0.5-1.0 micron particle size collection capability.

G. The equipment room shall be used for storage of equipment and tools at the end of a shift after they have been decontaminated using a HEPA filtered vacuum and/or wet cleaning techniques as appropriate. Replacement filters (in sealed containers until used) for filtration equipment, extra tools, containers or surfactant and other materials and equipment that may be required during the abatement may also be stored here as needed.
   1. A walk-off pan (a small children's swimming pool or equivalent filled with water shall be located in the room for workers to clean off foot coverings after leaving the work area and prevent excessive contamination of the worker decontamination enclosure system.
   2. A drum lined with a labeled 6-mil polyethylene bag for collection of disposable clothing shall be located in this room. Contaminated footwear shall be stored in this area for reuse the following workday.

H. Maintenance of Work Place Barriers and Worker Decontamination Enclosure Systems:
   1. After the construction of all polyethylene barriers and decontamination system enclosures are complete, allow sufficient settling time to insure that barriers will remain intact and secured to walls and fixtures before actual abatement activities.
   2. Inspect all polyethylene barriers inside the work place and worker decontamination enclosure systems constructed to isolate the work area at least twice daily, prior to the start of each day's abatement activities. Contractor shall document inspections and observations in the daily project log.
   3. Damage and defects in the enclosure system shall be repaired immediately upon discovery.
   4. Use smoke tubes to test the integrity of the barrier system at least once for each 24 hour period or when requested by City of Inglewood's Representative.
   5. At any time during the abatement activities after barriers have been erected, if visible hazardous material is observed outside of the work area or if damage occurs to barriers, work shall immediately stop, repairs made to barriers and the debris or residue cleaned up using appropriate HEPA vacuuming and wet mopping.
   6. If air samples collected outside of the work area during abatement activities indicate airborne concentrations greater than any applicable PEL or pre-measured background levels (whichever is higher) work shall immediately stop for inspection and repair of barriers. Cleanup of surfaces outside of the work area using HEPA vacuums or wet cleaning techniques will be required.
   7. Install and initiate operation of differential pressure air filtration equipment as needed to provide one air change in the work area at least every 15 minutes. Openings made in the enclosure system to accommodate these units shall be made airtight with tape and/or caulking as needed. Insure that adequate power supply is available to satisfy the requirements of the filtration devices. Differential pressure air filtration devices shall be exhausted to the outside of the building. These shall not be exhausted into occupied areas of the building. Careful installation, air monitoring and daily inspections shall be conducted to insure that the ducting does not release fibers into the uncontaminated building areas.

I. Once barriers are constructed, and the differential pressure air filtration devices are in operation, the containment shall be tested for leakage utilizing smoke tubes. Repair the barriers as needed.

J. Monitor negative pressure within removal area to ensure that an adequate level is maintained. Check readings, and record, 3 times each work shift; at the beginning, at midpoint, and end.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1:

1. Support vertical conduits passing through sleeves with UL approved riser clamps secured to the conduit and resting on the building structure. Support vertical conduits 1-1/4" and larger a minimum of once, and on 15' centers maximum. For vertical conduits smaller than 1-1/4" provide standoffs on 8' centers maximum. Support conduits adjacent to walls with preformed channels. Support freestanding risers with conduit racks of angle iron or channel iron members, rigidly bolted or welded together, and adequately braced.
2. Support rigid steel conduit, and intermediate metal conduit 1" and larger on 10' intervals, smaller than 1" on 7' intervals, all sizes within 3' of connection to any electrical enclosure, box, cabinet, or fitting, including couplings.
3. Support electric metallic tubing on maximum spacing of 10' and within 3' of connection to any electrical enclosure, box, cabinet, or fitting, including couplings.
4. Support flexible metal conduit on 4' intervals, within 1' of outlet box or fitting (except at connections to recessed lighting fixtures) and within 2' of vibrating equipment.
5. Support gutter and wireways at 5' intervals and at changes of direction, in a manner to allow full access.
6. Do not fasten rigid conduit or tubing to equipment subject to vibration or mounted on shock mounts.
7. Where not otherwise specified herein, support all sizes of suspended conduit from beams or girders with factory made pipe hangers with split hinged malleable iron or springable steel pipe rings and solid round mild steel rods, 1/4" diameter for up to 1–1/4" conduit, 3/8" diameter up to 2" conduit, and 1/2" diameter for larger conduit. Friction type conduit support hardware and attachments are acceptable for a maximum of two 1/2" or 3/4" conduits. Where required conduit support spacing is more frequent than structural members, provide intermediate steel support as required.
8. Provide plated or galvanized hangers, threaded rods, channels and metallic support and fastening material or provide two coats of rust resistant paint, in all damp or corrosive locations.
9. Support conduit to structure above suspended ceilings 3" minimum above ceiling to allow removal of tile. Do not support from T-bars or T-bar hanger wires. Maintain 2" clearance above recessed light fixtures.
10. Do not use perforated metal strap or wood as support material.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.

5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Sections "Cast-in-Place Concrete, Cast-in-Place Concrete (Limited Applications)."

C. Anchor equipment to concrete base.

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

D. Provide for:

1. Switchboards, switchgears, unit substation and floor mounted ATS.
2. Standby power plants.
3. Floor mounted transformers.
4. Motor control centers.
5. Outdoor light fixture standards.
6. UPS.
7. All other floor mounted equipment.

3.5 PAINTING

A. Areas Exposed to View: Field paint all hangers, supports and other hardware in public areas where exposed to view. Coordinate color with Architect.

B. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

C. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

D. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 26 0529

SECTION 26 0533

RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

B. Related Sections include the following:
   1. Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
   2. Division 26 Section "Common Work Results for Electrical."

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. EPDM: Ethylene-propylene-diene terpolymer rubber.

C. FMC: Flexible metal conduit.

D. IMC: Intermediate metal conduit.

E. LFMC: Liquidtight flexible metal conduit.

F. LFNC: Liquidtight flexible nonmetallic conduit.

G. NBR: Acrylonitrile-butadiene rubber.

H. RNC: Rigid nonmetallic conduit.

I. ID: Inner duct.

1.4 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.
   1. Custom enclosures and cabinets.
   2. For handholes and boxes for underground wiring, including the following:

a. Duct entry provisions, including locations and duct sizes.
b. Frame and cover design.
c. Grounding details.
d. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
e. Joint details.

C. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
1. Structural members in the paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.

D. Manufacturer Seismic Qualification Certification: Submit certification that enclosures and cabinets and their mounting provisions, including those for internal components, will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the cabinet or enclosure will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will retain its enclosure characteristics, including its interior accessibility, after the seismic event."
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Qualification Data: For professional engineer and testing agency.

F. Source quality-control test reports.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AFC Cable Systems, Inc.
2. Alflex Inc.
3. Allied Tube & Conduit; a Tyco International Ltd. Co.
4. Anamet Electrical, Inc.; Anaconda Metal Hose.
5. Electri-Flex Co.
6. Manhattan/CDT/Cole-Flex.

7. Maverick Tube Corporation.
8. O-Z Gedney; a unit of General Signal.
9. Wheatland Tube Company.

C. Rigid Steel Conduit: ANSI C80.1.

D. IMC: ANSI C80.6.

E. PVC-Coated Steel Conduit: PVC-coated IMC.
1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch, minimum.

F. EMT: ANSI C80.3.

G. FMC: Zinc-coated steel or aluminum.

H. LFMC: Flexible steel conduit with PVC jacket.

I. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
2. Fittings for EMT: Compression type.
3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch, with overlapping sleeves protecting threaded joints.

J. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2 NONMETALLIC CONDUIT AND TUBING

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AFC Cable Systems, Inc.
2. Anamet Electrical, Inc.; Anaconda Metal Hose.
3. Arnco Corporation.
4. CANTEX Inc.
5. CertainTeed Corp.; Pipe & Plastics Group.
6. Condux International, Inc.
7. ElecSYS, Inc.
8. Electri-Flex Co.
9. Lamson & Sessions; Carlon Electrical Products.
10. Manhattan/CDT/Cole-Flex.
11. RACO; a Hubbell Company.
12. Thomas & Betts Corporation.

C. RNC: NEMA TC 2, [**Type EPC-40-PVC,**]unless otherwise indicated.

D. LFNC: UL 1660.

E. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.

F. Fittings for LFNC: UL 514B.

2.3 OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY AND FITTINGS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Arnco Corporation.
2. Endot Industries Inc.
3. IPEX Inc.
4. Lamson & Sessions; Carlon Electrical Products.

2.4 METAL WIREWAYS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.

C. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type [**1**] [**12**] [**3R**], unless otherwise indicated.

D. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

E. Wireway Covers: Screw-cover type.

F. Finish: Manufacturer's standard enamel finish.

2.5 NONMETALLIC WIREWAYS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Hoffman.
2. Lamson & Sessions; Carlon Electrical Products.

C. Description: Fiberglass polyester, extruded and fabricated to size and shape indicated, with no holes or knockouts. Cover is gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections are flanged, with stainless-steel screws and oil-resistant gaskets.

D. Description: PVC plastic, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.

E. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

2.6 SURFACE RACEWAYS

A. Surface Metal Raceways: Galvanized steel with snap-on covers. Enamel finish in color selected by Architect.
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Thomas & Betts Corporation.
      b. Walker Systems, Inc.; Wiremold Company (The).
      c. Wiremold Company (The); Electrical Sales Division.

B. Surface Nonmetallic Raceways: Two-piece construction, manufactured of rigid PVC with texture and color selected by Architect from [**manufacturer's standard**] [**custom**] colors.
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Butler Manufacturing Company; Walker Division.
      b. Enduro Systems, Inc.; Composite Products Division.
      c. Hubbell Incorporated; Wiring Device-Kellems Division.
      d. Lamson & Sessions; Carlon Electrical Products.
      e. Panduit Corp.
      f. Walker Systems, Inc.; Wiremold Company (The).
      g. Wiremold Company (The); Electrical Sales Division.

2.7 BOXES, ENCLOSURES, AND CABINETS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
   2. EGS/Appleton Electric.
   3. Erickson Electrical Equipment Company.
   4. Hoffman.
   5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
   6. O-Z/Gedney; a unit of General Signal.
   7. RACO; a Hubbell Company.
   8. Robroy Industries, Inc.; Enclosure Division.
   9. Scott Fetzer Co.; Adalet Division.
   10. Spring City Electrical Manufacturing Company.
   11. Thomas & Betts Corporation.
   12. Walker Systems, Inc.; Wiremold Company (The).
   13. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.

C. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

D. Cast-Metal Outlet and Device Boxes: NEMA FB 1, [**ferrous alloy**] [**aluminum**], Type FD, with gasketed cover.

E. Nonmetallic Outlet and Device Boxes: NEMA OS 2.

F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

G. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized, cast iron with gasketed cover.

H. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Nonmetallic Enclosures: Plastic[**, finished inside with radio-frequency-resistant paint**].

I. Cabinets:
1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.

2.8 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
1. Tests of materials shall be performed by a independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
1. Exposed Conduit: Rigid steel conduit.
2. Concealed Conduit, Aboveground: EMT.
3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFNC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
6. Application of Handholes and Boxes for Underground Wiring:
   a. Handholes and Pull Boxes in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Polymer concrete Fiberglass-reinforced polyester resin, SCTE 77, Tier 15 structural load rating.
   b. Handholes and Pull Boxes in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: [**Polymer-concrete units**] [**Heavy-duty fiberglass units with polymer-concrete frame and cover**], SCTE 77, Tier 8 structural load rating.
   c. Handholes and Pull Boxes Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf vertical loading.

B. Comply with the following indoor applications, unless otherwise indicated:
1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:

a. Loading dock.
b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
c. Mechanical rooms.
d. **<Insert designations of applicable spaces or locations.>**

4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: Rigid steel conduit.
7. Raceways for Optical Fiber or Communications Cable in Spaces Used for Environmental Air: EMT.
8. Raceways for Optical Fiber or Communications Cable Risers in Vertical Shafts: EMT.
9. Raceways for Concealed General Purpose Distribution of Optical Fiber or Communications Cable: EMT.
10. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

F. Do not install aluminum conduits in contact with concrete.

3.2 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."

E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.

H. Raceways Embedded in Slabs:
1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Change from Type EPC-40-PVC to rigid steel conduit, before rising above the floor.

3.4 WASTE CONTAINER REMOVAL AIRLOCK

A. The waste container pass-out airlock shall be constructed away from the Decontamination Enclosure System. This airlock shall be in a location that provides direct access from Abatement Work area to the outside of the building if possible.

B. This system shall consist of an airlock, container Staging Area, and another airlock providing access to outside Abatement Work area.

C. The waste container airlock shall be constructed in similar fashion with similar materials as the Decontamination Enclosure System.

D. This airlock system shall not be used to enter or exit the Abatement Work area.

3.5 EMERGENCY EXITS

A. Emergency exits shall be established and clearly marked with duct tape arrows or other effective ways to permit easy location from anywhere within the work area. If duct tape arrows are utilized, the arrows shall be a different color from the tape used to secure the polyethylene sheeting. Red or yellow duct tape is preferred to mark emergency exits.

B. Emergency exits shall be secured to prevent access from uncontaminated areas and still permit emergency exiting. These exits shall be properly sealed with polyethylene sheeting which can be cut to permit exiting, if needed. A utility knife shall be taped close to the bottom of the exit for use in cutting the polyethylene sheeting in case of emergency.

3.6 WORKPLACE ENTRY AND EXIT PROCEDURES

A. Personnel Entry and Exit:
   1. All workers and authorized personnel shall enter the work area through the worker decontamination enclosure system.
   2. Contractor shall ensure that all personnel who enter the work area sign the entry/exit log.
   3. Contractor shall ensure that all personnel, before entering the work area, read and are familiar with all posted regulations, personal protection requirements (including work place entry and exit procedures) and emergency procedures.
   4. All personnel shall proceed first to the clean room, remove all street clothes and appropriately don respiratory protection and disposable coveralls, head covering and foot covering. Hard hats, eye protection and gloves shall also be utilized. Clean respirator and protective clothing shall be provided and utilized by each person for each separate entry into the work area.
   5. Personnel wearing designated personal protective equipment shall proceed from the clean room through the shower room and equipment room to the main work area.
   6. Before leaving the work area, all personnel shall remove gross contamination from the outside of respirators and protective clothing by brushing and/or wet wiping procedures (small HEPA vacuums with brush attachments may be utilized for this purpose). Each person shall clean bottom of protective footwear in the walk off pan prior to entering the equipment room.
   7. Personnel shall proceed to the equipment room where they remove all protective equipment except respirators. Upon completion of abatement, protective equipment shall be properly cleaned for reuse or disposed of as hazardous materials contaminated waste.
   8. Reusable, contaminated footwear shall be stored in equipment room when not in use in the work area. Upon completion of abatement, it shall be properly cleaned for reuse or disposed of as hazardous materials contaminated waste.
   9. Still wearing respirators, personnel shall proceed to the shower area, clean the outside of the respirators and the exposed face area under running water prior to removal of respirator then shower and shampoo to remove residual hazardous materials contamination. Various types of respirators will require slight modification of these procedures. An airline respirator with a HEPA filtered disconnect protection may be disconnected in the equipment room and worn into the shower. A powered air purifying respirator face piece will have to be disconnected from the filter/power pack assemble which is not waterproof, upon entering the shower. A dual

I. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

J. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

K. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.

L. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid inner duct and flexible, as follows:
1. 3/4-Inch Trade Size and Smaller: Install raceways in maximum lengths of 50 feet.
2. 1-Inch Trade Size and Larger: Install raceways in maximum lengths of 75 feet.
3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
4. Install 1¼" orange or blue inner duct system in raceways for all fiber optic cables.

M. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where otherwise required by NFPA 70.

N. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F, and that has straight-run length that exceeds 25 feet.
1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:
   a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg Ftemperature change.
   b. Outdoor Locations Exposed to Direct Sunlight: 155 deg Ftemperature change.
   c. Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F temperature change.
   d. Attics: 135 deg F temperature change.
2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change.
3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.

O. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

P. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.

Q. Set metal floor boxes level and flush with finished floor surface.

R. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:
1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Division 31 Section "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
   a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
   b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
6. Warning Planks: Bury warning planks approximately 12 inches above direct-buried conduits, placing them 24 inches o.c. Align planks along the width and along the centerline of conduit.

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

D. Install handholes and boxes with bottom below the frost line, below grade.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.

F. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 26 0533

SECTION 26 0543

UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Division 26 Section "Common Work Results for Electrical."

C. Division 26 Section "Medium Voltage Cables."

D. Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

E. Division 26 Section "Grounding and Bonding for Electrical Systems."

F. Division 26 Section "Identification for Electrical Systems."

1.2 SUMMARY

A. This Section includes the following:

1. Conduit, ducts, and duct accessories for [**direct-buried**] [**and**] [**concrete-encased**] duct banks[**, and in single duct runs**].
2. Handholes and boxes.
3. Manholes.

1.3 DEFINITION

A. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Duct-bank materials, including separators and miscellaneous components.
2. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Accessories for manholes, handholes, boxes[**, and other utility structures**].
4. Warning tape.
5. Warning planks.

B. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:

1. Duct entry provisions, including locations and duct sizes.

2. Reinforcement details.
3. Frame and cover design and manhole frame support rings.
4. [**Ladder**] [**Step**] details.
5. Grounding details.
6. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
7. Joint details.

C. Shop Drawings for Factory-Fabricated Handholes and Pull Boxes other than Precast Concrete: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:

1. Duct entry provisions, including locations and duct sizes.
2. Cover design.
3. Grounding details.
4. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

D. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.

1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
2. Drawings shall be signed and sealed by a qualified professional engineer.

E. Product Certificates: For concrete and steel used in precast concrete [**manholes**] [, **pull boxes**] [**and**] [**handholes**], as required by ASTM C 858.

F. Qualification Data: For professional engineer and testing agency.

G. Source quality-control reports.

H. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

B. Comply with ANSI C2.

C. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

B. Store [**precast concrete**] [**and**] [**other factory-fabricated**] underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.

C. Lift and support precast concrete units only at designated lifting or supporting points.

1.7 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify **[Architect]** **[Construction Manager]** **[Owner]** no fewer than **thirty [30]** <**Insert number**> days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without **[Architect's]** **[Construction Manager's]** **[Owner's]** written permission.

1.8 COORDINATION

A. Coordinate layout and installation of ducts, manholes, handholes, and pull boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.

B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and pull boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.

1.9 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Furnish cable-support stanchions, arms, [**insulators,**] and associated fasteners in quantities equal to **5** percent of quantity of each item installed.

PART 2 - PRODUCTS

2.1 CONDUIT

A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.

B. RNC: NEMA TC 2, **Type EPC-80-PVC**, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.2 NONMETALLIC DUCTS AND DUCT ACCESSORIES

A. Available Manufacturers: Subject to compliance with requirements, **provide products by one of the following**] ~~**[available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**~~

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:

1. ARNCO Corp.
2. Beck Manufacturing.
3. Cantex, Inc.
4. CertainTeed Corp.; Pipe & Plastics Group.
5. Condux International, Inc.
6. ElecSys, Inc.
7. Electri-Flex Company.
8. IPEX Inc.
9. Lamson & Sessions; Carlon Electrical Products.
10. Manhattan/CDT; a division of Cable Design Technologies.
11. Spiraduct/AFC Cable Systems, Inc.

D. Underground Plastic Utilities Duct: NEMA TC 6 & 8, Type EB-20-PVC, ASTM F 512, UL 651A, with matching fittings by the same manufacturer as the duct, complying with NEMA TC 9.

E. Underground Plastic Utilities Duct: NEMA TC 6 & 8, **Type DB-120-PVC**, ASTM F 512, with matching fittings by the same manufacturer as the duct, complying with NEMA TC 9.

F. Duct Accessories:

1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
2. Warning Tape: Underground-line warning tape specified in Division 26 Section "Identification for Electrical Systems."
3. Concrete Warning Planks: 12 by 24 by 3 inches in size, manufactured from 6000-psiconcrete.

   a. Color: Red dye added to concrete during batching.
   b. Mark each plank with "ELECTRIC" in 2-inch-high, 3/8-inch-deep letters.

2.3 PRECAST CONCRETE HANDHOLES AND PULL BOXES

A. Available Manufacturers: Subject to compliance with requirements, [**provide products by one of the following**] ~~[**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:~~

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Carder Concrete Products.
2. Christy Concrete Products.
3. Elmhurst-Chicago Stone Co.
4. Oldcastle Precast Group.
5. Riverton Concrete Products; a division of Cretex Companies, Inc.
6. Utility Concrete Products, LLC.
7. Utility Vault Co.
8. Wausau Tile, Inc.
9. Jensen.

C. Comply with ASTM C 858 for design and manufacturing processes.

D. Ferrous metal hardware shall be hot-dip galvanized in accordance with ASTM A153and ASTM A123.

E. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or pull box.

1. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
2. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
3. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.

   a. Cover Hinges: Concealed, with hold-open ratchet assembly.
   b. Cover Handle: Recessed.

4. Frame and Cover: Weatherproof aluminum frame with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing bolts.

   a. Cover Hinges: Concealed, with hold-open ratchet assembly.
   b. Cover Handle: Recessed.

5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, **["ELECTRIC."]** **["TELEPHONE."]** **[As indicated for each service.]** ~~<**Insert legend.**>~~
7. Configuration: Units shall be designed for flush burial and have **[open]** **[closed]** **[integral closed]** bottom, unless otherwise indicated.
8. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.

   a. Extension shall provide increased depth of **12 inches.**
   b. Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.

9. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches vertically and horizontally to accommodate alignment variations.

   a. Windows shall be located no less than 6 inches from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
   b. Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
   c. Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.

10. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

    a. Type and size shall match fittings to duct or conduit to be terminated.
    b. Fittings shall align with elevations of approaching ducts and be located near interior corners of handholes to facilitate racking of cable.

11. Handholes **12 inches wide by 24 inches long** and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.4 HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Description: Comply with SCTE 77.

1. Color: [**Gray**] ~~[**Green**].~~
2. Configuration: Units shall be designed for flush burial and have [**open**] [**closed**] [**integral closed**] bottom, unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering,

    a. [**"ELECTRIC."**] [**"TELEPHONE."**] [**As indicated for each service.**] ~~<**Insert legend**>.~~
    b. Tier level number, indicating that the unit complies with the structural load test for that tier according to SCTE 77.

6. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
7. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
8. Handholes **12 inches wide by 24 inches long** and larger shall have factory-installed inserts for cable racks and pulling-in irons.

B. Polymer Concrete Handholes and Pull Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two. Handholes and pull boxes shall comply with the requirements of SCTE 7 ~~[**Tier 5**] [**Tier 8**]~~ [**Tier 15**] [**Tier 22**] loading.

1. Available Manufacturers: Subject to compliance with requirements, [**provide products by one of the following**] ~~[**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:~~
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:

    a. Armorcast Products Company.
    b. Carson Industries LLC.
    c. CDR Systems Corporation.
    d. NewBasis.

C. Fiberglass Handholes and Pull Boxes with Polymer Concrete Frame and Cover: Complying with SCTE 77 **Tier 15** loading. Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.

1. Available Manufacturers: Subject to compliance with requirements, [**provide products by one of the following**] ~~[**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:~~
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:

    a. Armorcast Products Company.
    b. Carson Industries LLC.

c. Christy Concrete Products.
d. Synertech Moulded Products, Inc.; a division of Oldcastle Precast.

D. Fiberglass Handholes and Pull Boxes: Molded of fiberglass-reinforced polyester resin, with covers of [**polymer concrete**] [**reinforced concrete**] [**cast iron**] [**hot-dip galvanized-steel diamond plate**] [**fiberglass**], complying with SCTE 77 [**Tier 8**] [**Tier 5**] loading.

1. Available Manufacturers: Subject to compliance with requirements, [**provide products by one of the following**] ~~**[available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**~~
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:

a. Carson Industries LLC.
b. Christy Concrete Products.
c. Nordic Fiberglass, Inc.

E. High-Density Plastic Pull Boxes: Injection molded of high-density polyethylene or copolymer-polypropylene, complying with SCTE 77 [**Tier 5**] [**Light Duty**] loading. Cover shall be **polymer concrete.**

1. Available Manufacturers: Subject to compliance with requirements, [**provide products by one of the following**] ~~**[available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**~~
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:

a. Carson Industries LLC.
b. Nordic Fiberglass, Inc.
c. PenCell Plastics.

2.5 PRECAST MANHOLES

A. Available Manufacturers: Subject to compliance with requirements, **[provide products by one of the following]** ~~**[available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**~~

B. Manufacturers: Subject to compliance with requirements**, [provide products by one of the following]** ~~**[available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**~~

1. Carder Concrete Products.
2. Christy Concrete Products.
3. Elmhurst-Chicago Stone Co.
4. Oldcastle Precast Group.
5. Riverton Concrete Products; a division of Cretex Companies, Inc.
6. Utility Concrete Products, LLC.
7. Utility Vault Co.
8. Wausau Tile, Inc.
9. Jensen.

cartridge respirator may be worn into the shower. Cartridges shall be replaced for each new entry into the work area.

10. After showering and drying off, personnel shall proceed to the clean room and don clean disposable clothing if there will be later reentry into the work area or street clothes if it is the end of the work shift.

3.7 REMOVAL PROCEDURES

A. Wet all hazardous and contaminated material with an amended water solution. The wetting agent will be mixed according to manufacturer's printed instructions and then applied using equipment capable of providing a fine spray mist, in order to reduce airborne particulate concentrations when the material is disturbed during removal and vacuuming. Saturate the hazardous material; however, do not allow excessive water to accumulate. Keep all removed material wet enough to prevent particulate release until it can be containerized for disposal. Maintain high humidity in the work area by misting or spraying to assist in particulate settling and reduce airborne concentrations.
   1. The following procedures shall apply to operations involving VOCs:
      a. VOC-contaminated soil stockpiles shall be sprayed with water and/or an approved vapor suppressant and cover with 6-mil plastic sheeting for all periods of inactivity greater than one-hour.
      b. All covered VOC-contaminated soil stockpiles shall be visually inspected to ensure integrity of the plastic covering.
      c. VOC-impacted stockpiles shall be segregated from non-VOC impacted stockpiles.

B. Saturated hazardous material shall be removed in manageable sections. Removed material should be containerized before moving to a new location for continuance of work. Surrounding areas shall be periodically sprayed and maintained in a wet condition until visible material is cleaned.

C. Material removed from building structures or components shall not be dropped or thrown to the floor. Material shall be removed as intact sections or components and carefully lowered to the floor.

D. Containers (double 6-mil polyethylene bags or drums) shall be sealed when full. Bags shall not be overfilled. They shall be securely sealed to prevent accidental opening and leakage by tying tops of bags in an overhand knot or by taping in gooseneck fashion. Do not seal bags with wire or cord. Bags shall be decontaminated on exterior surfaces by wet cleaning and HEPA vacuuming.

E. Generator name and address labels shall be affixed to waste containers prior to disposal.

F. Hazardous waste with sharp-edged components (e.g., nails, screws, metal lath, tin sheeting) will tear the polyethylene bags and sheeting and shall be placed into drums for disposal.

G. Containment of Released Substances:
   1. If a hazardous material appears to be leaking or otherwise spreading, contain the release of the material. Provide all measures to prevent the release of the material to the environment and protect all Project site personnel, adjacent properties and occupants, and the general public from potential exposure.
   2. During the course of substance containment or evacuation of Project site personnel, protect personnel (onsite workers, non-workers, or the general public) from contact with or exposure to the released substances.
   3. The abatement or evaluation of any suspected hazardous material shall only be performed by properly trained and/or certified personnel.

H. After removal of the hazardous material, surfaces from which hazardous materials have been removed shall be wet brushed and sponged or cleaned by some equivalent method to remove all visible residues.

I. After the work area has been rendered free of visible residue, a thin coat of a satisfactory encapsulating agent shall be applied to all surfaces in the work area including structural members, building components and plastic sheeting on walls, floors, and covering non-removable items, to seal in non-visible residue.

C. Comply with ASTM C 858[**, with structural design loading as specified in Part 3 "Underground Enclosure Application" Article**] and with interlocking mating sections, complete with accessories, hardware, and features.

1. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches vertically and horizontally to accommodate alignment variations.

   a. Windows shall be located no less than 6 inches from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
   b. Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
   c. Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.

2. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

   a. Type and size shall match fittings to duct or conduit to be terminated.
   b. Fittings shall align with elevations of approaching ducts and be located near interior corners of manholes to facilitate racking of cable.

D. Concrete Knockout Panels: 1-1/2 to 2 inches thick, for future conduit entrance and sleeve for ground rod.

E. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.6 CAST-IN-PLACE MANHOLES

A. Description: Underground utility structures, constructed in place, complete with accessories, hardware, and features. Include concrete knockout panels for conduit entrance and sleeve for ground rod.

B. Materials: Comply with ASTM C 858 and with Division 03 Section "Cast-in-Place Concrete."

1. Concrete shall have a minimum compressive strength of 3000 psi.

C. Structural Design Loading: As specified in Part 3 "Underground Enclosure Application" Article.

2.7 UTILITY STRUCTURE ACCESSORIES

A. Available Manufacturers: Subject to compliance with requirements, [**provide products by one of the following**] ~~[available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:~~

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Bilco Company (The).
2. Campbell Foundry Company.
3. Carder Concrete Products.
4. Christy Concrete Products.
5. East Jordan Iron Works, Inc.

6. Elmhurst-Chicago Stone Co.
7. McKinley Iron Works, Inc.
8. Neenah Foundry Company.
9. NewBasis.
10. Oldcastle Precast Group.
11. Osburn Associates, Inc.
12. Pennsylvania Insert Corporation.
13. Riverton Concrete Products; a division of Cretex Companies, Inc..
14. Strongwell Corporation; Lenoir City Division.
15. Underground Devices, Inc.
16. Utility Concrete Products, LLC.
17. Utility Vault Co.
18. Wausau Tile, Inc.
19. Jensen.

C. Ferrous metal hardware, where indicated, shall be hot-dip galvanized complying with ASTM A 153 and A 123.

D. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.

1. Frame and Cover: Weatherproof, **cast aluminum** with milled cover-to-frame bearing surfaces; diameter, **26 inches.**

    a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
    b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.

2. Cover Legend: Cast in. Selected to suit system.

    a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
    b. Legend: "ELECTRIC-HV" for duct systems with medium-voltage cables.
    c. Legend: "SIGNAL" for communications, data, and telephone duct systems.

3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.

    a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. where packaged mix complying with ASTM C 387/C387M, Type M, may be used.

E. Manhole Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.

F. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch-diameter eye, and 1-by-4-inch bolt. Pulling eye shall be installed in four wells, top and bottom.

1. Working Load Embedded in 6-Inch, 4000-psi Concrete: 13,000-lbf minimum tension.

G. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4-inch-diameter eye, rated **2500-lbf** minimum tension.

H. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch-diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.

1. Ultimate Yield Strength: 40,000-lbf shear and 60,000-lbf tension.

I. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch ID by 2-3/4 inches deep, flared to 1-1/4 inches minimum at base.

1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.

J. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch bolt, 5300-lbf rated pullout strength, and minimum 6800-lbf rated shear strength.

K. Cable Rack Assembly: Steel, **hot-dip** galvanized, except insulators.

1. Stanchions: T-section or channel; 2-1/4-inch nominal size; punched with 14 holes on 1-1/2-inch centers for cable-arm attachment.
2. Arms: 1-1/2 inches wide, lengths ranging from 3 inches with 450-lb minimum capacity to 18 inches with 250-lb minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.
3. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.

L. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.

1. Stanchions: Nominal 36 inches high by 4 inches wide, with minimum of 9 holes for arm attachment.
2. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches with 450-lb minimum capacity to 20 inches with 250-lb minimum capacity. Top of arm shall be nominally 4 inches wide, and arm shall have slots along full length for cable ties.

M. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F. Capable of withstanding temperature of 300 deg F without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

N. Fixed Manhole Ladders: Arranged for attachment to [**roof**] [**or**] [**wall**] [**and floor**] of manhole. Ladder and mounting brackets and braces shall be fabricated from **nonconductive, structural-grade, fiberglass-reinforced resin.**

O. Portable Manhole Ladders: UL-listed, heavy-duty **fiberglass** specifically designed for portable use for access to electrical manholes. Minimum length equal to distance from deepest manhole floor to grade plus 36 inches. **One** required.

P. Cover Hooks: **Heavy duty, designed for lifts 60 lbf and greater**. **Two** required.

2.8 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C 1037.

B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and pull boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by an independent testing agency.

2. Strength tests of complete boxes and covers shall be by either an independent testing agency or the manufacturer as determined by the Owner. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 CORROSION PROTECTION

A. Aluminum shall not be installed in contact with earth or concrete.

3.2 UNDERGROUND DUCT APPLICATION

A. Ducts for Electrical Cables Over 600 V: RNC, NEMA Type [**EPC-80**] [**EPC-40**]~~[**Type EB-20**]~~-PVC, in concrete-encased duct bank, unless otherwise indicated.

B. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type [**EPC-80**] [**EPC-40**]~~[**Type EB-20**]~~ - PVC, in concrete-encased duct bank, unless otherwise indicated.

C. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type [**EPC-80**] ~~[**EPC-40**]~~-PVC, in direct-buried duct bank, unless otherwise indicated.

D. Ducts for Electrical Branch Circuits: RNC, NEMA Type [**EPC-80**] ~~[**EPC-40**]~~-PVC, in direct-buried duct bank, unless otherwise indicated.

E. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type **EPC-40** PVC, in concrete-encased duct bank, unless otherwise indicated.

F. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: **RNC, NEMA Type EPC-40-PVC,** installed in **concrete-encased** duct bank, unless otherwise indicated.

G. Underground Ducts for Telephone, Communications, or Data Circuits: RNC, NEMA Type [**DB-60**] [**DB-120**]-PVC, in direct-buried duct bank, unless otherwise indicated.

H. Underground Ducts for Telephone, Communications, or Data Circuits: RNC, NEMA Type EB-20-PVC, in concrete-encased duct bank, unless otherwise indicated.

I. Underground Ducts Crossing [**Paved Paths**] [**Walks**] [**and**] [**Driveways**] [**Roadways**] [**and Railroads**]: RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete.

3.3 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Pull Boxes for 600 V and Less[**, Including Telephone, Communications, and Data Wiring**]:

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, ~~[**H-10**]~~ [**H-20**] structural load rating.
2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: [**Precast concrete, AASHTO HB 17, H-20**] [**Polymer concrete, SCTE 77, Tier 15 or Tier 22**] [**Fiberglass enclosures with polymer**

concrete frame and cover, SCTE 77, Tier 15] [**Fiberglass-reinforced polyester resin, SCTE 77, Tier 15**] structural load rating.

3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: [**Precast concrete, AASHTO HB 17, H-10**] [**Polymer concrete units, SCTE 77, Tier 8**] [**Heavy-duty fiberglass units with polymer concrete frame and cover, SCTE 77, Tier 8**] structural load rating.
4. Units Subject to Light-Duty Pedestrian Traffic Only: **Fiberglass-reinforced polyester resin** structurally tested according to SCTE 77 with 3000-lbf vertical loading.

B. Manholes: [**Precast**] [**or**] [**cast-in-place**] concrete.

1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
2. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.

3.4 EARTHWORK

A. Excavation and Backfill: Comply with Division 31 Section "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Division 32 Sections "Turf and Grasses" and "Plants."

D. Cut and patch existing pavement in the path of underground ducts and utility structures according to Division 01 Section "Cutting and Patching."

3.5 DUCT INSTALLATION

A. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.

B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of [**48 inches**] ~~[**12.5 feet**] [**25 feet**],~~ both horizontally and vertically, at other locations, unless otherwise indicated.

C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.

D. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch ducts, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell without reducing duct line slope and without forming a trap in the line.
2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to manhole or handhole.
3. Grout end bells into structure walls from both sides to provide watertight entrances.

E. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 feet outside the building wall without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Division 26 Section "Common Work Results for Electrical."

F. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.

G. Pulling Cord: Install 100-lbf-test nylon cord in ducts, including spares.

H. Concrete-Encased Ducts: Support ducts on duct separators.

1. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than **5** spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
2. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.

   a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations, or use other specific measures to prevent expansion-contraction damage.
   b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing rod dowels extending 18 inches into concrete on both sides of joint near corners of envelope.

3. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.
4. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
5. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
6. Minimum Space between Ducts: 3 inches between ducts and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and signal ducts.
7. Depth: Install top of duct bank at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 30 inches below finished grade in deliberate traffic paths for vehicles, unless otherwise indicated.
8. Stub-Ups: Use manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Extend concrete encasement throughout the length of the elbow.
9. Stub-Ups: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

   a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
   b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.

10. Warning Tape: Bury warning tape approximately 12 inches above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches of the centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

I. Direct-Buried Duct Banks:

1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
2. Space separators close enough to prevent sagging and deforming of ducts, with not less than ~~[4]~~ [**5**] spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches between tiers.
3. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Division 31 Section "Earth Moving" for pipes less than 6 inches in nominal diameter.
4. Install backfill as specified in Division 31 Section "Earth Moving."
5. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4 inches over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
6. Install ducts with a minimum of 3 inches between ducts for like services and 6inches between power and signal ducts.
7. Depth: Install top of duct bank at least 36 inches below finished grade, unless otherwise indicated.
8. Set elevation of bottom of duct bank below the frost line.
9. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
10. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
    b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

11. Warning Planks: Bury warning planks approximately 12 inches above direct-buried ducts and duct banks, placing them 24 inches o.c. Align planks along the width and along the centerline of duct bank. Provide an additional plank for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional planks 12 inches apart, horizontally.

3.6 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

A. Cast-in-Place Manhole Installation:

1. Finish interior surfaces with a smooth-troweled finish.
2. Windows for Future Duct Connections: Form and pour concrete knockout panels 1-1/2 to 2 inches thick, arranged as indicated.
3. Cast-in-place concrete, formwork, and reinforcement are specified in Division 03 Section "Cast-in-Place Concrete."

B. Precast Concrete Handhole and Manhole Installation:

1. Comply with ASTM C 891, unless otherwise indicated.
2. Install units level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevations:

1. Manhole Roof: Install with rooftop at least 15 inches below finished grade.
2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch above finished grade.
3. Install handholes with bottom below the frost line, 12" below grade.
4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
5. Where indicated, cast handhole cover frame integrally with handhole structure.

D. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

E. Manhole Access: Circular opening in manhole roof; sized to match cover size.

1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
2. Install chimney, constructed of precast concrete collars and rings to support frame and cover and to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for cast-iron frame to chimney.

F. Waterproofing: Apply waterproofing to exterior surfaces of manholes[**and handholes**] after concrete has cured at least three days. Waterproofing materials and installation are specified in Division 07 Section **Elastomeric Sheet Waterproofing**. After ducts have been connected and grouted, and before backfilling, waterproof joints and connections and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.

G. Dampproofing: Apply dampproofing to exterior surfaces of manholes [**and handholes**] after concrete has cured at least three days. Dampproofing materials and installation are specified in Division 07 Section "Bituminous Dampproofing." After ducts have been connected and grouted, and before backfilling, dampproof joints and connections and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.

H. Hardware: Install removable hardware, including pulling eyes, cable stanchions, [**and**] cable arms, [**and insulators,**]as required for installation and support of cables and conductors and as indicated.

I. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

J. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches for manholes and 2 inches for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

K. Warning Sign: Install "Confined Space Hazard" warning sign on the inside surface of each manhole cover.

3.7 INSTALLATION OF HANDHOLES AND PULL BOXES OTHER THAN PRECAST CONCRETE

A. Install handholes and pull boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.

B. Unless otherwise indicated, support units on a level 6-inchthick bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and trafficways, set so cover surface will be flush with finished grade. Set covers of other handholes 1 inch above finished grade.

D. Install handholes and boxes with bottom below the frost line, 12" below grade.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.

F. Field-cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

G. For enclosures installed in **asphalt paving** and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on **compacted earth.**

1. Concrete: 3000 psi, 28-day strength, complying with Division 03 Section "Cast-in-Place Concrete," with a troweled finish.
2. Dimensions: 10 inches wide by 12 inches deep.

3.8 GROUNDING

A. Ground underground ducts and utility structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Provide 4/0 bare copper counterpoise in concrete duct banks for all current carrying ducts.

C. Extend ground cables into manholes and connect to ground rod.

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
3. Test manhole[**and handhole**] grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

C. Provide signed and sealed test and inspection documents prepared by a Licensed Professional Structural Engineer showing design of precast underground manholes and handholes.

3.10 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION 26 0543

3.8 CLEAN-UP PROCEDURES

A. Remove and containerize all visible accumulations of hazardous material and hazardous materials contaminated debris utilizing rubber dust pans and rubber squeegees to move material around. Do not use metal shovels to pick up or move accumulated waste. Special care shall be taken to minimize damage to floor sheeting.

B. Wet clean all surfaces in the work area using rags, mops and sponges as appropriate.

C. Remove the cleaned secondary layer of plastic sheeting from walls and floors. Windows, doors, HVAC system vents and all other opening shall remain sealed. The differential pressure air filtration devices shall remain in continuous operation. Decontamination enclosure systems shall remain in place and be utilized.

D. After cleaning the work area, furnish a period of time to allow fibers to settle and HEPA vacuum and wet clean all objects and surfaces in the work area again.

E. Remove all containerized waste from the work area and waste container pass-out airlock.

F. Decontaminate all tools and equipment and remove at the appropriate time in the cleaning sequence.

G. City of Inglewood's Representative will inspect the work area for visible residue. If any accumulation of residue is observed, it will be assumed to be hazardous materials and a second settling period and cleaning cycle repeated at no additional cost to City of Inglewood.

H. The work area shall be cleaned until it is in compliance with Applicable Code Requirements and any requirements specified herein. The criteria shall be in the form of visual inspections and airborne fiber concentrations. Additional cleaning cycles shall be provided, as necessary, at no cost to City of Inglewood until these criteria have been met.

I. Following the satisfactory completion of clearance air monitoring, the remaining barriers may be removed and prepared for proper disposal. A final visual inspection by City of Inglewood's Representative will be performed. Unsatisfactory conditions may require additional cleaning and air monitoring at no additional cost to City of Inglewood.

3.9 AIR MONITORING

A. Background Air Monitoring: Upon request from Contractor, City of Inglewood's Representative will conduct air monitoring to determine ambient baseline concentrations levels prior to abatement. Ambient baseline levels are presumed to be any applicable Action Level (AL) or PEL in the absence of an AL or less in the event background air sampling is not performed.

B. Area Air Monitoring: City of Inglewood's Representative may conduct in-progress air monitoring daily to determine area concentration levels outside and inside of containment, within the decontamination unit and in air exhausted by negative air machines.

C. Personal Air Monitoring:
   1. At a minimum, Contractor shall conduct representative (10% of crew) breathing zone personal air monitoring of its employees twice each shift and repeated daily for asbestos, chromium, lead and/or any other applicable constituent.
   2. Monitoring shall be conducted by a qualified air professional experienced and knowledgeable about the methods of air monitoring and in accordance with 29 CFR 1926.1101 and 29 CFR 1926. 62.
   3. Monitoring results and appropriate laboratory analysis work shall be submitted to City of Inglewood's Representative within twenty-four (24) hours of the monitoring work.

D. Clearance Air Monitoring:
   1. Following the completion of clean-up operations, notify City of Inglewood's Representative that work areas are ready for clearance air monitoring.

SECTION 26 0544

SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:
1. Division 07 Section "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:
1. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit EQ 4: For sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:
1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

F. Sleeves for Rectangular Openings:
   1. Material: Galvanized sheet steel.
   2. Minimum Metal Thickness:
      a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
      b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Advance Products & Systems, Inc.
      b. CALPICO, Inc.
      c. Metraflex Company (The).
      d. Pipeline Seal and Insulator, Inc.
      e. Proco Products, Inc.
   2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   3. Pressure Plates: Carbon steel.
   4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Presealed Systems.

2.4 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
   1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
   2. Sealant shall have VOC content of g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
   1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
      a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."
      b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
   2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
   3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed[**or unless seismic criteria require different clearance**].
   4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
   5. Install sleeves for floor penetrations. Extend sleeves installed in floors [**2 inches**] <**Insert dimension**> above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
   1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
   2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 26 0544

SECTION 26 0548

VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Isolation pads.
   2. Spring isolators.
   3. Restrained spring isolators.
   4. Channel support systems.
   5. Restraint cables.
   6. Hanger rod stiffeners.
   7. Anchorage bushings and washers.

B. Related Sections include the following:
   1. Division 26 Section "Hangers And Supports For Electrical Systems" for commonly used electrical supports and installation requirements.

1.3 DEFINITIONS

A. The IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:
   1. Site Class as Defined in the IBC.
   2. Assigned Seismic Use Group or Building Category as Defined in the IBC: III.
      a. Component Importance Factor: 1.5.
      b. Component Response Modification Factor: 3.5.
      c. Component Amplification Factor: 2.5.
   3. Design Spectral Response Acceleration at Short Periods (0.2 Second).
   4. Design Spectral Response Acceleration at 1.0-Second Period.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
   a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
   b. Annotate to indicate application of each product submitted and compliance with requirements.
3. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.
   a. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other Division 26 Sections for equipment mounted outdoors.
2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
3. Field-fabricated supports.
4. Seismic-Restraint Details:
   a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
   c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.

D. Welding certificates.

E. Qualification Data: For professional engineer.

F. Field quality-control test reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

E. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
   1. Amber/Booth Company, Inc.
   2. Kinetics Noise Control.
   3. Mason Industries.
   4. Vibration Eliminator Co., Inc.
   5. Vibration Mountings & Controls, Inc.

D. Vibration Isolator Types:
   1. Type A: Spring isolators shall incorporate the following:
      a. Minimum diameter of 0.8 of the loaded operating height.
      b. Corrosion resistance where exposed to corrosive environment with:
         1) Springs cadmium plated or electro-galvanized.
         2) Hardware cadmium plated.
         3) All other metal parts hot-dip galvanized.
      c. Reserve deflection (from loaded to solid height) of 50 percent of rated deflection.
      d. Minimum 1/4 inch thick neoprene acoustical base pad on underside, unless designated otherwise.
      e. Designed and installed so that ends of springs remain parallel and all springs installed with adjustment bolts.
      f. Non-resonant with equipment forcing frequencies or support structure natural frequencies.
      g. Spring isolators to be Mason Type SLF, or as approved.
      h. This isolator must be accompanied by seismic isolator Type II.
   2. Type B: Spring isolators shall be same as Type A, except:
      a. Provide built-in vertical limit stops with minimum 1/4 inch clearance under normal operation.
      b. Tapped holes in top plate for bolting to equipment when subject to wind load.
      c. Capable of supporting equipment at a fixed elevation during equipment erection. Installed and operating heights shall be identical.
      d. Adjustable and removable spring pack with separate neoprene pad isolation.
      e. Housing shall be designed to accept 1 G of acceleration.
      f. Mason Type SLR, or as approved.
   3. Type C: Spring hanger rod isolators shall incorporate the following:

a. Spring element seated on a steel washer within a neoprene cup incorporating a rod isolation bushing.
b. Steel retainer box encasing the spring and neoprene cup.
c. Requires seismic restraint Type III.
d. Mason Type HS, or as approved.

4. Type E: Elastomer hanger rod isolators shall be incorporate the following:
   a. Molded unit type neoprene element with projecting bushing lining rod clearance hole.
   b. Neoprene element shall be minimum 1-3/4 inch thick.
   c. Steel retainer box encasing neoprene mounting.
   d. Clearance between mounting hanger rod and neoprene bushing shall be minimum of 1/8 inch.
   e. Requires seismic restraint Type III.
   f. Mason Type HD, or as approved.
5. Type F: Combination spring/elastomer hanger rod isolators to incorporate the following:
   a. Spring and neoprene isolator elements in a steel box retainer. Neoprene of double deflection type. Single deflection is unacceptable. Spring seated in a neoprene cup with extended rod bushing.
   b. Characteristics of spring and neoprene as describe in Type A and Type E isolators.
   c. Requires seismic restraint Type III.
   d. Mason Type 30N, or as approved.
6. Type G: Pad type elastomer mountings to incorporate the following:
   a. 0.750 inch minimum thickness.
   b. 50 psi maximum loading.
   c. Ribbed or waffled design.
   d. 0.10 inch deflection per pad thickness.
   e. 1/16 inch galvanized steel plate between multiple layers or pad thickness.
   f. Suitable bearing plate to distribute load.
   g. Mason Type Super W, or as approved.
7. Type H: Pad type elastomer mountings to incorporate the following:
   a. Laminate canvas duck and neoprene.
   b. Maximum loading 1000 psi.
   c. Suitable bearing plate to distribute load.
   d. Minimum thickness, 1/2 inch.
   e. Mason Type HL, or as approved.
8. Type J: Rail type spring isolators:
   a. Rail type spring isolators shall provide steel members of sufficient strength to prevent flexure with equipment operation.
   b. Springs shall be the same as Type A with seismic restraint Type II or seismic restraint Type I or IV isolation.
   c. Mason Type ICS, or equal.
9. Type K: Pipe anchors:
   a. Vibration isolator manufacturer shall provide an all directional acoustical pipe anchor, consisting of a telescopic arrangement of two sizes of steel tubing separated by a minimum half inch thickness of heavy duty neoprene and duck or neoprene isolation material.
   b. Vertical restraints shall be provided by similar material arranged to prevent vertical travel in either direction.
   c. Allowable loads on the isolation material shall not exceed 500 psi and the design shall be balanced for equal resistance in any direction.
   d. Mason Type ADA, or as approved.

2.2 SEISMIC-RESTRAINT DEVICES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Cooper B-Line, Inc.; a division of Cooper Industries.
4. Hilti Inc.
5. Loos & Co.; Seismic Earthquake Division.
6. Mason Industries.
7. TOLCO Incorporated; a brand of NIBCO INC.
8. Unistrut; Tyco International, Ltd.

D. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least [**four**] **<Insert number>** times the maximum seismic forces to which they will be subjected.

E. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

F. Restraint Cables: ASTM A 603 galvanized-steel cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

G. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Do not weld stiffeners to rods.

H. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.

I. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices.

J. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

K. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

L. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

M. Provide for:
1. Major equipment:
   a. Main switchboard.
   b. Floor mounted distribution panels.
   c. Motor control centers.

d. Transformers.
e. Generator with related switchboard, muffler, battery, fuel tank and automatic transfer switch.

2. Other equipment and apparatus:
   a. Panelboards.
   b. Busways.
   c. Starters including those furnished under other sections.
   d. Lighting fixtures.
   e. Life Safety related enclosures and devices.

2.3 FACTORY FINISHES

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
   1. Powder coating on springs and housings.
   2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
   3. Baked enamel or powder coat for metal components on isolators for interior use.
   4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive [**vibration isolation and**]seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment and Hanger Restraints:
   1. Install restrained isolators on electrical equipment.

2. Following a successful visual inspection as specified herein, City of Inglewood's Representative will collect sufficient air samples within the work are to determine airborne concentration levels.
3. All samples at all locations shall indicate concentrations levels less than the AL or PEL in the absence of an AL, or less for release of the work area.
4. Areas exceeding this level shall be re-cleaned using procedures specified in Paragraph 3.8 above, and retested at no additional cost to City of Inglewood until satisfactory levels are obtained.

E. The following shall apply for all air monitoring:
1. All testing shall be conducted by individuals trained in the appropriate NIOSH, OSHA or other alternate analytical method.
2. All analysis shall be performed by a laboratory accredited by the NVLAP, AIHA, ELLAP or other certifying body for the constituent being analyzed.

F. The following shall apply for operations involving VOCs:
1. When excavating or grading soil containing VOCs, the Contractor shall monitor for VOC contamination.

3.10 STOP WORK ORDER

A. City of Inglewood's Representative shall have the right to issue a Stop Work Order whenever Contractor's work, engineering controls, or air monitoring results are not in accordance with published regulations, contractual restrictions, or the abatement specifications. All costs resulting from the Stop Work Order shall be at Contractor's expense. Refer to General Conditions Article 2.3.1.

B. The Stop Work Order shall first be given verbally to Contractor by City of Inglewood's Representative, at which point all work shall cease. This shall be immediately followed by a written notification to stop work. If the situation is not corrected to City of Inglewood's Representative's satisfaction within forty-eight (48) hours, Contractor shall be considered to be in breach of the Contract and will be subject to termination in accordance with General Conditions Article 13.2.

3.11 TESTING AND TRANSPORT

A. Collect one composite sample from each media type (solid, liquid, or sludge) of potentially hazardous substance stored in drums, stockpiled, or otherwise identified at the Project site for the purposes of obtaining approvals for proper transport and disposal of the suspect materials. Submit all analytical results to the City of Inglewood's Representative.

B. If required, over-pack any leaking or deteriorated drums to prevent leaks or spills, and pack small 5-gallon containers into larger new 55-gallon drums. Cover all solid waste materials and stockpiled soils with an HDPE liner to prevent stormwater runoff from contaminating surrounding areas.

C. Prepare manifests, material profiles, and submit lab analysis for all drums/containers and any other documentation required by the receiving facility for signature by the City of Inglewood's Representative.

D. Coordinate waste sampling and analysis requirements with the disposal facility and properly complete all profiling and transport documents prior to loading and transport.

E. A State registered "Hazardous Waste Hauler" shall transport the waste to a lawfully permitted and City of Inglewood approved facility.

F. Prior to transport, the manifests shall list the generator's name and address, site address, Generator's EPA ID number, to include the waste profile number. Attach the land disposal restriction (LDR) form to the manifest prior to submission. Generator Address for all waste manifests:

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2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

B. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

C. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

D. Drilled-in Anchors:
1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Perform tests and inspections.

C. Tests and Inspections:
1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.

8. Verify snubber minimum clearances.
9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after isolated equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 26 0548

SECTION 26 0553

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
1. Identification for raceway and metal-clad cable.
2. Identification for power conductors and communication and control cable.
3. Underground-line warning tape.
4. Warning labels and signs, including arc flash labeling.
5. Instruction signs.
6. Equipment identification labels.
7. Miscellaneous identification products.

1.3 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Identification Schedule: An index of nomenclature of electrical cables, equipment and system components used in identification signs and labels.

C. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

1.4 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and ANSI C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with NFPA 70E.

E. Comply with ANSI Z535, arc flash labels.

F. Comply with OSHA requirements for electrical labeling.

G. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.5 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in other sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 RACEWAY AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Colors for Raceways Carrying Circuits at 600 V or Less:
   1. Black letters on an orange field.
   2. Legend: Indicate voltage.

C. Colors for Raceways Carrying Circuits at More Than 600 V:
   1. Black letters on an orange field.
   2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- high letters on 20-inch centers.

D. Self-Adhesive Vinyl Labels for raceways carrying circuits 600V or less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

E. Snap-Around Labels for raceways carrying circuits 600V or less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

F. Snap-Around, Color-Coding Bands for raceways carrying circuits 600V or less: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

G. Tape and Stencil for Raceways Carrying Circuits More Than 600 V: 4-inch- wide black stripes on 10-inch centers diagonally over orange background that extends full length of raceway or duct and is 12 inches wide. Stop stripes at legends.

H. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.

I. Write-On Tags: Polyester tag, 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
   1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.2 ARMORED AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Colors for Raceways Carrying Circuits at 600 V and Less:
1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

C. Colors for Raceways Carrying Circuits at More Than 600 V:
1. Black letters on an orange field.
2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- high letters on 20-inch centers.

D. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

E. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches wide; compounded for outdoor use.

2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

C. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.

D. Write-On Tags: Polyester tag, 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

E. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

F. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.4 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

C. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

D. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

E. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

F. Write-On Tags: Polyester tag, 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.5 FLOOR MARKING TAPE

A. 2-inch- wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.6 UNDERGROUND-LINE WARNING TAPE

A. Tape:
1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical [**and communications**]utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Color and Printing:
1. Comply with ANSI Z535.1 through ANSI Z535.5.
2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE,.

C. Tag: Type I:
1. Pigmented polyolefin, bright-colored, [**continuous-printed on one side with the inscription of the utility,**]compounded for direct-burial service.
2. Thickness: 4 mils.
3. Weight: 18.5 lb/1000 sq. ft..
4. 3-Inch Tensile According to ASTM D 882: 30 lbf, and 2500 psi.

D. Tag: Type II:
1. Multilayer laminate consisting of high-density polyethylene scrim coated with pigmented polyolefin, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
2. Thickness: 12 mils.
3. Weight: 36.1 lb/1000 sq. ft..
4. 3-Inch Tensile According to ASTM D 882: 400 lbf, and 11,500 psi.

E. Tag: Type ID:
   1. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, [**continuous-printed on one side with the inscription of the utility,**]compounded for direct-burial service.
   2. Overall Thickness: 5 mils.
   3. Foil Core Thickness: 0.35 mil.
   4. Weight: 28 lb/1000 sq. ft..
   5. 3-Inch Tensile According to ASTM D 882: 70 lbf, and 4600 psi.

F. Tag: Type IID:
   1. Reinforced, detectable three-layer laminate, consisting of a printed pigmented woven scrim, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
   2. Overall Thickness: 8 mils.
   3. Foil Core Thickness: 0.35 mil.
   4. Weight: 34 lb/1000 sq. ft..
   5. 3-Inch Tensile According to ASTM D 882: 300 lbf, and 12,500 psi.

2.7 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

B. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

C. Aluminum Wraparound Marker Labels: Cut from 0.014-inch- thick aluminum sheet, with stamped, embossed, or scribed legend, and fitted with tabs and matching slots for permanently securing around wire or cable jacket or around groups of conductors.

D. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking nylon tie fastener.

E. Write-On Tags: Polyester tag, [**0.010 inch**] [**0.015 inch**] thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.
   1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

2.8 WARNING LABELS AND SIGNS

A. Comply with NFPA 70, NFPA 70E and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.

C. Baked-Enamel Warning Signs:
   1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
   2. 1/4-inch grommets in corners for mounting.
   3. Nominal size, 7 by 10 inches.

D. Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal size, 10 by 14 inches.

E. Warning label and sign shall include, but are not limited to, the following legends:
   1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
   2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.9 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. in. and 1/8 inch thick for larger sizes.
   1. Engraved legend with black letters on white face.
   2. Punched or drilled for mechanical fasteners.
   3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.

C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

2.10 EQUIPMENT IDENTIFICATION LABELS

A. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.

B. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and ultraviolet-resistant seal for label.

C. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

D. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

E. Stenciled Legend: In nonfading, waterproof, [**black**] <**Insert color**> ink or paint. Minimum letter height shall be [**1 inch**] <**Insert height**>.

2.11 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.
   1. Minimum Width: 3/16 inch.
   2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.
   3. Temperature Range: Minus 40 to plus 185 deg F.
   4. Color: Black except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one piece, self locking, Type 6/6 nylon.
   1. Minimum Width: 3/16 inch.
   2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.
   3. Temperature Range: Minus 40 to plus 185 deg F.
   4. Color: Black.

C. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.
   1. Minimum Width: 3/16 inch.
   2. Tensile Strength at 73 deg F, According to ASTM D 638: 7000 psi.
   3. UL 94 Flame Rating: 94V-0.
   4. Temperature Range: Minus 50 to plus 284 deg F.
   5. Color: Black.

2.12 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
   1. Minimum Width: 3/16 inch.
   2. Tensile Strength: 50 lb, minimum.
   3. Temperature Range: Minus 40 to plus 185 deg F.
   4. Color: Black, except where used for color-coding.

B. Paint: Paint materials and application requirements are specified in Division 09 painting Sections.
   1. Exterior Concrete, Stucco, and Masonry (Other Than Concrete Unit Masonry):
      a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
         1) Primer: Exterior concrete and masonry primer.
         2) Finish Coats: Exterior semigloss acrylic enamel.
   2. Exterior Concrete Unit Masonry:
      a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a block filler.
         1) Block Filler: Concrete unit masonry block filler.
         2) Finish Coats: Exterior semigloss acrylic enamel.
   3. Exterior Ferrous Metal:
      a. Semigloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.
         1) Primer: Exterior ferrous-metal primer.
         2) Finish Coats: Exterior semigloss alkyd enamel.
   4. Exterior Zinc-Coated Metal (except Raceways):
      a. Semigloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.
         1) Primer: Exterior zinc-coated metal primer.
         2) Finish Coats: Exterior semigloss alkyd enamel.
   5. Interior Concrete and Masonry (Other Than Concrete Unit Masonry):
      a. Semigloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.
         1) Primer: Interior concrete and masonry primer.
         2) Finish Coats: Interior semigloss alkyd enamel.
   6. Interior Concrete Unit Masonry:
      a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a block filler.
         1) Block Filler: Concrete unit masonry block filler.
         2) Finish Coats: Interior semigloss acrylic enamel.
   7. Interior Gypsum Board:
      a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
         1) Primer: Interior gypsum board primer.
         2) Finish Coats: Interior semigloss acrylic enamel.
   8. Interior Ferrous Metal:
      a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
         1) Primer: Interior ferrous-metal primer.
         2) Finish Coats: Interior semigloss acrylic enamel.

9. Interior Zinc-Coated Metal (except Raceways):
   a. Clean/pickle bare metal with white vinegar.
   b. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
      1) Primer: Interior zinc-coated metal primer.
      2) Finish Coats: Interior semigloss acrylic enamel.

C. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 APPLICATION

A. Raceways and Duct Banks More Than 600 V Concealed within Buildings: 4-inch- wide black stripes on 10-inch centers over orange background that extends full length of raceway or duct and is 12 inches wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- high black letters on 20-inch centers. Stop stripes at legends. Apply to the following finished surfaces:
   1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.
   2. Wall surfaces directly external to raceways concealed within wall.
   3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

B. Accessible Raceways and Metal-Clad Cables More Than 600 V: Identify with "DANGER-HIGH VOLTAGE" in black letters at least 2 inches high, with **[self-adhesive vinyl labels]** **[snap-around labels]**. Repeat legend at 10-foot maximum intervals.

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A: Identify with orange self-adhesive vinyl label.

D. Accessible Raceways and Cables of Auxiliary Systems: Identify the following systems with color-coded, self-adhesive vinyl tape applied in bands:
   1. Fire Alarm System: Red.
   2. Fire-Suppression Supervisory and Control System: Red and yellow.
   3. Combined Fire Alarm and Security System: Red and blue.
   4. Security System: Blue and yellow.
   5. Mechanical and Electrical Supervisory System: Green and blue.
   6. Telecommunication System: Green and yellow.
   7. Control Wiring: Green and red.

E. Power-Circuit Conductor Identification: For primary and secondary conductors No. 1/0 AWG and larger in vaults, pull and junction boxes, manholes, and handholes use aluminum wraparound marker labels. Identify source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above.

F. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use aluminum wraparound marker labels. Identify each ungrounded conductor according to source and circuit number.

G. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source and circuit number.

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G. Load, handle, and transport all 55-gallon drums and other waste containers to the appropriate disposal facility in accordance with Applicable Code Requirements.

H. All transport documentation from the receiving facility verifying acceptance and receipt of drums/containers at the facility and all sampling and associated test results shall be submitted to the City of Inglewood's Representative, within fifteen (15) days following receipt of all hazardous substances to the disposal facility.

I. All materials identified as hazardous wastes under the EPA's Resource Conservation and Recovery Act (RCRA) are not permitted to remain at the Project site more than 30 days after being deemed to be a hazardous waste. During this period of Project site storage, provide all precautions to contain and prevent the release of hazardous or potentially hazardous materials to the environment.

3.12 DISPOSAL PROCEDURES

A. As work progresses, to prevent exceeding available storage capacity on site, sealed and labeled containers of hazardous waste shall be removed and transported to an approved disposal location.

B. All hazardous materials and contaminated soils must be transported by a California licensed and insured company.

C. Disposal shall occur at an approved facility in accordance with regulatory requirements of NESHAP and the Cal/EPA Department of Toxic Substances Control, and Applicable Code Requirements.

D. Disposal Facilities:

1. All hazardous material cooling tower waste and contaminated soil shall be disposed of at one of the following approved facilities:

   US Ecology, Inc.
   P.O. Box 578
   Beatty, NV 89003
   Highway 95 – 12 Miles South of Beatty, Nevada
   (800) 239-3943

   Clean Harbors
   2500 West Lokern Road
   Buttonwillow, CA 93206
   (661) 762-6200

2. All PCB-containing ballasts shall be disposed of at one of the following approved facilities:

   AERC Recycling Solutions
   30677 Huntwood Avenue
   Hayward, CA 94544
   (510) 429-1129

   Veolia ES Technical Solutions
   5736 W Jefferson Street
   Phoenix, AZ 85043-3633
   (602) 278-3433

3. All other non-PCB-containing ballasts, fluorescent light tubes and other mercury-containing universal waste shall be disposed of at one of the following approved facilities:

   AERC Recycling Solutions
   30677 Huntwood Avenue
   Hayward, CA 94544
   (510) 429-1129

   Veolia ES Technical Solutions

H. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
   1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
   2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
   3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.

I. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable. Limit use of underground-line warning tape to direct-buried cables.

J. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning labels. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.
   1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:
      a. Power transfer switches.
      b. Controls with external control power connections.
   2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.

K. Instruction Signs:
   1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
   2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8-inch- high letters for emergency instructions at equipment used for power transfer.

L. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
   1. Labeling Instructions:
      a. Indoor and Outdoor Equipment: Screwed-on engraved white laminated plastic sheet with minimum 3/8 inch to 3/4 inch black lettering for normal systems and red laminated plastic sheet with lettering for energy systems.
      b. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
   2. Equipment to Be Labeled:
      a. Panelboards, electrical cabinets, and enclosures.
      b. Access doors and panels for concealed electrical items.
      c. Electrical switchgear and switchboards.
      d. Transformers.
      e. Electrical substations.
      f. Emergency system boxes and enclosures.
      g. Motor-control centers.
      h. Disconnect switches.
      i. Enclosed circuit breakers.
      j. Motor starters.
      k. Push-button stations.
      l. Power transfer equipment.

m. Contactors.
n. Remote-controlled switches, dimmer modules, and control devices.
o. Battery inverter units.
p. Battery racks.
q. Power-generating units.
r. Voice and data cable terminal equipment.
s. Master clock and program equipment.
t. Intercommunication and call system master and staff stations.
u. Television/audio components, racks, and controls.
v. Fire-alarm control panel and annunciators.
w. Security and intrusion-detection control stations, control panels, terminal cabinets, and racks.
x. Monitoring and control equipment.
y. Uninterruptible power supply equipment.
z. Terminals, racks, and patch panels for voice and data communication and for signal and control functions.

3.2 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach nonadhesive signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

F. System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

G. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

H. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

I. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

J. Painted Identification: Comply with requirements in Division 09 painting Sections for surface preparation and paint application.

3.3 IDENTIFICATION SCHEDULE

A. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil 4-inch- wide black stripes on 10-inch centers over orange background that extends full length of raceway or duct and is 12 inches wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- high black letters on 20-inch centers. Stop stripes at legends. Apply to the following finished surfaces:
   1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.
   2. Wall surfaces directly external to raceways concealed within wall.
   3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

B. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: Self-adhesive vinyl labels. Install labels at 10-foot maximum intervals.

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A, and 120 V to ground: Identify with self-adhesive vinyl label. Install labels at 30-foot maximum intervals.

D. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:
   1. Emergency Power.
   2. Power.
   3. UPS.

E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.
   1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service feeder and branch-circuit conductors.
      a. Color shall be factory applied[**or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit**].
      b. Colors for 208/120-V Circuits:
         1) Phase A: Black.
         2) Phase B: Red.
         3) Phase C: Blue.
      c. Colors for 480/277-V Circuits:
         1) Phase A: Brown.
         2) Phase B: Orange.
         3) Phase C: Yellow.
      d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

F. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

G. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 10 to 12 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

H. Painted Identification: Prepare surface and apply paint according to Division 09 painting Sections.

I. Power-Circuit Conductor Identification, More than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use write-on tags.

J. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

K. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.

L. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.

M. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.
1. Limit use of underground-line warning tape to direct-buried cables.
2. Install underground-line warning tape for both direct-buried cables and cables in raceway.

N. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

O. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.
1. Comply with 29 CFR 1910.145.
2. Identify system voltage with black letters on an orange background.
3. Apply to exterior of door, cover, or other access.
4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
   a. Power transfer switches.
   b. Controls with external control power connections.

P. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

Q. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- high letters for emergency instructions at equipment used for **[power transfer] [load shedding]** <**Insert emergency operations**>.

R. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
1. Labeling Instructions:
   a. Indoor Equipment: Adhesive film label. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high label; where two lines of text are required, use labels 2 inches high.
   b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.

c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2. Equipment to Be Labeled:
a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be self-adhesive, engraved, laminated acrylic or melamine label.
b. Enclosures and electrical cabinets.
c. Access doors and panels for concealed electrical items.
d. Switchgear.
e. Switchboards.
f. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
g. Substations.
h. Emergency system boxes and enclosures.
i. Motor-control centers.
j. Enclosed switches.
k. Enclosed circuit breakers.
l. Enclosed controllers.
m. Variable-speed controllers.
n. Push-button stations.
o. Power transfer equipment.
p. Contactors.
q. Remote-controlled switches, dimmer modules, and control devices.
r. Battery-inverter units.
s. Battery racks.
t. Power-generating units.
u. Monitoring and control equipment.
v. UPS equipment.

END OF SECTION 26 0553

SECTION 26 0573

OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes computer-based, fault-current and overcurrent protective device coordination including ground fault protection studies to be performed by the contractor. Protective devices shall be set based on results of the protective device coordination study. Settings and adjustments of the relays shall be provided by an independent qualified agency familiar with this work and the agency is to be retained by this contractor. The person performing this work to have a minimum of five years experience.
   1. Coordination of series-rated devices is permitted where indicated on Drawings.

1.3 SUBMITTALS

A. Provide overcurrent protective device coordination study prior to submittal of electrical service and distribution equipment.

B. Product Data: For computer software program to be used for studies.

C. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.

D. Qualification Data: For coordination-study specialist.

E. Other Action Submittals: The following submittals shall be made after the approval process for system protective devices has been completed. Submittals may be in digital form.
   1. Coordination-study input data, including completed computer program input data sheets.
   2. Study and Equipment Evaluation Reports.
   3. Coordination-Study Report, including setting tables.
   4. Report indicating variances.
   5. Recommendations.

1.4 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

B. Coordination-Study Specialist Qualifications: An entity experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
   1. Professional engineer, licensed in the state where Project is located, shall be responsible for the study. All elements of the study shall be performed under the direct supervision and control of engineer. The registered professional electrical engineer shall have a minimum of 5 years of experience in performing power system studies.

C. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

D. Comply with IEEE 399 for general study procedures.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Available Computer Software Developers: Subject to compliance with requirements, companies offering computer software programs that may be used in the Work include, but are not limited to, the following:

B. Computer Software Developers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide or a comparable product by one of the following:
   1. SKM Systems Analysis, Inc.

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399.

B. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.
   1. Required Features: Arcing faults per NFPA 70E.
   2. Optional Features:
      a. Simultaneous faults.
      b. Explicit negative sequence.
      c. Mutual coupling in zero sequence.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 POWER SYSTEM DATA

A. Gather and tabulate the following input data to support coordination study:
   1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
   2. Impedance of utility service entrance.
   3. Electrical Distribution System Diagram: In hard-copy and electronic-copy formats, showing the following:
      a. Circuit-breaker and fuse-current ratings and types.
      b. Relays and associated power and current transformer ratings and ratios.
      c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
      d. Generator kilovolt amperes, size, voltage, and source impedance.
      e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length. Use actual conductor impedances if known, otherwise use impedances based on IEEE 141.
      f. Busway ampacity and impedance.
      g. Motor horsepower and code letter designation according to NEMA MG 1.
   4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
      a. Special load considerations, including starting inrush currents and frequent starting and stopping.
      b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
      c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
      d. Generator thermal-damage curve.
      e. Ratings, types, and settings of utility company's overcurrent protective devices.
      f. Special overcurrent protective device settings or types stipulated by utility company.
      g. Time-current-characteristic curves of devices indicated to be coordinated.
      h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
      i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
      j. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes rms symmetrical.

3.3 FAULT-CURRENT STUDY

A. Calculate the maximum available short-circuit current in amperes rms symmetrical at circuit-breaker positions of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit at each of the following:
   1. Switchgear and switchboard bus including medium voltage.
   2. Unit substations.
   3. Medium-voltage controller.
   4. Motor-control center.

5. Distribution panelboard.
6. Branch circuit panelboard.
7. Standby generators and automatic transfer switches.
8. Variable frequency drives.
9. Lighting and dimming control panels.
10. Uninterruptible power source (UPS).

B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.

C. Calculate momentary and interrupting duties on the basis of maximum available fault current.

D. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 241 and IEEE 242.
1. Transformers:
   a. ANSI C57.12.10.
   b. ANSI C57.12.22.
   c. ANSI C57.12.40.
   d. IEEE C57.12.00.
   e. IEEE C57.96.
2. Medium-Voltage Circuit Breakers: IEEE C37.010.
3. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.1.
4. Low-Voltage Fuses: IEEE C37.46.
5. C37.13.
6. C37.41.

E. Study Report:
1. Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram.
2. Show interrupting (5-cycle) and time-delayed currents (6 cycles and above) on medium- and high-voltage breakers as needed to set relays and assess the sensitivity of overcurrent relays.

F. Equipment Evaluation Report:
1. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
2. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
3. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

3.4 COORDINATION STUDY

A. Perform coordination study using approved computer software program. Prepare a written report using results of fault-current study. Comply with IEEE 399.
1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.
2. Calculate the maximum and minimum interrupting duty (5 cycles to 2 seconds) short-circuit currents.
3. Calculate the maximum and minimum ground-fault currents.

B. Comply with **[IEEE 241]** **[IEEE 242]** recommendations for fault currents and time intervals.

C. Transformer Primary Overcurrent Protective Devices:
   1. Device shall not operate in response to the following:
      a. Inrush current when first energized.
      b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
      c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
   2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

D. Motors served by voltages more than 600 V shall be protected according to IEEE 620.

E. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

F. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:
   1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
      a. Device tag.
      b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
      c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
      d. Fuse-current rating and type.
      e. Ground-fault relay-pickup and time-delay settings.
   2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
      a. Device tag.
      b. Voltage and current ratio for curves.
      c. Three-phase and single-phase damage points for each transformer.
      d. No damage, melting, and clearing curves for fuses.
      e. Cable damage curves.
      f. Transformer inrush points.
      g. Maximum fault-current cutoff point.

G. Completed data sheets for setting of overcurrent protective devices.

END OF SECTION 26 0573

5736 W Jefferson Street
Phoenix, AZ 85043-3633
(602) 278-3433

Lighting Resources, LLC
805 East Francis Street
Ontario, CA 91761
(909) 923-7252

WM Lamp Tracker, Earth Protection Services, Inc.
5355 N. 51st Avenue #26
Glendale, AZ 85301
(623) 934-4409

4. Other facilities may be used only if prior written approval is obtained from City of Inglewood's Division of Environment Services.

E. Polychlorinated Biphenyl (PCB) and non PCB ballasts
   1. Dispose of cleaned carcasses and components and incinerate PCB waste at facility(s) approved by City of Inglewood's Representative.
   2. Determine current waste handling, transportation and disposal regulations for the work site and for each waste disposal landfill.
   3. Document actual incineration, recycling and disposal of the waste at the designated facility(s) and landfill by completing waste manifest(s), waste certification form(s), waste profiles, and by ensuring their proper completion by City of Inglewood's Representative, waste transporter, and waste disposal site operator.
      a. Within 24 hours of the time waste materials have been removed from the site, deliver all landfill receipts, trip tickets, manifest or other documentation of disposal to:

         City of Inglewood - Division of Environmental Services

         1 Manchester Boulevard, Inglewood, CA 90301
      b. Utilize manifest(s) to accompany each load of waste that leaves the site. Include the name and address of the Generator (City of Inglewood), Contractor, pick-up site, disposal site, quantity of PCB waste disposed and the type of container utilized. Obtain signatures of the Generator (City of Inglewood), Transporter and the Disposal Site Operator as the responsibility of the material changes hands.
      c. Secondary Transporters are not allowed unless approved in writing by City of Inglewood's Representatives.

   4. Furnish a statement certifying recycling/disposal/destruction of the identified PCB waste, including the date(s) of recycling/disposal/ destruction, and identifying the disposal/destruction process used.
   5. Dispose of PCB-containing liquids in United States Department of Transportation (USDOT) 17E containers.
   6. Dispose of ballasts in "UN1A2" or 17C or 17H lockable "ring top" 55-gallon steel drums. Transport on a hazardous waste manifest. Label the containers with the following descriptions:
      a. USDOT "Class 9" waste classification placards and the following description:

         RQ Polychlorinated Biphenyls Mixture, 9, UN2315, PG III

      b. Warning Labels:

         CAUTION HAZARDOUS WASTE
         CONTAINS PCBs
         POLYCHLORINATED BIPHENYLS

      c. Generator Name and Address and Disposal Identification Number

SECTION 26 1200

MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following types of transformers with medium-voltage primaries:
1. 4160v dry-type transformer.
2. Contractor shall provide standard/custom made transformer to fit the space.

1.3 DEFINITIONS

A. NETA ATS: Acceptance Testing Specification.

1.4 SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, location of each field connection, and performance for each type and size of transformer indicated.

B. Shop Drawings: Diagram power signal and control wiring.

C. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
1. Underground primary and secondary conduit stub-up location.
2. Dimensioned concrete base, outline of transformer, and required clearances.
3. Ground rod and grounding cable locations.

D. Manufacturer Seismic Qualification Certification: Submit certification that transformer assembly and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems" Include the following:
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
   b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Qualification Data: For testing agency.

F. Source quality-control test reports.

G. Field quality-control test reports.

H. Follow-up service reports.

I. Operation and Maintenance Data: For transformer and accessories to include in emergency, operation, and maintenance manuals.

J. Approval of local utility.

K. Key Interlock scheme.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
   1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of transformers and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with IEEE C2.

E. Comply with ANSI C57.12.10, ANSI C57.12.28, IEEE C57.12.70, and IEEE C57.12.80.

F. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store transformers protected from weather and so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.

B. Protect transformers from dust and debris during construction.

1.7 PROJECT CONDITIONS

A. Service Conditions: IEEE C37.121, usual service conditions except for the following:
   1. Exposure to significant solar radiation.
   2. Altitudes above 3300 feet.
   3. Exposure to fumes, vapors, or dust.
   4. Exposure to explosive environments.

5. Exposure to hot and humid climate or to excessive moisture, including steam, salt spray, and dripping water.
6. Exposure to seismic shock or to abnormal vibration, shock, or tilting.
7. Exposure to excessively high or low temperatures.
8. Unusual transportation or storage conditions.
9. Unusual grounding-resistance conditions.
10. Unusual space limitations.

1.8 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of louvers, doors, spill retention areas, and sumps. Coordinate installation so no piping or conduits are installed in space allocated for medium-voltage transformers except those directly associated with transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cutler-Hammer.
2. GE Electrical Distribution & Control.
3. Siemens Energy & Automation, Inc.
4. Square D; Schneider Electric.

2.2 DRY-TYPE DISTRIBUTION AND POWER TRANSFORMERS

A. Description: NEMA ST 20, IEEE C57.12.01, ANSI C57.12.52, UL 1562 listed and labeled, dry-type, 2-winding transformers.
1. Totally enclosed, nonventilated, cast coil/encapsulated coil, with primary and secondary windings individually cast in epoxy; with insulation system rated at 185 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.
2. Totally enclosed, nonventilated, vacuum-pressure impregnated and with insulation system rated at 220 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.

B. Primary Connection: Air terminal compartment with hinged door. Tin-plated copper bar for incoming line termination, predrilled to accept terminals for indicated conductors.

C. Primary Connection: Transition terminal compartment with connection pattern to match switchgear.

D. Secondary Connection: Air terminal compartment with hinged door. Tin-plated copper bar for incoming line termination, predrilled to accept terminals for indicated conductors.

E. Secondary Connection: Transition terminal compartment with connection pattern to match conductors.

F. Insulation Materials: IEEE C57.12.01, rated at 220 deg C.

G. Insulation Temperature Rise: 80 deg C, maximum rise above 40 deg C.

H. Basic Impulse Level: 95 kV.

I. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, 2 above and 2 below rated primary voltage.

J. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps below rated primary voltage.

K. Coils shall be wound with aluminum conductors.

L. Cooling System: Class AA, self-cooled, complying with IEEE C57.12.01.
   1. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm silencing relay.
   2. Include mounting provision for fans.

M. Sound level may not exceed sound levels listed in NEMA TR 1, without fans operating.

N. Impedance: 5.7 percent.

O. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm.

2.3 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to ANSI C57.12.50.

B. Factory Tests: Perform the following factory-certified tests on each transformer:
   1. Resistance measurements of all windings on rated-voltage connection and on tap extreme connections.
   2. Ratios on rated-voltage connection and on tap extreme connections.
   3. Polarity and phase relation on rated-voltage connection.
   4. No-load loss at rated voltage on rated-voltage connection.
   5. Excitation current at rated voltage on rated-voltage connection.
   6. Impedance and load loss at rated current on rated-voltage connection and on tap extreme connections.
   7. Applied potential.
   8. Induced potential.
   9. Temperature Test: If transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kilovolt-ampere Class OA or Class AA rating and highest kilovolt-ampere Class OA/FA or Class AA/FA rating.
      a. Temperature test is not required if record of temperature test on an essentially duplicate unit is available.

10. Owner assigned representative will witness all required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for medium-voltage transformers.

B. Examine roughing-in of conduits and grounding systems to verify the following:
1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and that requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install transformers on concrete bases.
1. Anchor transformers to concrete bases according to manufacturer's written instructions, seismic codes at Project, and requirements in Division 26 Section "Hangers and Supports for Electrical Systems."
2. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit and 4 inches high.
3. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."
4. Install dowel rods to connect concrete bases to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
5. Install epoxy-coated anchor bolts, for supported equipment, that extend through concrete base and anchor into structural concrete floor.
6. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
7. Tack-weld or bolt transformers to channel-iron sills embedded in concrete bases. Install sills level and grout flush with floor or base.

B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.3 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."

3.4 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. After installing transformers but before primary is energized, verify that grounding system at substation is tested at specified value or less.
   2. After installing transformers and after electrical circuitry has been energized, test for compliance with requirements.
   3. Perform visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

C. Test Reports: Prepare written reports to record the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Test results that do not comply with requirements and corrective actions taken to achieve compliance with requirements.

3.6 FOLLOW-UP SERVICE

A. Voltage Monitoring and Adjusting: If requested by Owner or Owner assigned representative, perform the following voltage monitoring after Substantial Completion but not more than six months after Final Acceptance:
   1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at secondary terminals of each transformer. Use voltmeters with calibration traceable to National Institute of Science and Technology standards and with a chart speed of not less than 1 inch per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.
   2. Corrective Actions: If test results are unacceptable, perform the following corrective actions, as appropriate:
      a. Adjust transformer taps.
      b. Prepare written request for voltage adjustment by electric utility.
   3. Retests: After corrective actions have been performed, repeat monitoring until satisfactory results are obtained.
   4. Report: Prepare written report covering monitoring and corrective actions performed.

B. Infrared Scanning: Perform as specified in Division 26 Section "Medium-Voltage Switchgear."

END OF SECTION 26 1200

SECTION 26 2413

SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Service and distribution switchboards rated 600 V and less.
2. Instrumentation.
3. Control power.
4. Accessory components and features.
5. Identification.
6. Mimic bus.

B. Related Sections include the following:
1. Division 26 Section "Overcurrent Protective Device Coordination Study."
2. Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
3. Division 26 Section "Grounding and Bonding for Electrical Systems."
4. Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
5. Division 26 Section "Identification for Electrical Systems."
6. Division 26 Section "Enclosed Switches and Circuit Breakers."

1.3 SUBMITTALS

A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.
1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
6. Detail utility company's metering provisions with indication of approval by utility company.
7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

8. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
9. Include diagram and details of proposed mimic bus.
10. Include schematic and wiring diagrams for power, signal, and control wiring.
11. Provide short circuit and coordination study based on proposed equipment.

C. Qualification Data: For qualified Installer.

D. Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Field Quality-Control Reports:
1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

F. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Routine maintenance requirements for switchboards and all installed components.
2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
3. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.
1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

C. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Comply with NEMA PB 2.

G. Comply with NFPA 70.

H. Comply with UL 489 and UL 891.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards and connect factory-installed space heaters to temporary electrical service to prevent condensation.

C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.6 PROJECT CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Environmental Limitations:
1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
    a. Ambient Temperature: Not exceeding 104 deg F.
    b. Altitude: Not exceeding 6600 feet.

C. Service Conditions: NEMA PB 2, usual service conditions, as follows:
1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet.

D. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
1. Notify Construction Manager no fewer than 10 days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Construction Manager's written permission.
4. Comply with NFPA 70E.

1.7 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
   3. Siemens Energy & Automation, Inc.
   4. Square D; a brand of Schneider Electric.

B. Front-Connected, Front-Accessible Switchboards:
   1. Main Devices: Fixed, individually mounted.
   2. Branch Devices: Panel mounted.
   3. Sections front and rear aligned.

C. Front- and Side-Accessible Switchboards:
   1. Main Devices: Fixed, individually mounted.
   2. Branch Devices: Panel mounted.
   3. Sections front and rear aligned.

D. Front- and Rear-Accessible Switchboards:
   1. Main Devices: Fixed, individually mounted.
   2. Branch Devices: Panel and fixed, individually mounted.
   3. Sections front and rear aligned.

E. Nominal System Voltage: 480Y.

F. Main-Bus Continuous: 2000 A.

G. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

H. Enclosures: Type NEMA I.
   1. Finish: Factory-applied finish in manufacturer's standard color; undersurfaces treated with corrosion-resistant undercoating.
   2. Enclosure: Flat roof; bolt-on rear covers for each section, with provisions for padlocking.

I. Barriers: Between adjacent switchboard sections.

J. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.

K. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

L. Removable, Hinged Rear Doors and Compartment Covers: Secured by standard bolts, for access to rear interior of switchboard.

d. Description of the Type of PCB-Containing Material
e. Date that the Drum was filled with Ballasts
f. Emergency Phone Numbers

F. Fluorescent Light Tubes and other Mercury Universal Waste
1. Dispose of fluorescent light tubes and mercury universal waste at recycling/treatment facility(s) approved by City of Inglewood's Representative, and authorized by Cal/EPA DTSC or the state in which they are located to receive the waste.
2. Determine current waste handling, transportation, and disposal regulations for the work site and for each recycling and disposal facility.
3. Document actual recycling/treatment, and disposal of the waste at the designated facility(s) by completing bill(s) of lading.
a. Within 24 hours of the time waste materials have been removed from the site, deliver all bill(s) of lading to:

City of Inglewood - Division of Environmental Services

1 Manchester Boulevard, Inglewood, CA 90301

b. Utilize bill(s) of lading to accompany each load of waste that leaves the site. Include the names and address of the Generator (City of Inglewood), Contractor, pick-up site, disposal site, and quantity of universal waste disposed.

4. Furnish a statement certifying recycling/disposal/destruction of the identified universal waste, including the date(s) of recycling/disposal/ destruction, and identifying the disposal/destruction process used.
5. Transport fluorescent light tubes in containers that prevent damage and release. Label the containers with the following:
a. Warning Labels:

LAMPS: "UNIVERSAL WASTE--LAMPS", OR "WASTE LAMP(S)" OR "USED LAMP(S)"

b. Generator Name and Address
c. Description of the type of universal waste
d. Accumulation start date of the universal waste
e. Emergency Phone numbers

G. Contaminated Soils:
1. Soils shown to contain contaminants that exceed federal or CA hazardous waste criteria are to be transported using a Uniform Hazardous Waste Manifest (UHWM) to an EH&S approved waste disposal facility.
2. Receiving facility shall furnish a weight certificate.
3. Contaminated soils that do not meet hazardous waste criteria may be eligible for landfill disposal. These soils may be removed to a solid waste landfill after filing an appropriate application and receiving approval from the landfill operator. A copy of the approval letter will be furnished to EH&S prior to any export of soil or fill material. These soils are to be shipped under a Bill of Lading and may be signed by either the City of Inglewood's Representative or by an EH&S representative
4. Final disposition of soils will be determined by the waste designation. Contaminated soils shall properly be managed and manifested for transportation and disposal offsite.

H. All Waste Certification Forms attesting to the content of the generated waste shall be signed and completed by Contractor.

M. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

N. Buses and Connections: Three phase, four wire unless otherwise indicated.
1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, with tin-plated aluminum or copper feeder circuit-breaker line connections.
2. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with compression connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
3. Ground Bus: 1/4-by-2-inch- or Minimum-size required by UL 891, hard-drawn copper of 98 percent conductivity, equipped with compression connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
4. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
5. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
6. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

O. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

P. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.

Q. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

2.2 INSTRUMENTATION

A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:
1. Potential Transformers: IEEE C57.13; 120 V, 60 Hz, single secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
2. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; wound type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based non-volatile memory unit suitable for three- or four-wire systems and with the following features:
1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
   a. Phase Currents, Each Phase: Plus or minus 1 percent.
   b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
   c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
   d. Megawatts: Plus or minus 2 percent.
   e. Megavars: Plus or minus 2 percent.
   f. Power Factor: Plus or minus 2 percent.
   g. Frequency: Plus or minus 0.5 percent.

h. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
i. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from five to 60 minutes.
j. Contact devices to operate remote impulse-totalizing demand meter.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

C. Ammeters, Voltmeters, and Power-Factor Meters: ANSI C39.1.
1. Meters: 4-inch diameter, flush or semiflush, with antiparallax 250-degree scales and external zero adjustment.
2. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent.

D. Instrument Switches: Rotary type with off position.
1. Voltmeter Switches: Permit reading of all phase-to-phase voltages and, where a neutral is indicated, phase-to-neutral voltages.
2. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.

E. Feeder Ammeters: 2-1/2-inch minimum size with 90- or 120-degree scale. Meter and transfer device with off position, located on overcurrent device door for indicated feeder circuits only.

F. Watt-Hour Meters and Wattmeters:
1. Comply with ANSI C12.1.
2. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
3. Suitable for connection to three- and four-wire circuits.
4. Potential indicating lamps.
5. Adjustments for light and full load, phase balance, and power factor.
6. Four-dial clock register.
7. Integral demand indicator.
8. Contact devices to operate remote impulse-totalizing demand meter.
9. Ratchets to prevent reverse rotation.
10. Removable meter with drawout test plug.
11. Semiflush mounted case with matching cover.
12. Appropriate multiplier tag.

G. Impulse-Totalizing Demand Meter:
1. Comply with ANSI C12.1.
2. Suitable for use with switchboard watt-hour meter, including two-circuit totalizing relay.
3. Cyclometer.
4. Four-dial, totalizing kilowatt-hour register.
5. Positive chart drive mechanism.
6. Capillary pen holding a minimum of one month's ink supply.
7. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
8. Capable of indicating and recording 15-minute integrated demand of totalized system.

2.3 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

B. Control Circuits: 120-V ac, supplied from remote branch circuit.

C. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.

D. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

E. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.4 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

2.5 IDENTIFICATION

A. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on a photoengraved nameplate.
   1. Nameplate: At least 0.032-inch- thick anodized aluminum, located at eye level on front cover of the switchboard incoming service section.

B. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on an engraved laminated-plastic (Gravoply) nameplate.
   1. Nameplate: At least 0.0625-inch- thick laminated plastic (Gravoply), located at eye level on front cover of the switchboard incoming service section.

C. Mimic Bus: Continuously integrated mimic bus factory applied to front of switchboard. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram.

D. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.

E. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.

F. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete." See Division 26 "Common Word Results for Electrical."

C. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

D. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

E. Install filler plates in unused spaces of panel-mounted sections.

F. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.
   1. Set field-adjustable switches and circuit-breaker trip ranges.

G. Install spare-fuse cabinet.

H. Comply with NECA 1.

I. Refinish damaged or scratched surfaces and rub down boards with approved polish.

J. Provide 24 inch wide insulating mat in front of boards and in rear of free standing ones.

3.3 CONNECTIONS

A. Comply with requirements for terminating feeder bus specified in Division 26 Section "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.

B. Comply with requirements for terminating cable trays specified in Division 26 Section "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Acceptance Testing Preparation:
1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

E. Tests and Inspections:
1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study."

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units.

SECTION 26 2416

PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Distribution panelboards.
2. Lighting, receptacle and appliance branch-circuit panelboards.
3. Load centers.
4. Electronic-grade panelboards.

B. Related Sections Include the Following:
1. Division 26 Section "Enclosed Switchboards and Circuit Breakers."
2. Division 26 Section "Transient Voltage Suppression for Low Voltage Electrical Power Circuits."
3. Division 26 Section Overcurrent Protective Device Coordination Study."

1.3 DEFINITIONS

A. SVR: Suppressed voltage rating.

B. TVSS: Transient voltage surge suppressor.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."

1.5 SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.
1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than NEMA 250, Type 1.

3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Include evidence of NRTL listing for series rating of installed devices.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include wiring diagrams for power, signal, and control wiring.
8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

C. Qualification Data: For qualified testing agency.

D. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Field Quality-Control Reports:
1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

F. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

G. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.
1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NEMA PB 1.

F. Comply with NFPA 70.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.8 PROJECT CONDITIONS

A. Environmental Limitations:
  1. Do not deliver or install panelboards until spaces are enclosed and weathertight, all work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
  2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
     a. Ambient Temperature: Not exceeding [**minus 22 deg F**] [**23 deg F**] to plus 104 deg F.
     b. Altitude: Not exceeding 6600 feet.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
  1. Ambient temperatures within limits specified.
  2. Altitude not exceeding 6600 feet.

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
  1. Notify Construction Manager no fewer than five days in advance of proposed interruption of electric service.
  2. Do not proceed with interruption of electric service without Construction Manager's written permission.
  3. Comply with NFPA 70E.

1.9 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
  1. Warranty Period: Five years from date of Substantial Completion.

1.11 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Keys: Two spares for each type of panelboard cabinet lock.
   2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two spares for each panelboard.
   3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
   4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

B. Every panelboard shall be fully rated unless specifically shown as series rated. All equipment shall be panelboard construction. Load center not permitted unless specifically indicated.

C. Enclosures: Flush- and surface-mounted cabinets.
   1. Rated for environmental conditions at installed location.
      a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
      b. Outdoor Locations: NEMA 250, Type 3R.
      c. [**Kitchen**] [**Wash-Down**] Areas: NEMA 250, Type 4X.
      d. Other Wet or Damp Indoor Locations: NEMA 250, [**Type 4**] <**Insert type**>.
      e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 5.
   2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
   3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover so that no tool is required to open the hinged cover.
   4. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
   5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
   6. Finishes:
      a. Panels and Trim: Galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
      b. Back Boxes: Galvanized steel.
      c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.
   7. Directory Card: Inside panelboard door, mounted in transparent card holder.

D. Phase, Neutral, and Ground Buses:
   1. Material: Hard-drawn copper, 98 percent conductivity.
   2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

E. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Main and Neutral Lugs: Compression type.
3. Ground Lugs and Bus-Configured Terminators: Compression type.
4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
5. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
6. Gutter-Tap Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

F. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.

G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

H. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include size and type of allowable upstream and branch devices, listed and labeled for series-connected short-circuit rating by an NRTL.

I. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

J. For installation of integral TVSS to the panelboards, refer to Section "Transient Voltage Suppression for Low Voltage Electrical Power Circuits."

2.2 DISTRIBUTION PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide comparable product by one of the following:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

C. Panelboards: NEMA PB 1, power and feeder distribution type.

D. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
1. For doors more than 36 inches high, provide two latches, keyed alike.

E. Mains: As indicated in schedules or shown in Single Line Diagram.

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

G. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

H. Branch Overcurrent Protective Devices: Fused switches.

I. All dump receipts, trip tickets, transportation manifests or other documentation of disposal shall be delivered to City of Inglewood, Division of Environmental Services at 1 Manchester Boulevard, Inglewood, CA 90301. Record keeping format shall utilize a chain of custody form which includes the names and addresses of the Generator (City of Inglewood), Contractor, pick-up site, disposal site, estimated quantity of hazardous materials waste disposed and the type of container utilized. This form shall be signed by the Generator (City of Inglewood), Transporter and the Disposal Site Operator as the responsibility of the material changes hands. Secondary Transporters are not allowed unless approved in writing by City of Inglewood's Division of Environment Services.

J. All waste manifests or other documentation of disposal shall require a minimum of 24-hour advance notice as a request prior to waste removal from the City of Inglewood to the following Division:

City of Inglewood - Division of Environmental Services

1 Manchester Boulevard, Inglewood, CA 90301

K. All waste transportation vehicles or containers shall be prepared as follows:
1. Following removal from the project site, all hazardous materials waste shall be immediately loaded into an enclosed truck, bin or dumpster for transportation.
2. Any debris or residue observed on waste containers or surfaces outside the work area resulting from clean-up or waste disposal activities shall be immediately cleaned up using HEPA vacuums and/or wet methods as appropriate.
3. The enclosed cargo area of the truck, bin or dumpster shall be free of debris and lined with at least one (1) layer of 6 mil. fire-resistant polyethylene sheeting to prevent contamination from leaking containers.
4. The enclosed cargo area of the truck, bin or dumpster shall have doors or tops that can be closed and locked to prevent vandalism or other disturbance of the packaged hazardous materials waste and wind dispersion of hazardous materials fibers. The door or top shall be secured and locked at all times with the exception of loading and unloading of hazardous materials waste.
5. Hazardous materials waste shall be transported from the Project site to the truck, bin or dumpster using appropriate drum dollies or covered debris carts.
6. Hazardous materials waste containers shall not contain loose, un-bagged material nor shall they contain non-hazardous materials waste.
7. Bags shall be placed, not thrown into the waste containers to prevent splitting and the release of hazardous materials fibers.
8. Drums or large structural components shall be placed on level surfaces in the cargo area and packed together to prevent shifting or tipping.

3.13 REESTABLISHMENT OF THE WORK AREAS AND SYSTEMS

A. Reestablishment of the work area shall only occur following the completion of clean-up procedures and after clearance air monitoring has been performed and documented to the satisfaction of City of Inglewood's Representative.

B. Polyethylene barriers shall be removed from walls, ceilings, and floors, maintaining decontamination enclosure systems and barriers over doors, window, etc. as required.

C. Contractor and City of Inglewood's Representative shall visually inspect the work area for any remaining visible residue. Evidence of contamination will necessitate additional cleaning and air sampling at no additional cost to City of Inglewood, until approved by City of Inglewood's Representative.

D. Following satisfactory clearance of the work area, remaining polyethylene barriers may be removed and disposed of as hazardous materials contaminated waste.

E. Repair all areas of damage that occurred as a result of abatement activities at no additional cost to City of Inglewood.

I. Contactors in Main Bus: NEMA ICS 2, Class A, electrically or mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
   1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
   2. External Control-Power Source: 120-V branch circuit 24-V control circuit.

J. For installation of integral TVSS to the distribution panelboards, refer to Section "Transient Voltage Suppression for Low Voltage Electrical Power Circuits."

2.3 LIGHTING, RECEPTACLE AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide comparable product by one of the following:
   1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
   3. Siemens Energy & Automation, Inc.
   4. Square D; a brand of Schneider Electric.

C. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

D. Mains: As indicated in Panel Schedules.

E. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

F. Contactors in Main Bus: NEMA ICS 2, Class A, electrically or mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
   1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
   2. External Control-Power Source: 120-V branch circuit, 24-V control circuit.

G. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

H. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.4 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Equipment Mounting: Install panelboards on concrete bases, 4-inch nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete."
   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
   2. For panelboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   4. Install anchor bolts to elevations required for proper attachment to panelboards.
   5. Attach panelboard to the vertical finished or structural surface behind the panelboard.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

D. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

E. Mount top of trim [**90 inches**] <**Insert height**> above finished floor unless otherwise indicated.

F. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

G. Install overcurrent protective devices and controllers not already factory installed.
   1. Set field-adjustable, circuit-breaker trip ranges.

H. Install filler plates in unused spaces.

I. Arrange conductors in gutters into groups and bundle and wrap with wire ties[**after completing load balancing**].

J. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads[**after balancing panelboard loads**]; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:
1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Tests and Inspections:
1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Panelboards will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies panelboards deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study."

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
1. Measure as directed during period of normal system loading.
2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.6 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 26 2416

SECTION 26 2713

ELECTRICITY METERING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes equipment for utility company's electricity metering and electricity metering by Owner.

B. Related Sections Include the Following:
   1. Division 26 Section "Overcurrent Protective Device Coordination Study."

1.3 DEFINITIONS

A. KY Pulse: Term used by the metering industry to describe a method of measuring consumption of electricity that is based on a relay opening and closing in response to the rotation of the disk in the meter.

B. PC: Personal computer.

1.4 SUBMITTALS

A. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, and finishes. Describe electrical characteristics, features, and operating sequences, both automatic and manual. Include the following:

   1. Electricity-metering equipment.

B. Shop Drawings for Electricity-Metering Equipment:

   1. Dimensioned plans and sections or elevation layouts.
   2. Wiring Diagrams: Power, signal, and control wiring specific to this Project. Identify terminals and wiring designations and color codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features.
   3. Mounting and anchoring devices recommended by manufacturer to resist seismic forces specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

C. Manufacturer Seismic Qualification Certification for Electricity-Metering Equipment: Submit certification that equipment components and their mounting and anchorage provisions have been designed to remain in place without separation of any parts or loosening of factory-made connections when subjected to the seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculations.
2. Detailed description of equipment mounting and anchorage devices on which the certification is based and their installation requirements.

D. Field quality-control test reports.

E. Operation and Maintenance Data. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Application and operating software documentation.
2. Software licenses.
3. Software service agreement.
4. Hard copies of manufacturer's operating specifications, design user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy Submittal.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Receive, store, and handle modular meter center as specified in NECA 400.

1.7 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify **[Architect]** **[Construction Manager]** **[Owner]** no fewer than **[two]** **<Insert number>** days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without **[Architect's]** **[Construction Manager's]** **[Owner's]** written permission.

1.8 COORDINATION

A. Electrical Service Connections: Coordinate with utility companies and components they furnish as follows:

1. Comply with requirements of utilities providing electrical power and communication services.
2. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

1.9 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for [**two**] <**Insert number**> years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within [**two**] <**Insert number**> years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide [**30**] <**Insert number**> days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade his computer equipment if necessary.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 EQUIPMENT FOR ELECTRICITY METERING BY UTILITY COMPANY

A. Meters will be furnished by utility company.

B. Current-Transformer Cabinets: Comply with requirements of electrical-power utility company.

C. Meter Sockets: Comply with requirements of electrical-power utility company.

D. Meter Sockets: Steady-state and short-circuit current ratings shall meet indicated circuit ratings.

E. Modular Meter Center: Factory-coordinated assembly of a main service [**terminal box with lugs only**] [**disconnect device**], wireways, tenant meter socket modules, and tenant feeder circuit breakers arranged in adjacent vertical sections. Assembly shall be complete with interconnecting buses and other features as specified below.

1. Manufacturers: Subject to compliance with requirements, [**provide products by one of the following**] [**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:
2. Basis-of-Design Product: Subject to compliance with requirements, provide [**product indicated on Drawings**] <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:

a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
c. Siemens Energy & Automation, Inc.

d. Square D; a brand of Schneider Electric.
e. **<Insert manufacturer's name>**.

3. Comply with requirements of utility company for meter center.
4. Housing: NEMA 250, [**Type 1**] [**Type 3R**] enclosure.

   a. Structural strength of the housing, its anchorage and component attachment provisions, and anchorage devices recommended for anchoring the housing in place shall be adequate to prevent separation of equipment and its components from their installed positions during a seismic event as defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

5. Minimum Short-Circuit Rating: [**22,000**] [**42,000**] [**65,000**] [**100,000**] **<Insert number>** amperes symmetrical at rated voltage.
6. Main Disconnect Device: Circuit breaker, series-combination rated for use with downstream feeder and branch circuit breakers.
7. Main Disconnect Device: Fusible switch, series-combination rated by circuit-breaker manufacturer to protect downstream feeder and branch circuit breakers.
8. Tenant Feeder Circuit Breakers: Series-combination-rated molded case units, rated to protect circuit breakers in downstream tenant and house loadcenters and panelboards that have 10,000-A interrupting capacity.

   a. Identification: Complying with requirements in Division 26 Section "Identification for Electrical Systems" with legend identifying tenant's address.
   b. Physical Protection: Tamper resistant, with hasp for padlock.
9. Meter Socket: Type as approved by utility company, with rating coordinated with indicated tenant feeder circuit rating.
10. Surge Protection: For main disconnect device, comply with requirements in Division 26 Section "Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits."

2.3 EQUIPMENT FOR ELECTRICITY METERING BY OWNER

A. Manufacturers: Subject to compliance with requirements, [**provide products by one of the following**] [**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:

B. Basis-of-Design Product: Subject to compliance with requirements, provide [**product indicated on Drawings**] **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:

   1. E-Mon; a division of Hunt Power.
   2. National Meter Industries.
   3. Osaki Meter Sales, Inc.
   4. Square D; a brand of Schneider Electric.
   5. **<Insert manufacturer's name>**.

C. General Requirements for Owner's Meters:

   1. Comply with UL 1244.
   2. Meters used for billing shall have an accuracy of [**0.2**] [**0.5**] [**1.0**] percent of reading, complying with requirements in ANSI C12.20.
   3. Meters shall be certified by [**California Type Evaluation Program**] **<Insert agency>** as complying with [**Title 4, California Code of Regulations, Article 2.2**] **<Insert regulatory requirements>**.

4. Enclosure: NEMA 250, [**Type 1**] [**Type 3R**] minimum, with hasp for padlocking or sealing.
5. Identification: Comply with requirements in Division 26 Section "Identification for Electrical Systems."
6. Memory Backup: Self-contained to maintain memory throughout power outages of 72 hours, minimum.
7. Sensors: Current-sensing type, with current or voltage output, selected for optimum range and accuracy for meters indicated for this application.

   a. Type: [**Split**] [**and**] [**solid**] core.

8. Current-Transformer Cabinet: Listed or recommended by metering equipment manufacturer for use with sensors indicated.
9. Building Automation System (BAS) Interface: One digital KY pulse to a user-definable increment of energy measurement. Match signal to [**BAS**] <**Insert signal destination**> input and arrange to convey the instantaneous, integrated, demand level measured by meter to provide data for processing and possible programmed demand control action by destination system.

D. Kilowatt-Hour Meter: Electronic [**single**] [**three**] [**single- and three**]-phase meters, measuring electricity use and demand. Demand shall be integrated over [**15-minute**] <**Insert Value**> interval.

1. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.
2. Display: LCD with characters not less than 0.25 inch high, indicating accumulative kilowatt-hours and current kilowatt load. Retain accumulated kilowatt-hour in a nonvolatile memory, until reset.
3. Display: Digital electromechanical counter, indicating accumulative kilowatt-hours.

E. Kilowatt-Hour/Demand Meter: Electronic [**single**] [**three**] [**single- and three**]-phase meters, measuring electricity use and demand. Demand shall be integrated over [**15 minute**] <**Insert Value**> interval.

1. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.
2. Display: LCD with characters not less than 0.25 inch high, indicating accumulative kilowatt-hours, [**current time and date,**]current demand,[**and**] historic peak demand[**, and time and date of historic peak demand**]. Retain accumulated kilowatt-hour and historic peak demand in a nonvolatile memory, until reset.
3. Demand Signal Communication Interface: Match signal to [**remote building automation system**] <**Insert signal destination**> input and arrange to convey the instantaneous, integrated, demand level measured by meter to provide data for processing and possible programmed demand control action by destination system.
4. Programmable Contact Module: Unit shall have push-button switches and a display for setting the demand level at which an integral set of Form C contacts shall be operated to initiate indicated action.
5. Enclosure: NEMA 250, Type [**1**] [**3R**] minimum, with hasp for padlocking or sealing.
6. Identification: Comply with Division 26 Section "Identification for Electrical Systems."
7. Memory Backup: Self-contained to maintain memory throughout power outages of 72 hours, minimum.
8. Sensors: Current-sensing type, with current or voltage output, selected for optimum range and accuracy for ratings of circuits indicated for this application.

   a. Type: [**Split**] [**and**] [**solid**] core.

9. Meter Accuracy: Nationally recognized testing laboratory certified to comply with ANSI C12.1.
10. Current-Transformer Cabinet: Listed or recommended by metering equipment manufacturer for use with sensors indicated.

F. Data Transmission Cable: Transmit KY pulse data over Class 1 control-circuit conductors in raceway. Comply with Division 26 Section "Control-Voltage Electrical Power Cables."

G. Software: PC based, a product of meter manufacturer, suitable for calculation of utility cost allocation[**and billing**].

1. Utility Cost Allocation: Automatically import energy-usage records to allocate energy costs for the following:

a. At least [**15**] <**Insert number**> departments.
b. At least [**30**] <**Insert number**> tenants.
c. At least [**five**] <**Insert number**> processes.
d. At least [**five**] <**Insert number**> buildings.
e. <**Insert entity**>.

2. Tenant or Activity Billing Software: Automatically import energy-usage records to automatically compute and prepare [**tenant bills**] [**activity demand and energy-use statements**] based on metering of energy use[**and peak demand**]. Maintain separate directory for each tenant's historical billing information. Prepare summary reports in user-defined formats and time intervals.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with equipment installation requirements in NECA 1.

B. Install meters furnished by utility company. Install raceways and equipment according to utility company's written requirements. Provide empty conduits for metering leads and extend grounding connections as required by utility company.

C. Install modular meter center according to NECA 400 switchboard installation requirements.

3.2 IDENTIFICATION

A. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

1. Series Combination Warning Label: Self-adhesive type, with text as required by NFPA 70.
2. Equipment Identification Labels: Adhesive film labels with clear protective overlay. For residential meters, provide an additional card holder suitable for [**printed, weather-resistant card**] [**typewritten card**] with occupant's name.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Connect a load of known kilowatt rating, [**1.5**] <**Insert number**> kW minimum, to a circuit supplied by metered feeder.
2. Turn off circuits supplied by metered feeder and secure them in off condition.
3. Run test load continuously for eight hours, minimum, or longer to obtain a measurable meter indication. Use test load placement and setting that ensures continuous, safe operation.
4. Check and record meter reading at end of test period and compare with actual electricity used based on test load rating, duration of test, and sample measurements of supply voltage at test load connection. Record test results.
5. Repair or replace deficient or malfunctioning metering equipment, or correct test setup; then retest. Repeat for each meter in installation until proper operation of entire system is verified.

C. Electricity metering will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 26 2713

END OF SECTION

SECTION 26 2726

WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes the following:

1. Standard-grade receptacles, 125 V, [**15**] [**20**] A.
2. USB receptacles.
3. GFCI receptacles, 125 V, 20 A.
4. SPD receptacles, 125 V, 20 A.
5. Hospital-grade receptacles, 125 V, 20 A.
6. Hazardous (classified) location receptacles.
7. Twist-locking receptacles.
8. Pendant cord-connector devices.
9. Cord and plug sets.
10. Toggle switches, 120/277 V, [**15**] [**20**] A.
11. Decorator-style devices, [**15**] [**20**] A.
12. Occupancy sensors.
13. Digital timer light switches.
14. Residential devices.
15. Wall-box dimmers.
16. Wall plates.
17. Floor service fittings.
18. Poke-through assemblies.
19. Prefabricated multioutlet assemblies.
20. Service poles.

B. Related Sections include the following:
1. Division 26 Section “Common Work Results for Electrical.”
2. Division 26 Section “Raceways and Boxes for Electrical Systems.”
3. Division 26 Section “Identification for Electrical Systems.”
4. Division 27 Section “Communications Horizontal Cabling” for workstation outlets.

1.3 DEFINITIONS

A. AFCI: Arc-fault circuit interrupter.

B. BAS: Building automation system.

C. EMI: Electromagnetic interference.

D. GFCI: Ground-fault circuit interrupter.

E. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

F. RFI: Radio-frequency interference.

G. SPD: Surge protective device.

1.4 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

D. Field quality-control reports.

E. Operation and Maintenance Data: To include all manufacturers' packing-label warnings and instruction manuals that include labeling conditions. Include wiring diagrams and set-up instructions.

1.5 EXTRA MATERIALS

A. Furnish extra materials described in sub-paragraphs below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Service/Power Poles: [**One for every 10**] <**Insert quantities**>, but no fewer than [**one**] <**Insert number**>.
2. Floor Service-Outlet Assemblies: [**One for every 10**] <**Insert quantities**>, but no fewer than [**one**] <**Insert number**>.
3. Poke-Through, Fire-Rated Closure Plugs: [**One for every five**] <**Insert quantities**> floor service outlets installed, but no fewer than [**two**] <**Insert number**>.
4. SPD Receptacles: [**One for every 10**] <**Insert quantities**> of each type installed, but no fewer than [**two of each type**] <**Insert number**>.
5. Every device not listed above, one of every type installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, **[provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:
1. Cooper Wiring Devices
2. Hubbell Incorporated
3. Leviton Mfg. Company Inc.
4. Pass & Seymour/Legrand
5. <Insert manufacturer's name>

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Comply with NFPA 70.

C. RoHS compliant.

D. Comply with NEMA WD 1.

E. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with requirements in this Section.

F. Devices for Owner-Furnished Equipment:

1. Receptacles: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

G. Device Color:

1. Wiring Devices Connected to Normal Power System: [**Almond**] [**Black**] [**Brown**] [**Gray**] [**Ivory**] [**White**] [**As selected by Architect**] <**Insert color**> unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Essential Electrical System: [**Red**] <**Insert color**>.
3. SPD Devices: Blue.
4. Isolated-Ground Receptacles: [**Orange**] [**As specified above, with orange triangle on face**].

H. Wall Plate Color: For plastic covers, match device color.

I. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.3 STANDARD-GRADE RECEPTACLES, 125 V, 20 A

A. Duplex Receptacles, 125 V, 20 A <**Insert drawing designation**>:
1. Description: Two pole, three wire, and self-grounding.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498 and FS W-C-596.

B. Isolated-Ground Duplex Receptacles, 125 V, 20 A <**Insert drawing designation**>:

1. Description: Straight blade; equipment grounding contacts shall be connected only to green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts. Two pole, three wire, and self-grounding.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498 and FS W-C-596.

C. Tamper-Resistant Duplex Receptacles, 125 V, 20 A <**Insert drawing designation**>:

1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498 and FS W-C-596.
4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

D. Weather-Resistant Duplex Receptacle, 125 V, 20 A <**Insert drawing designation**>:

1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498.
4. Marking: Listed and labeled as complying with NFPA 70, "Receptacles in Damp or Wet Locations" Article.

E. Tamper- and Weather-Resistant Duplex Receptacles, 125 V, 20 A <**Insert drawing designation**>:

1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498.
4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

2.4 STANDARD-GRADE RECEPTACLES, 125 V, 15 A

A. Duplex Receptacles, 125 V, 15 A <**Insert drawing designation**>:

1. Description: Two pole, three wire, and self-grounding.
2. Configuration: NEMA WD 6, Configuration 5-15R.
3. Standards: Comply with UL 498 and FS W-C-596.

B. Isolated-Ground Duplex Receptacles, 125 V, 15 A <**Insert drawing designation**>:

1. Description: Straight blade; equipment grounding contacts shall be connected only to green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts. Two pole, three wire, and self-grounding.
2. Configuration: NEMA WD 6, Configuration 5-15R.
3. Standards: Comply with UL 498 and FS W-C-596.

C. Tamper-Resistant Duplex Receptacles, 125 V, 15 A <**Insert drawing designation**>:

1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.
2. Configuration: NEMA WD 6, Configuration 5-15R.
3. Standards: Comply with UL 498 and FS W-C-596.
4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

D. Weather-Resistant Duplex Receptacle, 125 V, 15 A <**Insert drawing designation**>:

1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
2. Configuration: NEMA WD 6, Configuration 5-15R.

3. Standards: Comply with UL 498.
4. Marking: Listed and labeled as complying with NFPA 70, "Receptacles in Damp or Wet Locations" Article.

E. Tamper- and Weather-Resistant Duplex Receptacles, 125 V, 15 A <**Insert drawing designation**>:

1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
2. Configuration: NEMA WD 6, Configuration 5-15R.
3. Standards: Comply with UL 498.
4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

2.5 USB RECEPTACLES

A. USB Charging Receptacles <**Insert drawing designation**>:

1. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap.
2. USB Receptacles: [**Dual**] [**and**] [**quad**], USB Type A, 5 V dc, and 2.1 A per receptacle (minimum).
3. Standards: Comply with UL 1310 and USB 3.0 devices.

B. Tamper-Resistant Duplex and USB Charging Receptacles <**Insert drawing designation**>:

1. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap. Integral shutters that operate only when a plug is inserted in the line voltage receptacle.
2. Line Voltage Receptacles: Two pole, three wire, and self-grounding; NEMA WD 6, Configuration 5-20R.
3. USB Receptacles: Dual USB Type A, 5 V dc, and 2.1 A per receptacle (minimum).
4. Standards: Comply with UL 498, UL 1310, USB 3.0 devices, and FS W-C-596.
5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

2.6 GFCI RECEPTACLES, 125 V, 20 A

A. Duplex GFCI Receptacles, 125 V, 20 A <**Insert drawing designation**>:

1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Type: [**Feed**] [**Non-feed**] through.
4. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.

B. Tamper-Resistant Duplex GFCI Receptacles, 125 V, 20 A <**Insert drawing designation**>:

1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Type: [**Feed**] [**Non-feed**] through.
4. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.
5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

C. Tamper- and Weather-Resistant, GFCI Duplex Receptacles, 125 V, 20 A <**Insert drawing designation**>:

1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
2. Configuration: NEMA WD 6, Configuration 5-15R.
3. Type: [**Feed**] [**Non-feed**] through.
4. Standards: Comply with UL 498 and UL 943 Class A.
5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

2.7 SPD RECEPTACLES, 125 V, 20 A

A. Duplex SPD Receptacles, 125 V, 20 A <**Insert drawing designation**>:

1. Description: Two pole, three wire, and self-grounding. Integral SPD in line to ground, line to neutral, and neutral to ground. LED indicator light.
2. SPD Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 400 V and minimum single transient pulse energy dissipation of 240 J, according to IEEE C62.41.2 and IEEE C62.45.
3. Active SPD Indication: Visual and audible, with light visible in face of device to indicate device is "active" or "no longer in service."
4. Configuration: NEMA WD 6, Configuration 5-20R.
5. Standards: Comply with NEMA WD 1, UL 498, UL 1449, and FS W-C-596.

B. Isolated-Ground Duplex SPD Receptacles, 125 V, 20 A <**Insert drawing designation**>:

1. Description: Two pole, three wire, and self-grounding. Integral SPD in line to ground, line to neutral, and neutral to ground. LED indicator light.
2. SPD Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 400 V and minimum single transient pulse energy dissipation of 240 J, according to IEEE C62.41.2 and IEEE C62.45.
3. Active SPD Indication: Visual and audible, with light visible in face of device to indicate device is "active" or "no longer in service."
4. Grounding: Equipment grounding contacts shall be connected only to green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.
5. Configuration: NEMA WD 6, Configuration 5-20R.
6. Standards: Comply with UL 498, UL 1449, and FS W-C-596.

2.8 HOSPITAL-GRADE RECEPTACLES, 125 V, 20 A

A. Hospital-Grade, Single Receptacles, 125 V, 20 A <**Insert drawing designation**>:

1. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap. Two pole, three wire, and self-grounding.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498 Supplement sd and FS W-C-596.
4. Marking: Listed and labeled as complying with NFPA 70, "Health Care Facilities" Article.

B. Hospital-Grade, Duplex Receptacles, 125 V, 20 A <**Insert drawing designation**>:

1. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap. Two pole, three wire, and self-grounding.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498 Supplement sd and FS W-C-596.
4. Marking: Listed and labeled as complying with NFPA 70, "Health Care Facilities" Article.

C. Hospital-Grade, Isolated-Ground, Duplex Receptacles, 125 V, 20 A <**Insert drawing designation**>:

1. Description: Straight blade; equipment grounding contacts shall be connected only to green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts. Two pole, three wire, and self-grounding.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498 Supplement sd and FS W-C-596.
4. Marking: Listed and labeled as complying with NFPA 70, "Health Care Facilities" Article.

D. Hospital-Grade, Tamper-Resistant, Duplex Receptacles, 125 V, 20 A <**Insert drawing designation**>:

1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with NEMA WD 1, UL 498 Supplement sd, and FS W-C-596.
4. Marking: Listed and labeled as complying with NFPA 70, "Health Care Facilities" Article.

E. Hospital-Grade, Tamper-Resistant, Duplex (125 V, 20 A) and USB Charging Receptacles <**Insert drawing designation**>:

1. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap. Integral shutters that operate only when a plug is inserted in the line voltage receptacle.
2. Line Voltage Receptacles: Two pole, three wire, and self-grounding, NEMA Configuration 5-20R.
3. USB Receptacles: Dual, USB Type A, 5 V dc, and 2.1 A per receptacle (minimum).
4. Standards: Comply with NEMA WD 1, UL 498 Supplement sd, UL 1310, and FS W-C-596.
5. Marking: Listed and labeled as complying with NFPA 70, "Health Care Facilities" Article.

F. Hospital-Grade, Duplex GFCI Receptacles, 125 V, 20 A <**Insert drawing designation**>:

1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding. Single-piece, rivetless, nickel-plated, all-brass grounding system.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Type: [**Feed**] [**Non-feed**] through.
4. Standards: Comply with UL 498 supplement sd, UL 943 Class A, and FS W-C-596.
5. Marking: Listed and labeled as complying with NFPA 70, "Health Care Facilities" Article.

G. Hospital-Grade, Tamper-Resistant, Duplex GFCI Receptacles, 125 V, 20 A <**Insert drawing designation**>:

1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Single-piece, rivetless, nickel-plated, all-brass grounding system.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Type: [**Feed**] [**Non-feed**] through.
4. Standards: Comply with UL 498 supplement sd, UL 943 Class A, and FS W-C-596.
5. Marking: Listed and labeled as complying with NFPA 70, "Health Care Facilities" Article.

H. Hospital-Grade, Duplex SPD Receptacles, 125 V, 20 A <**Insert drawing designation**>:

1. Description: Two pole, three wire, and self-grounding. Integral SPD in line to ground, line to neutral, and neutral to ground. LED indicator light. With single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap.
2. SPD Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 400 V and minimum single transient pulse energy dissipation of 240 J, according to IEEE C62.41.2 and IEEE C62.45.
3. Active SPD Indication: Visual and audible, with light visible in face of device to indicate device is "active" or "no longer in service."
4. Configuration: NEMA WD 6, Configuration 5-20R.
5. Standards: Comply with UL 498 supplement sd, UL 1449, and FS W-C-596.
6. Marking: Listed and labeled as complying with NFPA 70, "Health Care Facilities" Article.

I. Hospital-Grade, Isolated-Ground, Duplex SPD Receptacles, 125 V, 20 A <**Insert drawing designation**>:

1. Description: With single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap. Two pole, three wire, and self-grounding.
2. SPD Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 400 V and minimum single transient pulse energy dissipation of 240 J, according to IEEE C62.41.2 and IEEE C62.45.
3. Active SPD Indication: Visual and audible, with light visible in face of device to indicate device is "active" or "no longer in service."
4. Grounding: Equipment grounding contacts shall be connected only to green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.
5. Configuration: NEMA WD 6, Configuration 5-20R.
6. Standards: Comply with NEMA WD 1, UL 498 supplement sd, UL 1449, and FS W-C-596.
7. Marking: Listed and labeled as complying with NFPA 70, "Health Care Facilities" Article.

2.9 HAZARDOUS (CLASSIFIED) LOCATION RECEPTACLES

A. Hazardous (Classified) Locations Receptacles <**Insert drawing designation**>:

1. Description: Pin and sleeve receptacle with matching connector.
2. Class I (Flammable Gases or Vapors).
   a. Division: [**1**] [**2**].
   b. Group: [**A**] [**B**] [**C**] [**D**]
   c.
   d.
3. Class II (Combustible Dusts):
   a. Division: [**1**] [**2**].
   b. Group: [**E**] [**F**] [**G**].
4. Class III (Combustible Fibers):
   a. Division: [**1**] [**2**].
5. Class I (Flammable Gases or Vapors)
   a. Zone: [**0**] [**1**] [**2**]

b. Material Group: **[IIA]** **[IIB]** **[IIC]**

6. Zone 2x (Combustible Dust or Ignitible Fibers/Flyings)
   a. Zone: **[20]** **[21]** **[22]**
   b. Material Group: **[IIIA]** **[IIIB]** **[IIIC]**

7. Raintight.
8. Voltage: **[250]** **[480]** **[600]** <**Insert value**> V ac.
9. Hertz: **[60]** <**Insert value**> Hz.
10. Amperage: **[20]** **[30]** **[60]** <**Insert value**> A.
11. Wires and Poles: **[Two wire, three pole]** **[Three wire, three pole]** **[Three wire, four pole]** **[Four wire, four pole]** **[Four wire, five pole]** **[Five wire, five pole]** <**Insert configuration**>.
12. Standards: Comply with NEMA FB 11 and UL 1203.

2.10 TWIST-LOCKING RECEPTACLES

A. Twist-Lock, Single Receptacles, 120 V, 20 A <**Insert drawing designation**>:

1. Configuration: NEMA WD 6, Configuration L5-20R.
2. Standards: Comply with UL 498.

B. Twist-Lock, Single Receptacles, 250 V, 20 A <**Insert drawing designation**>:

1. Configuration: NEMA WD 6, Configuration L6-20R.
2. Standards: Comply with UL 498.

C. Twist-Lock, Single Receptacles, 277 V, 20 A <**Insert drawing designation**>:

1. Configuration: NEMA WD 6, Configuration L7-20R.
2. Standards: Comply with UL 498.

D. Twist-Lock, Isolated-Ground, Single Receptacles, 125 V, 20 A <**Insert drawing designation**>:

1. Grounding: Equipment grounding contacts shall be connected only to green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.
2. Configuration: NEMA WD 6, Configuration L5-20R.
3. Standards: Comply with UL 498.

2.11 PENDANT CORD-CONNECTOR DEVICES <Insert drawing designation>

A. Description: Matching, locking-type plug and receptacle body connector, heavy-duty grade.

Revise NEMA configuration in "Configuration" Paragraph below to suit Project.

B. Configuration: NEMA WD 6, Configurations L5-20P and L5-20R.

C. Body: Nylon, with screw-open, cable-gripping jaws and provision for attaching external cable grip.

D. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

E. Standards: Comply with FS W-C-596.

2.12 CORD AND PLUG SETS

A. Match voltage and current ratings and number of conductors to requirements of equipment being connected.

B. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.

C. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.13 TOGGLE SWITCHES, 120/277 V, 15 A

A. Single-Pole Switches, 120/277 V, 15 A <**Insert drawing designation**>:

1. Standards: Comply with UL 20 and FS W-S-896.

B. Two-Pole Switches, 120/277 V, 15 A <**Insert drawing designation**>:

1. Comply with UL 20 and FS W-S-896.
2. Description: Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
3. Standards: Comply with UL 20 and FS W-S-896.

C. Three-Way Switches, 120/277 V, 15 A <**Insert drawing designation**>:

1. Comply with UL 20 and FS W-S-896.

D. Four-Way Switches, 120/277 V, 15 A <**Insert drawing designation**>:

1. Standards: Comply with UL 20 and FS W-S-896.

E. Pilot-Light, Single-Pole Switches: 120/277 V, 15 A <**Insert drawing designation**>:

1. Description: Illuminated when switch is [**on**] [**off**].
2. Standards: Comply with UL 20 and FS W-S-896.

F. Lighted Single-Pole Switches, 120/277 V, 15 A <**Insert drawing designation**>:

1. Description: Handle illuminated when switch is [**on**] [**off**].
2. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

G. Key-Operated, Single-Pole Switches, 120/277 V, 15 A <**Insert drawing designation**>:

1. Description: Factory-supplied key in lieu of switch handle.
2. Standards: Comply with UL 20 and FS W-S-896.

H. Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches, 120/277 V, 15 A <**Insert drawing designation**>:

1. Description: For use with mechanically held lighting contactors.
2. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

SECTION 031000

CONCRETE FORMING AND ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes cast-in-place concrete formwork and accessories, for the following:
   1. Retaining Walls and Footings.
   2. Shear Walls.
   3. Slabs-on-grade.
   4. Concrete Toppings.
   5. Post-Installed Reinforcing Bars Connections.

B. Related Sections:
   1. Section 033000 "Cast-In-Place Concrete".
   2. Section 032000 "Concrete Reinforcement".

1.3 REFERENCES

A. Abbreviations & Acronyms
   1. ACI – American Concrete Institute

B. Reference Standards
   1. ACI 301-10: Specification for Structural Concrete Buildings.
   2. ACI 117-10: Specification for Tolerances for Concrete Construction and Materials
   3. ACI 347-04: Guide to Formwork for Concrete

1.4 INFORMATIONAL SUBMITTALS

A. Material Certificates: For each of the following, signed by manufacturers:
   1. Form materials and form-release agents.

1.5 QUALITY ASSURANCE

A. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:
   1. ACI 301-10, "Specifications for Structural Concrete for Buildings"
   2. ACI 117-10, "Specification for Tolerances for Concrete Construction and Materials"

PART 2 - PRODUCTS

2.1 FORM-FACING MATERIALS

A. Smooth-Formed Finished Concrete: Form-facing panels that will provide continuous, true, and smooth concrete surfaces. Furnish in largest practicable sizes to minimize number of joints.
   1. Plywood, metal, or other approved panel materials.
   2. Exterior-grade plywood panels, suitable for concrete forms, complying with DOC PS 1, and as follows:
      a. High-density overlay, Class 1 or better.

I. Key-Operated, Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches, 120/277 V, 15 A <**Insert drawing designation**>:

1. Description: For use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.
2. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

2.14 TOGGLE SWITCHES, 120/277 V, 20 A

A. Single-Pole Switches, 120/277 V, 20 A <**Insert drawing designation**>:

1. Standards: Comply with UL 20 and FS W-S-896.

B. Antimicrobial, Single-Pole Switches, 120/277 V, 20 A <**Insert drawing designation**>:

1. Description: Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
2. Standards: Comply with UL 20 and FS W-S-896.

C. Two-Pole Switches, 120/277 V, 20 A <**Insert drawing designation**>:

1. Comply with UL 20 and FS W-S-896.

D. Antimicrobial, Double-Pole Switches, 120/277 V, 20 A <**Insert drawing designation**>:

1. Description: Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
2. Standards: Comply with UL 20 and FS W-S-896.

E. Three-Way Switches, 120/277 V, 20 A <**Insert drawing designation**>:

1. Comply with UL 20 and FS W-S-896.

F. Antimicrobial, Three-Way Switches, 120/277 V, 20 A <**Insert drawing designation**>:

1. Description: Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
2. Standards: Comply with UL 20 and FS W-S-896.

G. Four-Way Switches, 120/277 V, 20 A <**Insert drawing designation**>:

1. Standards: Comply with UL 20 and FS W-S-896.

H. Pilot-Light, Single-Pole Switches: 120/277 V, 20 A <**Insert drawing designation**>:

1. Description: Illuminated when switch is [**on**] [**off**].
2. Standards: Comply with UL 20 and FS W-S-896.

I. Lighted Single-Pole Switches, 120/277 V, 20 A <**Insert drawing designation**>:

1. Description: Handle illuminated when switch is [**on**] [**off**].
2. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

J. Key-Operated, Single-Pole Switches, 120/277 V, 20 A <**Insert drawing designation**>:

1. Description: Factory-supplied key in lieu of switch handle.
2. Standards: Comply with UL 20 and FS W-S-896.

K. Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches, 120/277 V, 20 A <**Insert drawing designation**>:

1. Description: For use with mechanically held lighting contactors.
2. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

L. Key-Operated, Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches, 120/277 V, 20 A <**Insert drawing designation**>:

1. Description: For use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.
2. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

2.15 DECORATOR-STYLE DEVICES, 15 A

A. Decorator Duplex Receptacles, 125 V, 15 A <**Insert drawing designation**>:

1. Description: Two pole, three wire, and self-grounding. Square face.
2. Configuration: NEMA WD 6, Configuration 5-15R.
3. Standards: Comply with UL 498.

B. Decorator, Tamper-Resistant, Duplex Receptacles, 125 V, 15 A, <**Insert drawing designation**>:

1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
2. Configuration: NEMA WD 6, Configuration 5-15R.
3. Standards: Comply with UL 498.
4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

C. Decorator, Tamper- and Weather-Resistant, Duplex Receptacles, 125 V, 15 A <**Insert drawing designation**>:

1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
2. Configuration: NEMA WD 6, Configuration 5-15R.
3. Standards: Comply with UL 498.
4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

D. Decorator Single-Pole Switches, 120/277 V, 15 A <**Insert drawing designation**>:

1. Comply with UL 20.

E. Decorator Single-Pole Lighted Switches,120/277 V, 15 A <**Insert drawing designation**>:

1. Description: Square face illuminated when circuit is switched off.
2. Standards: Comply with UL 20.

F. Decorator, Antimicrobial, Single-Pole Switches, 120/277 V, 15 A <**Insert drawing designation**>:

1. Description: Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
2. Standards: Comply with UL 20 and FS W-S-896.

2.16 DECORATOR-STYLE DEVICES, 20 A

A. Decorator Duplex Receptacles, 125 V, 20 A <**Insert drawing designation**>:

1. Description: Two pole, three wire, and self-grounding. Square face.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498.

B. Decorator Tamper-Resistant Duplex Receptacles, 125 V, 20 A <**Insert drawing designation**>:

1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498.
4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

C. Decorator, Tamper- and Weather-Resistant, Duplex Receptacles, 125 V, 20 A <**Insert drawing designation**>:

1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498.
4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

D. Decorator Single-Pole Switches, 120/277 V, 20 A <**Insert drawing designation**>:

1. Comply with UL 20.

E. Decorator Single-Pole Lighted Switches,120/277 V, 20 A <**Insert drawing designation**>:

1. Description: Square face illuminated when circuit is switched off.
2. Standards: Comply with UL 20.

F. Decorator, Antimicrobial, Single-Pole Switches, 120/277 V, 20 A <**Insert drawing designation**>:

1. Description: Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
2. Standards: Comply with UL 20 and FS W-S-896.

2.17 OCCUPANCY SENSORS

A. Wall Switch Sensor Light Switch, Dual Technology <**Insert drawing designation**>:

1. Description: Switchbox-mounted, combination lighting-control sensor and conventional switch lighting-control unit using dual (ultrasonic and passive infrared) technology.
2. Standards: Comply with UL 20.

3. Rated 960 W at 120 V ac for tungsten lighting, 10 A at 120 V ac or 10 A at 277 V ac for fluorescent or LED lighting, and 1/4 hp at 120 V ac.
4. Adjustable time delay of [**five**] [**10**] [**15**] [**20**] minutes.
5. Able to be locked to [**Automatic**] [**Manual**]-On mode.
6. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc.
7. Connections: Provisions for connection to BAS.
8. Connections: RJ-45 communications outlet.
9. Connections: Integral wireless networking.

B. Wall Sensor Light Switch, Passive Infrared <**Insert drawing designation**>:

1. Description: Switchbox-mounted, combination, lighting-control sensor and conventional switch lighting-control unit using passive infrared technology.
2. Standards: Comply with UL 20.
3. Connections: Provisions for connection to BAS.
4. Connections: Hard wired.
5. Connections: Wireless.
6. Rated 960 W at 120 V ac for tungsten lighting, 10 A at 120 V ac or 10 A at 277 V ac for fluorescent or LED lighting, and 1/4 hp at 120 V ac.
7. Integral relay for connection to BAS.
8. Adjustable time delay of [**five**] [**10**] [**15**] [**20**] minutes.
9. Able to be locked to [**Automatic**] [**Manual**]-On mode.
10. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc.

C. Wall Sensor Light Switch, Ultrasonic <**Insert drawing designation**>:

1. Description: Switchbox-mounted, combination, lighting-control sensor and conventional switch lighting-control unit using ultrasonic technology.
2. Standards: Comply with UL 20.
3. Connections: Provisions for connection to BAS.
4. Connections: RJ-45 communications outlet.
5. Connections: Integral wireless networking.
6. Rated 960 W at 120 V ac for tungsten lighting, 10 A at 120 V ac or 10 A at 277 V ac for fluorescent or LED lighting, and 1/4 hp at 120 V ac.
7. Integral relay for connection to BAS.
8. Adjustable time delay of [**five**] [**10**] [**15**] [**20**] minutes.
9. Able to be locked to [**Automatic**] [**Manual**]-On mode.
10. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc.

2.18 TIMER LIGHT SWITCH

A. Digital Timer Light Switch <**Insert drawing designation**>:

1. Description: Switchbox-mounted, combination digital timer and conventional switch lighting-control unit, with backlit digital display, with selectable time interval in [**10**] [**20**]-minute increments.
2. Standards: Comply with UL 20.
3. Rated 960 W at 120 V ac for tungsten lighting, 10 A at 120 V ac or 10 A at 277 V ac for fluorescent or LED lighting, and 1/4 hp at 120 V ac.
4. Integral relay for connection to BAS.

2.19 RESIDENTIAL DEVICES

A. Residential-Grade, Tamper-Resistant, GFCI Receptacles, 125 V, 15 A <**Insert drawing designation**>:

1. Configuration: NEMA WD 6, Configuration 5-15R.
2. Feed-through connectors.
3. Standards: Comply with UL 943 and UL 1699.

B. Residential-Grade, Tamper-Resistant, AFCI Receptacles, 125 V, 15 A <**Insert drawing designation**>:

1. Configuration: NEMA WD 6, Configuration 5-15R.
2. Feed-through connectors.
3. Standards: Comply with UL 943 and UL 1699.

C. Residential-Grade, Tamper-Resistant Receptacles, 125 V, 15 A <**Insert drawing designation**>:

1. Configuration: NEMA WD 6, Configuration 5-15R.
2. Feed-through connectors.
3. Standards: Comply with UL 498.

D. Weather- and Tamper-Resistant Receptacles, 125 V, 15 A <**Insert drawing designation**>:

1. Configuration: NEMA WD 6, Configuration 5-15R.
2. Feed-through connectors.
3. Standards: Comply with UL 498.
4. Marked as "Weather Resistant."

E. Fan-Speed Controls <**Insert drawing designation**>:

1. Description: Modular, [**120**] [**277**]-V ac, full-wave, solid-state units with integral, quiet on-off switches and audible frequency and EMI/RFI filters.
2. Standards: Comply with UL 1917.
3. Continuously adjustable [**slider**] [**toggle switch**] [**rotary knob**], [**5**] [**1.5**] A.
4. Three-speed adjustable [**slider**] [**rotary knob**], 1.5 A.

F. Telephone Outlet <**Insert drawing designation**>:

1. Description: Single RJ-11 jack for terminating [**Category 3**], balanced twisted pair cable complying with Section 26 0523 "Control-Voltage Electrical Power Cables."
2. Description: Single RJ-11 jack for terminating [**Category 3**], balanced twisted pair cable complying with Section 27 1513 "Communications Copper Horizontal Cabling."
3. Standards: Comply with UL 1863.

G. Combination Telephone and Coaxial Outlet <**Insert drawing designation**>:

1. Description: Single RJ-11 jack for terminating [**Category 3**], twisted pair cable complying with Section 26 0523 "Control-Voltage Electrical Power Cables" and a single BNC connector for terminating coaxial cable.
2. Description: Single RJ-11 jack for terminating [**Category 3**], twisted pair cable complying with Section 27 1513 "Communications Copper Horizontal Cabling" and a single BNC connector for terminating coaxial cable complying with Section 27 1533 "Communications Coaxial Horizontal Cabling."
3. Standards: Comply with UL 1863.

2.20 DIMMERS

A. Wall-Box Dimmers:

1. Description: Modular, full-wave, solid-state dimmer switch with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
2. Control: Continuously adjustable **[slider]** **[toggle switch]** **[rotary knob]**; with single-pole or three-way switching.
3. Standards: Comply with UL 1472.
4. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.

    a. 600 W; dimmers shall require no derating when ganged with other devices.[**Illuminated when "off."**]
    b. <**Insert wattage ratings and descriptions**>.

5. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.
6. LED Lamp Dimmer Switches: Modular; compatible with LED lamps; trim potentiometer to adjust low-end dimming; capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.21 WALL PLATES

A. Single Source: Obtain wall plates from same manufacturer of wiring devices.

B. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: **[Steel with white baked enamel, suitable for field painting]** **[Smooth, high-impact thermoplastic]** **[0.035-inch-thick, satin-finished, Type 302 stainless steel]** **[0.04-inch-thick, brushed brass with factory polymer finish]** **[0.05-inch-thick, anodized aluminum]** **[0.04-inch-thick steel with chrome-plated finish]**.
3. Material for Unfinished Spaces: **[Galvanized steel]** **[Smooth, high-impact thermoplastic]**.
4. Material for Damp Locations: **[Thermoplastic]** **[Cast aluminum]** with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant**[, die-cast aluminum]** **[thermoplastic]** with lockable cover.

D. Antimicrobial Cover Plates:

1. Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
2. Tarnish resistant.

2.22 FLOOR SERVICE FITTINGS

A. Flush-Type Floor Service Fittings:

1. Description: Type: Modular, flush-type, dual-service units suitable for wiring method used, with cover flush with finished floor.

2. Compartments: Barrier separates power from voice and data communication cabling.
3. Service Plate and Cover: [**Rectangular**] [**Round**], [**die-cast aluminum**] [**solid brass**] with satin finish.
4. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.
5. Data Communication Outlet: [**Blank cover with bushed cable opening.**] [**Two modular, keyed, color-coded, RJ-45 jacks for twisted pair cable, complying with requirements in Section 27 1513 "Communications Copper Horizontal Cabling."**]

B. Flap-Type Service Fittings:

1. Description: Type: Modular, flap-type, dual-service units suitable for wiring method used, with flaps flush with finished floor.
2. Compartments: Barrier separates power from voice and data communication cabling.
3. Flaps: [**Rectangular**] [**Round**], [**die-cast aluminum**] [**solid brass**] with satin finish.
4. Service Plate: Same finish as flaps.
5. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.
6. Data Communication Outlet: [**Blank cover with bushed cable opening.**] [**Two modular, keyed, color-coded, RJ-45 jacks for twisted pair cable, complying with requirements in Section 27 1513 "Communications Copper Horizontal Cabling."**]

C. Above-Floor Service Fittings:

1. Description: Type: Modular, above-floor, dual-service units suitable for wiring method used.
2. Compartments: Barrier separates power from voice and data communication cabling.
3. Service Plate: [**Rectangular**] [**Round**], [**die-cast aluminum**] [**solid brass**] with satin finish.
4. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.
5. Data Communication Outlet: [**Blank cover with bushed cable opening.**] [**Two modular, keyed, color-coded, RJ-45 jacks for twisted pair cable, complying with requirements in Section 27 1513 "Communications Copper Horizontal Cabling."**]

2.23 POKE-THROUGH ASSEMBLIES <Insert drawing designation>

A. Description: Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service-outlet assembly.

B. Standards: Comply with scrub water exclusion requirements in UL 514.

C. Service-Outlet Assembly: [**Pedestal type with services indicated**] [**Flush type with two simplex receptacles and space for two RJ-45 jacks**] [**Flush type with four simplex receptacles and space for four RJ-45 jacks**], complying with requirements in Section 27 1513 "Communications Copper Horizontal Cabling."

D. Size: Selected to fit nominal [**3-inch**] [**4-inch**] cored holes in floor and matched to floor thickness.

E. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.

F. Closure Plug: Arranged to close unused [**3-inch**] [**4-inch**] cored openings and reestablish fire rating of floor.

G. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of [**two**] [**four**], four-pair cables that comply with requirements in Section 27 1513 "Communications Copper Horizontal Cabling."

2.24 PREFABRICATED MULTIOUTLET ASSEMBLIES <Insert drawing designation>

A. Description: Two-piece surface metal raceway, with factory-wired multioutlet harness.

B. Components shall be products from single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

C. Raceway Material: [**Metal, with manufacturer's standard finish**] [**PVC**].

D. Multioutlet Harness:

1. Receptacles: 15-A, 125-V, NEMA WD 6 Configuration 5-15R receptacles complying with NEMA WD 1, UL 498, and FS W-C-596.
2. Receptacle Spacing: [**6 inches**] [**9 inches**] [**12 inches**] [**18 inches**].
3. Wiring: No. 12 AWG solid, Type THHN copper, [**single circuit**] [**two circuit, connecting alternating receptacles**].

2.25 SERVICE POLES

A. Dual-Channel Service Poles <**Insert drawing designation**>:

1. Description: Factory-assembled and -wired units to extend power and voice and data communication from distribution wiring concealed in ceiling to devices or outlets in pole near floor.
2. Poles: Nominal 2.5-inch-square cross-section, with height adequate to extend from floor to at least 6 inches above ceiling, and with separate channels for power wiring and voice and data communication cabling.
3. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to ceiling supports; with pole foot and carpet pad attachment.
4. Material: [**Aluminum**] <**Insert material**>.
5. Finishes: [**Manufacturer's standard painted finish and trim combination**] [**Satin-anodized aluminum**].
6. Wiring: Sized for minimum of five No. 12 AWG power and ground conductors and a minimum of four, balanced twisted pair data communication cables.
7. Power Receptacles: Two duplex, 20-A, straight-blade receptacles complying with requirements in this Section.
8. Data Communication Outlets: [**Blank insert with bushed cable opening.**] [**Two RJ-45 jacks, complying with requirements in Section 27 1513 "Communications Copper Horizontal Cabling."**] [**Four RJ-45 jacks, complying with requirements in Section 27 1513 "Communications Copper Horizontal Cabling."**]

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes, and do not cut holes for boxes with routers that are guided by riding against outside of boxes.

2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall comply with NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

   a. Cut back and pigtail, or replace all damaged conductors.
   b. Straighten conductors that remain and remove corrosion and foreign matter.
   c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles [**up**] [**down**], and on horizontally mounted receptacles to the [**right**] [**left**].
2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan-speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device, listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

A. Install non-feed-through GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

A. Comply with Section 26 0553 "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with [**black**] [**white**] [**red**]-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

C. Essential Electrical System: Mark receptacles supplied from the essential electrical system to allow easy identification using a self-adhesive label.

3.4 FIELD QUALITY CONTROL

A. Test Instruments: Use instruments that comply with UL 1436.

B. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:

1. In healthcare facilities, prepare reports that comply with NFPA 99.
2. Test Instruments: Use instruments that comply with UL 1436.
3. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

D. Tests for Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault-current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

E. Test straight-blade [**convenience outlets in patient-care areas**] [**hospital-grade outlets**] for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz.

b. Medium-density overlay, Class 1 or better; mill-release agent treated and edge sealed.
c. Structural 1, B-B or better; mill oiled and edge sealed.
d. B-B (Concrete Form), Class 1 or better; mill oiled and edge sealed.

B. Rough-Formed Finished Concrete: Plywood, lumber, metal, or another approved material. Provide lumber dressed on at least two edges and one side for tight fit.

C. Pan-Type Forms: Glass-fiber-reinforced plastic or formed steel, stiffened to resist plastic concrete loads without detrimental deformation.

D. Void Forms: Biodegradable paper surface, treated for moisture resistance, structurally sufficient to support weight of plastic concrete and other superimposed loads.

E. Chamfer Strips: Wood, metal, PVC, or rubber strips, 3/4 by 3/4 inch (19 by 19 mm), minimum.

F. Rustication Strips: Wood, metal, PVC, or rubber strips, kerfed for ease of form removal.

G. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.
1. Formulate form-release agent with rust inhibitor for steel form-facing materials.

H. Form Ties: Factory-fabricated, removable or snap-off metal or glass-fiber-reinforced plastic form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.
1. Furnish units that will leave no corrodible metal closer than 1 inch (25 mm) to the plane of exposed concrete surface.
2. Furnish ties that, when removed, will leave holes no larger than 1 inch (25 mm) in diameter in concrete surface.
3. Furnish ties with integral water-barrier plates to walls indicated to receive dampproofing or waterproofing.

PART 3 - EXECUTION

3.1 FORMWORK

A. Design, erect, shore, brace, and maintain formwork, according to ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads.

B. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.

C. Limit concrete surface irregularities, designated by ACI 347 as abrupt or gradual, as follows:
1. Class A, 1/8 inch for smooth-formed finished surfaces.
2. Class C, 1/2 inch for rough-formed finished surfaces.

D. Construct forms tight enough to prevent loss of concrete mortar.

E. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.
1. Install keyways, reglets, recesses, and the like, for easy removal.
2. Do not use rust-stained steel form-facing material.

F. Wiring device will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

END OF SECTION 26 2726

SECTION 26 2816

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Bolted pressure contact switches.
   2. Molded-case circuit breakers (MCCBs).
   3. Molded-case switches.
   4. Enclosures.

B. Related Sections:
   1. Division 26 "Low Voltage Electrical Cables."
   2. Division 26 "Overcurrent Protective Device Coordination Study."
   3. Division 26 "Identification for Electrical Systems."
   4. Division 26 "Switchboards."
   5. Division 26 "Panelboards."
   6. Division 26 "Enclosed Bus Assemblies."
   7. Division 26 "Power Distribution Systems."

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."

1.5 SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
   1. Enclosure types and details for types other than NEMA 250, Type 1.
   2. Current and voltage ratings.
   3. Short-circuit current ratings (interrupting and withstand, as appropriate).
   4. Include evidence of NRTL listing for series rating of installed devices.
   5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
   6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.[**Submit on translucent log-log graph paper.**]

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
   1. Wiring Diagrams: For power, signal, and control wiring.

C. Qualification Data: For qualified testing agency.

D. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Field quality-control reports.
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

F. Manufacturer's field service report.

G. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
   2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.[**Submit on translucent log-log graph paper.**]

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.
   1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NFPA 70.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
1. Notify Construction Manager no fewer than seven days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Construction Manager's written permission.
4. Comply with NFPA 70E.

1.8 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Electrical Inc.; Cutler-Hammer.
2. General Electric Company.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 400A and larger.

D. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

E. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
   1. Instantaneous trip.
   2. Long- and short-time pickup levels.
   3. Long- and short-time time adjustments.
   4. Ground-fault pickup level, time delay, and I^2t response.

F. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.

G. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

H. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

I. Features and Accessories:
   1. Standard frame sizes, trip ratings, and number of poles.
   2. Lugs: Compression type, suitable for number, size, trip ratings, and conductor material.
   3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
   4. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system, specified in Division 26 Section "Electrical Power Monitoring and Control."
   5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
   6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
   7. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
   8. Alarm Switch: One NO contact that operates only when circuit breaker has tripped.
   9. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
   10. Zone-Selective Interlocking: Integral with ground-fault trip unit; for interlocking ground-fault protection function.
   11. Electrical Operator: Provide remote control for on, off, and reset operations.
   12. Accessory Control Power Voltage: Integrally mounted, self-powered mounted and powered; 24-V DC.

2.2 MOLDED-CASE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Electrical Inc.; Cutler-Hammer.
   2. General Electric Company.

3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.
5. **<Insert manufacturer's name>**.

B. General Requirements: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

C. Features and Accessories:
1. Standard frame sizes and number of poles.
2. Lugs: Compression type, suitable for number, size, trip ratings, and conductor material.
3. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
6. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
7. Alarm Switch: One NC contact that operates only when switch has tripped.
8. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
9. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
10. Electrical Operator: Provide remote control for on, off, and reset operations.
11. Accessory Control Power Voltage: Integrally mounted, self-powered 24-V DC.

2.3 ENCLOSURES

A. All enclosed disconnect switches and circuit breakers shall have NEMA 1 general purpose enclosures unless otherwise noted. Provide enclosures suitable for locations as indicated on the drawings and as described below.
1. NEMA 1 surface or flush-mounted general purpose enclosures primarily intended for indoor use.
2. NEMA 12 dust-tight enclosures intended for indoor use primarily to provide protection against circulating dust, falling dirt and dripping non-corrosive liquids.
3. NEMA 3R raintight enclosures intended for outdoor use primarily to provide against rain, sleet, and damage from external ice formation.
4. NEMA 4 watertight stainless steel intended for indoor or outdoor use primarily to provide protection against windblown dust and rain, splashing rain, hose-directed water, and damage from external ice formation.
5. NEMA 7, Class I, Group D hazardous location cast aluminum intended for indoor use in locations classified as Class I, Group D as defined in the National Electrical Code.
6. NEMA 9, Class II, Groups E, F, and G hazardous location cast aluminum intended for indoor use in locations classified as Class II, Groups E, F, and G as defined in the National Electrical Code.

B. All enclosed disconnect switches and circuit breakers shall have nameplates, front cover mounted, that contain a permanent record of catalog number and maximum rating, provide handle mechanisms that are padlockable in the OFF position.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."
   1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
   2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Acceptance Testing Preparation:
   1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

E. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges[**as specified in Division 26 Section "Overcurrent Protective Device Coordination Study"**].

3.6 SCHEDULES

A. Interrupting Capacities (AMP): RMS Symmetrical.
1. Power Type: 240 volts AC, 3 pole.

Frame (amps)	**Interrupting Capacity**	**Short Time Rating**
250	65,000	25,000
800	65,000	25,000
1,600	85,000	35,000
3,000	100,000	35,000

2. Power Type: 480 volts AC, 3 pole.

Frame (amps)	**Interrupting Capacity**	**Short Time Rating**
250	50,000	25,000
800	50,000	25,000
1,600	65,000	35,000
3,000	100,000	35,000

3. Molded Case: Adjustable trips, 600 amp frame and above, unless noted.
a. 120/240 volts AC, 1, 2, or 3 pole, thermal magnetic type.

Frame (amps)	**Interrupting Capacity**
100	10,000

b. 240 volts AC, 2 or 3 pole, thermal magnetic type.

Frame (amps)	**Interrupting Capacity**
225	25,000
400	42,000
H100	65,000
H250	65,000

H400	65,000

c. 240 volts AC, 2 or 3 pole, solid state type.

Frame (amps)	Interrupting Capacity
600	42,000
800	42,000
1,200	42,000
3,000	125,000
H600	65,000
H800	65,000
H1,200	65,000

d. 277/480 volts AC, 1, 2, or 3 pole, thermal magnetic type.

Frame (amps)	Interrupting Capacity
100	14,000
H100	25,000

e. 480 volts AC, 2 or 3 pole, thermal magnetic type.

Frame (amps)	Interrupting Capacity
100	14,000
225	22,000
400	30,000
H10	25,000
H250	25,000
H400	35,000

f. 480 volts AC, 2 or 3 pole, solid state type.

Frame (amps)	Interrupting Capacity
600	30,000
800	30,000
1,200	30,000
H600	50,000
H800	50,000
H1,200	50,000

g. Combination molded case circuit breaker and current limiting fuses: 2 or 3 pole.

Frame (amps)	Interrupting Capacity
100	200,000
400	200,000
800	200,000
1,600	200,000

END OF SECTION 26 2816

SECTION 26 2923

VARIABLE FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes solid-state, PWM, variable frequency controllers (VFCs) for speed control of three-phase, squirrel-cage induction motors.

B. Related Sections include the following:
   1. Division 26 Section "Electrical Power Monitoring and Control" for monitoring and control of motor circuits.
   2. Division 26 Section "Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits" for low-voltage power, control, and communication surge suppressors.
   3. Division 26 Section "Enclosed Switches and Circuit Breakers."

1.3 DEFINITIONS

A. BMS: Building management system.

B. IGBT: Insulated gate bipolar transistor.

C. LAN: Local area network.

D. PID: Control action, proportional plus integral plus derivative.

E. PWM: Pulse-width modulated.

F. VFC: Variable frequency controller (equals VFD-variable frequency drive or VSD-variable speed drive).

1.4 SUBMITTALS

A. Product Data: For each type of VFC. Include dimensions, mounting arrangements, location for conduit entries, shipping and operating weights, and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.

B. Shop Drawings: For each VFC.
   1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
      a. Each installed unit's type and details.
      b. Nameplate legends.

F. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.

G. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.

H. Chamfer exterior corners and edges of permanently exposed concrete.

I. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.

J. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.

K. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

L. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

M. REMOVING AND REUSING FORMS

N. General: Formwork for sides of beams, walls, columns, and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50 deg F (10 deg C) for 24 hours after placing concrete. Concrete has to be hard enough to not be damaged by form-removal operations and curing and protection operations need to be maintained.
   1. Leave formwork for beam soffits, joists, slabs, and other structural elements that supports weight of concrete in place until concrete has achieved its 28-day design compressive strength.
   2. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.

O. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing material will not be acceptable for exposed surfaces. Apply new form-release agent.

P. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces unless approved by Architect.

3.2 FINISHING FORMED SURFACES

A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defects repaired and patched. Remove fins and other projections that exceed specified limits on formed-surface irregularities.
   1. Apply to concrete surfaces not exposed to public view.

B. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defects. Remove fins and other projections that exceed specified limits on formed-surface irregularities.
   1. Apply to concrete surfaces exposed to public view or to receive a rubbed finish.

C. Rubbed Finish: Apply the following to smooth-formed finished as-cast concrete where indicated:

c. Short-circuit current rating of integrated unit.
d. Listed and labeled for series rating of overcurrent protective devices in combination controllers by an NRTL acceptable to authorities having jurisdiction.
e. Features, characteristics, ratings, and factory settings of each motor-control center unit.

2. Wiring Diagrams: Power, signal, and control wiring for VFCs. Provide schematic wiring diagram for each type of VFC.

C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs where pipe and ducts are prohibited. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Manufacturer Seismic Qualification Certification: Submit certification that VFCs, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
   b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Qualification Data: For [**manufacturer**] [**testing agency**] [**manufacturer and testing agency**].

F. Field quality-control test reports.

G. Operation and Maintenance Data: For VFCs, all installed devices, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for VFCs and all installed components.
2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

H. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

I. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain VFCs of a single type through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with NFPA 70.

F. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, minimum clearances between VFCs, and adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver VFCs in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.

B. Store VFCs indoors in clean, dry space with uniform temperature to prevent condensation. Protect VFCs from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. If stored in areas subject to weather, cover VFCs to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions, unless otherwise indicated:
1. Ambient Temperature: 0 to 40 deg C.
2. Humidity: Less than 90 percent (noncondensing).
3. Altitude: Not exceeding 3300 feet.
4. **<Insert unusual service conditions.>**

B. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
1. Notify [**Architect**] [**Construction Manager**] [**Owner**] no fewer than [**two**] <**Insert number**> days in advance of proposed interruption of electrical service.
2. Indicate method of providing temporary electrical service.
3. Do not proceed with interruption of electrical service without [**Architect's**] [**Construction Manager's**] [**Owner's**] written permission.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, minimum clearances between VFCs, and adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

1.8 COORDINATION

A. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete. (For floor mounted VFC's)."

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

D. Coordinate features of VFCs, installed units, and accessory devices with pilot devices and control circuits to which they connect.

E. Coordinate features, accessories, and functions of each VFC and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load. Short-circuit withstand rating shall be same as short-circuit current rating of upstream overcurrent protective device or as indicated in contract documents, whichever is higher.

F. Coordinate monitoring and control features of VFC's with communication requirements of BMS. Communication between the systems shall be seamless with specified features of the VFC fully integrated into the BMS.

1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fuses: Furnish one set of each type and rating.
   2. Circuit Breakers: furnish one of each type and rating
   3. Indicating Lights: **[Two]** <**Insert number**> of each type installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB Power Distribution, Inc.
   2. Eaton Corporation; Cutler-Hammer Products.
   3. General Electric Company.
   4. Allen-Bradley Co.; Industrial Control Group.
   5. Siemens Energy and Automation.
   6. Square D.
   7. Toshiba International Corporation.
   8. **<Insert manufacturer's name.>**

2.2 VARIABLE FREQUENCY CONTROLLERS

A. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.
   1. Provide unit suitable for operation of [**standard**] [**premium**]-efficiency motor as defined by NEMA MG 1.
   2. Both driven motor manufacturer and drive manufacturer shall have published lists showing compatibility with each other's equipment.

B. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

C. Output Rating: 3-phase; 6 to [**60 Hz, with voltage proportional to frequency throughout voltage range**] [**66 Hz, with torque constant as speed changes**] [**120 Hz, with horsepower constant throughout speed range**].

D. Unit Operating Requirements:
   1. Input ac voltage tolerance of [**208 V, plus or minus 5**] [**380 to 500 V, plus or minus 10**] [**525 to 575 V, plus or minus 10**] percent.
   2. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.
   3. Minimum Efficiency: 96 percent at 60 Hz, full load.
   4. Minimum Displacement Primary-Side Power Factor: 96 percent.
   5. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
   6. Starting Torque: 100 percent of rated torque or as indicated.
   7. Speed Regulation: Plus or minus 1 percent.

E. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.
   1. Electrical Signal: 4 to 20 mA at 24 V.
   2. Pneumatic Signal: 3 to 15 psig (20 to 104 kPa).

F. Internal Adjustability Capabilities:
   1. Minimum Speed: 5 to 25 percent of maximum rpm.
   2. Maximum Speed: 80 to 100 percent of maximum rpm.
   3. Acceleration: 2 to a minimum of 22 seconds.
   4. Deceleration: 2 to a minimum of 22 seconds.
   5. Current Limit: 50 to a minimum of 110 percent of maximum rating.

G. Self-Protection and Reliability Features:
   1. Input transient protection by means of surge suppressors.
   2. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
   3. Motor Overload Relay: Adjustable and capable of NEMA ICS 2, Class [**10**] [**20**] [**30**] performance.
   4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
   5. Instantaneous line-to-line and line-to-ground overcurrent trips.
   6. Loss-of-phase protection.
   7. Reverse-phase protection.
   8. Short-circuit protection.
   9. Motor overtemperature fault.

H. Multiple-Motor Capability: Controller suitable for service to multiple motors and having a separate overload relay and protection for each controlled motor. Overload relay shall shut off controller and motors served by it when overload relay is tripped.

I. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

J. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.

K. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

L. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

M. Input Line Conditioning: <**Insert requirements.**>

N. VFC Output Filtering: <**Insert requirements.**>

O. Status Lights: Door-mounted LED indicators shall indicate the following conditions:
   1. Power on.
   2. Run.
   3. Overvoltage.
   4. Line fault.
   5. Overcurrent.
   6. External fault.

P. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.

Q. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:
   1. Output frequency (Hz).
   2. Motor speed (rpm).
   3. Motor status (running, stop, fault).
   4. Motor current (amperes).
   5. Motor torque (percent).
   6. Fault or alarming status (code).
   7. PID feedback signal (percent).
   8. DC-link voltage (VDC).
   9. Set-point frequency (Hz).
   10. Motor output voltage (V).

R. Control Signal Interface:
   1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
   2. Pneumatic Input Signal Interface: 3 to 15 psig.
   3. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:
      a. 0 to 10-V dc.
      b. 0-20 or 4-20 mA.
      c. Potentiometer using up/down digital inputs.
      d. Fixed frequencies using digital inputs.
      e. RS485.
      f. Keypad display for local hand operation.
   4. Output Signal Interface:

a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:
   1) Output frequency (Hz).
   2) Output current (load).
   3) DC-link voltage (VDC).
   4) Motor torque (percent).
   5) Motor speed (rpm).
   6) Set-point frequency (Hz).

5. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
   a. Motor running.
   b. Set-point speed reached.
   c. Fault and warning indication (overtemperature or overcurrent).
   d. PID high- or low-speed limits reached.

S. Communications: Provide an RS485 interface allowing VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via BMS control. Provide capability for VFC to retain these settings within the nonvolatile memory.

T. Manual Bypass: Magnetic contactor arranged to safely transfer motor between controller output and bypass controller circuit when motor is at zero speed. Controller-off-bypass selector switch sets mode, and indicator lights give indication of mode selected. Unit shall be capable of stable operation (starting, stopping, and running), with motor completely disconnected from controller (no load).

U. Bypass Controller: NEMA ICS 2, full-voltage, nonreversing enclosed controller with across-the-line starting capability in manual-bypass mode. Provide motor overload protection under both modes of operation with control logic that allows common start-stop capability in either mode.

V. Integral Disconnecting Means: [**NEMA AB 1, instantaneous-trip circuit breaker**] [**NEMA AB 1, molded-case switch**] [**NEMA KS 1, nonfusible switch**] [**NEMA KS 1, fusible switch**] with lockable handle.

W. Isolating Switch: Non-load-break switch arranged to isolate VFC and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.

X. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

2.3 ENCLOSURES

A. **<Insert enclosure requirements.>**

2.4 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.

C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

D. Control Relays: Auxiliary and adjustable time-delay relays.

E. Standard Displays:
1. Output frequency (Hz).
2. Set-point frequency (Hz).
3. Motor current (amperes).
4. DC-link voltage (VDC).
5. Motor torque (percent).
6. Motor speed (rpm).
7. Motor output voltage (V).

F. Historical Logging Information and Displays:
1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

G. Current-Sensing, Phase-Failure Relays for Bypass Controller: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage; with adjustable response delay.

2.5 FACTORY FINISHES

A. Finish: Manufacturer's standard <**Insert color**> paint applied to factory-assembled and -tested VFCs before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs for compliance with requirements, installation tolerances, <**Insert Project-specific conditions,**> and other conditions affecting performance.

B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Select features of each VFC to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, controller, and load.

B. Select horsepower rating of controllers to suit motor controlled.

3.3 INSTALLATION

A. Anchor each VFC assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with mounting surface.

B. Install VFCs on concrete bases.

C. Comply with mounting and anchoring requirements specified in Division 26 Section "Hangers and Supports for Electrical Systems."

D. Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26 Section "Fuses."

3.4 CONCRETE BASES

A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

B. Concrete base is specified in Division 26 Section "Common Work Results for Electrical," and concrete materials and installation requirements are specified in Division 03.

3.5 IDENTIFICATION

A. Identify VFCs, components, and control wiring according to Division 26 Section "Identification for Electrical Systems."

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.6 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect hand-off-automatic switch and other automatic-control devices where applicable.
   1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
   2. Connect selector switches with control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.7 CONNECTIONS

A. Conduit installation requirements are specified in other Division 26 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.8 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:
   1. Test insulation resistance for each enclosed controller element, bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
   1. Inspect controllers, wiring, components, connections, and equipment installation.[**Test and adjust controllers, components, and equipment.**]
   2. Assist in field testing of equipment[**including pretesting and adjusting of solid-state controllers**].
   3. Report results in writing.

C. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

D. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

E. Perform the following field tests and inspections and prepare test reports:
   1. Perform each electrical test and visual and mechanical inspection, except optional tests, stated in NETA ATS. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.9 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain variable frequency controllers. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 26 2923

SECTION 26 5100

INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes interior luminaires, lamps, ballasts, and accessories.

B. Dimmable LED's shall be required in lieu of linear fluorescent luminaires.

1.2 DEFINITIONS

A. LED: Light Emitting Diode.

B. Luminaire: Complete lighting fixture, including driver or ballast if included.

1.3 SUBMITTALS

A. Shop Drawings: Indicate dimensions and components for each luminaire not standard product of manufacturer.

B. Product Data: Submit product catalog data showing specified features.

C. Samples: Submit two color chips 3 x 3 inch in size illustrating luminaire finish color where indicated in luminaire schedule.

D. Maintained light level value as specified by the Technical Provisions Illuminating Engineering Society standards and the LA Department of Public Works Guidelines as applicable.

PART 2 - PRODUCTS

2.1 INTERIOR LUMINAIRES

A. Product Description: Complete interior luminaire assemblies, with features, options, and accessories as scheduled.

2.2 LED LIGHTING FIXTURES AND COMPONENTS

A. Product Testing: Comply with U.L. 1598 and 8750. Test according to IES LM-79 and LM-80.

B. Drivers: Operation to be at standard rated voltage of driver, and not "over-driven."

1. Smooth-Rubbed Finish: Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.
2. Grout-Cleaned Finish: Wet concrete surfaces and apply grout of a consistency of thick paint to coat surfaces and fill small holes. Mix one part portland cement to one and one-half parts fine sand with a 1:1 mixture of bonding admixture and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Scrub grout into voids and remove excess grout. When grout whitens, rub surface with clean burlap and keep surface damp by fog spray for at least 36 hours.
3. Cork-Floated Finish: Wet concrete surfaces and apply a stiff grout. Mix one part portland cement and one part fine sand with a 1:1 mixture of bonding agent and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Compress grout into voids by grinding surface. In a swirling motion, finish surface with a cork float.

D. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces unless otherwise indicated.

3.3 FIELD QUALITY CONTROL

A. Testing and Inspecting: Owner will engage a special inspector and qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. All concrete work is subject to special inspection and testing. This section specifies the minimum testing and inspection required. Additional testing and inspection may be required by the Testing Agency, the Owner, or the Engineer/Architect if project conditions warrant.

C. Special Inspector Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, and qualified according to ASTM C 1077 and ASTM E 329 to conduct the testing indicated, as documented according to ASTM E 548.

D. Tests and inspections shall be in conformance with Division 1, Section "Quality Requirements".

E. Independent Testing Agency shall check batch tickets for compliance with required mix design(s).

F. Continuous Field Inspection: The Independent Testing Agency shall be present at all times during the placing of structural reinforced concrete. Work shall not proceed until all inspections are completed. Prior to placing concrete, the Inspector shall inspect:
1. Accuracy, configuration, and cleanliness of all formwork
2. Quantity, cleanliness, and placement of all reinforcing steel.
3. Testing Agency need not be present during entire reinforcing steel placing operations, provided he has inspected for conformance with the approved placement drawings prior to closing of forms or the delivery of concrete to the job site.

G. No concrete shall be placed until placement of reinforcement steel has been inspected and approved. Provide 48 hours notice to the Inspector prior to placing concrete.

END OF SECTION

2.3 LED DRIVER

A. Manufacturers:
1. Philips.
2. Osram.
3. General Electric.
4. ELDO LED
5. Advanced
6. Or equal

B. Product Description: Electronic ballasts shall be instant start and designed for the type and quantity of lamps served. Ballast shall be designed for full light output unless dimmer or bi- level control is indicated. Comply with ANSI C82.11.

2.4 FLUORESCENT DIMMING BALLASTS AND CONTROLS

A. Manufacturers:
1. Philips.
2. General Electric.
3. Lutron.
4. Or equal

B. Product Description: Electrical assembly of control unit and ballast to furnish smooth dimming of fluorescent lamps.

C. Control Unit: Selected for energy efficiency and daylight harvesting capability,where required.

D. Ballast: Selected by dimming system manufacturer as suitable for operation with control unit and suitable for lamp type and quantity specified for luminaire.

2.5 LED LAMPS

A. Manufacturers:
1. Philips.
2. Osram.
3. General Electric.
4. Or Equal

2.6 FLUORESCENT LAMPS

A. Manufacturers:
1. Philips.
2. Osram.
3. General Electric.
4. Or Equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide labor and materials to install and structurally support fixtures in accordance with all applicable codes and safety practices.

B. Luminaires for utility & electrical rooms shall provide & maintain access & working space about luminaires to permit ready and safe operation & maintenance.
   1. Working space about luminaires shall be width of luminaire side plus 30 in. & shall be clear and extend from the grade, floor, or platform to a height of luminaire plus 30 in.
   2. Equipment NOT directly related to luminaire installation or operation shall be allowed within this space.
      a. Exception: no more than two side may be used for installation of emergency related systems.
   3. Adjacent luminaire working spaces may overlap.

END OF SECTION 26 5100

SECTION 26 5600

EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Conditions of the Contract and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. General:
   1. Section specifies requirements for luminaires, lamps, and accessories.
   2. The Contractor shall be responsible for luminaire quantities, lengths and clearances required, and shall inform the Designer in writing at the time the bid submission is made, of discrepancies or variances found with fixtures or details specified herein or in the luminaire schedule and other contract documents.
   3. Catalog numbers listed in the fixture schedule may not include every necessary installation component. The Contractor shall provide all necessary housings, pour kits, stems, connectors, supplementary support hardware, junction boxes, and other necessary equipment for a complete installation.
   4. Fixtures requiring structural anchoring or suspension should be reviewed by the Structural Engineer. The Designer cannot provide structural engineering services.

1.3 STANDARDS

A. Luminaires, components, and installation shall be in accordance with the American National Standards Institute (ANSI), the latest revision of the National Electrical Code (NEC), Occupational Safety and Health Administration (OSHA), and applicable federal, state, and local codes and regulations.

B. All work shall be executed in a neat, professional manner in accordance with ANSI/NECA 1 – 2015.

C. All luminaires, equipment and materials provided under this contract shall be new (except where otherwise noted) and shall be listed, labeled or certified by a Nationally Recognized Testing Laboratory (NRTL) to meet Underwriters Laboratories, Inc. (UL) standards, or equivalent by Intertek (ETL) or Canadian Standards Association (CSA- US), where test standards have been established. Luminaires, equipment, and materials which are not covered by UL standards will be accepted, providing that materials and equipment are listed, labeled, certified or otherwise determined to meet the safety requirements of an OSHA-recognized NRTL.
   1. The Contractor shall be responsible for coordinating the characteristics and the appropriate UL labeling of luminaires and their components with the ambient conditions which will exist when the luminaires are installed.

1.4 SUBMITTALS

A. Product Data Submittals: For each luminaire type, submit catalog numbers and manufacturer sheets which enumerate:
   1. Material and physical description of luminaire including features, dimensions finishes and accessories.
   2. Electrical requirements, including wattage, voltage, and dimming type.
   3. Light source details, including expected life (L70), lumens, distribution, Kelvin temperature, color rendering, and manufacturer.
   4. Driver, power supply, transformer and/or ballast information, as applicable.

B. Shop Drawings for Custom, Modified, Complex-Component, or Linear Luminaires Mounted in Continuous Rows:
   1. Submit scaled drawings prepared by the manufacturer showing all details of construction, segment lengths in runs, corner and/or end plate details, pendant and/or power feed locations, connecting components, accessories, finishes and lists of materials.
   2. Indicate dimensions, weights, method of field assembly, components, features and accessories.
   3. Provide electrical requirements, including wattage, voltage, dimming type, circuit quantity, and wiring diagrams.

   4. Provide light source details, including expected life (L70), lumens, distribution, Kelvin temperature, color rendering, and manufacturer.

   5. Provide driver, power supply, transformer and/or ballast information, as applicable, including manufacturer.

   6. Contractor shall provide the fixture manufacturer with accurate field dimensions where required.

C. Substitutions and Other Deviations from Specified Product:
   1. Should the Contractor anticipate that the delivery schedule of specified product may adversely impact the construction schedule, it shall be brought to the attention of the Developer within fourteen days of contract award. Request for fixture substitution on the basis of standard delivery schedule will not be permitted.

   2. Upon request, submit working samples of substitution items for the purpose of ascertaining photometric performance, quality of visible parts and details,

      maintenance features, methods of installation, and safety features. These samples shall be submitted for approval at no expense to the Developer, with transportation prepaid. The samples will be returned to the Contractor after the review has been completed at the expense of the Contractor.

   3. Provide photometric data in IES format, based on certified results of laboratory tests for each type, outfitted with components, drivers and accessories identical to those indicated for the luminaire.

      a. Manufacturer Certified Data: Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

      b. Testing Agency Certified Data: Where no Manufacturer Certified Data is available, photometric data shall be certified by a qualified independent testing agency.

      c. LM-79 and LM-80 data shall be included for solid state lighting.

4. Upon request, provide photometric calculation showing proposed substitution in layout and quantity matching contract documents, to ensure no deficiency in performance. If substitution affects layout or quantity, approval may be delayed or denied.

1.5 CUSTOM LUMINAIRES

A. All custom luminaires require a prototype to be submitted prior to commencement of fabrication. The purpose of the prototype will be to review construction, light source quality and placement, optical assembly, finishes, etc. Modifications may be required as a result of prototype review, which should be assumed when setting the cost and delivery schedule.

1.6 ATTIC STOCK AND SURPLUS MATERIALS

A. Furnish extra materials that match installed products, packaged with protective covering for storage and identified with labels describing contents.
   1. Glass, Plastic Diffusers and Lenses: 10% or one dozen (whichever is less) of each type and rating installed. Furnish at least one of each type.
   2. Optics: For fixture types supplied with multiple optics and lenses, or where the optics and lenses were changed during the aim-and-focus process, provide all unused materials to the Developer.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver luminaires individually wrapped in factory-fabricated fiberboard type containers.

B. Handle luminaires carefully to prevent breakage, denting and scouring of the luminaire finish. Use gloves to prevent fingerprints on specular finishes.

C. Store product in a clean, dry space, protected from weather.

1.8 COORDINATION

A. Coordinate layout and installation of luminaires with ceiling system and other construction that penetrates ceilings or is supported by them, including mechanical system, fire suppression, security, audio/visual system, and partition assemblies.

B. Verify mounting heights for all wall-mounted and suspended luminaires before ordering fixtures. Notifiy the Designer of any conflicts or code issues prior to order.

C. Recessed luminaires shall have housings that are compatible with the ceiling system provided, which may vary throughout the project. Note that some specialty ceilings and/or thick ceilings may require additional mounting accessories or options.

1.9 WARRANTY

A. Comply with Division 1 requirements.

B. Ensure luminaire manufacturers' warranties meet or exceed Developer's requirements to replace components that fails in materials or workmanship within specified period.

1. LED boards: 5 years from date of Occupancy.

2. Drivers: 3 years from date of Occupancy.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Provide products to the specifications described above, hereafter, and as listed in the Lighting Fixture Schedule, or comparable products approved in writing through the submittal process.

2.2 GENERAL LUMINAIRE DESIGN AND CONSTRUCTION

A. Provide proper thickness of code gauge sheet steel so that luminaires are rigid, stable, and will resist deflection, twisting and warping under normal installation procedures, re- lamping, and maintenance.

B. Luminaire designs shall include, as applicable, plaster frames, trim rings, shrouds, flanges, backboxes, support hardware, and other components required for proper installation of the luminaire.

C. Luminaires with covers, cones, or diffuser frames, which are to be mounted above twelve feet from the finished floor level, shall be provided with safety chains or other acceptable backup means of support to properly secure such items to main housing.

D. Fixtures shall be Underwriter Laboratory approved for their application and location and have the appropriate UL label adhered to the fixture visible within the housing of each fixture.

E. Rows of luminaires shall be designed with concealed splice plates and shall be free of light leaks. Components such as reflectors, trims, diffusers and other visible items shall be properly aligned with no overlaps, gaps, or other imperfections.

F. Adjustable fixtures shall provide methods to lock rotation and tilt in place.

G. Hardware shall be concealed where it is appropriate, unless it is a design feature.

H. Where hardware is exposed the hardware is to be painted to match adjacent surfaces unless otherwise noted.

I. Materials, accessories, and other related fixture parts shall be new and free of defects, which may impair their character, appearance, strength, ability, or function. Fixtures must be protected from damage from the time of fabrication until final acceptance of work.

J. Contractor is responsible for coordination of special mounting conditions for custom fixtures and must supply necessary mounting devices.

K. Fixtures shall be completely wired at the factory. Fixtures shall come with electrical wiring in accordance with local codes and in accordance with actual installation requirements.

L. Provide finished product with smooth clean ground metal edges, trims, and frames as well as tight fitting connections, hinges, and closures.

M. Provide access for servicing the installed luminaire and for replacement of electrical parts without removal or disassembly of the luminaire.

N. Unless otherwise noted, provide emergency battery packs or stand-by systems as required for luminaires connected to emergency circuits.

O. Low voltage fixtures which require a remote transformer must be supplied with transformers as necessary to complete a working installation.

P. Luminaire doors shall be provided as follows: Positive light seal, concealed safety hinges, and inconspicuous "positive spring loaded" holding latches, which are hingeable from either side and operable without the use of tools.

Q. Where luminaires are mounted in tandem in continuous runs, the Contractor shall field coordinate fixture quantity and length required to provide a continuous band of light without gaps to within 6" of row ends.

R. No internal wiring shall be visible at normal viewing angles.

S. Provide redundant support cables for attachment to structure as required by code.

T. Where accessible to the public, lens temperatures shall not exceed 100°F (38°C).

2.3 LIGHT EMITTING DIODES (LEDS)

A. Contractor will supply necessary drivers, connectors and adapters, and necessary mounting and electrical feed equipment.

B. Contractor to confirm wiring and dimming requirements (0-10V with switched mains power, ELV, etc.) prior to installation. 10% dimming is required unless otherwise noted.

C. Where remote transformers, drivers, power supplies, and/or dimming units are specified, the remote device(s) must be installed in accessible areas large enough to dissipate the

heat of the device. Temperatures should not exceed 100°F (38°C), or other as recommended by the manufacturer.

D. Remote transformers/drivers/power supplies/dimming units should be mounted as close to the feed for the luminaire as practical to keep the secondary feed as short as possible. Confirm parameters with luminaire manufacturer; confirm locations with Designer.

E. Where integral transformers, drivers, power supplies, and/or dimming units are specified, the device(s) must be accessible through means that do not require damage to the ceiling or other finished surfaces. Luminaires shall have internal thermal protection.

F. Transformers/drivers/power supplies/dimming units shall be rated for operation on the electrical system voltage to which they are shown connected.

G. Luminaires shall not draw power in the off state. Luminaires with integral motion sensors, photo-controls, or individually addressable luminaires with external control and intelligence are exempt from this requirement but the power draw for such luminaires shall not exceed 0.5 watts when in the off state.

H. Luminaires shall have a minimum CRI of 80, with a CCT of 3500K.

2.4 LOW VOLTAGE LIGHTING

A. Where remote transformers are specified, transformers must be installed in accessible areas large enough to dissipate the heat of the transformer. Temperatures should not exceed 100°F (38°C).

B. Remote transformers should be mounted as close to the feed for the luminaire as practical to keep the secondary feed as short as possible. Confirm parameters with luminaire manufacturer; confirm locations with Designer.

C. Where integral ballasts are specified, the device must be accessible through means that do not require damage to the ceiling or other finished surfaces. Luminaires shall have internal thermal protection.

D. Transformers shall be rated for operation on the electrical system voltage to which they are shown connected.

E. Low voltage transformers shall be fused on the primary and secondary side with protection devices sized as appropriate to conductors, lamps, and transformers.

F. Contractor is responsible to lay out and install low voltage systems to prevent excessive light loss due to voltage drop.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

A. Provide luminaires at locations, and of types, as indicated on the contract drawings. Install luminaires in strict conformance with manufacturer's recommendation and instructions, and applicable codes.

B. Contractor shall be responsible for coordinating with the other trades to ensure and maintain adequate recess clearance as lighting positions are critical and shall take precedence over other concealed building systems.

C. Contractor shall be responsible for installing fixtures with proper ventilation so as not to exceed the temperature rating of the lighting fixtures or accessories.

D. Notify the Designer about field conditions at variance with plans and/or specifications before commencing installation. Failure to do so shall exonerate the Designer from responsibility for problems resulting from same, and work required to correct the discrepancy shall be performed by the Contractor with no additional compensation.

E. Prior to ordering lighting equipment, the Contractor shall verify locations and recess depths, and final voltages. Additional charges for failure to verify locations will not be allowed.

F. Where required by the local building or health department, provide approved wire guards and or plastic sleeves over fixtures.

G. Install luminaires properly and safely. Provide hangers, rods, mounting brackets, supports, frames, yokes, support bars, safety cables and other equipment required for a complete installation. Double-sided tape, zip ties, and similar devices are not acceptable means for permanent installations.

H. Luminaires shall be complete with lamps of the type noted in the schedules and shall have metal parts, glassware, plastic diffusers etc., free from scratches, cracks, and other defects. Items damaged during shipment handling, or installation shall be replaced without expense to the Developer.

I. Use tools only as required for installation. Do not use power tools to make fine adjustments where hand tools should be used to prevent damage to fixtures and accessories.

J. Fixtures installed with plastic lenses shall be cleaned and de-staticized after installation. Install and leave with no fingerprints or dirt marks on the lens or diffuser. Use white gloves if necessary.

K. Luminaires to be operational and cleaned prior to opening the facility. Remove protective plastic covers from luminaires and luminaire diffusers only after construction work, painting and clean-up are completed. Remove, clean, and reinstall any dirty reflectors and diffusers.

L. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

M. Fixtures shall be installed so that no labels will be visible under normal operating conditions of the fixture.

N. If fixtures are installed in a fire rated ceiling or wall, the Contractor will preserve the fire rating according to the UL assembly number.

O. Do not modify any lighting elements without the express direction of the Designer and Manufacturer. If field modification is required by the factory, a letter from the factory stating the authorization and continuance of warranty is required. No modifications will be allowed that void the fixture warrenty.

P. Any fixtures with a discernable color shift after 100 hours of operation shall be replaced with no additional cost to the Developer.

Q. Grazing fixtures are to be installed prior to the finishing of walls where they are found. They are to be used as the sole work light when finishing the adjacent wall.

R. Matte white face plates for pinhole and slot downlights shall be painted prior to installation to match the soffit in which each is to be located.

3.2 RECESSED LUMINAIRES

A. Comply with NEMA LE 4 for ceiling compatibility for recessed luminaires, and any other local codes that may be applicable.

B. Provide plaster frame or concrete pour kit for recessed luminaires mounted in ceiling soffits. Verify mounting with Designer prior to ordering luminaires.

C. Housings for recessed fixtures shall be installed in a rigid manner so as not to allow fixture frame or housing to move or shift when trim is removed or fixture is re-lamped.

D. Luminaires recessed in inaccessible ceiling soffits shall have all connections accessible through the luminaire.

E. Luminaire housings are not to be within three inches of insulation, unless an Insulation- Contact (IC) housing is used.

3.3 SURFACE MOUNTED LUMINAIRES

A. Luminaire to completely conceal the junction box to which it is attached. Check each fixture type to verify any specialty junction box sizes prior to rough in.

B. Wall Mounted Luminaires: Installation must comply with ADA restrictions; fixture may not project more than four inches from vertical surface below a height of eighty inches in a path of travel. Confirm mounting heights and fixture connection points prior to rough in of junction box.

3.4 SOFTSCAPE MOUNTED LUMINAIRES

A. The exact placement of landscape luminaires to be selected on site by the Designer.

B. Provide level concrete footings for anchor bolt mounting. Use template for anchor bolts from the fixture manufacturer and confirm details of the footing with the Structural Engineer.

C. Use three-prong stakes or similar for sturdy, permanent installation. Wrap at least 24" of cord under stake-canopy to allow slack to reposition light during aiming/focus.

D. Use all-in-one mounting and junction box stake (i.e. power pipe). Confirm height above grade prior to installation.

E. Where fixtures are mounted to above-ground junction boxes, seek approval of mounting height prior to installation.

F. Exact location of transformer/driver/power supply to be determined in the field.

G. Provide cable gauge as needed to minimize voltage drop between transformers and luminaires.

3.5 TREE MOUNTED LUMINAIRES

A. The exact placement of tree-mounted luminaires to be selected on site by the Designer.

SECTION 032000

CONCRETE REINFORCEMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes concrete reinforcement for the following:
1. Retaining Walls and Footings.
2. Shear Walls.
3. Slabs-on-grade.
4. Concrete Toppings.
5. Post-Installed Reinforcing Bars Connections.

B. Related Sections:
1. Section 031000 “Concrete Forming and Accessories”
2. Section 033000 “Cast-In-Place Concrete”

1.3 REFERENCES

A. Abbreviations & Acronyms
1. ACI – American Concrete Institute
2. CRSI – Concrete Reinforcing Steel Institute

B. Reference Standards
1. ACI 301-10: Specification for Structural Concrete Buildings.
2. ACI 117-10: Specification for Tolerances for Concrete Construction and Materials.

1.4 ACTION SUBMITTALS

A. Submit in accordance with Division 01 Section "Administrative Requirements."

B. Steel Reinforcement Shop Drawings: Placing drawings that detail fabrication, bending, and placement. Include bar sizes, lengths, material, grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and laps, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement.
1. Provide details of fabrication, bending, and placement, prepared according to ACI 315, “Details and Detailing of Concrete Reinforcement.” Include special reinforcement required for openings through concrete structures.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For welder

B. Welding certificates.

C. Material Certificates: For each of the following, signed by manufacturers:

B. Consult the Landscape Architect and/or an Arborist for approval of any tree-mounted luminaires.

C. Tree Rings/Straps
1. Attach conduit to tree trunk with a stainless steel screw of proportionate size to penetrate the bark and enter the wood. Once the screw is in place it is important to the health of the tree that it not be removed.
2. Use only tree rings/straps that are adjustable so that they may be loosened as the tree grows.

D. Leave an appropriate "growth loop" in conduit and cables to allow for growth of the tree. All attachments to trees should be inspected every six months for fast-growing specimins or every twelve months for slower-growing specimins.

E. When multiple fixtures of a given voltage are mounted in trees, power shall be provided from base of tree to junction box on tree strap in tree canopy (or at base of bulb for palm trees) through single exterior grade MC cable with black coating.

3.6 AIMING AND ADJUSTMENTS

A. Adjustable lighting units shall be aimed, focused, and locked, etc., by the Contractor under the supervision of the Lighting Consultant.

B. Aiming and adjusting shall be carried out after installation is complete, prior to the facility's turn-over to the Developer. Ladders and scaffolding, etc., required shall be furnished by the Contractor at the direction of the Lighting Consultant. As aiming and adjusting is completed, locking setscrews, bolts, and nuts shall be tightened securely.

C. Assume that all aiming of exterior fixtures must be done in hours of darkness. Where possible, aim and focus shall be conducted during normal working daytime hours; however, where daylighting interferes with aiming and focusing, the aiming shall be performed at night.

3.7 COORDINATION WITH AMBIENT CONDITIONS

A. The Contractor is responsible for coordinating the characteristics and the UL labeling of the luminaires and their components with the ambient conditions which will exist when the luminaires are installed. These areas of coordination include, but are not limited to, the following:
1. Wet location labels. Damp location labels. Low temperature ballasts. Dimming ballasts.
2. Very low heat rise ballasts. Plenums and air handling spaces. Fire rated ceilings.
3. Low density ceiling.
4. Insulated ceilings.

END OF SECTION 26 5600

SECTION 28 3111

DIGITAL ADDRESSABLE FIRE ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Fire/life safety system shall be Design Build. Contractor shall be responsible for the system design obtaining required approvals and installation.
   1. Prepare construction documents.
   2. Submit construction documents to all agencies having plan check authority.
   3. Approval shall be obtained prior to installation of the system.
   4. Contractor shall be responsible for preparing plans with device and equipment locations, raceways and wiring sizes, voltage drop and battery calculations and one line diagram of the system.

B. The Contractor is required by the contract documents to design and provide a code complying, complete and operational fire alarm system for building in the project. All parts of the system described herein shall be furnished for building in the project. The Contractor shall also provide all labor and materials related to the system, not necessarily stipulated in Section 28 3111. In addition to the fire alarm system, this includes the following elements related to the installation of the fire alarm system:
   1. Excavating and backfilling for exterior raceways (where required)
   2. Caulking and sealants
   3. Acoustical treatment
   4. Painting
   5. Controls and instrumentation (interface with mechanical systems)
   6. Conduits and raceways
   7. Conductors
   8. Outlet and junction boxes
   9. Interior pullboxes and wireways
   10. Cabinets
   11. Nameplates and warning signs
   12. Grounding

C. Equipment related to the work which may require interconnection with Fire Alarm System:
   1. Fire sprinkler flow and tamper switches.
   2. Elevator recall controls.
   3. Corridor fire door closure.
   4. Fan shutdown.
   5. Hardware.
   6. Interface with PA and sound system.

D. System Description and Function:
   1. The system shall consist of addressable fire alarm control panel(s), color graphics annunciation system with touchscreen display, remotely mounted building annunciator panels, automatic

detection devices, manual reporting stations, speakers with visual alarms, voice communication system, and all wiring. The entire system shall be equipped with an emergency battery backup system. The system shall be fully field programmable.

2. The system shall be capable of being expanded at any time up to the predetermined maximum capacity of the system.
3. The system shall be capable of operating both addressable and non-addressable devices.
4. The control panel shall provide power, annunciation, supervision and control for the fire detection and alarm system. The control panel shall be modular in construction, and contain all equipment necessary to operate according to the schedule in the following paragraphs of this Specification and the Fire Alarm Drawings. The system shall be designed so that alarm indications override trouble conditions. The panel shall be capable of measuring the sensitivity of the addressable ionization and photoelectric detectors connected to it.
5. The Contractor shall furnish the services of the approved fire alarm manufacturer to program the Fire Alarm Control Panel (FACP).
6. Fire alarm system wiring shall be Class A.
7. There shall be no limit, other than maximum system capacity, as to the number of addressable devices which may be in alarm simultaneously.

1.3 SYSTEMS OPERATIONAL DESCRIPTION

A. The system shall function as follows under an alarm condition:
   1. Sound the audio alarm and cause visual signals to flash on all floors of the building.
   2. Automatically notify the Owner Police Station and Command Center with one of the signals specified in Paragraph 2.4.C.
   3. Display individual addressable device number on Liquid Crystal Display (LCD) annunciator in the fire alarm control panel.
   4. Shut down the HVAC system as required in Paragraph 2.7 and as required in NFPA 90.
   5. Display device/floor on the remote annunciators.
   6. Close all magnetically held fire doors in the building.
   7. Unlock security doors.
   8. Perform all functions in the Sequence of Operations shown on the design build drawings approved by Authority Having Jurisdiction (AHJ). In the event of any conflict between the Sequence of Operations and requirements in the specification.

B. The system shall function as follows when any area elevator detector operates:
   1. Perform the functions listed above (Paragraphs 1.1.D.7.a through 1.1.D.7.i).
   2. Close associated elevator screen door on the activated floor only.
   3. Activate elevator return sequence on the associated elevator bank.

C. Fire alarm signal initiation shall be by one or more of the following devices:
   1. Manual stations.
   2. Heat detectors.
   3. Area smoke detectors.
   4. Duct smoke detectors.
   5. Automatic sprinkler system water flow switches
   6. Heat detectors in elevator shaft, equipment room and where needed.
   7. Fire standpipe system water flow switches

D. Fire alarm signal shall initiate the following actions:
   1. Continuously operate alarm notification appliances.
   2. Identify alarm at fire alarm control unit and remote annunciators.
   3. Transmit an alarm signal to the remote alarm receiving station.
   4. Unlock electric door locks in designated egress paths.
   5. Release fire and smoke doors held open by magnetic door holders.
   6. Activate voice/alarm communication system.

7. Switch heating, ventilating, and air conditioning equipment controls to fire alarm mode.
8. Close smoke dampers in air ducts of designated air conditioning duct systems.
9. Recall elevators to primary or alternate recall floors.
10. Activate emergency lighting control.
11. Activate emergency shutoffs for gas and fuel supplies.
12. Record events in the system memory.
13. Record events by the system printer.

E. Supervisory signal initiation shall be by one or more of the following devices and actions:
1. Valve supervisory switch.
2. Low air pressure switch of a dry pipe sprinkler system.
3. Elevator shunt trip supervision.

F. System trouble signal initiation shall be by one or more of the following devices and actions:
1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm initiating and supervisory signal initiating devices.
3. Loss of primary power at fire alarm control unit.
4. Ground or a single break in fire alarm control unit internal circuits.
5. Abnormal ac voltage at fire alarm control unit.
6. Break in standby battery circuitry.
7. Failure of battery charging.
8. Abnormal position of any switch at fire alarm control unit or annunciator.

G. System Trouble and Supervisory Signal Actions: Initiate notification appliance and annunciate at fire alarm control unit and remote annunciators. Record the event on system printer.

1.4 QUALITY ASSURANCE

A. Codes and Standards: Comply with the following codes and standards.
1. Title 19, California Code of Regulations (CCR)
2. Title 24, CCR:
   a. Part 2, UBC with California Amendments
   b. Part 3, NEC with California Amendments
   c. Part 4, UMC with California Amendments
   d. Part 9, UFC with California Amendments
3. NFPA Codes
   a. NFPA 72, as amended by the California Code of Regulations.
   b. All other Health and Safety Applicable Code requirements.

B. Contractor Qualifications: Contractor (or subcontractor if Contractor is utilizing a subcontractor to perform the installation of the fire alarm system(s)), shall have installed at least five complete fire alarm systems manufactured by the manufacturer listed in Part 2.
1. Each of the projects submitted shall have been successfully completed within five years of the bid date of the project currently being bid. These projects shall have been in successful operation at least one year prior to bid date of the current project.
2. Each project shall have been performed within the State of California.
3. Each project shall have had a construction cost in excess of $100,000 for the fire alarm work only.
4. Each project shall have provided a complete Fire Alarm System including the following:
   a. A main FACP.
   b. 256 or more addressable devices. "Devices" are smoke, heat or other type of fire detectors, manual stations, water flow or tamper switches, alarm horns, strobe lights.
   c. Voice evacuation system.
   d. Complete programming of the system.

e. A master annunciator panel showing the location of each device or group of devices in the system, as well as the FACP.
f. Complete testing of the entire system.
g. Approval by the CSFM office.
h. Installation of a shielded cable system, with all shields properly terminated and grounded according to the manufacturer's instructions.
   1) Installer shall be in possession of a valid C 10 license.
   2) Three (3) of the required 5 fire alarm systems shall have been fully addressable systems.

C. Prior to the commencement of work, Contractor shall provide in writing the following information for Owner's Representative's approval:
   1. The name of the factory trained and certified Technical Supervisor who will be called upon in the course of the work to perform duties. This individual shall provide on site technical supervision for the project.
   2. Qualifications and certification dates for the Technical Supervisor.

D. Contractor shall provide the services of a Testing and Balancing (TAB) service who is a member of either the Associated Air Balance Council (AABC) or the National Environmental Balancing Bureau (NEBB) and is familiar with fire alarm technology.
   1. The TAB shall measure the air velocity and static pressure at each duct detector location shown on the drawings. If the air velocity and static pressure at the locations shown do not meet the criteria for proper functioning of any of the duct air detectors, the Air Balance Agency shall test alternate locations at no extra cost to Owner until appropriate locations are identified.
   2. Upon conclusion of the air measurements, the TAB shall provide a written report clearly indicating the results of its measurements, and recommendations for relocation of duct detectors if necessary. Upon approval of the air balance report by Owner's Representative, Contractor shall install the duct detectors in the exact locations specified by the TAB.
   3. Selection of the TAB shall be subject to the approval of Owner's Representative. Services of the TAB shall be included in the Contractor's base bid. No extra compensation will be paid by the Owner for its services.

E. Tests: Contractor shall provide all personnel, meters and test equipment, and shall test the system in the presence of Owner's Representative. The tests shall be as described in Paragraph 3.2.

F. Contractor shall schedule its work so that Fire Marshal witness testing of the fire alarm system in each building will be called for at intervals not less than two weeks apart. The testing schedule shall not affect the scheduled completion date for the project.

G. System shall be tested, accepted and in use without malfunction for thirty five (35) days prior to completion of Contract. See Paragraph 3.2.G for additional detail.

H. Contractor shall maintain one set of redlined as built drawings and program printout at the FACP during the 35 day test period through receipt of final as builts.

1.5 SUBMITTALS

A. Submit the following in accordance with the procedures and requirements specified in Division 01 of the Specifications.
   1. Qualifications:
      a. Submit qualifications for the following within ten (10) days after receipt of Notice of Selection:
         1) Contractor (or subcontractor if Contractor is utilizing a subcontractor to perform the installation of the fire alarm system(s).

b. Submit qualifications for Contractor's Technical Supervisor as specified in Paragraph 1.2.C above within thirty five (35) days from the date specified in the Notice to Proceed.

2. Fire Alarm Manufacturer/Supplier (defined as an authorized distributor of the fire alarm manufacturer's products): Submit within thirty five (35) days from the date specified in the Notice to Proceed (refer to Division 01 of the specifications).
   a. Submit the information shown in the "Fire Alarm System Submittal Checklist" shown at the end of this section. Contractor shall indicate by check marks which items are being submitted. Contractor's submittal will be reviewed and returned for corrections along with a copy of the checklist.

B. Submit initial shop drawings within 60 days of the date shown in the Notice to Proceed. All shop drawing deliveries after initial submittal shall be hand carried or sent by special messenger involving no more than one day travel time. In projects containing more than one building, fire alarm drawing submittals shall be staggered. After submittal of fire alarm drawings for the initial building, submit each additional set of drawings within seven to ten calendar days, until drawings have been submitted for all buildings.

C. All fire alarm shop drawings shall be approved, with California Fire Marshal's stamp, within 60 days of initial submittal of each set.

D. Furnish a certified letter from the manufacturer indicating compliance with the following:
   1. There is a factory warehouse located within 75 miles of the Project Site, at which spare parts are stocked.

E. A field service engineer who is a full time employee of the fire alarm equipment manufacturer, or their authorized distributor, resides within 75 miles of the Project site. He/she shall be factory trained and his/her primary function shall be field service. In the event of a trouble call from Owner, the manufacturer's service engineer will respond to the call and arrive in the building where the problem exists within 2 to 4 hours of the time the call was made. In no case shall the response time exceed 4 hours. This requirement will remain in effect throughout the construction and guarantee phases of the project.

F. Within thirty (30) days after Owner's Representative's approval of fire alarm manufacturer/supplier, submit a copy of the purchase order and delivery schedule as proof fire alarm system parts will be received in time to maintain approved contract schedule.

G. Operating and Maintenance manual (6 copies). See Paragraph 3.2.I herein for details.

H. Acceptance Test Results and Test and Maintenance Program Schedules. See Paragraph 3.2 and 3.6.

I. Record Drawings (Plans, Details, Wiring Diagrams):
   1. All record drawings shall be prepared utilizing a computer generated system .
   2. Fire Alarm Drawings shall utilize standard NFPA symbols as shown in NFPA 170, Chapter 5.
   3. Final record drawings shall be equal in size to the Contract Drawings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide comparable product by one of the following:
   1. NOTIFIER; a Honeywell company.
   2. Siemens Building Technologies, Inc.; Fire Safety Division.

3. SimplexGrinnell LP; a Tyco International company.

2.2 MATERIALS AND EQUIPMENT

A. All materials, equipment, accessories, devices and other facilities and appurtenances covered by these Specifications or noted on the Design Build Drawings shall be listed by the CSFM and by UL, and shall be new, best suited for the intended use, and shall conform to applicable and recognized standards for their use.

B. Spare parts shall be furnished for each of the following devices: detectors (each type), manual pull stations, horns, strobes, horn/strobe units, speakers (where applicable) flow switches, tamper switches, and door holders. Provide 5% spare parts of the total quantity of each device used in the Project; the maximum number of spare parts of any single device, however, shall be limited to 25. Provide a minimum of one (1) device of each type.

2.3 CONTROL EQUIPMENT

A. The control panel shall provide power, annunciation, supervision and control for the detection and alarm system.

B. The control panel shall be capable of supporting non addressable as well as addressable detection devices.

C. The panel annunciator shall be a 80 character alpha numeric display.

D. The control system shall provide supervision and self diagnostics for the system electronics, wiring, detection devices and software.

E. Ground fault detection shall be provided for all initiating device, notification appliance and signaling line circuits.

F. The system trouble lamp shall flash and an integral trouble buzzer shall sound upon the occurrence of any trouble condition. Acknowledgement of the trouble condition by operation of the silence switch shall silence the audible alarm and cause the trouble lamp to light steadily. Receipt of subsequent troubles shall cause the trouble buzzer to resound and the trouble lamp to flash.

G. Individual input and output device addressability as well as remote sensitivity measurement, where available, shall all be performed on the same set of wires.

H. The service mode shall permit the arming and disarming of individual detection or output devices as well as manually operating output devices.

I. Individual device or zone groups shall be programmed via function switches to disable selected output functions when activated. Output disable functions shall include but not be limited to:
   1. Elevator recall
   2. Fan control/shutdown
   3. Audible/visual alarms

J. The panel shall be capable of receiving and processing alarms even when in the service mode.

K. The control panel shall operate from a three wire 120 VAC power supply and internal 24V back up battery. Battery shall be the sealed, lead calcium type. All battery calculations shall be done by the IEEE method. The batteries shall be sized to provide 4 hours of standby power, and 5 minutes of alarm. A battery charger shall be provided which is capable of recharging the batteries to 80% capacity in 12 hours. Loss of commercial power shall be annunciated as a system trouble. System trouble shall be indicated for over or under voltage conditions, blown fuse or disconnected batteries. The system shall automatically restart upon the return of commercial power. No operator intervention shall be required, except to reset the trouble indication. The control panel shall also have an external 5 minute UPS system to provide protection during the building's Main Power Generator testing. The control panel shall have a supplementary outboard transient voltage surge suppressor.

L. In addition to other requirements, the Fire Alarm Control Panel shall provide isolated contact outputs as follows:
   1. Alarm automatic device.
   2. Alarm manual pull station.
   3. Alarm water flow device.
   4. Trouble.
   5. Subsequent trouble.

M. The fire alarm control panel shall have 110% of the capacity required to supply all the devices in the system. The 110% shall be calculated based upon the full rated capacity of each circuit. Each circuit shall have the capacity to add 20% more devices than specified for this Project. The power supply itself shall have 20% spare capacity over and above the requirements for this Project.

N. The smoke panel shall display custom messages on an alpha numeric display. Each device on an addressable initiating circuit shall be checked continuously to include the following, as a minimum: response, opens, shorts, ground faults, functionality and status.

O. The system shall also be capable of measuring and adjusting the sensitivity of addressable detectors.

P. The control panel shall report failure, open, or short, on devices on addressable initiating circuits. A failed device shall be recognized and identified by location within its circuit. All other devices on the circuit shall continue to function.

Q. The control panel shall report, by specific device number, any device removed from an addressable initiating circuit and all other devices shall continue to function.

R. The control panel shall allow changing the status of configured circuits (arming and disarming and changing status of relays). If any change in status degrades system operation as configured, a trouble condition shall be reported and remain until system operation again meets configured status.

S. The control panel shall have the ability to perform multiple operations at the same time. These operations shall include timed functions and multiple configured sequences.

T. The control panel shall have the ability to support a printer terminal. When used, this terminal shall provide permanent records of the system's status and detector chamber voltages, and shall also be capable of system control as configured.

U. The control panel shall allow for expansion and shall also be configurable without system inter-wiring.

V. Provide an active RS232 printer port for connection of a printer or CRT. When a printer is connected, the system shall provide a hard copy written record of all alarms, troubles, and system activity.

W. New unacknowledged alarms and troubles shall be distinctively displayed on both the visual display and the printer (when connected) and differentiated from previous alarms and troubles.

X. The control panel, data gathering panel, or equivalent, shall be capable of providing the following information to an external printer (when connected):

1. Alarm with time, date, and location.
2. Trouble with time, date, and location.
3. Status of output functions, "on" or "off."
4. Sensitivity of addressable smoke detectors.
5. Detection device number, type, and location.
6. Status of remote relays, "on" or "off."
7. Acknowledgement time and date.
8. Signal silence time and date.
9. Reset time and date.

Y. The system shall be capable of:
   1. Differentiating among types of addressable detectors such as smoke detectors, manual stations, water flow switches and thermal detectors.
   2. Assigning priorities to types of detectors, zones or groups of detectors.
   3. Cross zoning.

Z. Control functions shall be assigned on the basis of system initiation patterns of detection devices such as "ending" zones, counting zones, counting devices, and "ending" groups, and "ending" types of detection devices.

AA. Control functions shall be assigned on the basis of time of day, day of week, and with a holiday schedule of up to thirty holidays per year. Each addressable detection device shall report its condition to the system control unit every four seconds in a manner such that failure of the connections to or internal electronics of the device will result in a trouble signal which identifies the specific device involved.

BB. It shall be possible to change the detector sensitivity from the control panel, data gathering panel, or equivalent, within maximum and minimum values as defined by the UL listing of the detectors.

CC. The system shall be capable of listing detector chamber voltage or sensitivity settings on an external printer for permanent record.

DD. Water flow switches, tamper switches, OS & Y valves, manual stations, and the thermal detectors shall be equipped with an electronic address device which shall be supervised identically as addressable detectors.

EE. The supervised and powered parallel output circuits shall be listed for use as audible/visual signal circuits, fire extinguishing release circuits, or general alarm release service. They shall provide 24 VDC, with amperage adequate for the service required.

FF. Control relays having dry contacts rated and listed for their intended use shall be included in the fire alarm control unit.

GG. Remote relays located on detector bases or double gang outlets throughout the building shall be controlled in the same manner as panel mounted relays.

HH. The control panel enclosure shall be manufacturer's standard color, manufactured for surface or semi-flush mounting. A locked door shall be provided to limit access to individuals authorized access to the panel.

II. All modules shall be plug in, dynamically supervised and easily replaceable. Field wiring shall be connected to the panel with removable multi conductor connectors to facilitate rapid removal and replacement of both the module and wiring for ease of servicing the panel.

JJ. Visual indicators shall be long life LEDs. Modules capable of initiating a system trouble shall display individual trouble indications on the alpha numeric annunciator.

KK. Password access shall allow the operator to change detector sensitivity settings, disarm input and output devices, control relays, execute display and lamp tests, and walk test. Access to the keypad shall require opening of the locked door through use of the system key.

2.4 COLOR GRAPHIC ANNUNCIATION SYSTEM

A. The system shall be a touchscreen display.
   1. The interactive display system shall include, but not be limited to, a touch screen interface, network communications media, power supplies, and wire / fiber optic media as shown on the drawings and specified herein.
   2. The interactive display shall support fire alarm, supervisory from the fire alarm control panel(s).
   3. The interface shall display building floor plans with respective active fire alarm devices, evacuation routes, access routes, and power and HVAC shutoffs.
   4. The system shall include an easy one touch method of viewing building, emergency contacts, the facility site plan, and active event information.
   5. The system shall be electrically supervised and monitor the integrity of all conductors.

B. The system shall operate on an UL listed Embedded platform operating at no less than 700 MHz on the Microsoft® Windows® XP Embedded platform.

C. The Embedded platform shall have: no less than 256 megabytes of RAM, a flash drive with no less than 1 Gigabytes of storage space, 100 Base T Ethernet NIC card, and USB ports.

D. The Embedded platform shall have a minimum 17" touchscreen display.

E. The Embedded platform shall come equipped with all necessary gateway modules to allow connection to the network it monitors as standard equipment.
   1. A UL listed Ethernet Hub shall be provided for connection of multiple interactive displays and/or gateways.

F. The system shall have the following UL listings:
   1. No. 864 Control Units for Fire Protective Signaling Systems (9th edition / Ancillary listing)
   2. CSFM: 7300 1525: 103.

G. The network shall have the ability to use fiber optic cable (single mode and multi-mode), wire (twisted pair copper media in a style 4 or style 7 configuration), or combination wire/fiber communications with support of up to 103 nodes.
   1. Wire networks shall support 12 AWG, 1 Pair Shielded to 24 AWG, 4 Pair Unshielded following the manufacturer's guidelines.
   2. Fiber optic networks shall support 62.5/125µm cable 8dB limit (50/125µm cable 4.2dB limit)
   3. Wire to fiber conversions using repeaters

H. High speed data communications (312,500 BPS).

I. True peer to peer communications between fire alarm control panels.

J. The network will interface and report the individually monitored system's alarm status via a user friendly Graphical User Interface (GUI) based software.

K. The software shall operate under Microsoft® Windows® XP Embedded platform as manufactured by Microsoft Corporation.

1. Steel reinforcement and accessories.

1.6 QUALITY ASSURANCE

A. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:
   1. ACI 301-10, "Specifications for Structural Concrete for Buildings"
   2. ACI 117-10, "Specification for Tolerances for Concrete Construction and Materials"

B. CRSI Publications: Comply with the following, unless more stringent provisions are indicated:
   1. Manual of Standard Practice
   2. Documents 63 and 65.

C. Qualifications
   1. Welding Qualifications: Qualify procedures and personnel according to AWS D1.4/D 1.4M, "Structural Welding Code - Reinforcing Steel."

1.7 DELIVERY, STORAGE, AND HANDLING

A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage.

PART 2 - PRODUCTS

2.1 STEEL REINFORCEMENT

A. Reinforcing Bars: See Structural Drawings

B. Plain-Steel Wire: See Structural Drawings

C. Deformed-Steel Wire: See Structural Drawings

2.2 DEFORMED BAR ANCHORS

A. Nelson, Type D2L automatically end-welded deformed bar

2.3 REINFORCEMENT ACCESSORIES

A. Tie Wire: Minimum 16 gage, ASTM A 82, or acceptable patented system.

B. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60, plain-steel bars, cut true to length with ends square and free of burrs.

C. Zinc Repair Material: ASTM A 780, zinc-based solder, paint containing zinc dust, or sprayed zinc.

D. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place. Manufacture bar supports from steel wire, plastic, or precast concrete according to CRSI's "Manual of Standard Practice," of greater compressive strength than concrete and as follows:

   1. For concrete surfaces exposed to view where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire or CRSI Class 2 stainless-steel bar supports.

L. The GUI based software must be capable of graphically representing the facility being monitored with floor plans and icons depicting the actual locations of the fire alarm device locations.

M. The software shall use a 1280 pixel x 1024 pixel GUI display capable of showing a large primary floor plan display, a site plan representative of an aerial view of the facility, the first active fire alarm on the system.

N. The software shall permit automatic navigation to the screen containing an icon that represents the first fire alarm device in alarm in the event of an off normal condition.

O. The fire alarm device icon shall be visible only when it is in an alarm (or active) condition.

P. The software shall display the activated smoke detectors in a time sequence to track smoke progression.

Q. The software shall allow the importation of externally developed floor plans in Windows Metafile (WMF), JPEG (JPG), Graphics Interchange Format (GIF) and Bitmap (BMP) format.

R. The software shall provide a intuitive and easy way to navigate to different screens representing floors and areas within a facility.

S. The system shall provide for continuous monitoring of all fire alarm conditions regardless of the current activity displayed on the screen.

T. The software shall display "YOU ARE HERE" along with icons representing standard building objects (stairs, elevators, etc) to be shown on the floor plan.

U. The software shall allow icons that represent hazardous materials stored in a facility.

V. The software shall provide a screen that displays preprogrammed building contact information.

W. The software shall provide a screen the displays building occupancy and other general building information.

X. The software shall allow a site plan to be imported that shows an aerial view of the facility.

Y. The software shall display all active fire, supervisory, and security events within an event list.

2.5 INITIATING CIRCUITS

A. Analog addressable/programmable initiating circuits shall be provided by an Addressable Input Module. The module shall be operable by the control unit.

B. Upon activation of any addressable/programmable device installed in the circuit, the system shall automatically report the status of the device and initiate the sequence of operations specified for that device, e.g., alarm, local, general, reporting, trouble reporting only, etc. Alarm shall have priority over trouble. Trouble conditions shall be reported to include the device number, location and type of trouble.

C. All initiating devices on all circuits may be in alarm at the same time and perform the sequences of operation prescribed by the system configuration.

D. The initiating circuits shall maintain complete reporting of device status while in trouble, due to any addressable device having its active transmitting component fail, open or shorted. The initiating circuits shall detect a line break and supply information to the control panel allowing the user to determine between which two devices the break has occurred.

2.6 OUTPUT CIRCUIT

A. Provide a 24VDC 100MA supervised battery backed up power source from the building Fire Alarm Control Panel (FACP) for use in remote annunciator panel.

B. Building Alarm and Trouble Signaling Relays:
   1. Provide 5 relays in the building FACP to be used as the interface means to the remote annunciators. These relays shall be CSFM listed for fire alarm system signaling service and function in the following manner:
      a. Relay No. 1: Manual Alarm
         1) Energize the relay coil and close its respective contacts upon activation of any manual fire alarm within the building.
      b. Relay No. 2: Automatic Alarm
         1) Energize the relay coil and close its respective contacts upon activation of any automatic fire alarm device within the building (i.e. smoke detectors, duct smoke detectors, heat detectors, etc.).
         2) De energize the relay coil and open its respective contacts after panel reset.
      c. Relay No. 3: Waterflow Alarm
         1) Energize the relay coil and close its respective contacts upon activation of any waterflow alarm within the building.
         2) De energize the relay coil and open its respective contacts after panel reset.
      d. Relay No. 4: Common Trouble
         1) Change the state of relay and close its respective contacts upon activation of any trouble or supervisory alarm within the building.
         2) Restore relay state to open its respective contacts upon either condition 1) or 2), or both:
            a) Panel reset.
            b) Restoration of trouble or supervisory alarm, "Auto Restore".
      e. Relay No. 5: Subsequent Trouble
         1) De energize the relay coil and close its respective contacts upon activation of any "unacknowledged" trouble or supervisory alarm within the building.
         2) Energize the relay coil and open its respective contacts upon condition 1) or 2) or both:
            a) Acknowledgement of trouble activation.
            b) Restoration of trouble or supervisory alarm, "Auto restore".

2.7 RELAY MODULE

A. Programmable supplementary relay module(s) as required shall be provided for control of door holders, accordion door, elevator recall and remote reporting as required.

B. Each relay module shall be independently operable by the control unit or manually.

C. The module shall contain four independent relays, fitted with form "C" contacts, rated at 120 VAC 5 amps inductive, or as required. The module shall be UL and CSFM listed.

2.8 MANUAL FIRE ALARM PULL STATIONS

A. Comply with UL 38. Boxes shall be finished in red with molded, raised letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box.

B. Single action mechanism, pull lever type; with integral addressable module arranged to communicate manual station status (normal, alarm, or trouble) to fire alarm control unit.

C. Station Reset: Key or wrench operated switch.

D. Indoor Protective Shield: Factory fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery powered audible horn intended to discourage false alarm operation.

E. Weatherproof Protective Shield: Factory fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

F. Provide manual pull stations in the concentrated storage areas such as loading dock and storage areas on Levels A and B.

G. Provide manual pull stations at Command Center on Level G, AV Control Room on Level G and Fire Command Center on Level A.

2.9 SYSTEM SMOKE DETECTORS

A. Operating at 24 V dc, nominal. Detectors shall be two wire type.

B. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire alarm control unit.

C. Base Mounting: Detector and associated electronic components shall be mounted in a twist lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.

D. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.

E. Integral Visual Indicating Light: LED type indicating detector has operated and power on status.

F. Detector sensitivity shall be programmable from control panel.

G. The detector shall not go into alarm when exposed to air velocities of up to 3000 cfm.

H. Photoelectric Smoke Detectors: Comply with UL 268.
   1. The analog addressable photoelectric smoke detector shall contain a long life LED as its light source, and a photo diode as a light receiver. An automatic gain control circuit shall be provided to maintain correct sensitivity by compensating for detector aging and dirt accumulation.
   2. The detector shall be a plug in twist/lock unit which allows for easy connection to its mounting base.
   3. It shall be possible to adjust and electronically measure the sensitivity of each individual addressable detector from the control panel, data gathering panel or equivalent.
   4. The detector mounting base shall be of the twist/lock type with screw terminals for field wiring. Pig tails or in line connectors will not be permitted.

I. Ionization Smoke Detector: Comply with UL 268.
   1. The analog addressable ionization type smoke detector shall be plug in, twist lock unit which allows for easy connection to its mounting base.
   2. The addressable detector sensitivity shall be individually adjustable from the control panel, data gathering panel or equivalent.
   3. The detector mounting base shall be of the twist/lock type with screw terminals for field wiring. Pig tails or in line connectors will not be permitted.

J. Duct Smoke Detectors: Photoelectric type complying with UL 268A.
   1. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
   2. Each sensor shall have multiple levels of detection sensitivity. Transparent cover for visual inspection. Remote indication and test station.
   3. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
   4. The Contractor shall provide all duct detectors as required per applicable codes for smoke detection, alarm, and HVAC equipment control. Provide all necessary wire, conduit, and relays necessary for interconnection of detectors, Fire Alarm Control Panel, and HVAC equipment and controls.
   5. Duct detectors to be installed per NFPA 72 and Manufacturer's installation requirements. Inlet tubes to be upstream of exhaust tube. Inlet tube holes to face into air stream. Provide access door at each duct detector for verification of tube installation.
   6. The duct smoke detector shall shut down its corresponding HVAC equipment and shall not restart until the smoke is cleared and the detector is reset at the Fire Alarm Control Panel. Duct detector shall be labeled to show HVAC unit affected.
   7. Remote alarm indicators shall be provided with all duct detectors, and any other detectors installed where not visible.

2.10 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

B. Actuated by either a fixed temperature of 135 deg F or a rate of rise that exceeds 15 deg F per minute unless otherwise indicated. The analog addressable thermal detectors shall be of the rate compensated fixed temperature type and shall be individually annunciated on the control panel. The addressable thermal detectors shall contain an integral alarm lamp.

C. Mounting: Twist lock base mounting interchangeable with smoke detector base.

D. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire alarm control unit.

E. Visual LED alarm indicators.

F. Remote alarm indicators shall be provided with all detectors installed where not visible.

2.11 NOTIFICATION APPLIANCES

A. Individually addressed and connected to a signaling line circuit.

B. Audio Visual Alarm speaker shall have a high intensity flashing light and an alarm speaker as an integral unit and shall function as a unit and shall meet ADA, and the CBC (with Amendments) standards.

C. The Audio/Visual Alarm speaker shall be UL1971 listed for indoor fire protection service. Components shall operate from 24VDC polarized indicating circuits. Each indicating circuit shall be equipped with a synchronizing control module which shall synchronize all of the horns in the NFPA/ANSI specified temporal pattern. Additionally, all strobes shall flash in synchronization.

D. The strobes shall flash at the rate of not less than one flash per second over the UL rated voltage range. Upon activation of the audible silence function at the Fire Alarm Control Panel, the speakers shall be silenced while maintaining strobe operation.

E. The strobe shall incorporate a xenon flashtube enclosed in a Lexan lens. The word FIRE shall appear on 2 sides of the housing. The lamp intensity shall be determined by the size of the protected space as required in NFPA 72.

F. Sound output at 10 ft. shall be selectable for 90, 95, or 99dBA.

G. The devices shall be polarized for DC supervision, and shall incorporate lugs for in/out field wiring of #18 to #12 AWG wire.

H. The audio/visual alarm device shall incorporate a universal mounting plate which shall allow mounting to single gang, double gang, 4" square, or 2 gang backboxes. The entire backbox depth shall be available for the installation wiring. There shall be no electronics protruding into the backbox. No additional trim plate shall be required for semi flush mounting.

I. Weatherproof devices shall be available as required.

2.12 OTHER INITIATING DEVICES

A. Provide necessary flow switches at locations determined by design build drawings approved by AHJ, or as otherwise required, and provide contacts at all shut off valves for supervision.

B. Provide necessary magnetic door holders. The door holder shall be mounted to a securely fastened backbox.
   1. Provide separate power supplies with self-contained battery charger(s), approved as required by UL and/or CSFM for the purpose, for all door release devices for new roll up type doors. The power supplies shall prevent dropping of doors upon loss of power. Power supplies shall be capable of sustaining normal operation for a minimum of 2 hours in the event of a power loss.
   2. A delay of 8 to 10 seconds, not to exceed 10 seconds, shall occur prior to start of descent of all roll up doors. Door descent will be triggered by initiation of fire alarm.
   3. Audible and visual alarms shall be provided at each door, warning of imminent descent of door. Audible and visual alarms shall have distinctive sound and appearance to distinguish them from building audio/visual alarms, and shall be approved as required for use with the roll up doors involved.

2.13 HVAC SYSTEM

A. Contractor shall provide all duct detectors as necessary and required per applicable codes for smoke detection, alarm, and HVAC equipment control. Provide all necessary wire, conduit, and relays necessary for interconnection of detectors, Fire Alarm Control Panel, and HVAC equipment and controls.

B. Duct detectors to be installed per NFPA 72 and Manufacturer's installation requirements. Inlet tubes to be upstream of exhaust tube. Inlet tube holes to face into air stream. Provide access door at each duct detector for verification of tube installation.

C. The duct smoke detector shall shut down its corresponding HVAC equipment and shall not restart until the smoke is cleared and the detector is reset at the Fire Alarm Control Panel. Duct detector shall be labeled to show HVAC unit affected. Refer to the approved shop drawings for complete Sequence of Operations of the duct smoke detectors.

D. Contractor shall provide the services of a Testing and Balancing (TAB) service who is a member of either the Associated Air Balance Council (AABC) or the National Environmental Balancing Bureau (NEBB) and is familiar with fire alarm technology.
   1. The TAB shall measure the air velocity and static pressure at each duct detector location shown on the drawings. If the air velocity and static pressure at the locations shown do not meet the criteria for proper functioning of any of the duct air detectors, the Air Balance Agency shall test alternate locations at no extra cost to Owner until appropriate locations are identified.
   2. Upon conclusion of the air measurements, the TAB shall provide a written report clearly indicating the results of its measurements, and recommendations for relocation of duct detectors if necessary. Upon approval of the air balance report by Owner's Representative, Contractor shall install the duct detectors in the exact locations specified by the TAB.
   3. Selection of the TAB shall be subject to the approval of Owner's Representative. Services of the TAB shall be included in the Contractor's base bid. No extra compensation will be paid by the Owner for its services.

2.14 AUDIO VISUAL ALARM SYSTEM

A. Audio Visual Alarm speaker shall have a high intensity flashing light and an alarm speaker as an integral unit and shall function as a unit and shall meet ADA, and the CBC (with Amendments) standards. The Audio/Visual Alarm speaker shall be UL1971 listed for indoor fire protection service. Components shall operate from 24VDC polarized indicating circuits. Each indicating circuit shall be equipped with a synchronizing control module which shall synchronize all of the horns in the NFPA/ANSI specified temporal pattern. Additionally, all strobes shall flash in synchronization. The strobes shall flash at the rate of not less than one flash per second over the UL rated voltage range. Upon activation of the audible silence function at the Fire Alarm Control Panel, the speakers shall be silenced while maintaining strobe operation.

B. The strobe shall incorporate a xenon flashtube enclosed in a Lexan lens. The word FIRE shall appear on 2 sides of the housing. The lamp intensity shall be determined by the size of the protected space as specified in NFPA 72.

C. Sound output at 10 ft. shall be selectable for 90, 95, or 99dBA. The devices shall be polarized for DC supervision, and shall incorporate lugs for in/out field wiring of #18 to #12 AWG wire. The audio/visual alarm device shall incorporate a universal mounting plate which shall allow mounting to single gang, double gang, 4" square, or 2 gang Wiremold backboxes. The entire backbox depth shall be available for the installation wiring. There shall be no electronics protruding into the backbox. No additional trim plate shall be required for semi flush mounting.

2.15 EMERGENCY VOICE COMMUNICATION SYSTEM

A. The Emergency Voice Alarm Communication System (EVCS) shall be fully compatible and listed with CSFM for use with the Fire Alarm Control Panel (FACP). The EVCS panel shall provide one way voice communication utilizing fire alarm speakers. The EVCS panel shall be incorporated with the FACP when feasible. The EVCS shall be equipped with digitized message module(s) as required to provide up to four (4) pre-recorded messages. The module shall be field programmable and continuously supervised.

B. The Emergency Evacuation Communication Panel shall be complete, factory wired and assembled and perform all functions as specified herein. The panel shall operate on 120 VAC, and shall be able to perform its intended functions independently from the Fire Alarm Control Panel. All communication lights shall be visible with the panel door closed. Identification signs for controls and annunciation shall be permanent type. The EVCS panel shall incorporate, but not be limited to, the following functions and features:

1. Electrical supervision of all communications circuits. For either a ground fault, an open circuit or a short on any components of the system, a distinctive audible visual trouble indication shall activate. The audible trouble signal shall be capable of being silenced. Trouble conditions shall be transmitted to the FACP.
2. Amplifiers shall be self-supervising and provide an audible and visual alarm in the event of decreased amplifier output. Amplifiers shall be rated to supply 150% of the installed load on each circuit, thereby allowing expansion of the speaker system. Backup amplifiers, sized the same as the primary amplifiers shall be provided. Switchover function shall be automatic. Amplifiers may be located remotely from the EVCS panel at a location approved by Owner's Representative.
3. Power on/off switches shall not be readily accessible. Each power amplifier shall be constantly monitored. Detection of an amplifier failure shall automatically cause substitution of the standby amplifier and shall activate the trouble light and audible signal at the EVCS panel. In addition, an amplifier failure shall illuminate a corresponding trouble annunciator to identify the amplifier which has failed.
4. Activation of the Fire Alarm System as described in preceding Paragraph 1.1.F shall cause the sounding of a digitally recorded message on all speakers in the EVCS system.
5. Manual select switches (illuminated when ON) for manual operation of speakers with one speaker zone per floor, stairwell zone, elevator zones. Manual select all call switches (illuminated when ON) for manual operation of all speakers.
6. Include a minimum of 8 active spare switches for future speakers.
7. Hand held master microphone for one way communication. Microphone input shall be adjustable and supervised.
8. Visual trouble lights, audible trouble signals and silencing switches for fire alarm and voice communication.
9. Green lamp to indicate system operating on normal A.C. operating power, red lamp to indicate system operating on secondary standby power supply.
10. Lamp test switch.
11. Pushbuttons, switches, lights, etc. labeled with engraved phenolic name tags, permanently attached.
12. Duplicate pre amplifiers, oscillators and microphone driver circuits shall be monitored and arranged so that failure of one of these will not prevent the transmission of any audible signal to the speaker circuits.
13. Operating voltage of all fire alarm voice/tone speakers shall be 25 VAC or 70 VAC.

2.16 CONDUITS

A. Rigid steel conduits shall be provided for all main horizontal runs, risers, exposed locations and locations otherwise subject to damage.

B. EMT may be installed for branch circuit runs where concealed and not subject to damage.

C. Liquidtight flexible steel conduits shall be provided for connection to sprinkler waterflow and tamper switches.

2.17 CONDUCTORS

A. Conductors shall be solid or stranded, based on applicable codes, manufacturer's recommendations, and standard good wiring practice. Conductors for Signaling Line Circuits and Initiating Device Circuits shall be shielded, minimum size AWG #18. Conductors for Notification Appliance Circuits shall be non-shielded sized as required to meet all design criteria. All conductors shall be insulated for 300 volts minimum. All fire alarm circuits wiring shall be sized so that voltage drop is less than 10%.

B. The following procedures shall be observed in installation:
   1. Avoid all unnecessary splices.
   2. Avoid terminating solid wire on circuit boards where flexing of such terminations could lead to breakage or damaging of the circuit board.
   3. Wiring in boxes, cabinets and fire alarm devices of all types shall be arranged so that closure of covers shall not unnecessarily compress the wiring and terminations contained therein.

2.18 CABINETS AND TERMINALS

A. All equipment installed including FACP, battery cabinets, annunciators, terminal cabinets, will be keyed alike.

B. Cabinets, Battery
   1. Separate Battery Cabinets, when used, shall be locking and manufactured for the purpose.
   2. No equipment shall be located below the batteries.

C. Terminal Cabinets shall be identified with permanent red with white lettered label or engraving designating it as:
   1. "Fire Alarm Terminal Cabinet No. XX" (provide coordinated numbering system), and correlated with the record drawings.
   2. Size of the label will be 4 inches by 2 inches, letters to be 1/4 inch tall.

D. Main Terminal Cabinets shall have a minimum depth of 6 inches; all others shall have a minimum depth of 4 inches. All shall have a hinged cover with integral lock, have a 3/4 inch deep fire retardant treated plywood (or integral formed steel) backboard, and be sized to allow neat wire and terminal installation. All wiring in terminal cabinets shall be landed on terminal blocks.

E. All field wiring and FACP wiring shall be terminated in Terminal Cabinets or on field devices. Wiring splices shall be prevented. If needed, they shall be made only at device mounting boxes and shall be done using set screw, wire nut, or insulation displacement connectors. Crimp type connectors may be used only for connection of stranded to stranded wire.
   1. Connectors shall be:
      a. Thomas and Betts, crimp on wire joints, Catalog numbers RB44, RC55, RP12.
      b. Or equal.
      c. All connectors shall be sized and installed in accordance with the manufacturer's instructions and recommendations.

F. Terminal Cabinet/Terminal Blocks: There shall be one electrically independent Terminal Block segment per outgoing conductor, with one per incoming spare conductor, plus 10% spare installed for future use minimum of 12". Terminal blocks shall be vertically oriented.

G. Terminal Blocks shall be pressure plate type intended for direct wire connections. Terminal Blocks shall be:
   1. Phoenix contact, Part number: MBK5 mounted on NS15 mini din rails, MBK10 mounted on NS15 mini din rails.
   2. Or equal.

PART 3 - EXECUTION

3.1 GENERAL

A. Control and other panels shall be mounted with clearances for observation and testing. All fire alarm junction boxes shall be marked for identification. Flexible connectors shall be used for all devices mounted in suspended lay in panels. All conduit, mounting boxes and panels shall be hung and fastened with fittings to insure positive grounding throughout the entire system.

B. Provide (4) 1" conduit stubs from the Fire Alarm Control Panel into the ceiling space, and (2) 1" stubs from the annunciator panel into the ceiling space. No wiring other than that directly associated with fire alarm detection, alarm or auxiliary fire protection functions shall be permitted in fire alarm conduits. Wiring splices shall be prevented. If needed, they shall be made only in junction boxes. Transposing or changing color coding of wires will not be permitted. All conductors in conduit containing more than one wire shall be labeled on each end with "E Z markers." Conductors in cabinets shall be formed and harnessed so that each drops off directly opposite to its terminal. Cabinet terminals shall be numbered and coded. All controls, function switches, etc., shall be labeled on all equipment panels. All wiring shall be checked and tested to insure that there are no grounds, opens or shorts.

C. Wiring for hold open devices shall be run in separate conduits.

D. Provide all wiring in conduits. All wire shall be identified with Cloth Type "E Z Marker." Terminate all wiring including cable drain wires as indicated in Operation, Installation and Maintenance Manuals (latest edition) for Fire Alarm Company whose equipment is being installed. Provide the following for Shielded Cables:
   1. Shielded cables shall have clear Teflon sleeving installed on the shield drain wire wherever the jacket has been removed. At the junction of sleeving and cable jacket, electrical tape shall be applied to ensure the shield is bare only at the point of termination.
   2. End of string shield drain wires shall be removed and electrical tape applied to prevent them from being grounded.
   3. Spare initiating device and signaling line system conductors shall be connected and terminated in the same manner as their respective shield drain wires, with the exception that they will not be connected to any system device other than the point of origin as will the main shield drain.
   4. Cable shield drains shall be connected at their point of origin and at devices as recommended by the equipment manufacturer.

E. Separate initiating circuits from all other wiring in enclosures and in the terminal cabinets.

F. Wire and cable identification shall be consistent and maintained throughout the entire system for the following types of circuits:
   1. Initiating device/signaling line circuits.
   2. Notification appliance circuits (horns, strobes, speakers, etc.).
   3. Control wiring and miscellaneous circuits.
   4. System interface circuits (data gathering panels, printers, annunciators, etc.).
   5. Associated loop and/or circuit numbers shall be identified for the following type of circuits:
      a. Initiating device/signaling line circuits.
      b. Notification appliance circuits.
      c. System interface circuits.
         1) In addition, the Contractor shall identify all wires as indicated by the following identification schedule. The identification shall be by NEMA colored "E Z" wire markers applied to the cable jacket or separate NEMA colored wires as indicated.

Circuit Types	Cable Jacket	Separate Conductors	Loop ID
Initiating	Red	N/A	Yes
Visuals	Yellow	Yellow(+) Violet(DDC)	Yes
Horn	Orange	Orange(+) Dark Blue(DDC)	Yes
Voice	Tan	Tan(+) Light Blue(COM)	Yes
Fireman's Phone	Brown	N/A	No
Control, Misc. Sys.	Gray	Gray, Red, Black, White	No
Interface	Pink	N/A	See Note 1

Note 1: Network type circuits shall be tagged using a vinyl tag attached to the cable or group of wires indicating the circuit type and number when applicable.

G. Provide permanent identification labels on each detector and detector base, such that each detector shall have an identification number matched to that of its base. In the event any detector is removed from its base after initial installation, it shall be reinstalled on its identically labeled base.

H. Labels shall contain 3/8" lettering, black letters on white background and shall be of high quality. Their placement on individual detectors and bases shall be done with care so they are mounted parallel to the ceiling (not skewed), all in the same orientation, and are clearly legible from the floor. Labels for detectors, detector buses, and other equipment where required shall be produced by the Kroy 1000 System, or equal. All labels shall have a laminated finish.

I. Submit proposed labeling and mounting scheme to Owner's Representative for approval prior to producing or attaching labels.

J. Field paint all fire alarm boxes red on exterior. Paint and label conduits and raceways as indicated in Section 26 0533.

K. Access: All fire alarm and electrical equipment shall be accessible as defined in NFPA 70. Access panels shall be provided as necessary for equipment which would otherwise be considered inaccessible.

L. Contractor shall ensure that mechanical equipment, piping, etc. are not installed in a manner so as to render fire alarm or electrical equipment inaccessible. Such installations, if made, shall be corrected as approved by Owner's Representative.

M. Access doors shall be fire rated where required.

N. Contractor shall review the fire alarm installation plans prior to installing any of the above devices or equipment. Any installation required to be weatherproof which is made without conforming to the above shall be corrected at Contractor's expense.

3.2 ACCEPTANCE TESTS AND REPORTS

A. In addition to tests required in this Section, perform all electrical and mechanical tests required by the equipment manufacturer. In addition, via the printer terminal, provide a printout of the analog chamber voltage readings of each addressable ionization or photoelectric detector connected to the control panel. The analog chamber voltage readings shall be for each detector at its operational location under environmental conditions. Where no permanently installed printer exists, a printer shall be provided by the Contractor for the printout described above.

2.4 FABRICATING REINFORCEMENT

A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

PART 3 - EXECUTION

3.1 STEEL REINFORCEMENT INSTALLATION

A. General: Comply with CRSI's "Manual of Standard Practice" for placing reinforcement.
   1. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that would reduce bond to concrete.

C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover. Do not tack weld crossing reinforcing bars.
   1. Weld reinforcing bars according to AWS D1.4/D 1.4M, where indicated.

D. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

E. Defective Work: The following reinforcing steel work will be considered defective, and shall be removed and replaced by the Contractor at no additional cost to the Owner:
   1. Bars with kinks or bends not shown on the drawings.
   2. Bars damaged due to bending or straightening.
   3. Bars heated for bending.
   4. Reinforcement not placed in accordance with the drawings.

3.2 DEFORMED BAR ANCHOR INSTALLATION

A. Install in accordance with ICC ESR-2907

3.3 FIELD QUALITY CONTROL

A. Testing and Inspecting: Owner will engage a special inspector and qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. All concrete work is subject to special inspection and testing. This section specifies the minimum testing and inspection required. Additional testing and inspection may be required by the Testing Agency, the Owner, or the Engineer/Architect if project conditions warrant.

C. Special Inspector Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, and qualified according to ASTM C 1077 and ASTM E 329 to conduct the testing indicated, as documented according to ASTM E 548.

D. Tests and inspections shall be in conformance with Division 1, Section "Quality Requirements".

E. Independent Testing Agency shall check batch tickets for compliance with required mix design(s).

F. Inspections:
   1. Steel reinforcement placement.
   2. Steel reinforcement welding.

G. Reinforcing Steel Testing: Independent Testing Agency will perform the following:

B. Testing Prior to Final Witness Testing:
1. Contractor shall pre-test the fire alarm system in the presence of Owner and the City Electrical Inspector. All problems on the system shall be cleared prior to calling for witness testing by Owner's Representative and CSFM.
2. Contractor shall provide all personnel, meters and other necessary test equipment. All testing shall be done under the supervision of a factory trained fire alarm engineer or technician authorized by the fire alarm equipment manufacturer to supervise the testing and to direct the Contractor in any equipment adjustments necessary.
3. The tests shall include, but not be limited to, the following:
   a. Before energizing the fire alarm wiring, check for correct connections and test for short circuits, ground faults, continuity, and integrity of insulation.
   b. Close each sprinkler system control valve, and verify proper supervisory alarm at the FACP.
   c. Verify activation of all flow switches.
   d. Open initiating device circuits and verify that the trouble signal actuates.
   e. Open and short signaling line circuits and verify that trouble signal actuates.
   f. Open and short indicating appliance circuits and verify that trouble signal actuates.
   g. Ground all circuits and verify response of trouble signals.
   h. Check presence and audibility of all alarm notification devices.
   i. If non addressable detectors are used in the system, they shall be measured and adjusted to the maximum stable setting. This shall be performed with the detector at its operational location and under normal environmental conditions in the area. Bench settings are not acceptable.
   j. Introduce each alarm condition that the system is supposed to detect. Verify proper receipt and processing of the signal at the FACP, and correct activation of the control points.
   k. Perform testing procedures for all optional features on the system including verification, and operation of controls which are to be actuated by individual addressable or grouped devices, etc.

C. Final Witness Testing:
1. Contractor shall provide the Owner's Representative 72 hours written notice prior to requesting testing specified in this Section.
2. Contractor shall bring the following to the final test (Items a. and b. shall have been corrected to show the latest information):
   a. Two (2) complete sets of fire alarm drawings, corrected to show accurate locations of all fire alarm equipment.
   b. Three (3) complete printouts of the fire alarm system, showing all devices identified as per Owner's Representative's requirements.
   c. Four (4) fully charged two way battery powered radios ("walkie talkies").
3. All testing shall be done under the supervision of a factory trained Fire Alarm Engineer or Technician authorized by the fire alarm equipment manufacturer to supervise the testing and to direct the Contractor in any equipment adjustments necessary.
4. Prior to conducting final tests:
   a. Test each initiating device (manual stations, area smoke detectors, elevator smoke detectors, duct detectors, flow and tamper switches).
   b. Test the audio system for acceptable sound level, and the visual system for adequate intensity, correct pulse rate, and duration.
   c. Verify correct style operation of all circuits.
   d. Verify supervisory device reporting.
   e. Verify operation of system in standby condition.
   f. Test each duct detector under correct air pressure condition (verify that differential pressure is adequate to actuate detector). All duct detectors shall be tested by an approved air balancing agency (refer to Section 23 0593, TESTING, ADJUSTING AND BALANCING FOR HVAC), according to the requirements in NFPA 72E, Section 8 3.4. A certified report signed by the testing technician on company stationery shall be submitted for approval to the Owner's Representative upon completion of duct detector tests. Tests

shall indicate required and tested values for differential pressure, air velocity, as well as any other manufacturers' requirements. for all duct detectors installed in the system.

g. Test door release systems (magnetically held open doors, overhead roll down doors, and accordion doors).

h. Test mechanical system control.

i. Test for correct output for connection to Campus Central Reporting System.

j. Operation of system under stand by power conditions.

k. Fireman's communication system (where required).

5. Upon completion of testing, furnish written report to the CSFM showing results of all tests. Additional tests shall be performed as required by the CSFM. Upon authorization by CSFM, system may be energized.

D. Prepare a checkout report. Submit six (6) copies to Owner's Representative and one (1) copy to the equipment manufacturer. The report shall include as a minimum:

1. A complete list of equipment installed and wired.
2. Certify that all equipment is correctly installed and functions and conforms with these Specifications.
3. A print out via the printer terminal of all devices connected to the system.
4. Chamber voltage (sensitivity) settings for each ionization and photoelectric detector as measured in place with the HVAC system operating.
5. Technician's name, certificate number and date.

E. After completion of all the tests and adjustments listed above, and review and approval by Owner's Representative of data and test report, submit the following information to Owner's Representative:

1. "As built" conduit layout diagrams including wire color code terminal number.
2. Complete "as built" wiring diagrams.
3. System line diagrams for:
   a. Air handlers with duct detectors showing areas served, detector locations, and system addresses.
   b. Fire sprinkler system with flow and tamper switch locations and system addresses
4. Detailed catalog data on all installed systems components (six (6) copies).
5. A final copy of the test and checkout reports described in Paragraphs 3.2.C and 3.2.D above (six (6) copies).

F. The fire alarm system shall be complete and operational prior to completion and acceptance of the Project. The fire alarm system shall be required to perform trouble free for a period of thirty five (35) days prior to acceptance by Owner's Representative. The 35 day test period shall be re started as many times as necessary as requested by the CSFM and approved by Owner's Representative. No extra compensation shall be given to Contractor due to the need to fulfill this requirement. Contractor shall be held liable for payment of liquidated damages for the period beyond the scheduled completion date that may be necessary for trouble free functioning of the fire alarm system as described above.

G. If the system does not perform to the above criteria it will not be accepted and Contractor shall correct all deficiencies and shall re test the system at Contractor's expense in the presence of Owner's Representative using the same test criteria.

H. Before final acceptance of the work, deliver to Owner's Representative six (6) bound copies of a composite "Operating and Shop Maintenance Manual." Each manual shall include the following:

1. A statement of guarantee including date of termination.
2. Name and 24 hour telephone number of the repair facility to call in the event of equipment failure.
3. Individual factory issued manuals containing all technical information on each specific piece of equipment installed ("typical" data sheets on manuals covering various items are not acceptable).
4. Copy of the system program and sequence of operations. System program shall identify device locations according to Press Box assigned room numbers. Copy of system program shall be furnished on computer disk.
5. Record drawings of the system installation.

I. It shall be the responsibility of Contractor to obtain the above items from factory, or elsewhere. Advertising brochures or operational instructions shall not be used in lieu of the required technical manuals. All information shall be for the specific installation for the current project.

3.3 BUILDING MATERIALS INSTALLATION

A. Installation shall conform to approved shop drawings, and manufacturer's installation details.

B. Installation shall conform to approved submittals and as specified in sections shown in Paragraph 2.14.

3.4 ELECTRICAL INSTALLATION

A. Installation shall conform to approved shop drawings, and manufacturer's installation details.

B. Installation shall be per approved submittals and as specified in sections shown in Paragraph 2.15.

3.5 PAINTING

A. Smoke Detectors: Contractor to remove covers and paint separately in a manner that will not affect the performance or code compliance of the detectors.

B. Fire Alarm/Visual Devices: Contractor to remove covers and paint separately in a manner that will not affect the performance or code compliance of the devices.

3.6 TESTING AND MAINTENANCE

A. Provide one year testing and maintenance, which shall include the following:
   1. Examine and test all fire alarm system devices and equipment in accordance with the methods and schedules shown in NFPA 72.
   2. Provide written reports on NFPA forms (Table 7 5.1) or some other form acceptable to Owner's Representative certifying that devices have been tested, and indicating the results of all tests and inspections.
   3. Contractor shall provide a schedule for the test and inspection program 2 weeks prior to job close out, and shall provide 7 days notice to Construction Manager prior to coming out to do the work.

B. Contractor shall offer a test and maintenance agreement to commence after expiration of test and maintenance included in this Contract. Test and maintenance agreement shall be in conformance with applicable sections of NFPA 72.

3.7 TRAINING

A. Contractor shall furnish a total of 8 hours of training of Owner's personnel by a field engineer employed by the equipment manufacture: 4 hours of training for Day shift and 4 hours of training for Swing shift. Training shall occur at the Project site after completion of the Fire Alarm System installation. Training sessions shall be coordinated with Owner's Representative.

END OF SECTION 28 3111

SECTION 32 17 26

TACTILE WARNING SURFACING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes:
   1. Surface-applied detectable warning tiles.

B. Related Requirements:

   1. Section 32 13 13 "Concrete Paving" for concrete walkways serving as substrates for tactile warning surfacing.
   2. Section 32 14 00 "Unit Paving" for unit paving installations incorporating detectable warning unit pavers specified in this Section.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples for Verification: For each type of tactile warning surface, in manufacturer's standard sizes unless otherwise indicated, showing edge condition, truncated-dome pattern, texture, color, and cross section; with fasteners and anchors.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For tactile warning surfacing, to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.

   1. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 PROJECT CONDITIONS

A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of tactile warning surfaces that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Deterioration of finishes beyond normal weathering and wear.
b. Separation or delamination of materials and components.

2. Warranty Period: 5 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 TACTILE WARNING SURFACING, GENERAL

A. Accessibility Requirements: Comply with applicable provisions in California Building Code (CBC) for tactile warning surfaces.

1. For tactile warning surfaces composed of multiple units, provide units that when installed provide consistent side-to-side and end-to-end dome spacing that complies with requirements.

B. Source Limitations: Obtain each type of tactile warning surfacing from single source with resources to provide materials and products of consistent quality in appearance and physical properties.

2.2 DETECTABLE WARNING TILES

A. Surface-Applied Detectable Warning Metal Tiles: Accessible truncated-dome detectable warning metal tiles or plates configured for fastening to surface of existing concrete walkway surfaces, with slip-resistant surface treatment on domes, field of tile, and beveled outside edges.

1. Basis-Of-Design Product: Tactile warning surfacing is based on Advantage Tactile Systems; Stainless Steel Surface Applied Detectable/Tactile Warning Surface Tile. Subject to compliance with requirements, provide the basis-of-design product or comparable product acceptable to
2. Material: Stainless-Steel Plate and Sheet: ASTM A 240/A 240M or ASTM A 666, - Type 304
3. Finish and Color:

a. Manufacturer's standard powder coat, [safety yellow] [red brick] [black] [gray] [color as selected by Architect from manufacturer's full line.
b. Mill finish.

4. Shapes and Sizes:

a. Rectangular panel, sizes as indicated.

5. Dome Spacing and Configuration: Manufacturer's standard compliant spacing, in manufacturer's standard compliant pattern.
6. Mounting:

    a. Replaceable surface-applied detectable warning tile adhered and fastened to concrete walkway.

2.3 ACCESSORIES

A. Fasteners and Anchors: Manufacturer's standard as required for secure anchorage of tactile warning surfaces, noncorrosive and compatible with each material joined, and complying with the following:

    1. Furnish Type 304 stainless-steel fasteners for exterior use.
    2. Fastener Heads: For nonstructural connections, use flathead or oval countersunk screws and bolts with tamper-resistant heads, colored to match tile.

B. Adhesive: As recommended by manufacturer for adhering tactile warning surfacing unit to pavement.

C. Sealant: As recommended by manufacturer for sealing perimeter of tactile warning surfacing unit.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that pavement is in suitable condition to begin installation according to manufacturer's written instructions. Verify that installation of tactile warning surfacing will comply with accessibility requirements upon completion.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF TACTILE WARNING SURFACING

A. General: Prepare substrate and install tactile warning surfacing according to manufacturer's written instructions unless otherwise indicated.

B. Place tactile warning surfacing units in dimensions and orientation indicated. Comply with location requirements of AASHTO MP 12.

3.3 INSTALLATION OF DETECTABLE WARNING TILES

A. Surface-Applied Detectable Warning Tiles:

    1. Lay out detectable warning tiles as indicated and mark concrete pavement.
    2. Prepare existing paving surface by grinding and cleaning as recommended by manufacturer.
    3. Install anchor devices through face of tiles and into pavement using anchors located as recommended by manufacturer. Set heads of anchors flush with top surface of mat.
    4. Mask perimeter of tiles and adjacent concrete, and apply sealant in continuous bead around perimeter of tile installation.

5. Remove masking, adhesive, excess sealant, and soil from exposed surfaces of detectable warning tiles and surrounding concrete pavement using cleaning agents recommended in writing by manufacturer.
6. Protect installed tiles from traffic until adhesive has set.

3.4 CLEANING AND PROTECTION

A. Remove and replace tactile warning surfacing that is broken or damaged or does not comply with requirements in this Section. Remove in complete sections from joint to joint unless otherwise approved by Architect. Replace using tactile warning surfacing installation methods acceptable to Architect.

B. Protect tactile warning surfacing from damage and maintain free of stains, discoloration, dirt, and other foreign material.

END OF SECTION 32 17 26

1. All steel bars that can be positively identified as to heat number and mill analysis shall have one tensile test bending test for each 10 tons, or fraction thereof, for all #5 bars and larger.
2. All steel bars that cannot be identified shall have one tensile and one bend test made for each 2 1/2 tons, or fraction thereof, of each size and kind of reinforcing steel.
3. Testing procedure shall conform to ASTM A 615.

H. Reinforcement Welding: All shop and field welds of reinforcing steel will be inspected. The Special Welding Inspector will check the materials and equipment, the qualifications and ability of the welder, and details of construction and procedure, as well as the welds themselves. The Inspector may use gamma ray, magneflux, trepanning, ultrasonics, or any other aid to visual inspection which the Inspector may deem necessary to determine the adequacy of the welding.

I. No concrete shall be placed until placement of reinforcement steel has been inspected and approved. Provide 48 hours notice to the Inspector prior to placing concrete.

END OF SECTION

SECTION 033000

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes cast-in-place concrete, including, concrete materials, mixture design, placement procedures, and finishes, for the following:
   1. Retaining Walls and Footings.
   2. Shear Walls
   3. Slabs-on-grade.
   4. Concrete Toppings.
   5. Post-Installed Reinforcing Bars Connections.

B. Related Sections:
   1. Section 031000 “Concrete Forming and Accessories”
   2. Section 032000 “Concrete Reinforcing”

1.3 REFERENCES

A. Abbreviations & Acronyms
   1. ACI – American Concrete Institute
   2. NRMCA – National Ready Mixed Concrete Association

B. Definitions
   1. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash and other pozzolans, ground granulated blast-furnace slag, and silica fume; subject to compliance with requirements.
   2. W/C Ratio: The ratio by weight of water to cementitious materials.

C. Reference Standards
   1. ACI 301-10: Specification for Structural Concrete Buildings.
   2. ACI 117-10: Specification for Tolerances for Concrete Construction and Materials

1.4 ADMINISTRATIVE REQUIREMENTS:

A. Steel and Concrete Preconstruction Coordination Meeting: Conduct coordinate meeting at project site a minimum of 3 weeks prior to submitting any shop drawings or procurement of materials.
   1. Require representatives of each entity directly concerned with steel fabrication and erection and concrete placement to attend, including but not limited to the following:
      a. Construction Manager
      b. Steel Fabricator
      c. Steel Erector
      d. Concrete Contractor
      e. Structural Engineer of Record
      f. Architect of Record
   2. Review and coordinate the following:
      a. Anchor rod installation requirements and tolerances
      b. Method for securing anchor rods against movement during concrete placement

c. Steel Embed Plates
d. Submittal Schedules
e. Critical Path and Long Lead Items
f. Any and all items that require cross-trade coordination

B. Preinstallation Meeting: Conduct meeting at project site
1. Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with cast-in-place concrete to attend, including the following:
a. Construction Manager
b. Independent testing agency responsible for concrete design mixtures
c. Ready-mix concrete manufacturer
d. Concrete contractor
e. Special concrete finish contractor
f. Structural Engineer of Record
g. Architect of Record
2. Review the following:
a. Special inspection and testing and inspecting agency procedures for field quality control.
b. Concrete finishes and finishing.
c. Cold- and hot-weather concreting procedures.
d. Curing procedures.
e. Construction contraction and isolation joints.
f. Forms and form removal limitations.
g. Shoring and re-shoring procedures.
h. Vapor-retarder installation.
i. Anchor rod and anchorage device installation tolerances.
j. Steel reinforcement installation.
k. Floor and slab flatness and levelness measurement.
l. Concrete repair procedures.
m. Concrete protection.

1.5 ACTION SUBMITTALS

A. Submit in accordance with Division 01 Section "Administrative Requirements."

B. Design Mixtures: For each concrete mixture. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
1. Submit proposed mix designs at least 15 days in advance of placing operations for each concrete mixture. The submitted mix design shall include the following:
a. Supporting strength test data not more than 12 months old. At the Engineer's request, reports from the independent testing agencies may be required to document the test data. Reports from the independent testing agencies will be required if fly ash is used in the design mix.
b. Statistical analysis in compliance with ACI 301.
c. Gradation of fine and coarse aggregates not more than 90 days old (ASTM C 33). No substitution of aggregate type or size from those submitted will be permitted.
d. Proportions of all ingredients, including all admixtures added either at time of batching or at job site. Aggregate weights shall be based upon saturated surface dry conditions.
e. Water/cement ratio.
f. Slump (ASTM C 143): When high range water-reducing admixtures are used, slump before and after addition of admixture are required.
g. Air content of freshly mixed concrete (ASTM C 231).
h. Material Certificates for the following:
1) Cementitious Materials
2) Admixtures
i. Certification that all ingredients in each mix design are compatible

j. Locations or intended use of each mix design.
k. Source of all materials.
l. Indicate amounts of mixing water to be withheld for later addition at Project site.

C. Embedded Item Placement Drawings: Drawings indicating the location and type of plates, anchorages, or other items to be embedded in the finished concrete surfaces. Include wall elevations, slab plans, and details required to locate and install embeds.

D. Samples: For waterstops and vapor retarder.

E. Construction Joint Layout: Indicate proposed construction joints required to construct the structure.
1. Location of construction joints is subject to approval of the Architect.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, manufacturer, and testing agency.

B. Welding certificates.

C. Material Certificates: For each of the following, signed by manufacturers:
1. Form materials and form-release agents.
2. Steel reinforcement and accessories.
3. Waterstops.
4. Curing compounds.
5. Floor and slab treatments.
6. Bonding agents.
7. Adhesives.
8. Semirigid joint filler.
9. Joint-filler strips.
10. Repair materials.

D. Material Test Reports: For the following, from a qualified testing agency, indicating compliance with requirements:
1. Aggregates. Include service record data indicating absence of deleterious expansion of concrete due to alkali aggregate reactivity.

E. Written curing procedure, including curing procedures for hot- and cold-weather placement.

F. Floor surface flatness and levelness measurements indicating compliance with specified tolerances.

G. Field quality-control reports.

H. Minutes of preinstallation conference.

1.7 QUALITY ASSURANCE

A. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:
1. ACI 301-10, "Specifications for Structural Concrete for Buildings"
2. ACI 117-10, "Specification for Tolerances for Concrete Construction and Materials"

B. CRSI Publications: Comply with the following, unless more stringent provisions are indicated:
1. Manual of Standard Practice
2. Documents 63 and 65.

C. Qualifications

1. Installer Qualifications: A qualified installer who employs on Project personnel qualified as ACI-certified Flatwork Technician and Finisher and a supervisor who is an ACI-certified Concrete Flatwork Technician.
2. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.
    a. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."
3. Testing Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.
    a. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.
    b. Personnel performing laboratory tests shall be ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician - Grade I. Testing Agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician - Grade II.

D. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from single source, and obtain admixtures from single source from single manufacturer.

E. Coordinate chemical and adhesion compatibility of curing compounds used for curing concrete with coatings, stains, paints, liquid flashings, sealers, waterproofing membranes, joint sealants and other materials that penetrate, adhere to or otherwise come into contact with concrete surfaces that are specified in other sections.

F. Batch Tickets: Provide batch tickets for review by inspector for each truckload of concrete used in the work, indicating project identification name and number, date, mix type, mix time, quantity, and amount of cement and water introduced.

G. Concrete Finishing and Curing:
1. Obtain each type, composition, and variety of liquid membrane-forming curing compound used for the Project from the same manufacturer.
2. Products from more than one approved manufacturer may be used for different applications, however all products for like applications shall be by the same manufacturer.
3. Liquid membrane curing compound manufacturer qualifications: Obtain materials only from a manufacturer that will send an experienced technical field representative to the Project site before the start of work to verify existing conditions, and during the execution of work to perform manufacturer's field services.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store materials in accordance with ACI 301. Admixtures which have been in storage at the project site for longer than six months or which have been subjected to freezing shall not be used, unless retested and proven to meet the specified requirements.

B. Waterstops: Store waterstops under cover to protect from moisture, sunlight, dirt, oil, and other contaminants.

1.9 FIELD CONDITIONS

A. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

When average high and low temperature is expected to fall below 40 deg F for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301.

1. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
2. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.

B. Hot-Weather Placement: Comply with ACI 301 and as follows:
   1. Maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
   2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.
   2. Products: Subject to compliance with requirements, provide one of the products specified.
   3. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
   4. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source, throughout Project:
   1. Portland Cement: ASTM C 150, Type II Supplement with the following:
      a. Fly Ash: ASTM C 618, Class C.
      b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.
      c. Silica Fume: ASTM C 1240, amorphous silica.

B. Normal-Weight Aggregates: ASTM C 33, coarse aggregate, graded. Provide aggregates from a single source.
   1. Unless maximum aggregate size is listed specifically under "Project Mix Requirements," the maximum aggregate size shall not exceed:
      a. Three-fourths of the minimum clear spacing between reinforcing bars.
      b. One-fifth of the narrowest dimension between the sides of the forms.
      c. One-third of the thickness of the slabs or toppings.
   2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

C. Water: ASTM C 94/C 94M and potable.

2.3 ADMIXTURES

A. General
   1. Admixtures certified by manufacturer to contain not more than 0.05 percent water-soluble chloride ions by mass of cementitious material. Do not use admixtures containing calcium chloride or thiocyanate.

2. Where more than one admixture is used in the mix, furnish manufacturer's certification to the Architect that the admixtures to be used are compatible in combination with the cement and aggregates.
3. Accelerating admixtures shall not be used.

B. Air-Entraining Admixture: ASTM C 260.

C. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Retarding Admixture: ASTM C 494/C 494M, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

D. Set-Accelerating Corrosion-Inhibiting Admixture: Commercially formulated, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete and complying with ASTM C494/C494M, Type C.
1. Products:
   a. Axim Italcementi Group, Inc.; CATEXOL CN-CI.
   b. BASF Construction Chemicals – Building Systems; Rheocrete CNI.
   c. Euclid Chemical Company (The); Eucon, CIA.
   d. Grace Construction Products, W.R. Grace & Co.; DCI.
   e. Sika Corporation; Sika CNI.

E. Non-Set-Accelerating Corrosion-Inhibiting Admixture: Commercially formulated, non-set-accelerating, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete.
1. Products:
   a. BASF Construction Chemicals – Building Systems; Rheocrete 222+.
   b. Cortec Corporation; MCI [2000] [2005NS].
   c. Grace Construction Products, W.R. Grace & Co.; DCI-S.
   d. Sika Corporation; FerroGard-901.

2.4 WATERSTOPS

A. Flexible Rubber Waterstops: CE CRD-C 513 for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes.
1. Profile: As indicated.
2. Dimensions: 6 inches by 3/8 inch thick; nontapered.

B. Self-Expanding Rubber Strip Waterstops: Manufactured rectangular or trapezoidal strip, bentonite-free hydrophilic polymer modified chloroprene rubber, for adhesive bonding to concrete, 3/8 by 3/4 inch.

2.5 VAPOR RETARDERS

A. Sheet Vapor Retarder: ASTM E 1745, Class A. Include manufacturer's recommended adhesive or pressure-sensitive
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Fortifiber Building Systems Group; Moistop Ultra 15
   b. Meadows, W.R., Inc; Perminator 15 mil.
   c. Raven Industries Inc.; Vapor Block 15.
   d. Reef Industries, Inc; Griffolyn 15 Green

e. Stego Industries, LLC; Stego Wrap 15 mil Class A.

2.6 LIQUID FLOOR TREATMENTS

A. Refer to section 033562 – Burnished Concrete Floor Finish

2.7 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) when dry.

B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

C. Water: Potable.

2.8 RELATED MATERIALS

A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber

B. Semirigid Joint Filler: Two-component, semirigid, 100 percent solids, epoxy resin with a Type A shore durometer hardness of 80 per ASTM D 2240.

C. Bonding Agent: ASTM C 1059/C 1059M, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

D. Epoxy Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to suit requirements, and as follows:
1. Types IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

2.9 REPAIR MATERIALS

A. Repair Underlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch (3.2 mm) and that can be feathered at edges to match adjacent floor elevations.
1. Cement Binder: ASTM C 150, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
2. Primer: Product of underlayment manufacturer recommended for substrate, conditions, and application.
3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch (3.2 to 6 mm) or coarse sand as recommended by underlayment manufacturer.
4. Compressive Strength: Not less than 4100 psi at 28 days when tested according to ASTM C 109/C 109M.

B. Repair Overlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/4 inch (6.4 mm) and that can be filled in over a scarified surface to match adjacent floor elevations.
1. Cement Binder: ASTM C 150, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
2. Primer: Product of topping manufacturer recommended for substrate, conditions, and application.
3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch (3.2 to 6 mm) or coarse sand as recommended by topping manufacturer.

4. Compressive Strength: Not less than 5000 psi (34.5 MPa) at 28 days when tested according to ASTM C 109/C 109M.

2.10 CONCRETE MIXTURES, GENERAL

A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.
   1. Use a qualified independent testing agency for preparing and reporting proposed mixture designs based on laboratory trial mixtures.

B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:
   1. Fly Ash: 25 percent.
   2. Combined Fly Ash and Pozzolan: 25 percent.
   3. Ground Granulated Blast-Furnace Slag: 50 percent.
   4. Combined Fly Ash or Pozzolan and Ground Granulated Blast-Furnace Slag: 50 percent portland cement minimum, with fly ash or pozzolan not exceeding 25 percent.
   5. Silica Fume: 10 percent.
   6. Combined Fly Ash, Pozzolans, and Silica Fume: 35 percent with fly ash or pozzolans not exceeding 25 percent and silica fume not exceeding 10 percent.
   7. Combined Fly Ash or Pozzolans, Ground Granulated Blast-Furnace Slag, and Silica Fume: 50 percent with fly ash or pozzolans not exceeding 25 percent and silica fume not exceeding 10 percent.

C. Limit water-soluble, chloride-ion content in hardened concrete to 0.06 percent by weight of cement.

D. Slump: 4 inches plus or minus 1 inch

E. Admixtures: Use admixtures according to manufacturer's written instructions.
   1. Use water-reducing high-range water-reducing or plasticizing admixture in concrete, as required, for placement and workability.
   2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
   3. Use water-reducing admixture in pumped concrete, concrete for heavy-use industrial slabs and parking structure slabs, concrete required to be watertight, and concrete with a water-cementitious materials ratio below 0.50.
   4. Use corrosion-inhibiting admixture in concrete mixtures where indicated.

2.11 CONCRETE MIXTURES FOR BUILDING ELEMENTS

A. Concrete mix design shall comply with the requirements of the structural drawings.

2.12 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M and furnish batch ticket information.
   1. When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.1 EMBEDDED ITEMS

A. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   1. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC 303, "Code of Standard Practice for Steel Buildings and Bridges."
   2. Install connection plates, angles, or other embedded items flush with concrete surface and at accurate locations per the approved embedded item placement drawings required by Part 1, "Submittals," section.

3.2 JOINTS

A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.

B. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.
   1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of strip placements of floors and slabs.
   2. Form keyed joints as indicated. Embed keys at least 1-1/2 inches (38 mm) into concrete.
   3. Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
   4. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
   5. Space vertical joints in walls at maximum of 30-foot spacing. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
   6. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
   7. Use epoxy-bonding adhesive at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
   8. Provide roughened surfaces at joints where shown on the drawings. Roughen to a full amplitude of approximately 1/4-inch.

C. Contraction Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of concrete thickness as follows:
   1. V-Grooved Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. V-Groove top with 1/8-inch wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.

D. Isolation Joints in Slabs-on-Grade: After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.
   1. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface unless otherwise indicated.
   2. Terminate full-width joint-filler strips not less than 1/2 inch (13 mm) or more than 1 inch (25 mm) below finished concrete surface where joint sealants, specified in Section 079200 "Joint Sealants," are indicated.
   3. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.

E. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt coat one-half of dowel length to prevent concrete bonding to one side of joint.

3.3 WATERSTOP INSTALLATION

A. Flexible Waterstops: Install in construction joints and at other joints indicated to form a continuous diaphragm. Install in longest lengths practicable. Support and protect exposed waterstops during progress of the Work. Field fabricate joints in waterstops according to manufacturer's written instructions.

3.4 VAPOR RETARDERS

A. Sheet Vapor Retarders: Place, protect, and repair sheet vapor retarder according to ASTM E 1643 and manufacturer's written instructions.
   1. Place vapor retarder directly on top of granular course
   2. Lap joints 6 inches and seal with manufacturer's recommended tape.

3.5 CONCRETE PLACEMENT

A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.

B. Do not add water to concrete during delivery, at Project site, or during placement unless approved by Architect.

C. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301.
   1. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.

D. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation.
   1. Deposit concrete in horizontal layers of depth to not exceed formwork design pressures and in a manner to avoid inclined construction joints.
   2. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.
   3. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches (150 mm) into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.

E. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.
   1. Consolidate concrete during placement operations so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
   2. Maintain reinforcement in position on chairs during concrete placement.
   3. Screed slab surfaces with a straightedge and strike off to correct elevations.
   4. Slope surfaces uniformly to drains where required.
   5. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.

3.6 FINISHING FORMED SURFACES

A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defects repaired and patched. Remove fins and other projections that exceed specified limits on formed-surface irregularities.
   1. Apply to concrete surfaces not exposed to public view.

B. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defects. Remove fins and other projections that exceed specified limits on formed-surface irregularities.
   1. Apply to concrete surfaces exposed to public view or to receive a rubbed finish.

C. Rubbed Finish: Apply the following to smooth-formed finished as-cast concrete where indicated:
   1. Smooth-Rubbed Finish: Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.
   2. Grout-Cleaned Finish: Wet concrete surfaces and apply grout of a consistency of thick paint to coat surfaces and fill small holes. Mix one part portland cement to one and one-half parts fine sand with a 1:1 mixture of bonding admixture and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Scrub grout into voids and remove excess grout. When grout whitens, rub surface with clean burlap and keep surface damp by fog spray for at least 36 hours.
   3. Cork-Floated Finish: Wet concrete surfaces and apply a stiff grout. Mix one part portland cement and one part fine sand with a 1:1 mixture of bonding agent and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Compress grout into voids by grinding surface. In a swirling motion, finish surface with a cork float.

D. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces unless otherwise indicated.

3.7 FINISHING FLOORS AND SLABS

A. General: Comply with ACI 302.1R recommendations for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.

B. Scratch Finish: While still plastic, texture concrete surface that has been screeded and bull-floated or darbied. Use stiff brushes, brooms, or rakes to produce a profile amplitude of 1/4 inch (6 mm) in one direction.
   1. Apply scratch finish to receive mortar setting beds for bonded cementitious floor finishes.

C. Float Finish: Consolidate surface with power-driven floats or by hand floating if area is small or inaccessible to power driven floats. Restraighten, cut down high spots, and fill low spots. Repeat float passes and restraightening until surface is left with a uniform, smooth, granular texture.
   1. Apply float finish to surfaces to receive trowel finish.

D. Trowel Finish: After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel. Continue troweling passes and restraighten until surface is free of trowel marks and uniform in texture and appearance. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.
   1. Apply a trowel finish to surfaces indicated to be covered with resilient flooring, carpet, ceramic or quarry tile set over a cleavage membrane, paint, or another thin-film-finish coating system.

E. Broom Finish: Apply a broom finish to exterior concrete, steps, ramps, and elsewhere as indicated.

1. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic rout. Coordinate required final finish with Architect before application.

3.8 MISCELLANEOUS CONCRETE ITEMS

A. Filling In: Fill in holes and openings left in concrete structures after work of other trades is in place unless otherwise indicated. Mix, place, and cure concrete, as specified, to blend with in-place construction. Provide other miscellaneous concrete filling indicated or required to complete the Work.

B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.

3.9 CONCRETE PROTECTING AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and ACI 301 for hot-weather protection during curing.

B. Evaporation Retarder: Apply evaporation retarder to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

C. Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing for the remainder of the curing period.

D. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces.

E. Cure concrete according to ACI 308.1, by one or a combination of the following methods:
   1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
      a. Water.
      b. Continuous water-fog spray.
      c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch (300-mm) lap over adjacent absorptive covers.
   2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm), and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
      a. Moisture cure or use moisture-retaining covers to cure concrete surface to be burnished.
      b. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive floor coverings.
      c. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive penetrating liquid floor treatments.

3.10 JOINT FILLING

A. Prepare, clean, and install joint filler according to manufacturer's written instructions.
   1. Defer joint filling until concrete has aged at least [one] [six] month(s). Do not fill joints until construction traffic has permanently ceased.

B. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joint clean and dry.

C. Install semirigid joint filler full depth in saw-cut joints and at least 2 inches (50 mm) deep in formed joints. Overfill joint and trim joint filler flush with top of joint after hardening.

3.11 CONCRETE SURFACE REPAIRS

A. Defective Concrete: Repair and patch defective areas when approved by Architect. Remove and replace concrete that cannot be repaired and patched to Architect's approval.

B. Patching Mortar: Mix dry-pack patching mortar, consisting of one part portland cement to two and one-half parts fine aggregate passing a No. 16 (1.18-mm) sieve, using only enough water for handling and placing.

C. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.
1. Immediately after form removal, cut out honeycombs, rock pockets, and voids more than 1/2 inch (13 mm) in any dimension to solid concrete. Limit cut depth to 3/4 inch (19 mm). Make edges of cuts perpendicular to concrete surface. Clean, dampen with water, and brush-coat holes and voids with bonding agent. Fill and compact with patching mortar before bonding agent has dried. Fill form-tie voids with patching mortar or cone plugs secured in place with bonding agent.
2. Repair defects on surfaces exposed to view by blending white portland cement and standard portland cement so that, when dry, patching mortar will match surrounding color. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike off slightly higher than surrounding surface.
3. Repair defects on concealed formed surfaces that affect concrete's durability and structural performance as determined by Architect.

D. Repairing Unformed Surfaces: Test unformed surfaces, such as floors and slabs, for finish and verify surface tolerances specified for each surface. Correct low and high areas. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.
1. Repair finished surfaces containing defects. Surface defects include spalls, popouts, honeycombs, rock pockets, crazing and cracks in excess of 0.01 inch (0.25 mm) wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width, and other objectionable conditions.
2. After concrete has cured at least 14 days, correct high areas by grinding.
3. Correct localized low areas during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar. Finish repaired areas to blend into adjacent concrete.
4. Correct other low areas scheduled to receive floor coverings with a repair underlayment. Prepare, mix, and apply repair underlayment and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface. Feather edges to match adjacent floor elevations.
5. Correct other low areas scheduled to remain exposed with a repair topping. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch (6 mm) to match adjacent floor elevations. Prepare, mix, and apply repair topping and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
6. Repair defective areas, except random cracks and single holes 1 inch (25 mm) or less in diameter, by cutting out and replacing with fresh concrete. Remove defective areas with clean, square cuts and expose steel reinforcement with at least a 3/4-inch (19-mm) clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials and mixture as original concrete except

without coarse aggregate. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.

7. Repair random cracks and single holes 1 inch (25 mm) or less in diameter with patching mortar. Groove top of cracks and cut out holes to sound concrete and clean off dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding agent. Place patching mortar before bonding agent has dried. Compact patching mortar and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.

E. Perform structural repairs of concrete, subject to Architect's approval, using epoxy adhesive and patching mortar.

F. Repair materials and installation not specified above may be used, subject to Architect's approval.

3.12 FIELD QUALITY CONTROL

A. Testing and Inspecting: Owner will engage a special inspector and qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. All concrete work is subject to special inspection and testing. This section specifies the minimum testing and inspection required. Additional testing and inspection may be required by the Testing Agency, the Owner, or the Engineer/Architect if project conditions warrant.

C. Special Inspector Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, and qualified according to ASTM C 1077 and ASTM E 329 to conduct the testing indicated, as documented according to ASTM E 548.

D. Tests and inspections shall be in conformance with Division 1, Section "Quality Requirements".

E. Independent Testing Agency shall check batch tickets for compliance with required mix design(s).

F. Continuous Field Inspection: The Independent Testing Agency shall be present at all times during the placing of structural reinforced concrete. Work shall not proceed until all inspections are completed. Prior to placing concrete, the Inspector shall inspect:
   1. Accuracy, configuration, and cleanliness of all formwork
   2. Quantity, cleanliness, and placement of all reinforcing steel.
   3. Testing Agency need not be present during entire reinforcing steel placing operations, provided he has inspected for conformance with the approved placement drawings prior to closing of forms or the delivery of concrete to the job site.

G. Inspections:
   1. Headed bolts and studs.
   2. Verification of use of required design mixture.
   3. Concrete placement, including conveying and depositing.
   4. Curing procedures and maintenance of curing temperature.

H. No concrete shall be placed until placement of reinforcement steel has been inspected and approved. Provide 48 hours notice to the Inspector prior to placing concrete.

I. Concrete Sampling: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:
   1. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. or fraction thereof of each concrete mixture placed each day.
      a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
3. Air Content: ASTM C 231, pressure method, for normal-weight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F and below and when 80 deg F and above, and one test for each composite sample.
5. Compression Test Specimens: ASTM C 31/C 31M.
   a. Cast and laboratory cure two sets of two standard cylinder specimens for each composite sample.
   b. At the Contractor's expense and direction, cast and field-cure standard cylinder specimens as may be required for construction. Number of specimens and testing age shall be determined by the Contractor based on construction sequence requirements.
6. Compressive-Strength Tests: ASTM C 39/C 39M; test one set of two laboratory-cured specimens at 7 days and one set of two specimens at 28 days.
7. Test field-cured specimens at the Contractor's direction.
8. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
9. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.
10. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mi xture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
11. Linear Shrinkage Tests: Test for linear shrinkage in accordance with ASTM C 157 (air storage method for 28 days. Take a minimum of 3 test samples from each mix, at the Project Representative's direction, of concrete for elevated slabs and beams. Take samples at truck and discharge end of pumped mix. Consistency of the concrete must not be altered after test samples have been taken.
12. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.
13. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42/C 42M or by other methods as directed by Architect.
14. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
15. Correct deficiencies in the Work that test reports and inspections indicate does not comply with the Contract Documents.

J. Measure floor and slab flatness and levelness according to ASTM E 1155 within 8 hours of finishing.
   1. Finish surfaces to the following tolerances, for a randomly trafficked floor surface:
      a. Specified overall values of flatness, F(F) 35; and of levelness, F(L) 25; with minimum local values of flatness, F(F) 24; and of levelness, F(L) 17; for slabs-on-grade.
      b. Specified overall values of flatness, F(F) 30; with minimum local values of flatness, F(F) 24; for suspended slabs.
      c. Specified overall values of flatness, F(F) 40; and of levelness, F(L) 25; with minimum local values of flatness, F(F) 24; and of levelness, F(L) 17; for concrete receiving polished concrete finish.

3.13 PROTECTION OF LIQUID FLOOR TREATMENTS

A. Protect liquid floor treatment from damage and wear during the remainder of construction period. Use protective methods and materials, including temporary covering, recommended in writing by liquid floor treatments installer.

END OF SECTION

SECTION 03 3301

CONCRETE FINISHING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes cast-in-place architectural concrete, including form facings, reinforcement and accessories, concrete materials, concrete mixture design, placement procedures, and finishes.

1. Requirements in Section 033000 "Cast-in-Place Concrete" apply to architectural concrete.

B. Related Requirements:

1. Section 03 30 00 "Cast-in-Place Concrete" for concrete not designated as architectural concrete.

1.3 DEFINITIONS

A. Cast-in-Place Architectural Concrete: Formed concrete that is exposed to view on surfaces of completed structure or building and that requires special concrete materials, formwork, placement, or finishes to obtain specified architectural appearance.

B. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash, slag cement, other pozzolans, and silica fume; materials subject to compliance with requirements.

C. Design Reference Sample: Sample designated by Architect in the Contract Documents that reflects acceptable surface quality and appearance of cast-in-place architectural concrete.

D. Reveal: Projection of coarse aggregate from matrix or mortar after completion of exposure operations.

E. W/C Ratio: The ratio by weight of water to cementitious materials.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Require representatives of each entity directly concerned with cast-in-place architectural concrete to attend, including the following:

   a. Contractor's superintendent.
   b. Independent testing agency responsible for concrete design mixtures.
   c. Ready-mix concrete manufacturer.

d. Cast-in-place architectural concrete Subcontractor.

2. Review concrete finishes and finishing, cold- and hot-weather concreting procedures, curing procedures, construction joints, forms and form-removal limitations, reinforcement accessory installation, concrete repair procedures, and protection of cast-in-place architectural concrete.
3. Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
2. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each regional material.

C. Design Mixtures: For each concrete mixture. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1. Indicate amounts of mixing water to be withheld for later addition at Project site.

D. Formwork Shop Drawings: Show formwork construction, including form-facing joints, rustications, construction and contraction joints, form joint-sealant details, form tie locations and patterns, inserts and embedments, cutouts, cleanout panels, and other items that visually affect cast-in-place architectural concrete.

E. Placement Schedule: Submit concrete placement schedule before start of placement operations. Include locations of all joints, including construction joints.

F. Samples: For each of the following materials:

1. Form-facing panels.
2. Form ties.
3. Form liners.
4. Exposed aggregates.
5. Coarse- and fine-aggregate gradations.
6. Chamfers and rustications.

G. Samples for Verification: Architectural concrete Samples, cast vertically, approximately 18 by 18 by 2 inches (450 by 450 by 50 mm), of finishes, colors, and textures to match design reference sample. Include Sample sets showing the full range of variations expected in these characteristics.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer testing agency.

B. Material Certificates: For each of the following, signed by manufacturers:

1. Cementitious materials.

2. Admixtures.
3. Form materials and form-release agents.
4. Repair materials.

C. Material Test Reports: For the following, by a qualified testing agency:

1. Aggregates. Include service-record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.

1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

1. Manufacturer certified according to NRMCA's "NRMCA Quality Control Manual - Section 3, Certification of Ready Mixed Concrete Production Facilities."

B. Testing Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.

1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-01 or an equivalent certification program.
2. Personnel performing laboratory tests shall be an ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician - Grade I. Testing agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician - Grade II.

C. Field Sample Panels: After approval of verification sample and before casting architectural concrete, produce field sample panels to demonstrate the approved range of selections made under Sample submittals. Produce a minimum of three sets of full-scale panels, cast vertically, approximately 48 by 48 by 6 inches (1200 by 1200 by 150 mm) minimum, to demonstrate the expected range of finish, color, and texture variations.

1. Locate panels as indicated or, if not indicated, as directed by Architect.
2. Demonstrate methods of curing, aggregate exposure, sealers, and coatings, as applicable.
3. In presence of Architect, damage part of an exposed-face surface for each finish, color, and texture, and demonstrate materials and techniques proposed for repair of tie holes and surface blemishes to match adjacent undamaged surfaces.
4. Maintain field sample panels during construction in an undisturbed condition as a standard for judging the completed Work.
5. Demolish and remove field sample panels when directed.

D. Mockups: Before casting architectural concrete, build mockups to verify selections made under Sample submittals and to demonstrate typical joints, surface finish, texture, tolerances, and standard of workmanship. Build mockups to comply with the following requirements, using materials indicated for the completed Work:

1. Build mockups in the location and of the size indicated or, if not indicated, as directed by Architect.
2. Build mockups of typical exterior wall of cast-in-place architectural concrete as shown on Drawings.
3. Demonstrate curing, cleaning, and protecting of cast-in-place architectural concrete, finishes, and contraction joints, as applicable.

4. In presence of Architect, damage part of the exposed-face surface for each finish, color, and texture, and demonstrate materials and techniques proposed for repair of tie holes and surface blemishes to match adjacent undamaged surfaces.
5. Obtain Architect's approval of mockups before casting architectural concrete.
6. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing on concrete mixtures.

1.9 FIELD CONDITIONS

A. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

1. When average high and low temperature is expected to fall below 40 deg F (4.4 deg C) for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301 (ACI 301M).
2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents.
4. Do not use chemical accelerators unless otherwise specified and approved in design mixtures.

B. Hot-Weather Placement: Comply with ACI 301 (ACI 301M) and as follows:

1. Maintain concrete temperature below 90 deg F (32 deg C) at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

A. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:

1. ACI 301 (ACI 301M).
2. ACI 303.1.

2.2 FORM-FACING MATERIALS

A. General: Comply with Section 03 30 00 "Cast-in-Place Concrete" for formwork and other form-facing material requirements.

B. Source Limitations: Obtain each type form-facing material from single source from single manufacturer.

C. Form-Facing Panels for As-Cast Exposed-Aggregate Finishes: Steel- and glass-fiber-reinforced plastic, or other approved nonabsorptive panel materials that provide continuous, true, and smooth architectural concrete surfaces. Furnish in largest practicable sizes to minimize number of joints.

D. Form-Facing Panels for As-Cast Exposed-Aggregate Finishes: Exterior-grade plywood panels, nonabsorptive, that will provide continuous, true, and smooth architectural concrete surfaces, high-density overlay, Class 1, or better, complying with DOC PS 1.

E. Forms for Cylindrical Columns, Pedestals, and Supports: Metal, glass-fiber-reinforced plastic, paper, or fiber tubes that provide surfaces with gradual or abrupt irregularities not exceeding specified formwork surface class. Provide units with sufficient wall thickness to resist plastic concrete loads without detrimental deformation.

F. Pan-Type Forms: Glass-fiber-reinforced plastic or formed steel, stiffened to resist plastic concrete loads without detrimental deformation.

G. Form Liners: Units of face design, texture, arrangement, and configuration to match design reference sample. Furnish with manufacturer's recommended liquid-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent surface treatments of concrete.

H. Rustication Strips: Metal or rigid plastic, or with sides beveled and back kerfed; nonstaining; in longest practicable lengths.

I. Chamfer Strips: Metal, rigid plastic, elastomeric rubber, or dressed wood, 3/4 by 3/4 inch (19 by 19 mm), minimum; nonstaining; in longest practicable lengths.

J. Form Joint Tape: Compressible foam tape; pressure sensitive; AAMA 800; minimum 1/4 inch (6 mm) thick.

K. Form Joint Sealant: Elastomeric sealant complying with ASTM C 920, Type M or Type S, Grade NS, that adheres to form joint substrates.

L. Sealer: Penetrating, clear, polyurethane wood form sealer formulated to reduce absorption of bleed water and prevent migration of set-retarding chemicals from wood.

M. Form-Release Agent: Commercially formulated, colorless form-release agent that will not bond with, stain, or adversely affect architectural concrete surfaces and will not impair subsequent treatments of those surfaces.

    1. Formulate form-release agent with rust inhibitor for steel form-facing materials.

N. Surface Retarder: Chemical liquid set retarder, for application on form-facing materials, capable of temporarily delaying final hardening of newly placed concrete surface to depth of reveal specified.

O. Form Ties: Factory-fabricated, glass-fiber-reinforced plastic internally disconnecting or removable ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.

    1. Furnish ties with tapered tie cone spreaders that, when removed, will leave holes 3/4 inch (19 mm) in diameter on concrete surface.
    2. Furnish internally disconnecting ties that will leave no metal closer than 1-1/2 inches (38 mm) from the architectural concrete surface.
    3. Furnish glass-fiber-reinforced plastic ties, not less than 1/2 inch (13 mm) in diameter, of color selected by Architect from manufacturer's full range.

4. Furnish ties with integral water-barrier plates to walls indicated to receive dampproofing or waterproofing.

2.3 STEEL REINFORCEMENT AND ACCESSORIES

A. General: Comply with Section 03 30 00 "Cast-in-Place Concrete" for steel reinforcement and other requirements for reinforcement accessories.

B. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

C. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded-wire fabric in place; manufactured according to CRSI's "Manual of Standard Practice."

   1. Where legs of wire bar supports contact forms, use gray, all-plastic CRSI Class 1, gray, plastic-protected or CRSI Class 2, stainless-steel bar supports.

2.4 CONCRETE MATERIALS

A. Regional Materials: Concrete shall be manufactured within 500 miles (800 km) of Project site from aggregates and cementitious materials that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles (800 km) of Project site.

B. Regional Materials: Concrete shall be manufactured within 500 miles (800 km) of Project site.

C. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from single source, and obtain admixtures from single source from single manufacturer.

D. Cementitious Materials:

   1. Portland Cement: ASTM C 150/C 150M, Type I, gray.
   2. Fly Ash: ASTM C 618, Class F.
   3. Slag Cement: ASTM C 989/C 989M, Grade 100 or Grade 120.
   4. Silica Fume: ASTM C 1240 amorphous silica.

E. Normal-Weight Aggregates: ASTM C 33/C 33M, Class 5S coarse aggregate or better, graded. Provide aggregates from single source with documented service-record data of at least 10 years' satisfactory service in similar applications and service conditions using similar aggregates and cementitious materials.

   1. Maximum Coarse-Aggregate Size: 3/8 inch (10 mm).
   2. Gradation: Gap graded.

F. Normal-Weight Fine Aggregate: ASTM C 33/C 33M, manufactured or natural sand, from same source for entire Project.

G. Air-Entraining Admixture: ASTM C 260/C 260M.

H. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures and that does not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Retarding Admixture: ASTM C 494/C 494M, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

I. Color Pigment: ASTM C 979/C 979M, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, nonfading, and resistant to lime and other alkalis.

1. Color: Match Architect's sample.

J. Water: Potable, complying with ASTM C 94/C 94M, except free of wash water from mixer washout operations.

2.5 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) when dry.

B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

C. Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B.

1. For integrally colored concrete, curing compound shall be pigmented type approved by color pigment manufacturer.
2. For concrete indicated to be sealed, curing compound shall be compatible with sealer.

2.6 REPAIR MATERIALS

A. Bonding Agent: ASTM C 1059/C 1059M, Type II, nonredispersible, acrylic emulsion or styrene butadiene.

B. Epoxy Bonding Adhesive: ASTM C 881/C 881M two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to suit requirements.

1. Types IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

2.7 CONCRETE MIXTURES

A. Obtain each color, size, type, and variety of concrete mixture from single manufacturer with resources to provide cast-in-place architectural concrete of consistent quality in appearance and physical properties.

B. Prepare design mixtures for each type and strength of cast-in-place architectural concrete proportioned on basis of laboratory trial mixture or field test data, or both, according to ACI 301 (ACI 301M).

1. Use a qualified independent testing agency for preparing and reporting proposed design mixtures based on laboratory trial mixtures.

C. Cementitious Materials: For cast-in-place architectural concrete exposed to deicers, limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 (ACI 301M) requirements. Use fly ash, pozzolan, slag cement, and silica fume as needed to reduce the total amount of portland cement, which would otherwise be used, by not less than 40 percent.

D. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.

E. Admixtures: Use admixtures according to manufacturer's written instructions.

F. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.

G. Concrete Mixtures:

1. Compressive Strength (28 Days): 4000 psi (27.6 MPa).
2. Maximum W/C Ratio: 0.46.
3. Slump Limit: Refer to Structural Drawings.
4. Air Content: 5-1/2 percent, plus or minus 1.5 percent at point of delivery for 1-1/2-inch (38-mm) nominal maximum aggregate size.
5. Air Content: 6 percent, plus or minus 1.5 percent at point of delivery for 1-inch (25-mm) nominal maximum aggregate size.

2.8 CONCRETE MIXING

A. Ready-Mixed Architectural Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M and furnish batch ticket information.

1. Clean equipment used to mix and deliver cast-in-place architectural concrete to prevent contamination from other concrete.
2. When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.

2.9 EXTERIOR CONCRETE SEALER

A. Where noted on the drawings provide exterior concrete sealer as described below.
1. Provide Pecora Corporation KlereSeal 9100-S, VOC compliant silane penetrating clear sealer, or approved equal.

PART 3 - EXECUTION

3.1 FORMWORK INSTALLATION

A. General: Comply with Section 03 30 00 "Cast-in-Place Concrete" for formwork, embedded items, and shoring and reshoring.

B. Limit deflection of form-facing panels to not exceed ACI 303.1 requirements.

C. In addition to ACI 303.1 limits on form-facing panel deflection, limit cast-in-place architectural concrete surface irregularities, designated by ACI 347 as abrupt or gradual, as follows:

1. Class A, 1/8 inch (3 mm).

D. Construct forms to result in cast-in-place architectural concrete that complies with ACI 117 (ASI 117M).

E. Construct forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast-in-place surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical. Kerf wood rustications, keyways, reglets, recesses, and the like, for easy removal.

1. Seal form joints and penetrations at form ties with form joint tape or form joint sealant to prevent cement paste leakage.
2. Do not use rust-stained steel form-facing material.

F. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.

G. Chamfer exterior corners and edges of cast-in-place architectural concrete.

H. Coat contact surfaces of wood rustications and chamfer strips with sealer before placing reinforcement, anchoring devices, and embedded items.

I. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.

J. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.

K. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

L. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

M. Coat contact surfaces of forms with surface retarder, according to manufacturer's written instructions, before placing reinforcement.

N. Place form liners accurately to provide finished surface texture indicated. Provide solid backing and attach securely to prevent deflection and maintain stability of liners during concreting. Prevent form liners from sagging and stretching in hot weather. Seal joints of form liners and form-liner accessories to prevent mortar leaks. Coat form liner with form-release agent.

3.2 REINFORCEMENT AND INSERT INSTALLATION

A. General: Comply with Section 03 30 00 "Cast-in-Place Concrete" for fabricating and installing steel reinforcement. Securely fasten steel reinforcement and wire ties against shifting during concrete placement.

B. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

3.3 REMOVING AND REUSING FORMS

A. Formwork for sides of beams, walls, columns, and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50 deg F (10 deg C) for 24 hours after placing concrete if concrete is hard enough to not be damaged by form-removal operations and curing and protection operations are maintained.

1. Schedule form removal to maintain surface appearance that matches approved mockups.
2. Cut off and grind glass-fiber-reinforced plastic form ties flush with surface of concrete.

B. Leave formwork for beam soffits, joists, slabs, and other structural elements that support weight of concrete in place until concrete has achieved 28-day design compressive strength. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.

C. Clean and repair surfaces of forms to be reused in the Work. Do not use split, frayed, delaminated, or otherwise damaged form-facing material. Apply new form-release agent.

D. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for cast-in-place architectural concrete surfaces.

3.4 JOINTS

A. Construction Joints: Install construction joints true to line, with faces perpendicular to surface plane of cast-in-place architectural concrete, so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.

1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints unless otherwise indicated.
2. Form keyed joints as indicated. Embed keys at least 1-1/2 inches (38 mm) into concrete. Align construction joint within rustications attached to form-facing material.
3. Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
4. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
5. Space vertical joints in walls as indicated. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
6. Use bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

B. Contraction Joints: Form weakened-plane contraction joints true to line, with faces perpendicular to surface plane of cast-in-place architectural concrete, so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.

3.5 CONCRETE PLACEMENT

A. Before placing concrete, verify that installation of formwork, form-release agent, reinforcement, and embedded items is complete and that required inspections have been performed.

B. Do not add water to concrete during delivery, at Project site, or during placement unless approved by Architect.

C. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301 (ACI 301M).

1. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.

D. Deposit concrete continuously between construction joints. Deposit concrete to avoid segregation.

1. Deposit concrete in horizontal layers of depth to not exceed formwork design pressures and in a manner to avoid inclined construction joints.
2. Consolidate placed concrete with mechanical vibrating equipment according to ACI 303.1.
3. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches (150 mm) into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. Do not permit vibrators to contact forms.

3.6 FINISHES, GENERAL

A. Bagged or Sak Finish: Match Architect's design reference sample, identified and described as indicated, to satisfaction of Architect.

B. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces.

1. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces unless otherwise indicated.

C. Maintain uniformity of special finishes over construction joints unless otherwise indicated.

3.7 AS-CAST FORMED FINISHES

A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defects repaired and patched. Remove fins and other projections exceeding specified limits on formed-surface irregularities.

B. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Remove fins and other projections exceeding specified limits on formed-surface irregularities. Repair and patch tie holes and defects.

C. Rubbed Finish: Apply the following to smooth-form-finished as-cast concrete where indicated:

1. Smooth-Rubbed Finish: Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.
2. Grout-Cleaned Finish: Wet concrete surfaces and apply grout of a consistency of thick paint to coat surfaces and fill small holes. Mix 1 part portland cement to 1-1/2 parts fine sand with a 1:1 mixture of bonding admixture and water. Add white portland cement in amounts determined by trial patches, so color of dry grout matches adjacent surfaces. Scrub grout into voids and remove excess grout. When grout whitens, rub surface with clean burlap and keep surface damp by fog spray for at least 36 hours.
3. Cork-Floated Finish: Wet concrete surfaces and apply a stiff grout. Mix 1 part portland cement and 1 part fine sand with a 1:1 mixture of bonding agent and water. Add white portland cement in

amounts determined by trial patches, so color of dry grout matches adjacent surfaces. Compress grout into voids by grinding surface. In a swirling motion, finish surface with a cork float.

D. Form-Liner Finish: Produce a textured surface free of pockets, streaks, and honeycombs, and of uniform appearance, color, and texture.

3.8 EXPOSED-AGGREGATE FINISHES

A. Scrubbed Finish: After concrete has achieved a compressive strength of from 1000 to 1500 psi (6.9 to 10.3 MPa), apply scrubbed finish. Wet concrete surfaces thoroughly and scrub with stiff fiber or wire brushes, using water freely, until top mortar surface is removed and aggregate is uniformly exposed. Rinse scrubbed surfaces with clean water. Maintain continuity of finish on each surface or area of Work. Remove only enough concrete mortar from surfaces to match design reference sample or mockup.

B. High-Pressure Water-Jet Finish: Perform high-pressure water jetting on concrete that has achieved a minimum compressive strength of 4500 psi (31 MPa). Coordinate with formwork removal to ensure that surfaces to be high-pressure water-jet finished are treated at same age for uniform results.

1. Surface Continuity: Perform high-pressure water-jet finishing in as continuous an operation as possible, maintaining continuity of finish on each surface or area of Work. Maintain required patterns or variances in reveal projection to match design reference sample or mockup.

C. Abrasive-Blast Finish: Perform abrasive blasting after compressive strength of concrete exceeds 2000 psi (13.8 MPa). Coordinate with formwork removal to ensure that surfaces to be abrasive blasted are treated at same age for uniform results.

1. Surface Continuity: Perform abrasive-blast finishing in as continuous an operation as possible, maintaining continuity of finish on each surface or area of Work. Maintain required patterns or variances in depths of blast to match design reference sample or mockup.
2. Abrasive Blasting: Abrasive blast corners and edges of patterns carefully, using backup boards, to maintain uniform corner or edge line. Determine type of nozzle, nozzle pressure, and blasting techniques required to match design reference sample or mockup.
3. Depth of Cut: Use an abrasive grit of proper type and gradation to expose aggregate and surrounding matrix surfaces to match design reference sample or mockup, as follows:

a. Brush: Remove cement matrix to dull surface sheen and expose face of fine aggregate; with no significant reveal.
b. Light: Expose fine aggregate with occasional exposure of coarse aggregate and uniform color; with maximum reveal of 1/16 inch (1.5 mm).
c. Medium: Generally expose coarse aggregate; with slight reveal, a maximum of 1/4 inch (6 mm).
d. Heavy: Expose and reveal coarse aggregate to a maximum projection of one-third its diameter; with reveal range of 1/4 to 1/2 inch (6 to 13 mm).

D. Bushhammer Finish: Allow concrete to cure at least 14 days before starting bushhammer surface finish operations.

1. Surface Continuity: Perform bushhammer finishing in as continuous an operation as possible, maintaining continuity of finish on each surface or area of Work. Maintain required patterns or variances of cut as shown on Drawings or to match design reference sample or mockup.
2. Surface Cut: Maintain required depth of cut and general aggregate exposure. Use power tool with hammer attachments for large, flat surfaces, and use hand hammers for small areas, at corners and edges, and for restricted locations where power tools cannot reach.
3. Remove impressions of formwork and form facings with exception of tie holes.

3.9 CONCRETE PROTECTING AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and with ACI 301 (ACI 301M) for hot-weather protection during curing.

B. Begin curing cast-in-place architectural concrete immediately after removing forms from concrete. Cure according to ACI 308.1, by one or a combination of the following methods that will not mottle, discolor, or stain concrete:

1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:

    a. Water.
    b. Continuous water-fog spray.
    c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch (300-mm) lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm), and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period, using cover material and waterproof tape.
3. Curing Compound: Mist concrete surfaces with water. Apply curing compound uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating, and repair damage during curing period.

3.10 FIELD QUALITY CONTROL

A. General: Comply with field quality-control requirements in Section 03 30 00 "Cast-in-Place Concrete."

3.11 REPAIR, PROTECTION, AND CLEANING

A. Repair and cure damaged finished surfaces of cast-in-place architectural concrete when approved by Architect. Match repairs to color, texture, and uniformity of surrounding surfaces and to repairs on approved mockups.

1. Remove and replace cast-in-place architectural concrete that cannot be repaired and cured to Architect's approval.

B. Protect corners, edges, and surfaces of cast-in-place architectural concrete from damage; use guards and barricades.

C. Protect cast-in-place architectural concrete from staining, laitance, and contamination during remainder of construction period.

D. Clean cast-in-place architectural concrete surfaces after finish treatment to remove stains, markings, dust, and debris.

E. Wash and rinse surfaces according to concrete finish applicator's written instructions. Protect other Work from staining or damage due to cleaning operations.

1. Do not use cleaning materials or processes that could change the appearance of cast-in-place architectural concrete finishes.

END OF SECTION 03 3300

SECTION 033710

SHOTCRETE

PART 1 - GENERAL

1.1 SUMMARY

A. Provisions of Division 01 apply to this section

B. Section Includes:

1. Pneumatically placed concrete.

C. Related Sections:

1. Section 03 2000: Concrete Reinforcement.

2. Section 03 3000: Cast-In-Place Concrete.

1.2 SYSTEM DESCRIPTION

A. Regulatory Requirements: Comply with CBC requirements, such as Section 1910A.

1.3 SUBMITTALS

A. Shop Drawings: Submit Shop Drawings indicating locations to receive shotcrete. Provide details of installation and reinforcement.

B. Product Data: Submit detailed product information identifying types and quality of materials, including admixtures.

C. Submit a mix design of each proposed mix to be provided for the Work. If data from prior experience is not available or applicable, provide and perform specimen testing of proposed mix designs.

1.4 QUALITY ASSURANCE

A. Comply with the following as a minimum requirement:

1. ACI 506.2 - Specification for Materials, Proportioning and Application of Shotcrete.

2. ASTM C 150 - Portland Cement.

3. Perform Work in accordance with ACI 506.2.

4. Testing: Refer to general notes on plans

B. Qualifications of Installer:

C. Mock-ups:

1. Test Panels: Construct a test panel of the thickness and reinforcing that reproduces the thickest and most congested area specified in the structural drawings. The IOR and special inspector will witness the assembly, reinforcing, installation, and disassembly of the test panel. The panel shall be at least 4 feet x 4 feet. After installation, but before the concrete has fully set, the panel shall be disassembled and inspected. The panel shall be free of voids, sags and defects.

2. Application of structural wet mix shotcrete in the finished Work shall not proceed until the test panel had been furnished, disassembled, and inspected by the IOR and special inspector.

1.5 DELIVERY, STORAGE AND HANDLING

A. Ensure materials and surrounding air temperature are a minimum 50 degrees F. prior to, during, and for at least 7 days after completion of Work.

B. During freezing or near freezing weather, provide equipment and cover to maintain 50 degrees F. and to protect Work completed or in progress.

C. Suspend installation during high winds, rainy weather, or near freezing temperature when Work cannot be protected.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Cement: ASTM C 150 Type II/V, low alkali.

B. Aggregate: Conform to ACI 506, Graduation No. 1 or No. 2, ASTM C 33.

C. Curing compound not detrimental to application of subsequent surface finish materials.

2.2 SHOTCRETE MIX

A. Conform to following requirements:

1. Compressive strength as indicated on Drawings; 28 day minimum.

2. Aggregate size (maximum): 3/8 inch.

3. Slump (plus or minus 1/2 inch): 1 inch to 2 inches.

B. Thoroughly mix shotcrete. Apply mix within 45 minutes.

C. Develop mix design to provide compaction and low percentage of rebound, but stiff enough not to sag.

D. Maintain quality control records during production of shotcrete. Submit records to the Architect.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces to receive shotcrete and verify unsuitable conditions have been corrected before proceeding. Verify that field conditions are acceptable and are ready to receive Work.

B. Verify fabricated forms are true to line and dimension, adequately braced against vibration, and constructed to permit escape of air and rebound during installation.

C. Ensure correct placement of reinforcement. Provide sufficient clearance around reinforcement to permit complete encasement.

D. Provide safe access to shotcrete surfaces for screeding and finishing, to permit uninterrupted application.

3.2 PREPARATION

A. Remove existing unsound concrete from substrate surfaces by chipping.

B. Minimize abrupt changes in thickness of repair. Remove square external corners from substrate by rounding the edge.

C. Sandblast existing surfaces that do not require chipping to remove oil, grease, and other contaminants, and to provide a roughed surface for proper bonding of the material.

D. Determine operating procedures for placement in close quarter, extended distances, or around unusual obstructions where placement velocities and mix consistency must be adjusted.

E. Clean and wet cementitious surfaces prior to installation. Maintain porous surfaces damp for several hours before installation. Do not install when there is visible free water present.

3.3 BATCHING AND MIXING

A. Shotcrete Mixes: Shall be designed based on the following minimum proportions:

1. Provide shrinkage tests, as specified under Section 03 3000: Cast-In-Place Concrete.

2. Provided mix with fine and 3/8 inch coarse aggregates shall contain between 20 and 30 percent pea gravel as specified, shotcrete-graded fine aggregate, at least 6.5 sacks of portland cement per cubic yard and sufficient water to produce a maximum slump of 2 inches plus-or-minus 1/2 inch.

3. Shotcrete mixes shall be proportioned, batched and transported to assure complete mixing. Truck mixers shall be charged to not more than 75 percent of their rated capacity. Mixes shall be batched to provide a maximum 2 inch slump plus-or-minus 1/2 inch at the mixer at time of discharge. Water may be added at the

Project site and in no case may the slump at the pump exceed 2 inches plus-or-minus 1/2 inch.

B. Thoroughly mix cement and aggregate for at least one minute before adding water.

3.4 APPLICATION

A. Install with suitable delivery equipment and procedures that will result in meeting the requirements of the Drawings and Specifications. Whenever possible, except when enclosing reinforcing steel, the nozzle shall be held at right angles to the surface to be placed and at a distance from 30 inches to 36 inches. When enclosing reinforcing steel, the nozzle shall be held so as to direct the material behind the bars. Each side of each bar shall be installed separately. Any deposits of loose sand or rebound shall be installed separately. Any deposits of loose sand or rebound shall be carefully removed from surfaces before material is installed. A second experienced nozzle operator equipped with an air jet shall attend the operators whenever reinforcing steel is being enclosed and shall carefully precede the nozzle and blow out rebound and sand which may have lodged behind the steel. Horizontal members shall not be installed from the top unless special methods are specified to eliminate rebound. The use of "puddled" shotcrete in which the water content of the mix is increased to facilitate the installation in difficult locations is not permitted. Shotcrete shall not be installed where the stream from the nozzle cannot directly impinge on the surface on which the shotcrete is to be installed.

B. No rebound material shall be installed in the Work.

C. The film of laitance, which forms on the surface of the shotcrete, shall be removed within approximately 2 hours after installation by brushing with a stiff broom. If this film is not removed within 2 hours, it shall be removed by wire brushing or sand blasting. Construction joints over 8 hours old shall be thoroughly cleaned before the installation of shotcrete.

D. Damage: Pneumatically placed concrete subsiding after installation shall be removed and replaced. Rebound pockets, sags, sloughing or other defects shall be cut out and replaced.

E. Surfaces to receive shotcrete shall have their entire surface thoroughly cleaned and roughened by sand blasting. Concrete and masonry shall be wetted before shotcrete is installed, but not so wet as to inhibit the installation. Sand for sand blasting shall be clean, sharp and uniform size, with no particles that will pass a 50 mesh screen.

F. Reinforcement: Before installing shotcrete around or upon reinforcement, reinforcement shall be thoroughly cleaned of grease, oil, paint, loose mill scale, heavy rust and hydrated concrete.

G. Reinforcing shall be supported and secured in place in such a manner that resulting vibrations from shotcrete installation will not damage and or dislodge reinforcing.

H. Walls: Where structural wet mix shotcrete is to be installed to walls, minimum spacing of reinforcing steel shall be 6 bar diameters for walls with one curtain of steel. Where 2 curtains of steel are provided, curtain nearest nozzle shall be provided with a minimum spacing of 12 bar diameters and remaining curtain shall be provided with a minimum spacing of 6 bar diameters. Reinforcing steel shall be provided with a minimum of 3 bar diameters at splices. Minimum clear distance between reinforcing bars, other than mesh, shall be a minimum of 3 times maximum aggregate size.

1. Contact splices shall not be provided for bars larger than No. 5. Splices shall be non-contact back to back.

I. Shotcrete forms shall be substantial and rigid. Forms shall be fabricated and installed to permit the effects of rebound.

1. Rigid or other required backing shall be installed against earth during application of wet mix shotcrete. Rigid or other required backing shall be provided where a void in embankment is to be bridged. Forms to be provided where required.

J. Line and Thickness Control: Provide adequate wires or other required means to establish thickness, surface planes, and finish lines of shotcrete. Maintain specified tolerances by maintaining wires secure and taut.

K. Placement Precautions: Do not install shotcrete if hydrating or stiffening of mix takes place at any time before delivery to nozzle.

L. The height of a layer shall be limited to not more than 3 feet and a succeeding layer shall not be installed in less than 3 hours. Sloughing or sagging is not permitted.

3.5 FINISHING

A. Install to a true, even surface by floating or rodding and providing a wood float finish to surfaces. Finish surfaces shall be within a tolerance of 1/8 inch in 10 feet. Finish to match existing conditions, if applicable.

3.6 CURING AND PROTECTING

A. Initial Curing: Immediately after finishing, maintain shotcrete continuously moist for at least 20 days by one of the following materials or methods:

I. Continuous sprinkling.

2. Absorptive mat or other covering maintained continuously wet.

B. Final Curing: Provide additional curing immediately following the initial curing and before shotcrete has hydrated with one of the following materials or methods:

1. Continue the method provided for initial curing.

2. Material conforming to ASTM C 171.

C. Duration Of Curing. Maintain curing for the first 14 days after installation. During the curing period, maintain shotcrete above 40 degrees F. and in a moist condition as specified previously. Prevent rapid drying at end of curing period.

3.7 FIELD QUALITY CONTROL

A. Shotcrete Work shall be continuously inspected during installation. A special inspector, approved by the City of Inglewood to inspect the Work of this section, shall inspect the materials, placing equipment, details of construction, and construction procedure. The IOR shall be responsible for monitoring the work of the special inspector and testing laboratories to ensure that the testing program is satisfactorily completed.

B. No less than 2 cores each day shall be obtained from the Work at locations designated by the special inspector. At least one core shall be obtained for each 5,000 square feet of floor or wall area. Cores shall be tested at approximately 28 days. Cores shall be 4 inches in diameter or larger. In addition, cores shall be obtained from 2 test panels each day. Test panels must be correlated with locations of wall being installed at same time as test panels.

C. The special inspector shall observe coring operations and will prepare a report of coring operations for the testing laboratory.

D. Obtain representative core samples in accordance with CBC recommendations, and test in accordance with ASTM C 42.

E. Remove and replace shotcrete which lacks uniformity, exhibits segregation, honeycombing, or lamination, or which contains any dry patches, slugs, voids, or sand pockets.

F. Remove and replace damaged shotcrete, which cannot be satisfactorily repaired.

G. Repair core holes in accordance with Chapter 9 of ACI 301. Do not fill core holes with shotcrete. Repair holes with non-shrink non-staining concrete.

3.8 PROTECTION

A. Before installation, protect interior and exterior trim, sash, doors, transoms, floors, ceilings and equipment. Debris shall be immediately cleaned up after installation but not less than once each day.

B. Protect the Work of this section until Substantial Completion.

3.9 CLEAN-UP

A. Remove rubbish, debris, and waste materials and legally dispose of off the Project site.

END OF SECTION

SECTION 03 9300

FIBER REINFORCED POLYMER (FRP) STRENGTHENING SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. This specification is intended for use in defining the requirements of reinforced concrete strengthening using fiber reinforced polymer systems.

B. The Contractor shall furnish all materials, tools, equipment, transportation, necessary storage, labor, and supervision required for the application of the composite system.

1.2 MEASUREMENT AND PAYMENT

A. The composite strengthening system shall be bid as a lump sum and is to include all costs associated with the work defined in this specification section. This includes the furnishing of all submittals, materials, tools, equipment, labor, surface preparation, transportation, storage, supervision, and testing required for the application of the FRP materials.

1.3 REFERENCES

A. American Concrete Institute (ACI)
1. ACI 440.2R, Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening of Concrete Structures
2. ACI 562, Code Requirements for Evaluation, Repair and Rehabilitation of Concrete Buildings

B. American Society for Testing and Materials (ASTM)
1. ASTM D3039, Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials
2. ASTM D4541, Standard Test Method for Pull-Off Strength for Coatings Using Portable Adhesion Testers
3. ASTM D7522, Standard Test Method for Pull-Off Strength for FRP Bonded to Concrete Substrate
4. ASTM D7565, Standard Test Method for Determining Tensile Properties of Fiber Reinforced Polymer Matrix Composites Used for Strengthening of Civil Structures

C. International Concrete Repair Institute (ICRI)
1. ICRI Technical Guideline No. 310.2R, Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays

D. ICC Evaluation Service (ICC-ES)
1. AC125, Acceptance Criteria for Concrete and Reinforced and Unreinforced Masonry Strengthening using Externally Bonded Fiber-Reinforced Polymer (FRP) Composite Systems

2. AC178, Acceptance Criteria for Inspection and Verification of Concrete and Reinforced and Unreinforced Masonry Strengthening using Fiber-Reinforced Polymer (FRP) Composite Systems

1.4 SUBMITTALS

A. Manufacturers' Product Data
   1. Current ICC Evaluation Service Report for the proposed materials.
   2. Technical data sheets for materials to be used.
   3. Safety data sheets (SDS) for each material component.
   4. Installation instructions, including temperature restrictions, moisture limitations, surface preparation methods, curing times, and finish requirements.

B. Calculations and Drawings
   1. Design calculations and shop drawings for the composite system shall be compliant with ACI 440.2R and must be stamped and signed by Civil or Structural Engineer registered in the state that the project site resides in.
   2. Design calculations must also conform to ACI 562 Equations 5.5.2a, 5.5.2b and 5.5.3 that stipulate the strength of the unstrengthened structure must be at least equal to the load combinations specified in section 5.5.2.
   3. Shop drawings, at a minimum, must detail the necessary surface preparation, composite system to be used, number of layers, locations, end details, primary fiber direction, and finish requirements.

C. Submit proof of testing agency qualifications specified in Paragraph 3.3.C.1.d below.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. All products shall be delivered, stored, and handled according to the manufacturer's recommendations.

B. Materials shall be clearly labeled and delivered in factory-sealed containers with manufacturing dates and shelf lives easily identifiable.

C. Materials shall be stored in a protected area free of moisture and UV exposure, with temperatures between 45°F and 95°F.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Simpson Strong-Tie®, Inc., 5956 W. Las Positas Boulevard, Pleasanton, CA 94588, Phone: 925.560.9000, Fax: 925.847.1605

B. Fyfe Co. LLC. Nancy Ridge Technology Center, 6310 Nancy Ridge Drive, Suite 103, San Diego, CA 92121. Tel: 858-642-0694, Fax: 858-642-0947, email: info@fyfeco.com.

C. Or equal. In addition to requirements specified in Section 01 25 13, Product Substitution Procedures, furnish the following for a substitution request related to this product:

1. Submit to the City of Inglewood's Representative the proposed manufacturers' QA/QC manual for the FRP materials and installation.

2. Design criteria for the shear strengthening of concrete beams for seismic forces, including design equations, shall be submitted for review of the City of Inglewood's Representative.

2.2 COMPOSITE STRENGTHENING SYSTEM FOR BEAMS

A. The FRP strengthening system for beams shall be a Composite Strengthening System™ supplied by Simpson Strong-Tie®, Inc., 5956 W. Las Positas Boulevard, Pleasanton, CA 94588, Phone: 925.560.9000, Fax: 925.847.1605, or equal.

1. Fabrics, FRP Anchors
   a. CSS-CUCF22: Code listed, unidirectional carbon fabric.
   b. CSS-CA: Carbon FRP anchor.

2. Epoxy Adhesive
   a. CSS-ES: Epoxy saturant and primer.

3. Filler
   a. CSS-EP: Epoxy paste and filler.
   b. CSS-ES thickened with fumed silica: Epoxy paste and filler.

4. Finish
   a. FX-207: Cementitious coating

B. FRP strengthening system shall be a code-listed, unidirectional fabric. The ICC code-listed cured composite design values shall meet or exceed the following minimum values:

Fabric	Tensile Strength	E x A per layer	Ultimate Strain	Thickness
CSS-CUCF22	128 ksi	568 k/in	0.9%	0.04 in

2.3 COMPOSITE STRENGTHENING SYSTEM FOR COLUMNS

A. The FRP strengthening system for columns shall be a TYFO® Fibrwrap® System to be supplied by Fyfe Company, Nancy Ridge Technology Center, 6310 Nancy Ridge Drive, Suite 103, San Diego, CA 92121. Tel: 858-642-0694, Fax: 858-642-0947, or equal. Products include the following or equal:

1. Composite fabric: SCH fiber – primary carbon fiber, uni-directional
2. Epoxy saturant: Tyfo® S epoxy to be combined with the fiber to form the TYFO® Fibrwrap® composite.
3. Primer/Filler: Tyfo® WS thickened epoxy for protective seal coat, filling voids and primer where needed.
4. Finish: Tyfo® A, Tyfo® U, Tyfo® HS, Tyfo® R&R or Tyfo® G paint to be color matched by the City of Inglewood's Representative. Alternate finishes must be approved by the system manufacturer.

B. The table below shows the minimum mechanical properties of the cured composite system used for the project design. FRP systems shall be equated based on the relative stiffness in terms of the tested modulus and associated gross laminate area (E x A). Net fiber values shall not be used for design or testing requirements:

Property	Unidirectional Carbon Composite System Requirement	ASTM TEST METHOD
Ultimate Tensile Strength in primary fiber direction, min.	100,000 psi	D 3039
Ultimate Breaking Load in primary fiber direction, min.	4,000 lb/in width	D 3039
Elongation (%): Minimum Maximum	 0.8 2.1	D 3039
Tensile Modulus, min.	8,900 ksi	D 3039
Stiffness in primary fiber direction based on the unit width of one-layer of cured FRP system. Modulus times measured area (E x A).	350 kips/inch	D 3039
Corresponding Thickness per layer	0.04 inches	N/A

PART 3 - EXECUTION OF WORK

3.1 SURFACE PREPARATION

A. Surfaces to be wrapped shall be clean, sound, and free of standing water at time of application. All dust, laitance, grease, curing compounds, and other foreign materials that may hinder the bond must be removed before installation.

B. Cracked substrates with cracks wider than 0.01 inch must be pressure injected with epoxy prior to FRP installation. For concrete substrates, refer to ACI 224.1R. Smaller cracks exposed to aggressive environments may require resin injection or sealing to prevent corrosion of existing steel reinforcement. Crack-width criteria for various exposure conditions are given in ACI 224.1R.

C. Existing concave and convex surfaces must be filled/transitioned with epoxy paste or a suitable repair mortar.

D. The concrete shall be abrasively prepared to achieve an ICRI CSP 3 profile by means of grinding, sand blasting, shot blasting, or pressure washing unless the FRP is being applied in a contact-critical application (i.e. horizontal wrapping of columns).

E. Any corners to be wrapped around shall be rounded to a ¾ inch minimum radius using a grinder or filler epoxy.

F. For folded FRP anchors, drill hole into substrate per approved shop drawings. If FRP anchor is to turn over edge of hole, that edge of hole must be rounded to a ¾ inch minimum radius. Clean hole and surrounding area of dust. Clean hole and surrounding area of dust.

3.2 APPLICATION

A. Verify ambient and concrete surface temperatures are between 45°F and 95°F.

B. Apply one coat of epoxy primer using a nap roller.

C. Apply epoxy paste where minor surface defects are present.

D. Allow the primer and/or paste to become tacky to the touch before applying the saturated fabric.

E. When manually saturating fabric, precut sheets to required length using heavy duty shears before saturating with hand rollers. If mechanically saturating fabric with rollers, cut sheets using heavy duty shears either before or after they go through the epoxy bath. In both cases, ensure full fabric saturation is achieved.

F. Apply the saturated sheet to the installation surface and remove entrapped air using hand pressure, rollers, or trowels.

G. Apply FRP anchors while the epoxy on the applied fabric is still tacky. If hole in substrate cannot be directly adjacent to applied fabric, provide a "ramp" of paste so FRP anchor is allowed to contact the applied fabric over a paste ramp slope of no greater than 1:3. Splay exposed end(s) of FRP anchor on the applied fabric per approved shop drawings. If FRP anchor cannot be applied to wet FRP sheet, lightly sand cured FRP fabric taking care not to damage fibers and clean area prior to FRP anchor installation.

H. Feather all fabric seams/edges with epoxy paste.

I. Confirm that intimate contact between composite system and substrate will be maintained throughout the curing process.

J. Apply finish coating after full epoxy cure, lightly sanding epoxy surfaces before installation.

3.3 QUALITY CONTROL

A. Field Monitoring

1. The work performed in Section 3.01 and Section 3.02 of this specification will be field monitored by the City of Inglewood's Special Inspection Agency and will be paid for by the City of Inglewood. The surface preparation shall be checked immediately before application of the composite system materials. Periodic inspection shall be furnished during the application process.
2. The special inspector shall create daily reports that document the following:
   a. Date and time of installation.
   b. Ambient temperature, relative humidity, and weather conditions.
   c. Substrate surface temperature and dryness.
   d. Surface preparation method and ICRI concrete surface profile.
   e. Surface cleanliness description.
   f. Fabric/FRP anchor batch numbers.
   g. Epoxy batch numbers, mix ratios, and mixing times.
   h. Application locations.
   i. Conformance with installation procedures.
   j. Location and size of any delaminations/voids identified or repaired.

3. For fabric systems, the Contractor shall create a minimum of two material sample sets daily. Each set will consist of two 12 in. by 12 in. panels made of two layers of saturated fabric and the sets shall be taken at different times during the working shift so that it is representative of maximum variances in material/site conditions. Prepare samples on a flat, level surface covered with heavy-duty vinyl (or similar). Prime vinyl with epoxy saturant, place saturated layers, and apply a top coat of epoxy saturant. Samples shall be cured at the site under the same environmental conditions as the production work they represent and must be marked with sample date, time, epoxy/fabric batch numbers, and installation locations.

B. Field Testing

1. Adhesion Tests
   a. Pull-off tests shall be conducted in accordance with ASTM D7522 and/or ASTM D4541 and performed on flat surfaces. 3 tests shall be executed on each type of substrate or surface preparation method used, with a minimum of 3 tests per 1000 square feet of surface area covered. Testing shall be done on an area adjacent to strengthening locations with substrate, surface preparation, and orientation (i.e. overhead, vertical, etc.) that are representative of that being strengthened. Before pull-off tests are performed, the composite system shall be allowed to reach full cure.
   b. Adhesion strengths shall be in excess of 200 psi

C. Lab Testing

1. Tension Tests

   a. Tension tests shall be performed to verify the tensile strength, strain, and modulus of the composite strengthening system based on the nominal layer thickness reported on the manufacturer's data sheet and used in the design calculations.

b. The composite tensile properties used in the design calculations must be lower than the average of the test results unless calculations are performed with the reported average tensile properties show that the strengthening requirements are satisfied.

c. Record lot number of fabric and resin used, and location of installation. A "sample batch" shall consist of two 12" x 12" samples of cured composite (please note that multi-axial fabrics typically require larger sample specimens. Material manufacturer shall furnish required specimen dimensions). A minimum of two sample batches shall be made daily. The two sample batches will be taken at appropriate times during the day so as to ensure the maximum material deviance in the components of the composite. Testing laboratory shall pre-condition samples at 140° F for 48 hours before testing. Samples shall be tested, at random, at the City of Inglewood's discretion and cost.

d. Tested samples shall be tested per ASTM D3039. The 12" x 12" panel shall have 5 coupons, ¾" x 9", removed and tested for their material properties in the longitudinal (primary fiber) direction. Tests shall conform to ASTM procedures and manufacturer's published testing methods. Testing laboratories shall have a minimum of 2 years of experience in similar projects and shall be reviewed and approved by FRP Manufacturer and the City of Inglewood's Representative.

e. Testing results shall be made available within 3 weeks of sample submission. The testing shall furnish average values of the following:
   i. Ultimate tensile strength
   ii. Tensile modulus
   iii. Percent elongation

f. 15% of all sample batches are suggested to be tested. If one 12" x 12" sample fails (on average), specimens from the same sample will be tested. If these specimens also fail (on average), the other 12" x 12" from the same sample batch will be tested. In the extreme case that this sample also fails, the remaining sample batch for that day will be tested and appropriate remedial measures, per Section 3.3.E.1, will be taken to ensure integrity of the system from the failed sample batch. In addition, 25% of the remaining sample batches will then be tested by the same criteria.

D. Defects
1. Small delaminations less than 2 square inches are acceptable so long as the delaminated area is less than 5% of the total laminate area and there are no more than 10 such delaminations per 10 square feet.
2. Large delaminations greater than 25 square inches shall be locally cut away and a new material shall be applied with an equivalent number of layers and sufficient development length overlaps.

3. Delaminations between 2 square inches and 25 square inches shall be injected with epoxy or replaced, depending on the size, number of delaminations, and locations.

E. Remedial Measures

1. In the event that material testing, per section 3.3.C, determines a sample batch to possess insufficient material properties, remedial measures shall be taken. If the tested composite system has material properties determined to be below the minimum specified values, additional layers shall be installed, at the Contractor's expense, until the final composite thickness is increased by the same percentage as the deficiency of the material's elastic modulus.

END OF SECTION 03 9300

SECTION 051200

STRUCTURAL STEEL FRAMING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
  1. Structural steel.
  2. Grout.

B. Related Requirements
  1. Section 051213 "Architecturally Exposed Structural Steel Framing" for additional requirements for architecturally exposed structural steel.

1.3 DEFINITIONS

A. Structural Steel: Elements of structural-steel frame, as classified by AISC 303, "Code of Standard Practice for Steel Buildings and Bridges."

1.4 ADMINISTRATIVE REQUIREMENTS

A. Preconstruction Coordination Meetings
  1. Steel and Concrete Preconstruction Coordination Meeting: Conduct coordination meeting at project site a minimum of 3 weeks prior to submitting any shop drawings or procurement of materials.
    a. Require representatives of each entity directly concerned with steel fabrication and erection and concrete placement to attend, including but not limited to the following:
      1) Construction Manager
      2) Steel Fabricator
      3) Steel Erector
      4) Concrete Contractor
      5) Structural Engineer of Record
      6) Architect of Record
    b. Review the following:
      1) Anchor rod installation and tolerances
      2) Method for securing anchor rods against movement during concrete placement
      3) Steel Embed Plates
      4) Submittal Schedules
      5) Critical Path and Long Lead Items
      6) Any and all items that require cross-trade coordination

B. Pre-installation Conference: Conduct conference at project site before submitting shop drawings.

1. Require representatives of each entity directly concerned with steel fabrication and erection to attend, including the following:
    a. Construction Manager
    b. Steel Fabricator
    c. Steel Erector
    d. Buckling Restrained Braced Frame Supplier
    e. Special Inspector
    f. Structural Engineer of Record
2. Review the following:
    a. Shop drawing development and review procedures.
    b. Special inspection and testing and inspecting agency procedures for field quality control.
    c. Procedures for fabricating, locating and erecting sloped columns
    d. Fabrication and erection tolerances.
    e. Anchor rod and anchorage device installation tolerances.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Show fabrication of structural-steel components.
1. Include details of cuts, connections, splices, camber, holes, and other pertinent data.
2. Include embedment drawings.
3. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld. Show backing bars that are to be removed and supplemental fillet welds where backing bars are to remain.
4. Indicate type, size, and length of bolts, distinguishing between shop and field bolts. Identify pretensioned and slip-critical high-strength bolted connections.
5. Identify members and connections of the seismic-load-resisting system.
6. Identify demand critical welds.

C. Welding Procedure Specifications (WPSs) and Procedure Qualification Records (PQRs): Provide according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for each welded joint qualified by testing, including the following:
1. Power source (constant current or constant voltage).
2. Electrode manufacturer and trade name, for demand critical welds.

1.6 INFORMATION SUBMITTALS

A. Qualification Data: For qualified Installer and fabricator.

B. Welding certificates.

C. Mill test reports for structural steel, including chemical and physical properties.

D. Product Test Reports: For the following:
1. Bolts, nuts, and washers including mechanical properties and chemical analysis.
2. Shear stud connectors.
3. Tension-control, high-strength, bolt-nut-washer assemblies.
4. Shop primers.
5. Nonshrink grout.

E. Shop drawings for temporary bracing required to erect the structure prior to completion

F. Source quality-control reports.

G. Field quality-control and special inspection reports.

1.7 QUALITY ASSURANCE

A. Fabricator Qualifications: A qualified fabricator that participates in the AISC Quality Certification Program and is designated an AISC-Certified Plant, Category BU.

B. Erector Qualifications: A qualified steel erector who participates in the AISC Quality Certification Program and is designated an AISC-Certified Erector, Category CSE, ACSE, or CSEA.

C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
   1. Welders and welding operators performing work on bottom-flange, demand-critical welds shall pass the supplemental welder qualification testing, as required by AWS D1.8. FCAW-S and FCAW-G shall be considered separate processes for welding personnel qualification.

D. Comply with applicable provisions of the following specifications and documents:
   1. AISC 303.
   2. AISC 341.
   3. AISC 360.
   4. RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store materials to permit easy access for inspection and identification. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from corrosion and deterioration.
   1. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials or structures as directed.

B. Store fasteners in a protected place in sealed containers with manufacturer's labels intact.
   1. Fasteners may be repackaged provided Owner's testing and inspecting agency observes repackaging and seals containers.
   2. Clean and relubricate bolts and nuts that become dry or rusty before use.
   3. Comply with manufacturers' written recommendations for cleaning and lubricating ASTM F 1852 fasteners and for retesting fasteners after lubrication.

1.9 COORDINATION

A. Coordinate installation of anchorage items to be embedded in or attached to other construction without delaying the Work. Provide setting diagrams, sheet metal templates, instructions, and directions for installation.

PART 2 - PRODUCTS

2.1 STRUCTURAL-STEEL MATERIALS

A. W-Shapes: See Structural Drawings

B. Channels, Angles, and Tees: See Structural Drawings

C. Plate and Bar: See Structural Drawings

D. Cold-Formed Hollow Structural Sections: See Structural Drawings

E. Steel Pipe: See Structural Drawings

F. Welding Electrodes: Comply with AWS requirements, indicated on Drawings.

2.2 BOLTS, CONNECTORS, AND ANCHORS

A. High-Strength Bolts, Nuts, and Washers:
1. Grade: See Structural Drawings, Type 1, heavy-hex steel structural bolts
2. Nuts: ASTM A 563, Grade C, heavy-hex carbon-steel
3. Washers: ASTM F 436, Type 1, hardened carbon-steel
4. Finish: Plain

B. Shear Connectors: ASTM A 108, Grades 1015 through 1020, headed-stud type, cold-finished carbon steel; AWS D1.1, Type B.

C. Unheaded Anchor Rods: See Structural Drawings, weldable.
1. Configuration: Straight.
2. Nuts: ASTM A 56 heavy-hex carbon steel.
3. Plate Washers: ASTM A 36 carbon steel.
4. Washers: ASTM F 436, Type 1, hardened carbon steel.
5. Finish: Plain.

D. Threaded Rods: ASTM A 36.
1. Nuts: ASTM A 563 heavy-hex carbon steel.
2. Washers: ASTM F 436, Type 1, hardened carbon steel.
3. Finish: Plain Hot-dip zinc coating, ASTM A 153, Class C.

E. Clevises and Turnbuckles: Made from cold-finished carbon steel bars, ASTM A 108, Grade 1035.

F. Eye Bolts and Nuts: Made from cold-finished carbon steel bars, ASTM A 108, Grade 1030.

G. Sleeve Nuts: Made from cold-finished carbon steel bars, ASTM A 108, Grade 1018.

2.3 PRIMER

A. Primer: SSPC-Paint 25, Type I, zinc oxide, alkyd, linseed oil primer.

B. Galvanizing Repair Paint: ASTM A780

2.4 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive and nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

2.5 FABRICATION

A. Structural Steel: Fabricate and assemble in shop to greatest extent possible. Fabricate according to AISC's "Code of Standard Practice for Steel Buildings and Bridges" and AISC 360.
   1. Camber structural-steel members where indicated.
   2. Fabricate beams with rolling camber up.
   3. Identify high-strength structural steel according to ASTM A6 and maintain markings until structural steel has been erected.
   4. Mark and match-mark materials for field assembly.
   5. Complete structural-steel assemblies, including welding of units, before starting shop-priming operations.

B. Thermal Cutting: Perform thermal cutting by machine to greatest extent possible.
   1. Plane thermally cut edges to be welded to comply with requirements in AWS D1.1.

C. Bolt Holes: Cut, drill, or punch standard bolt holes perpendicular to metal surfaces.

D. Finishing: Accurately finish ends of columns and other members transmitting bearing loads.

E. Cleaning: Clean and prepare steel surfaces that are to remain unpainted according to SSPC-SP 3, "Power Tool Cleaning."

F. Shear Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Use automatic end welding of headed-stud shear connectors according to AWS D1.1 and manufacturer's written instructions.

G. Holes: Provide holes required for securing other work to structural steel and for other work to pass through steel framing members.
   1. Cut, drill, or punch holes perpendicular to steel surfaces. Do not thermally cut bolt holes or enlarge holes by burning.
   2. Baseplate Holes: Cut, drill, or punch holes perpendicular to steel surfaces.
   3. Weld threaded nuts to framing and other specialty items indicated to receive other work.

2.6 SHOP CONNECTIONS

A. High-Strength Bolts: Shop install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.
   1. Joint Type: Snug tightened.

B. Weld Connections: Comply with AWS D1.1 and AWS D1.8 for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.

1. Assemble and weld built-up sections by methods that will maintain true alignment of axes without exceeding tolerances in AISC 303 for mill material.

2.7 SHOP PRIMING

A. Shop prime steel surfaces except the following:
   1. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2 inches.
   2. Surfaces to be field welded.
   3. Surfaces to be high-strength bolted with slip-critical connections.
   4. Surfaces to receive sprayed fire-resistive materials (applied fireproofing).
   5. Galvanized surfaces.

B. Surface Preparation: Clean surfaces to be painted. Remove loose rust and mill scale and spatter, slag, or flux deposits. Prepare surfaces according to the following specifications and standards:
   1. SSPC-SP 3, "Power Tool Cleaning."

C. Priming: Immediately after surface preparation, apply primer according to manufacturer's written instructions and at rate recommended by SSPC to provide a minimum dry film thickness of 1.5 mils. Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces.
   1. Stripe paint corners, crevices, bolts, welds, and sharp edges.
   2. Apply two coats of shop paint to surfaces that are inaccessible after assembly or erection. Change color of second coat to distinguish it from first.

D. Painting: Prepare steel and apply a one-coat, primer complying with SSPC-Paint 25, Type I, zinc oxide, alkyd, linseed oil primer to provide a dry film thickness of not less than 1.5 mils.

2.8 GALVANIZING

A. Hot-Dip Galvanized Finish: Apply zinc coating by the hot-dip process to structural steel according to ASTM A 123.
   1. Fill vent and drain holes that are exposed in the finished Work unless they function as weep holes, by plugging with zinc solder and filing off smooth.

B. Galvanize lintels, shelf angles, and other steel exposed to weather unless specified as painted.

2.9 SOURCE QUALITY CONTROL

A. Testing Agency: Owner will engage an independent testing and inspecting agency to perform shop tests and inspections and prepare test reports.
   1. Provide testing agency with access to places where structural-steel work is being fabricated or produced to perform tests and inspections.

B. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.

C. Bolted Connections: Shop-bolted connections will be tested and inspected according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."

D. Welded Connections: In addition to visual inspection, shop-welded connections will be tested and inspected according to AWS D1.1 and the following inspection procedures, at testing agency's option:
   1. Liquid Penetrant Inspection: ASTM E 165.
   2. Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
   3. Ultrasonic Inspection: ASTM E 164.
   4. Radiographic Inspection: ASTM E 94.

E. In addition to visual inspection, shop-welded shear connectors will be tested and inspected according to requirements in AWS D1.1 for stud welding and as follows:
   1. Bend tests will be performed if visual inspections reveal either a less-than-continuous 360-degree flash or welding repairs to any shear connector.
   2. Tests will be conducted on additional shear connectors if weld fracture occurs on shear connectors already tested, according to requirements in AWS D1.1.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify, with steel Erector present, elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedments for compliance with requirements.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Provide temporary shores, guys, braces, and other supports during erection to keep structural steel secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural steel, connections, and bracing are in place unless otherwise indicated.
   1. Do not remove temporary shoring supporting composite deck construction until cast-in-place concrete has attained its design compressive strength.

3.3 ERECTION

A. Set structural steel accurately in locations and to elevations indicated and according to AISC 303 and AISC 360.

B. Provide temporary bracing as required to maintain support structure during construction, prior to completion of the superstructure.

C. Baseplates and Bearing Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting plates. Clean bottom surface of plates.
   1. Set plates for structural members on wedges, shims, or setting nuts as required.
   2. Weld plate washers to top of baseplate.
   3. Snug-tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.

4. Promptly pack grout solidly between bearing surfaces and plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure. Comply with manufacturer's written installation instructions for shrinkage-resistant grouts.

D. Maintain erection tolerances of structural steel within AISC's "Code of Standard Practice for Steel Buildings and Bridges."

E. Align and adjust various members that form part of complete frame or structure before permanently fastening. Before assembly, clean bearing surfaces and other surfaces that will be in permanent contact with members. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.
1. Level and plumb individual members of structure.
2. Make allowances for difference between temperature at time of erection and mean temperature when structure is completed and in service.

F. Splice members only where indicated.

G. Do not use thermal cutting during erection.

H. Do not enlarge unfair holes in members by burning or using drift pins. Ream holes that must be enlarged to admit bolts.

3.4 FIELD CONNECTIONS

A. High-Strength Bolts: Install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.
1. Joint Type: See structural drawings

B. Weld Connections: Comply with AWS D1.1 and AWS D1.8 for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.
1. Comply with AISC 303 and AISC 360 for bearing, alignment, adequacy of temporary connections, and removal of paint on surfaces adjacent to field welds.
2. Remove backing bars or runoff tabs where indicated, back gouge, and grind steel smooth.
3. Assemble and weld built-up sections by methods that will maintain true alignment of axes without exceeding tolerances in AISC's "Code of Standard Practice for Steel Buildings and Bridges" for mill material.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified independent testing and inspecting agency to inspect field welds and high-strength bolted connections.

B. Bolted Connections: Bolted connections will be tested and inspected according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."

C. Welded Connections: Field welds will be visually inspected according to AWS D1.1/D1.1M.
1. In addition to visual inspection, field welds will be tested and inspected according to AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:
a. Liquid Penetrant Inspection: ASTM E 165.
b. Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
c. Ultrasonic Inspection: ASTM E 164.

d. Radiographic Inspection: ASTM E 94.

D. In addition to visual inspection, field-welded shear connectors will be tested and inspected according to requirements in AWS D1.1 for stud welding and as follows:
1. Perform bend tests if visual inspections reveal either a less-than-continuous 360-degree flash or welding repairs to any shear connector.
2. Conduct tests on additional shear connectors if weld fracture occurs on shear connectors already tested, according to requirements in AWS D1.1.

E. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.

3.6 REPAIRS AND PROTECTION

A. Galvanized Surfaces: Clean areas where galvanizing is damaged or missing and repair galvanizing to comply with ASTM A780.

B. Touchup Painting: Immediately after erection, clean exposed areas where primer is damaged or missing and paint with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
1. Clean and prepare surfaces by SSPC-SP 2 hand-tool cleaning or SSPC-SP 3 power-tool cleaning.

END OF SECTION

SECTION 05 1213

ARCHITECTURALLY EXPOSED STRUCTURAL STEEL FRAMING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes architecturally exposed structural-steel framing.

1. Requirements in Section 051200 "Structural Steel Framing" also apply to AESS framing.

B. Related Sections:

1. Section 014000 "Quality Requirements" for independent testing agency procedures and administrative requirements.
2. Section 051200 "Structural Steel Framing" for additional requirements applicable to AESS.
3. Section 055000 "Metal Fabrications" for miscellaneous steel fabrications not defined as structural steel.
4. Section 099600 "High-Performance Coatings" for surface preparation and priming requirements.

1.2 DEFINITIONS

A. Architecturally Exposed Structural Steel: Structural steel designated as "architecturally exposed structural steel" or "AESS" in the Contract Documents.

1.3 ACTION SUBMITTALS

A. Shop Drawings: Show fabrication of AESS components. Shop Drawings for structural steel may be used for AESS provided items of AESS are specifically identified and requirements below are met for AESS.

1. Include details of cuts, connections, splices, camber, holes, and other pertinent data.
2. Include embedment drawings.
3. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld. Show backing bars that are to be removed and supplemental fillet welds where backing bars are to remain. Indicate grinding, finish, and profile of welds.
4. Indicate type, size, and length of bolts, distinguishing between shop and field bolts. Identify pretensioned and slip-critical high-strength bolted connections.
5. Indicate exposed surfaces and edges and surface preparation being used.
6. Indicate special tolerances and erection requirements.

B. Samples: Submit samples of AESS to set quality standards for exposed welds.

1. Two steel plates, 3/8 by 8 by 4 inches (9.5 by 200 by 100 mm), with long edges joined by a groove weld and with weld ground smooth.
2. Steel plate, 3/8 by 8 by 8 inches (9.5 by 200 by 200 mm), with one end of a short length of rectangular steel tube, 4 by 6 by 3/8 inches (100 by 150 by 9.5 mm), welded to plate with a continuous fillet weld and with weld ground smooth and blended.

3. Round steel tube or pipe, minimum 8 inches (200 mm) in diameter, with end of another round steel tube or pipe, approximately 4 inches (100 mm) in diameter, welded to its side at a 45-degree angle with a continuous fillet weld and with weld ground smooth and blended.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer and fabricator.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who participates in the AISC Quality Certification Program and is designated an AISC-Certified Erector, Category CSE.

B. Fabricator Qualifications: A qualified fabricator that participates in the AISC Quality Certification Program and is designated an AISC-Certified Plant, Category STD.

C. Shop-Painting Applicators: Qualified according to AISC's Sophisticated Paint Endorsement P3 or SSPC-QP 3, "Standard Procedure for Evaluating Qualifications of Shop Painting Applicators."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Use special care in handling to prevent twisting, warping, nicking, and other damage. Store materials to permit easy access for inspection and identification. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from corrosion and deterioration.

1. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials or structures as directed.

1.7 PROJECT CONDITIONS

A. Field Measurements: Where AESS is indicated to fit against other construction, verify actual dimensions by field measurements before fabrication.

1.8 COORDINATION

A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' recommendations to ensure that shop primers and topcoats are compatible with one another.

PART 2 - PRODUCTS

2.1 PRIMER

A. Primer: Comply with Section 099600 "High-Performance Coatings."

2.2 FABRICATION

A. Shop fabricate and assemble AESS to the maximum extent possible. Locate field joints at concealed locations if possible. Detail assemblies to minimize handling and to expedite erection.

B. In addition to special care used to handle and fabricate AESS, comply with the following:

1. Fabricate with exposed surfaces smooth, square, and free of surface blemishes including pitting, rust, scale, and roughness.
2. Grind sheared, punched, and flame-cut edges of AESS to remove burrs and provide smooth surfaces and edges.
3. Fabricate AESS with exposed surfaces free of mill marks, including rolled trade names and stamped or raised identification.
4. Fabricate AESS with exposed surfaces free of seams to maximum extent possible.
5. Remove blemishes by filling or grinding or by welding and grinding, before cleaning, treating, and shop priming.
6. Fabricate with piece marks fully hidden in the completed structure or made with media that permits full removal after erection.
7. Fabricate AESS to the tolerances specified in AISC 303 for steel that is designated AESS.

   a. For HSS shapes, comply with applicable ASTM tolerances for respective types, reduced by 50 percent.

8. Seal-weld open ends of hollow structural sections with 3/8-inch (9.5-mm) closure plates for AESS.

C. Curved Members: Fabricate indicated members to curved shape by rolling to final shape in fabrication shop.

1. Distortion of webs, stems, outstanding flanges, and legs of angles shall not be visible from a distance of 20 feet (6 m) under any lighting conditions.
2. Tolerances for walls of hollow steel sections after rolling shall be approximately 1/2 inch (13 mm).

D. Coping, Blocking, and Joint Gaps: Maintain uniform gaps of 1/8 inch (3.2 mm) with a tolerance of 1/32 inch (0.8 mm) for AESS.

E. Bolt Holes: Cut, drill, or punch standard bolt holes perpendicular to metal surfaces.

F. Holes: Provide holes required for securing other work to structural steel and for other work to pass through steel framing members.

1. Cut, drill, or punch holes perpendicular to steel surfaces. Do not thermally cut bolt holes or enlarge holes by burning.
2. Baseplate Holes: Cut, drill, mechanically thermal cut, or punch holes perpendicular to steel surfaces.
3. Weld threaded nuts to framing and other specialty items indicated to receive other work.

2.3 SHOP CONNECTIONS

A. High-Strength Bolts: Shop install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.

1. Joint Type: Snug tightened.

B. Weld Connections: Comply with AWS D1.1/D1.1M and AWS D1.8/D1.8M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work, and comply with the following:

1. Assemble and weld built-up sections by methods that will maintain true alignment of axes without exceeding specified tolerances.
2. Use weld sizes, fabrication sequence, and equipment for AESS that limit distortions to allowable tolerances.
3. Provide continuous, sealed welds at angle to gusset-plate connections and similar locations where AESS is exposed to weather.
4. Provide continuous welds of uniform size and profile where AESS is welded.
5. Grind butt and groove welds flush to adjacent surfaces within tolerance of plus 1/16 inch, minus 0 inch (plus 1.5 mm, minus 0 mm) for AESS.
6. Remove backing bars or runoff tabs; back-gouge and grind steel smooth for AESS.
7. At locations where welding on the far side of an exposed connection of AESS occurs, grind distortions and marking of the steel to a smooth profile aligned with adjacent material.
8. Make fillet welds for AESS oversize and grind to uniform profile with smooth face and transition.

2.4 SHOP PRIMING

A. Shop prime steel surfaces except the following:

1. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2 inches (50 mm).
2. Surfaces to be field welded.
3. Surfaces to be high-strength bolted with slip-critical connections.

B. Surface Preparation: Clean surfaces to be painted. Remove loose rust and mill scale and spatter, slag, or flux deposits. Prepare surfaces according to the following specifications and standards:
1. SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."

C. Priming: Immediately after surface preparation, apply primer according to manufacturer's written instructions and at rate recommended by SSPC to provide a minimum dry film thickness of 2.5 mils . Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces.

1. Stripe paint corners, crevices, bolts, welds, and sharp edges.
2. Apply two coats of shop paint to surfaces that are inaccessible after assembly or erection. Change color of second coat to distinguish it from first.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify, with steel erector present, elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedments for compliance with requirements.

1. Prepare a certified survey of bearing surfaces, anchor rods, bearing plates, and other embedments showing dimensions, locations, angles, and elevations.

B. Examine AESS for twists, kinks, warping, gouges, and other imperfections before erecting.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Provide temporary shores, guys, braces, and other supports during erection to keep AESS secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural steel, connections, and bracing are in place unless otherwise indicated.

1. If possible, locate welded tabs for attaching temporary bracing and safety cabling where they will be concealed from view in the completed Work.

3.3 ERECTION

A. Set AESS accurately in locations and to elevations indicated and according to AISC 303 and AISC 360.

1. Erect AESS to the tolerances specified in AISC 303 for steel that is designated AESS.

B. Do not use thermal cutting during erection unless approved by Architect. Finish thermally cut sections within smoothness limits in AWS D1.1/D1.1M.

3.4 FIELD CONNECTIONS

A. High-Strength Bolts: Install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.

1. Joint Type: Snug tightened.
2. Orient bolt heads in same direction for each connection and to maximum extent possible in same direction for similar connections.

B. Weld Connections: Comply with requirements in "Weld Connections" Paragraph in "Shop Connections" Article.

1. Remove backing bars or runoff tabs; back-gouge and grind steel smooth for AESS.
2. Remove erection bolts in AESS, fill holes, and grind smooth.
3. Fill weld access holes in AESS and grind smooth.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner may engage a qualified independent testing and inspecting agency to inspect AESS as specified in Section 051200 "Structural Steel Framing." The testing agency will not be responsible for enforcing requirements relating to aesthetic effect.

B. Architect will observe AESS in place to determine acceptability relating to aesthetic effect.

3.6 REPAIRS AND PROTECTION

A. Remove welded tabs that were used for attaching temporary bracing and safety cabling and that are exposed to view in the completed Work. Grind steel smooth.

B. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780.

C. Touchup Painting: Cleaning and touchup painting are specified in Section 099600 "High-Performance Coatings."

END OF SECTION 05 1213

SECTION 05 4000

COLD-FORMED METAL FRAMING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes cold-formed metal framing.

1.2 ACTION SUBMITTALS

A. Product Data: Submit product data for each product indicated.

B. LEED Submittals:

1. Completed "LEED Criteria Worksheet," for each component material of the product or assembly used in the installation of Work of this Section. Refer to Section 01 81 13 "Sustainable Design Requirements."
2. Credit MR 4, Recycled Content: For products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content. Include a statement indicating costs for each product having recycled content.
3. Credit MR 5, Local/Regional Materials: Product Data indicating location of materials manufacturer for regionally manufactured materials.

    a. Include a statement indicating cost and distance from manufacturer to Project Site for each regionally manufactured material.
    b. Include a statement indicating the cost and distance from point of extraction, harvest, or recovery to Project Site for each raw material used in regionally manufactured materials.

C. Shop Drawings: Submit shop drawings including layout, spacings, sizes, thicknesses, and types of cold-formed metal framing; fabrication; and fastening and anchorage details, including mechanical fasteners.

1. Include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

A. Submit mill certificates.

B. Submit welder certificates.

C. Submit research/evaluation reports.

1.4 QUALITY ASSURANCE

A. Comply with AISI's "Specification for the Design of Cold-Formed Steel Structural Members" for calculating structural characteristics of cold-formed metal framing.

1. Engineering Responsibility: Engage a qualified professional engineer to prepare design calculations, Shop Drawings, and other structural data.

B. Mill certificates signed by steel sheet producer or test reports from a qualified independent testing agency.

C. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," and AWS D1.3, "Structural Welding Code--Sheet Steel."

D. Fire-Test-Response Characteristics: Where metal framing is part of a fire-resistance-rated assembly, provide framing identical to that of assemblies tested for fire resistance per ASTM E 119 by a testing agency acceptable to authorities having jurisdiction.

1. Fire-Resistance Ratings: Indicated by GA File Numbers in GA-600, "Fire Resistance Design Manual," or by design designations from UL's "Fire Resistance Directory" or from the listings of another testing agency.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Provide cold-formed metal framing capable of withstanding design loads without deflections greater than the following:

1. Interior Non-Load-Bearing Wall Framing: Horizontal deflection of 1/240 of the wall height.
2. Exterior Non-Load-Bearing, Curtain-Wall Framing: Horizontal deflection of 1/360 of the wall height.

2.2 MATERIALS

A. Recycled Content of Steel Products: Provide products with an average recycled content of steel products so post-consumer recycled content plus one-half of pre-consumer recycled content is not less than 25 percent.

B. Steel Sheet: ASTM A 653/A 653M, structural steel, G60 zinc coating, Grade 33 for minimum uncoated steel thickness of 0.0428 inch and less; Grade 50 for minimum uncoated steel thickness of 0.0538 inch and greater.

C. Wall Framing: Manufacturer's standard steel studs, of web depths indicated, with stiffened flanges, complying with ASTM C 955, and as follows:

1. Minimum Uncoated-Steel Thickness: 0.0538 inch.
2. Flange Width: 1-5/8 inches.
3. Track: Manufacturer's standard U-shaped steel track, unpunched, with straight flanges, complying with ASTM C 955, manufacturer's standard flange width, and minimum uncoated-steel thickness matching steel studs.

2.3 ACCESSORIES AND MISCELLANEOUS MATERIALS

A. Fabricate steel-framing accessories of the same material and finish used for framing members, with a minimum yield strength of 33,000 psi, of manufacturer's standard thickness and configuration, unless otherwise indicated.

B. Steel Shapes and Clips: ASTM A 36/A 36M, zinc coated by hot-dip process according to ASTM A 123.

C. Anchor Bolts: ASTM F 1554, Grade 36, threaded carbon-steel headless, hooked bolts and carbon-steel nuts; and flat, hardened-steel washers; zinc coated by hot-dip process according to ASTM A 153/A 153M, Class C.

D. Expansion Anchors: Fabricated from corrosion-resistant materials, with capability to sustain, without failure, a load equal to 5 times design load, as determined by testing per ASTM E 488 conducted by a qualified independent testing agency.

E. Power-Actuated Anchors: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with capability to sustain, without failure, a load equal to 10 times design load, as determined by testing per ASTM E 1190 conducted by a qualified independent testing agency.

F. Mechanical Fasteners: Corrosion-resistant-coated, self-drilling, self-threading steel drill screws.

G. Galvanizing Repair Paint: SSPC-Paint 20 or DOD-P-21035.

H. Cement Grout: Portland cement, ASTM C 150, Type I; and clean, natural sand, ASTM C 404. Mix at ratio of 1 part cement to 2-1/2 parts sand, by volume, with minimum water required for placement and hydration.

I. Thermal Insulation: Refer to Section 07 21 00 "Thermal Insulation."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cold-formed metal framing and accessories plumb, square, and true to line, and with connections securely fastened, according to ASTM C 1007, manufacturer's written recommendations, and requirements in this Section.

1. Cut framing members by sawing or shearing; do not torch cut.
2. Fasten cold-formed metal framing members by welding or screw fastening, as standard with fabricator. Wire tying of framing members is not permitted.
3. Install framing members in one-piece lengths.
4. Install temporary bracing and supports to secure framing and support loads comparable in magnitude to those for which structure was designed.
5. Install insulation in built-up exterior framing members, such as headers, sills, and multiple studs at openings, that are inaccessible on completion of framing work.
6. Fasten hole-reinforcing plate over web penetrations that exceed size of manufacturer's standard punched openings.

B. Erection Tolerances: Install cold-formed metal framing level, plumb, and true to line to a maximum allowable tolerance variation of 1/8 inch in 10 feet and as follows:

1. Space individual framing members no more than plus or minus 1/8 inch from plan location. Cumulative error shall not exceed minimum fastening requirements of sheathing or other finishing materials.

C. Non-Load-Bearing, Curtain-Wall Installation: Install continuous tracks sized to match studs. Align tracks accurately and securely anchor to supporting structure. Space studs as indicated; set plumb, align, and fasten both flanges of studs to track, unless otherwise indicated.

1. Isolate non-load-bearing steel framing from building structure to prevent transfer of vertical loads while providing lateral support.
2. Install horizontal bridging in curtain-wall studs, spaced in rows indicated on Shop Drawings but not more than 54 inches apart. Fasten at each stud intersection.
3. Install miscellaneous framing and connections, including stud kickers, web stiffeners, clip angles, continuous angles, anchors, fasteners, and stud girts, to provide a complete and stable curtain-wall-framing system.

D. Galvanizing Repairs: Prepare and repair damaged galvanized coatings on fabricated and installed cold-formed metal framing with galvanized repair paint according to ASTM A 780 and manufacturer's written instructions.

END OF SECTION 05 4000

SECTION 05 5000

METAL FABRICATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes metal fabrications.

1.2 ACTION SUBMITTALS

A. Product Data: Submit product data for the following:

1. Extruded nosings and treads.
2. Paint products.
3. Grout.

B. LEED Submittals:

1. Completed "LEED Criteria Worksheet," for each component material of the product or assembly used in the installation of Work of this Section. Refer to Section 01 81 13 "Sustainable Design Requirements."
2. Credit MR 4, Recycled Content: For products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content. Include a statement indicating costs for each product having recycled content.
3. Credit MR 5, Local/Regional Materials: Product Data indicating location of materials manufacturer for regionally manufactured materials.

a. Include a statement indicating cost and distance from manufacturer to Project Site for each regionally manufactured material.
b. Include a statement indicating the cost and distance from point of extraction, harvest, or recovery to Project Site for each raw material used in regionally manufactured materials.

4. Laboratory Test Reports for Credit IEQ 4: For primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings: Submit shop drawings detailing the fabrication and erection of each metal fabrication indicated. Include plans, elevations, sections, and details of metal fabrications and their connections. Show anchorage and accessory items.

1. For installed products indicated to comply with design loads, include structural analysis data, for information only, signed and sealed by the qualified professional engineer responsible for their preparation.

D. Samples: Submit samples of the following:

1. Each type and finish of extruded nosing and tread.

1.3 INFORMATIONAL SUBMITTALS

A. Welding Certificates: Copies of certificates for welding procedures and personnel.

B. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

1.4 QUALITY ASSURANCE

A. Fabricator/Installer Qualifications: A firm experienced in producing metal fabrications similar to those indicated for this Project for a minimum of 5 years, with a record of successful in-service performance, with sufficient production capacity to produce required units without causing delay in the work.

B. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of metal fabrications that are similar to those indicated for this Project in material, design, and extent.

C. Welding: Qualify procedures and personnel according to the following:

1. AWS D1.1, "Structural Welding Code--Steel."
2. AWS D1.2, "Structural Welding Code--Aluminum."
3. AWS D1.3, "Structural Welding Code--Sheet Steel."
4. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

D. Sample Installation:

1. Following review of samples, construct sample installation of the following:

    a. Countertop and vanity.

2. The sample installation shall be complete with all anchors, jointing, plywood, finished countertop surfacing, lavatory bowls and supports, as shown in accordance with the final shop drawings. Sample installations shall be reviewed by the Architect for acceptance of workmanship only. Replace unsatisfactory work as directed for final acceptance. Maintain sample installations during construction as a standard for judging acceptability of countertop work. Properly finished and maintained sample installation may be retained as a portion of the completed work.

1.5 STORAGE, DELIVERY AND HANDLING

A. Store metal fabrications in a dry, well-ventilated, weathertight place. Deliver and handle so as to prevent any type of damage to the fabricated work.

1.6 PROJECT CONDITIONS

A. Field Measurements: Where metal fabrications are indicated to fit walls and other construction, verify dimensions by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

B. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating metal fabrications without field measurements. Coordinate construction to ensure that actual dimensions correspond to established dimensions. Allow for trimming and fitting.

1.7 COORDINATION

A. Coordinate installation of anchorages for metal fabrications. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance:

1. Counter Tops and Vanities: Provide countertop and vanity framing capable of withstanding the following structural loads without exceeding the allowable design working stress of the materials involved, including anchors and connections, or of exhibiting excessive deflections in any of the components making up the countertops and vanities:

a. All deadloads.
b. 500 pound live load placed on the countertop and vanity.
c. Deflection at Midspan: L/1000 times span or 1/8" whichever is less.

2. Brick shelf angle deflection shall be sized and anchored to carry the imposed loads such that total deflection is limited to the lesser of 1/600 or 0.3 inch and rotations are less than 1/16 inch. Size angle so that at least 2/3 of brick thickness is supported.
3. Sectional Doors : Fabricate and install support framing capable of supporting all deadloads and withstanding live loads imposed from functioning operations.

B. Exterior Metal Fabrications: All exterior metal fabrications shall be fabricated and installed to prevent buckling, opening up of joints and overstressing of welds and fasteners under the following temperature conditions:

1. Base fabrication on a temperature of +70 deg F at time of installation with allowance made for an exposed metal surface temperature range of -5 deg F to +180 deg F. Make all necessary adjustments and provisions for concealed expansion.

2.2 METALS, GENERAL

A. Metal Surfaces, General: For metal fabrications exposed to view in the completed Work, provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, rolled trade names, or roughness.

2.3 FERROUS METALS

A. Recycled Content of Steel Products: Provide products with an average recycled content of steel products so post-consumer recycled content plus one-half of pre-consumer recycled content is not less than 25 percent.

B. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.

C. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A 666, Type 304.

D. Stainless-Steel Bars and Shapes: ASTM A 276, Type 304.

E. Cold Finished Steel Bars: ASTM A108, grade as selected by fabricator.

F. Steel Tubing: Cold-formed steel tubing complying with ASTM A 500, or hot formed steel tubing complying with ASTM A 501.

G. Steel Pipe: ASTM A 53, standard weight (Schedule 40) minimum, unless otherwise indicated or required to satisfy the performance requirements; finish as follows:

1. Black finish, unless otherwise indicated.
2. Galvanized finish for exterior installations and where indicated.

H. Slotted Channel Framing: Cold-formed metal channels with continuous slot and with flanged edges returned toward web complying with MFMA-3 and fabricated from steel complying with ASTM A 1008/A 1008M. Width, depth, and metal thickness as required to suit performance requirements.

I. Malleable-Iron Castings: ASTM A 47, Grade 32510 (ASTM A 47M, Grade 22010).

J. Gray-Iron Castings: ASTM A 48, Class 30 (ASTM A 48M, Class 200), unless another class is indicated or required by structural loads.

K. Cast-in-Place Anchors in Concrete: Anchor channel type, with filler strips, manufactured from formed hot or cold rolled carbon steel channels with flange edges returned toward web, having a minimum of 2 stud, or I, anchors shop welded to the back of each channel, complying with ASTM A 1011. Provide channels, bolts, washers, and shims hot-dip galvanized per ASTM A 153/A 153M. Width, depth, and metal thickness as required to suit performance requirements.

L. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

2.4 ALUMINUM

A. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), alloy 6063-T6.

2.5 PAINT

A. Low-Emitting Materials: Paints and coatings shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Shop Primer for Ferrous Metal: Organic zinc-rich primer, complying with SSPC-Paint 20 and compatible with topcoat.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Carboline 621; Carboline Company.
    b. Aquapon Zinc-Rich Primer 97-670; PPG Industries, Inc.
    c. Tneme-Zinc 90-97; Tnemec Company, Inc.

C. Galvanizing Repair Paint: High-zinc-dust-content paint for regalvanizing welds in steel, complying with SSPC-Paint 20.

D. Bituminous Paint: Cold-applied asphalt mastic complying with SSPC-Paint 12, except containing no asbestos fibers, or cold-applied asphalt emulsion complying with ASTM D 1187.

2.6 FASTENERS

A. General: Provide Type 304 or 316 stainless-steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B 633, Class Fe/Zn 5, where built into exterior walls. Select fasteners for type, grade, and class required.

2.7 GROUT

A. Non-shrink, Non-metallic Grout: Factory-packaged, non-staining, non-corrosive, non-gaseous grout complying with ASTM C 1107. Provide grout specifically recommended by manufacturer for interior and exterior applications.

2.8 FABRICATION, GENERAL

A. Shop Assembly: Preassemble items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.

    1. Welded connections may be used where bolted connections are shown.

B. Shear and punch metals cleanly and accurately. Remove burrs.

C. Ease exposed edges to a radius of approximately 1/32 inch (1 mm), unless otherwise indicated. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.

D. Weld corners and seams continuously along entire line of contact to comply with the following:

    1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
    2. Obtain fusion without undercut or overlap.
    3. Remove welding flux immediately.
    4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

E. Provide for anchorage of type indicated; coordinate with supporting structure. Fabricate and space anchoring devices and fasteners to secure metal fabrications rigidly in place and to support indicated loads.

F. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.

G. Fabricate joints that will be exposed to weather in a manner to exclude water, or provide weep holes where water may accumulate.

H. Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges.

I. Remove sharp or rough areas on exposed traffic surfaces.

J. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Use exposed fasteners of type indicated or, if not indicated, Phillips flat-head (countersunk) screws or bolts. Locate joints where least conspicuous. Make up threaded connections tight so that threads are entirely concealed.

K. Hot-dip galvanize all exterior ferrous metal fabrications embedded in concrete. Hot-dip galvanize all other items where specified or shown.

1. Exterior ferrous metal fabrications are defined as those items which are indicated to be installed in areas exposed to conditions which are not controlled by the building heating and cooling systems.
2. Interior ferrous metal fabrications are defined as those items which are indicated to be installed in areas exposed to conditions which are controlled by the building heating and cooling systems.

2.9 LOOSE BEARING AND LEVELING PLATES

A. Provide loose bearing and leveling plates for steel items bearing on masonry or concrete construction. Drill plates to receive anchor bolts and for grouting.

B. Galvanize exterior plates after fabrication; prime paint interior plates after fabrication.

2.10 LOOSE STEEL LINTELS

A. Fabricate loose structural-steel lintels from steel angles and shapes of size indicated for openings and recesses in masonry walls and partitions at locations indicated.

B. Weld adjoining members together to form a single unit where indicated.

C. Size loose lintels to provide bearing length at each side of openings equal to one-twelfth of clear span, but not less than 8 inches (200 mm), unless otherwise indicated.

D. Galvanize loose steel lintels located in exterior walls. Prime paint loose steel lintels located in interior walls.

2.11 SHELF ANGLES

A. Fabricate shelf angles from steel angles of sizes indicated and for attachment to concrete framing. Provide machined horizontally slotted holes to receive 3/4 inch (19 mm) bolts, spaced not more than 6 inches (150 mm) from ends and 24 inches (600 mm) o.c., unless otherwise indicated.

B. Provide joint gaps in angles where control and expansion joints in exterior cladding skin are shown or required. Size joint gaps to match width of the masonry joints in the location of use. Provide joints in other locations, as required for fabrication only, with tight joints.

1. Provide units at corners and other transitions fabricated into one piece.

C. Galvanize shelf angles to be installed in exterior walls; prime paint shelf angles to be installed in interior walls.

D. Furnish wedge-type concrete inserts, complete with fasteners, to attach shelf angles to cast-in-place concrete.

2.12 MISCELLANEOUS FRAMING AND SUPPORTS

A. General: Provide steel framing and supports indicated and as necessary to complete the Work and which are not a part of the structural framework, including but not limited to framing and supports for elevator hoistway beams, elevator car and counterweight rail supports, support angles for elevator door sills, sectional doors, countertop and vanities, ceiling hung toilet compartments, CMU partition head supports, and mechanical and electrical equipment.

B. Fabricate units from structural-steel shapes, plates, and bars of welded construction, unless otherwise indicated. Fabricate to sizes, shapes, and profiles indicated and as necessary to receive adjacent construction retained by framing and supports. Cut, drill, and tap units to receive hardware, hangers, and similar items.

C. Framing for Ceiling Hung Toilet Compartments: Provide framing for ceiling hung toilet compartments, coordinated with the partitions and including provisions for partition anchorage as required to sustain imposed loads and to limit deflections to L/360 between hangers, fabricated from the following.

1. Structural Steel Shapes, Plates and Bars: ASTM A36/A36M.
2. Modular Structural Framing System: Modular, structural quality steel pre-formed "U" channel framing system with continuous open slot prepared to receive attachment nuts, bolts, straps, threaded rods, beam clamps, hanger rods support brackets and other accessories. Provide manufacturer's standard corrosion resistant finish.
3. Provide steel rods, 1/2 inch diameter, spaced not more than 36 inches o.c. Thread rods to receive anchor and stop nuts. Fit hangers with wedge shape washers for full bearing on sloping flanges of support beam.
4. Coordinate installation with toilet compartment manufacturer's written instructions and recommendations.

D. Countertop and Vanity Framing: Custom fabricate countertop and vanity framing, using steel shapes and plates, and cold finished mild steel bars at exposed conditions, for support framing and plywood, to the thicknesses, sizes and shapes shown, and as required to produce work of adequate strength and durability, without objectionable deflections. Use proven details of fabrication, as required, to achieve proper assembly and alignment of the various components of the work.

E. CMU Partition Head Supports: Fabricate supports from 4 inch by 4 inch by 1/4 inch by 36 inch long structural steel angles. Drill supports a maximum of 12 inches o.c. to receive expansion bolts.

F. Galvanize miscellaneous framing and supports at exterior locations; prime paint miscellaneous framing and supports at interior locations.

2.13 MISCELLANEOUS STEEL TRIM

A. Unless otherwise indicated, fabricate units from structural-steel shapes, plates, and bars of profiles shown with continuously welded joints, and smooth exposed edges. Miter corners and use concealed field splices where possible.

B. Provide cutouts, fittings, and anchorages as needed to coordinate assembly and installation with other work. Provide anchors, welded to trim, for embedding in concrete or masonry construction, spaced not more than 6 inches (150 mm) from each end, 6 inches (150 mm) from corners, and 24 inches (600 mm) o.c., unless otherwise indicated.

C. Cast-In Pit Angles and Edge Angles: Provide edge angles, and pit angles, fabricated from angles of size as shown, or required, with welded-on stud anchors spaced 24 inches on center. Provide pit and edge angles in as long lengths as possible. Miter and weld corners and provide splice plates for alignment between sections.

D. Galvanize exterior miscellaneous steel trim; prime paint interior miscellaneous steel trim.

2.14 EXTRUDED NOSINGS AND TREADS

A. Fabricate units in sizes and configurations indicated and in lengths necessary to accurately fit openings or conditions. For poured in place concrete stairs nosings shall terminate not more than 3" from ends of steps. Provide extruded-aluminum units with abrasive filler consisting of aluminum oxide, silicon carbide, or a combination of both, in an epoxy-resin binder.

1. Provide ribbed units, with abrasive filler strips projecting 1/16 inch (1.5 mm) above aluminum extrusion.

B. Configurations: Provide units in the following configurations, unless otherwise indicated:

1. Nosings: Units, 3 inches (75 mm) wide, for casting into concrete steps.

C. Provide anchors for embedding units in concrete, either integral or applied to units, as standard with manufacturer.

D. Apply clear lacquer to concealed bottoms, sides, and edges of units set into concrete.

E. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. American Safety Tread Co., Inc.
2. Safe-T-Metal Co.
3. Wooster Products Inc.

2.15 BICYCLE RACKS

A. Fabricate from Schedule 40 steel pipe, fully welded together, to lengths indicated.

B. Fabricate with NPS 3 (DN 80) top rails and end posts, NPS 1-1/2 (DN 40) bottom rails, and NPS 3/4 (DN 20) vertical separators at approximately 8 inches (200 mm) o.c.

C. Make top rails 36 inches (900 mm) above pavement/floor and bottom rails 4 inches (100 mm) above pavement/floor.

D. Fabricate end posts with 1/4 inch (6.4 mm) thick steel baseplates for bolting to concrete slab. Drill end post baseplates at all 4 corners for 1/2 inch (12.7 mm) anchor bolts.

E. Galvanize bicycle racks after fabrication.

2.16 FINISHES, GENERAL

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Finish metal fabrications after assembly.

2.17 STEEL AND IRON FINISHES

A. Galvanizing: Hot-dip galvanize items as indicated to comply with applicable standard listed below:

1. ASTM A 123, for galvanizing steel and iron products.
2. ASTM A 153/A 153M, for galvanizing steel and iron hardware.

B. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces by removing oil, grease, and similar contaminants in accordance with SSPC -SP 1 "Solvent Cleaning," followed with the SSPC surface-preparation specifications listed below and environmental exposure conditions of installed metal fabrications. Surface preparation shall be done after fabrication and immediately prior to shop painting. Apply shop coat of paint within 4 hours after cleaning and before rust bloom occurs.

1. Interiors (SSPC Zone 1A): SSPC-SP 3, "Power Tool Cleaning."

C. Apply a minimum of one coat of shop primer to uncoated surfaces of metal fabrications, except those with galvanized finishes and those to be field welded, and those to be embedded in concrete, sprayed-on fireproofing, or masonry, unless otherwise indicated. Comply with SSPC-PA 1, "Paint Application Specification No. 1," for shop painting.

1. Stripe paint corners, crevices, bolts, welds, and sharp edges.
2. Dry Film Thickness of Primer: 2.5 to 3.0 mils, dry film thickness. Apply paint thoroughly and evenly to dry surfaces, free from holidays and pinholes, in accordance with manufacturer's directions.

2.18 ALUMINUM FINISHES

A. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

B. As-Fabricated Finish: AA-M10 (Mechanical Finish: as fabricated, unspecified).

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing metal fabrications to in-place construction. Include threaded fasteners for concrete and masonry inserts, toggle bolts, through-bolts, lag bolts, wood screws, and other connectors. Drill holes for bolts to the exact diameter of the bolt. Provide screws threaded full length to the screw head.

B. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.

C. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.

D. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.

E. Field Welding: Comply with the following requirements:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

F. Corrosion Protection: Coat concealed surfaces of aluminum that will come into contact with grout, concrete, masonry, wood, or dissimilar metals with a heavy coat of bituminous paint.

3.2 SETTING BEARING AND LEVELING PLATES

A. Clean concrete and masonry bearing surfaces of bond-reducing materials, and roughen to improve bond to surfaces. Clean bottom surface of plates.

B. Set bearing and leveling plates on wedges, shims, or leveling nuts. After bearing members have been positioned and plumbed, tighten anchor bolts. Do not remove wedges or shims but, if protruding, cut off flush with edge of bearing plate before packing with grout.

1. Use non-shrink grout, either metallic or non-metallic, in concealed locations where not exposed to moisture; use non-shrink, non-metallic grout in exposed locations, unless otherwise indicated.
2. Pack grout solidly between bearing surfaces and plates to ensure that no voids remain.

3.3 INSTALLING MISCELLANEOUS FRAMING AND SUPPORTS

A. General: Install framing and supports to comply with requirements of items being supported, including manufacturers' written instructions and requirements indicated on Shop Drawings, if any.

B. Sectional Door Framing: Anchor supports securely to and rigidly brace from building structure. Laser level horizontal framing.

C. Anchor supports for operable partitions securely to and rigidly brace from building structure.

D. Ceiling Hung Toilet Partitions: Anchor supports securely to, and rigidly brace from, overhead building structure.

E. CMU Partition Head Supports: Unless otherwise indicated place partition head supports on alternate faces of CMU partitions every 6'-0" o.c. and expansion bolt to underside of structure. Do not bolt to CMU partitions.

3.4 INSTALLING NOSINGS AND TREADS

A. Install with anchorage system indicated to comply with manufacturer's written instructions.

B. Center nosings on tread widths.

C. For nosings embedded in concrete steps or curbs, align nosings flush with riser faces and level with tread surfaces.

3.5 ADJUSTING AND CLEANING

A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.

1. Apply by brush or spray to provide a minimum 2.0 mil (0.05 mm) dry film thickness.

B. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780.

END OF SECTION 05 5000

SECTION 05 5213

PIPE AND TUBE RAILINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel pipe and tube railings.

B. Related Sections:

1. Section 057300 "Decorative Metal Railings" for ornamental railings fabricated from pipes and tubes.
2. Section 061053 "Miscellaneous Rough Carpentry" for wood blocking for anchoring railings.
3. Section 092216 "Non-Structural Metal Framing" for metal backing for anchoring railings.

1.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design railings, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. General: In engineering railings to withstand structural loads indicated, determine allowable design working stresses of railing materials based on the following:

1. Steel: 72 percent of minimum yield strength.

C. Structural Performance: Railings shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:

1. Handrails and Top Rails of Guards:

a. Uniform load of 50 lbf/ ft. (0.73 kN/m) applied in any direction.
b. Concentrated load of 200 lbf (0.89 kN) applied in any direction.
c. Uniform and concentrated loads need not be assumed to act concurrently.

2. Infill of Guards:

a. Concentrated load of 50 lbf (0.22 kN) applied horizontally on an area of 1 sq. ft. (0.093 sq. m).
b. Infill load and other loads need not be assumed to act concurrently.

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes acting on exterior metal fabrications by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

E. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

1.3 ACTION SUBMITTALS

A. Product Data: For the following:

1. Manufacturer's product lines of mechanically connected railings.
2. Railing brackets.
3. Grout, anchoring cement, and paint products.

B. LEED Submittals:

1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.
2. Laboratory Test Reports for Credit IEQ 4: For primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

D. Samples for Verification: For each type of exposed finish required.

1. Sections of each distinctly different linear railing member, including handrails, top rails, posts, and balusters.
2. Fittings and brackets.

E. Delegated-Design Submittal: For installed products indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified professional engineer.

B. Welding certificates.

C. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers certifying that shop primers are compatible with topcoats.

D. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, according to ASTM E 894 and ASTM E 935.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of railing from single source from single manufacturer.

B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."

1.6 PROJECT CONDITIONS

A. Field Measurements: Verify actual locations of walls and other construction contiguous with metal fabrications by field measurements before fabrication.

1.7 COORDINATION AND SCHEDULING

A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.

B. Coordinate installation of anchorages for railings. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

C. Schedule installation so wall attachments are made only to completed walls. Do not support railings temporarily by any means that do not satisfy structural performance requirements.

PART 2 - PRODUCTS

2.1 METALS, GENERAL

A. Metal Surfaces, General: Provide materials with smooth surfaces, without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.

B. Brackets, Flanges, and Anchors: Cast or formed metal of same type of material and finish as supported rails unless otherwise indicated.

2.2 STEEL AND IRON

A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Tubing: ASTM A 500 (cold formed) or ASTM A 513.

C. Pipe: ASTM A 53/A 53M, Type F or Type S, Grade A, Standard Weight (Schedule 40), unless another grade and weight are required by structural loads.

1. Provide galvanized finish for exterior installations and where indicated.

D. Plates, Shapes, and Bars: ASTM A 36/A 36M.

E. Cast Iron: Either gray iron, ASTM A 48/A 48M, or malleable iron, ASTM A 47/A 47M, unless otherwise indicated.

2.3 FASTENERS

A. General: Provide the following:

1. Ungalvanized-Steel Railings: Plated steel fasteners complying with ASTM B 633 or ASTM F 1941 (ASTM F 1941M), Class Fe/Zn 5 for zinc coating.
2. Hot-Dip Galvanized Railings: Type 304 stainless-steel or hot-dip zinc-coated steel fasteners complying with ASTM A 153/A 153M or ASTM F 2329 for zinc coating.

B. Fasteners for Anchoring Railings to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings to other types of construction indicated and capable of withstanding design loads.

C. Fasteners for Interconnecting Railing Components:

1. Provide concealed fasteners for interconnecting railing components and for attaching them to other work, unless exposed fasteners are unavoidable or are the standard fastening method for railings indicated.
2. Provide tamper-resistant flat-head machine screws for exposed fasteners unless otherwise indicated.

D. Post-Installed Anchors: Torque-controlled expansion anchors or chemical anchors capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E 488, conducted by a qualified independent testing agency.

1. Material for Interior Locations: Carbon-steel components zinc-plated to comply with ASTM B 633 or ASTM F 1941 (ASTM F 1941M), Class Fe/Zn 5, unless otherwise indicated.
2. Material for Exterior Locations and Where Stainless Steel is Indicated: Alloy Group 1 (A1) stainless-steel bolts, ASTM F 593 (ASTM F 738M), and nuts, ASTM F 594 (ASTM F 836M).

2.4 MISCELLANEOUS MATERIALS

A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

B. Low-Emitting Materials: Paints and coatings shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Etching Cleaner for Galvanized Metal: Complying with MPI#25.

D. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.

E. Shop Primers: Provide primers that comply with Section 099600 "High-Performance Coatings."

F. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout specifically recommended by manufacturer for interior and exterior applications.

G. Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with water at Project site to create pourable anchoring, patching, and grouting compound.

1. Water-Resistant Product: At exterior locations and where indicated provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating and that is recommended by manufacturer for exterior use.

2.5 FABRICATION

A. General: Fabricate railings to comply with requirements indicated for design, dimensions, member sizes and spacing, details, finish, and anchorage, but not less than that required to support structural loads.

B. Assemble railings in the shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Use connections that maintain structural value of joined pieces.

C. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.

D. Form work true to line and level with accurate angles and surfaces.

E. Fabricate connections that will be exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.

F. Cut, reinforce, drill, and tap as indicated to receive finish hardware, screws, and similar items.

G. Connections: Fabricate railings with welded connections unless otherwise indicated.

H. Welded Connections: Cope components at connections to provide close fit, or use fittings designed for this purpose. Weld all around at connections, including at fittings.

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove flux immediately.
4. At exposed connections, finish exposed surfaces smooth and blended so no roughness shows after finishing and welded surface matches contours of adjoining surfaces.

I. Form changes in direction as follows:

1. As detailed.

J. Bend members in jigs to produce uniform curvature for each configuration required; maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.

K. Close exposed ends of railing members with prefabricated end fittings.

L. Provide wall returns at ends of wall-mounted handrails unless otherwise indicated. Close ends of returns unless clearance between end of rail and wall is 1/4 inch (6 mm) or less.

M. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, miscellaneous fittings, and anchors to interconnect railing members to other work unless otherwise indicated.

1. At brackets and fittings fastened to plaster or gypsum board partitions, provide crush-resistant fillers, or other means to transfer loads through wall finishes to structural supports and prevent bracket or fitting rotation and crushing of substrate.

N. Provide inserts and other anchorage devices for connecting railings to concrete or masonry work. Fabricate anchorage devices capable of withstanding loads imposed by railings. Coordinate anchorage devices with supporting structure.

O. For railing posts set in concrete, provide steel sleeves not less than 6 inches (150 mm) long with inside dimensions not less than 1/2 inch (13 mm) greater than outside dimensions of post, with metal plate forming bottom closure.

2.6 FINISHES, GENERAL

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

D. Provide exposed fasteners with finish matching appearance, including color and texture, of railings.

2.7 STEEL AND IRON FINISHES

A. Galvanized Railings:

1. Hot-dip galvanize exterior steel and iron railings, including hardware, after fabrication.
2. Comply with ASTM A 123/A 123M for hot-dip galvanized railings.
3. Comply with ASTM A 153/A 153M for hot-dip galvanized hardware.
4. Do not quench or apply post galvanizing treatments that might interfere with paint adhesion.
5. Fill vent and drain holes that will be exposed in the finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.

B. For galvanized railings, provide hot-dip galvanized fittings, brackets, fasteners, sleeves, and other ferrous components.

C. Preparing Galvanized Railings for Shop Priming: After galvanizing, thoroughly clean railings of grease, dirt, oil, flux, and other foreign matter, and treat with etching cleaner.

D. For nongalvanized steel railings, provide nongalvanized ferrous-metal fittings, brackets, fasteners, and sleeves, except galvanize anchors to be embedded in exterior concrete or masonry.

E. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with requirements indicated below:

1. Exterior Railings: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
2. Railings Indicated to Receive Primers Specified in Section 099600 "High-Performance Coatings": SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."

3. Other Railings: SSPC-SP 3, "Power Tool Cleaning."

F. Primer Application: Apply shop primer to prepared surfaces of railings unless otherwise indicated. Comply with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Primer need not be applied to surfaces to be embedded in concrete or masonry.

1. Shop prime uncoated railings with unless primers specified in Section 099600 "High-Performance Coatings" are indicated. EXECUTION

2.8 EXAMINATION

A. Examine plaster and gypsum board assemblies, where reinforced to receive anchors, to verify that locations of concealed reinforcements have been clearly marked for Installer. Locate reinforcements and mark locations if not already done.

2.9 INSTALLATION, GENERAL

A. Fit exposed connections together to form tight, hairline joints.

B. Perform cutting, drilling, and fitting required for installing railings. Set railings accurately in location, alignment, and elevation; measured from established lines and levels and free of rack.

1. Do not weld, cut, or abrade surfaces of railing components that have been coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.
2. Set posts plumb within a tolerance of 1/16 inch in 3 feet (2 mm in 1 m).
3. Align rails so variations from level for horizontal members and variations from parallel with rake of steps and ramps for sloping members do not exceed 1/4 inch in 12 feet (5 mm in 3 m).

C. Corrosion Protection: Coat concealed surfaces of aluminum that will be in contact with grout, concrete, masonry, wood, or dissimilar metals, with a heavy coat of bituminous paint.

D. Adjust railings before anchoring to ensure matching alignment at abutting joints.

E. Fastening to In-Place Construction: Use anchorage devices and fasteners where necessary for securing railings and for properly transferring loads to in-place construction.

2.10 RAILING CONNECTIONS

A. Welded Connections: Use fully welded joints for permanently connecting railing components. Comply with requirements for welded connections in "Fabrication" Article whether welding is performed in the shop or in the field.

B. Expansion Joints: Install expansion joints at locations indicated but not farther apart than required to accommodate thermal movement. Provide slip-joint internal sleeve extending 2 inches (50 mm) beyond joint on either side, fasten internal sleeve securely to one side, and locate joint within 6 inches (150 mm) of post.

2.11 ANCHORING POSTS

A. Use metal sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions.

B. Cover anchorage joint with flange of same metal as post, attached to post with set screws.

2.12 ATTACHING RAILINGS

A. Anchor railing ends at walls with round flanges anchored to wall construction and connected to railing ends using nonwelded connections.

B. Anchor railing ends to metal surfaces with flanges bolted to metal surfaces and connected to railing ends using nonwelded connections.

C. Attach railings to wall with wall brackets, except where end flanges are used. Provide brackets with 1-1/2-inch (38-mm) clearance from inside face of handrail and finished wall surface. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.

1. Use type of bracket with flange tapped for concealed anchorage to threaded hanger bolt.
2. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.

D. Secure wall brackets and railing end flanges to building construction as follows:

1. For concrete and solid masonry anchorage, use drilled-in expansion shields and hanger or lag bolts.
2. For hollow masonry anchorage, use toggle bolts.
3. For steel-framed partitions, use any method below:

    a. Hanger or lag bolts set into fire-retardant-treated wood backing between studs. Coordinate with stud installation to locate backing members.
    b. Self-tapping screws fastened to steel framing or to concealed steel reinforcements.
    c. Toggle bolts installed through flanges of steel framing or through concealed steel reinforcements.

2.13 ADJUSTING AND CLEANING

A. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Section 099600 "High-Performance Coatings."

B. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780.

2.14 PROTECTION

A. Protect finishes of railings from damage during construction period with temporary protective coverings approved by railing manufacturer. Remove protective coverings at time of Substantial Completion.

END OF SECTION 05 52 13

SECTION 05 70 00

DECORATIVE METAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

1. Decorative metal elements indicated

B. Related Sections:

1. Section 055000 "Metal Fabrications" for non-decorative metal fabrications.
2. Section 057300 "Decorative Metal Railings" for decorative metal railings.
3. Section 057500 "Decorative Formed Metal" for decorative metal items made from sheet metal.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated, including finishing materials.

B. Shop Drawings: Show fabrication and installation details for decorative metal.

1. Include plans, elevations, component details, and attachments to other work.
2. Indicate materials and profiles of each decorative metal member, fittings, joinery, finishes, fasteners, anchorages, and accessory items.

C. Patterns, Models, or Plaster Castings: Made from proposed patterns for each design of custom casting required.

D. Samples for Verification: For each type of exposed finish required.

1. Sections of linear shapes.
2. Full-size Samples of castings and forgings.
3. Samples of joints showing quality of workmanship and color matching of materials where applicable.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified fabricator; finisher/finish applicator.

B. Mill Certificates: Signed by manufacturers of stainless-steel certifying that products furnished comply with requirements.

C. Welding certificates.

1.5 QUALITY ASSURANCE

A. Fabricator Qualifications: A firm experienced in producing decorative metal similar to that indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.

B. Installer Qualifications: Fabricator of products.

C. Organic-Coating Applicator Qualifications: A firm experienced in successfully applying organic coatings, of type indicated, to aluminum extrusions and employing competent control personnel to conduct continuing, effective quality-control program to ensure compliance with requirements.

D. Anodic Finisher Qualifications: A firm experienced in successfully applying anodic finishes of type indicated and employing competent control personnel to conduct continuing, effective quality-control program to ensure compliance with requirements.

E. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
3. AWS D1.3, "Structural Welding Code - Sheet Steel."
4. AWS D1.6, "Structural Welding Code - Stainless Steel."

F. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.

1. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store decorative metal in a well-ventilated area, away from uncured concrete and masonry, and protected from weather, moisture, soiling, abrasion, extreme temperatures, and humidity.

B. Deliver and store cast-metal products in wooden crates surrounded by sufficient packing material to ensure that products will not be cracked or otherwise damaged.

1.7 PROJECT CONDITIONS

A. Field Measurements: Verify actual locations of walls and other construction contiguous with decorative metal by field measurements before fabrication and indicate measurements on Shop Drawings.

1.8 COORDINATION

A. Coordinate installation of anchorages for decorative metal items. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

PART 2 - PRODUCTS

2.1 METALS, GENERAL

A. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. Provide materials without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.

2.2 ALUMINUM

A. Aluminum, General: Provide alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with strength and durability properties for each aluminum form required not less than that of alloy and temper designated below.

B. Extruded Bars and Shapes: ASTM B 221 (ASTM B 221M), Alloy 6063-T5/T52.

C. Extruded Structural Pipe and Round Tubing: ASTM B 429/B 429M, Alloy 6063-T6.

D. Drawn Seamless Tubing: ASTM B 210 (ASTM B 210M) or ASTM B 483/B 483M, Alloy 6063-T832.

E. Plate and Sheet: ASTM B 209 (ASTM B 209M), Alloy 5005-H32.

F. Die and Hand Forgings: ASTM B 247 (ASTM B 247M), Alloy 6061-T6.

G. Castings: ASTM B 26/B 26M, Alloy A356.0-T6.

2.3 STAINLESS STEEL

A. Tubing: ASTM A 554, Grade MT 304.

B. Pipe: ASTM A 312/A 312M, Grade TP 304.

C. Castings: ASTM A 743/A 743M, Grade CF 8 or CF 20.

D. Sheet, Strip, Plate, and Flat Bar: ASTM A 666, Type 304.

E. Bars and Shapes: ASTM A 276, Type 304.

F. Wire Rope and Fittings:

1. Wire Rope: ASTM A 492, Type 316.
2. Wire-Rope Fittings: Connectors of types indicated, fabricated from stainless steel, and with capability to sustain, without failure, a load equal to minimum breaking strength of wire rope with which they are used.

2.4 STEEL AND IRON

A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Tubing: ASTM A 500 (cold formed) or ASTM A 513, Type 5 (mandrel drawn).

C. Bars: Hot-rolled, carbon steel complying with ASTM A 29/A 29M, Grade 1010.

D. Plates, Shapes, and Bars: ASTM A 36/A 36M.

E. Cast Iron: Either gray iron, ASTM A 48/A 48M, or malleable iron, ASTM A 47/A 47M unless otherwise indicated.

F. Steel Sheet, Cold Rolled: ASTM A 1008/A 1008M, either commercial steel or structural steel, exposed.

2.5 FASTENERS

A. Fastener Materials: Unless otherwise indicated, provide the following:

1. Aluminum Items: Type 304 stainless-steel fasteners.
2. Stainless-Steel Items: Type 304 stainless-steel fasteners.
3. Uncoated-Steel Items: Plated steel fasteners complying with ASTM B 633, Class Fe/Zn 25 for electrodeposited zinc coating where concealed, Type 304 stainless-steel fasteners where exposed.
4. Galvanized-Steel Items: Plated steel fasteners complying with ASTM B 633, Class Fe/Zn 25 for electrodeposited zinc coating.
5. Dissimilar Metals: Type 304 stainless-steel fasteners.

B. Fasteners for Anchoring to Other Construction: Unless otherwise indicated, select fasteners of type, grade, and class required to produce connections suitable for anchoring indicated items to other types of construction indicated.

C. Provide concealed fasteners for interconnecting components and for attaching decorative metal items to other work unless exposed fasteners are unavoidable.

1. Provide tamper-resistant flat-head machine screws for exposed fasteners unless otherwise indicated.

D. Anchors, General: Anchors capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E 488, conducted by a qualified independent testing agency.

E. Post-Installed Anchors: Chemical type.

1. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B 633 or ASTM F 1941 (ASTM F 1941M), Class Fe/Zn 5 unless otherwise indicated.
2. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy Group 1 (A1) stainless-steel bolts, ASTM F 593 (ASTM F 738M), and nuts, ASTM F 594 (ASTM F 836M).

2.6 MISCELLANEOUS MATERIALS

A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

1. For aluminum, provide type and alloy as recommended by producer of metal to be welded and as required for color match, strength, and compatibility in fabricated items.

B. Etching Cleaner for Galvanized Metal: Complying with MPI#25.

C. Low-Emitting Paints and Coatings: Paints and coatings applied to interior decorative metal items shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.

E. Shop Primers: Provide primers that comply with Section 099600 "High-Performance Coatings."

F. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.7 FABRICATION, GENERAL

A. Assemble items in the shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Use connections that maintain structural value of joined pieces.

B. Make up wire-rope assemblies in the shop to field-measured dimensions with fittings machine swaged. Minimize amount of turnbuckle take-up used for dimensional adjustment so maximum amount is available for tensioning wire ropes. Tag wire-rope assemblies and fittings to identify installation locations and orientations for coordinated installation.

C. Form decorative metal to required shapes and sizes, true to line and level with true curves and accurate angles and surfaces. Finish exposed surfaces to smooth, sharp, well-defined lines and arris.

D. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing the Work.

E. Form simple and compound curves in bars, pipe, tubing, and extruded shapes by bending members in jigs to produce uniform curvature for each configuration required; maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces.

F. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.

G. Mill joints to a tight, hairline fit. Cope or miter corner joints. Fabricate connections that will be exposed to weather in a manner to exclude water.

H. Provide weep holes where water may accumulate. Locate weep holes in inconspicuous locations.

I. Provide necessary rebates, lugs, and brackets to assemble units and to attach to other work. Cut, reinforce, drill, and tap as needed to receive finish hardware, screws, and similar items unless otherwise indicated.

J. Comply with AWS for recommended practices in shop welding. Weld behind finished surfaces without distorting or discoloring exposed side. Clean exposed welded joints of flux, and dress exposed and contact surfaces.

1. Where welding cannot be concealed behind finished surfaces, finish joints to comply with NOMMA's "Voluntary Joint Finish Standards" for Type 1 Welds: no evidence of a welded joint.

K. Provide castings that are sound and free of warp, cracks, blowholes, or other defects that impair strength or appearance. Grind, wire brush, sandblast, and buff castings to remove seams, gate marks, casting flash, and other casting marks.

2.8 FINISHES, GENERAL

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

2.9 ALUMINUM FINISHES

A. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

B. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm (exterior surfaces); AA-M12C22A31, Class II, 0.010 mm (interior surfaces); or thicker.

C. Color Anodic Finish: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm (exterior surfaces); AA-M12C22A32/A34, Class II, 0.010 mm (interior surfaces); or thicker.

D. High-Performance Organic Coating Finish: AA-C12C42R1x and the following:

1. Polyvinylidene fluoride finish coating containing not less than 70 percent of "Kynar 500" or "Hylar 5000" fluorocarbon resin specially formulated for spray application to extrusions and preformed aluminum metal shapes. Coating films shall be uniform and visibly free from flow lines, streaks, blisters, sags or other surface imperfections in the dry-film state on all surfaces.

a. Metal Preparation and Pretreatment: Pretreatment of aluminum surface and application of the finish shall be performed under specifications issued by the licensed formulator to approved applicator and the following as a minimum:

1) The products used to form the chemical conversion coating on aluminum extrusions shall conform with ASTM D 1730, Type B, Method 5 (Amorphous Chromium Phosphate Treatment) or Method 7 (Amorphous Chromate Treatment).

a) All aluminum framing surfaces indicated to receive structural glazing compounds shall be amorphous chromate phosphate wash-coat pretreatment; (a.k.a. Alodine treated) as a minimum; mill finishes are prohibited.

2) The coating weight of the chemical conversion coating shall be a minimum of 40 mg. per ft.^{2} on exposed surfaces as specified in ASTM B 449, Section 6, Class I. Processing shall conform with that specified in ASTM B 449, Section 5.

b. Thickness:

1) Fluoropolymer 2-Coat Coating System: Minimum 1.2 mil total dry film thickness (0.25 mil primer +/- 0.05 mil and 1.0 mil topcoat).
2) Fluoropolymer 3-Coat Coating System: Minimum 1.6 mil total dry film thickness (0.25 mil primer +/- 0.05 mil and 1.35 mil topcoat).

c. Coating Performance Criteria: Meets or exceeding AAMA 2605.

1) Two Coat, Mica Flake System; one of the following:

a) PPG Industries; Duranar Sunstorm.
b) Valspar, Inc.; Fluropon Classic II.

2) Three Coat, Opaque System; one of the following:

a) PPG Industries; Duranar XL.
b) Valspar, Inc.; Fluropon Classic.

2. Colors: As indicated by reference to manufacturer's designations.

2.10 STAINLESS-STEEL FINISHES

A. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.

B. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.

1. Run grain of directional finishes with long dimension of each piece.

C. Bright, Cold-Rolled, Unpolished Finish: No. 2B.

D. Directional Satin Finish: No. 4.

E. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

2.11 STEEL AND IRON FINISHES

A. Galvanizing: Hot-dip galvanize products made from rolled, pressed, and forged steel shapes, castings, plates, bars, and strips indicated to be galvanized to comply with ASTM A 123/A 123M.

1. Hot-dip galvanize steel and iron hardware indicated to be galvanized to comply with ASTM A 153/A 153M.
2. Do not quench or apply post-galvanizing treatments that might interfere with paint adhesion.
3. Fill vent and drain holes that will be exposed in finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.

B. Preparing Galvanized Items for Shop Priming: After galvanizing, thoroughly clean decorative metal of grease, dirt, oil, flux, and other foreign matter, and treat with etching cleaner.

C. Preparing Nongalvanized Items for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with coating manufacturer's recommendations, but no less than SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."

D. Primer Application: Apply shop primer to prepared surfaces of items unless otherwise indicated. Comply with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Primer need not be applied to surfaces to be embedded in concrete or masonry.

1. Shop prime uncoated ferrous-metal surfaces with primers specified in Section 099600 "High-Performance Coatings".
2. Do not apply primer to galvanized surfaces.

E. Shop-Painted Finish: Comply with Section 099600 "High-Performance Coatings."

1. Color: As indicated by manufacturer's designations.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of decorative metal.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Provide anchorage devices and fasteners where needed to secure decorative metal to in-place construction.

B. Perform cutting, drilling, and fitting required to install decorative metal. Set products accurately in location, alignment, and elevation, measured from established lines and levels. Provide temporary bracing or anchors in formwork for items to be built into concrete, masonry, or similar construction.

C. Fit exposed connections accurately together to form tight, hairline joints or, where indicated, uniform reveals and spaces for sealants and joint fillers. Where cutting, welding, and grinding are required for proper shop fitting and jointing of decorative metal, restore finishes to eliminate evidence of such corrective work.

D. Do not cut or abrade finishes that cannot be completely restored in the field. Return items with such finishes to the shop for required alterations, followed by complete refinishing, or provide new units as required.

E. Install concealed gaskets, joint fillers, insulation, and flashings as work progresses.

F. Restore protective coverings that have been damaged during shipment or installation. Remove protective coverings only when there is no possibility of damage from other work yet to be performed at same location.

1. Retain protective coverings intact; remove coverings simultaneously from similarly finished items to preclude nonuniform oxidation and discoloration.

G. Field Welding: Comply with applicable AWS specification for procedures of manual shielded metal arc welding and requirements for welding and for finishing welded connections in "Fabrication, General"

Article. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations.

H. Corrosion Protection: Coat concealed surfaces of aluminum that will be in contact with grout, concrete, masonry, wood, or dissimilar metals, with a heavy coat of bituminous paint.

3.3 CLEANING AND PROTECTION

A. Unless otherwise indicated, clean metals by washing thoroughly with clean water and soap, rinsing with clean water, and drying with soft cloths.

B. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Section 099600 "High-Performance Coatings."

C. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780.

D. Protect finishes of decorative metal from damage during construction period with temporary protective coverings approved by decorative metal fabricator. Remove protective covering at time of Substantial Completion.

E. Restore finishes damaged during installation and construction period so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit, or provide new units.

END OF SECTION 05 70 00

SECTION 05 7300

DECORATIVE METAL RAILINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Glass- supported railings.
2. Glass- supported railings serving as partial- height sound walls at roof deck.

1.2 DEFINITIONS

A. Railings: Guards, handrails, and similar devices used for protection of occupants at open-sided floor areas, pedestrian guidance and support, visual separation, or wall or wind protection.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design railings, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. General: In engineering railings to withstand structural loads indicated, determine allowable design working stresses of railing materials based on the following:

1. Stainless Steel: 60 percent of minimum yield strength.
2. Steel: 72 percent of minimum yield strength.
3. Glass: 25 percent of mean modulus of rupture (50 percent probability of breakage), as listed in "Mechanical Properties" in AAMA's Aluminum Curtain Wall Series No. 12, "Structural Properties of Glass."

C. Structural Performance: Railings shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:

1. Handrails and Top Rails of Guards:

   a. Uniform load of 50 lbf/ft. (0.73 kN/m) applied in any direction.
   b. Concentrated load of 200 lbf (0.89 kN) applied in any direction.
   c. Uniform and concentrated loads need not be assumed to act concurrently.

2. Infill of Guards:

   a. Concentrated load of 50 lbf (0.22 kN) applied horizontally on an area of 1 sq. ft. (0.093 sq. m).
   b. Infill load and other loads need not be assumed to act concurrently.

3. Glass-Supported Railings: Support each section of top rail by a minimum of three glass panels or by other means so top rail will remain in place if any one panel fails.

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes acting on exterior metal fabrications by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

E. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:

1. Manufacturer's product lines of railings assembled from standard components.
2. Grout, anchoring cement, and paint products.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

C. Samples for Verification: For each type of exposed finish required.

1. Sections of each distinctly different linear railing member.
2. Each type of glass required.
3. Fittings and brackets.
4. Welded connections.
5. Assembled Samples of railing systems, made from full-size components, including top rail, post, handrail, and infill. Show method of finishing members at intersections. Samples need not be full height.

D. Delegated-Design Submittal: For installed products indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified professional engineer .

B. Mill Certificates: Signed by manufacturers of stainless-steel products certifying that products furnished comply with requirements.

C. Welding certificates.

D. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, according to ASTM E 894 and ASTM E 935.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of railing from single source from single manufacturer.

B. Product Options: Information on Drawings and in Specifications establishes requirements for system's aesthetic effects and performance characteristics. Aesthetic effects are indicated by dimensions, arrangements, alignment, and profiles of components and assemblies as they relate to sightlines, to one another, and to adjoining construction. Performance characteristics are indicated by criteria subject to verification by one or more methods including structural analysis, preconstruction testing, field testing, and in-service performance.

1. Do not modify intended aesthetic effects, as judged solely by Architect, except with Architect's approval. If modifications are proposed, submit comprehensive explanatory data to Architect for review.

C. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.6, "Structural Welding Code - Stainless Steel."

D. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.

1. Build mockups for each form and finish of railing consisting of two glass panels, top rail, and anchorage system components that are full height and are not less than 24 inches (600 mm) in length.
2. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

E. Preinstallation Conference: Conduct conference at Project site .

1.7 PROJECT CONDITIONS

A. Field Measurements: Verify actual locations of walls and other construction contiguous with railings by field measurements before fabrication and indicate measurements on Shop Drawings.

1.8 COORDINATION AND SCHEDULING

A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.

B. Coordinate installation of anchorages for railings. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

C. Schedule installation so wall attachments are made only to completed walls. Do not support railings temporarily by any means that do not suit structural performance requirements.

PART 2 - PRODUCTS

2.1 METALS, GENERAL

A. Metal Surfaces, General: Provide materials with smooth surfaces, without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.

B. Anchors: Same metal and finish as supported rails unless otherwise indicated.

2.2 STAINLESS STEEL

A. Castings: ASTM A 743/A 743M, Grade CF 8 or CF 20.

B. Sheet, Strip, Plate, and Flat Bar: ASTM A 666, Type 304.

C. Bars and Shapes: ASTM A 276, Type 304.

2.3 STEEL AND IRON

A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Bars: Hot-rolled, carbon steel complying with ASTM A 29/A 29M, Grade 1010.

C. Plates, Shapes, and Bars: ASTM A 36/A 36M.

D. Cast Iron: Either gray iron, ASTM A 48/A 48M, or malleable iron, ASTM A 47/A 47M, unless otherwise indicated.

2.4 GLASS AND GLAZING MATERIALS

A. Laminated Glass: ASTM C 1172, Condition A (uncoated), Type I (transparent flat glass), Quality-Q3 with two plies of glass and polyvinyl butyral interlayer of thickness required by performance requirements.

1. Kind: LT (laminated tempered) .
2. Glass Color: Clear .
3. Interlayer Color and Pattern: Match Architect's sample, unless otherwise indicated.
4. Glass Plies for Structural Glass Balusters: As indicated, but no less than thickness required by structural loads.

B. Glazing Cement and Accessories for Structural Glazing: Glazing cement, setting blocks, shims, and related accessories as recommended or supplied by railing manufacturer for installing structural glazing in metal subrails.

1. Glazing Cement: Nonshrinking organic cement designed for curing by passing an electric current through metal subrail holding glass panel, as standard with manufacturer.

C. Glass Assemblies:

1. Glass- supported railings:

   a. Inner and Outer Plies: 1/4-inch ultra-clear (low iron) glass, clear, tempered.
   b. Interlayer: SGP, 0.60-inch, clear.

2. Glass- supported railings serving as partial- height sound walls at roof deck:

   a. Inner and Outer Plies: 3/8-inch ultra-clear (low iron) glass, clear, tempered.
   b. Interlayer: SGP, 0.60-inch, clear.
   c. Decorative Frit: Outer (No. 1) surface, with clear overcoating; Viracon V-1086 Simulated Sandblast Frit.

2.5 FASTENERS

A. Fastener Materials: Unless otherwise indicated, provide the following:

1. Stainless-Steel Components: Type 304 stainless-steel fasteners.
2. Galvanized-Steel Components: Plated-steel fasteners complying with ASTM B 633, Class Fe/Zn 25 for electrodeposited zinc coating.
3. Dissimilar Metals: Type 304 stainless-steel fasteners.

B. Fasteners for Anchoring to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings to other types of construction indicated and capable of withstanding design loads.

C. Provide concealed fasteners for interconnecting railing components and for attaching railings to other work unless otherwise indicated .

D. Anchors, General: Anchors capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E 488, conducted by a qualified independent testing agency.

2.6 MISCELLANEOUS MATERIALS

A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

B. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.

C. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout specifically recommended by manufacturer for interior and exterior applications.

D. Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with water at Project site to create pourable anchoring, patching, and grouting compound.

1. Water-Resistant Product: At exterior locations provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating and that is recommended by manufacturer for exterior use.

2.7 FABRICATION

A. General: Fabricate railings to comply with requirements indicated for design, dimensions, member sizes and spacing, details, finish, and anchorage, but not less than that required to support structural loads.

B. Assemble railings in the shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Use connections that maintain structural value of joined pieces.

C. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.

D. Form work true to line and level with accurate angles and surfaces.

E. Fabricate connections that will be exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate. Locate weep holes in inconspicuous locations.

F. Cut, reinforce, drill, and tap as indicated to receive finish hardware, screws, and similar items.

G. Welded Connections: Cope components at connections to provide close fit, or use fittings designed for this purpose. Weld all around at connections, including at fittings.

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove flux immediately.
4. At exposed connections, finish exposed welds to comply with NOMMA's "Voluntary Joint Finish Standards" for Type 1 welds: no evidence of a welded joint.

H. Mechanical Connections: Connect members with concealed mechanical fasteners and fittings. Fabricate members and fittings to produce flush, smooth, rigid, hairline joints.

1. Fabricate splice joints for field connection using an epoxy structural adhesive if this is manufacturer's standard splicing method.

I. Provide inserts and other anchorage devices for connecting railings to concrete or masonry work. Fabricate anchorage devices capable of withstanding loads imposed by railings. Coordinate anchorage devices with supporting structure.

2.8 GLAZING PANEL FABRICATION

A. General: Fabricate to sizes and shapes required; provide for proper edge clearance and bite on glazing panels.

1. Clean-cut or flat-grind edges at butt-glazed sealant joints to produce square edges with slight chamfers at junctions of edges and faces
2. Grind smooth exposed edges, including those at open joints, to produce square edges with slight chamfers at junctions of edges and faces.

B. Structural Glass Balusters: Factory-bond glass to stainless steel base and top-rail channels in railing manufacturer's plant using glazing cement to comply with manufacturer's written specifications, unless field glazing is standard with manufacturer.

C. Structural Balusters: Provide laminated, tempered glass panels.

2.9 GENERAL FINISH REQUIREMENTS

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipment.

C. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.10 STAINLESS-STEEL FINISHES

A. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.

B. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.

1. Run grain of directional finishes with long dimension of each piece.

C. Directional Satin Finish: No. 4.

D. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Fit exposed connections together to form tight, hairline joints.

B. Perform cutting, drilling, and fitting required for installing railings. Set railings accurately in location, alignment, and elevation; measured from established lines and levels and free of rack.

1. Do not weld, cut, or abrade surfaces of railing components that have been coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.
2. Align rails so variations from level for horizontal members and variations from parallel with rake of steps and ramps for sloping members do not exceed 1/4 inch in 12 feet (5 mm in 3 m).

C. Adjust railings before anchoring to ensure matching alignment at abutting joints.

3.2 RAILING CONNECTIONS

A. Nonwelded Connections: Use mechanical or adhesive joints for permanently connecting railing components. Use wood blocks and padding to prevent damage to railing members and fittings. Seal recessed holes of exposed locking screws using plastic cement filler colored to match finish of railings.

B. Welded Connections: Use fully welded joints for permanently connecting railing components. Comply with requirements for welded connections in "Fabrication" Article whether welding is performed in the shop or in the field.

C. Expansion Joints: Install expansion joints at locations indicated but not farther apart than required to accommodate thermal movement. Provide slip-joint internal sleeve extending 2 inches (50 mm) beyond joint on either side, fasten internal sleeve securely to one side, and locate joint within 6 inches (150 mm) of post.

3.3 INSTALLING GLASS PANELS

A. Glass-Supported Railings: Install assembly to comply with railing manufacturer's written instructions.

1. Attach base channel to building structure, then insert and connect factory-fabricated and -assembled glass panels if glass was bonded to base and top rail channels in factory.

2. Attach base channel to building structure, then insert glass into base channel and bond with glazing cement unless glass was bonded to base and top rail channels in factory.

    a. Support glass panels in base channel at quarter points with channel-shaped setting blocks that also act as shims to maintain uniform space for glazing cement. Fill remaining space in base channel with glazing cement for uniform support of glass.

3. Adjust spacing of glass panels so gaps between panels are equal before securing in position.
4. Erect glass railings under direct supervision of manufacturer's authorized technical personnel.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner may engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports. Payment for these services will be made by Owner .

B. Extent and Testing Methodology: Testing agency will randomly select completed railing assemblies for testing that are representative of different railing designs and conditions in the completed Work. Railings will be tested according to ASTM E 894 and ASTM E 935 for compliance with performance requirements.

C. Remove and replace railings where test results indicate that they do not comply with specified requirements unless they can be repaired in a manner satisfactory to Architect and will comply with specified requirements.

D. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.5 CLEANING

A. Clean stainless steel by washing thoroughly with clean water and soap, rinsing with clean water, and wiping dry.

B. Clean and polish glass as recommended in writing by manufacturer. Wash both exposed surfaces in each area of Project not more than four days before date scheduled for inspections that establish date of Substantial Completion.

3.6 PROTECTION

A. Protect finishes of railings from damage during construction period with temporary protective coverings approved by railing manufacturer. Remove protective coverings at time of Substantial Completion.

B. Restore finishes damaged during installation and construction period so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit, or provide new units.

END OF SECTION 05 7300

SECTION 05 75 00

DECORATIVE FORMED METAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Closures and trim.
2. Filler panels between dissimilar construction.
3. Metal base.
4. Pockets for window treatment.
5. Perforated exterior formed-metal-shaped panels.
6. Other shapes indicated.

B. Related Requirements:

1. Section 05 70 00 "Decorative Metal" for decorative items made primarily from plate, bars, extrusions, tubes, castings, and other forms of metal, but which may include sheet metal components.
2. Section 07 71 13 "Premanufactured Coping and Edge Systems" for items made of formed metal for parapets and copings.

1.3 COORDINATION

A. Coordinate installation of anchorages for decorative formed metal items. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver items to Project site in time for installation.

B. Coordinate installation of decorative formed metal with adjacent construction to ensure that wall assemblies, flashings, trim, and joint sealants, are protected against damage from the effects of weather, age, corrosion, and other causes of deterioration.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including finishing materials.

B. Shop Drawings: Show fabrication and installation details for decorative formed metal.

1. Include plans, elevations, component details, and attachment details.
2. Indicate materials and profiles of each decorative formed metal member, fittings, joinery, finishes, fasteners, anchorages, and accessory items.

C. Samples for Verification: For each type of exposed finish required, prepared on 6-inch- (150-mm-) square Samples of metal of same thickness and material indicated for the Work.

D. Delegated-Design Submittal: For installed products indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: For decorative formed metal elements that house items specified in other Sections. Show dimensions of housed items, including locations of housing penetrations and attachments, and necessary clearances.

B. Qualification Data: For Installer; fabricator; finish applicator/finisher; and professional engineer.

C. Evaluation Reports: For post-installed anchors, from ICC-ES.

1.6 QUALITY ASSURANCE

A. Fabricator Qualifications: A firm experienced in producing decorative formed metal similar to that indicated for this Project and with a record of successful in-service performance as well as sufficient production capacity to produce required units.

B. Organic-Coating Applicator Qualifications: A firm experienced in successfully applying organic coatings of type indicated to metals of types indicated and that employs competent control personnel to conduct continuing, effective quality-control program to ensure compliance with requirements.

C. Anodic Finisher Qualifications: A firm experienced in successfully applying anodic finishes of type indicated and that employs competent control personnel to conduct continuing, effective quality-control program to ensure compliance with requirements.

D. Installer Qualifications: Fabricator of products.

E. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for fabrication and installation.

1. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver decorative formed metal products wrapped in protective coverings and strapped together in suitable packs or in heavy-duty cartons. Remove protective coverings before they stain or bond to finished surfaces.

B. Store products on elevated platforms in a dry location.

1.8 FIELD CONDITIONS

A. Field Measurements: Verify actual locations of walls, columns, beams, and other construction contiguous with decorative formed metal by field measurements before fabrication and indicate measurements on Shop Drawings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 40 00 "Quality Requirements," to design decorative formed metal, including attachment to building construction.

B. Structural Performance: Decorative formed metal items, including anchors and connections, shall withstand the effects of gravity loads and the following loads and stresses without exceeding the allowable design working stress of materials involved and without exhibiting permanent deformation in any components:

1. Wind Loads on Exterior Items: As indicated on Drawings.

C. Seismic Performance: Exterior decorative formed metal items, including anchors and connections, shall withstand the effects of earthquake motions determined according to California Building Code (CBC).

1. Component Importance Factor: 1.0.

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes acting on exterior metal fabrications by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 SHEET METAL

A. General: Fabricate products from sheet metal without pitting, seam marks, roller marks, stains, discolorations, or other imperfections where exposed to view on finished units.

B. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

C. Aluminum Sheet: Flat sheet complying with ASTM B 209 (ASTM B 209M), alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with strength and durability properties of not less than Alloy 5005-H32.

D. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90 (Z275) coating, either commercial steel or forming steel.

E. Steel Sheet: Uncoated, cold-rolled, ASTM A 1008/A 1008M, commercial steel, exposed or electrolytic zinc-coated, ASTM A 879/A 879M, with steel sheet substrate complying with ASTM A 1008/A 1008M, commercial steel, exposed.

F. Stainless-Steel Sheet: ASTM A 240/A 240M or ASTM A 666, Type 304, stretcher-leveled standard of flatness.

2.3 MISCELLANEOUS MATERIALS

A. Gaskets: As required to seal joints in decorative formed metal and remain airtight (interior) or weathertight (exterior); as recommended in writing by decorative formed metal manufacturer.

1. ASTM D 1056, Type 1, Class A, grade as recommended by gasket manufacturer to obtain seal for application indicated.

B. Sealants, Exterior: ASTM C 920; elastomeric silicone sealant; of type, grade, class, and use classifications required to seal joints in decorative formed metal and remain weathertight; and as recommended in writing by decorative formed metal manufacturer.

C. Sealants, Interior: Nonsag, paintable, nonstaining, latex sealant complying with ASTM C 834; of type and grade required to seal joints in decorative formed metal; and as recommended in writing by decorative formed metal manufacturer.

1. Sealants shall have a VOC content of not more than 250 g/L when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Sealants shall comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Department of Health Services') "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

D. Filler Metal and Electrodes: Provide type and alloy of filler metal and electrodes as recommended by producer of metal to be welded or brazed and as necessary for strength, corrosion resistance, and compatibility in fabricated items.

1. Use filler metals that will match the color of metal being joined and will not cause discoloration.

E. Fasteners: Fabricated from same basic metal and alloy as fastened metal unless otherwise indicated. Do not use metals that are incompatible with materials joined.

1. Provide concealed fasteners for interconnecting decorative formed metal items and for attaching them to other work unless exposed fasteners are unavoidable or are the standard fastening method.
2. Provide tamper-resistant flat-head machine screws for exposed fasteners unless otherwise indicated.

F. Structural Anchors: For applications indicated to comply with certain design loads, provide fastener systems with working capacity greater than or equal to the design load, according to an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC193 or ICC-ES AC308.

G. Nonstructural Anchors: For applications not indicated to comply with design loads, provide fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC193 or ICC-ES AC308.

H. Anchor Materials:

1. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B 633 or ASTM F 1941 (ASTM F 1941M), Class Fe/Zn 5, unless otherwise indicated.
2. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy Group 1 (A1) stainless-steel bolts, ASTM F 593 (ASTM F 738M), and nuts, ASTM F 594 (ASTM F 836M).

I. Sound-Deadening Materials:

1. Insulation: Unfaced, mineral-fiber blanket insulation complying with ASTM C 665, Type I, and passing ASTM E 136 test.
2. Mastic: Cold-applied asphalt emulsion complying with ASTM D 1187/D 1187M.

J. Backing Materials: Provided or recommended by decorative formed metal manufacturer.

K. Laminating Adhesive: Adhesive recommended by metal fabricator that will fully bond metal to metal, will prevent telegraphing and oil-canning, and is compatible with substrate and noncombustible after curing.

1. Contact Adhesive: VOC content of not more than 80 g/L when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Metal-to-Metal Adhesive: VOC content of not more than 30 g/L when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Multipurpose Construction Adhesive: VOC content of not more than 70 g/L when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
4. Special-Purpose Contact Adhesive: (Contact adhesive used to bond melamine-covered board, metal, unsupported vinyl, ultrahigh molecular weight polyethylene, and rubber or wood veneer, 1/16 inch thick or less, to any surface): 250 g/L.
5. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Department of Health Services') "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

L. Isolation Coating: Manufacturer's standard epoxy coating.

1. Coating shall comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Department of Health Services') "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.4 PAINTS AND COATINGS

A. Low-Emitting Materials: Paints and coatings applied to interior decorative formed metal items shall comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Department of Health Services') "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. Etching Cleaner for Galvanized Metal: Complying with MPI#25.

C. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.

D. Shop Primers: Comply with Section 09 96 00 "High-Performance Coatings."

E. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187/D 1187M.

2.5 FABRICATION, GENERAL

A. Shop Assembly: Preassemble decorative formed metal items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

B. Coordinate dimensions and attachment methods of decorative formed metal items with those of adjoining construction to produce integrated assemblies with closely fitting joints and with edges and surfaces aligned unless otherwise indicated.

C. Form metal to profiles indicated, in maximum lengths to minimize joints. Produce flat, flush surfaces without cracking or grain separation at bends. Fold back exposed edges of unsupported sheet metal to form a 1/2-inch- (12-mm-) wide hem on the concealed side, or ease edges to a radius of approximately 1/32 inch (1 mm) and support with concealed stiffeners.

D. Increase metal thickness or reinforce with concealed stiffeners, backing materials, or both, as needed to provide surface flatness equivalent to stretcher-leveled standard of flatness and sufficient strength for indicated use.

   1. Support joints with concealed stiffeners as needed to hold exposed faces of adjoining sheets in flush alignment.

E. Build in straps, plates, and brackets as needed to support and anchor fabricated items to adjoining construction. Reinforce decorative formed metal items as needed to attach and support other construction.

F. Provide support framing, mounting and attachment clips, splice sleeves, fasteners, and accessories needed to install decorative formed metal items.

G. Where welding or brazing is indicated, weld or braze joints and seams continuously. Grind, fill, and dress to produce smooth, flush, exposed surfaces in which joints are not visible after finishing is completed.

   1. Use welding and brazing procedures that will blend with and not cause discoloration of metal being joined.

2.6 CLOSURES AND TRIM

A. Form closures and trim from metal of type and thickness indicated. Fabricate to fit tightly to adjoining construction, with weathertight joints at exterior installations.

   1. Closures and trim may be fabricated from prefinished metal sheet in lieu of finishing after fabrication provided unfinished edges are concealed from view and not exposed to weather.

B. Conceal fasteners where possible; otherwise, locate where they are as inconspicuous as possible. Size fasteners to support closures and trim, with fasteners spaced to prevent buckling or waviness in finished surfaces.

C. Drill and tap holes needed for securing closures and trim to other surfaces.

D. Incorporate gaskets where indicated or needed for concealed, continuous seal at abutting surfaces.

E. Miter or cope trim members at corners and reinforce with bent metal splice plates to form tight joints.

2.7 FILLER PANELS

A. Form filler panels for closing ends of partition systems and for other applications indicated. Form from two sheets of metal of type and thickness matching adjacent panels, separated by channels formed from the same material, producing a panel of same thickness as filled materials unless otherwise indicated. Incorporate reveals, trim, and concealed anchorages for attaching to adjacent surfaces.

1. Filler panels may be fabricated from prefinished metal sheet in lieu of finishing after fabrication provided unfinished edges are concealed from view.

B. Fill interior of panel with sound-deadening insulation permanently attached to inside panel faces.

2.8 METAL BASE

A. Form metal base from metal of type and thickness indicated.

2.9 POCKETS FOR WINDOW TREATMENT

A. Form pockets from metal of type and thickness indicated, with end closures. Coordinate dimensions and attachment methods with window treatment equipment, window frames, ceiling suspension system, and other related construction to produce a coordinated, closely fitting assembly.

1. Pockets for window treatment may be fabricated from prefinished metal sheet in lieu of finishing after fabrication provided unfinished edges are concealed from view.

B. Reinforce pockets for attaching window treatment equipment and hardware or increase metal thickness.

C. Divide continuous pockets with built-in partitions located to separate adjoining drapery and blind units, to coincide with window mullions, and to receive filler panels at ends of partitions.

2.10 PERFORATED EXTERIOR FORMED-METAL-SHAPED PANELS

A. Form shaped panels from metal of type and thickness indicated below. Coordinate size of panels, location of openings, and method of attachment to adjoining construction.

1. Aluminum Sheet: 0.040 inch (1.02 mm).

   a. Finish: High-performance organic coating. Apply finish after all fabrication operations are complete.

   b. Pattern: 51 per cent openness; 0-3/8 inch round perforations spaced 0-1/2 inches apart in a staggered manner approved by Architect.

2.11 GENERAL FINISH REQUIREMENTS

A. Complete mechanical finishes of flat sheet metal surfaces before fabrication where possible. After fabrication, finish all joints, bends, abrasions, and other surface blemishes to match sheet finish.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Apply organic and anodic finishes to formed metal after fabrication unless otherwise indicated.

D. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.12 ALUMINUM FINISHES

A. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

B. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm (exterior surfaces); AA-M12C22A31, Class II, 0.010 mm (interior surfaces); or thicker.

C. Color Anodic Finish: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm (exterior surfaces); AA-M12C22A32/A34, Class II, 0.010 mm (interior surfaces); or thicker.

D. High-Performance Organic Coating Finish: AA-C12C42R1x and the following:

1. Polyvinylidene fluoride finish coating containing not less than 70 percent of "Kynar 500" or "Hylar 5000" fluorocarbon resin specially formulated for spray application to extrusions and preformed aluminum metal shapes. Coating films shall be uniform and visibly free from flow lines, streaks, blisters, sags or other surface imperfections in the dry-film state on all surfaces.

a. Metal Preparation and Pretreatment: Pretreatment of aluminum surface and application of the finish shall be performed under specifications issued by the licensed formulator to approved applicator and the following as a minimum:

1) The products used to form the chemical conversion coating on aluminum extrusions shall conform with ASTM D 1730, Type B, Method 5 (Amorphous Chromium Phosphate Treatment) or Method 7 (Amorphous Chromate Treatment).

a) All aluminum framing surfaces indicated to receive structural glazing compounds shall be amorphous chromate phosphate wash-coat pretreatment; (a.k.a. Alodine treated) as a minimum; mill finishes are prohibited.

2) The coating weight of the chemical conversion coating shall be a minimum of 40 mg. per ft.^{2} on exposed surfaces as specified in ASTM B 449, Section 6, Class I. Processing shall conform with that specified in ASTM B 449, Section 5.

b. Thickness:

1) Fluoropolymer 2-Coat Coating System: Minimum 1.2 mil total dry film thickness (0.25 mil primer +/- 0.05 mil and 1.0 mil topcoat).
2) Fluoropolymer 3-Coat Coating System: Minimum 1.6 mil total dry film thickness (0.25 mil primer +/- 0.05 mil and 1.35 mil topcoat).

c. Coating Performance Criteria: Meets or exceeding AAMA 2605.

1) Two Coat, Mica Flake System; one of the following:

a) PPG Industries; Duranar Sunstorm.

b) Valspar, Inc.; Fluropon Classic II.

2) Three Coat, Opaque System; one of the following:

a) PPG Industries; Duranar XL.
b) Valspar, Inc.; Fluropon Classic.

2. Colors: As indicated by reference to manufacturer's designations.

2.13 STAINLESS-STEEL FINISHES

A. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.

B. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.

1. Run grain of directional finishes with long dimension of each piece.

C. Bright, Cold-Rolled, Unpolished Finish: No. 2B.

D. Directional Satin Finish: No. 4.

E. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

2.14 STEEL AND IRON FINISHES

A. Galvanizing: Hot-dip galvanize products made from rolled, pressed, and forged steel shapes, castings, plates, bars, and strips indicated to be galvanized to comply with ASTM A 123/A 123M.

1. Hot-dip galvanize steel and iron hardware indicated to be galvanized to comply with ASTM A 153/A 153M.
2. Do not quench or apply post-galvanizing treatments that might interfere with paint adhesion.
3. Fill vent and drain holes that will be exposed in finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.

B. Preparing Galvanized Items for Shop Priming: After galvanizing, thoroughly clean decorative metal of grease, dirt, oil, flux, and other foreign matter, and treat with etching cleaner.

C. Preparing Nongalvanized Items for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with coating manufacturer's recommendations, but no less than SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."

D. Primer Application: Apply shop primer to prepared surfaces of items unless otherwise indicated. Comply with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Primer need not be applied to surfaces to be embedded in concrete or masonry.

1. Shop prime uncoated ferrous-metal surfaces with primers specified in Section 099600 "High-Performance Coatings".
2. Do not apply primer to galvanized surfaces.

E. Shop-Painted Finish: Comply with Section 099600 "High-Performance Coatings."

1. Color: As indicated by manufacturer's designations.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of decorative formed metal.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Locate and place decorative formed metal items level and plumb and in alignment with adjacent construction. Perform cutting, drilling, and fitting required to install decorative formed metal.

1. Do not cut or abrade finishes that cannot be completely restored in the field. Return items with such finishes to the shop for required alterations, followed by complete refinishing, or provide new units as required.

B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where needed to protect metal surfaces and to make a weathertight connection.

C. Form tight joints with exposed connections accurately fitted together. Provide reveals and openings for sealants and joint fillers as indicated.

D. Install concealed gaskets, joint fillers, insulation, sealants, and flashings, as the Work progresses, to make exterior decorative formed metal items weatherproof.

E. Install concealed gaskets, joint fillers, sealants, and insulation, as the Work progresses, to make interior decorative formed metal items soundproof or lightproof as applicable to type of fabrication indicated.

F. Corrosion Protection: Apply bituminous paint or other permanent separation materials on concealed surfaces where metals would otherwise be in direct contact with substrate materials that are incompatible or could result in corrosion or deterioration of either material or finish.

G. Install decorative-formed-metal-clad doors and frames to comply with requirements specified in Section 08 11 13 "Hollow Metal Doors and Frames."

3.3 ADJUSTING AND CLEANING

A. Unless otherwise indicated, clean metals by washing thoroughly with water and soap, rinsing with clean water, and drying with soft cloths.

B. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Section 09 96 00 "High-Performance Coatings."

C. Restore finishes damaged during installation and construction period so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit or provide new units.

3.4 PROTECTION

A. Protect finishes of decorative formed metal items from damage during construction period. Remove temporary protective coverings at time of Substantial Completion.

END OF SECTION 05 75 00

SECTION 06 1053

MISCELLANEOUS ROUGH CARPENTRY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Wood blocking and nailers.
2. Wood furring.
3. Plywood backing panels.

B. Related Requirements:

1. Section 061600 "Sheathing."
2. Section 061753 "Shop-Fabricated Wood Trusses."

1.2 DEFINITIONS

A. Lumber grading agencies, and the abbreviations used to reference them, include the following:

1. NLGA: National Lumber Grades Authority.
2. WCLIB: West Coast Lumber Inspection Bureau.
3. WWPA: Western Wood Products Association.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.

1. Include data for wood-preservative treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Indicate type of preservative used and net amount of preservative retained.
2. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Include physical properties of treated materials based on testing by a qualified independent testing agency.
3. For fire-retardant treatments, include physical properties of treated lumber both before and after exposure to elevated temperatures, based on testing by a qualified independent testing agency according to ASTM D 5664.
4. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.
5. Include copies of warranties from chemical treatment manufacturers for each type of treatment.

1.4 INFORMATIONAL SUBMITTALS

A. Evaluation Reports: For the following, from ICC-ES:

1. Preservative-treated wood.
2. Fire-retardant-treated wood.
3. Power-driven fasteners.
4. Powder-actuated fasteners.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: For testing agency providing classification marking for fire-retardant treated material, an inspection agency acceptable to authorities having jurisdiction that periodically performs inspections to verify that the material bearing the classification marking is representative of the material tested.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Stack lumber flat with spacers beneath and between each bundle to provide air circulation. Protect lumber from weather by covering with waterproof sheeting, securely anchored. Provide for air circulation around stacks and under coverings.

PART 2 - PRODUCTS

2.1 WOOD PRODUCTS, GENERAL

A. Certified Wood: **[Lumber]** **[and]** **[plywood]** shall be produced from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship."

B. Lumber: DOC PS 20 and applicable rules of grading agencies indicated. If no grading agency is indicated, provide lumber that complies with the applicable rules of any rules-writing agency certified by the ALSC Board of Review. Provide lumber graded by an agency certified by the ALSC Board of Review to inspect and grade lumber under the rules indicated.

1. Factory mark each piece of lumber with grade stamp of grading agency.
2. Where nominal sizes are indicated, provide actual sizes required by DOC PS 20 for moisture content specified. Where actual sizes are indicated, they are minimum dressed sizes for dry lumber.
3. Provide dressed lumber, S4S, unless otherwise indicated.

C. Maximum Moisture Content of Lumber: 15 percent unless otherwise indicated.

2.2 WOOD-PRESERVATIVE-TREATED MATERIALS

A. Preservative Treatment by Pressure Process: AWPA U1; Use Category UC2 for interior construction not in contact with the ground, Use Category UC3b for exterior construction not in contact with the ground, and Use Category UC4a for items in contact with the ground.

1. Preservative Chemicals: Acceptable to authorities having jurisdiction and containing no arsenic or chromium.
2. For exposed items indicated to receive a stained or natural finish, use chemical formulations that do not require incising, contain colorants, bleed through, or otherwise adversely affect finishes.

B. Kiln-dry lumber after treatment to a maximum moisture content of 19 percent. Do not use material that is warped or does not comply with requirements for untreated material.

C. Mark lumber with treatment quality mark of an inspection agency approved by the ALSC Board of Review.

D. Application: Treat items indicated on Drawings, and the following:

1. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, and waterproofing.
2. Wood sills, sleepers, blocking, furring, and similar concealed members in contact with masonry or concrete.

2.3 FIRE-RETARDANT-TREATED MATERIALS

A. General: Where fire-retardant-treated materials are indicated, use materials complying with requirements in this article, that are acceptable to authorities having jurisdiction, and with fire-test-response characteristics specified as determined by testing identical products per test method indicated by a qualified testing agency.

B. Fire-Retardant-Treated Lumber and Plywood by Pressure Process: Products with a flame spread index of 25 or less when tested according to ASTM E 84, and with no evidence of significant progressive combustion when the test is extended an additional 20 minutes, and with the flame front not extending more than 10.5 feet (3.2 m) beyond the centerline of the burners at any time during the test.

1. Use treatment that does not promote corrosion of metal fasteners.
2. Exterior Type: Treated materials shall comply with requirements specified above for fire-retardant-treated lumber and plywood by pressure process after being subjected to accelerated weathering according to ASTM D 2898. Use for exterior locations and where indicated.
3. Interior Type A: Treated materials shall have a moisture content of 28 percent or less when tested according to ASTM D 3201 at 92 percent relative humidity. Use where exterior type is not indicated.
4. Design Value Adjustment Factors: Treated lumber shall be tested according ASTM D 5664, and design value adjustment factors shall be calculated according to ASTM D 6841.

C. Kiln-dry lumber after treatment to a maximum moisture content of 19 percent. Kiln-dry plywood after treatment to a maximum moisture content of 15 percent.

D. Identify fire-retardant-treated wood with appropriate classification marking of testing and inspecting agency acceptable to authorities having jurisdiction.

E. Application: Treat items indicated on Drawings, and the following:

1. Concealed blocking.
2. Plywood backing panels.

2.4 MISCELLANEOUS LUMBER

A. General: Provide miscellaneous lumber indicated and lumber for support or attachment of other construction, including the following:

1. Blocking.
2. Nailers.
3. Furring.

B. For items of dimension lumber size, provide Construction or No. 2 grade lumber and any of the following species:

1. Western woods; WCLIB or WWPA.

C. For blocking not used for attachment of other construction, Utility, Stud, or No. 3 grade lumber of any species may be used provided that it is cut and selected to eliminate defects that will interfere with its attachment and purpose.

D. For blocking and nailers used for attachment of other construction, select and cut lumber to eliminate knots and other defects that will interfere with attachment of other work.

E. For furring strips for installing plywood or hardboard paneling, select boards with no knots capable of producing bent-over nails and damage to paneling.

2.5 PLYWOOD BACKING PANELS

A. Equipment Backing Panels: DOC PS 1, Exterior, AC , fire-retardant treated, in thickness indicated or, if not indicated, not less than 3/4-inch (19-mm) nominal thickness.

1. Plywood shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.6 FASTENERS

A. General: Provide fasteners of size and type indicated that comply with requirements specified in this article for material and manufacture.

1. Where carpentry is exposed to weather, in ground contact, pressure-preservative treated, or in area of high relative humidity, provide fasteners with hot-dip zinc coating complying with ASTM A 153/A 153M .

B. Nails, Brads, and Staples: ASTM F 1667.

C. Power-Driven Fasteners: NES NER-272.

D. Wood Screws: ASME B18.6.1.

E. Screws for Fastening to Metal Framing: ASTM C 1002 , length as recommended by screw manufacturer for material being fastened.

F. Lag Bolts: ASME B18.2.1 (ASME B18.2.3.8M).

G. Bolts: Steel bolts complying with ASTM A 307, Grade A (ASTM F 568M, Property Class 4.6); with ASTM A 563 (ASTM A 563M) hex nuts and, where indicated, flat washers.

H. Expansion Anchors: Anchor bolt and sleeve assembly of material indicated below with capability to sustain, without failure, a load equal to 6 times the load imposed when installed in unit masonry assemblies and equal to 4 times the load imposed when installed in concrete as determined by testing per ASTM E 488 conducted by a qualified independent testing and inspecting agency.

1. Material: Carbon-steel components, zinc plated to comply with ASTM B 633, Class Fe/Zn 5.

2. Material: Stainless steel with bolts and nuts complying with ASTM F 593 and ASTM F 594, Alloy Group 1 or 2 (ASTM F 738M and ASTM F 836M, Grade A1 or A4).

2.7 MISCELLANEOUS MATERIALS

A. Adhesives for Gluing Furring to Concrete or Masonry: Formulation complying with ASTM D 3498 that is approved for use indicated by adhesive manufacturer.

1. Adhesives shall have a VOC content of [**70**] **<Insert value>** g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Adhesives shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Flexible Flashing: Composite, self-adhesive, flashing product consisting of a pliable, butyl rubber or rubberized-asphalt compound, bonded to a high-density polyethylene film, aluminum foil, or spunbonded polyolefin to produce an overall thickness of not less than 0.025 inch (0.6 mm).

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Set carpentry to required levels and lines, with members plumb, true to line, cut, and fitted. Fit carpentry to other construction; scribe and cope as needed for accurate fit. Locate furring, nailers, blocking, and similar supports to comply with requirements for attaching other construction.

B. Where wood-preservative-treated lumber is installed adjacent to metal decking, install continuous flexible flashing separator between wood and metal decking.

C. Install plywood backing panels by fastening to studs; coordinate locations with utilities requiring backing panels. Install fire-retardant treated plywood backing panels with classification marking of testing agency exposed to view.

D. Provide blocking and framing as indicated and as required to support facing materials, fixtures, specialty items, and trim.

1. Provide metal clips for fastening gypsum board or lath at corners and intersections where framing or blocking does not provide a surface for fastening edges of panels. Space clips not more than 16 inches (406 mm) o.c.

E. Sort and select lumber so that natural characteristics will not interfere with installation or with fastening other materials to lumber. Do not use materials with defects that interfere with function of member or pieces that are too small to use with minimum number of joints or optimum joint arrangement.

F. Comply with AWPA M4 for applying field treatment to cut surfaces of preservative-treated lumber.

1. Use inorganic boron for items that are continuously protected from liquid water.
2. Use copper naphthenate for items not continuously protected from liquid water.

G. Securely attach carpentry work to substrate by anchoring and fastening as indicated, complying with the following:

1. NES NER-272 for power-driven fasteners.
2. Table 2304.9.1, "Fastening Schedule," in ICC's International Building Code.

H. Use steel common nails unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood. Drive nails snug but do not countersink nail heads unless otherwise indicated.

3.2 WOOD BLOCKING AND NAILER INSTALLATION

A. Install where indicated and where required for attaching other work. Form to shapes indicated and cut as required for true line and level of attached work. Coordinate locations with other work involved.

B. Attach items to substrates to support applied loading. Recess bolts and nuts flush with surfaces unless otherwise indicated.

3.3 WOOD FURRING INSTALLATION

A. Install level and plumb with closure strips at edges and openings. Shim with wood as required for tolerance of finish work.

B. Furring to Receive Plywood or Hardboard Paneling: Install 1-by-3-inch nominal-size (19-by-63-mm actual-size) furring vertically at 24 inches (610 mm) o.c.

3.4 PROTECTION

A. Protect wood that has been treated with inorganic boron (SBX) from weather. If, despite protection, inorganic boron-treated wood becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.

B. Protect miscellaneous rough carpentry from weather. If, despite protection, miscellaneous rough carpentry becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.

END OF SECTION 06 1053

SECTION 06 16 00

SHEATHING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Wall sheathing.
2. Sheathing joint and penetration treatment.

B. Related Requirements:

1. Section 06 10 53 "Miscellaneous Rough Carpentry" for plywood backing panels.
2. Section 07 27 27 "Fluid-Applied Membrane Air Barriers" for water-resistive barrier applied over wall sheathing.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.

B. CALgreen Submittals:

1. Product Data for Section 5.504.4.1: For sealants, adhesives and caulks, provide documentation including printed statement of VOC content showing compliance with SCAQMD Rule 1168 VOC limits and CCR Title 17 for aerosols.
2. Product Data for Section 5.504.4.3: For paints and coatings, provide documentation that products comply with VOC limits of Air Resource Board Architectural Coatings Suggested Control Measure and CCAR Title 17 for aerosols.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: For testing agency providing classification marking for fire-retardant-treated material, an inspection agency acceptable to authorities having jurisdiction that periodically performs inspections to verify that the material bearing the classification marking is representative of the material tested.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Stack panels flat with spacers beneath and between each bundle to provide air circulation. Protect sheathing from weather by covering with waterproof sheeting, securely anchored. Provide for air circulation around stacks and under coverings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics: For assemblies with fire-resistance ratings, provide materials and construction identical to those of assemblies tested for fire resistance per ASTM E 119 by a testing and inspecting agency acceptable to authorities having jurisdiction.

1. Fire-Resistance Ratings: Indicated by design designations from UL's "Fire Resistance Directory"; GA-600, "Fire Resistance Design Manual."; or other agency acceptable to authorities having jurisdiction.

2.2 WALL SHEATHING

A. Glass-Mat Gypsum Wall Sheathing: ASTM C 1177/1177M.

1. Type and Thickness: Type X, 5/8 inch (15.9 mm) thick.

2.3 FASTENERS

A. General: Provide fasteners of size and type indicated that comply with requirements specified in this article for material and manufacture.

B. Power-Driven Fasteners: NES NER-272.

C. Screws for Fastening Gypsum Sheathing to Cold-Formed Metal Framing: Steel drill screws, in length recommended by sheathing manufacturer for thickness of sheathing to be attached, with organic-polymer or other corrosion-protective coating having a salt-spray resistance of more than 800 hours according to ASTM B 117.

1. For steel framing less than 0.0329 inch (0.835 mm) thick, use screws that comply with ASTM C 1002.
2. For steel framing from 0.033 to 0.112 inch (0.84 to 2.84 mm) thick, use screws that comply with ASTM C 954.

2.4 SHEATHING JOINT-AND-PENETRATION TREATMENT MATERIALS

A. Sealant for Glass-Mat Gypsum Sheathing: Silicone emulsion sealant complying with ASTM C 834, compatible with sheathing tape and sheathing and recommended by tape and sheathing manufacturers for use with glass-fiber sheathing tape and for covering exposed fasteners.

1. Sheathing Tape: Self-adhering glass-fiber tape, minimum 2 inches (50 mm) wide, 10 by 10 or 10 by 20 threads/inch (390 by 390 or 390 by 780 threads/m), of type recommended by sheathing

and tape manufacturers for use with silicone emulsion sealant in sealing joints in glass-mat gypsum sheathing and with a history of successful in-service use.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Do not use materials with defects that impair quality of sheathing or pieces that are too small to use with minimum number of joints or optimum joint arrangement. Arrange joints so that pieces do not span between fewer than three support members.

B. Cut panels at penetrations, edges, and other obstructions of work; fit tightly against abutting construction unless otherwise indicated.

C. Securely attach to substrate by fastening as indicated, complying with the following:

1. NES NER-272 for power-driven fasteners.
2. Table 2304.9.1, "Fastening Schedule," in ICC's "International Building Code."

D. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections. Install fasteners without splitting wood.

E. Coordinate wall sheathing installation with flashing and joint-sealant installation so these materials are installed in sequence and manner that prevent exterior moisture from passing through completed assembly.

F. Do not bridge building expansion joints; cut and space edges of panels to match spacing of structural support elements.

G. Coordinate sheathing installation with installation of materials installed over sheathing so sheathing is not exposed to precipitation or left exposed at end of the workday when rain is forecast.

3.2 GYPSUM SHEATHING INSTALLATION

A. Comply with GA-253 and with manufacturer's written instructions.

1. Fasten gypsum sheathing to cold-formed metal framing with screws.
2. Install boards with a 3/8-inch (9.5-mm) gap where non-load-bearing construction abuts structural elements.
3. Install boards with a 1/4-inch (6.4-mm) gap where they abut masonry or similar materials that might retain moisture, to prevent wicking.

B. Apply fasteners so heads bear tightly against face of sheathing, but do not cut into facing.

C. Horizontal Installation: Install sheathing with V-grooved edge down and tongue edge up. Interlock tongue with groove to bring long edges in contact with edges of adjacent boards without forcing. Abut ends of boards over centers of studs, and stagger end joints of adjacent boards not less than one stud spacing. Attach boards at perimeter and within field of board to each steel stud.

1. Space fasteners approximately 8 inches (200 mm) o.c. and set back a minimum of 3/8 inch (9.5 mm) from edges and ends of boards.

D. Vertical Installation: Install board vertical edges centered over studs. Abut ends and edges of each board with those of adjacent boards. Attach boards at perimeter and within field of board to each stud.

1. Space fasteners approximately 8 inches (200 mm) o.c. and set back a minimum of 3/8 inch (9.5 mm) from edges and ends of boards.

E. Seal sheathing joints according to sheathing manufacturer's written instructions.

1. Apply glass-fiber sheathing tape to glass-mat gypsum sheathing joints and apply and trowel silicone emulsion sealant to embed entire face of tape in sealant. Apply sealant to exposed fasteners with a trowel so fasteners are completely covered. Seal other penetrations and openings.

END OF SECTION 06 16 00

SECTION 06 40 23

INTERIOR ARCHITECTURAL WOODWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes interior architectural woodwork:

1. Plastic-laminate cabinets.
2. Plastic-laminate countertops.
3. Wood cabinets.
4. Wood paneling.
5. Closet and utility shelving.
6. Interior standing and running trim.
7. Shop priming of interior woodwork to receive painted finish.

B. Related Sections:

1. Section 05 50 00 "Metal Fabrications" for concealed countertop supports.
2. Section 05 70 00 "Decorative Metal" for metal trim.
3. Section 06 10 53 "Miscellaneous Rough Carpentry" for concealed blocking for millwork items.
4. Section 12 36 40 "Stone Countertops"
5. Section 12 36 61 "Simulated Stone Countertops"

1.2 ACTION SUBMITTALS

A. Product Data: Submit product data for each material and product specified and incorporated into items of architectural woodwork during fabrication, finishing, and installation.

1. Cabinet hardware and accessories.
2. Finishing materials and processes.
3. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements.

B. Product Data: Submit product data for each glass product and glazing material indicated.

C. CALgreen Submittals:

1. Product Data for Section 5.504.4.1: For sealants, adhesives and caulks, provide documentation including printed statement of VOC content showing compliance with SCAQMD Rule 1168 VOC limits and CCR Title 17 for aerosols.
2. Product Data for Section 5.504.4.3: for paints and coatings, provide documentation that products comply with VOC limits of Air Resource Board Architectural Coatings Suggested Control Measure and CCAR Title 17 for aerosols.
3. Product Certificates for Section A5.405.1: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. For the purposes of this requirement, "regional" is interpreted to mean within 500 miles of the project location or within the State of California.

4. Product Certificate for Section 5.504.4.5: for Composite Wood Products: Meet CARB Air Toxics Control Measure for Composite Wood.
5. Compliance with Section A5.404.1: show compliance with advanced wood framing techniques meeting all applicable codes for fire and life safety.

D. Shop Drawings: Submit shop drawings showing locations of each item, dimensioned plans and elevations, large-scale details, attachment devices, and other components. Elevations shall be drawn at a scale of not less than 1/2" = 1'-0" (1:20). Details shall be drawn at a scale of not less than 3" = 1'-0" (1:5).

1. Show locations and sizes of furring, blocking, and hanging strips, including concealed blocking and reinforcement specified in other Sections.
2. Show locations and sizes of cutouts and holes for plumbing, electrical, computer and telephone equipment and other items installed in architectural woodwork.

E. Samples: Submit samples of the following:

1. Thermoset decorative-overlay surfaced panel products, for each type, color, pattern, and surface finish.
2. Solid-surfacing materials, 6 inches (150 mm) square.
3. Quartz-surfacing materials, 6 inches (150 mm) square.
4. Edge Pulls, 3 samples of each type.

1.3 CLOSEOUT SUBMITTALS

A. Maintenance Instructions: Submit maintenance instructions for man-made stone tops.

1.4 QUALITY ASSURANCE

A. Single-Source Manufacturing and Installation Responsibility: Engage a qualified Manufacturer - acceptable to the Architect - to assume undivided responsibility for woodwork specified in this Section, including fabrication, finishing, and installation. The manufacturer shall have a minimum of 15 years successful experience in the custom fabrication and installation of architectural woodwork comparable to that shown and specified, be a member of the AWI, maintain an organized quality control program, perform its own in-house veneer lay-up work, and who retains facilities with sufficient capacity and quality to produce the required architectural woodwork without causing delay to the Project.

B. Quality Standard: Fabricate and install all architectural woodwork in accordance with the applicable requirements of Architectural Woodwork Standards, 1st edition, published jointly by AWI, AWMAC, and WI, unless more stringent requirements are specified or shown.

C. Fire Performance Characteristics: Provide materials identical to those tested for the following fire performance characteristics per ASTM test methods indicated by UL or other testing and inspecting organizations acceptable to authorities having jurisdiction. Identify treated lumber with classification marking of inspecting and testing organization in the form of separable paper label or, where required by authorities having jurisdiction, of imprint on lumber surfaces that will be concealed from view after installation.

1. Surface Burning Characteristics for Concealed Blocking, Furring, and Door Subframing: Not exceeding a flame spread of 25, and smoke developed of 50 when tested per ASTM E 84 for 30 minutes.

2. The fire performance finish requirements for all exposed interior wall and ceiling woodwork (including the paneling but not limited to paneling) substrates in fully sprinklered spaces shall be as follows which has been taken from the IBC 2006, Table 803.5.

Use Group	Exit Enclosures and Exit Passageways	Corridors	Rooms and Enclosed Spaces
A-1, and A-2	Class B	Class B	Class C
A-3	Class B	Class B	Class C
B, E, M, R-1	Class B	Class C	Class C
S	Class C	Class C	Class C

Class B: Flame spread 26-75, smoke developed 0-450 when tested in accordance with ASTM E 84.
Class C: Flame spread 76-200, smoke developed 0-450 when tested in accordance with ASTM E 84.

D. Forest Certification: Provide interior architectural woodwork produced from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship."

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect woodwork during transit, delivery, storage, and handling to prevent damage, soilage, and deterioration. Do not deliver woodwork until painting, wet work, grinding, and similar operations that could damage, soil, or deteriorate woodwork have been completed in installation areas. If woodwork must be stored in other than installation areas, store only in areas whose environmental conditions meet requirements specified in "Project Conditions" Article.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install woodwork until building is enclosed, wet work is complete, and HVAC system is operating and maintaining temperature and relative humidity at levels planned for building occupants during the remainder of the construction period.

B. Field Measurements: Where woodwork is indicated to fit to other construction, verify actual dimensions of other construction by accurate field measurements before fabrication of woodwork; and indicate measurements on final shop drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

1. Locate concealed framing, blocking, and reinforcements that support woodwork by field measurements before being enclosed and indicate measurements on shop drawings.
2. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating woodwork without field measurements. Provide allowance for trimming at site, and coordinate construction to ensure that actual dimensions correspond to established dimensions.

1.7 COORDINATION

A. Coordinate sizes and locations of framing, blocking, furring, reinforcements, and other related units of Work specified in other Sections to ensure that interior architectural woodwork can be supported and installed as indicated.

1.8 PRE-INSTALLATION COORDINATION MEETING

A. Meet at the Project site, prior to installation of architectural woodwork, to review the substrate preparation, installation and coordination with other trades, special details and conditions, and other topics related to the architectural woodwork. The preinstallation meeting shall include the Architect, the Contractor, architectural woodworker, and any subcontractors affected by the architectural woodwork installation.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Provide materials that comply with requirements of the AWI quality standard for each type of woodwork and quality grade specified.

B. Lumber Standards: Comply with applicable provisions for grading and workmanship of AWS Architectural Woodwork Standards, Section 3, and the requirements shown and specified; where standards conflict the more stringent shall apply. Provide lumber surfaced 4 sides (S4S) and fabricated to profiles shown. All lumber shall be kiln dried to the moisture content indicated in AWS, Section 2.

1. Furring, Blocking, Shims: No. 1 Common; Southern Pine.
2. Door Subframes: No. 1 Common Southern Pine, fire retardant treated to reduce combustibility.
3. Solid Hardwood for Opaque Finish: Plain sawn Yellow Poplar, free from checks, splits, sound knots.

C. Wood Panel Products:

1. Recycled Content of Medium-Density Fiberboard and Particleboard: Provide products with an average recycled content so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 50 percent.

2. Medium-Density Fiberboard (non-moisture resistant): A sustainable, medium density fiberboard (MDF) panel manufactured from 100 percent post industrial recycled wood fiber complying with ANSI A208.2, having a minimum 48 pcf (769 kg/m^3) density except that minimum for screw holding capacity on face shall be 300 pounds (1333 N); an ASTM E 84 minimum Class C flame spread rating, minimum 3/4 inches (19 mm) thick, edged and faced as specified, fabricated with binder containing no added urea formaldehyde.

   a. SierraPine Composite Solutions; FSC Certified Medite II , as manufactured in the Rocklin, CA plant.
   b. Panel Source International; Purekor Platinum MDF, as manufactured in the Rocklin, CA plant.

3. Medium-Density Fiberboard (moisture resistant): A sustainable, moisture-resistant, medium density fiberboard (MDF) panel manufactured from 100 percent post industrial recycled wood fiber complying with ANSI A208.2, having a minimum 48 pcf (769 kg/m^3) density except that minimum for screw holding capacity on face shall be 300 pounds (1333 N) respectively; an ASTM

E 84 Class C flame spread rating, minimum 3/4 inches (19 mm) thick, edged and faced as specified, fabricated with binder containing no added urea formaldehyde.

a. SierraPine Composite Solutions; FSC Certified Medex, as manufactured in the Rocklin, CA plant.
b. Panel Source International; Purekor Platinum MDF, as manufactured in the Rocklin, CA plant.

4. Medium-Density Fiberboard (fire rated): A sustainable, fire rated, medium density fiberboard (MDF) panel manufactured from 100 percent post industrial recycled wood fiber complying with ANSI A208.2, having a minimum 48 pcf (769 kg/m^3) density except that minimum for screw holding capacity on face shall be 230 pounds (1022 N); an ASTM E 84 Class A flame spread rating, minimum 3/4 inches (19 mm) thick, edged and faced as specified, fabricated with binder containing no added urea formaldehyde.

   a. SierraPine Composite Solutions; FSC Certified Medite FR, as manufactured in the Rocklin, CA plant.
   b. Panel Source International; Pyroblock Platinum Grade MDF.

5. Medium Density Particleboard: A medium density particleboard (MDP) panel manufactured from 100 percent post industrial recycled wood residuals complying with ANSI A208.1, Grade M-3- with a minimum 45 pcf (721 kg/m^3) density except that minimum for screw holding capacity on face shall be 247 pounds (1098 N), an ASTM E 84 minimum Class C flame spread rating; minimum 3/4 inches (19 mm) thick, edged and faced as specified and manufactured with binder containing no added urea-formaldehyde.

   a. SierraPine Composite Solutions; FSC Certified Encore.
   b. Panel Source International; Purekor Platinum Particleboard, as manufactured in the Klamath Falls, or Roseville, CA plants.

6. Potlatch Forest Products Corporation, Forest Products Div.
7. Hardboard: ANSI A135.4.
8. Veneer-Faced Panel Products (Hardwood Plywood): HPVA HP-1, made with adhesive containing no urea formaldehyde. Available Products:

   a. PanelSource International, Inc.; PureKor.

D. Thermoset Decorative Overlay (Melamine): Particleboard or medium-density fiberboard with surface of thermally fused, melamine-impregnated decorative paper complying with the recommendations of the Composite Panel Association's Technical Bulletin "Laminating Composite Panels."

   1. Types: As indicated in the Finish Schedule on the Drawings.

E. Glass: Clear tempered float glass, complying with ASTM C 1036, Type I, Class 1, Quality q3, and ASTM C 1048 Kind FT, thickness as indicated.

   1. Prior to tempering, cut glass to required sizes and profiles as determined by accurate measurement of supporting standoff hole locations.
   2. Hole Cutting: Unless otherwise recommended by the glass manufacturer, comply with the requirements of ASTM C 1048, Article 7.8 for hole placement, minimum hole diameter, and dimensional tolerances of holes and this specification. Unless otherwise recommended by the glass manufacturer, locate holes not less than 4 inches (102 mm) from glass edges, hole diameter shall be at least 1/8 inch (3 mm) larger than the shank of the screw fastener and screw sleeve spacers used for the rosette assemblies. Chips and flakes at hole edges shall not be permitted, and the inner surfaces of holes shall be smooth polished to match glass panel edges.

3. Edge Treatment: All glass edges shall have an arrised edge profile (small bevel of width not exceeding 1/16 inch (1.5 mm) at an angle of approximately 45 degrees to the surface of the glass) with a polished (surface is reflective in appearance similar to the major surface of glass) surface.

F. High-Pressure Decorative Laminate: Complying with NEMA LD 3 for Horizontal General Purpose Grade (HGS) typically and Vertical General Purpose Grade (VGS) where specified. Nominal thickness for HGS and VGS laminates to be 0.048 inches (1.2 mm) +/- 0.005 inches (0.12 mm) and 0.028 inches (0.71 mm) +/- 0.004 inches (.10 mm), respectively. Where high pressure decorative laminate is indicated to be faced with aluminum, provide aluminum sheet goods specifically made for laminating to vertical MDF and particleboard substrates in sheet thickness of 0.025 inches (0.63 mm) +/- 0.002 inches (0.05 mm).

1. Types: As indicated in the Finish Schedule on the Drawings.

a. Provide factory applied protective peel coat to prevent surface damage during fabrication and handling of aluminum faced decorative laminates. Remove protective peel coat after installation in accordance with the manufacturer's recommendations. If the film is left in place after installation, exposure to direct sunlight for a prolonged period may cause a paste residue and create other problems.

2. Backing Sheets: Non-decorative, high pressure laminate, NEMA LD3, Grade, types and thickness to match face sheets and equalize pull.

G. Adhesives, General: Use only low emitting VOC adhesives that leave no glue lines on finished surfaces of architectural woodwork. Do not use adhesives that contain urea formaldehyde.

1. VOC Limits for Installation Adhesives and Glues: Use installation adhesives that comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):

a. Wood Glues: 30 g/L.
b. Contact Adhesives: 80 g/L.

2.2 FIRE-RETARDANT-TREATED MATERIALS

A. General: Where indicated, use materials impregnated with fire-retardant chemical formulations indicated by a pressure process or other means acceptable to authorities having jurisdiction to produce products with fire-test-response characteristics specified.

1. Do not use treated material that does not comply with requirements of referenced woodworking standard. Do not use twisted, warped, bowed, discolored, or otherwise damaged or defective lumber or panel products.
2. Use fire-retardant-treatment formulations that do not bleed through or otherwise adversely affect finishes. Do not use colorants in solution to distinguish treated material from untreated material.
3. Treat only door subframing, blocking and furring items.

B. Fire-Retardant-Treated Lumber: Materials impregnated with fire-retardant chemical formulations to comply with AWPA U1, Use Category UCFA. Kiln-dry material after treatment to levels required for untreated woodwork.

C. Fire-Retardant Particleboard: Panels made from softwood particles and fire-retardant chemicals mixed together at time of panel manufacture and complying with fire-test-response characteristics specified.

D. Fire-Retardant Fiberboard: ANSI A208.2 medium-density fiberboard panels made from softwood fibers, synthetic resins, and fire-retardant chemicals mixed together at time of panel manufacture and complying with fire-test-response characteristics specified.

2.3 CABINET HARDWARE AND ACCESSORIES

A. General: Provide cabinet hardware and accessory materials for a complete installation of architectural woodwork, except for items specified in Section 08 71 00 "Door Hardware."

B. Hardware Standard: Comply with BHMA A156.9 for items indicated by referencing BHMA numbers or items referenced to this standard.

C. Frameless Concealed Hinges for Cabinet Doors (European Type): Concealed all-metal furniture hinges shall be Grass 3000 Series or equal with free swing only at cabinet doors that are provided with magnetic latches, adaptable or engineered for 35 mm hinge cup boring pattern, with minimum 165 degree opening angle, 3 dimensional hinge having adjustments located in the steel hinge arm, steel or die-cast zinc hinge cups, and plastic insertion dowels to receive hinge screws. Automatic closing shall engage only in the last 10 degrees of swing. All hinge pins and linkages shall be hardened. Complying with BHMA A156.9, B01602. Bright nickel finish (US15).

1. Hinge Quantity: Provide hinge quantity as recommended by hinge manufacturer based on cabinet door width, weight, thickness, door material, and hinge cup selection.
2. Metal Furniture Hinge Manufacturers: One of the following:

a. Grass America, Inc.
b. Blum USA

D. Hidden Gate Hinges: Full mortised, invisible "SOSS" type hinges as manufactured by Universal Industrial Products Company, Pioneer, OH, and specifically manufactured for door thickness indicated and fabricated from high strength plated steel, heavy duty zinc alloy castings, and non-removable riveted hinge pins. Each hinge shall be engineered for smooth performance with laminated link construction supplemented by anti-friction materials that reduce friction for smooth, free hinge operation. Complying with BHMA A156.9, B01501.

1. Hinge Quantity: Provide hinge quantity as recommended by hinge manufacturer based on cabinet door width, weight, thickness, door material, and hinge cup selection.

E. Piano Hinges: Continuous type, satin finished stainless steel and complying with BHMA A156.9, B51491.

F. Wire Pulls: Back mounted, 4 inches (100 mm) long, 5/16 inches (8 mm) in diameter fabricated from satin finished stainless steel (US32D), complying with BHMA A156.9, B52011, unless otherwise indicated.

G. Edge Pulls: Full mortised, solid, bronze or brass door edge pull, with 1/2 inch finger clearance, 1/4 inch diameter roll diameter, having nominal overall roll length dimension of 4 inches long, with backbend drilled and countersunk to receive 2 screw fasteners; form for full mortise application; satin finished chrome (US26D); one of the following:

1. SRO Style Edge Pull; Tydix Products, Inc.
2. DP3A Tab Drawer Pull; Doug Mockett and Co., Inc.

H. Catches: Magnetic, complying with BHMA A156.9, B03141 for single doors and B03161 for double doors.

1. For Single Doors:

a. CD41 Single Magnetic Cabinet Catch; Stanley Commercial Hardware.

2. For Double Doors:

a. 901; Rockwood Manufacturing Company.
b. CD45 Double Magnetic Cabinet Catch; Stanley Commercial Hardware.

I. Cabinet Shelf Rests: Nickel plated brass or steel, or stainless steel, minimum 6 mm diameter shelf support pegs in sockets, complying with BHMA A156.9, B04013. One of the following:

1. Hafele 282.01.701 x 282.50.704; Hafele America, Co.
2. K-10S with K-2 Sleeve; Brusso, Inc.
3. 331 Series Flat Top Shelf Support Pin with 325 Series Insert Grommet; Knape and Vogt.

J. Closet Rods and Flanges: 1-1/2 inch (38 mm) diameter, satin finished chrome plated steel or satin finished stainless steel with matching end flanges.

K. Adjustable Shelf Standards and Brackets for Wall-Hung Open-Shelving:

1. Standards: Model No. 87ANO Extra Heavy Duty 87-187 Series; lengths as indicated, by Knape and Vogt.
2. Brackets: Model No. 186 LL ANO for 8- and 10-inch (200- to 250-mm) Model No. 187 LL ANO for 12- to 24-inch (300- to 600-mm) deep shelves by Knape and Vogt.
3. Shelf Rests: Model No. 210 ANO End Rest and Model No. 211 ANO Center Rest with Model No. 129 RUB Rubber Cushions.

L. Drawer Slides:

1. Pencil Drawer Slides: Similar to Accuride 2006 having 3/4 extension carburized steel ball bearing, side mounting, 45 lbs. capacity medium duty load rating, cold rolled steel slide members and ball retainers, bright electro zinc plate finish.
2. Drawers less than 4 inches (102 mm) deep: Similar to Accuride 7432 having full extension carburized steel ball bearing, side mounting, 100 lb. capacity medium duty load rating, cold rolled steel slide members and ball retainers, cushioned in and outstops, detent-in, progressive action, positive stop, bright electro zinc plate finish.
3. Drawers greater than 4 inches (102 mm) but less than 8 inches (203 mm) deep: Similar to Accuride 7432 having full extension carburized steel ball bearing, side mounting, 100 lb. capacity medium duty load rating, cold rolled steel slide members and ball retainers, cushioned in and outstops, detent-in, progressive action, positive stop, bright electro zinc plate finish.
4. Drawers greater than 8 inches (203 mm) deep: Similar to Accuride 4032 having full extension carburized steel ball bearing, rail mounting, 150 lb. capacity heavy duty load rating, cold rolled steel slide members and ball retainers, cushioned in and outstops, detent-in, progressive action, positive stop, bright electro zinc plate finish.
5. Refuse Cabinets: Similar to Accuride 3600-201 having full extension carburized steel ball bearing, bottom mounting, 175 lb. capacity heavy duty load rating, cold rolled steel slide members and ball retainers, cushioned in and outstops, progressive action, positive stop, bright electro zinc plate finish.
6. **Manufacturing Facility: Accuride International, S.A. de C.V., Mexicali, B.C., C.P. 21395 México.**

M. Flipper Door Slides: For vertically mounted retracting cabinet doors up to 75 pounds (34 kg) and 72 inches (1800 mm) tall, Model No. 1432, black color, with hinge carrier strip by Accuride, Inc., as manufactured in the Accuride International, S.A. de C.V., Mexicali, B.C., C.P. 21395 México plant.

N. Silencers: Provide rubber silencers on jamb and/or head and sill strike areas of all cabinet doors and drawers, 2 for paired doors, and 3 for single doors. Silencers shall be approximately 1/4-inch (6.4-mm) diameter, color compatible with adjacent finish.

O. Aluminum Slides for Sliding Glass Doors: Heavy duty track assembly consisting of upper guide, shoe-H bar, lower track and rollers; clear anodized finish:

1. No. D123A by C. R. Laurence Company, Inc., Chicago, IL.

P. Door and Drawer Locks: All cabinet doors and drawers shall be furnished with locks. Finish exposed portions of locks to match cabinet pull finish. Furnish 2 keys with each lock and key all locks inside one room alike and provide masterkey for all locks in Project.

1. Drawers: Provide one of the following lock assemblies:

a. Cam lock similar to Hafele 235.12.261, chrome plated, with Offset Cam 219.13.9xx, sized to fit opening; Hafele America, Co..
b. Cam lock similar to Hafele 235.12.221, chrome plated, with surface-mounted strike 251.60.703; Hafele America, Co.

2. Single Doors: Provide one of the following lock assemblies:

a. Cam lock similar to Hafele 235.12.261, chrome plated, with Offset Cam 219.13.9xx, sized to fit opening; Hafele America, Co.
b. Cam lock similar to Hafele 235.12.221, chrome plated, with surface-mounted strike 251.60.703; Hafele America, Co.

3. Pairs of Doors: Provide the following:

a. At inactive leaf, Furniture bolt similar to Hafele 252.02.644, polished chrome, with strike 251.60.703; Hafele America, Co.
b. At active leaf, provide Single Door lock assembly.

Q. Grommets for Cable Passage through Countertops: 2-1/2-inch (64-mm) OD, black, molded-plastic grommets and matching plastic caps with slot for wire passage.

1. Product: Subject to compliance with requirements, provide " MM series" by Doug Mockett and Co., Inc.

R. Grommets for trash opening through Countertops: 6-inch and 12 inch x 1inch, stainless steel grommets.

1. Product: Subject to compliance with requirements, provide " TM1 and TM12" by Doug Mockett and Co., Inc.

S. Exposed Hardware Finishes: Unless otherwise specified above, or on the Drawings, all exposed portions of the woodwork hardware shall comply with BHMA A156.18 for BHMA finish number indicated.

1. Satin Stainless Steel: BHMA 630.

T. Stainless Steel Trim: Custom fabricate stainless steel trim shapes to the sizes, shapes and profiles shown from the following materials. Provide in standard commercial tempers and hardness, as required for fabrication, strength and durability from Type 304 alloy. Form exposed work true to line and level, with flush surfaces and accurate angles. Ease exposed edges to a radius of approximately 1/32 inch (0.79 mm) radius, unless otherwise shown. Miter exposed corner joints and machine fit to a hairline joint. All sheet goods shall be provided finished one side only. Finish designation shown on the Drawings are NAAMM nomenclature.

1. Sheet and Plate: ASTM A 666.
2. Bar Stock: ASTM A 276.
3. Pipe: ASTM A 312, Grade TP 304.
4. Tubing: ASTM A 554, Grade MT 304.
5. Rosettes for Capping Brushed Stainless Steel Standoffs at Glass Tops: Custom fabricate rosettes from satin finished stainless steel materials. All fasteners shall be concealed. Fastener for joining rosette assemblies shall be of a type, design, and size as recommended by the glazier for the application shown and specified. Isolate glass from stainless steel using clear plastic cushions sized to fit under the rosettes.

U. Stainless Steel Trim Finish: Provide the following mechanical finish to the exposed surfaces of the fabricated work to the extent indicated (NAAMM nomenclature), with texture and reflectivity as required to match the Architect's sample.

1. No. 4 (bright directional polish).
2. No. 8 (non-directional mirror polish).

V. Steel Reinforcing: Carbon steel shapes, tubes and plates complying with ASTM A 36 (shapes and plates), and ASTM A 500 or A 501 (for tubes).

1. Shop Primer for Concealed Steel Reinforcing: Provide fast curing, lead and chromate free, universal modified alkyd primer complying with performance requirements in FS TT-P-664.
2. Electrodes for Concealed Steel Reinforcing: Provide type and alloy of filler metal and electrodes as recommended by producer of metal to be welded.

W. Resilient Base: Refer to Section 09 65 13 "Resilient Wall Base and Accessories."

X. Light Fixtures: Approximately 1-1/4 inch (32 mm) high surface mounted continuous undercabinet LED task light, with adjustable rotation of plus or minus 30 degrees. Task lighting shall have end butted, fixture to fixture, ganging with concealed wiring. Provide each ganged section of light fixtures with a single dimmer switch that, when activated, will switch the entire ganged section of light fixtures to either "on" or "off," and also offers dimming from full capacity to 5 percent capacity.

1. Basis-of-Design Manufacturer and Fixture: Workrite Ergonomics Inc.; Verano Series undercabinet lighting, (800) 959-9675. Other manufacturers will be considered subject to Architect's acceptance.
2. All light fixture components shall be UL Approved and Listed for the applications indicated. Housings shall be constructed of recycled aluminum with water based enamel finish; with transformer to connect to 120 VAC electrical voltage. Provide NEC acceptable wiring, and conduits if required, from light fixtures complete with 3 prong connector for plugging into outlet strips or power receptacles.
3. Lamp Type and Wattage: Each fixture shall include evenly spaced 1W LED lamps with a color temperature of 3500 degrees Kelvin and a CRI of 92; length as required to suit applications shown; other manufacturers will be considered subject to Architect's acceptance.

Y. Light Fixtures: Approximately 1-1/2 inch (38 mm) high surface mounted continuous undercabinet fluorescent task light with solid front and non-yellowing acrylic prismatic lens. Task lighting shall have end butted, fixture to fixture, ganging with concealed wiring. Provide each ganged section of light fixtures with a single rocker switch that, when activated, will switch the entire ganged section of light fixtures to either "on" or "off."

1. All light fixture components shall be UL Approved and Listed for the applications indicated. Housings shall be constructed of minimum 22 ga. cold rolled steel with bonderized white baked enamel finish; 120 VAC electrical voltage. Provide NEC acceptable wiring, and conduits if required, from light fixtures complete with 3 prong connector for plugging into outlet strips or power receptacles.
2. Provide each fixture with high efficiency, electronic ballast, completely contained within light fixture housing sized for specified lamps.
3. Lamp Type and Wattage: (1)F17T8/F25T8/F32T8/F40T8/SPX35; General Electric, length as required to suit applications shown; other manufacturers will be considered subject to Architect's acceptance.

Z. Door Hardware: At full sized doors, provide door hardware as scheduled under Section 08 71 00 "Door Hardware."

AA. Hanging (Zee Clip) Strips: Extruded aluminum zee type interlocking clips; type, size and quantity for the condition of use.

BB. Brushed Aluminum Trim Shapes: Custom fabricate aluminum trim shapes to the sizes, shapes and profiles shown from the following materials. Provide in standard commercial tempers and hardness, as required for fabrication, strength and durability. Form exposed work true to line and level, with flush surfaces and accurate angles. Miter exposed corner joints and machine fit to a hairline joint. Finish designations are NAAMM nomenclature.

1. Plate: Alloy 5005 and ASTM B 209 (ASTM B 209M).
2. Bar Stock: ASTM B 211 (ASTM B 211M).
3. Extrusions: Alloy 6063 and ASTM B 221 (ASTM B 221M).
4. Aluminum Trim Finishes: Provide the following finishes to the exposed surfaces of the fabricated work to the extent indicated (NAAMM nomenclature), with texture and reflectivity as required to match the Architect's sample.

    a. Class II, Clear Anodic Finish: Complying with AA-M10M32A31 for an Architectural Class II, medium satin, clear natural anodized finish.

CC. Screws: Select material, type, size, and finish required for each use. Comply with ASME B18.6.1.

DD. Nails, Wire, Brads, and Staples: Select material, type, size, and finish required for each use.

1. ASTM F 1667 for driven fasteners such as nails, spikes and staples.
2. ASTM F 547 for nails used with wood and wood based products.

EE. Anchors: Select material, type, size, and finish required by each substrate for secure anchorage. Provide toothed steel or lead expansion bolt devices for drilled-in-place anchors.

FF. Blind Splines: Specialty devices, as required for tight butt joining, types and size as recommended by woodwork fabricator.

GG. Covercaps: Where mortises of fastener heads, or draw downs are exposed (blind holes) in finished work, provide black plastic covercaps.

2.4 FABRICATION, GENERAL

A. General: Complete fabrication, including assembly, finishing, and hardware application, before shipment to Project site to the maximum extent possible. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide allowance for scribing, trimming, and fitting.

The width of scribe and filler panels shall not exceed 1/2 inch (13 mm), or 1/2 inch (13 mm) clear dimension from adjacent wall to outside face of cabinet door in a 90 degree position, whichever is greater.

1. Interior Woodwork Grade: Premium complying with the referenced quality standard.

B. Fabricate woodwork to dimensions, profiles, and details indicated.

1. Reinforcing shown is minimum. Provide additional steel and lumber reinforcing as required to sustain imposed loads and to ensure a rigid assembly.
2. Exposed surfaces shall be free from dents, tool marks, warpage, buckle, glue and open joints, or other defects affecting serviceability or appearance. Accurately fit all joints, corners and miters. Conceal all fasteners. Make threaded connections up tight so that threads are entirely concealed.

C. Shop cut openings to maximum extent possible, to receive hardware, appliances, plumbing fixtures, electrical work, and similar items. Locate openings accurately and use templates or roughing in diagrams to produce accurately sized and shaped openings. Sand edges of cutouts to remove splinters and burrs.

1. Seal edges of openings in countertops with a coat of varnish.
2. Install glass to comply with applicable requirements in Section 08 80 00 "Glazing" and in GANA's "Glazing Manual." For glass in wood frames, secure glass with removable stops.

2.5 WOOD CABINETS FOR PLASTIC LAMINATE FINISH

A. AWS Type of Cabinet Construction: Flush overlay.

B. Laminate Cladding for Exposed Surfaces: High-pressure decorative of grade indicated.

1. Horizontal Surfaces Other Than Tops: HGS.
2. Postformed Surfaces: HGP.
3. Vertical Surfaces: VGS.
4. Edges: HGS unless otherwise indicated.
5. Colors, Patterns, and Finishes: As indicated on the Drawings and in the Finish Schedule.

C. Materials for Semiexposed Surfaces Other Than Drawer Bodies: High-pressure decorative laminate, Grade VGS.

1. Drawer Sides and Backs: Solid-hardwood lumber.
2. Drawer Bottoms: Hardwood plywood.

D. Provide dust panels of 1/4-inch (6.4-mm) plywood or tempered hardboard above compartments and drawers, unless located directly under tops.

E. Cabinet Locks: Provide door and drawer locks.

2.6 PLASTIC LAMINATE COUNTERTOPS

A. High-Pressure Decorative Laminate Grade: HGS.

B. Colors, Patterns, and Finishes: As indicated on the Drawings and in the Finish Schedule.

C. Edge Treatment: Same as laminate cladding on horizontal surfaces unless otherwise indicated.

D. Core Material at Sinks: Particleboard or exterior-grade plywood.

2.7 FLUSH WOOD PANELING

A. Core Material:

1. Opaque Finished Paneling: Medium density fiberboard.
2. Transparent Finished Paneling: Medium density particleboard or medium density fiberboard.

B. Veneered Surfaces:

1. Veneer Types:

a. Opaque Finished Paneling: Exposed MDF.
b. Transparent Finished Paneling: As indicated on the Drawings and in the Finish Schedule.

2. Transparent Finished Panel Matching:

a. Matching of Adjacent Veneer Leaves: Book matched, unless otherwise indicated.
b. Veneer Matching With Panel Face: Center balance match, unless otherwise indicated.
c. Panel Matching Method: Match panels to one another within each separate area by the following method:

1) Blueprint sequenced matched panels and components.

C. Edge Detail: Edge veneer banded with continuous hardwood strips matching face veneer. Panel joints to be flush type unless otherwise shown.

2.8 INTERIOR STANDING AND RUNNING TRIM FOR OPAQUE AND TRANSPARENT FINISHES

A. General: Complying with AWS Sections 3, 6, and 12, fabricated from solid hardwood with scarfed joints, profiles as indicated, finishes as indicated.

B. Backout or groove backs of flat trim members and kerf backs of other wide, flat members, except for members with ends exposed in finished work.

C. Wood Species: Poplar for opaque finishes; solid hardwood plank finished with transparent finished wood veneer in veneer cut as indicated on the Drawings to match adjacent transparent finished veneered items.

2.9 CLOSET & UTILITY SHELVING

A. Shelf Material: Medium density fiberboard where indicated to be painted; medium density particle board where indicated for plastic laminate or melamine veneer.

B. Cleats: 3/4-inch (19-mm) solid lumber or thermoset decorative panel.

C. Finishes: As shown and scheduled on the Drawings.

2.10 SHOP FINISHING

A. Production finish architectural woodwork at fabrication shop. Defer only final touchup, cleaning, and polishing until after installation.

B. Priming of interior architectural woodwork with field applied opaque finish required to be performed at fabrication shop are specified in this Section. Refer to Section 09 91 23 "Interior Painting" for finishing opaque finished architectural woodwork.

C. Preparations for Finishing: Comply with referenced quality standard for sanding, filling countersunk fasteners, sealing concealed surfaces, and similar preparations for finishing architectural woodwork, as applicable to each unit of work.

1. Backpriming: Apply one coat of sealer or primer, compatible with finish coats, to concealed surfaces of woodwork. Apply two coats to back of paneling and to end grain surfaces. Concealed surfaces of plastic-laminate-clad woodwork do not require backpriming when surfaced with plastic laminate, backing paper, or thermoset decorative overlay.
2. Gluing of face veneers shall, where possible, be by the hot plate method; glued surfaces shall be in close contact throughout. Glue stains will not be permitted.
3. Grain of all transparent finished wood shall run in the direction shown, or if not shown, as accepted on the shop drawings.

D. Exposed Surfaces:

1. Opaque Finish:

a. Grade: Custom.
b. AWS System 5: Conversion Varnish for close grain woods.
c. Color and Sheen: Match Architect's paint samples.

2. Plastic Laminate Finish: Gluing of plastic laminate surfacing materials shall be by the hot plate method, glued surfaces shall be in close contact throughout. Glue stains shall not be permitted.
3. Matte finish is standard, and requires the least amount of maintenance.
4. Solid Surfacing Finish: As scheduled.

E. Unexposed Wood Finish: Alkyd type primer-sealer.

PART 3 - EXECUTION

3.1 PREPARATION

A. Condition woodwork to average prevailing humidity conditions in installation areas.

B. Before installing architectural woodwork, examine shop-fabricated work for completion and complete work as required, including removal of packing and backpriming before installation.

3.2 INSTALLATION

A. Quality Standard: Install woodwork to comply with AWI Section 1700 for the same grade specified in this Section for type of woodwork involved.

1. Install woodwork level, plumb, true, with no distortions, and with no variations in flushness of adjoining surfaces. Shim as required with concealed shims.
2. Scribe and cut woodwork to fit adjoining work, and refinish cut surfaces and repair damaged finish at cuts.

B. Anchor woodwork to blocking built in or directly attached to substrates. Secure to blocking with countersunk, concealed fasteners and blind nailing as required for complete installation. Use fine finishing nails or finishing screws for exposed fastening, countersunk and filled flush with woodwork and matching final finish if transparent finish is indicated.

C. Standing and Running Trim: Install with minimum number of joints possible, using full-length pieces (from maximum length of lumber available) to greatest extent possible. Do not use pieces less than 96 inches (2438 mm) long, except where shorter single-length pieces are necessary. Scarf running joints and stagger in adjacent and related members.

1. Fill gaps, if any, between top of base and wall with plastic wood filler, sand smooth, and finish same as wood base, if finished.

D. Cabinets: Install without distortion so doors and drawers fit openings properly and are accurately aligned. Adjust hardware to center doors and drawers in openings and to provide unencumbered operation. Complete installation of hardware and accessory items as indicated.

1. Install cabinets without sag, bow, or other variation from a straight line.
2. Maintain veneer sequence matching of cabinets with transparent finish.
3. Fasten wall cabinets through back, near top and bottom, at ends and not more than 16 inches (400 mm) on center with No. 10 wafer-head screws sized for 1-inch (25-mm) penetration into wood blocking, or hanging strips or with No. 10 wafer-head sheet metal screws through metal backing or metal framing behind wall finish.

E. Countertops: Anchor securely by screwing through corner blocks of base cabinets or other supports into underside of countertop.

1. Calk space between backsplash and wall with silicone sanitary sealant specified in Section 07 92 00 "Joint Sealants."
2. Align adjacent solid-surfacing-material countertops and form seams to comply with manufacturer's written recommendations using adhesive in color to match countertop. Carefully dress joints smooth, remove surface scratches, and clean entire surface.
3. Secure backsplashes to tops with concealed metal brackets at 16 inches (406 mm) on center and to walls with adhesive.
4. Natural Stone Tops: Refer to Section 09 75 00 "Stone Facing."

F. Paneling: Anchor paneling to supporting substrate with concealed panel-hanger clips, by blind nailing on backup strips, splined connection strips, and associated trim and framing. Do not use face fastening, unless otherwise indicated. Space panels so that reveals are parallel and of widths indicated.

G. Built-In Desks and Credenzas: Install without distortion so that doors, and drawers, fit openings properly and are accurately aligned. Adjust hardware to center doors, and drawers, in openings and to provide unencumbered operation. Complete the installation of hardware and accessory items as indicated.

1. Anchor glass tops securely to supporting framing as indicated on the shop drawings.

H. Complete the finishing work specified in this Section to extent not completed at shop or before installation of woodwork.

3.3 ADJUSTING AND CLEANING

A. Repair damaged and defective woodwork to eliminate functional and visual defects; where not possible to repair, replace woodwork. Adjust joinery for uniform appearance.

B. Clean woodwork on exposed and semiexposed surfaces. Touchup shop-applied finishes to restore damaged or soiled areas.

1. Anodized aluminum surfaces shall be cleaned with warm water and mild soaps such as those used for hands or dishes. Do NOT use cleaners that contain abrasives, acids or alkalis, as they will mar the surface. Do NOT clean metal face with solvents, paint thinner or adhesive remover. After washing, always wipe the surface completely dry with a soft, clean cloth. Stubborn stains may be removed with a thin, clean oil and dry cloth.

3.4 PROTECTION

A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer, that ensures that woodwork will be without damage or deterioration at time of Substantial Completion.

END OF SECTION 06 4023

SECTION 07 1326

SELF-ADHERING SHEET WATERPROOFING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Modified bituminous sheet waterproofing.
2. Modified bituminous sheet waterproofing, fabric reinforced.
3. Modified bituminous deck-paving sheet waterproofing.
4. Blindside sheet waterproofing.

B. Related Requirements:

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review waterproofing requirements including surface preparation, substrate condition and pretreatment, minimum curing period, forecasted weather conditions, special details and sheet flashings, installation procedures, testing and inspection procedures, and protection and repairs.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, and tested physical and performance properties of waterproofing.
2. Include manufacturer's written instructions for evaluating, preparing, and treating substrate.

B. Sustainable Design Submittals:

1. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each regional material.

C. Shop Drawings: Show locations and extent of waterproofing and details of substrate joints and cracks, expansion joints, sheet flashings, penetrations, inside and outside corners, tie-ins with adjoining waterproofing, and other termination conditions.

D. Samples: For each exposed product and for each color and texture specified, including the following products:

1. 8-by-8-inch (200-by-200-mm) square of waterproofing and flashing sheet.
2. 4-by-4-inch (100-by-100-mm) square of drainage panel.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Field quality-control reports.

C. Sample Warranties: For special warranties.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by waterproofing manufacturer.

B. Mockups: Build mockups to verify selections made under Sample submittals and to set quality standards for installation.

1. Build for each typical waterproofing installation including accessories to demonstrate surface preparation, crack and joint treatments, inside and outside corner treatments, and protection.
   a. Description: Each type of wall and deck installation.

2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 FIELD CONDITIONS

A. Environmental Limitations: Apply waterproofing within the range of ambient and substrate temperatures recommended in writing by waterproofing manufacturer. Do not apply waterproofing to a damp or wet substrate.

1. Do not apply waterproofing in snow, rain, fog, or mist.

B. Maintain adequate ventilation during preparation and application of waterproofing materials.

1.8 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to furnish replacement waterproofing material for waterproofing that does not comply with requirements or that fails to remain watertight within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations for Waterproofing System: Obtain waterproofing materials, protection course, and molded-sheet drainage panels from single source from single manufacturer.

B. Source Limitations for Plaza-Deck Paving: Obtain plaza-deck pavers from single source from single manufacturer.

2.2 MODIFIED BITUMINOUS SHEET WATERPROOFING

A. Modified Bituminous Sheet: Minimum 60-mil (1.5-mm) nominal thickness, self-adhering sheet consisting of 56 mils (1.4 mm) of rubberized asphalt laminated on one side to a 4-mil- (0.10-mm-) thick, polyethylene-film reinforcement, and with release liner on adhesive side; formulated for application with primer or surface conditioner that complies with VOC limits of authorities having jurisdiction.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Physical Properties:

    a. Tensile Strength, Membrane: 250 psi (1.7 MPa) minimum; ASTM D 412, Die C, modified.
    b. Ultimate Elongation: 300 percent minimum; ASTM D 412, Die C, modified.
    c. Low-Temperature Flexibility: Pass at minus 20 deg F (minus 29 deg C); ASTM D 1970/D 1970M.
    d. Crack Cycling: Unaffected after 100 cycles of 1/8-inch (3-mm) movement; ASTM C 836/C 836M.
    e. Puncture Resistance: 40 lbf (180 N) minimum; ASTM E 154/E 154M.
    f. Water Absorption: 0.2 percent weight-gain maximum after 48-hour immersion at 70 deg F (21 deg C); ASTM D 570.
    g. Water Vapor Permeance: 0.05 perm (2.9 ng/Pa x s x sq. m) maximum; ASTM E 96/E 96M, Water Method.
    h. Hydrostatic-Head Resistance: **200 feet (60 m)** minimum; ASTM D 5385.

3. Sheet Strips: Self-adhering, rubberized-asphalt strips of same material and thickness as sheet waterproofing.

B. Modified Bituminous Sheet, Fabric Reinforced: Minimum 60-mil (1.5-mm) nominal thickness, self-adhering sheet consisting of rubberized-asphalt membrane with embedded fabric reinforcement, and with release liner on adhesive side.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Physical Properties:

    a. Pliability: No cracks when bent 180 degrees over a 1-inch (25-mm) mandrel at minus 25 deg F (minus 32 deg C); ASTM D 146/D 146M.
    b. Puncture Resistance: **40 lbf (180 N)** minimum; ASTM E 154/E 154M.
    c. Water Vapor Permeance: 0.05 perm (2.9 ng/Pa x s x sq. m) maximum; ASTM E 96/E 96M, Water Method.

3. Sheet Strips: Self-adhering, reinforced, rubberized-asphalt strips of same material and thickness as sheet waterproofing.

2.3 MODIFIED BITUMINOUS DECK-PAVING SHEET WATERPROOFING

A. Modified Bituminous Deck-Paving Sheet: Minimum 65-mil (1.6-mm) nominal thickness, self-adhering sheets designed to be overlaid with asphalt paving; consisting of rubberized-asphalt membrane with woven or nonwoven fabric reinforcement laminated to one surface or embedded within the membrane, and with release liner on adhesive side.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Physical Properties:

    a. Tensile Strength, Membrane: **50 lbf/in. (8.75 kN/m)** minimum; ASTM D 882.
    b. Pliability: Unaffected when bent 180 degrees over a 1/4-inch (6.4-mm) mandrel at minus 15 deg F (minus 26 deg C); ASTM D 146/D 146M.
    c. Puncture Resistance: **[40 lbf (180 N)] [100 lbf (445 N)] [200 lbf (890 N)]** minimum; ASTM E 154/E 154M.

3. Sheet Strips: Self-adhering, reinforced, rubberized-asphalt strips of same material and thickness as sheet waterproofing.

2.4 BLINDSIDE SHEET WATERPROOFING

A. Blindside Sheet Waterproofing for Vertical Applications: Uniform, flexible, multilayered-composite sheet membrane that forms a permanent bond with fresh concrete placed against it; complete with accessories and preformed shapes for an unbroken waterproofing assembly; with the following physical properties:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Physical Properties:

    a. Low-Temperature Flexibility: Pass at minus 20 deg F (minus 29 deg C); ASTM D 1970/D 1970M.
    b. Peel Adhesion to Concrete: 5 lbf/in. (875 N/m) minimum; ASTM D 903, modified.
    c. Lap Adhesion: 5 lbf/in. (875 N/m) minimum; ASTM D 1876, modified.
    d. Hydrostatic-Head Resistance: 230 feet (70 m); ASTM D 5385, modified.
    e. Puncture Resistance: 100 lbf (445 N) minimum; ASTM E 154/E 154M.
    f. Water Vapor Permeance: 0.1 perm (6 ng/Pa x s x sq. m) maximum; ASTM E 96/E 96M, Water Method.
    g. Ultimate Elongation: 335 percent minimum; ASTM D 412, modified.

B. Blindside Sheet Waterproofing for Horizontal Applications: Uniform, flexible, multilayered-composite sheet membrane that forms a permanent bond with fresh concrete placed against it; complete with accessories and preformed shapes for an unbroken waterproofing assembly; with the following physical properties:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Physical Properties:

    a. Low-Temperature Flexibility: Pass at minus 20 deg F (minus 29 deg C); ASTM D 1970/D 1970M.
    b. Peel Adhesion to Concrete: 5 lbf/in. (875 N/m) minimum; ASTM D 903, modified.
    c. Lap Adhesion: 5 lbf/in. (875 N/m) minimum; ASTM D 1876, modified.
    d. Hydrostatic-Head Resistance: 230 feet (70 m); ASTM D 5385, modified.
    e. Puncture Resistance: 200 lbf (890 N) minimum; ASTM E 154/E 154M.

f. Water Vapor Permeance: 0.1 perm (6 ng/Pa x s x sq. m) maximum; ASTM E 96/E 96M, Water Method.
g. Ultimate Elongation: 335 percent minimum; ASTM D 412, modified.

C. Mastic, Adhesives, and Detail Tape: Liquid mastic and adhesives, and adhesive tapes recommended by waterproofing manufacturer.

2.5 AUXILIARY MATERIALS

A. Furnish auxiliary materials recommended by waterproofing manufacturer for intended use and compatible with sheet waterproofing.

1. Furnish liquid-type auxiliary materials that comply with VOC limits of authorities having jurisdiction.

B. Primer: Liquid waterborne primer recommended for substrate by sheet-waterproofing material manufacturer.

C. Surface Conditioner: Liquid, waterborne surface conditioner recommended for substrate by sheet-waterproofing material manufacturer.

D. Liquid Membrane: Elastomeric, two-component liquid, cold fluid applied, of trowel grade or low viscosity.

E. Substrate Patching Membrane: Low-viscosity, two-component, modified asphalt coating.

F. Metal Termination Bars: Aluminum bars, approximately 1 by 1/8 inch (25 by 3 mm), predrilled at 9-inch (229-mm) centers.

G. Protection Course: ASTM D 6506, semirigid sheets of fiberglass or mineral-reinforced-asphaltic core, pressure laminated between two asphalt-saturated fibrous liners and as follows:

1. Thickness: Nominal 1/4 inch (6 mm).
2. Adhesive: Rubber-based solvent type recommended by waterproofing manufacturer for protection course type.

H. Protection Course: Fan folded, with a core of extruded-polystyrene board insulation faced on one side or both sides with plastic film, nominal thickness 1/4 inch (6 mm), with compressive strength of not less than 8 psi (55 kPa) per ASTM D 1621, and maximum water absorption by volume of 0.6 percent per ASTM C 272/C 272M.

I. Protection Course: Extruded-polystyrene board insulation, unfaced, ASTM C 578, Type X, 1/2 inch (13 mm) thick.

J. Protection Course: Molded-polystyrene board insulation, ASTM C 578, Type I, 0.90-lb/cu. ft. (15-kg/cu. m) minimum density, 1-inch (25-mm) minimum thickness.

2.6 MOLDED-SHEET DRAINAGE PANELS

A. Nonwoven-Geotextile-Faced, Molded-Sheet Drainage Panel with Polymeric Film: Composite subsurface drainage panel acceptable to waterproofing manufacturer and consisting of a studded, nonbiodegradable, molded-plastic-sheet drainage core; with a nonwoven, needle-punched geotextile facing with an apparent opening size not exceeding No. 70 (0.21-mm) sieve laminated to one side of the core and a polymeric film bonded to the other side; and with a vertical flow rate through the core of 9 to 21 gpm per ft. (112 to 261 L/min. per m).

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Nonwoven-Geotextile-Faced, Molded-Sheet Drainage Panel without Polymeric Film: Composite subsurface drainage panel acceptable to waterproofing manufacturer and consisting of a studded, nonbiodegradable, molded-plastic-sheet drainage core; with a nonwoven, needle-punched geotextile facing with an apparent opening size not exceeding No. 70 (0.21-mm) sieve laminated to one side of the core, without a polymeric film bonded to the other side; and with a vertical flow rate through the core of 9 to 21 gpm per ft. (112 to 261 L/min. per m).

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2.7 INSULATION DRAINAGE PANELS

A. Insulation: Comply with Section 07 21 00 "Thermal Insulation" for general building insulation, including insulation drainage panels.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of waterproofing.

1. Verify that concrete has cured and aged for minimum time period recommended in writing by waterproofing manufacturer.
2. Verify that substrate is visibly dry and within the moisture limits recommended in writing by manufacturer. Test for capillary moisture by plastic sheet method according to ASTM D 4263.
3. Verify that compacted subgrade is dry, smooth, sound, and ready to receive waterproofing sheet.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean, prepare, and treat substrates according to manufacturer's written instructions. Provide clean, dust-free, and dry substrates for waterproofing application.

B. Mask off adjoining surfaces not receiving waterproofing to prevent spillage and overspray affecting other construction.

C. Remove grease, oil, bitumen, form-release agents, paints, curing compounds, and other penetrating contaminants or film-forming coatings from concrete.

D. Remove fins, ridges, mortar, and other projections and fill honeycomb, aggregate pockets, holes, and other voids.

E. Prepare, fill, prime, and treat joints and cracks in substrates. Remove dust and dirt from joints and cracks according to ASTM D 4258.

1. Install sheet strips of width according to manufacturer's written instructions and center over treated construction and contraction joints and cracks exceeding a width of 1/16 inch (1.6 mm) or 1/8 inch (3 mm) for modified bituminous deck-paving waterproofing.

F. Bridge and cover isolation joints, expansion joints, and discontinuous deck-to-wall and deck-to-deck joints with overlapping sheet strips of widths according to manufacturer's written instructions.

1. Invert and loosely lay first sheet strip over center of joint. Firmly adhere second sheet strip to first and overlap to substrate.

G. Corners: Prepare, prime, and treat inside and outside corners according to ASTM D 6135.

1. Install membrane strips centered over vertical inside corners. Install 3/4-inch (19-mm) fillets of liquid membrane on horizontal inside corners and as follows:

a. At footing-to-wall intersections, extend liquid membrane in each direction from corner or install membrane strip centered over corner.
b. At plaza-deck-to-wall intersections, extend liquid membrane or sheet strips onto deck waterproofing and to finished height of sheet flashing.

H. Prepare, treat, and seal vertical and horizontal surfaces at terminations and penetrations through waterproofing and at drains and protrusions according to ASTM D 6135.

3.3 MODIFIED BITUMINOUS SHEET-WATERPROOFING APPLICATION

A. Install modified bituminous sheets according to waterproofing manufacturer's written instructions and per recommendations in ASTM D 6135.

B. Apply primer to substrates at required rate and allow it to dry. Limit priming to areas that will be covered by sheet waterproofing in same day. Reprime areas exposed for more than 24 hours.

C. Apply and firmly adhere sheets over area to receive waterproofing. Accurately align sheets and maintain uniform 2-1/2-inch- (64-mm-) minimum lap widths and end laps. Overlap and seal seams, and stagger end laps to ensure watertight installation.

1. When ambient and substrate temperatures range between 25 and 40 deg F (minus 4 and plus 5 deg C), install self-adhering, modified bituminous sheets produced for low-temperature application. Do not use low-temperature sheets if ambient or substrate temperature is higher than 60 deg F (16 deg C).

D. Two-Ply Application: Install sheets to form a membrane with lap widths not less than 50 percent of sheet widths, to provide a minimum of two thicknesses of sheet membrane over areas to receive waterproofing.

E. Horizontal Application: Apply sheets from low to high points of decks to ensure that laps shed water.

F. Apply continuous sheets over already-installed sheet strips, bridging substrate cracks, construction, and contraction joints.

G. Seal edges of sheet-waterproofing terminations with mastic.

H. Install sheet-waterproofing and auxiliary materials to tie into adjacent waterproofing.

I. Repair tears, voids, and lapped seams in waterproofing not complying with requirements. Slit and flatten fishmouths and blisters. Patch with sheet waterproofing extending 6 inches (150 mm) beyond repaired areas in all directions.

J. Immediately install protection course with butted joints over waterproofing membrane.

1. Board insulation may be used in place of a separate protection course to vertical applications when approved by waterproofing manufacturer and installed immediately.

3.4 BLINDSIDE SHEET-WATERPROOFING APPLICATION

A. Install blindside sheet waterproofing according to manufacturer's written instructions.

B. Place and secure molded-sheet drainage panels over substrate. Lap edges and ends of geotextile to maintain continuity.

C. Vertical Applications: Install sheet with face against substrate. Accurately align sheets and maintain uniform side and end laps of minimum dimensions required by membrane manufacturer. Overlap and seal seams, and stagger and tape end laps to ensure watertight installation. Mechanically fasten to substrate.

1. Securely fasten top termination of membrane with continuous metal termination bar anchored into substrate and cover with detail tape.

D. Horizontal Applications: Install sheet with face against substrate. Accurately align sheets and maintain uniform side and end laps of minimum dimensions required by membrane manufacturer. Overlap and seal seams, and stagger and tape end laps to ensure watertight installation.

E. Corners: Seal lapped terminations and cut edges of sheet waterproofing at inside and outside corners with detail tape.

F. Seal penetrations through sheet waterproofing to provide watertight seal with detail tape patches or wraps and a liquid-membrane troweling.

G. Install sheet-waterproofing and auxiliary materials to produce a continuous watertight tie into adjacent waterproofing.

H. Repair tears, voids, and lapped seams in waterproofing not complying with requirements. Tape perimeter of damaged or nonconforming area extending 6 inches (150 mm) beyond repaired areas in all directions. Apply a patch of sheet waterproofing and firmly secure with detail tape.

3.5 MOLDED-SHEET DRAINAGE-PANEL INSTALLATION

A. Place and secure molded-sheet drainage panels, with geotextile facing away from wall or deck substrate, according to manufacturer's written instructions. Use adhesive or another method that does not penetrate waterproofing. Lap edges and ends of geotextile to maintain continuity. Protect installed molded-sheet drainage panels during subsequent construction.

1. For vertical applications, install board insulation before installing drainage panels.

3.6 INSULATION DRAINAGE-PANEL INSTALLATION

A. Install insulation drainage panels over waterproofed surfaces. Cut and fit to within 3/4 inch (19 mm) of projections and penetrations.

B. Ensure that drainage channels are aligned and free of obstructions.

C. On vertical surfaces, set insulation drainage panels in adhesive or tape applied according to manufacturer's written instructions.

D. On horizontal surfaces, loosely lay insulation drainage panels according to manufacturer's written instructions. Stagger end joints and tightly abut insulation units.

3.7 PLAZA-DECK PAVER INSTALLATION

A. Install pavers according to manufacturer's written instructions.

B. Install paver pedestals and accessories to required elevations. Adjust for final level and slope of paved surfaces.

C. Loosely lay pavers on pedestals, maintaining a uniform open joint width. Tightly seat pavers against spacers to eliminate lateral movement or drift of paving assembly. Align joint patterns parallel in each direction.

1. Lay out pavers to avoid less-than-half-width pavers at perimeter or other terminations.

D. Install pavers to vary no more than 1/16 inch (1.6 mm) in elevation between adjacent pavers and no more than 1/16 inch (1.6 mm) from surface plane elevation of individual paver.

E. Limit variation in paving installation to within 1/4 inch in 10 feet (6 mm in 3 m) of surface plane in any direction; noncumulative.

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests.

B. Flood Testing: Flood test each deck area for leaks, according to procedures in ASTM D 5957, after completing waterproofing but before placing overlying construction. Install temporary containment assemblies, plug or dam drains, and flood with potable water.

1. Flood to an average depth of 2-1/2 inches (64 mm) with a minimum depth of 1 inch (25 mm) and a maximum depth of 4 inches (100 mm). Maintain 2 inches (51 mm) of clearance from top of sheet flashings.
2. Flood each area for 24 hours.
3. Testing agency shall observe flood testing and examine underside of decks and terminations for evidence of leaks during flood testing.
4. After flood testing, repair leaks, repeat flood tests, and make further repairs until waterproofing installation is watertight.

C. Waterproofing will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.9 PROTECTION, REPAIR, AND CLEANING

A. Do not permit foot or vehicular traffic on unprotected membrane.

B. Protect waterproofing from damage and wear during remainder of construction period.

C. Protect installed insulation drainage panels from damage due to UV light, harmful weather exposures, physical abuse, and other causes. Provide temporary coverings where insulation is subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.

D. Correct deficiencies in or remove waterproofing that does not comply with requirements; repair substrates, reapply waterproofing, and repair sheet flashings.

E. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended in writing by manufacturer of affected construction.

END OF SECTION 07 1326

SECTION 07 2100

THERMAL INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Foam-plastic board insulation.
2. Glass-fiber board insulation.
3. Glass-fiber blanket insulation.
4. Loose-fill insulation.
5. Load bearing insulation.
6. Vapor retarders.

B. Related Sections:

1. Section 071413 "Hot Fluid-Applied Rubberized Asphalt Waterproofing" for insulated drainage panels installed with waterproofing.
2. Section 078446 "Fire-Resistive Joint Systems" for insulation installed as part of a perimeter fire-resistive joint system.
3. Sections 092900 "Gypsum Board" and 092116.23 "Gypsum Board Shaft Wall Assemblies" for installation in metal-framed assemblies of insulation specified by referencing this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.3 INFORMATIONAL SUBMITTALS

A. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for each product.

B. Research/Evaluation Reports: For foam-plastic insulation, from ICC-ES or other reporting organization acceptable to authorities having jurisdiction.

1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect insulation materials from physical damage and from deterioration due to moisture, soiling, and other sources. Store inside and in a dry location. Comply with manufacturer's written instructions for handling, storing, and protecting during installation.

B. Protect foam-plastic board insulation as follows:

1. Do not expose to sunlight except to necessary extent for period of installation and concealment.
2. Protect against ignition at all times. Do not deliver foam-plastic board materials to Project site before installation time.
3. Quickly complete installation and concealment of foam-plastic board insulation in each area of construction.

PART 2 - PRODUCTS

2.1 FOAM-PLASTIC BOARD INSULATION

A. Extruded-Polystyrene Board Insulation: ASTM C 578, of type and minimum compressive strength indicated below, with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, per ASTM E 84.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following :

a. DiversiFoam Products.
b. Dow Chemical Company (The).
c. Owens Corning.
d. Pactiv Building Products.

2. Type X, 15 psi (104 kPa).

B. Adhesive for Bonding Insulation: Product with demonstrated capability to bond insulation securely to substrates without damaging insulation and substrates.

2.2 GLASS-FIBER BOARD INSULATION

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following :

1. CertainTeed Corporation.
2. Johns Manville.
3. Knauf Insulation.
4. Owens Corning.

B. Dark-Surfaced, Glass-Fiber Board Insulation: ASTM C 612, Type IA; faced on one side with black glass-fiber mat or black polymer finish; maximum flame-spread and smoke-developed indexes of 25 and 50, respectively, per ASTM E 84.

1. Nominal density of 6 lb/cu. ft. (96 kg/cu. m), thermal resistivity of 4.5 deg F x h x sq. ft./Btu x in. at 75 deg F (31.2 K x m/W at 24 deg C).

2.3 GLASS-FIBER BLANKET INSULATION

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following :

1. CertainTeed Corporation.
2. Guardian Building Products, Inc.

3. Johns Manville.
4. Knauf Insulation.
5. Owens Corning.

B. Unfaced, Glass-Fiber Blanket Insulation: ASTM C 665, Type I; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively, per ASTM E 84; passing ASTM E 136 for combustion characteristics.

2.4 LOOSE-FILL INSULATION

A. Glass-Fiber Loose-Fill Insulation: ASTM C 764, Type I for pneumatic application or Type II for poured application; with maximum flame-spread and smoke-developed indexes of 5, per ASTM E 84.

2.5 LOAD BEARING INSULATION

A. Load Bearing Insulation: Polystyrene, high density extruded type in accordance with ASTM C 578, Type V, 100 psi compressive strength, 3.00 lb/cu. ft. (48 kg/cu. m),
   1. Thermal Resistance: (180 day real-time aging as mandated by ASTM C578, measured per ASTM C 518 at mean temperature of 75F): R-5.0, 5.6 per inch of thickness, with 90% lifetime limited warranty on thermal resistance
   2. Edge condition: Square.
   3. Surface Burning Characteristics (ASTM E 84): Flame spread less than 25, smoke developed less than 450, certified by independent third party such as Underwriters Laboratories
   4. Recycle Content: Minimum 20%, certified by independent third party such as Scientific Certification Systems
   5. Warranty: Limited lifetime warranty covering all ASTM C578 physical properties
   6. Board size: 24 inches x 48 inches x 2 inches or thickness as indicated on Drawings
   7. Water absorption (% by volume) maximum 0.7% in conformation with ASTM D2842.
   8. Acceptable Materials:
      a. Dow Styrofoam, Hiload 100
      b. Owens-Corning, Foamular 1000

2.6 VAPOR RETARDERS

A. Reinforced-Polyethylene Vapor Retarders: Two outer layers of polyethylene film laminated to an inner reinforcing layer consisting of either nylon cord or polyester scrim and weighing not less than 25 lb/1000 sq. ft. (12 kg/100 sq. m), with maximum permeance rating of 0.0507 perm (2.9 ng/Pa x s x sq. m).

   1. Products: Subject to compliance with requirements, provide one of the following :

      a. Raven Industries Inc.; DURA-SKRIM 6WW.
      b. Reef Industries, Inc.; Griffolyn T-65.

B. Vapor-Retarder Tape: Pressure-sensitive tape of type recommended by vapor-retarder manufacturer for sealing joints and penetrations in vapor retarder.

C. Vapor-Retarder Fasteners: Pancake-head, self-tapping steel drill screws; with fender washers.

D. Single-Component Nonsag Urethane Sealant: ASTM C 920, Type I, Grade NS, Class 25, Use NT related to exposure, and Use O related to vapor-barrier-related substrates.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean substrates of substances that are harmful to insulation or vapor retarders, including removing projections capable of puncturing vapor retarders, or that interfere with insulation attachment.

3.2 INSTALLATION, GENERAL

A. Comply with insulation manufacturer's written instructions applicable to products and applications indicated.

B. Install insulation that is undamaged, dry, and unsoiled and that has not been left exposed to ice, rain, or snow at any time.

C. Extend insulation to envelop entire area to be insulated. Cut and fit tightly around obstructions and fill voids with insulation. Remove projections that interfere with placement.

D. Provide sizes to fit applications indicated and selected from manufacturer's standard thicknesses, widths, and lengths. Apply single layer of insulation units to produce thickness indicated unless multiple layers are otherwise shown or required to make up total thickness.

3.3 INSTALLATION OF INSULATION FOR FRAMED CONSTRUCTION

A. Apply insulation units to substrates by method indicated, complying with manufacturer's written instructions. If no specific method is indicated, bond units to substrate with adhesive or use mechanical anchorage to provide permanent placement and support of units.

B. Foam-Plastic Board Insulation: Seal joints between units by applying adhesive, mastic, or sealant to edges of each unit to form a tight seal as units are shoved into place. Fill voids in completed installation with adhesive, mastic, or sealant as recommended by insulation manufacturer.

C. Glass-Fiber or Mineral-Wool Blanket Insulation: Install in cavities formed by framing members according to the following requirements:

1. Use insulation widths and lengths that fill the cavities formed by framing members. If more than one length is required to fill the cavities, provide lengths that will produce a snug fit between ends.
2. Place insulation in cavities formed by framing members to produce a friction fit between edges of insulation and adjoining framing members.
3. Maintain 3-inch (76-mm) clearance of insulation around recessed lighting fixtures not rated for or protected from contact with insulation.
4. For metal-framed wall cavities where cavity heights exceed 96 inches (2438 mm), support unfaced blankets mechanically and support faced blankets by taping flanges of insulation to flanges of metal studs.

D. Loose-Fill Insulation: Apply according to ASTM C 1015 and manufacturer's written instructions. Level horizontal applications to uniform thickness as indicated, lightly settle to uniform density, but do not compact excessively.

E. Miscellaneous Voids: Install insulation in miscellaneous voids and cavity spaces where required to prevent gaps in insulation using the following materials:

1. Loose-Fill Insulation: Compact to approximately 40 percent of normal maximum volume equaling a density of approximately 2.5 lb/cu. ft. (40 kg/cu. m).

3.4 INSTALLATION OF INSULATION IN CEILINGS FOR SOUND ATTENUATION

A. Where glass-fiber blankets are indicated for sound attenuation above ceilings, install blanket insulation over entire ceiling area in thicknesses indicated. Extend insulation 48 inches (1219 mm) up either side of partitions.

3.5 INSTALLATION OF CURTAIN-WALL INSULATION

A. Install board insulation in curtain-wall construction where indicated on Drawings according to curtain-wall manufacturer's written instructions.

1. Hold insulation in place by securing metal clips and straps or integral pockets within window frames, spaced at intervals recommended in writing by insulation manufacturer to hold insulation securely in place without touching spandrel glass. Maintain cavity width of dimension indicated between insulation and glass.
2. Install insulation where it contacts perimeter fire-containment system to prevent insulation from bowing under pressure from perimeter fire-containment system.

3.6 INSTALLATION OF VAPOR RETARDERS

A. Place vapor retarders on side of construction indicated on Drawings. Extend vapor retarders to extremities of areas to protect from vapor transmission. Secure vapor retarders in place with adhesives or other anchorage system as indicated. Extend vapor retarders to cover miscellaneous voids in insulated substrates, including those filled with loose-fiber insulation.

B. Seal vertical joints in vapor retarders over framing by lapping no fewer than two studs.

1. Before installing vapor retarders, apply urethane sealant to flanges of metal framing including runner tracks, metal studs, and framing around door and window openings. Seal overlapping joints in vapor retarders with vapor-retarder tape according to vapor-retarder manufacturer's written instructions. Seal butt joints with vapor-retarder tape. Locate all joints over framing members or other solid substrates.
2. Firmly attach vapor retarders to metal framing and solid substrates with vapor-retarder fasteners as recommended by vapor-retarder manufacturer.

C. Seal joints caused by pipes, conduits, electrical boxes, and similar items penetrating vapor retarders with vapor-retarder tape to create an airtight seal between penetrating objects and vapor retarders.

D. Repair tears or punctures in vapor retarders immediately before concealment by other work. Cover with vapor-retarder tape or another layer of vapor retarders.

3.7 PROTECTION

A. Protect installed insulation and vapor retarders from damage due to harmful weather exposures, physical abuse, and other causes. Provide temporary coverings or enclosures where insulation is subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.

END OF SECTION 07 2100

SECTION 07 6200

SHEET METAL FLASHING AND TRIM

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following:

1. Manufactured reglets.
2. Formed roof drainage system.
3. Formed low-slope roof flashing and trim.
4. Formed wall flashing and trim.
5. Formed equipment support flashing.
6. Formed overhead-piping safety pans.

1.2 ACTION SUBMITTALS

A. Product Data: For each product indicated.

B. LEED Submittals: Submit the following in compliance with Section 01 81 13 "Sustainable Design Requirements":

1. LEED Criteria Worksheet for each component material of the product or assembly used in the installation of Work of this Section.
2. Product Data for Credit MR 4: For products having recycled content.
3. Product Certificates for Credit MR 5: For products and materials required to comply with requirements for regional materials.

C. Shop Drawings: Show layouts, profiles, shapes, seams, dimensions, and details for fastening, joining, supporting, and anchoring sheet metal flashing and trim.

D. Samples: For each exposed finish and for joint sealants.

1.3 INFORMATIONAL SUBMITTALS

A. Sealant Compatibility and Adhesion Test Reports: From sealant manufacturer for each combination of joint substrate, primer, backing, and sealant.

1.4 QUALITY ASSURANCE

A. Sheet Metal Flashing and Trim Standard: Comply with SMACNA's "Architectural Sheet Metal Manual." Conform to dimensions and profiles shown unless more stringent requirements are indicated.

B. Sealant Compatibility and Adhesion Testing: Use sealant manufacturer's standard test methods to determine whether priming and other specific joint preparation techniques are required to obtain rapid, optimum adhesion of joint sealants to joint substrates.

C. Preinstallation Conference: Conduct conference at Project site.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SHEET METALS

A. Aluminum Sheet: ASTM B 209, Alloy 3003, 3004, 3105, or 5005, Temper suitable for forming and structural performance required, but not less than H14, finished as follows:

1. Mill Finish: Standard one-side bright.
2. Factory Prime Coating: Factory-applied, baked-on epoxy primer coat.
3. Siliconized-Polyester Coating: Epoxy primer and silicone-modified, polyester-enamel topcoat.

   a. Color: Match Architect's samples.

4. High-Performance Organic Finish: Three-coat, thermocured system containing not less than 70 percent polyvinylidene fluoride resin by weight; complying with AAMA 2604.

   a. Color: Match Architect's samples.

5. Clear Anodic Finish: Class II, AA-M12C22A31, complying with AAMA 611.

B. Stainless-Steel Sheet: ASTM A 240/A 240M, Type 304, No. 2B finish.

C. Zinc-Tin Alloy-Coated Stainless-Steel Sheet: ASTM A 240/A 240M, Type 304, dead-soft, fully annealed stainless-steel sheet, coated on both sides with a zinc-tin alloy (50 percent zinc, 50 percent tin).

D. Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, G90 coating designation; structural quality, mill phosphatized for field painting.

E. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, Class AZ50 coating designation, Grade 40; structural quality with manufacturer's standard clear acrylic coating both sides.

F. Prepainted, Metallic-Coated Steel Sheet: Steel sheet metallic coated by the hot-dip process and prepainted by the coil-coating process to comply with ASTM A 755/A 755M.

1. Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, G90 coating designation; structural quality.
2. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, Class AZ50 coating designation, Grade 40; structural quality.
3. Exposed Finishes: Apply the following coil coating:

   a. Factory Prime Coating: Factory-applied, baked-on epoxy primer coat.
   b. Siliconized-Polyester Coating: Epoxy primer and silicone-modified, polyester-enamel topcoat; with a dry film thickness of not less than 0.2 mil for primer and 0.8 mil for topcoat.

      1) Color: As selected by Architect from manufacturer's full range.

G. Lead Sheet: ASTM B 749, Type L51121, copper-bearing lead sheet.

2.3 MISCELLANEOUS MATERIALS

A. General: Provide materials and types of fasteners, solder, welding rods, protective coatings, separators, sealants, and other miscellaneous items as required for complete sheet metal flashing and trim installation.

B. Felt Underlayment: ASTM D 226, Type II (No. 30), asphalt-saturated organic felt, nonperforated.

1. Slip Sheet: Rosin-sized paper, minimum 3 lbs./100 sq. ft..

C. Fasteners: Wood screws, annular threaded nails, self-tapping screws, self-locking rivets and bolts, and other suitable fasteners designed to withstand design loads.

1. Nails for Copper Sheet: Copper or hardware bronze, 0.109 inch minimum and not less than 7/8 inch long, barbed with large head.
2. Exposed Fasteners: Heads matching color of sheet metal by means of plastic caps or factory-applied coating.
3. Fasteners for Flashing and Trim: Blind fasteners or self-drilling screws, gasketed, with hex washer head.
4. Blind Fasteners: High-strength aluminum or stainless-steel rivets.

D. Sealing Tape: Pressure-sensitive, 100 percent solids, polyisobutylene compound sealing tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape.

E. Elastomeric Sealant: ASTM C 920 and Section 07 92 00 "Joint Sealants," elastomeric polyurethane polymer sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.

F. Butyl Sealant: ASTM C 1311, single-component, solvent-release butyl rubber sealant, polyisobutylene plasticized, heavy bodied for hooked-type expansion joints with limited movement.

G. Epoxy Seam Sealer: Two-part, noncorrosive, aluminum seam-cementing compound.

H. Bituminous Coating: Cold-applied asphalt mastic, SSPC-Paint 12, compounded for 15 mil dry film thickness per coat.

2.4 REGLETS

A. Reglets: Units of type, material, and profile indicated, formed to provide secure interlocking of separate reglet and counterflashing pieces, and compatible with flashing indicated with factory- mitered and -welded corners and junctions.

1. Manufacturers:

   a. Cheney Flashing Company, Inc.
   b. Fry Reglet Corporation.
   c. Heckmann Building Products Inc.
   d. Hickman, W. P. Company.
   e. Keystone Flashing Company, Inc.
   f. Sandell Manufacturing Company, Inc.

2. Material: Stainless steel, 0.0187 inch thick.

2.5 FABRICATION, GENERAL

A. General: Custom fabricate sheet metal flashing and trim to comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and other characteristics of item indicated. Shop fabricate items where practicable. Obtain field measurements for accurate fit before shop fabrication.

B. Fabricate sheet metal flashing and trim without excessive oil canning, buckling, and tool marks and true to line and levels indicated, with exposed edges folded back to form hems.

1. Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.
2. Seams for Other Than Aluminum: Fabricate nonmoving seams in accessories with flat-lock seams. Tin edges to be seamed, form seams, and solder.

C. Sealed Joints: Form nonexpansion but movable joints in metal to accommodate elastomeric sealant to comply with SMACNA recommendations.

D. Expansion Provisions: Where lapped or bayonet-type expansion provisions in the Work cannot be used, form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with elastomeric sealant concealed within joints.

E. Conceal fasteners and expansion provisions where possible on exposed-to-view sheet metal flashing and trim, unless otherwise indicated.

F. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal, and in thickness not less than that of metal being secured.

2.6 LOW-SLOPE ROOF SHEET METAL FABRICATIONS

A. Copings: Fabricate in minimum 96 inches long, but not exceeding 10 foot long, sections. Fabricate joint plates of same thickness as copings. Furnish with continuous cleats to support edge of external leg and drill elongated holes for fasteners on interior leg. Miter corners, seal, and solder or weld watertight.

1. Fabricate copings from the following material:

a. Aluminum: 0.050 inch thick.

B. Roof and Roof to Wall Transition Expansion-Joint Cover: Fabricate from the following material:

1. Aluminum: 0.050 inch thick.

C. Base Flashing: Fabricate from the following material:

1. Aluminum: 0.040 inch thick.

D. Counterflashing and Flashing Receivers: Fabricate from the following material:

1. Aluminum: 0.0320 inch thick.

E. Roof-Penetration Flashing: Fabricate from the following material:

1. Galvanized Steel: 0.0276 inch thick.

F. Roof-Drain Flashing: Fabricate from the following material:

1. Stainless Steel: 0.0156 inch thick.

G. Wall Expansion-Joint Cover: Fabricate from the following material:

1. Stainless Steel: 0.0187 inch thick.

2.7 WALL SHEET METAL FABRICATIONS

A. Openings Flashing in Frame Construction: Fabricate through wall head, sill, jamb, spandrel, base course/foundation, and similar flashings to extend 4 inches beyond wall openings. Form head and sill flashing with 2-inch- high end dams. Fabricate from the following material:

1. Stainless Steel: 0.0156 inch thick.

B. Flashing at Level 01 - IGU Base: Fabricate base and slab edge flashing as indicated on drawings. Fabricate from the following material:

1. Stainless Steel: 0.083 inch thick

2.8 MISCELLANEOUS SHEET METAL FABRICATIONS

A. Equipment Support Flashing: Fabricate from the following material:

1. Galvanized Steel: 0.0276 inch thick.

B. Overhead-Piping Safety Pans: Fabricate from the following material:

1. Galvanized Steel: 0.0396 inch thick.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Examine substrates, areas, and conditions, with Installer present, to verify actual locations, dimensions and other conditions affecting performance of work.

1. Verify that substrate is sound, dry, smooth, clean, sloped for drainage, and securely anchored.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

B. General: Anchor sheet metal flashing and trim and other components of the Work securely in place, with provisions for thermal and structural movement. Use fasteners, solder, welding rods, protective coatings, separators, sealants, and other miscellaneous items as required to complete sheet metal flashing and trim system.

1. Torch cutting of sheet metal flashing and trim is not permitted.

C. Metal Protection: Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with bituminous coating or by other permanent separation as recommended by fabricator or manufacturers of dissimilar metals.

D. Install exposed sheet metal flashing and trim without excessive oil canning, buckling, and tool marks.

E. Install sheet metal flashing and trim true to line and levels indicated. Provide uniform, neat seams with minimum exposure of solder, welds, and elastomeric sealant.

F. Install sheet metal flashing and trim to fit substrates and to result in watertight performance. Verify shapes and dimensions of surfaces to be covered before fabricating sheet metal.

1. Space cleats not more than 12 inches apart. Anchor each cleat with two fasteners. Bend tabs over fasteners.

G. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet with no joints allowed within 24 inches of corner or intersection. Where lapped or bayonet-type expansion provisions cannot be used or would not be sufficiently watertight, form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with elastomeric sealant concealed within joints.

H. Fasteners: Use fasteners of sizes that will penetrate substrate not less than 1-1/4 inches for nails and not less than 3/4 inch for wood screws.

1. Galvanized or Prepainted, Metallic-Coated Steel: Use stainless-steel fasteners.
2. Aluminum: Use aluminum or stainless-steel fasteners.
3. Copper: Use copper or stainless-steel fasteners.
4. Stainless Steel: Use stainless-steel fasteners.

I. Seal joints with elastomeric sealant as required for watertight construction. Comply with recommendations of ASTM C 1193 and Section 07 92 00 "Joint Sealants."

J. Soldered Joints: Clean surfaces to be soldered, removing oils and foreign matter. Pretin edges of sheets to be soldered to a width of 1-1/2 inches except where pretinned surface would show in finished Work.

1. Do not solder prepainted, metallic-coated steel and aluminum sheet.

3.2 ROOF FLASHING INSTALLATION

A. General: Install sheet metal roof flashing and trim to comply with performance requirements and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, set units true to line, and level as indicated. Install work with laps, joints, and seams that will be permanently watertight.

B. Roof Edge Flashing: Anchor to resist uplift and outward forces according to recommendations in FMG Loss Prevention Data Sheet 1-49.

1. Interlock bottom edge of roof edge flashing with continuous cleats anchored to substrate at 16 inch centers.

C. Copings: Anchor to resist uplift and outward forces according to recommendations in FMG Loss Prevention Data Sheet 1-49.

1. Interlock exterior bottom edge of coping with continuous cleats anchored to substrate at 16 inch centers.
2. Anchor interior leg of coping with screw fasteners and washers at 18 inch centers.

D. Expansion-Joint Covers: Install expansion-joint covers at locations and of configuration indicated. Lap joints a minimum of 4 inches in direction of water flow.

E. Pipe or Post Counterflashing: Install counterflashing umbrella with close-fitting collar with top edge flared for elastomeric sealant, extending a minimum of 4 inches over base flashing. Install stainless-steel draw band and tighten.

F. Counterflashing: Coordinate installation of counterflashing with installation of base flashing. Insert counterflashing in reglets or receivers and fit tightly to base flashing. Secure in a waterproof manner. Extend counterflashing 4 inches over base flashing. Lap counterflashing joints a minimum of 4 inches and bed with elastomeric sealant.

G. Roof-Penetration Flashing: Coordinate installation of roof-penetration flashing with installation of roofing and other items penetrating roof. Install flashing as follows:

1. Turn lead flashing down inside vent piping, being careful not to block vent piping with flashing.
2. Seal with elastomeric sealant and clamp flashing to pipes penetrating roof except for lead flashing on vent piping.

3.3 WALL FLASHING INSTALLATION

A. General: Install sheet metal wall flashing to intercept and exclude penetrating moisture according to SMACNA recommendations and as indicated. Coordinate installation of wall flashing with installation of wall-opening components such as windows, doors, and louvers.

B. Reglets: Installation of reglets is specified in Section 03 30 00 "Cast-in-Place Concrete."

C. Through-Wall Flashing: Installation of manufactured and formed through-wall flashing is specified in Section 04 20 00 "Unit Masonry."."

D. Openings Flashing in Frame Construction: Install continuous through wall head, sill, jamb, and similar flashings to extend 4 inches beyond wall openings.

E. Overhead-Piping Safety Pans: Suspend pans from pipe and install drain line to plumbing waste or drain line.

F. Equipment Support Flashing: Coordinate installation of equipment support flashing with installation of roofing and equipment. Weld or seal flashing with elastomeric sealant to equipment support member.

G. Clean exposed metal surfaces for uniform oxidation and weather exposure; neutralize flux materials; clean off excess solder and sealants; and remove strippable films, if any.

END OF SECTION 07 6200

SECTION 07 8100

APPLIED FIREPROOFING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes low density cementitious sprayed fire-resistive materials.

1.2 DEFINITIONS

A. Low density sprayed fire-resistive material is applied to surfaces that are concealed from view behind other construction when the Work is completed or that are exposed to view in locations where they will not be physically abused meaning that the materials are not in contact with end user or end user's equipment causing dislocation or reduction in required thickness of material.

1.3 ACTION SUBMITTALS

A. Product Data: Submit current edition of manufacturer's application and installation instruction manual and referenced bulletins.

B. Shop Drawings: Submit a "Fire-Resistive Materials Design Schedule Keyed to the Structural Drawings and Schedules" indicating the following:

1. Schedule for each building element receiving spray fire-resistive materials showing hourly rating and material thickness and UL Design Number.
2. When UL Designs are used for beams and columns smaller and larger than those listed in the UL Design, provide explanation of thickness adjustment based on W (weight per lineal foot)/D (perimeter of exposure) formulas for each element.
3. Locations and types of surface preparations required before applying sprayed fire-resistive material.
4. Extent of sprayed fire-resistive material for each construction and fire-resistance rating, including a schedule indicating the following:

    a. Applicable fire-resistance design designations of a qualified testing and inspecting agency acceptable to authorities having jurisdiction.
    b. Minimum thicknesses needed to achieve required fire-resistance ratings of structural components and assemblies.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: Submit qualification data for installer.

B. Test Reports: Submit reports of required testing.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer certified, licensed, or otherwise qualified by sprayed fire-resistive material manufacturer as having the necessary experience staff, and training to install manufacturer's products according to specified requirements. A manufacturer's willingness to sell its sprayed fire-resistive materials to Contractor or to an installer engaged by Contractor does not in itself confer qualification on the buyer.

B. Fire-Test-Response Characteristics: Provide sprayed fire-resistive materials with the fire-test-response characteristics indicated, as determined by testing identical products per test method indicated below by UL or another testing and inspecting agency acceptable to authorities having jurisdiction.

1. Fire-Resistance Ratings: Indicated by design designations from UL's "Fire Resistance Directory" or from the listings of another testing and inspecting agency acceptable to authorities having jurisdiction, for sprayed fire-resistive material serving as direct-applied protection tested per ASTM E 119.
2. Surface-Burning Characteristics: ASTM E 84.

C. Sample Installations: 40 days prior to installation of sprayed fire-resistive material, apply products specified to demonstrate aesthetic effects, where applicable, adhesion/cohesion, and quality of workmanship. Build sample installations to comply with the following requirements, using materials indicated for completed Work:

1. Locate sample installations in a location(s) as directed by the Architect.
2. Extent of Sample Installations: Include each of the following surfaces for which spray fire-resistive materials are required: 48 inches (1219 mm) linear of column, 48 inches (1219 mm) linear of beam and 4 square feet (0.37 sm) of metal deck. Make areas contiguous. Where steel is not available 40 days prior to installation of sprayed fire-resistive materials erect freestanding sample installation. Test installation for adhesion/cohesion in accordance with manufacturer's tested assemblies proposed for the Work and as specified.
3. Testing: The Owner's Testing and Inspection Agency will perform testing on sample installations in accordance with requirements of Part 3, "Field Quality Control."
4. Notify Architect 7 days in advance of the dates and times when sample installations will be constructed.
5. Demonstrate the proposed range of aesthetic effects and workmanship, including patching.
6. Approved sample installations may become part of the completed Work if undisturbed at time of Substantial Completion.

D. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Section 01 31 00 "Project Management and Coordination." Contractor, installer and independent testing agency shall attend a pre-installation conference to review the substrates for acceptability, method of application, applied thicknesses, and testing and inspection procedures.

E. Regulatory Requirements: Conform to the applicable building code requirements of the authorities having jurisdiction. Products, execution, and the thickness spray fire resistive materials shall conform to the applicable code requirements for the required fire resistance ratings.

1. UL Degree of Restraint: Unrestrained.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to Project site in original, unopened packages with intact and legible manufacturers' labels identifying product and manufacturer, date of manufacture, shelf life if applicable, and fire-resistance ratings applicable to Project.

B. Use materials with limited shelf life within period indicated. Remove from Project site and discard materials whose shelf life has expired.

C. Store materials inside, under cover, aboveground, in a dry location, until ready for use. Remove from Project site and discard wet or deteriorated materials.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Do not apply sprayed fire-resistive material when ambient or substrate temperatures are 40 deg F (4 deg C) or lower. When ambient or substrate temperatures are lower, provide temporary enclosures and heat to maintain temperatures at or above this level for 24 hours before and during application, and after application for a minimum of 24 hours or more, until the sprayed fire resistive material is cured.

B. Ventilation: Ventilate spaces during and after application of sprayed fire-resistive material. Provide a minimum of 4 air changes per hour until fire resistive material cures by the following:

1. Using natural means.
2. When natural means are inadequate, provide forced-air circulation at a rate of 4 air exchanges per hour.

1.8 COORDINATION

A. Sequence and coordinate application of sprayed fire-resistive materials with other related work specified in other Sections to comply with the following requirements:

1. Provide temporary enclosures for interior applications to prevent deterioration of fire-resistive material due to exposure to unfavorable environmental conditions.
2. Avoid unnecessary exposure of fire-resistive material to abrasion and other damage likely to occur during construction operations subsequent to its application.
3. Do not apply fire-resistive material to metal roof deck substrates until concrete fill, if any, and roofing has been completed; prohibit roof traffic during application and drying of fire-resistive material.
4. Do not apply fire-resistive material to metal floor deck substrates until concrete fill has been completed.
5. Do not begin applying fire-resistive material until clips, hangers, supports, sleeves, and other items penetrating fire protection are in place.
6. Defer installing ducts, piping, and other items that would interfere with applying fire-resistive material until application of fire protection is completed.
7. Do not install enclosing or concealing construction until after fire-resistive material has been applied, inspected, tested and corrections have been made to defective applications.

1.9 WARRANTY

A. General Warranty: The special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

B. Special Warranty: Submit a written warranty, signed by Contractor and by Installer, agreeing to repair or replace sprayed fire-resistive materials that fail in materials or workmanship within specified warranty period. Failures include, but are not limited to, the following:

1. Failures include, but are not limited to, cracking, flaking, or eroding by air or weather, in excess of specified requirements; peeling; and delaminating of sprayed fire-resistive materials from substrates due to defective materials and workmanship.
2. Not covered under the warranty are failures due to damage by occupants and Owner's maintenance personnel, exposure to environmental conditions other than those investigated and approved during fire-response testing, and other causes not reasonably foreseeable under conditions of normal use.

C. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LOW DENSITY SPRAYED FIRE-RESISTIVE MATERIALS

A. General: For low density applications of sprayed fire-resistive materials, provide manufacturer's standard products complying with requirements indicated for material composition and physical properties representative of installed products.

B. Subject to compliance with requirements, provide products by one of the following:

1. Cementitious Sprayed Fire-Resistive Material:

a. Carboline Co., Fireproofing Products Div.; Pyrolite 15 High Yield.
b. Grace, W. R. & Co.--Conn., Construction Products Div.; Monokote Type MK-6.
c. Isolatek International Corp., Cafco Products; Cafco 300.
d. Southwest Vermiculite Co., Inc.; 5EF.

C. Material Composition: Cementitious sprayed fire-resistive material consisting of factory-mixed, dry formulation of gypsum or portland cement binders and lightweight, asbestos free, mineral or synthetic aggregates mixed with water at Project site to form a slurry or mortar for conveyance and application.

D. Physical Properties: Minimum values, unless otherwise indicated, or higher values required to attain designated fire-resistance ratings, measured per standard test methods referenced with each property as follows:

1. Dry Density: 15 lbs./cu. ft. (240 kg/cu. m) for average and individual densities regardless of density indicated in referenced fire-resistance design, or greater if required to attain fire-resistance ratings indicated, per ASTM E 605 or AWCI Technical Manual 12-A, (Third Ed.) Section 5.4.5, "Displacement Method."

2. Thickness: Provide minimum average thickness required for each fire-resistance design indicated according to ASTM E 605.
3. Bond Strength: 200 lbf/sq. ft. (9.5 kPa) minimum per ASTM E 736:

    a. If surfaces of structural steel receiving sprayed fire-resistive material are primed or otherwise painted for coating materials, perform series of bond tests specified in UL's "Fire Resistance Directory." Provide bond strength indicated in referenced UL fire-resistance criteria, but not less than 150 lbf/sq. ft. (7.2 kPa) minimum per ASTM E 736.

4. Air Erosion: Maximum weight loss of 0.001 g/sq. ft. (0.01 g/sq. m) in 24 hours per ASTM E 859. For laboratory tests, minimum thickness of sprayed fire-resistive material is 0.75 inch (19 mm), maximum dry density is 15 lbs./cu. ft. (240 kg/cu. m), test specimens are not prepurged by mechanically induced air velocities, and tests are terminated after 24 hours.
5. Fire-Test-Response Characteristics: Provide sprayed fire-resistive materials with the following surface-burning characteristics as determined by testing identical products per ASTM E 84 by UL or another testing and inspecting agency acceptable to authorities having jurisdiction:

    a. Flame-Spread Index: 10 or less .
    b. Smoke-Developed Index: 0 .

2.2 AUXILIARY FIRE-RESISTIVE MATERIALS

A. General: Provide auxiliary fire-resistive materials that are compatible with sprayed fire-resistive materials and substrates and are approved by UL or another testing and inspecting agency acceptable to authorities having jurisdiction for use in fire-resistance designs indicated.

B. Adhesive for Bonding Fire-Resistive Material: Product approved by manufacturer of sprayed fire-resistive material.

C. Metal Lath: Expanded metal lath fabricated from material of weight, configuration, and finish required to comply with fire-resistance designs indicated and fire-resistive material manufacturer's written recommendations. Include clips, lathing accessories, corner beads, and other anchorage devices required to attach lath to substrates and to receive sprayed fire-resistive material.

D. Water: Potable. Provide water with sufficient pressure and volume to meet the fireproofing application schedule.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, with installer and representative of the testing laboratory present, to determine that they are in satisfactory condition to receive sprayed fire-resistive material. Contractor, Installer and testing laboratory shall submit written statement of each area's substrate acceptability to the Architect prior to beginning application of fire-resistive materials. A substrate is in satisfactory condition if it complies with the following:

1. Substrates comply with requirements in the Section where the substrate and related materials and construction are specified.
2. Substrates are free of oil, grease, rolling compounds, incompatible primers, loose mill scale, dirt, and other foreign substances capable of impairing bond of fire-resistive material with substrate under conditions of normal use or fire exposure.
3. Objects penetrating fire-resistive material, including clips, hangers, support sleeves, and similar items, are securely attached to substrates prior to application.
4. Substrates are not obstructed by ducts, piping, equipment, and other suspended construction that will interfere with applying fire-resistive material.

B. Prior to application of fireproofing to steel beams and decks verify that placement of concrete fill on floor and roof decks has been completed.

C. On roof decks without concrete fill complete all roofing applications and roof mounted equipment installation prior to application of fireproofing to the underside of supporting beams.

D. Do not proceed with installation of fire resistive materials until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean substrates of substances that could impair bond of fire-resistive material, including dirt, oil, grease, release agents, rolling compounds, loose mill scale, and incompatible primers, paints, and encapsulants and other foreign substances which may impair proper adhesion of fireproofing to substrate.

B. Metal Lathing: Where required by rated assembly and bond, install metal lath, as required, to comply with fire-resistance ratings and fire-resistive material manufacturer's written recommendations for conditions of exposure and intended use. Securely attach lath to substrate in position required for support and reinforcement of fire-resistive material. Use anchorage devices of type recommended in writing by sprayed fire-resistive material manufacturer. Attach lathing accessories where indicated or required for secure attachment to substrate.

C. Cover other work subject to damage from fallout or overspray of fire-resistive materials before application. Provide temporary enclosure as required to confine spraying operations, protect the environment, and ensure maintenance of adequate ambient conditions for temperature and ventilation.

1. Cover floor slabs with polyethylene sheeting.

3.3 INSTALLATION, GENERAL

A. Comply with fire-resistive material manufacturer's written instructions for mixing materials, application procedures, and types of equipment used to mix, convey, and spray on fire-resistive material, as applicable to particular conditions of installation and as required to achieve fire-resistance ratings indicated.

B. Extend fire-resistive material in full thickness over entire area of each substrate to be protected. Unless otherwise recommended in writing by sprayed fire-resistive material manufacturer, install body of fire-resistive covering in a single course.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified independent testing and inspecting agency to verify the adequacy of the Contractor's quality control of the sprayed-fire resistive materials work.

1. The independent testing and inspection agency will promptly submit weekly test results to the Contractor and Architect in the form required under ASTM E 605 and E 736. The reports shall clearly indicate the location of each test, the test result at that location, and whether or not the tested fire resistive materials at each test location complies with the Contract Documents.

B. Testing and Inspection: Testing and inspection of completed applications of sprayed fire-resistive material shall be conducted as the work progresses. Each thickness, density and bond strength test location shall be selected at random by the testing and inspection agency. Do not proceed with application of sprayed fire-resistive material for the next area until test results for previously completed applications of sprayed fire-resistive material show compliance with requirements.

1. Testing and inspection of the sprayed fire resistive material shall comply with the statutory requirements of New York City Controlled Inspections Program for Spray-On Fireproofing and for the requirements of the component materials and installation.
2. Visual Inspection:

   a. Prior to Application: Visually inspect all surfaces intended to receive sprayed fire resistive materials prior to its installation for conformance with the requirements of the Contract Documents.
   b. After Application: Visually inspect all surfaces that received sprayed fire resistive materials, including patched areas, for conformance with the requirements of the Contract Documents. Cracks in the fireproofing which expose the fireproofed substrate will not be permitted.
   c. Final Inspection: After the work of adjacent trades has been completed, but before sprayed structural elements are enclosed, conduct a final visual inspection of sprayed-fire resistive materials work.

3. Thickness Testing:

   a. Thickness for Floor and Roof Deck Assemblies: For each 1000 sq. ft. (93 sq. m) area, or partial area, on each floor, make four random tests for thickness per ASTM E 605.
   b. Thickness for Beams, Girders, Joists, Trusses and Columns: One test for beams, girders, joists or trusses, and one test for columns, per 25 percent of structural members per floor per ASTM E 605.

4. Density Testing: For each 10,000 sq. ft. (929 sq. m) area, or partial area, on each floor, test one protected beam, one protected column, and one protected deck surface per ASTM E 605 or AWCI Technical Manual 12-A, (Third Ed.), Section 5.4.5, "Displacement Method."
5. Cohesion-Adhesion (Bond Strength) Testing: For each 10,000 sq. ft. (929 sq. m) area, or partial area, on each floor, test one protected beam, one protected column, and one protected deck surface, for cohesion and adhesion per ASTM E 736.
6. Compatibility and Adhesion Testing: Test primers and other coatings which have been applied to surfaces which are to be protected by sprayed firm resistive materials to confirm that they are compatible with, and can be adhered to by, sprayed fire-resistive material. Determine compatibility and adhesion according to the following requirements:

a. Testing for bond per ASTM E 736 and requirements in UL's "Fire Resistance Directory" for coating materials. Provide bond strength indicated in referenced fire-resistance design, but not less than minimum specified in Part 2.

b. Verify that manufacturer, through its own laboratory testing or field experience, has not found primers or coatings to be incompatible with, or incapable of being adhered to by, sprayed fire-resistive material.

7. Where testing and inspection reveals applications of sprayed fire-resistive material are not in compliance with requirements, testing and inspecting agency will perform additional random testing to determine extent of noncompliance.

C. Apply additional sprayed fire-resistive material per manufacturer's written instructions where test results indicate that thickness does not comply with specified requirements.

D. Remove and replace, at Contractor's expense, including costs of delays to the work caused by removal and replacement, sprayed fire-resistive material where test results indicate that they do not comply with specified requirements for both cohesion and adhesion and for density.

E. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.5 CLEANING, PROTECTING, AND REPAIR

A. Cleaning: Immediately after completing spraying operations in each confinable area of Project, remove material overspray and fallout from surfaces of other construction and clean exposed surfaces.

B. Cure exposed cementitious-sprayed fire-resistive material according to product manufacturers' written recommendations to prevent premature drying.

C. Protect sprayed fire-resistive material, according to advice of product manufacturer and Installer, from damage resulting from construction operations or other causes so fire protection will be without damage or deterioration at time of Substantial Completion.

1. Trades, other than fireproofing installer, who remove fireproofing material will be responsible for replacement of same.

D. Coordinate application of sprayed fire-resistive material with other construction to minimize need to cut or remove fire protection. As installation of other construction proceeds, inspect sprayed fire-resistive material and patch any damaged or removed areas prior to covering by other construction.

END OF SECTION 07 8100

SECTION 07 8413

PENETRATION FIRESTOPPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes through-penetration firestop systems for penetrations through the following fire-resistance-rated assemblies, including both empty openings and openings containing penetrating items:

1. Floors.
2. Roofs.
3. Walls and partitions.
4. Smoke barriers.

B. Related Sections:

1. Section 03 30 00 "Cast-in-Place Concrete" for construction of openings in concrete slabs and walls.
2. Division 22 Sections specifying piping penetrations.
3. Division 23 Sections specifying duct penetrations.
4. Division 26 Sections specifying cable and conduit penetrations.

1.2 ACTION SUBMITTALS

A. Through-Penetration Firestopping Schedule: Submit, for information only, a Through-Penetration Firestopping Schedule indicating the type of through-penetration firestop system to be installed for each penetration. Indicate each kind of construction condition penetrated and kind of penetrating item. Include firestop design designation of Underwriters Laboratories that evidences compliance with requirements for each condition indicated, and listed in the "Through Penetration Firestopping Schedule" at the end of Part 3 of this Section.

1. Submit documentation, including illustrations, from Underwriters Laboratories applicable to each through-penetration firestop.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: Signed by manufacturers of through-penetration firestop system products certifying that products furnished comply with requirements.

1.4 CLOSEOUT SUBMITTALS

A. At Project Closeout, submit a list of systems installed, the UL design designations, and the location of each system. The submittal must have the Installer's signature.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A firm or individual certified or licensed, by firestop system manufacturer as experienced and with sufficient trained staff to install manufacturer's products according to specified requirements. A manufacturer's willingness to sell its firestop system materials to Contractor or to an installer engaged by Contractor does not in itself confer qualification on the buyer.

B. Source Limitations: Obtain through-penetration firestop systems, for each kind of penetration and construction condition indicated, from a single manufacturer.

C. Fire-Test-Response Characteristics: Provide through-penetration firestop systems that comply with the following requirements and those specified in "Performance Requirements" Article:

1. Firestop tests performed by Underwriters Laboratories.
2. Through-penetration firestop systems identical to those tested per ASTM E 814. Provide rated systems complying with the following requirements.

    a. Through-penetration firestop system products bearing classification marking of Underwriters Laboratories.
    b. Through-penetration firestop systems corresponding to those indicated by reference to through-penetration firestop system designations listed in the UL "Fire Resistance Directory."

D. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Section 01 31 00 "Project Management and Coordination."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver through-penetration firestop system products to Project site in original, unopened containers or packages with intact and legible manufacturers' labels identifying product and manufacturer; date of manufacture; lot number; shelf life, if applicable; qualified testing and inspecting agency's classification marking applicable to Project; curing time; and mixing instructions for multi-component materials.

B. Store and handle materials for through-penetration firestop systems to prevent their deterioration or damage due to moisture, temperature changes, contaminants, or other causes.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Do not install through-penetration firestop systems when ambient or substrate temperatures are outside limits permitted by through-penetration firestop system manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.

B. Ventilate through-penetration firestop systems per manufacturer's written instructions by natural means or, where this is inadequate, forced-air circulation.

1.8 COORDINATION

A. Coordinate construction of openings and penetrating items to ensure that through-penetration firestop systems are installed according to specified requirements.

B. Provide through-penetration firestop systems to accommodate sizes of sleeves, openings, core-drilled holes, or cut openings.

C. Notify Owner's inspecting agency at least seven days in advance of through-penetration firestop system installations; confirm dates and times on days preceding each series of installations.

D. Do not cover up through-penetration firestop system installations that will become concealed behind other construction until Architect, Owner's inspecting agency and building inspector, if required by authorities having jurisdiction, have examined each installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide through-penetration firestop systems that are produced by manufacturers listed in UL-Classified Through Penetration Fire Stopping Assemblies in the Schedule at the end of Part 3 of this Section.

2.2 PERFORMANCE REQUIREMENTS

A. General: For the following constructions, provide through-penetration firestop systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of assembly penetrated.

1. Fire-resistance-rated load-bearing walls, including partitions, with fire-protection-rated openings.
2. Fire-resistance-rated non-load-bearing walls, including partitions, with fire-protection-rated openings.
3. Fire-resistance-rated floor assemblies.
4. Fire-resistance-rated roof assemblies.

B. F-Rated Systems: Provide through-penetration firestop systems with F-ratings indicated, as determined by tests conducted according to UBC Standard 7-5, but not less than that equaling or exceeding fire-resistance rating of constructions penetrated. F-rating shall be not less than the required rating of the element penetrated, but not less than 1 hour, minimum

C. T-Rated Systems: For the following conditions, provide through-penetration firestop systems with T-ratings indicated, as well as F-ratings, as determined per UBC Standard 7-5, where systems protect penetrating items exposed to potential contact with adjacent materials in occupiable floor areas:

1. Penetrations located outside wall cavities.
2. Penetrations located outside fire-resistive shaft enclosures.
3. Penetrations located in construction containing fire-protection-rated openings.
4. Penetrating items larger than 4 inch diameter nominal pipe or 16 sq. in. in overall cross-sectional area.
5. Provide T-rating not less than the required rating of the element penetrated, but not less than 1 hour, minimum.

D. For through-penetration firestop systems exposed to view, traffic, moisture, and physical damage, provide products that after curing do not deteriorate when exposed to these conditions both during and after construction.

1. For piping penetrations for plumbing and wet-pipe sprinkler systems, provide moisture-resistant through-penetration firestop systems.

2. For floor penetrations with annular spaces exceeding 4 inches in width and exposed to possible loading and traffic, provide firestop systems capable of supporting floor loads involved either by installing floor plates or by other means.
3. For penetrations involving insulated piping, provide through-penetration firestop systems not requiring removal of insulation.

E. For through-penetration firestop systems exposed to view, provide products with flame-spread ratings of less than 25 and smoke-developed ratings of less than 450, as determined per ASTM E 84.

2.3 FIRESTOPPING, GENERAL

A. Compatibility: Provide through-penetration firestop systems that are compatible with one another, with the substrates forming openings, and with the items, if any, penetrating through-penetration firestop systems, under conditions of service and application, as demonstrated by through-penetration firestop system manufacturer based on testing and field experience.

B. Accessories: Provide components for each through-penetration firestop system needed to install fill materials and to comply with "Performance Requirements" Article. Use only components specified by through-penetration firestop system manufacturer and approved by Underwriters Laboratories for firestop systems indicated. Accessories include, but are not limited to, the following items:

1. Permanent forming/damming/backing materials, including the following:

   a. Slag-/rock-wool-fiber insulation.
   b. Sealants used in combination with other forming/damming/backing materials to prevent leakage of fill materials in liquid state.
   c. Fire-rated form board.

2. Substrate primers.
3. Collars.

C. Gypsum Products: The use of gypsum products for through-penetration firestopping is strictly prohibited.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with UL firestopping design requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Cleaning: Clean out openings immediately before installing through-penetration firestop systems to comply with written recommendations of firestop system manufacturer and the following requirements:

1. Remove from surfaces of opening substrates and from penetrating items foreign materials that could interfere with adhesion of through-penetration firestop systems.
2. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with through-penetration firestop systems. Remove loose particles remaining from cleaning operation.
3. Remove laitance and form-release agents from concrete.

B. Priming: Prime substrates where recommended in writing by through-penetration firestop system manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

C. Protection: Prevent through-penetration firestop systems from contacting adjoining surfaces that will remain exposed on completion of Work and that would otherwise be permanently stained or damaged by such contact or by cleaning methods used to remove smears from firestop system materials. Remove smears as soon as possible without damaging substrate or disturbing firestop system's seal with substrates.

3.3 THROUGH-PENETRATION FIRESTOP SYSTEM INSTALLATION

A. General: Install through-penetration firestop systems to comply with "Performance Requirements" Article and firestop system manufacturer's written installation instructions and published drawings for products and applications indicated.

B. Install forming/damming/backing materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.

1. After installing fill materials, remove combustible forming materials and other accessories not indicated as permanent components of firestop systems.

C. Install fill materials for firestop systems by proven techniques to produce the following results:

1. Fill voids and cavities formed by openings, forming materials, accessories, and penetrating items as required to achieve fire-resistance ratings indicated.
2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
3. For fill materials that will remain exposed after completing Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

3.4 FIELD QUALITY CONTROL

A. Inspecting Agency: Owner may engage a qualified independent inspecting agency to inspect through-penetration firestop systems and to prepare test reports.

1. Inspecting agency will state in each report whether inspected through-penetration firestop systems comply with or deviate from requirements.
2. Proceed with enclosing through-penetration firestop systems with other construction only after inspection reports are issued.
3. Where deficiencies are found, repair or replace through-penetration firestop systems so they comply with requirements.

3.5 IDENTIFICATION

A. Identify through-penetration firestop systems with pressure-sensitive, self-adhesive, preprinted vinyl labels. Attach labels permanently to surfaces of penetrated construction on both sides of each firestop system installation where labels will be visible to anyone seeking to remove penetrating items or firestop systems. Include the following information on labels:

1. The words: "Warning--Through-Penetration Firestop System--Do Not Disturb. Notify Building Management of Any Damage."
2. Contractor's name, address, and phone number.
3. Through-penetration firestop system designation of applicable testing and inspecting agency.
4. Date of installation.
5. Through-penetration firestop system manufacturer's name.
6. Installer's name.

3.6 CLEANING AND PROTECTION

A. Clean off excess fill materials adjacent to openings as Work progresses by methods and with cleaning materials that are approved in writing by through-penetration firestop system manufacturers and that do not damage materials in which openings occur.

B. Provide final protection and maintain conditions during and after installation that ensure through-penetration firestop systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated through-penetration firestop systems immediately and install new materials to produce through-penetration firestop systems complying with specified requirements.

3.7 THROUGH-PENETRATION FIRESTOP SYSTEM SCHEDULE

A. Select UL-classified systems from the attached schedule and submit "Through-Penetration Firestopping Schedule" as specified in Article 1.4, Submittals.

END OF SECTION 07 84 13

SECTION 07 84 43

JOINT FIRESTOPPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Joints in or between fire-resistance-rated constructions.
2. Joints in smoke barriers.

B. Related Requirements:

1. Section 07 84 13 "Penetration Firestopping" for penetrations in fire-resistance-rated walls, horizontal assemblies, and smoke barriers.
2. Section 07 84 53 "Building Perimeter Firestopping" for joints in or between floor edges and interior face of exterior wall.
3. Section 09 22 16 "Non-Structural Metal Framing" for firestop tracks for metal-framed partition heads.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. CALgreen Submittals:

1. Product Data for Section 5.504.4.1: For sealants, adhesives and caulks, provide documentation including printed statement of VOC content showing compliance with SCAQMD Rule 1168 VOC limits and CCR Title 17 for aerosols.

C. Product Schedule: For each joint firestopping system. Include location, illustration of firestopping system, and design designation of qualified testing agency.

1. Engineering Judgments: Where Project conditions require modification to a qualified testing agency's illustration for a particular joint firestopping system condition, submit illustration, with modifications marked, approved by joint firestopping system manufacturer's fire-protection engineer as an engineering judgment or equivalent fire-resistance-rated assembly.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Product Test Reports: For each joint firestopping system, for tests performed by a qualified testing agency.

C. Engineering Judgements: For joint firestopping conditions not accommodated by promulgated designs from UL, Intertek Group, or other agencies acceptable to authorities having jurisdiction.

1.6 CLOSEOUT SUBMITTALS

A. Installer Certificates: From Installer indicating that joint firestopping systems have been installed in compliance with requirements and manufacturer's written instructions.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A firm that has been approved by FM Global according to FM Global 4991, "Approval of Firestop Contractors," or been evaluated by UL and found to comply with UL's "Qualified Firestop Contractor Program Requirements."

1.8 PROJECT CONDITIONS

A. Environmental Limitations: Do not install joint firestopping systems when ambient or substrate temperatures are outside limits permitted by joint firestopping system manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.

B. Install and cure joint firestopping systems per manufacturer's written instructions using natural means of ventilation or, where this is inadequate, forced-air circulation.

1.9 COORDINATION

A. Coordinate construction of joints to ensure that joint firestopping systems can be installed according to specified firestopping system design.

B. Coordinate sizing of joints to accommodate joint firestopping systems.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics:

1. Perform joint firestopping system tests by a qualified testing agency acceptable to authorities having jurisdiction.
2. Test per testing standards referenced in "Joint Firestopping Systems" Article. Provide rated systems complying with the following requirements:

a. Joint firestopping systems shall bear classification marking of a qualified testing agency.

1) UL in its "Fire Resistance Directory."
2) Intertek Group in its "Directory of Listed Building Products."

2.2 JOINT FIRESTOPPING SYSTEMS

A. Joint Firestopping Systems: Systems that resist spread of fire, passage of smoke and other gases, and maintain original fire-resistance rating of assemblies in or between which joint firestopping systems are installed. Joint firestopping systems shall accommodate building movements without impairing their ability to resist the passage of fire and hot gases.

B. Joints in or between Fire-Resistance-Rated Construction: Provide joint firestopping systems with ratings determined per ASTM E 1966 or UL 2079.

1. Fire-Resistance Rating: Equal to or exceeding the fire-resistance rating of the wall, floor, or roof in or between which it is installed.

C. Joints in Smoke Barriers: Provide fire-resistive joint systems with ratings determined per UL 2079 based on testing at a positive pressure differential of 0.30-inch wg (74.7 Pa).

1. L-Rating: Not exceeding 5.0 cfm/ft. (0.00775 cu. m/s x m) of joint at both ambient and elevated temperatures.

D. Exposed Joint Firestopping Systems: Flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.

E. VOC Content: Fire-resistive joint system sealants shall comply with the following limits for VOC content:

1. Architectural Sealants: 250 g/L.
2. Sealant Primers for Nonporous Substrates: 250 g/L.
3. Sealant Primers for Porous Substrates: 775 g/L.

F. Low-Emitting Materials: Fire-resistive joint system sealants shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

G. Accessories: Provide components of fire-resistive joint systems, including primers and forming materials, that are needed to install elastomeric fill materials and to maintain ratings required. Use only components specified by joint firestopping system manufacturer and approved by the qualified testing agency for conditions indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for joint configurations, substrates, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Cleaning: Before installing fire-resistive joint systems, clean joints immediately to comply with fire-resistive joint system manufacturer's written instructions and the following requirements:

1. Remove from surfaces of joint substrates foreign materials that could interfere with adhesion of elastomeric fill materials or compromise fire-resistive rating.
2. Clean joint substrates to produce clean, sound surfaces capable of developing optimum bond with elastomeric fill materials. Remove loose particles remaining from cleaning operation.
3. Remove laitance and form-release agents from concrete.

B. Prime substrates where recommended in writing by joint firestopping system manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

3.3 INSTALLATION

A. General: Install fire-resistive joint systems to comply with manufacturer's written installation instructions and published drawings for products and applications indicated.

B. Install forming materials and other accessories of types required to support elastomeric fill materials during their application and in position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.

1. After installing elastomeric fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not indicated as permanent components of fire-resistive joint system.

C. Install elastomeric fill materials for fire-resistive joint systems by proven techniques to produce the following results:

1. Elastomeric fill voids and cavities formed by joints and forming materials as required to achieve fire-resistance ratings indicated.
2. Apply elastomeric fill materials so they contact and adhere to substrates formed by joints.
3. For elastomeric fill materials that will remain exposed after completing the Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

3.4 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:

1. Test and inspect as required by the California Building Code (CBC), 1705.16.

B. Comply with requirements for tests and inspections of completed Work in successive stages. Do not proceed with application of joint firestopping for the next area until test results for previously completed applications of joint firestopping show compliance with requirements. Tested values must equal or exceed values as specified and as indicated and required for approved fire-resistance design.

C. Joint firestopping will be considered defective if it does not pass tests and inspections.

1. Remove and replace joint firestopping that does not pass tests and inspections, and retest.

2. Prepare test and inspection reports.

3.5 CLEANING AND PROTECTION

A. Clean off excess elastomeric fill materials adjacent to joints as the Work progresses by methods and with cleaning materials that are approved in writing by joint firestopping system manufacturers and that do not damage materials in which joints occur.

B. Provide final protection and maintain conditions during and after installation that ensure joint firestopping systems are without damage or deterioration at time of Substantial Completion. If damage or deterioration occurs despite such protection, cut out and remove damaged or deteriorated fire-resistive joint systems immediately and install new materials to produce fire-resistive joint systems complying with specified requirements.

3.6 JOINT FIRESTOPPING SYSTEM SCHEDULE

A. Where UL-classified systems are indicated, they refer to system numbers in UL's "Fire Resistance Directory" under product Category XHBN.

B. Where Intertek Group-listed systems are indicated, they refer to design numbers in Intertek Group's "Directory of Listed Building Products" under product category Expansion/Seismic Joints or Firestop Systems.

C. Reference Drawings for specific systems.

END OF SECTION 07 84 43

SECTION 07 9200

JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes sealants for the following applications:

1. Exterior joints in the following vertical surfaces and nontraffic horizontal surfaces:

    a. Joints between composite architectural precast panels.
    b. Joints between architectural precast concrete units.
    c. Control and expansion joints in cast-in-place concrete.
    d. Joints in Portland cement plaster (stucco) systems.
    e. Joints between different materials listed above.
    f. Perimeter joints between materials listed above and frames of doors and windows and louvers.
    g. Other joints as indicated.

2. Interior joints in the following vertical surfaces and horizontal nontraffic surfaces:

    a. Control and expansion joints on exposed interior surfaces of exterior walls.
    b. Perimeter joints of exterior openings where indicated.
    c. Tile control and expansion joints.
    d. Perimeter joints between interior wall surfaces and frames of interior doors, windows, and elevator entrances.
    e. Joints between plumbing fixtures and adjoining walls, floors, and counters.
    f. Joints between glass and glass to adjoining walls.
    g. Other joints as indicated.

3. Interior joints in the following horizontal traffic surfaces:

    a. Control and expansion joints in cast-in-place concrete slabs.
    b. Control and expansion joints in tile flooring.
    c. Other joints as indicated.

B. Refer to Section 01 81 13 "Sustainable Design Requirements" for additional LEED requirements.

1.2 ACTION SUBMITTALS

A. Product Data: Submit product data for each joint-sealant product indicated and the following:

1. Written certification from manufacturers of joint sealants attesting that their products comply with specification requirements and are suitable for the use(s) indicated as verified through manufacturer's in-house testing laboratory.

    a. Test results for all job specific concealed and exposed (custom colored) sealants confirming compatibility and adhesion are mandatory for all materials in contact with exterior glazing, curtain wall components, metal panels, architectural precast concrete, and exterior stone cladding, prior to mockup and testing .

b. Complete instructions for handling, storage, mixing, priming, installation, curing and protection of each type of sealant.

2. Laboratory and field test results confirming joint preparation (cleaning/priming), chemical compatibility, and proper adhesion for specified joint sealant for each of the joint profiles and substrate materials included in the design of this project.

B. CALgreen Submittals:

1. Product Data for Section 5.504.4.1: For sealants, adhesives and caulks, provide documentation including printed statement of VOC content showing compliance with SCAQMD Rule 1168 VOC limits and CCR Title 17 for aerosols.
2. Product Certificates for Section A5.405.1: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. For the purposes of this requirement, "regional" is interpreted to mean within 500 miles of the project location or within the State of California.

C. Samples: Submit samples of each type and color of exposed joint sealant required. Provide fully cured joint sealant samples in 3/4 inch (19 mm) wide joints 12 inches (300 mm) long formed between two strips of material to be sealed as they will appear on the Project.

1.3 INFORMATIONAL SUBMITTALS

A. Warranties: Submit specified warranties.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Exposed sealant work including, but not limited to, sealants used for air and weatherseals which are external to precast-to-precast joints, shall be performed by one firm specializing in the installation of sealants who has successfully produced work comparable to this project, in not less than three projects of similar scope to the satisfaction of the Architect, and whose work has resulted in construction with a record of successful in-service performance for a period of 10 years. Concealed sealant work (sealants which are internal to precast-to-precast joints necessary for air and moisture penetration resistance under applied loads) shall be the responsibility of the subcontractor responsible for the final design, installation, and performance of the respective system.

B. Source Limitations: Obtain each type of joint sealant, and each type of structural silicone adhesive, from a single manufacturer.

C. Preconstruction Compatibility and Adhesion Testing (All Exterior Wall Sealants Only): Submit to joint sealant manufacturers, prior to full size building mockup(s) , samples of materials that will contact or affect, by direct or indirect chemical or mechanical means, exterior wall joint sealants for compatibility and adhesion testing below.

1. General: Test results confirming compatibility and adhesion are mandatory for all concealed and exposed sealant materials in contact with exteriorprecast, other sealants, flashings, metal framing, and shims, prior to the construction of full sized mockup and testing .

a. Schedule sufficient time for testing and analysis of results to prevent delay in the progress of the work.

1) It is anticipated that a minimum of 3 months will be required to complete preconstruction sealant compatibility and adhesion testing.

b. Investigate materials that fail compatibility and adhesion testing and obtain sealant manufacturer's written recommendations for corrective measures, which may include the use of primers, cleaners, cleaning measures, curing time, temperature limitations (surface and air), humidity conditions, moisture content of substrate, etc.

c. Definitions:

1) Compatibility: The capability of the sealant materials and substrates to be placed in direct contact with each other and maintain their required physical, chemical and visual qualities with the absence of softening, staining, oil exudation, discoloration or other detrimental, deleterious or degradative effects caused by chemical interactions.
2) Adhesion: The mechanical or chemical ability of the sealant materials and substrates to adhere or bond together at their interface.

d. Specimen Sizes and Shapes: As required by the manufacturer's testing laboratory for the tests listed, unless otherwise specified.

2. Tests Required:

a. Adhesion in Peel Testing:

1) Test Methods:

a) Comply with ASTM C794 'Adhesion and Peel of Elastomeric Joint Sealants,' modified to include project specific substrates and to report cohesive or adhesive failure mode. Samples of each exterior precast, other sealants, flashings, metal framing in contact with the concealed and exposed sealant materials are required to be tested.

2) All specimens shall be tested for primed and unprimed performance.
3) Report:

a) Date(s) of testing.
b) Project identification.
c) Test method (as identified herein).
d) Specimen substrate(s) tested.
e) Sealant(s) tested.
f) Substrate preparation (cleaning materials, methods and primers used).
g) Test results for each specimen tested (type of failure - adhesive or cohesive - force measured at failure in pounds per lineal inch).
h) Recommendations. Where testing shows equal or better performance without a primer, a primer will not be required.
i) Additional remarks, if any (i.e., color change of substrate or sealant, voids in the body of the sealant when examined in cross section, blistering, bubbling, sealant softening, or evidence of improperly mixed or cured sealant).

b. Compatibility Testing: This test method describes an accelerated laboratory procedure to determine if the proposed sealant materials and substrates are compatible.

1) Test Methods:

a) Comply with ASTM C1248 'Staining of Porous Substances by Joint Sealants,' modified to include project specific substrates. Samples of each exterior precast and other sealants, in contact with the concealed and exposed sealant materials are required to be tested.

2) All specimens for ASTM C1248 testing shall be tested for primed and unprimed performance.
3) Report:

a) Date(s) of testing.
b) Project identification.
c) Test method (as identified herein).
d) Substrate preparation (cleaning materials, methods and primers used).
e) Name of sealant, type of sealant, rated movement capability and identifying batch number.
f) Substrates used.
g) Testing Equipment: Manufacturer of apparatus, type of lamps.
h) Statement describing curing conditions if other than at standard conditions.
i) Description of, and reasons for, any variations from the test procedure.
j) Description of test effects observed, such as change in finished surface appearance, discoloration into the substrate, adhesion failure, or other characteristics; average measurement of stain width and depth.
k) Recommendations. Where testing shows equal or better performance without a primer, a primer will not be required.
l) Additional remarks, if any. (i.e., color change of substrate or sealant, voids in the body of the sealant when examined in cross section, blistering, bubbling, sealant softening, or evidence of improperly mixed or cured sealant).

c. Preconstruction Field-Adhesion Testing: Before installing exposed exterior elastomeric sealants, field test their adhesion to joint substrates as follows:

1) Locate test joints where indicated or, if not indicated, as directed by Architect.
2) Conduct field tests for each type of exposed exterior elastomeric sealant and joint substrate indicated.
3) The Architect and manufacturer's technical representative, shall be present when joints are tested.
4) Test Method: Test exterior elastomeric joint sealants by hand-pull method described below:

a) Install joint sealants in 60 inch (1500 mm) long joints using same materials and methods for joint preparation and joint-sealant installation in accordance with manufacturer's final laboratory testing recommendations. Allow sealants to cure.
b) Make knife cuts from one side of joint to the other, followed by two cuts approximately 3 inch (75 mm) long at sides of joint and meeting cross cut at one end. Place a mark 1 inch (25 mm) from cross-cut end of 3 inch (75 mm) piece.
c) Use fingers to grasp 3 inch (75 mm) piece of sealant between cross-cut end and 1 inch (25 mm) mark; pull firmly down at a 90-degree angle to the joint and hold sealant in this position for ten seconds; following the ten second time duration pull sealant at a 180 degree angle parallel to the joint and hold the sealant in this position for ten seconds. Pull sealant away from joint to the distance recommended by sealant manufacturer for testing adhesion.
d) Repair joint as recommended by the sealant manufacturer.

5) Sealants evidencing adhesive failure with one or both substrates during testing, and/or a level of elongation prior to failure that is not in compliance with the performance characteristics specified herein or otherwise published by the sealant manufacturer will be subject to rejection by the Architect. Discontinue use of joint sealants, cleaning agents, primers, and application methods associated with failures documented during testing and immediately notify manufacturer and Architect for further review.

3. Report: Provide written summary of each compatibility and adhesion test.

D. Mockups: Provide mockups of sealants at locations indicated or required by the Architect. Mockups shall represent the primary types of materials, substrate surfaces, joint size, exposure, and other conditions to be encountered in the work. Preparation, priming, application, and curing, shall comply with manufacturer's recommendations and actual proposed methods. Schedule the applications, with allowance for sufficient curing time, so that samples may be examined and necessary adjustments made at least 1 week prior to date scheduled for commencing installation of the work.

1. The mockups shall be visually examined for staining, dirt pickup, shrinkage, color, general workmanship and appearance. Cut and pull the sealant from each sample joint to examine for internal bubbles or voids, adhesion, and general compatibility with substrate.

2. Mockups are required in conjunction with the following Sections:

a. 07 42 13.16 Metal Plate Wall Panels
b. 07 42 13.23 Metal Composite Material Wall Panels
c. 07 92 13 Façade Insulation And Safing
d. 08 41 26 All-Glass Entrances And Storefronts
e. 08 44 13 Glazed Aluminum Systems
f. 08 44 26 Structural Glass Wall Systems
g. 08 80 00 Exterior Glass And Glazing
h. Other Sections indicated.

E. Preinstallation Conference: As soon as possible after award of exterior joint sealant work, but no later than 2 weeks before the installation of the joint sealants, meet with Installer, Owner, Architect, installers of the substrate construction, and other work adjoining joint sealants and representatives of any other entities directly concerned with joint sealant performance. Conduct conference at Project site to comply with the following:

1. Review foreseeable methods and procedures related to sealing substrates, including but not limited to, the following:

a. Discuss substrates to be sealed, discuss as fabricated and installed condition of substrate, sealant application, flashing details, and other preparatory work.
b. Review joint sealant requirements: drawings, specifications, and other contract documents.
c. Review required submittals, both complete and incomplete.
d. Review weather and forecasted weather conditions and procedures for coping with unfavorable conditions.
e. Review schedule and intended sequence of work.
f. Review changes arising from the pre-construction mockup and performance testing program, if any.
g. Review the purpose and method of integration of field quality assurance programs developed by Contractor and suppliers/subcontractors responsible for the Work.
h. Review purpose and method of integration of field quality assurance program administered by the Owner's Exterior Wall Testing and Inspection Agency with similarly aligned programs developed by the Contractor and suppliers/subcontractors responsible for the Work.

2. Record discussion and furnish copy of recorded discussions to each attendee.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Project site in original unopened containers or bundles with labels indicating manufacturer, product name and designation, color, expiration date, pot life, curing time, and mixing instructions for multicomponent materials.

B. Store and handle materials in compliance with manufacturer's written instructions to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Do not proceed with installation of joint sealants under the following conditions:

1. When ambient and substrate temperature conditions are outside limits permitted by joint sealant manufacturer or are below 40 deg F (4.4 deg C).
2. When joint substrates are wet.

B. Joint-Width Conditions: Do not proceed with installation of joint sealants where joint widths are less than those allowed by joint sealant manufacturer for applications indicated.

C. Joint-Substrate Conditions: Do not proceed with installation of joint sealants until contaminants capable of interfering with adhesion are removed from joint substrates.

1.7 WARRANTY

A. Special Installer's Warranty: Written warranty, signed by Installer agreeing to repair or replace elastomeric joint sealant work which has failed to provide a weathertight system within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

B. Special Manufacturer's Warranties: Written warranties (weatherseal and stain resistance), signed by elastomeric sealant manufacturer agreeing to furnish elastomeric joint sealants to repair or replace those that fail to provide airtight and watertight joints, or fail in adhesion, cohesion, abrasion-resistance, stain-resistance, weather resistance, or general durability or appear to deteriorate in any other manner not clearly specified in the manufacturer's data as an inherent quality of the material within specified warranty period.

1. Warranty Period (Urethanes): 5 years from date of Substantial Completion.
2. Warranty Period (Silicones): 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Compatibility: Provide joint sealants, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as stated by sealant manufacturer's published data, and as substantiated by the manufacturer for each application through testing.

B. VOC Content of Interior Sealants: Provide sealants and sealant primers for use inside the weatherproofing system that comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):

1. Architectural Sealants: Not more than 250 g/L.
2. Nonmembrane Roof Sealants: 300 g/L.
3. Single-Ply Roof Membrane Sealants: 450 g/L.
4. Sealant Primers for Nonporous Substrates: Not more than 250 g/L.
5. Sealant Primers for Porous Substrates: Not more than 775 g/L.

C. Low-Emitting Interior Sealants: Sealants and sealant primers used inside the weatherproofing system shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. Colors: For fully concealed joints, provide manufacturer's standard color of sealant which has the best overall performance characteristics for the application shown. For exposed joints provide custom colors to match Architect's samples of the following:

1. Architectural precast concrete, each color.
2. Walks and pavings, each color.
3. Exterior field applied paints and coatings, each color.
4. Other exterior and interior materials, each color as indicated.

E. Manufacturer's Representative: Do not use elastomeric sealant produced by a manufacturer who will not agree to send a qualified technical representative to the project site when requested, for the purpose of rendering advice concerning the proper installation of manufacturer's materials.

2.2 ELASTOMERIC JOINT SEALANTS

A. Silicone Sealants for Vertical Applications (Non-Sag):

1. Typical Exterior Wall Joints:

a. Properties:

1) Standards: Comply with ASTM C920, Type M or S, Grade NS, Class 25 or 50; use NT, M, A and O.
2) Performance: Non-stain, non-bleed, non-streaking to sealed and adjacent substrates. The minimum peel adhesion value after 7 day immersion shall not be less than 13 pli (2.27 kN/m) when tested in strict accordance with ASTM C794 Adhesion in Peel.
3) Cure System and Oil Content: Neutral-cure, low or medium modulus system specifically manufactured with controlled oil content to eliminate oil migration into sealed substrates and residue rundown over and onto adjacent substrates.

b. Products and Manufacturers: One of the following:

1) 756 SMS; Dow Corning.
2) Spectrem 3 or Spectrem 4-TS; Tremco, an RPM Co.
3) Silpruf NB SCS 9000; GE Advanced Materials – Silicones.

B. Two-Part Polyurethane Sealant for Paving Applications:

1. For Paving Applications with Slopes not Exceeding 5% (Self Leveling): ASTM C 920, Type M, Grade P, Class 25; use T and I; with high durometer hardness and abrasion resistance, and rated for water immersion; one of the following:

a. Pecora Corporation; Urexpan NR-200.
b. BASF; Sonneborn Systems, Sonolastic SL 2™.
c. Tremco, an RPM Co.; THC 900.

2. For Paving Applications with Slopes Exceeding 5%: ASTM C 920, Type M, Grade P "Slope Grade", Class 25; uses T and I; with high durometer hardness and abrasion resistance, and rated for water immersion; one of the following:

a. Pecora Corporation; Dynatred.
b. BASF; Sonneborn Systems, Sonolastic SL 2™.
c. Tremco, an RPM Co.; THC-901.

C. Mildew-Resistant Silicone Sealant (use for joints at toilet fixtures, toilet room countertops and vanities, and at janitor closet mop receptor to wall transition): Complying with ASTM C 920, Type S (single component), Grade NS (non-sag), class 25, Use NT (non-traffic), Substrate uses G, A, and O; and containing a fungicide for mildew resistance; white color.

1. Products: Provide one of the following:

a. Dow Corning; 786 Mildew Resistant Silicone Sealant.
b. GE Advanced Materials - Silicones; Sanitary SCS 1700.
c. Pecora Corporation; 898 Silicone Sanitary Sealant.
d. Tremco, an RPM Co.; Tremsil 200 Sanitary.

2.3 LATEX JOINT SEALANTS

A. Latex Sealant: Non-elastomeric, one part, non-sag, paintable latex sealant that is recommended for exposed applications on the interior. Complying with ASTM C 834, Type OP (opaque sealants):

1. Products: Provide one of the following:

a. Pecora Corporation; AC-20 + Silicone.
b. BASF; Sonneborn Systems, Sonolastic Sonolac.
c. Tremco, an RPM Co.; Tremflex 834.

2.4 JOINT-SEALANT BACKING

A. General: Provide sealant backings of material and type that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.

B. Cylindrical Sealant Backings: One of the following preformed, compressible, resilient, nonstaining, nonwaxing, nonextruding backings of flexible plastic foam complying with ASTM C 1330, and of type indicated below. Select shape and density of cylindrical sealant backings in consultation with the manufacturer for proper performance in specific condition of use in each case.

1. Type C: Closed-cell polyethylene foam material with a surface skin, which is nonabsorbent to liquid water and gas, non-outgassing in unruptured state; one of the following:

    a. HBR Closed Cell Backer Rod; Nomaco, Inc.
    b. Sonneborn Closed-Cell Backer-Rod; BASF.

2. Type B: Bi-cellular reticulated, polymeric foam material with a surface skin, nonoutgassing, with a density of between 1.5-3.0 pcf (24-48 kg/cubic meter) per ASTM D 1622 and minimum tensile strength of greater than 29-38 psi (200-267 kPa) per ASTM D 1623, and with water absorption less than 0.058 oz./cubic inch (0.10 gm/cc) per ASTM C 1016; one of the following:

    a. SOFROD; Nomaco, Inc.
    b. Sonneborn Sonolastic Soft Backer-Rod; BASF.

C. Bond-Breaker Tape: Polyethylene, TFE fluorocarbon, or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint where such adhesion would result in sealant failure. Provide self-adhesive tape where applicable.

D. Weep and Vent Tubes: Clear plastic (PVC) tubing, minimum 1/4 inch (6.35 mm) inside diameter, and of length as required to extend between exterior face of sealant and open cavity behind.

E. Cork Joint Filler: Resilient and nonextruding, ASTM D1752, Type II.

2.5 MISCELLANEOUS MATERIALS

A. Primer: Material recommended, as verified through compatibility and adhesion testing, by joint sealant manufacturer for the substrates indicated to be sealed.

B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants with joint substrates.

C. Masking Tape: Nonstaining, nonabsorbent material compatible with joint sealants and which will not stain nor mar the finish of surfaces adjacent to joints to which it is applied.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint sealant manufacturer's written instructions and the following requirements:

1. Remove foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer), existing joint sealants, existing backer rods, existing waterproofing materials, existing water repellent treatments, oil, grease, water, surface dirt, and frost.
2. Clean concrete, masonry, unglazed surfaces of tile, and similar porous joint substrate surfaces by brushing, grinding, blast cleaning, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining from above cleaning operations by vacuuming or blowing out joints with oil-free compressed air.
3. Remove laitance and form-release agents from concrete.
4. Clean metal, glass, porcelain enamel, glazed surfaces of tile, and other nonporous surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants.

B. Joint Priming (Elastomeric Sealants Only): Prime joint substrates with primers selected through the preconstruction compatibility and adhesion testing. Apply primer to comply with joint sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

C. Masking Tape: Use masking tape where required to prevent contact of sealant or primer with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant and primer smears. Remove tape immediately after tooling without disturbing joint seal.

3.3 INSTALLATION OF JOINT SEALANTS

A. General: Comply with joint sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.

B. Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.

C. Installation of Sealant Backings: Install sealant backings to comply with the following requirements:

1. Install sealant backings of type indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.

    a. Do not leave gaps between ends of sealant backings. Trim for tight fit around obstructions or elements penetrating the joint.
    b. Do not stretch, twist, puncture, or tear sealant backings.
    c. Remove absorbent sealant backings that have become wet before sealant application and replace them with dry sealant backings.

2. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and back of joints.
3. Install weeps and vents into joints at the same time sealants are being installed. Unless otherwise shown on the drawings, or directed by the Architect, locate weeps and vents spaced as recommended by the sealant manufacturer and the window and curtain wall fabricator and erector. Do not install weeps and vents at outside building corners. Do not install vents at horizontal joints immediately below shelf angles, sills, and through wall flashings.

D. Installation of Sealants: Install sealants by proven techniques that result in sealants directly contacting and fully wetting joint substrates, completely filling recesses provided for each joint configuration, and providing uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability. Install sealants at the same time sealant backings are installed.

1. Apply sealants in the depth shown or, if none is shown, apply in accordance with the manufacturer's recommendations and the following general proportions and limitations:

a. Apply elastomeric sealants in sidewalk, pavement and similar horizontal joints to a depth equal to 75% of the joint width, but not less than 3/8 inch (10 mm) and not more than 3/4 inch (19 mm).
b. Apply elastomeric sealants, in joints not subject to traffic or other abrasion, to a depth equal to 50% of the joint width, but not less than 1/4 inch (6 mm) and not more than 1/2 inch (13 mm).
c. Apply non-elastomeric sealants to a depth approximately equal to the joint width.
d. Fill horizontal traffic bearing joints slightly recessed to avoid direct contact with wheel, and pedestrian traffic. Fill horizontal traffic bearing joints with slope grade polyurethane sealants to a depth approximately equal to the joint width.

2. Pour self leveling sealants to a depth approximately equal to the joint width.

E. Tooling of Nonsag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants to form smooth, uniform, beads to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces. Tool exposed surfaces of sealants to the profile shown, or if none is shown, tool slightly concave.

1. Use masking tape to protect adjacent surfaces of recessed tooled joints.
2. Provide a slight wash on horizontal joints where horizontal and vertical surfaces meet.
3. Against rough surfaces or in joints of uneven widths avoid the appearance of excess sealant or compound by locating the compound or sealant well back into joint wherever possible.

3.4 FIELD QUALITY CONTROL

A. Field-Adhesion Testing: Field-test exterior wall joint-sealant adhesion to joint substrates as follows:

1. Perform 10 tests for the first 1000 feet (300 m) of joint length for each type of exposed exterior wall sealant and joint substrate.
2. Perform one test for each 1000 feet (300 m) of joint length thereafter or one test per each floor per elevation.

B. Field adhesion testing of sealants shall take place in the presence of a qualified technical representative of the sealant manufacturer.

1. Test Method: Test joint sealants by hand-pull method described below:

a. Make knife cuts from one side of joint to the other, followed by two cuts approximately 3 inches (75 mm) long at sides of joint and meeting cross cut at one end. Place a mark 1 inch (25 mm) from cross-cut end of 3 inch (75 mm) piece.
b. Use fingers to grasp 3 inch (75 mm) piece of sealant between cross-cut end and 1 inch (25 mm) mark; pull firmly at a 90-degree angle to the joint in the direction of side cuts and hold the sealant in this position for 10 seconds; following the 10 second time duration pull sealant at a 180 degree angle parallel to the joint and hold the sealant in this position for

10 seconds. Pull sealant away from joint to the distance recommended by sealant manufacturer for testing adhesion.

c. For joints with dissimilar substrates, check adhesion to each substrate separately. Do this by extending cut along one side, checking adhesion to opposite side, and then repeating this procedure for opposite side.

2. The sealant manufacturer's qualified technical representative shall record test results, and observations of joint and sealant conditions, in a field adhesion test log.
3. Repair joint sealants pulled from test area as recommended by sealant manufacturer.
4. The sealant manufacturer shall provide written documentation of changes in product and/or application method required to address sealant failure, observe and document retesting as required by the Architect, and provide a written statement of compliance with applicable warranties.

C. Sealants not evidencing adhesive failure from testing will be considered satisfactory. Remove sealants that fail to adhere to joint substrates during testing or to comply with other requirements. Retest failed applications until test results prove sealants comply with indicated requirements.

3.5 CLEANING

A. Clean off excess sealants or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.6 PROTECTION

A. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from the original work.

END OF SECTION 07 9200

SECTION 08 1113

HOLLOW METAL DOORS AND FRAMES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes steel doors and frames.

1. Where the integration of a security system into the steel door and frame work is required, the Contractor shall be responsible for the total and complete coordination of the security system components into the Work.

1.2 ACTION SUBMITTALS

A. Product Data: Submit product data for each product indicated. Include material descriptions, core descriptions, label compliance, sound and fire-resistance ratings, and finishes for each type of door and frame specified.

B. CALgreen Submittals:
1. Product Data for Section 5.504.4.1 : For sealants, adhesives and caulks, provide documentation including printed statement of VOC content showing compliance with SCAQMD Rule 1168 VOC limits and CCR Title 17 for aerosols.
2. Product Certificates for Section A5.405.1: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. For the purposes of this requirement, "regional" is interpreted to mean within 500 miles of the project location or within the State of California.
3. Section A5.405.4 Recycled Content, Tier 1: use recycled content materials, equivalent in performance to virgin materials. Provide cost documentation showing value of recycled content using A5.405.02

C. Shop Drawings: Submit door and frame schedule using same reference designations indicated on Drawings. Include opening size(s), handing of doors, frame throat dimensions, details of each frame type, elevations of door design types, details of construction, location and installation requirements of door hardware and reinforcements, hardware group numbers, details of joints and connections, fire label requirements including fire rating time duration, maximum temperature rise requirements, and smoke label requirements.

1. Indicate routing of electrical conduit and dimensions and locations of cutouts in doors and frames to accept electric hardware devices.

1.3 INFORMATIONAL SUBMITTALS

A. Certificate of Compliance for Fire Rated Doors: Provide copies of Certificate of Compliance for all fire rated door assemblies, all smoke and draft control door assemblies, and all temperature rise rated door assemblies.

1.4 QUALITY ASSURANCE

A. ***Heavy-Duty Doors and Frames: SDI A250.8, Level 2. Unless more stringent requirements are indicated.***

B. Manufacturer Qualifications: A firm experienced in manufacturing steel doors and frames similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.

C. Fire-Rated Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire ratings indicated, based on testing according to NFPA 252.

D. Fire-Rated Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing according to NFPA 252, 1997 UBC Standard 7-2 "Fire Test of Door Assemblies," and 1997 UBC Standard 7-4 "Fire Test of Window Assemblies," and UL 10C "Standard for Positive Pressure Fire Tests of Door Assemblies." Fire classification labels at all doors with fire ratings greater than 20 minutes shall indicate the temperature rise developed on the unexposed surface of the door after the first 30 minutes of fire exposure.

1. Provide metal labels permanently fastened on each door which is within the size limitations established by the labeling authority having jurisdiction.
2. Temperature-Rise Rating: Where indicated, provide doors that have a temperature-rise rating of 450 deg F (250 deg C) maximum in 30 minutes of fire exposure.
3. Provide fire rated door assemblies in compliance with 1997 UBC Standard 7-2, Part 1 for positive pressure. Sizes and configurations as shown on the drawings. Installed door assemblies shall be in accordance with door manufacturer's certified assemblies.

    a. Test Pressure: After 5 minutes into the test, neutral pressure level in furnace shall be established at 40 inches (1000 mm) or less above the sill.

4. Provide fire rated door assemblies with smoke and draft control rating in compliance with 1997 UBC Standard 7-2 Part 2 at corridors, stairwells, and where required by applicable codes. Sizes and configurations as shown on the drawings. Installed door assemblies shall be in accordance with door manufacturer's certified assemblies.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver doors and frames palleted, wrapped, or crated to provide protection during transit and Project site storage.

B. Inspect doors and frames, on delivery, for damage. Tool marks, rust, blemishes, and any other damage on exposed surfaces will not be acceptable. Remove and replace damaged items as directed by Architect. Store doors and frames at building site in a dry location, off the ground, and in such a manner as to prevent deterioration.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide doors and frames by one of the following:

1. ***Acme Steel Door and Hardware.***
2. Ceco Door Products; a United Dominion Company.
3. Curries Company.
4. Steelcraft; a division of Ingersoll-Rand.

2.2 MATERIALS

A. Recycled Content of Steel Products: Provide products with an average recycled content of steel products so post-consumer recycled content plus one-half of pre-consumer recycled content is not less than 20 percent.

B. Cold-Rolled Steel Sheets: ASTM A 1008/A 1008M, CS (commercial steel), and ASTM A 568/A 568M, free from scale, pitting, coil breaks, or other defects, exposed (matte) dull finish.

C. Metallic-Coated Steel Sheets: ASTM A924/A924M and ASTM A 653/A 653M, CS (commercial steel), Type B; with G60 (Z180) zinc (galvanized) or A60 (ZF180) zinc-iron-alloy (galvannealed) coating, mill phosphatized.

D. Inserts, Bolts, and Fasteners: Galvanized or cadmium plated steel.

1. Expansion Bolts and Shields: FS FF-S-325, Group III, Type 1 or 2.
2. Machine Screws: FS FF-S-92, carbon steel, Type III cross recessed, design I or II recess, style 2C flat head.

E. Filler: Sound deadening and heat retarding mineral fiber insulating material.

F. Glass and Glazing: Refer to Section 08 80 00 "Glazing."

2.3 DOORS

A. General: Provide flush-design doors, 1-3/4 inches (44 mm) thick, of seamless hollow construction, unless otherwise indicated. Construct doors with sheets joined at their vertical edges by continuous welding the full height of the door, with no visible seams on their faces or vertical edges, and all welds ground and finished flush.

1. Visible joints or seams around glazed or louvered panel inserts are permitted.
2. For single-acting swing doors, bevel both vertical edges 1/8 inch in 2 inches (3 mm in 50 mm).
3. For double-acting swing doors, round vertical edges with 2-1/8 inch (54 mm) radius.

B. Core Construction: Provide one of the following core constructions welded to both door faces:

1. Steel-Stiffened Core: 0.032 inch (0.8 mm) steel vertical stiffeners extending full-door height, spaced not more than 6 inches (150 mm) apart and spot welded to face sheets a maximum of 5 inches (127 mm) o.c. Place filler between stiffeners for full height of door.

2. Continuous Truss-Form Inner Core: 0.013 inch (0.33 mm) thick steel reinforcement spot welded to face sheets a maximum of 2-3/4 inches (69.9 mm) o.c. vertically and horizontally.

C. Fire Door Cores: A continuous mineral fiberboard core permanently bonded to the inside face of the outer face sheet unless otherwise required to provide fire-protection and temperature-rise ratings indicated.

D. Astragals: As required by NFPA 80 to provide fire ratings indicated.

E. Top and Bottom Channels: Spot weld metal channel not less than thickness of face sheet to face sheets not more than 6 inches (150 mm) o.c.

1. Reinforce tops and bottoms of doors with inverted horizontal channels of same material as face sheet so flanges of channels are even with bottom and top edges of face sheets.
2. For exterior doors, close bottom edge with metallic-coated steel closing channel and top edge with filler channel of same material, so webs of channels are flush with bottom and top door edges. Weld inverted steel channels to both face sheets or form integrally with edge construction of door.

F. Hardware Reinforcement: Fabricate reinforcing from the same material as door to comply with the following. Offset reinforcement so that faces of mortised hardware items are flush with door surfaces.

1. Hinges and Pivots: 0.167 inch (4.2 mm) thick by 1-1/2 inches (38 mm) wide by 9 inches (229 mm).
2. Lock Front, Strike, and Flushbolt Reinforcements: 0.093 inch (2.3 mm) thick by size as required by hardware manufacturer.
3. Lock Reinforcement Units: 0.067 inch (1.7 mm) thick by size as required by hardware manufacturer.
4. Closer Reinforcements: 0.093 inch (2.3 mm) thick one-piece channel by size as required by hardware manufacturer.
5. Other Hardware Reinforcements: As required for adequate strength and anchorage.
6. In lieu of reinforcement specified, hardware manufacturer's recommended reinforcing units may be used.
7. Exit Device Reinforcements: 0.250 inch (6.35 mm) thick by 10 inches (245 mm) high by 4 inches (101 mm) wide centered on exit device case body, unless otherwise recommended by exit device manufacturer.

G. Electrical Requirements: Make provisions for installation of electrical items specified elsewhere; arrange so wiring can be readily removed and replaced.

1. Provide all cutouts and reinforcements required for steel doors to accept security system components.
2. Doors with Electric Hinges and Pivots: Provide with metal conduit or raceway to permit wiring from electric hinge or pivot to other electric door hardware.

a. Hinge Location: Center for doors less than 90 inches (2286 mm) tall or second hinge from door bottom for doors greater than 90 inches (2286 mm); top or bottom electric hinge locations shall not be permitted.

H. Interior Steel Doors: Flush design with 0.042 inch (1.06 mm) thick cold-rolled stretcher-leveled steel face sheets and other metal components from hot- or cold-rolled steel sheets.

I. Exterior Steel Doors: Flush design with 0.053 inch (1.3 mm) thick metallic-coated stretcher leveled steel face sheets and other metal components from metallic coated steel sheets. Provide weep-hole openings in bottom of doors to permit entrapped moisture to escape.

2.4 FRAMES

A. Fabricate steel door frames, formed to profiles indicated, with full 5/8 inch (16 mm) stops, and of the following minimum thicknesses.

1. For exterior use, form frames from 0.067 inch (1.7 mm) thick, metallic-coated steel sheets.
2. For interior use, form frames from cold- rolled steel sheet of the following thicknesses:

    a. Openings up to and Including 48 inches (1200 mm) Wide: 0.053 inch (1.3 mm).
    b. Openings More Than 48 inches (1200 mm) Wide: 0.067 inch (1.7 mm).

B. Provide frames either saw mitered and full (continuously) welded, or machine mitered and full welded, on back side at frame corners and stops with edges straight and true. Grind welds smooth and flush on exposed surfaces.

C. Hardware Reinforcement: Fabricate reinforcements from same material as frame to comply with the following. Offset reinforcement so that faces of mortised hardware items are flush with surface of the frame.

1. Hinges and Pivots: 0.167 inch (4.2 mm) thick by 1-1/4 inches (32 mm) wide by 10 inches (254 mm).
2. Strike, Surface Mounted Hold Open Arms, and Flushbolt Reinforcements: 0.093 inch (2.3 mm) thick by size as required by hardware manufacturer.
3. Closer Reinforcements: 0.093 inch (2.3 mm) thick one piece channel by size as required by hardware manufacturer.
4. Other Hardware Reinforcements: As required for adequate strength and anchorage.

D. Electrical Requirements: Make provisions for installation of electrical items specified elsewhere; arrange so wiring can be readily removed and replaced.

1. Provide all cutouts and reinforcements required for steel frames to accept security system components.
2. Frames with Electric Hinges and Pivots: Provide welded on UL listed back boxes with metal conduit or raceway to permit wiring from electric hinge or pivot to other electric door hardware.

    a. Hinge Location: Center for doors less than 90 inches (2286 mm) tall or second hinge from door bottom for doors greater than 90 inches (2286 mm); top or bottom electric hinge locations shall not be permitted.

E. Mullions and Transom Bars: Provide closed or tubular mullions and transom bars where indicated. Fasten mullions and transom bars at crossings and to jambs by butt welding. Reinforce joints between frame members with concealed clip angles or sleeves of same metal and thickness as frame.

F. Jamb Anchors: Locate jamb anchors above hinges and directly opposite on strike jamb as required to secure frames to adjacent construction. At metal stud partitions locate the additional jamb anchor below the top hinge.

1. Masonry Construction: Adjustable, corrugated or perforated, anchors to suit frame size; formed of same material and gauge thickness as frame; at non-rated frames use friction fit T-shaped anchors, at rated frames use anchors consisting of spot welded strap and adjustable anchor; with leg not less than 2 inches (50 mm) wide by 10 inches (250 mm) long. Furnish at least the number of anchors per jamb according to the following frame heights:

    a. Two anchors per jamb up to 60 inches (1500 mm) in height.
    b. Three anchors per jamb from 60 to 90 inches (1500 to 2250 mm) in height.

c. Four anchors per jamb from 90 to 96 inches (2250 to 2400 mm) in height.
d. One additional anchor per jamb for each 24 inches (600 mm) or fraction thereof more than 96 inches (2400 mm) in height.

2. Metal-Stud Partitions: Metal channel stud zee anchor sized to match stud width, welded to back of frames, formed of same material and gauge thickness as frame. Provide at least the number of anchors for each jamb according to the following heights:

a. Three anchors per jamb up to 60 inches (1500 mm) in height.
b. Four anchors per jamb from 60 to 90 inches (1500 to 2250 mm) in height.
c. Five anchors per jamb from 90 to 96 inches (2250 to 2400 mm) in height.
d. One additional anchor per jamb for each 24 inches (600 mm) or fraction thereof more than 96 inches (2400 mm) in height.

3. In-Place Concrete or Masonry: Anchor frame jambs with minimum 3/8 inch (9 mm) diameter countersunk flat head bolts into expansion shields or inserts 6 inches (150 mm) from top and bottom of each jamb with intermediate anchors spaced a maximum of 26 inches (650 mm) o.c. Soffit face of frame shall be punched and dimpled to accept countersunk bolt head. Reinforce frame with spacer to prevent bowing. Bolt head shall be set slightly below soffit face, filled and ground smooth at time of installation.

G. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor, formed of same material as frame, 0.093 inch (2.3 mm) thick, and punched with two holes to receive two (2) 0.375 inch (9.5 mm) fasteners. Where floor fill or setting beds occur support frame by adjustable floor anchors bolted to the structural substrate. Terminate bottom of frames at finish floor surface.

H. Head Strut Supports: Provide 3/8-by-2 inch (9-by-50 mm) vertical steel struts extending from top of frame at each jamb to supporting construction above. Bend top of struts to provide flush contact for securing to supporting construction above by bolting, welding, or other suitable anchorage. Provide adjustable wedged or bolted anchorage to frame jamb members to permit height adjustment during installation. Adapt jamb anchors at struts to permit adjustment.

I. Head Reinforcement: For frames more than 48 inches (1200 mm) wide in masonry wall openings, provide continuous steel channel or angle stiffener, 0.093 inch (2.3 mm) thick for full width of opening, welded to back of frame at head. Head reinforcements shall not be used as a lintel or load-bearing member for masonry.

J. Spreader Bars: Provide removable spreader bar across bottom of frames, tack welded to jambs and mullions to serve as bracing during shipment and handling and to hold frames in proper position until anchorage and adjacent construction have been completed.

K. Door Silencer Holes: Drill strike jamb stop to receive three silencers on single door frames and for two silencers on double door frames. Insert plastic plugs in holes to keep holes clear during installation.

L. Plaster Guards and Removable Access Plates: Provide 0.016 inch (0.4 mm) thick plaster guards or dust-cover boxes of same material as frame, welded to frame at back of hardware cutouts to close off interior of openings and prevent mortar or other materials from obstructing hardware operation. Provide removable access plates in the heads of frames to receive overhead concealed door closers.

2.5 STOPS AND MOLDINGS

A. Provide continuous stops and moldings around solid, glazed, and louvered panels where indicated.

B. Form fixed stops and moldings integral with frame, on the exterior (non-secured) side of the frame.

C. Provide removable stops and moldings formed of 0.032 inch (0.8 mm) thick steel sheets matching steel frames. Secure with countersunk oval head machine screws spaced uniformly not more than 12 inches (300 mm) o.c. Form corners with butted hairline joints.

D. Coordinate rabbet width between fixed and removable stops with type of glass or panel and type of installation indicated.

2.6 FABRICATION

A. Fabricate doors and frames rigid, neat in appearance, and free of defects, warp, wave, and buckle. Accurately form metal to sizes and profiles indicated. Accurately machine, file, and fit exposed connections with hairline joints. Weld exposed joints continuously; grind, fill, dress, and make smooth, flush, and invisible.

B. Exposed Fasteners: Provide countersunk flat heads for exposed screws and bolts, unless otherwise indicated.

C. Hardware Preparation: Prepare doors and frames to receive hardware, including cutouts, reinforcement, mortising, drilling, and tapping, according to final hardware schedule and templates provided by hardware supplier. Secure reinforcement by spot welding. Comply with applicable requirements of ANSI A115 Series specifications for door and frame preparation for hardware. Factory-reinforce doors and frames to receive surface-applied hardware. Factory drill and tap for surface-applied hardware, except at pushplates and kickplates provide reinforcing only.

1. Locate hardware as indicated on the drawings or in Section 08 71 00 "Door Hardware" or, if not indicated, according to HMMA 831, "Recommended Hardware Locations for Custom Hollow Metal Doors and Frames."

2.7 METALLIC-COATED STEEL FINISHES

A. General: Clean, treat and prime surfaces of fabricated steel door and frame work, inside and out, whether exposed or concealed in the construction.

B. Surface Preparation: Clean surfaces with non-petroleum solvent so surfaces are free of oil and other contaminants. After cleaning, apply a conversion coating suited to the organic coating to be applied over it. Clean welds, mechanical connections, and abraded areas, and apply galvanizing repair paint specified below to comply with ASTM A 780.

1. Galvanizing Repair Paint: High-zinc-dust-content paint for regalvanizing welds in steel, complying with SSPC-Paint 20.

C. Factory Priming for Field-Painted Finish: Apply shop primer immediately after surface preparation and pretreatment. Apply a sufficient number of coats, baked on, to obtain uniformly smooth exposed surfaces. Touch up surfaces having runs, smears, or bare spots.

1. Shop Primer: Manufacturer's or fabricator's standard, fast-curing, lead- and chromate-free, primer complying with ANSI A250.10 acceptance criteria; recommended by primer manufacturer for zinc-coated steel; compatible with substrate and field-applied finish paint system indicated.

2.8 STEEL SHEET FINISHES

A. General: Clean, treat and prime surfaces of fabricated steel door and frame work, inside and out, whether exposed or concealed in the construction.

B. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning"; remove dirt, oil, grease, or other contaminants that could impair paint bond. Remove mill scale, shavings, filings, and rust, if present, complying with SSPC-SP 3, "Power Tool Cleaning."

C. Factory Priming for Field-Painted Finish: Apply shop primer immediately after surface preparation and pretreatment. Apply a sufficient number of coats, baked on, to obtain uniformly smooth exposed surfaces. Touch up surfaces having runs, smears, or bare spots.

1. Shop Primer: Manufacturer's or fabricator's standard, fast-curing, corrosion-inhibiting, lead- and chromate-free, universal primer complying with ANSI A250.10 acceptance criteria; compatible with substrate and field-applied finish paint system indicated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Install doors and frames according to DHI A115.IG, the Architect reviewed shop drawings, and manufacturer's written recommendations and installation instructions.

B. Frames: Install frames where indicated. Extend frame anchorages below fills and finishes. Coordinate the installation of built-in anchors for wall and partition construction as required with other work.

1. Welded Frames:

a. Set masonry anchorage devices where required for securing frames to in-place concrete or masonry construction.

1) Set anchorage devices opposite each anchor location as specified and anchorage device manufacturer's written instructions. Leave drilled holes rough, not reamed, and free of dust and debris.

b. Placing Frames: Set frames accurately in position; plumb; align, and brace securely until permanent anchors are set. After wall construction is complete, remove temporary braces and spreaders, leaving surfaces smooth and undamaged.

1) At concrete or masonry construction, set frames and secure in place with machine screws and masonry anchorage devices. Anchor bottom of frames to floors with anchor bolts or power driven fasteners.
2) Field splice only at approved locations indicated on the shop drawings. Weld, grind, and finish as required to conceal evidence of splicing on exposed faces.
3) Remove spreader bars only after frames are properly set and secured.

2. At fire-rated openings, install frames according to NFPA 80.

C. Doors:

1. Non-Fire Rated Doors: Fit non-fire-rated doors accurately in their respective frames, with the following clearances:

a. Jambs and Head: 3/32 inch (2 mm).
b. Meeting Edges, Pairs of Doors: 1/8 inch (3 mm).
c. Bottom: 3/8 inch (9 mm), if no threshold or carpet.
d. Bottom: 1/8 inch (3 mm), at threshold or carpet.

2. Fire-Rated Doors: Install with clearances as specified in NFPA 80.
3. Smoke Control Doors: Install according to NFPA 105.

D. Wood Door Installation: Refer to Section 08 14 16 "Flush Wood Doors."

E. Apply hardware in accordance with hardware manufacturer's instructions and Section 08 71 00 "Door Hardware." Drill and tap for machine screws as required. Do not use self tapping sheet metal screws. Adjust door installation to provide uniform clearance at head and jambs, and to contact stops uniformly. Adjust hardware items just prior to final inspection. Leave work in complete and proper operating condition.

3.2 ADJUSTING AND CLEANING

A. Final Adjustments: Check and readjust operating hardware items just before final inspection. Leave work in complete and proper operating condition. Remove and replace defective work, including doors or frames that are warped, bowed, or otherwise unacceptable.

B. Prime-Coat Touchup: Immediately after erection, sand smooth any rusted or damaged areas of prime coat and apply touchup of compatible air-drying primer.

1. Finish Painting: Refer to Section 09 91 23 "Interior Painting" (interior doors and frames) and Section 09 96 00 "High-Performance Coatings" (exterior doors and frames).

C. Remove and replace defective work, including doors or frames that are warped, bowed, or otherwise defective.

D. Institute protective measures required throughout the remainder of the construction period to ensure that steel doors and frames will be without any damage or deterioration, at time of substantial completion.

END OF SECTION 08 11 13

SECTION 08 1216

ALUMINUM FRAMES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes extruded aluminum frames for doors, glazed openings, and partitions for interior locations:

B. Related Sections:

1. Section 08 14 16 "Flush Wood Doors" for doors to be installed into aluminum frames.
2. Section 08 71 00 "Door Hardware" for door hardware and gasketing.

1.2 ACTION SUBMITTALS

A. Product Data: For each product indicated. Include frame designation, type, level and model, material description, label compliance, fire-resistance ratings, smoke- and draft-control ratings, finishes, and installation instructions.

1. Fire-Rated Door Assemblies and Smoke- and Draft-Control Door Assemblies: Provide door manufacturer's and hardware manufacturer's installation instructions and templates for all components required in the labeled assembly.

B. CALgreen Submittals:

1. Product Data for Section 5.504.4.1: For sealants, adhesives and caulks, provide documentation including printed statement of VOC content showing compliance with SCAQMD Rule 1168 VOC limits and CCR Title 17 for aerosols.
2. Product Certificates for Section A5.405.1: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. For the purposes of this requirement, "regional" is interpreted to mean within 500 miles of the project location or within the State of California.
3. Section A5.405.4 Recycled Content, Tier 1: use recycled content materials, equivalent in performance to virgin materials. Provide cost documentation showing value of recycled content using A5.405.02

C. Shop Drawings: Indicate frame throat dimensions, details of each frame type, elevations of door design types, details of construction; location and installation requirements of door hardware and reinforcements, hardware group numbers; details of joints and connections; and finishes.

D. Samples: For each type of corner construction and each type of exposed finish required. Prepare samples from same material to be used for the Work.

E. Door and Frame Schedule. Use same reference designations indicated on Drawings.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer, with not less than five years experience, who has completed interior aluminum framing systems similar in material, design, and extent to those indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.

B. Source Limitations: Obtain aluminum frames through one source from a single manufacturer with the capacity and resources to provide products of consistent quality in appearance and physical properties.

C. Product Options: Drawings indicate dimensions, arrangements, alignment, and profiles of components and assemblies as they relate to sightlines, to one another, and to adjoining construction dimensions. Other manufacturers' products complying with requirements may be considered. Refer to Section 01 60 00 "Product Requirements."

1. Do not modify intended aesthetic effects, as judged solely by Architect, except with Architect's approval. If modifications are proposed, submit comprehensive explanatory data to Architect for review.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect doors and frames from damage during transit, job storage, and installation.

B. Inspect frames on delivery for damage. Tool marks, rust, blemishes and any other damage on exposed surfaces will not be acceptable. Remove and replace damaged items that cannot be repaired as directed by Architect. Store frames at building site in a dry location, off the ground, and in such a manner as to prevent deterioration.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Alutech Corporation.
2. Architectural Components, Incorporated.
3. Custom Components Company.
4. Dual Lock Partition Systems, Inc.; Alumax.
5. Frameworks Manufacturing Co., Inc.
6. Modulex, Inc.
7. Versatrac; a division of A. J. May, Inc.
8. Western Integrated Materials, Inc.
9. Wilson Partitions, Inc.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Advanced Architectural Frames; with Venus trim; furnished with head and jamb seals.
2. Eclipse Systems, Inc.; with flush trim; furnished with head and jamb seals.

3. Western Integrated Materials, Inc.; Type 300, with Series 304 trim reverse miter; furnished with head and jamb seals.

2.2 MATERIALS

A. Extruded Aluminum: ASTM B 221 alloy 6063-T5 or alloy and temper required to suit structural and finish requirements.

B. Recycled Content of Aluminum Products: Provide products with an average recycled content so that post-consumer recycled content plus one-half of pre-consumer recycled content is not less than 45 percent.

2.3 COMPONENTS

A. General: Provide interior aluminum frame components that comply with dimensions, profiles, and relationships to adjoining work of components indicated on Drawings.

B. Door Frames: Extruded aluminum, not less than 0.062 inch thick, reinforced for hinges and strikes with 0.125 inch thick hinge back up plates.

C. Glass Frames: Extruded aluminum, not less than 0.062 inch thick, designed for glass thickness indicated.

D. Ceiling Tracks: Extruded aluminum, not less than 0.062 inch thick.

E. Trim: Extruded aluminum, not less than 0.062 inch thick, glass stops and door stops without exposed fasteners.

1. Trim Profile: Flat-faced 1-1/2 inch wide by 1/2 inch deep snap-on trim with 90 degree return.

2.4 ACCESSORIES

A. Fasteners: Aluminum, nonmagnetic stainless-steel or other non-corrosive metal fasteners compatible with frames, stops, panels, reinforcement plates, hardware, anchors, and other items being fastened.

B. Glazing Gaskets: Manufacturer's standard extruded or molded plastic, to accommodate 6-mm thick glass.

C. Glazing: As specified in Section 08 80 00 "Glazing."

D. Hardware: As specified in Section 08 71 00 "Door Hardware."

E. Gaskets/ Silencers:

1. Door Openings: Provide vinyl or pile continuous gasket/silencer in Architect's choice of white, gray, or black.
2. Fire-Rated Smoke- and Draft-Control Door Assemblies: Provide continuous smoke- and draft-control gasket complying with fire-rating requirements in Architect's choice of white or black.
3. Glazed Units: Provide continuous vinyl gasket in Architect's choice of white, gray, or black.

2.5 FABRICATION

A. Fabricate all components to allow secure installation without exposed fasteners.

B. Fabricate frames with butt, mitered, or coped and continuously welded corners and seamless face joints. Provide concealed corner reinforcements and alignment clips for precise butt or mitered connections.

C. Prepare frames to receive mortised and concealed hardware according to final door hardware schedule and templates provided by hardware supplier.

D. Reinforce frames to receive surface-applied hardware. Machine jambs and prepare for hardware, with concealed reinforcement plates, drilled and tapped as required, and fastened within frame with concealed screws.

E. Locate hardware as indicated.

F. Provide terminated stops.

G. Door Silencers: Continuous gasket at frame head and both jambs.

H. Fabricate frames for glass to allow glass replacement without dismantling frame.

I. Glazing Stops: Provide non-removable stops on secure side of interior doors for glass, louvers, and other panels in doors. Provide screw-applied, removable, glazing stops on inside of glass, louvers, and other panels in doors.

J. Clearances for Non-Fire-Rated Door Frames: Not more than 1/8 inch at jambs and heads, except not more than 1/4 inch between pairs of doors. Not more than 3/4 inch at bottom.

2.6 ALUMINUM FINISHES

A. Anodic Finish: Class I, clear, complying with AAMA 611.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install frames plumb and square, securely anchored to substrates with fasteners recommended by frame manufacturer.

B. Install partition components in the longest possible lengths; components up to 48 inches long must be one piece. Fasten to suspended ceiling grid on maximum 48 inch centers, using sheet metal screws or other fasteners approved by frame manufacturer.

1. Use concealed installation clips to ensure that splices and connections are tightly butted and properly aligned.
2. Secure clips to main structural extrusion components and not to snap-in or trim members.
3. Do not leave screws or other fasteners exposed to view when installation is complete.

C. After installation, remove protective wrappings from frames. Refinish or replace frames damaged during installation. Touch up marred areas so touchup is not visible from a distance of 48 inches. Remove and replace frames that cannot be refinished to satisfaction of the Architect.

END OF SECTION 08 1216

SECTION 08 1416

FLUSH WOOD DOORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes solid core flush wood doors.

1. The integration of a security system into the flush wood door work is required. The Contractor shall be responsible for the total and complete coordination of the security system components into the Work.

1.2 ACTION SUBMITTALS

A. Product Data: Submit product data for each type of door required. Include factory-finishing specifications.

1. Submit laboratory test report results of hinge loading, cycle/slam, stile edge screw withdrawals, and stile edge split resistance for fire rated doors.

B. Shop Drawings: Submit shop drawings indicating location, size, thickness, and hand of each door; elevation of each kind of door; construction details not covered in the product data; location and extent of hardware blocking; undercuts, special beveling, and other pertinent data.

1. Indicate dimensions and locations of mortises and holes for hardware of factory machined doors.
2. Indicate dimensions and locations of cutouts.
3. Indicate fire label requirements including fire rating time duration, maximum temperature rise requirements, and smoke label requirements.
4. Indicate routing of electrical conduit and dimensions and locations of cutouts in wood doors to accept electric hardware devices.

C. Samples: Cut away corner section of each door type approximately 8 by 10 inches demonstrating door construction, face veneer and finish.

1.3 INFORMATIONAL SUBMITTALS

A. Certificate of Compliance for Fire Rated Doors: Provide copies of testing agency's Certificate of Compliance for all fire rated door assemblies, all smoke and draft control door assemblies, and all temperature rise rated door assemblies.

1.4 QUALITY ASSURANCE

A. Quality Standard: Comply with the applicable provisions and recommendations of AWS "Architectural Woodwork Standards."

B. Forest Certification: Provide doors made from wood products obtained from forests certified by an FSC-accredited certification body to comply with STD-01-001, "FSC Principles and Criteria for Forest Stewardship."

C. Fire-Rated Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing according to NFPA 252, and UL 10C "Standard for Positive Pressure Fire Tests of Door Assemblies." Fire classification labels at all doors with fire ratings greater than 20 minutes shall indicate the temperature rise developed on the unexposed surface of the door after the first 30 minutes of fire exposure.

1. Provide metal labels permanently fastened on each door which is within the size limitations established by the labeling authority having jurisdiction.
2. Temperature-Rise Rating: Where indicated, provide doors that have a temperature-rise rating of 450 deg F maximum in 30 minutes of fire exposure.
3. Positive Pressure Rated Door Assemblies: Where indicated provide positive pressure rated fire rated door assemblies. Sizes and configurations as shown on the Drawings. Installed door assemblies shall be in accordance with door manufacturer's certified assemblies.

   a. Test Pressure: Test according to NFPA 252 or UL 10C. After 5 minutes into the test, neutral pressure level in furnace shall be established at 40 inches or less above the sill.

4. Provide fire rated door assemblies with smoke and draft control rating at corridors, stairwells, and where required by applicable codes. Sizes and configurations as shown on the Drawings. Installed door assemblies shall be in accordance with door manufacturer's certified assemblies.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect wood doors during transit, storage, and handling to prevent damage, soiling, and deterioration. Comply with requirements of referenced standard and manufacturer's written instructions.

B. Package doors individually in heavy duty cardboard cartons or poly bags.

C. Handle wood doors with clean gloves. Lift and carry wood doors when moving them around the site, do not drag wood doors across one another.

1.6 FIELD CONDITIONS

A. Environmental Limitations: Do not deliver or install doors until wet work , such as masonry, concrete, stone, tile, terrazzo, plastering, wallboard joint treatment, is complete and dried, and HVAC system is operating and will maintain temperature and relative humidity at occupancy levels during the remainder of the construction period. Do not expose doors to sudden changes in temperature such as forced heat used to dry out the site.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form, signed by manufacturer, Installer, and Contractor, in which manufacturer agrees to repair or replace doors that are defective in materials or workmanship for the life of the original installation of the door. A representative of the door manufacturer shall inspect the installed doors and shall note on the warranty that no provisions of the warranty have been nullified in the manufacture and/or installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance to requirements, provide products by one of the following:

1. Algoma Hardwoods, Inc.
2. Eggers Industries, Architectural Door Division.
3. Marshfield Door Systems, Inc.
4. VT Industries.

2.2 DOOR CONSTRUCTION

A. General:

1. Low-Emitting Materials: Provide doors made with adhesives and composite wood products that do not contain added formaldehyde.

B. Doors for Opaque Finish:

1. Grade: Custom.
2. Face Veneer: Medium-density overlay.
3. Thickness: 1-3/4 inch unless otherwise indicated.
4. Materials:

   a. Particleboard Core Material: Complying with ANSI A208.1, Grade 1-LD-1 or 1-LD-2.
   b. Blocking: 5-1/2 inch wide minimum top-rail blocking at doors with closers and bottom rail blocking at doors with kickplates consisting of minimum 1/2 inch wide single length structural composite lumber (SCL) outer band and single length SCL inner band. Provide blocking at all hardware locations, including hinges, lock and latch sets, and thumb turns. Provide minimum screw pullout withdrawal at face of 700 lbf and 400 lbf at edge.
   c. Vertical Edges: 1-3/8 inch wide minimum prior to fitting, 2 ply laminated wood construction consisting of a single piece hardwood outer band, without fingerjoints, and an inner band of SCL. Trim non-rated door width equally on both jamb edges.
   d. Crossbanding: Minimum 1/16 inch thick, low density hardwood, composite, or high density hardboard.

5. Construction: AWI Section 1300, PC-5 CE. Stiles, rails, and blocking bonded to core then entire unit abrasive planed before veneering. Crossbanding materials shall extend full width of door with grain running horizontally, tapeless spliced without voids or show through (telegraphing), and directly glued to core and blocking. Sand cross banding before application of face veneer. Face veneer shall extend full height of door with grain running vertically, tapeless spliced without voids or show through (telegraphing), and directly glued to cross band. Glue lines between face veneer, crossbanding, and blocking shall be of a type to comply with the specified warranty using the hot plate process.

C. Fire Rated Door Construction:

1. Construction: AWI Section 1300, FD-5, with particleboard or mineral core as required to provide fire rating indicated, and faced to match non-rated fire doors. Provide required label(s) on each door.
2. Blocking: For mineral-core doors, provide composite blocking, of same thickness as core, approved for use in doors of fire ratings indicated, and as follows:

a. 5-1/2 inch wide minimum top-rail blocking consisting of minimum 1/2 inch wide single length mill option hardwood outer band and single length lumber inner band fabricated of same materials as vertical edges.
b. Provide either two 4-1/2 inch by 18 inch minimum sized lock blocks on each door stile or a single 10 inch high continuous lock rail located on lockcase body centerlines.

3. Vertical Edge Construction: Provide manufacturer's standard laminated-edge construction meeting label requirements, with intumescent seals concealed by outer stile matching face veneer, and meeting or exceeding the specified direct screw withdrawal, split resistance, cycle slam, and hinge loading criteria. Finish outer bands to match door faces without joints.

a. Split Resistance: Not less than 696 pounds when tested in accordance with WDMA TM-5; or, not less than 1305 pounds when tested in accordance with ASTM D143.
b. Cycle/Slam: Not less than 200,000 cycles with no loosening of hinge screws or other visible signs of failure when tested in accordance with the requirements of WDMA TM-7; or, not less than 502,000 cycles when tested in accordance with ANSI A151.1
c. Direct Screw Withdrawal: Not less than 700 pounds when tested in accordance with WDMA TM-10; or, not less than 877 pounds when tested in accordance with ASTM D1037 using #12 x 1-1/4 steel screws, threaded to the head with either A or AB wood threads.
d. Hinge Loading: Not less than 684 pounds average when tested in accordance with WDMA TM-8.

4. Pairs: Provide fire-rated pairs with fire-retardant stiles matching face veneer that are labeled and listed for kinds of applications indicated without formed-steel edges and astragals. Provide stiles with concealed intumescent seals.
5. Thickness: 1-3/4 inch unless otherwise indicated.

D. Wood Beads for Light Openings in Wood Doors: Manufacturer's standard flush designed, solid wood, rectangular shaped, back beveled or quirked, beads matching veneer species of door faces. Include glazing compounds or tapes sized for back bevel or quirk provided. Include finish nails for removable stops sized in accordance with wood door manufacturer's recommendations.

2.3 FABRICATION

A. Fabricate doors in sizes indicated for Project-site fitting.

B. Factory fit doors to suit frame-opening sizes indicated.

1. Comply with clearance requirements of referenced quality standard for fitting. Comply with requirements in NFPA 80 for fire-rated doors.

C. Factory machine doors for hardware that is not surface applied. Locate hardware to comply with DHI-WDHS-3 unless otherwise indicated to match existing frame hardware preparations. Comply with final hardware schedules, door frame Shop Drawings, AWI Section 1300-G-20, BHMA A156.115-W standards, and hardware templates.

1. Coordinate measurements of hardware mortises in frames to verify dimensions and alignment before factory machining.
2. Locate lock and latchsets in doors to match existing strike locations on existing door frames; locate hinges in doors to match hinge locations on existing door frames.
3. Metal Astragals: Premachine astragals and formed-steel edges for hardware for pairs of fire-rated doors.

D. Openings: Cut and trim openings through doors to comply with applicable requirements of referenced standards for kind(s) of door(s) required. Install light beads with fasteners spaced for opening size and fire rating indicated. Install wood bead moldings with finish nails and countersink without striking bead. Fill countersunk heads with putty matching wood bead color.

2.4 SHOP PRIMING

A. Doors for Opaque Finish: Shop prime faces and edges of doors, including cutouts, with one coat of wood primer/sealer as standard with door manufacturer. Surfaces shall be clean and dry before priming. Apply primer/sealer uniformly without bare spots, runs, or sags.

2.5 FACTORY FINISHING

A. General: Finish doors at factory that are indicated to receive transparent finish.

B. Grade: Premium.

C. Finish: Manufacturer's standard finish with performance meeting or exceeding either AWS System TR-4 conversion varnish or AWS System 5 catalyzed polyurethane.

D. Staining: Prepare door faces, stiles, rails, and cutouts, with toners, or stains, prior to the application of finish to match Architect's sample.

E. Effect and Sheen: Match Architect's sample.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Hardware: Apply hardware to new doors in accordance with hardware manufacturer's instructions and Section 08 71 00 "Door Hardware." For particleboard core doors drill pilot holes of proper size for installing hinge screws. Adjust hardware items just prior to final inspection. Leave work in complete and proper operating condition.

1. Factory wrapping shall be maintained on new doors during construction period, and all hardware shall be installed by cutting the factory wrapping at the mounting location of the hardware item.

B. General Door Installation Standards: Install doors in locations indicated to comply with manufacturer's written instructions, referenced quality standard, and as indicated. Where standards conflict the more stringent shall apply.

1. Install fire-rated doors in corresponding fire-rated frames according to fire label requirements.

C. Job-Fitted Doors: Align and fit doors in frames with uniform clearances and bevels; and to contact stops uniformly, do not trim stiles and rails in excess of limits set by manufacturer or permitted for fire-rated doors. Field cutting, fitting or trimming, shall be executed in a workmanlike manner. Machine doors for hardware. Seal cut and trimmed surfaces immediately after fitting and machining using clear varnish or sealer.

1. Clearances: Provide 1/8 inch at heads, jambs, and between pairs of doors. Provide 1/8 inch from bottom of door to top of decorative floor finish or covering. Where threshold is shown or scheduled, provide 1/4 inch from bottom of door to top of threshold.
2. Comply with fire label requirements for fire-rated doors.

D. Factory-Fitted Doors: Align in frames for uniform clearance at each edge, matching clearances specified for factory prefitting, and to contact stops uniformly. Field cutting, fitting or trimming, if required, shall be executed in a workmanlike manner.

1. Clearances: Provide 1/8 inch at heads, jambs, and between pairs of doors. Provide 1/8 inch from bottom of door to top of decorative floor finish or covering. Where threshold is shown or scheduled, provide 1/4 inch from bottom of door to top of threshold.

E. Field-Finished Doors: Refer to the following for finishing requirements:

1. Section 09 91 23 "Interior Painting."

3.2 ADJUSTING AND PROTECTION

A. Rehang or replace doors that do not swing or operate freely.

B. Protection: Protect wood doors to ensure that the wood door work will be without damage or deterioration at the time of Substantial Completion.

1. Refinish or replace wood doors damaged during installation. Replace any new wood doors that are warped, twisted, demonstrate core show through, are not true in plane, or cannot be refinished to the satisfaction of the Architect.

END OF SECTION 08 1416

SECTION 08 31 13

ACCESS DOORS AND FRAMES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Access doors and frames.
2. Fire-rated access doors and frames.

B. Related Sections:

1. Section 08 71 00 "Door Hardware" for mortise or rim cylinder locks and master keying.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of access door indicated.

B. LEED Submittals:

1. Completed "LEED Criteria Worksheet," for each component material of the product or assembly used in the installation of Work of this Section. Refer to Section 01 81 13 "Sustainable Design Requirements."
2. Product Certificates for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.

    a. Include a statement indicating costs for each product having recycled content.

3. Product Certificates for Credit MR 5: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material.

    a. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.

C. Coordination Drawings: Drawn to scale and coordinating access door and frame installation with ceiling support, ceiling-mounted items, and concealed Work above ceiling.

D. Samples: For each exposed finish.

E. Schedule: Door and frame schedule, including types, general locations, sizes, construction details, latching or locking provisions, and other data pertinent to installation.

1.3 QUALITY ASSURANCE

A. Fire-Rated Access Doors and Frames: Units complying with NFPA 80 and that are labeled and listed by UL, ITS, or another testing and inspecting agency acceptable to authorities having jurisdiction per test method indicated.

1. Vertical Access Doors: NFPA 252 or UL 10B.
2. Horizontal Access Doors and Frames: ASTM E 119, UBC Standard 7.1, or UL 263.

B. Size and Location Verification: Determine specific locations and sizes for access doors needed to gain access to concealed equipment, and indicate on schedule.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.

1. Hot-Dip Galvanized Steel: Coat to comply with ASTM A 123/A 123M for steel and iron products and ASTM A 153/A 153M for steel and iron hardware.

B. Steel Sheet:

1. Hot-Rolled: ASTM A 1011/A 1011M, Commercial Steel (CS), Type B; free of scale, pitting, and surface defects; pickled and oiled.
2. Cold-Rolled: ASTM A 1008/A 1008M, Commercial Steel (CS) or Drawing Steel (DS), Type B; stretcher-leveled standard of flatness.

   a. Electrolytic zinc-coated steel sheet, complying with ASTM A 591/A 591M, Class C coating, may be substituted at fabricator's option.

C. Drywall Beads: Edge trim formed from 0.0299 inch (0.76 mm) zinc-coated steel sheet formed to receive joint compound and in size to suit thickness of gypsum panels indicated.

D. Paint:

1. Shop Primer for Ferrous Metal: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with performance requirements in FS TT-P-664; selected for good resistance to normal atmospheric corrosion, compatibility with finish paint systems indicated, and capability to provide sound foundation for field-applied topcoats despite prolonged exposure.

2.2 ACCESS DOORS AND FRAMES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Babcock- Davis.
2. J. L. Industries, Inc.
3. Karp Associates, Inc.
4. MIFAB Manufacturing, Inc.
5. Nystrom Building Products Co.
6. Williams Bros. Corporation of America (The).

B. Flush, Uninsulated, Fire-Rated Access Doors and Trimless Frames:

1. Material: Prime-painted steel sheet.
2. Surface Type: Gypsum board.
3. Locations: Walls and ceilings.
4. Fire-Resistance Rating: Match surrounding construction rating.
5. Door: Flush panel with core of mineral-fiber insulation enclosed in sheet metal with a minimum thickness of 0.036 inch (0.9 mm).
6. Frame: Minimum 0.060 inch (1.5 mm) thick sheet metal with drywall bead.
7. Hinges: Concealed pin type or continuous piano hinge.
8. Automatic Closer: Spring type.
9. Lock: Key-operated cylinder lock with interior release.

C. Flush Access Doors and Trimless Frames:

1. Material: Prime-painted steel sheet.
2. Surface Type: Gypsum board.
3. Locations: Walls and ceilings.
4. Door: Minimum 0.060 inch (1.5 mm) thick sheet metal, set flush with surrounding finish surfaces.
5. Frame: Minimum 0.060 inch (1.5 mm) thick sheet metal with bead for type of surface indicated.
6. Hinges: Spring-loaded concealed pin type or continuous piano hinge.
7. Lock: Key-operated cylinder lock.

2.3 FABRICATION

A. Latching Mechanisms: Furnish number required to hold doors in flush, smooth plane when closed.

1. For cylinder lock, furnish two keys per lock and key all locks alike.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Advise installers of other work about specific requirements relating to access door and floor door installation, including sizes of openings to receive access door and frame, as well as locations of supports, inserts, and anchoring devices.

B. Set frames accurately in position and attach securely to supports with plane of face panels aligned with adjacent finish surfaces.

C. Install access doors flush with adjacent finish surfaces or recessed to receive finish material.

D. Adjust doors and hardware after installation for proper operation.

END OF SECTION 08 3113

SECTION 08 4113

ALUMINUM-FRAMED ENTRANCES AND STOREFRONTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes aluminum entrances and storefronts.

1. Security system components may be incorporated into the door and frame openings of all aluminum entrances and storefronts at the Owner's option. Cooperate with the Owner's security system contractors if the Owner chooses to incorporate security system components during the course of the Work.

2. Delegated-Design Submittal: For aluminum-framed entrances and storefronts indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

3. Manual door hardware to be provided by this section (Automatic Door Operators are described in 08 71 13).

4. This Section includes materials designated MT-3 on Drawings.

B. Section includes aluminum entrances and storefronts. The aluminum entrance and storefront work includes the following:

1. Aluminum swing entrance doors and framing, including hardware, stripping and thresholds.
2. Aluminum sliding entrance doors, and framing, including hardware, stripping and thresholds.
3. Aluminum trim, flashings, and similar items in conjunction with aluminum entrance and storefronts.
4. Painting and coating in conjunction with the above aluminum items.
5. Internal steel and aluminum reinforcements for aluminum entrances and storefronts.
6. Internal and perimeter sealing, joint fillers, weeps, vents and gasketing systems for aluminum entrances and storefronts.
7. Anchors, shims, fasteners, inserts, expansion devices, accessories, support brackets and attachments for aluminum entrances and storefronts.
8. Glass and glazing for aluminum entrances and storefronts.
9. Security system components may be incorporated into the door and frame openings of all aluminum entrance and storefront work at the Owner's option. Cooperate with the Owner's security system contractors if the Owner chooses to incorporate security system components during the course of the Work.

C. The Owner will engage an independent testing and inspection agency to verify the adequacy of the Contractor's quality control; refer to Section 01 40 00 "Quality Requirements." Before concealing the window, window wall and curtain wall work obtain the required inspections of same from a representative of the Owner's independent testing and inspection agency.

1.2 ACTION SUBMITTALS

A. Product Data: Submit manufacturer's specifications and installation instructions for each aluminum entrance and storefront product specified.

B. Shop Drawings: Submit shop drawings showing scaled elevations, plans, and sections of the aluminum entrance and storefront work. Full-scale sections shall be prepared and submitted for details of the assemblies that cannot be shown in the elevations or sections. Include with shop drawings metal thickness of all metal components, glass thicknesses, metal finishes, and all other pertinent information as necessary or requested by the Architect to indicate compliance with the Contract Documents. Details of field connections, anchorage, and their relationship to the work of others shall be clearly indicated for the coordination of the work by other building trades. Details of fastening and sealing methods and product joinery shall be shown to ensure proper performance of the field installation. No work shall be fabricated until shop drawings for that work have been approved by Architect for fabrication. Shop drawings shall be signed and sealed by a Professional Engineer registered in the state wherein the work is to be erected and who is responsible for the Structural Calculations of the work.

C. Structural Calculations: Submit with the shop drawing submittal copies of structural calculations indicating complete compliance with the specified performance requirements. Include calculations to show that maximum deflections do not exceed specified performance requirements under full design loading, calculations for louvers, panels, frames, connections and precast anchors and panels, stone anchors, computer glass analyses showing that probability of breakage at the design wind pressure, and under the specified service temperature range, will not exceed the specified probability of breakage for each type, size, and thickness of glass. Calculations shall be prepared, signed and sealed by a Professional Engineer registered in the state wherein the work is to be erected.

D. Hardware Schedule: Organize schedule into sets based on hardware specified. Include name of item and manufacturer, and complete designation of every item required for each entrance door.

E. Samples: Submit samples of the following before any work is fabricated:

1. 3 paired sets of samples for each exposed metal finish required. Sample finishes shall be on the specified alloy, temper, and thickness of metal required for the work. Where finishes involve color and texture variations, include sample sets showing the full range of variations expected. Furnish samples in either 12 inch (300 mm) or 12 inch (300 mm) squares of sheet.

1.3 INFORMATIONAL SUBMITTALS

A. Field Test Reports: Submit field testing reports.

B. Product Test Reports: Submit certified product test reports based on tests performed by an AAMA Accredited Laboratory clearly describing in written form, and in shop drawing form, compliance of each aluminum entrance and storefront assembly (each swinging and sliding door) with requirements indicated based on comprehensive testing and conditions similar to project requirements

C. Pre-Construction Sealant Compatibility and Adhesion Testing: Submit test results.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Instructions: Submit copies of manufacturer's written instructions for adjustment, operation and maintenance of doors.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Subcontract the aluminum entrance and storefront work to a firm which is specialized in the erection of entrances and storefronts and who has successfully installed work similar in design and extent to that required for the Project, in not less than three projects of similar scope to the satisfaction of the Architect, and whose work has resulted in construction with a record of successful in-service performance for a period of 10 years.

1. Testing laboratories shall be specifically qualified to conduct laboratory and field performance tests required by these specifications and acceptable to the Architect.

2. Field Testing: Test the curtain wall, and punched opening window, sample installations erected to the opaque portions of the exterior wall cladding in accordance with the specified field test methods. Conduct tests of each specified sample installation under the direction of the testing laboratory in the presence of the Owner, Architect, the Contractor, various component manufacturers and fabricators and the installer for each specified system incorporated in the sample installations.

a. Field Test for Water Leakage:

1) Water Spray Test without Static Air Pressure Difference: AAMA 501.2.
2) Correct all deficiencies observed as a result of this test and retest. For each unsuccessful field test, another similar sample installation area shall be selected and tested. Any repairs or remediation conducted to pass a test, if they constitute a change to the design (e.g. sealing of a joint that was previously open, or adding a weep hole) must be implemented throughout the work. Any remedial repairs which increase the maintenance requirements of the system (i.e., face sealing of a drained system), will not be accepted.

B. Pre-construction Sealant Compatibility and Adhesion Testing: Test results confirming compatibility and adhesion are mandatory for all concealed and exposed sealant materials in contact with exterior glazing, stone, precast, other sealants, flashings, metal framing, and shims prior to full size sample installation construction. Refer to Section 07 92 00 "Joint Sealants" for specific testing requirements, and anticipated lead time necessary to perform testing.

C. Standards: Comply with the applicable provisions and recommendations of the following standards below, where standards conflict the more stringent shall apply:

1. Aluminum Association (AA):

a. No. 1 "Aluminum Standards and Data."
b. "The Aluminum Design Manual."

2. American Architectural Manufacturers Association (AAMA):

a. AAMA "Aluminum Curtain Wall Design Guide Manual," Volumes 1-9.
b. AAMA "Aluminum Store Front and Entrance Design Guide Manual."
c. AAMA 611 "Anodized Architectural Aluminum."
d. AAMA 2603 "Voluntary Performance Requirements and Test Procedures for Pigmented Organic Coatings on Extruded Aluminum."
e. AAMA 2605 "Specification for Superior Performing Organic Coatings on Architectural Extrusions and Panels".

3. American Institute of Steel Construction (AISC), "Steel Construction Manual," Current Edition.
4. Steel Structures Painting Council (SSPC): "Steel Structures Painting Manual, Vol. 2, Systems and Specifications."
5. Federal Standard 16 CFR 1201, Consumer Product Safety Commission (CPSC): "Safety Standard for Architectural Glazing Materials," as published in the Code of Federal Regulations (CFR). Comply with the applicable requirements of the laws, codes, ordinances and regulations of Federal and Municipal authorities having jurisdiction, wherever requirements conflict the more stringent shall be required. Obtain approvals from all such authorities. As a minimum provide safety glazing complying with ANSI Z97.1 and testing requirements of 16 CFR Part 1201 for Category II materials.
6. Welding Standards: Welding shall be performed by skilled and qualified mechanics. Welding shall be performed in accordance with the applicable provisions of AWS D1.1 "Structural Welding Code - Steel" and AWS D1.2, "Structural Welding Code--Aluminum."

D. Sample Installations:

1. General: Sample installations will be used as a standard for judging acceptability of work for the Project. Replace unsatisfactory work as directed. Maintain sample installations during construction as a standard for judging acceptability of the exterior wall work. Properly finished, maintained, and performing sample installations shall be retained as a portion of the completed work.
2. Size: Provide full sized sample installations to the extent indicated on the Drawings, or if not indicated, as directed by the Architect. Sample installations shall be built on site complete with all glass, aluminum framing, adjacent cladding materials, anchors, connections, flashings, sealants, and joint fillers as accepted on the final shop drawings. Do not take special precautions or use techniques that do not represent those to be used on the work. Do not enclose the interior side of the wall with interior finishes and insulation materials.

3. Mock up: Provide visual mock up for areas indicated on Architects drawings.
Provide mock-ups complete with support structure and backing as required to ensure viewing conditions closely reassembling project conditions. Maintain Visual mock-ups for the duration of construction, or dispose as directed by the owner.

E. Pre-installation Conference: Conduct conference at Project site to comply with requirements in Section 01 31 00 "Project Management and Coordination." Prior to the start of the aluminum entrance and storefront work, and at the Contractor's direction, meet at the site and review the installation procedures and coordination with other work. Meeting shall include Contractor, Owner, aluminum entrance and storefront installer, sealant installer, as well as any other subcontractors or material technical service representatives whose work, or products, must be coordinated with the aluminum entrance and storefront work.

1.6 IDENTIFICATION, DELIVERY, STORAGE, AND HANDLING

A. General: Comply with the applicable provisions of AAMA "Curtain Wall Manual #10" for the care and handling of aluminum entrance and storefront work from shop to site.

B. All components of the aluminum entrance and storefront work shall be identified after fabrication by marks clearly indicating their location in the building. Packaging of components shall be so selected to protect the components from damage during shipping and handling.

C. Storage on Site:

1. Store aluminum entrance and storefront components in a location and in a manner to avoid damage to the components. Stacking shall be done in a way which will prevent bending,

excessive pressure, abrasion or other permanent damage of the component and its finished surfaces.

2. Store aluminum entrance and storefront components and materials in a clean, dry location, away from uncured concrete, masonry work, sprayed on fireproofing work, and other construction activities. Cover with non-staining waterproof paper, tarpaulin, or polyethylene sheeting in a manner that will permit circulation of air inside the covering.

D. Keep handling on site to a minimum. Exercise particular care to avoid damage to finishes of metals.

1.7 PROJECT CONDITIONS

A. Field Measurements: Verify dimensions of supporting structure by field measurements before fabrication so that the entrance and storefront work will be accurately designed, fabricated and fitted to the structure. Indicate measurements on shop drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work. Use Contractor's lines and benchmarks as a basis for measurements.

B. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating entrance and storefront work without field measurements. Coordinate supporting structure construction to ensure actual dimensions correspond to established dimensions.

1.8 WARRANTY

A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.

B. Special Warranty: Submit a 2 year written warranty, beginning from date of substantial completion, and executed by the Contractor, manufacturer and the aluminum entrance and storefront installer agreeing to repair or replace components of entrance and storefront systems that develop defects in materials or workmanship within the specified warranty period. Defects include, structural failures, sealant failures, deterioration of metals, metal finishes, and other materials beyond normal weathering, failure of operating components to function properly, uncontrolled water leakage, uncontrolled air leakage, and any other evidence of failure or deterioration of the aluminum entrance and storefront work to meet performance requirements.

C. Warranty; Anodized Coatings: Submit a warranty for a period of 3 years, warranting that the anodized aluminum will not develop excessive fading or excessive non-uniformity of color or shade, and will not crack, peel, pit, or corrode; all within the limits defined as follows:

1. "Excessive Fading" means a change in appearance which is perceptible and objectionable as determined by the Architect when viewed visually in comparison with the original color range samples.
2. "Excessive Non-Uniformity" means non-uniform fading during the period of the warranty to the extent that adjacent panels have a color difference greater than the original acceptable range of color.
3. "Will Not Pit or Otherwise Corrode" means there shall be no pitting or other type of corrosion discernable from a distance of 10 feet (3000 mm), resulting from the natural elements in the atmosphere at the Project site.

D. Warranty, High Performance Organic Coatings: Submit a warranty for a period of 20 years, warranting the integrity of film and permanence of color of the high performance organic coatings for the following:

1. Color fade not to exceed 5 delta E units (Hunter) as calculated in accordance with ASTM D2244 on exposed surfaces cleaned with clean water and a soft cloth.
2. Degree of chalking not to exceed rating No. 8 when measured in accordance with ASTM D659 on exposed unwashed surfaces.
3. Will not crack, check or peel.

E. Warranty, Thermosetting Acrylic Enamel Coatings: Submit a warranty for a period of 5 years, warranting the integrity of film against cracking, chipping, flaking, peeling and blistering of the thermosetting acrylic enamel coatings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General:

1. Design and fabricate aluminum entrances to withstand the operating loads which result from heavy traffic conditions using the specified hardware, without measurable permanent deflection. Limit elastic deflections so as to provide the normal degree of rigidity required to avoid glass breakage, air leaks and other objectionable results of excessive flexibility. Provide weatherstripping at stiles, sill and head rails of door leaves, to minimize air, water and sound leaks.

2. Basis of Design Product:
   a. Kawneer Company, Inc.
   b. 1600 SS – Pre Glazed Curtain Wall.
      ~~1.~~1) Frame depth: 3 ½" x 6".

B. General: Provide aluminum entrance and storefront systems meeting or exceeding the following performance requirements:

1. Structural Properties:

   a. Wind Loads: The aluminum entrance and storefront work, including glass, shall be designed, fabricated and installed to withstand the maximum inward and outward wind pressures as required by CBC and **ASCE 7**

      1) Basic Wind Speed: ~~<**Insert load**>~~110 mph.
      2) Exposure Category: ~~<**Insert category**>~~B.
      3) Importance Factor: ~~<**Insert factor**>~~1.0.

   b. Seismic Loads: As required by CBC and **ASCE 7**.
   c. Deflection Limitations:

      1) Deflections: Base calculations for the following deflections upon the combination of maximum direct wind loads, building deflections, thermal stresses, and erection tolerances.

a) The deflection of any framing member in a direction normal to the plane of the wall when subjected to the full code required wind loads specified above shall not exceed 1/175 of its clear span or 3/4 inch (19 mm) whichever is less, except limit deflection of glass to 1 inch (25.4 mm).

b) Glass, sealants and interior finishes shall not be included to contribute to framing member strength, stiffness or lateral stability.

2) Do not permit any permanent deformation (set) in the metal framing work. Permanent deformation, fastener, weld, or gasket failure, component breakage or disengagement shall not occur under wind loading equal to 1.5 times the wind loads (positive or negative). Permanent deformation shall be taken as deflection without recovery exceeding 1/1000 times span.

d. Dead Loads:

1) Maximum full deadload deflections, parallel (in-plane) to wall plane, of framing members shall not reduce glass bite or glass coverage, to less than 75 percent of the design dimension, and shall not reduce edge clearance to less than 25 percent of design dimension or 1/8 inch (3 mm) whichever is greater.

2) Limit deflections of metal members spanning door openings to 1/300. The clearance between the member and an operable door shall be no less than 1/16 inch (1.5 mm).

3) Twisting (rotation) of the horizontals due to the weight of the glass shall not exceed 1 degree, measured between ends and center of each span.

e. Uniform Structural Loads: Satisfactory uniform wind loading tests of each aluminum entrance and storefront assembly (each swinging and sliding door) shall have been conducted in accordance with the requirements of ASTM E330. Each assembly shall have been subjected to inward and outward acting uniform loads equal to 1.5 times the inward and outward acting design wind loads specified above under paragraph 'wind loads'. Satisfactory performance at these loads shall mean no glass or other component breakage, component disengagement, and no permanent deformation of main framing members in excess of the permanent deformation criteria specified above.

f. Operational (Traffic) Loads: Design and fabricate aluminum entrances to withstand the operating loads which result from heavy traffic conditions using the specified hardware, without measurable permanent deflection. Limit elastic deflections so as to provide the normal degree of rigidity required to avoid glass breakage, air leaks and other objectionable results of excessive flexibility. Provide weatherstripping at stiles, sill and head rails of door leaves, to minimize air, water and sound leaks.

C. Air Leakage: Air leakage through each aluminum entrance and storefront assembly shall not have exceeded 0.06 cfm/sq. ft. (0.03 L/s per sq. m) of fixed wall area when tested in accordance with ASTM E 283 at a static-air-pressure difference of 6.24 lbf/sq. ft. (300 Pa).

D. Water Penetration:

1. Water penetration in this specification is defined as the appearance of uncontrolled water, other than condensation, on any indoor face of any part of the wall.
2. Provision shall be made to drain to the exterior face of the wall any water entering the system.
3. No uncontrolled water penetration shall have occurred when each entrance and storefront assembly (each entrance and storefront wall) was tested in accordance with the ASTM E331 for one 15 minute cycle at a static pressure difference of 12 lbf/sq. ft. (600 Pa) minimum.

E. Thermal Movements: Fabricate the entrance and storefront work to accommodate for such expansion and contraction of component materials, and supporting elements, as will be caused by surface temperatures ranging from -5 to +180 deg F (-20.5 to +82 deg C), without causing buckling, glass breakage, failure of joint sealants, undue stress on metal members and fasteners, failure of doors or other operating units to function properly, reduction of performance, and other detrimental effects.

1. Dimensions shown on Drawings are based on an assumed design temperature of +70 deg F (+21 deg C). Fabrication and erection procedures shall take into account the ambient temperature range at the time of the respective operations.

F. Building Frame Movement: Design, fabricate and install aluminum entrances and storefronts to withstand building movements including thermal movements, loading deflections, shrinkage, creep and similar movements. Thermal movements shall be as specified above. Building frame deflections, shrinkage, creep and other movements are available from the structural engineer.

G. Condensation Resistance: Provide storefront systems with condensation resistance factor (CRF) of not less than 45 when tested according to AAMA 1503.1.

H. Average Thermal Conductance: Provide storefront systems with average U-values of not more than 0.63 Btu/sq. ft. x h x deg F (3.57 W/sq. m x K) when tested according to AAMA 1503.1.

I. Glass Statistical Factor: Glass thicknesses when shown on the Drawings, or specified, are for convenience of detailing only and are to be confirmed by the Contractor and/or glass manufacturer. All glass for the size openings shown will be provided in thicknesses such that the probability of breakage at the design "Wind Load" will not exceed 8 lights per 1000 lights (S.F. 2.5) based on a 60 second uniform wind load duration, and reflectance and shading indicated. The glass manufacturer shall provide, on request, substantiating glass breakage data if such data is not otherwise available as manufacturer's published data.

J. Design Modifications:

1. Submit design modifications necessary to meet the performance requirements and field coordination.
2. Variations in details or materials shall not adversely affect the appearance, durability or strength of components.
3. Maintain the general design concept without altering size of members, profiles and alignment.

2.2 MATERIALS

A.

B. Aluminum: Conform to the requirements published in AA "Aluminum Standards and Data," referenced ASTM standards and the following. All aluminum extrusions shall be manufactured to dimensional tolerances so as to eliminate any edge projection or misalignment at joints. Unless otherwise specified, provide alloy and temper as required to suit performance requirements and finish(es) indicated. Provide concealed extruded bars, rods, shapes and tubes in alloys as recommended by the fabricator to join or reinforce assembly of exposed aluminum components.

1. Alloys:

a. Sheet and Plate: Alloy 5005 and ASTM B 209 (ASTM B 209M), 'Anodizing Quality.'
b. Extruded Bars, Rods, Shapes, and Tubes: Alloy 6063 and ASTM B 221 (ASTM B 221M), 'Anodizing Quality.'

c. Bars, Rods, and Wire: ASTM B 211 (ASTM B 211M).

2. Welding Rods and Bare Electrodes: AWS A5.10.

C. Carbon Steel: For carbon steel components required to join, reinforce or support the assembly of aluminum components provide carbon steel conforming to ASTM A 36/A 36M for structural shapes, plates, and bars; ASTM A 1008/A 1008M for cold-rolled sheet and strip; or ASTM A 1011/A 1011M for hot-rolled sheet and strip.

D. Stainless Steel

1. Tubing: ASTM A 554, Grade MT 316 .
2. Pipe: ASTM A 312/A 312M, Grade TP 316 .
3. Castings: ASTM A 743/A 743M, Grade CF 8 M .
4. Plate: ASTM A 666, Type 316 .

E. Glass and Glazing Materials: As specified in Section 08 80 00 "Glazing."

F. Anchors and Fasteners:

1. Material: Stainless steel.
2. Anchor and Fastener Metal Alloy Types, Designations and Standards: Alloys as selected by fabricator to prevent corrosion resistance with the components fastened. Do not use self-drilling, self-tapping type fasteners.
3. Do not use exposed anchors and fasteners, except for hardware application. For hardware application, use countersunk Phillips flat-head machine screws finished to match framing members or hardware being fastened, unless otherwise indicated.
4. Where fasteners are subject to loosening or turn out from thermal and structural movements, wind loads, or vibration, use self-locking devices.

G. Concrete and Masonry Inserts: Hot-dip galvanized cast-iron, malleable-iron, or steel inserts complying with ASTM A 123 or ASTM A 153 requirements.

H. Concealed Flashing: Dead-soft, 0.018 inch (0.457 mm) thick stainless steel, complying with ASTM A 666, Type 304.

I. Weather Stripping: Manufacturer's standard replaceable weather stripping as follows:

1. Compression Weather Stripping: Molded neoprene complying with ASTM D 2000 requirements or molded PVC complying with ASTM D 2287 requirements.
2. Sliding Weather Stripping: Wool, polypropylene, or nylon woven pile with nylon-fabric or aluminum-strip backing complying with AAMA 701 requirements.

2.3 HARDWARE

A. General: Provide hardware As specified in Section 08 71 00 "Door Hardware.". Finish exposed parts per hardware schedule, unless otherwise indicated.

B. Provide Standard 12" long x 1" diameter door pulls.

C. Closers, General: Comply with manufacturer's recommendations for closer size, depending on door size, exposure to weather, and anticipated frequency of use.

1. Closing Cycle: Comply with requirements of authorities having jurisdiction or the Americans with Disabilities Act (ADA), "Accessibility Guidelines for Buildings and Facilities (ADAAG)," whichever are more stringent.
2. Opening Force: Comply with the following maximum opening-force requirements for locations indicated:

   a. Exterior Doors: 5 lbf (22.2 N)..
   b. Interior Doors: 5 lbf (22.2 N).

D. Center-Hung Concealed Floor Closers: Provide bottom arm, top pivot, cement cases, closer cover pans, extended spindles, and accessories required for a complete installation, and the following:

1.

2. Hold Open: Automatic, at angle selected by Architect from manufacturer's standard options.
3. Hold Open: Selective.
4. Hold Open: None.

2.4 SEALING MATERIALS

A. Concealed Sealing Materials: All sealing materials concealed within the entrances and storefronts shall be silicone, compatible with and adherent to each material it will be in contact with, as recommended by the manufacturer to fulfill performance requirements.

B. Exposed Sealing Materials: All sealing materials exposed at entrance and storefront perimeter joints in contact with adjacent cladding materials: 2 component silicone, refer to Section 07 92 00 "Joint Sealants."

2.5 FABRICATION

A. General: Fabricate the entrances and storefronts to the designs, shapes, and sizes shown using the materials specified and shown to produce assemblies that meet or exceed the performance requirements. To the greatest extent possible complete fabrication, assembly, finishing, hardware applications and other work before shipment to Project site.

1. Metal Wall Thickness: Provide shapes as shown and as required to suit the performance requirements but with wall thickness of not less than 1/8 inch (3 mm).
2. Door Stile and Rail Dimensions:

   a. Bottomrails: Provide minimum 10 inch (254 mm) high one piece bottomrail unless otherwise indicated on the Drawings.
   b. Stiles and Top Rail Dimensions: ~~: [Thin stile; less than 1-3/4 inches (44.5 mm) wide~~] Medium stile; 3-1/2 inch (88.9 mm) nominal width.
   c. Door Thickness: 1-3/4 inch (44.5 mm).
   d. Preglaze door units to greatest extent possible, in coordination with installation and hardware requirements. Glazing, whether in factory or in field, shall be performed in accordance with Section 08 80 00 "Glazing."
   e. Fabricate all doors and frames to accommodate the swing direction shown.

3. Provide extruded aluminum entrance door inserts at door frames designed with bosses sized to receive selected door gasket.

B. Provide continuous interior glazing stops with concealed fasteners for all doors and frames. Provide stops with hairline joints at corners. Provide stops with square, not beveled, shouldered profile unless otherwise shown.

C. Doors and frames shall be cut, reinforced, drilled and tapped in strict accordance with the printed door hardware manufacturer's templates and instructions. Provide solid stainless steel or bronze hardware reinforcements, securely fastened to doors and frames where door hardware is to be attached.

1. Security system components may be incorporated into the door and frame openings of all entrance doors and frames. Provide all cutouts required by the Owner's security system vendor and all prewiring for vendor provided security system devices. Wherever storefront and entrance framing components are to receive wiring provide unobstructed clear paths free of burrs and sharp objects with pull strings to facilitate wiring.

D. Joints in Metal Work: All exposed work shall be carefully fitted and matched to produce continuity of line and design, with all joints, being accurately fitted for hairline contact and rigidly secured. Where additional rigidity or strength is required to satisfy the performance requirements reinforce entrance components with aluminum or carbon steel shapes, bars, and plates.

E. Shop Assembly: As far as practicable, all fitting and assembly work shall be done in a fabrication shop.

1. For exterior entrances, provide weepholes and internal water passages in the glazing framing recesses as recommended by the respective glass and framing manufacturers to conduct infiltrating water to the exterior. Provide weep baffles secured to inside of frame behind weepholes.

F. Exposed Fasteners: Not permitted.

G. Protection of Metals: Wherever dissimilar metals are in contact, except in the case of aluminum in contact with galvanized steel, zinc, separate such surfaces with a coating of zinc rich primer, bituminous paint, or separation gaskets as the condition requires. Wherever aluminum comes in contact with concrete surfaces separate such surfaces with a coating of zinc rich primer, bituminous paint, or separation gaskets as the condition requires.

2.6 ALUMINUM FINISHES

A. General: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations relative to applying and designating finishes.

B. Finish Application:

1. Apply high performance organic coatings to all exposed exterior surfaces of storefront and entrance components. Apply thermosetting acrylic enamel coatings to all exposed interior surfaces of storefront and entrance components.
2. Apply anodized coatings to all exposed surfaces of storefront and entrance components.
3. Extent of Coating Types:

a. Anodic Coatings: Except for exposed surfaces of exterior (weathering side) snap on exterior caps, metal panels, column covers, and the exposed interior surfaces of the main entry lobby ground floor storefront, apply anodized coatings to all exposed interior surfaces of storefront and entrance components.

b. High Performance Organic Coating: Apply high performance organic coatings to all exposed surfaces of exterior (weathering side) snap on exterior caps, metal panels, column covers, and the exposed interior surfaces of the main entry lobby ground floor storefront.

C. Appearance of Finished Work: During production, maintain large size color range samples for use in comparing against production material. Variations in appearance of abutting or adjacent pieces are acceptable if they are within the range of approved samples. Noticeable variations in the same piece are not acceptable.

D. Finish designations prefixed by AA conform to the system established by the Aluminum Association for designating aluminum finishes.

E. Class II, Clear Anodic Finish: Complying with AA-M10C22A31 for an Architectural Class II finish and the following:

1. Metal Preparation and Pretreatment: Remove die markings prior to finishing operations. Perform this work in addition to the finish specified. Scratches, abrasions, dents and similar defects are unacceptable.
2. Thickness: Minimum 0.4 mil, weighing not less than 15.5 mg per sq. in., minimum apparent density of 38 g per cubic in.
3. Performance Criteria: Meets or exceeding AAMA 611.
4. Color: Medium matte finished, clear natural anodized.
5. Post Anodizing Finish (Sealing): Anodized finishes shall be fully sealed by the manufacturer or processor according to procedures recommended by the licensor of the process. Maximum weight loss shall be 2.6 mg/ sq. in.

F. Class I, Clear Anodic Finish: Complying with AA-M10C22A41 for an Architectural Class I finish and the following:

1. Metal Preparation and Pretreatment: Remove die markings prior to finishing operations. Perform this work in addition to the finish specified. Scratches, abrasions, dents and similar defects are unacceptable.
2. Thickness: Minimum 0.7 mil, weighing not less than 27.0 mg per sq. in., minimum apparent density of 38 g per cubic in.
3. Performance Criteria: Meets or exceeding AAMA 611.
4. Color: Medium matte finished, clear natural anodized.
5. Post Anodizing Finish (Sealing): Anodized finishes shall be fully sealed by the manufacturer or processor according to procedures recommended by the licensor of the process. Maximum weight loss shall be 2.6 mg/ sq. in.

G. Class II, Color Anodic Finish: Complying with AA-M12C22A32/A34 for an Architectural Class II finish and the following:

1. Metal Preparation and Pretreatment: Remove die markings prior to finishing operations. Perform this work in addition to the finish specified. Scratches, abrasions, dents and similar defects are unacceptable.
2. Thickness: Minimum 0.4 mil, weighing not less than 15.5 mg per sq. in., minimum apparent density of 38 g per cubic in.
3. Performance Criteria: Meets or exceeding AAMA 611.
4. Color: Medium matte finished, integrally colored or electrolytically deposited color anodized.
5. Post Anodizing Finish (Sealing): Anodized finishes shall be fully sealed by the manufacturer or processor according to procedures recommended by the licensor of the process. Maximum weight loss shall be 2.6 mg/ sq. in.

H. Class I, Color Anodic Finish: Complying with AA-M12C22A42/A44 for an Architectural Class I finish and the following:

1. Metal Preparation and Pretreatment: Remove die markings prior to finishing operations. Perform this work in addition to the finish specified. Scratches, abrasions, dents and similar defects are unacceptable.
2. Thickness: Minimum 0.7 mil, weighing not less than 27.0 mg per sq. in., minimum apparent density of 38 g per cubic in.
3. Performance Criteria: Meets or exceeding AAMA 611.
4. Color: Medium matte finished, integrally colored or electrolytically deposited color anodized.
5. Post Anodizing Finish (Sealing): Anodized finishes shall be fully sealed by the manufacturer or processor according to procedures recommended by the licensor of the process. Maximum weight loss shall be 2.6 mg/ sq. in.

I. High-Performance Organic Coating Finish: AA-C12C42R1x and the following:

1. Polyvinylidene fluoride finish coating containing not less than 70 percent of "ATO Atochem Kynar 500" or "Ausimont Hylar 5000" fluorocarbon resin specially formulated for spray application to extrusions and preformed aluminum metal shapes. Remove die markings, scratches, abrasions, dents and other blemishes before applying finish. Coating films shall be uniform and visibly free from flow lines, streaks, blisters, sags or other surface imperfections in the dry-film state on all surfaces.

   a. Metal Preparation and Pretreatment: Pretreatment of aluminum surface and application of the finish shall be performed under specifications issued by the licensed formulator to approved applicator and the following as a minimum:

      1) The products used to form the chemical conversion coating on aluminum extrusions shall conform to ASTM D1730, Type B, Method 5 (Amorphous Chromium Phosphate Treatment) or Method 7 (Amorphous Chromate Treatment).
      2) The coating weight of the chemical conversion coating shall be a minimum of 40 mg. per ft.^{2} on exposed surfaces as specified in ASTM B449, Section 6, Class I. Processing shall conform to that specified in ASTM B449, Section 5.

   b. Thickness:

      1) Fluoropolymer 2-Coat Coating System: Minimum 1.2 mil total dry film thickness (0.25 mil primer +/- 0.05 mil and 1.0 mil topcoat).
      2) Fluoropolymer 3-Coat Coating System: Minimum 1.6 mil total dry film thickness (0.25 mil primer +/- 0.05 mil and 1.35 mil topcoat).

   c. Coating Performance Criteria: Meets or exceeding AAMA 2605.
   d. Color: One custom color to be determined by Architect.
   e. Manufacturer, Coating System:

      1) Two Coat, Opaque System; one of the following:

         a) PPG Industries; Duranar.
         b) Valspar, Inc.; Fluropon Standard.

      2) Two Coat, Mica Flake System; one of the following:

         a) PPG Industries; Duranar Sunstorm.
         b) Valspar, Inc.; Fluropon Classic II.

3) Three Coat, Opaque System; one of the following:

a) PPG Industries; Duranar XL.
b) Valspar, Inc.; Fluropon Classic.

4) Three Coat, Metal Flake System; one of the following:

a) PPG Industries; Duranar XL.
b) Valspar, Inc.; Fluropon Classic.

J. Thermosetting Acrylic Enamel Coating: Complying with AAC12R1X and the following:

1. Thermosetting acrylic enamel finish coating containing not less than 50 percent of "ATO Atochem Kynar 500" or "Ausimont Hylar 5000" fluorocarbon resin specially formulated for spray application to extrusions and preformed aluminum metal shapes. Pretreatment of aluminum surface and application of the finish shall be performed under specifications issued by the licensed formulator to approved applicator. Remove die markings, scratches, abrasions, dents and other blemishes before applying finish. Coating films shall be uniform and free from flow lines, streaks, blisters, sags or other surface imperfections in the dry-film state on all surfaces.
2. Thickness: Minimum 1.0 mil total dry film thickness (+/- 0.2 mil).
3. Coating Performance Criteria: Meets or exceeding AAMA 2603.
4. Color: One custom color to be determined by Architect.
5. Manufacturer, Coating System: one of the following:

a. PPG Industries; Duracron or Polycron.
b. Valspar, Inc.; Acroflur.

2.7 COATINGS FOR CONCEALED METAL SURFACES

A. General: The following protective coatings shall be applied to surfaces of metals which are to be concealed in the construction:

1. Coating for Carbon Steel: Hot dip galvanized, complying with ASTM A123.
2. Coating for Aluminum, Carbon Steel, and Bronze: Where aluminum or carbon steel surfaces are to be in contact with each other or in contact with dissimilar materials such as masonry or concrete, and where hot dip galvanizing of carbon steel is incompatible with component parts because of galvanic action or component fabrication tolerances provide one of the following:

a. Bituminous Paint: Cold-applied, non-sagging, asphalt-mastic paint complying with SSPC-Paint 12 requirements, except containing no asbestos. Apply in two coats for an overall minimum dry film thickness of 25 mils.
b. Zinc Rich Primer: Organic zinc-rich primer, complying with SSPC-Paint 20.

2.8 FRAMING SYSTEMS

A. Framing System Gaskets and Sealants: Manufacturer's standard, recommended by manufacturer for joint type.

1. <u>Sealant shall have a VOC</u> content of 250 g/L or less.
2. <u>Sealant shall comply with the</u> testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.9 GLAZING SYSTEMS

A. Glazing Sealants: For structural-sealant-glazed systems, as recommended by manufacturer for joint type, and as follows:

1. Structural Sealant: ASTM C 1184, single-component neutral-curing silicone formulation that is compatible with system components with which it comes in contact, specifically formulated and tested for use as structural sealant and approved by a structural-sealant manufacturer for use in aluminum-framed systems indicated.

1. Sealant shall have a VOC content of 250 g/L or less.
2. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. Weatherseal Sealant: ASTM C 920 for Type S, Grade NS, Class 25, Uses NT, G, A, and O; single-component neutral-curing formulation that is compatible with structural sealant and other system components with which it comes in contact; recommended by structural-sealant, weatherseal-sealant, and aluminum-framed-system manufacturers for this use.

1. Sealant shall have a VOC content of 250 g/L or less.
2. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.10 ACCESSORY MATERIALS

A. Joint Sealants: For installation at perimeter of aluminum-framed systems, as specified in Section 07 92 00 "Joint Sealants."

PART 3 - EXECUTION

3.1 Factory glaze Aluminum Framed Storefront Systems to the extend possible.

3.2 PREPARATION

A. Coordinate entrance and storefront work with the work of other Sections and provide items to be placed during the installation of other work at the proper time to avoid delays in the work.

B. Templates and Diagrams: Furnish templates, diagrams, and other data to fabricators and installers of related work, as necessary for coordinating entrance and storefront installation.

C. Place such items, including concealed overhead framing, accurately in relation to the final location of entrance and storefront components.

3.3 EXAMINATION

A. Examine the substrates, adjoining construction, and conditions under which the Work is to be installed. Proceed with installation only after unsatisfactory conditions have been corrected.

1. Before beginning installation of the entrance and storefront work examine all parts of the existing building structural frame and the existing building cladding indicated to support the entrance and storefront work. Ensure that the existing swing door thresholds, existing swing doors, swing door framing and subframes have been completely removed with all projecting anchors cut off flush. Notify Contractor in writing, of any dimensions, or conditions, found which will prevent the proper execution of the entrance and storefront work, including specified tolerances. Use Contractor's offset lines and bench marks as basis of measurements.

3.4 INSTALLATION

A. General: Refer to Section 08 44 13 "Glazed Aluminum Curtain Walls."

B. General: Comply with manufacturer's written instructions for protecting, handling, and installing entrance and storefront systems. Do not install damaged components. Fit frame joints to produce hairline joints free of burrs and distortion. Rigidly secure nonmovement joints. Seal joints watertight. Clean excess joint sealants from finished surfaces.

1. Cut and trim component parts of the entrance and storefront work during erection only with the approval of the manufacturer or fabricator, and in accordance with his recommendations. Restore finish completely to protect material and remove all evidence of cutting and trimming. Remove and replace members where cutting and trimming has impaired strength or appearance, as directed by Architect.
2. Set components within the erection tolerances with uniform joints. Place components on shims and fasten to supporting substrates using bolts and similar fasteners. Use stainless steel shims at structural connections only. U shaped shims at structural connections are not permitted. Use aluminum, stainless steel, or high impact polystyrene shims at other connections.
3. Do not erect components that are warped, deformed, bowed, dented, defaced or otherwise damaged as to impair its strength or appearance. Remove and replace members damaged in the process of erection.
4. Coat concealed surfaces of dissimilar materials, and any ferrous metal components, with a heavy coating of bituminous paint, zinc rich primer or other separation in accordance with manufacturer's recommendations. Where aluminum components will contact concrete or masonry, protect against corrosion by painting contact surfaces with bituminous paint.
5. No holes or slots shall be burned, cut into, or field drilled in any building framing member without the written acceptance of the structural engineer.

C. Entrance and Storefront Framing: Install framing components plumb and true in alignment with established lines and grades without warp or rack of framing members.

D. Entrance Doors: Doors shall be securely anchored in place to a straight, plumb and level condition, without distortion. Adjust doors to provide a tight fit at contact points for weathertight closure and to operate smoothly, without binding, with hardware functioning properly. Weatherstripping contact, and hardware movement, shall be field tested and final adjustment, and lubrication, made for proper operation and performance of doors.

1. Door Hardware: Refer to Section 08 71 00 "Door Hardware."
2. Install surface-mounted hardware according to manufacturer's written instructions using concealed fasteners to greatest extent possible.
3. Set, seal, and grout floor closer cases as required to suit hardware and substrate indicated.
4. Set sill members in a bed of polyurethane sealant to provide weathertight construction. Comply with requirements of Section 07 92 00 "Joint Sealants."

E. Install glazing to comply with requirements of Section 08 80 00 "Glazing," unless otherwise indicated.

F. Install perimeter sealant to comply with requirements of Section 07 92 00 "Joint Sealants," unless otherwise indicated.

G. Concealed Sealing Components: Apply sealant and gasket components that are integral to the entrance and storefront systems in strict accordance with the each component manufacturer's printed instructions. Before applying components remove all mortar, dust, dirt, moisture, and other foreign matter that will be deleterious to the intended performance of the component. Mask adjoining exposed surfaces to avoid spilling, dripping, dropping or other unintended contact of the sealing components onto adjacent exposed surfaces.

3.5 ERECTION TOLERANCES

A. The entrance and storefront systems shall be fabricated and erected to accommodate the dimensional tolerances of the structural frame and surrounding cladding while providing the following as installed tolerances.

1. Variation from theoretical calculated position as located in plan or elevation in relation to established floors lines, column lines and other fixed elements of the structure, including variations from plumb, level, straight and member size: +/- 1/4 inch max in any 20'-0" (+/- 6 mm in any 6 m) run, column-to-column bay, or floor-to-floor height.
2. Alignment: Where surfaces abut in line, and where they meet at corners, limit offset from true alignment to 1/32 inch (.75 mm).
3. Variation from angle, or plumb, shown: +/- 1/8 inch max in any 10'-0" (+/- 3 mm in any 3 m) run or story height, non-cumulative.
4. Variation from slope, or level, shown: +/- 1/8 inch max in any 20'-0" (+/- 3 mm in any 6 m) run or column-to-column bay, non-cumulative.

3.6 ANCHORAGE

A. Anchorage of the entrance and storefront work to the structure and surrounding cladding shall be in accordance with the accepted shop drawings.

3.7 WELDING

A. Weld with electrodes and by methods recommended by manufacturer of material being welded, and in accordance with AWS D1.1 for concealed steel members.

B. Welds and adjacent metal areas shall be thoroughly cleaned and coated with a single coat of bituminous paint.

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified independent testing agency to perform field quality-control testing indicated. Conduct tests of each specified sample installation under the direction of the testing agency in the presence of the Owner, Architect, the Contractor, various component manufacturers and fabricators and the Installer for each system incorporated in the sample installation.

B. Water Spray Without Air Pressure Difference Test: After completing the installation of test areas indicated, but before the installation of interior finishes has begun, test storefront system for water penetration according to AAMA 501.2 requirements.

C. Repair or remove and replace Work that does not meet requirements or that is damaged by testing; replace to conform to specified requirements.

3.9 REMOVAL OF DEBRIS

A. All debris caused by, or incidental to, the erection of the entrance and storefront work shall be removed from the site and disposed of legally.

3.10 CLEANING

A. Clean metal surfaces promptly after installation, exercising care to avoid damage to factory finished exposed surfaces.

B. Wash glass on both faces not more than 4 days prior to date scheduled for inspections that establish date of Substantial Completion. Wash glass as recommended by glass manufacturer. Remove excess glazing and sealant compounds, dirt, and other substances.

C. Immediately remove any deleterious material from surfaces of aluminum.

3.11 PROTECTION

A. Institute protective measures required throughout the remainder of the construction period to ensure that entrance and storefront work will be without damage or deterioration, other than normal weathering, at time of acceptance.

END OF SECTION 08 4113

SECTION 08 4126

ALL-GLASS ENTRANCES AND STOREFRONTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes all-glass entrance and storefront systems.

1. Security system components may be incorporated into the door and frame openings of all glass entrances and storefronts at the Owner's option. Cooperate with the Owner's security system contractors if the Owner chooses to incorporate security system components during the course of the Work.
2. Single Subcontract Responsibilities: Refer to Section 01 83 16 "Exterior Cladding Design Criteria" for the requirements of single subcontract responsibilities for all glass entrances and storefronts.

B. Section includes all-glass entrance and storefront systems. The all glass entrance and storefront work includes the following:

1. All glass swing entrance doors and framing, including hardware, stripping and thresholds.
2. Metal trim, flashings, and similar items in conjunction with all glass entrance and storefronts.
3. Sealants, joint fillers, and gasketing systems for all glass entrances and storefronts.
4. Anchors, shims, fasteners, inserts, expansion devices, accessories, support brackets and attachments for all glass entrances and storefronts.
5. Glass and glazing for all glass entrances and storefronts.
6. Security system components may be incorporated into the door and frame openings of all glass entrance and storefront work at the Owner's option. Cooperate with the Owner's security system contractors if the Owner chooses to incorporate security system components during the course of the Work.

1.2 ACTION SUBMITTALS

A. Product Data: Submit manufacturer's specifications and installation instructions for each all glass entrance and storefront product specified.

B. CALgreen Submittals:

1. Product Data for Section 5.504.4.1: For sealants, adhesives and caulks, provide documentation including printed statement of VOC content showing compliance with SCAQMD Rule 1168 VOC limits and CCR Title 17 for aerosols.

C. Shop Drawings: Submit shop drawings showing scaled elevations, plans, and sections of the all glass entrance and storefront work. Full scale sections shall be prepared and submitted for details of the assemblies that cannot be shown in the elevations or sections. Include with shop drawings metal thickness of all metal components, glass thicknesses, metal finishes, details of fittings, and all other pertinent information as necessary or requested by the Architect to indicate compliance with the Contract Documents. Details of field connections, anchorage, and their relationship to the work of others shall be clearly indicated for the coordination of the work by other building trades. Details of fastening and sealing methods and product joinery shall be shown to ensure proper performance of the field installation. No work shall be fabricated until shop drawings for that work have been approved by Architect for fabrication.

1. Show direction of satin finish for each component receiving a directional finish.

D. Samples: Submit samples of the following before any work is fabricated:

1. 3 paired sets of samples for each exposed metal finish required. Sample finishes shall be on the specified alloy, temper, and thickness of metal required for the work. Where finishes involve color and texture variations, include sample sets showing the full range of variations expected. Furnish samples in either 12 inch (300 mm) lengths of patch fittings, rails, or 12 inch (300 mm) squares of sheet.
2. Glass: 6 inches (150 mm) square, showing exposed-edge finish.

1.3 INFORMATIONAL SUBMITTALS

A. Structural Calculations: Submit, for information only, copies of structural calculations indicating complete compliance with the specified performance requirements. Calculations shall be prepared, signed and sealed by a Professional Engineer registered in the state wherein the work is to be erected.

B. Product Test Reports: Submit certified product test reports based on tests performed by an AAMA Accredited Laboratory clearly describing in written form, and in shop drawing form, compliance of each all glass entrance and storefront assembly (each swinging and sliding door) with requirements indicated based on comprehensive testing.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Instructions: Submit copies of manufacturer's written instructions for adjustment, operation and maintenance of swinging doors.

1.5 QUALITY ASSURANCE

A. Award the fabrication of all glass entrance and storefront door and frame components to a single firm specializing in the fabrication of all glass entrance and storefront components who has successfully produced work similar in design and extent to that required for the project, in not less than three projects of similar scope to the satisfaction of the Architect, and whose work has resulted in construction with a record of successful in-service performance for a period of 5 years. The fabricator shall have sufficient production capacity, have organized quality control and testing procedures, and published written and illustrated installation manuals, to produce and properly install the entrance assemblies required without causing delay in progress of the Work.

1. Welding Standards: Welding shall be performed by skilled and qualified mechanics. Welding shall be performed in accordance with the applicable provisions of AWS D1.1 "Structural Welding Code - Steel" and AWS D1.2, "Structural Welding Code--Aluminum."

B. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Section 01 31 00 "Project Management and Coordination." Prior to the start of the all glass entrance and storefront work, and at the Contractor's direction, meet at the site and review the installation procedures and coordination with other work. Meeting shall include Contractor, Owner, all glass entrance and storefront installer, sealant installer, as well as any other subcontractors or material technical service representatives whose work, or products, must be coordinated with the all glass entrance and storefront work.

1.6 DELIVERY, STORAGE, AND HANDLING

A. General: Refer to Section 08 92 50 "Structural Glass Wall System."

1.7 PROJECT CONDITIONS

A. Field Measurements: Verify dimensions of supporting structure by field measurements before fabrication so that the entrance and storefront work will be accurately designed, fabricated and fitted to the structure. Indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work. Use Contractor's lines and benchmarks as a basis for measurements.

1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating entrance and storefront work without field measurements. Coordinate supporting structure construction to ensure that actual dimensions correspond to established dimensions.

1.8 WARRANTY

A. General: Refer to Section 08 92 50 "Structural Glass Wall System."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General: Refer to Section 01 83 16 “Exterior Cladding Design Criteria” for performance requirements, fabrication and erection standards; in addition provide the following:

1. Design and fabricate all glass entrances to withstand the operating loads which result from heavy traffic conditions using the specified hardware, without measurable permanent deflection. Limit elastic deflections so as to provide the normal degree of rigidity required to avoid glass breakage, air leaks and other objectionable results of excessive flexibility. Provide weatherstripping at stiles, sill and head rails of door leaves, to minimize air, water and sound leaks.

2.2 MATERIALS

A. Aluminum: AA Alloy 6063 and ASTM B 221 (ASTM B 221M), 'Anodizing Quality,' with tempering as required to suit performance requirements and finishes specified.

1. Stainless-Steel Cladding: ASTM A 666, Type 316.

   a. Surface Texture and Color: Use only materials which are smooth and free of surface blemishes, including, but not limited to, pitting, seam marks, roller marks, rolled trade names and roughness. Do not use materials which have stains and discolorations which do not match the Architect's sample in color and grain characteristics.
   b. Surface Flatness and Edges: Provide materials which have been cold-rolled, cold-finished, cold-drawn, stretcher leveled, machine cut and otherwise produced to the highest commercial standard for flatness with edges and corners sharp and true to angle, as required.

c. Tempers: Fabricate from standard commercial tempers and hardnesses, as required for forming, fabrication, strength and durability and which will finish to match the Architect's sample.

B. Stainless-Steel: ASTM A 666, Type 316 for plate and flat bar and ASTM A 276, Type 316 for bars and shapes.

1. Surface Texture and Color: Use only materials which are smooth and free of surface blemishes, including, but not limited to, pitting, seam marks, roller marks, rolled trade names and roughness. Do not use materials which have stains and discolorations which do not match the Architect's sample in color and grain characteristics.
2. Surface Flatness and Edges: Provide materials which have been cold-rolled, cold-finished, cold-drawn, stretcher leveled, machine cut and otherwise produced to the highest commercial standard for flatness with edges and corners sharp and true to angle, as required.
3. Tempers: Fabricate from standard commercial tempers and hardnesses, as required for forming, fabrication, strength and durability and which will finish to match the Architect's sample.

2.3 COMPONENTS

A. Glass Entrances and Sidelights: Provide and extruded aluminum retained, glass and metal framing system fabricated and finished to suit the conditions indicated and specified. System shall be complete with all aluminum framing members, fasteners, anchors, gaskets, washers, glass and glazing components. All aluminum members shall be finished as specified under Article 2.5 'Aluminum Finishes.' Verify availability of stainless steel fittings made from solid, not clad, stainless steel stock.

B. Floating Transom Bar: Steel, clad in metal matching fittings and in size indicated or, if not indicated, in size recommended by manufacturer for application indicated.

1. Adhesively laminate or mechanically clad base metal members, returning cladding around extrusions to eliminate exposed edges.

C. Rails:

1. Material: Stainless-steel-clad aluminum.

   a. Adhesively laminate or mechanically clad base metal members, returning cladding around extrusions to eliminate exposed edges.

2. Height: As indicated.
3. Style: As indicated.
4. Locations: As indicated.

D. Accessory Fittings: Match rail metal and finish.

1. Adhesively laminate or mechanically clad base metal members, returning cladding around extrusions to eliminate exposed edges.

E. Anchors, Fastenings, Stiffener End Cap Pins and Plugs, Friction Coupling Assemblies:

1. Material: Stainless steel.
2. Anchor and Fastener Metal Alloy Types, Designations and Standards: Alloys as selected by fabricator to prevent corrosion resistance with the components fastened. Do not use self-drilling, self-tapping type fasteners.

F. Weather Stripping: Sweep type.

G. Spacers, Setting Blocks, Gaskets: Permanent, nonmigrating types of material and in hardness recommended by all glass storefront and entrance manufacturer and complying with the performance requirements.

H. Slip and Separator Gaskets:

1. Bolted Slip-Joints: Non-metallic, low friction material bearing temperature and moisture resistances and low abrasion properties as required to suit performance criteria.
2. Non-Bolted Slip-Joints: Non-corrosive, non-toxic impregnated felt, or butyl, tape with a pressure sensitive adhesive on one surface which is formulated for proper adhesion to metals shown; gasket shall bear temperature and moisture resistance properties as required to suit performance criteria; thickness and width as required.

I. Adhesives and Epoxies: As required for laminating cladding to base components.

2.4 GLAZING

A. Reference Section 08 80 00 "Exterior Glass and Glazing".

2.5 HARDWARE

A. Reference Division 8 Hardware Sections.

2.6 FABRICATION

A. General: Fabricate the entrances and storefronts to the designs, shapes, and sizes shown using the materials, and components, specified and shown to produce assemblies which meet or exceed the performance requirements. To the greatest extent possible complete fabrication, assembly, finishing, hardware applications and other work before shipment to Project site.

B. Provide holes and cutouts in glass to receive hardware, fittings, rails, and accessories before tempering glass. Do not cut, drill, or make other alterations to glass after tempering.

1. Fully temper glass using horizontal (roller-hearth) process and fabricate so, when installed, roll-wave distortion is parallel with bottom edge of door or lite.
2. Factory assemble components and factory install hardware to greatest extent possible.

C. Fabricate all entrances to accommodate the swing direction shown.

D. Metal components of entrances and storefronts shall be cut, reinforced, drilled and tapped in strict accordance with the printed door hardware manufacturer's templates and instructions. Provide solid stainless steel or bronze hardware reinforcements, securely fastened to doors and frames where door hardware is to be attached.

1. Security system components may be incorporated into the door and frame openings of all entrance doors and frames. Provide all cutouts required by the Owner's security system vendor and all prewiring for vendor provided security system devices. Wherever storefront and entrance framing components are to receive wiring provide unobstructed clear paths free of burrs and sharp objects with pull strings to facilitate wiring.

E. Joints in Metal Work: All exposed metal work shall be carefully fitted and matched to produce continuity of line and design, with all joints, being accurately fitted for hairline contact and rigidly secured. Where additional rigidity or strength is required to satisfy the performance requirements reinforce entrance components with aluminum or carbon steel shapes, bars, and plates.

F. Shop Assembly: As far as practicable, all fitting and assembly work shall be done in a fabrication shop.

1. For exterior entrances, provide weepholes and internal water passages in the glazing framing recesses as recommended by the respective glass and framing manufacturers to conduct infiltrating water to the exterior. Provide weep baffles secured to inside of frame behind weepholes.

G. Exposed Fasteners: Not permitted.

H. Protection of Metals: Wherever dissimilar metals are in contact, except in the case of aluminum in contact with galvanized steel, zinc, separate such surfaces with a coating of zinc rich primer, bituminous paint, or separation gaskets as the condition requires. Wherever aluminum comes in contact with concrete surfaces separate such surfaces with a coating of zinc rich primer, bituminous paint, or separation gaskets as the condition requires.

2.7 STAINLESS-STEEL FINISHES

A. General: Remove tool and die marks and stretch lines or blend into finish. Grind and polish surfaces to produce uniform, texture, graining and reflectivity matching Architect's sample.

1. Stainless-Steel Finish: NAAMM No. 4, bright, directional polish matching Architect's sample.
2. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Refer to Section 08 92 50 "Structural Glass Wall System."

END OF SECTION 08 4126

SECTION 08 7100
DOOR HARDWARE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Door hardware, including electric hardware.
2. Storefront and entrance door hardware.
3. Third-party inspection report for fire-rated door assemblies.
4. Wall-mounted electromagnetic hold-open devices.
5. Low energy door operators and actuators.
6. Padlocks.

B. Related Divisions:

1. Division 06 – door hardware installation
2. Division 07 – sealant at exterior thresholds
3. Division 08 – metal doors and frames, interior aluminum frames, wood doors, integrated security systems, specialty doors, storefront and glazed curtainwall systems.
4. Division 10 – operable partitions
5. Division 21 – fire and life safety systems

C. Specific Omissions: Hardware for the following is specified or indicated elsewhere.

1. Windows.
2. Cabinets, including open wall shelving and locks.
3. Signs
4. Toilet accessories, including grab bars.
5. Installation.
6. Rough hardware.
7. Conduit, junction boxes & wiring.
8. Folding partitions.

1.2 REFERENCES:

A. Use date of standard in effect as of Bid date.

1. American National Standards Institute
   a) ANSI 156.18 – Materials and Finishes.
   b) ICC/ANSI A117.1 - 1998 – Specifications for making buildings and facilities usable by physically handicapped people. [omit for CA work – not applicable]
2. BHMA – Builders Hardware Manufacturers Association
3. 2014 California Building Code
   a) Chapter 11B – Accessibility To Public Buildings, Public Accommodations, Commercial Buildings and Public Housing
4. DHI – Door and Hardware Institute
5. NFPA – National Fire Protection Association
   a) NFPA 80 2013 Edition – Standard for Fire Doors and Other Opening Protectives.
   b) NFPA 105 – Smoke and Draft Control Door Assemblies
   c) NFPA 252 – Fire Tests of Door Assemblies

6. UL – Underwriters Laboratories
    a) UL10C – Positive Pressure Fire Tests of Door Assemblies.
    b) UL 305 – Panic Hardware
7. WHI – Warnock Hersey Incorporated State of California Building Code
8. Local applicable codes
9. SDI – Steel Door Institute
10. WI – Woodwork Institute
11. AWI – Architectural Woodwork Institute
12. NAAMM – National Association of Architectural Metal Manufacturers

B. Abbreviations

1. Manufacturers: see table at 2.1.A of this section
2. Finishes: see 2.7 of this section.

1.3 SUBMITTALS & SUBSTITUTIONS

A. SUBMITTALS: Submit six copies of schedule per D. Only submittals printed one sided will be accepted and reviewed. Organize vertically formatted schedule into "Hardware Sets" with index of doors and headings, indicating complete designations of every item required for each door or opening. Minimum 10pt font size. Include following information:

1. Type, style, function, size, quantity and finish of hardware items.
2. Use BHMA Finish codes per ANSI A156.18.
3. Name, part number and manufacturer of each item.
4. Fastenings and other pertinent information.
5. Location of hardware set coordinated with floor plans and door schedule.
6. Explanation of abbreviations, symbols, and codes contained in schedule.
7. Mounting locations for hardware.
8. Door and frame sizes, materials and degrees of swing.
9. List of manufacturers used and their nearest representative with address and phone number.
10. Catalog cuts.
11. Point-to-point wiring diagrams.
12. Manufacturer's technical data and installation instructions for electronic hardware.

B. Bid and submit manufacturer's updated/improved item if scheduled item is discontinued.

C. Deviations: Highlight, encircle or otherwise identify deviations from "Schedule of Finish Hardware" on submittal with notations clearly designating those portions as deviating from this section.

D. If discrepancy between drawings and scheduled material in this section, bid the more expensive of the two choices, note the discrepancy in the submittal and request direction from Architect for resolution.

E. Substitutions per Division 1. Include product data and indicate benefit to the Project. Furnish operating samples on request.

F. Furnish as-built/as-installed schedule with closeout documents, including keying schedule, riser and point-to-point wiring diagrams, manufacturers' installation, adjustment and maintenance information, and supplier's final inspection report.

1.4 QUALITY ASSURANCE:

A. Qualifications:

1. Hardware supplier: direct factory contract supplier who employs a certified architectural hardware consultant (AHC), available at reasonable times during course of work for project hardware consultation to Owner, Architect and Contractor.
    a) Responsible for detailing, scheduling and ordering of finish hardware. Detailing implies that the submitted schedule of hardware is correct and complete for the intended function and performance of the openings.

B. Hardware: Free of defects, blemishes and excessive play. Obtain each kind of hardware (latch and locksets, exit devices, hinges and closers) from one manufacturer.

C. Exit Doors: Operable from inside with single motion without the use of a key or special knowledge or effort.

D. Fire-Rated Openings: NFPA 80 compliant. Hardware UL10C (positive pressure) compliant for given type/size opening and degree of label. Provide proper latching hardware, non-flaming door closers, approved-bearing hinges, and resilient seals. Coordinate with wood door section for required intumescent seals. Furnish openings complete.

E. Furnish hardware items required to complete the work in accordance with specified performance level and design intent, complying with manufacturers' instructions and code requirements.

F. Pre-Installation Meetings: Initiate and conduct with supplier, installer and related trades, coordinate materials and techniques, and sequence complex hardware items and systems installation. Include manufacturers' representatives of locks, panic hardware and door closers in the meetings. Convene prior to commencement of related work.

1.5 DELIVERY, STORAGE AND HANDLING:

A. Delivery: coordinate delivery to appropriate locations (shop or field).
    1. Permanent keys and cores: secured delivery direct to Owner's representative.

B. Acceptance at Site: Items individually packaged in manufacturers' original containers, complete with proper fasteners and related pieces. Clearly mark packages to indicate contents, locations in hardware schedule and door numbers.

C. Storage: Provide securely locked storage area for hardware, protect from moisture, sunlight, paint, chemicals, dust, excessive heat and cold, etc.

1.6 PROJECT CONDITIONS AND COORDINATION:

A. Where exact types of hardware specified are not adaptable to finished shape or size of members requiring hardware, provide suitable types having as nearly as practical the same operation and quality as type specified, subject to Architect's approval.

B. Coordination: Coordinate hardware with other work. Furnish hardware items of proper design for use on doors and frames of the thickness, profile, swing, security and similar requirements indicated, as necessary for proper installation and function, regardless of omissions or conflicts in the information on the Contract Documents. Furnish related trades with the following information:
    1. Location of embedded and attached items to concrete.
    2. Location of wall-mounted hardware, including wall stops.
    3. Location of finish floor materials and floor-mounted hardware.
    4. At masonry construction, coordinate with the anchoring and hollow metal supplier prior to frame installation by placing a strip of insulation, wood, or foam, on the back of the hollow metal frame behind the rabbet section for continuous hinges, as well as at rim panic hardware strike locations, silencers, coordinators, and door closer arm locations. When the frame is grouted in place, the backing will allow drilling and tapping without dulling or breaking the installer's bits.

5. Locations for conduit and raceways as needed for electrical, electronic and electro-pneumatic hardware items. Fire/life-safety system interfacing. Point-to-point wiring diagrams plus riser diagrams to related trades.
6. Coordinate: low-voltage power supply locations.
7. Coordinate: back-up power for doors with automatic operators.
8. Coordinate: flush top rails of doors at outswinging exteriors, and throughout where adhesive-mounted seals occur.
9. Manufacturers' templates to door and frame fabricators.

C. Check Shop Drawings for doors and entrances to confirm that adequate provisions will be made for proper hardware installation.

D. Environmental considerations: segregate unused recyclable paper and paper product packaging, uninstalled metals, and plastics, and have these sent to a recycling center.

1.7 WARRANTY:

A. Part of respective manufacturers' regular terms of sale. Provide manufacturers' written warranties.

B. Include factory order numbers with close-out documents to validate warranty information, required for Owner in making future warranty claims:

C. Minimum warranties:

1.	Locksets:	Three years
2.	Exit Devices:	Three years
3.	Closers:	Thirty years
4.	Hinges:	One year
5.	Other Hardware	Two years

1.8 COMMISSIONING:

A. Conduct these tests prior to request for certificate of substantial completion:

1. With installer present, test door hardware operation with climate control system at rest and while in full operation.
2. With installer and electrical contractor present, test hardware interfaced with fire/life-safety system for proper operation and release.

PART 2 PRODUCTS

2.1 MANUFACTURERS:

A. Listed acceptable alternate manufacturers: these will be considered; submit for review products with equivalent function and features of scheduled products.

ITEM:	MANUFACTURER:	ACCEPTABLE ALTERNATE:
Hinges	(IVE) Ives	Bommer, Stanley
Continuous Hinges	(IVE) Ives	Select, Markar
Floor Closers	(RIX) Rixson	Dorma
Key System	(SCH) Schlage	Best
Mechanical Locks	(SCH) Schlage	Best
Exit Devices	(VON) Von Duprin	Sargent, Falcon
Closers	(LCN) LCN	Sargent, Falcon
Auto Flush Bolts	(IVE) Ives	DCI, Trimco
Coordinators	(IVE) Ives	DCI, Trimco
Silencers	(IVE) Ives	Rockwood, Trimco
Kickplates	(IVE) Ives	Rockwood, Trimco
Stops & Holders	(IVE) Ives	Rockwood, Trimco
Overhead Stops	(GLY) Glynn-Johnson	ABH
Thresholds	(ZER) Zero	NGP, Reese, Pemko
Seals & Bottoms	(ZER) Zero	NGP, Reese, Pemko
Key Cabinets	(LUN) Lund	TelKee
Aluminum Door Locks	(ADA) Adams Rite	None

2.2 HINGING METHODS:

A. Drawings typically depict doors at 90 degrees, doors will actually swing to maximum allowable. Use wide-throw conventional or continuous hinges as needed up to 8 inches in width to allow door to stand parallel to wall for true 180-degree opening. Advise architect if 8-inch width is insufficient.

B. Conform to manufacturer's published hinge selection standard for door dimensions, weight and frequency, and to hinge selection as scheduled. Where manufacturer's standard exceeds the scheduled product, furnish the heavier of the two choices, notify Architect of deviation from scheduled hardware.

C. Conventional Hinges: Steel or stainless steel pins and approved bearings. Hinge open widths minimum, but of sufficient throw to permit maximum door swing.

1. Outswinging exterior doors: non-ferrous with non-removable (NRP) pins.

D. Continuous Hinges:

1. Pinned steel/stainless steel type: continuous stainless steel, 0.25-inch diameter stainless-steel hinge pin.

a) Use engineered application-specific wide-throw units as needed to provide maximum swing degree of swing, advise architect if required width exceeds 8 inches.

E. Pivots: high-strength forged bronze or stainless steel, tilt-on precision bearing and bearing pin.

1. Bottom and intermediate pivots: adjustability of minus 0.063 inch, plus 0.125 inch.

F. Floor Closers: hydraulically controlled, cement case, maximum degree dead stop permitted by trim or adjacent structure. Special pins, floor pans and longer spindles when needed to accommodate floor and jamb conditions.

2.3 LOCKSETS, LATCHSETS, DEADBOLTS:

A. Mortise Locksets and Latchsets: as scheduled.

1. Chassis: cold-rolled steel, handing field-changeable without disassembly.
2. Universal lock case – 10 functions in one case.
3. Floating mounting tabs automatically adjusts to fit a beveled door edge.
4. Latchbolts: 0.75 inch throw stainless steel anti-friction type.
5. Lever Trim: through-bolted, accessible design, cast lever or solid extruded bar type levers as scheduled. Filled hollow tube design unacceptable.

a) Spindles: security design independent breakaway. Breakage of outside lever does not allow access to inside lever's hubworks to gain wrongful entry.
b) Inside lever applied by screwless shank mounting – no exposed trim mount screws.
c) Levers rotate up or down for ease of use.

6. Furnish solid cylinder collars with wave springs. Wall of collar to cover rim of mortise cylinder.
7. Turnpieces: accessible offset turn-lever design not requiring pinching or twisting motions to operate.
8. Deadbolts: stainless steel 1-inch throw.
9. Electric operation: Manufacturer-installed continuous duty solenoid.
10. Strikes: 16 gage curved steel, bronze or brass with 1 inch deep box construction, lips of sufficient length to clear trim and protect clothing.
11. Scheduled Lock Series and Design: Schlage L series, Longitude (LON) design.
12. Certifications:

a) ANSI A156.13, 1994, Grade 1 Operational, Grade 2.
b) ANSI/ASTM F476-84 Grade 31 UL Listed.

13. Accessibility: Require not more than 5 lb to retract the latchbolt or deadbolt, or both, per CBC 2013 11B-404.2.7 and 11B-309.4.

2.4 EXIT DEVICES / PANIC HARDWARE

A. General features:

1. Independent lab-tested 1,000,000 cycles.

2. Push-through push-pad design. No exposed push-pad fasteners, no exposed cavities when operated. Return stroke fluid dampeners and rubber bottoming dampeners, plus anti-rattle devices.
3. Deadlocking latchbolts, 0.75 inch projection.
4. End caps: impact-resistant, flush-mounted. No raised edges or lips to catch carts or other equipment.
5. No exposed screws to show through glass doors.
6. Non-handed basic device design with center case interchangeable with all functions, no extra parts required to effect change of function.
7. Releasable in normal operation with 15-pound maximum operating force per UBC Standard 10-4, and with 32-pound maximum pressure under 250-pound load to the door.
8. Accessibility: Require not more than 5 lb to retract the latchbolt, per CBC 2013 11B-404.2.7 and 11B-309.4.

   a) Mechanical method: Von Duprin "AX-" feature, where touchpad directly retracts the latchbolt with 5 lb or less of force. Provide testing lab certification confirming that the mechanical device is independent third-party tested to meet this 5 lb requirement.

B. Specific features:

1. Lever Trim: breakaway type, forged brass or bronze escutcheon min. 0.130 inch thickness, compression spring drive, match lockset lever design.
2. Fire-Labeled Devices: UL label indicating "Fire Exit Hardware". Vertical rod devices less bottom rod (LBR) unless otherwise scheduled.

2.5 CLOSERS

A. Surface Closers:

1. Full rack-and-pinion type cylinder with removable non-ferrous cover and cast iron body. Double heat-treated pinion shaft, single piece forged piston, chrome-silicon steel spring.
1. ISO 2000 certified. Units stamped with date-of-manufacture code.
2. Independent lab-tested 10,000,000 cycles.
3. Non-sized and adjustable. Place closers inside building, stairs and rooms.
4. Plates, brackets and special templating when needed for interface with particular header, door and wall conditions and neighboring hardware.
5. Advanced Variable Backcheck (AVB): where scheduled, these units commence backcheck at approximately 45 degrees.
6. Adjust doors to open with not more than 5.0-pounds pressure to open at exterior doors and 5.0-pounds at interior doors. As allowed per 2013 California Building Code Section 11B-404.2.9, local authority may increase the allowable pressure for fire doors to achieve positive latching, but not to exceed 15-pounds.

   a) Exception: exterior doors' pressure-to-open may be increased to 8.5-pounds if: at a single location, and one of a bank of eight leafs or fraction of eight, and one leaf of this bank is fitted with a low- or high-energy operator.

7. Separate adjusting valves for closing speed, latching speed and backcheck, fourth valve for delayed action where scheduled.
8. Extra-duty arms (EDA) at exterior doors scheduled with parallel arm units. EDA arms: rigid main and forearm, reinforced elbow.
9. Exterior door closers: tested to 100 hours of ASTM B117 salt spray test, furnish data on request.
10. Exterior doors: seasonal adjustments not required for temperatures form 120 degrees F to -30 degrees F, furnish checking fluid data on request.
11. Non-flaming fluid, will not fuel door or floor covering fires.
12. Pressure Relief Valves (PRV) not permitted.

B. Floor Closers: See 2.2: HINGING METHODS.

C. Overhead Concealed Closers: Power transmitted to door separately from hanging means. Closer spindle does not support the door. Cast iron cylinders with hydraulically checked rack and pinion construction and single piece forged pistons. Separate non-critical sweep and latch speed valves.

1. (2030) concealable in 1-3/4inch x 4inch tube, forged single-lever arm & extruded track power transmission, concealed-in-track bumpers where scheduled.

2.6 OTHER HARDWARE

A. Automatic Flush Bolts: Low operating force design.

B. Overhead Stops: Non-plastic mechanisms and finished metal end caps. Field-changeable hold-open, friction and stop-only functions.

C. Kick Plates: Four beveled edges, .050 inches minimum thickness, height and width as scheduled. Sheet-metal screws of bronze or stainless steel to match other hardware.

D. Door Stops: Provide stops to protect walls, casework or other hardware.

1. Unless otherwise noted in Hardware Sets, provide floor type with appropriate fasteners. Where floor type cannot be used, provide wall type. If neither can be used, provide overhead type.
2. Locate overhead stops for maximum possible opening. Consult with Owner for furniture locations. Minimum: 90deg stop / 95deg deadstop. Note degree of opening in submittal.

E. Thresholds: As scheduled and per details. Comply with CBC 2013 11B-404.2.5. Substitute products: certify that the products equal or exceed specified material's thickness. Proposed substitutions: submit for approval.

1. Saddle thresholds: 0.125 inches minimum thickness.
2. Exteriors: Seal perimeter to exclude water and vermin. Use sealant complying with requirements in Division 7 "Thermal and Moisture Protection". Minimum 0.25 inch diameter fasteners and lead expansion shield anchors, or Red-Head #SFS-1420 (or approved equivalent) Flat Head Sleeve Anchors..
3. Fire-rated openings, 90-minutes or less duration: use thresholds to interrupt floor covering material under the door where that material has a critical radiant flux value less than 0.22 watts per square centimeter, per NFPA 253. Use threshold unit as scheduled. If none scheduled, include a 0.25in high 5in wide saddle in the bid, and request direction from Architect.
4. Acoustic openings: Set units in full bed of Division-7-compliant, leave no air space between threshold and substrate.
5. Plastic plugs with wood or sheet metal screws are not an acceptable substitute for specified fastening methods.
6. Fasteners: Generally, exposed screws to be Phillips or Robertson drive. Pinned TORX drive at high security areas. Flat head sleeve anchors (FHSL) may be slotted drive. Sheet metal and wood screws: full-thread. Sleeve nuts: full length to prevent door compression.

F. Through-bolts: Do not use. Coordinate with wood doors; ensure provision of proper blocking to support wood screws for mounting panic hardware and door closers. Coordinate with metal doors and frames; ensure provision of proper reinforcement to support machine screws for mounting panic hardware and door closers.

1. Exception: surface-mounted overhead stops, holders, and friction stays.

G. Silencers: Interior hollow metal frames, 3 for single doors, 4 for pairs of doors. Leave no unfilled/uncovered pre-punched silencer holes. Intent: door bears against silencers, seals make minimal contact with minimal compression – only enough to effect a seal.

H. Wall- & Floor-mounted electromagnetic door holders: LCN's SEM series or approved equivalent. Incorporate into U.L. listed fire & life-safety system, doors release to allow closure and latching when door's zone is in alarm state. Use minimum projection required to allow door to open as widely as allowed by wall conditions and projection of door hardware.

2.7 FINISH:

A. Generally: BHMA 626 Satin Chromium.

1. Areas using BHMA 626: furnish push-plates, pulls and protection plates of BHMA 630, Satin Stainless Steel, unless otherwise scheduled.

B. Door closers: factory powder coated to match other hardware, unless otherwise noted.

2.8 KEYING REQUIREMENTS:

A. Key System: Schlage Everest 29 utility-patented keyway, interchangeable core. Utility patent protection to extend at least until 2029. Key blanks available only from factory-direct sources, not available from after-market key blank manufacturers. For estimate use factory GMK charge. Initiate and conduct meeting(s) with Owner and I-R Security & Safety Consultants representatives to determine system keyway(s), keybow styles, structure and degree of geographic exclusivity. Furnish Owner's written approval of the system; do not order keys or cylinders without written confirmation of actual requirements from the Owner. Contractor will install permanent cylinders/cores.

B. Keys

1. New factory registered master key system.
2. Construction keying: furnish temporary keyed-alike cores. Remove at substantial completion and install permanent cylinders/cores in Owner's presence. Demonstrate that construction key no longer operates.
3. Furnish 10 construction keys.
4. Furnish 2 construction control keys.

C. Key Cylinders: furnish utility patented, 6-pin solid brass construction.

D. Cylinder cores: furnish keyed at factory of lock manufacturer where permanent records are maintained. Locks and cylinders same manufacturer.

E. Permanent keys: use secured shipment direct from point of origination to Owner.

1. For estimate: 3 keys per change combination, 5 master keys per group, 5 grand-master keys, 3 control keys.
2. For estimate: VKC stamping plus "DO NOT DUPLICATE".
3. Bitting List: use secured shipment direct from point of origination to Owner upon completion.

PART 3 - EXECUTION

3.1 ACCEPTABLE INSTALLERS:

A. Can read and understand manufacturers' templates, suppliers' hardware schedule and printed installation instructions. Can readily distinguish drywall screws from manufacturers' furnished fasteners. Available to meet with manufacturers' representatives and related trades to discuss installation of hardware.

3.2 PREPARATION:

A. Ensure that walls and frames are square and plumb before hardware installation. Make corrections before commencing hardware installation. Installation denotes acceptance of wall/frame condition.

B. Locate hardware per SDI-100 and applicable building, fire, life-safety, accessibility, and security codes.

1. Notify Architect of code conflicts before ordering material.
1. Locate latching hardware between 34 inches to 44 inches above the finished floor, per California Building Code, Section 1008.1.9.2 and 11B-404.2.7.
2. Locate panic hardware between 36 inches to 44 inches above the finished floor.
3. Where new hardware is to be installed near existing doors/hardware scheduled to remain, match locations of existing hardware.

C. Overhead stops: before installing, determine proposed locations of furniture items, fixtures, and other items to be protected by the overhead stop's action.

3.3 INSTALLATION

A. Install hardware per manufacturer's instructions and recommendations. Do not install surface-mounted items until finishes have been completed on substrate. Set units level, plumb and true to line and location. Adjust and reinforce attachment substrate for proper installation and operation. Remove and reinstall or replace work deemed defective by Architect.

1. Gaskets: install jamb-applied gaskets before closers, overhead stops, rim strikes, etc; fasten hardware over and through these seals. Install sweeps across bottoms of doors before astragals, cope sweeps around bottom pivots, trim astragals to tops of sweeps.
2. When hardware is to be attached to existing metal surface and insufficient reinforcement exists, use RivNuts, NutSerts or similar anchoring device for screws.
3. Use manufacturers' fasteners furnished with hardware items, or submit Request for Substitution with Architect.
4. Replace fasteners damaged by power-driven tools.

B. Locate floor stops no more that 4 inches from walls and not within paths of travel. See paragraph 2.2 regarding hinge widths, door should be well clear of point of wall reveal. Point of door contact no closer to the hinge edge than half the door width. Where situation is questionable or difficult, contact Architect for direction.

C. Core concrete for exterior door stop anchors. Set anchors in approved non-shrink grout.

D. Locate overhead stops for minimum 90 degrees at rest and for maximum allowable degree of swing.

E. Drill pilot holes for fasteners in wood doors and/or frames.

3.4. ADJUSTING

A. Adjust and check for proper operation and function. Replace units, which cannot be adjusted to operate freely and smoothly.

1. Hardware damaged by improper installation or adjustment methods: repair or replace to Owner's satisfaction.
2. Adjust doors to fully latch with no more than 1 pound of pressure.

   a) Door closer valves: turn valves clockwise until at bottom – do not force. Turn valves back out one and one-half turns and begin adjustment process from that point. Do not force valves beyond three full turns counterclockwise.

3. Adjust delayed-action closers on fire-rated doors to fully close from fully-opened position in no more than 10 seconds.
4. Adjust door closers per 1.9 this section.

B. Fire-rated doors:

1. Wood doors: adjust to 0.125 inches clearance at heads, jambs, and meeting stiles.
2. Steel doors: adjust to 0.063 inches minimum to 0.188 inches maximum clearance at heads, jambs, and meeting stiles.
3. Adjust wood and steel doors to 0.75 inches maximum clearance (undercut) above threshold or finish floor material under door.

C. Final inspection: Installer to provide letter to Owner that upon completion installer has visited the Project and has accomplished the following:

1. Has re-adjusted hardware.
2. Has evaluated maintenance procedures and recommend changes or additions, and instructed Owner's personnel.
3. Has identified items that have deteriorated or failed.
4. Has submitted written report identifying problems.

3.5 DEMONSTRATION:

A. Demonstrate mechanical hardware and electrical, electronic and pneumatic hardware systems, including adjustment and maintenance procedures.

3.6 PROTECTION/CLEANING:

A. Cover installed hardware, protect from paint, cleaning agents, weathering, carts/barrows, etc. Remove covering materials and clean hardware just prior to substantial completion.

B. Clean adjacent wall, frame and door surfaces soiled from installation / reinstallation process.

3.7 SCHEDULE OF FINISH HARDWARE

A. See door schedule in drawings for hardware set assignments.

CARD READER, DOOR CONTACT SWITCH AND WIRING BY SECURITY CONTRACTOR

END OF SECTION

SECTION 08 7113

AUTOMATIC DOOR OPERATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes in floor power door operators for swing doors.

1. Security system components may be incorporated into the door and frame openings indicated to receive power door operators at the Owner's option. Cooperate with the Owner's security system contractors if the Owner chooses to incorporate security system components during the course of the Work.

1.2 DEFINITIONS

A. Activation Device: A device that, when actuated, sends a signal to an automatic door operator to open a door.

B. Safety Device: Device that prevents a door from opening or closing.

1.3 COORDINATION

A. Templates: Obtain and distribute templates for doors, frames, and other work specified to be factory prepared for installing power door operators. Check shop drawings of adjacent work to confirm that adequate provisions are made for locating and installing power door operators to comply with indicated requirements.

B. Electrical System Roughing In: Coordinate layout and installation of power door operators with connections to power supplies and security access control systems (if any).

1.4 ACTION SUBMITTALS

A. Product Data: Submit product data for each door operator type required. Include manufacturer's standard details, material descriptions, dimensions of individual components and profiles, certified performance reports, installation instructions, and parts lists.

B. Shop Drawings: Submit shop drawings showing fabrication and installation details for automatic door operators. Include locations and elevations of door openings indicating activation and safety devices.

1. Wiring Diagrams: Detail wiring for power operator, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

C. Samples: Submit 3 inch (75 mm) square samples for each exposed finish required.

1.5 INFORMATIONAL SUBMITTALS

A. Reports: Submit field adjustment test reports.

B. Warranties: Submit specified warranties.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: Submit maintenance, emergency, and operation data for power door operators.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Engage a factory trained installer, with a minimum of 3 years successful experience in the installation of power door operators and, who is an authorized representative of the product manufacturer for both installation and maintenance of power door operators required for this Project.

B. Source Limitations: Obtain automatic door operators through one source from a single manufacturer.

C. BHMA Standard: Provide and install power door operators that comply with applicable requirements of BHMA A156.19, "Power Assist and Low Energy Power Operated Doors."

D. UL Standard: Provide power door operators that comply with UL 325. All electrical components, devices, and accessories shall be listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to the authorities having jurisdiction, and marked for intended use.

E. Fire-Rated Doors and Emergency Exit Openings: Provide door operators that comply with NFPA 80 requirements for doors in emergency exits that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing according to NFPA 252, and UL 10C "Standard for Positive Pressure Fire Tests of Door Assemblies."

1.8 FIELD CONDITIONS

A. Field Measurements: Verify dimensions of supporting structure by field measurements before fabrication so that the power door operator work will be accurately fabricated and fitted to the structure. Indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work. Use Contractor's lines and benchmarks as a basis for measurements.

1.9 WARRANTY

A. Special Warranty: Submit a written warranty, executed by the manufacturer, agreeing to repair or replace components of the power door operator system that fail in materials or workmanship within specified warranty period. Failures include, but are not limited to, the following:

1. Faulty or sporadic operation of operator or activation and safety devices.
2. Deterioration of metals, metal finishes, and other materials beyond normal weathering or use.

B. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PRODUCTS AND MANUFACTURERS

A. In-Floor Swing Door Operator Products and Manufacturers: Provide electromechanical, power door operators complying with BHMA A156.19 and UL 325. :

1. Opcon In-Floor Swing Door Operator, or approved equal.
    a. Opcon Manufacturing Systems, Inc.
    b. PO Box 308, Carlsbad, California 92018.
    c. www.opconusa.com

2.2 GENERAL DOOR OPERATOR REQUIREMENTS

A. General: Provide operators of size recommended by manufacturer for door size, weight, and movement; for condition of exposure; and for long-term, maintenance-free operation under normal traffic load for type of occupancy indicated.

1. Provide door operators with features for field adjustment of opening speed, closing speed, back check, hold open time, opening force, and acceleration during opening and recycling for soft start.
2. Provide door operators with precision machined gear systems, and motors, especially engineered and fabricated by the power door operator manufacturer for the use indicated. Fabricate gear systems and motors complete with sealed bearings, all weather lubricants and fluids, and vibration and noise isolation to provide long term, quiet and smooth service.
3. Provide door operators with microprocessor controls to accommodate site specific security system interface conditions such as required for card reader access, electric strike delay timers, electric strike power functions, electromechanical locks, and electromagnetic locks.
4. Provide door arm assemblies finished to match exposed housing.
5. Provide door operators that comply with NFPA 80 requirements for doors as emergency exits and that do not interfere with fire ratings.

B. Exposed Housing: Extruded aluminum cover, concealing all operating parts except arms and manual control switches, with provisions for maintenance access. Provide with fasteners concealed when door is in closed position. Provide exposed housing in manufacturer's standard natural anodized finish complying with NAAMM AA-M12C22A31 (Architectural Class II Clear Anodized Coating) unless otherwise indicated.

2.3 SWINGING DOOR OPERATORS

A. Electromechanical Operators for Swinging Doors: Manufacturer's standard electromechanical unit with doors power opened and spring closed, with closing speed controlled mechanically by gear train and dynamically by braking action of electric motor, and with easy manual operation including spring closing when power is off. Provide operator action as indicated and mounting as follows:

1. Operator Mounting Type: Surface-mounted overhead operator.
2. Power-Assisted and Low-Energy Operators: Provide power-assisted and low-energy operators meeting requirements of BHMA A156.19 and ADA's "Accessibility Guidelines for Buildings and Facilities" (ADAAG) for "Automatic Doors and Power-Assisted Doors."
3. Fire-Door Accessories: Provide fire-door accessory package consisting of UL-listed latch mechanism, power-reset box, and caution labels for fire-resistance-rated doors indicated for electromechanical operation.

4. For center-pivoted doors, provide emergency release for reverse-swing action of doors indicated or required to function as exits.

2.4 OPERATOR CONTROLS

A. Wall Push-Plate Switches (Actuators): Manufacturer's standard semiflush, pylon mounted, door-control switch plate for operation by touch. Coordinate with security device in same pylon.

B. Provide "Push and Go" operation when exiting, in lieu of an interior wall push plate switch.

C. Provide each push button actuator with a decal to be applied adjacent to the actuator instructing the user as to the operation and function of the door.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances, door and frame supports, and other conditions affecting performance of power door operators. Examine roughing-in for electrical and security services to verify actual locations of connections, and to verify that the proper types of electrical and security services have been provided, before power door operator installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install complete power door operator system according to manufacturer's written instructions and BHMA A156.19, including activation and safety devices, control wiring, and remote power units.

3.3 ADJUSTING

A. Adjust power door operators and activation and safety devices to operate smoothly, easily, and properly, quietly, and for a safe operation and weathertight closure without binding, scraping, and excessive noise. Adjust doors with low energy door operators to function according to BHMA A156.19.

B. Lubricate operators, hardware and other moving parts.

C. Repair damaged exposed component finishes after completing power door operator installation.

END OF SECTION 08 7113

SECTION 08 8000

GLAZING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes glazing for the following products and applications, including those specified in other Sections where glazing requirements are specified by reference to this Section:

1. Windows.
2. Doors.
3. Glazed entrances.
4. Interior borrowed lites.
5. Storefront framing.

B. Related Requirements:

1. Refer to **Section 08 41 13 "Aluminum-Framed Entrances and Storefronts,"** for requirements applicable to single subcontract responsibility for glazing.

C. This Section includes materials designated as GL-1, GL-2, GL-5, GL-6 on Drawings.

1.2 ACTION SUBMITTALS

A. Product Data: Submit product data for each glass product and glazing material indicated.

B. Samples: Label samples with glass fabricators label to indicate product, substrates,, coatings, interlayer, performance, heat treatment and locations in the Work. Furnish samples of the following:

1. Submit samples of each glass type specified, in the form of 12 inch (300 mm) square Samples.
2. Submit samples of each glass type specified where production run variations and defects are expected.
3. Submit samples with representative and project specific edge work, spacers and seals.

1.3 INFORMATIONAL SUBMITTALS

A. Manufacturer Certificates: Submit a letter from glass manufacturer certifying that he has reviewed the glazing details proposed for the Project, including the use of gaskets and sealants, and that each product to be furnished is recommended for the application shown.

B. Design Data: Submit the following from the glass manufacturer:

1. Thermal Stress Analysis: For each exterior glass unit type, each building elevation. The analysis shall clearly indicate all the expected service temperature ranges and the effects of partial and full shading on the glass. Append to the thermal stress analysis a statement from the glass manufacturer that based upon this analysis that the resulting thermal stresses will not reduce the specified "statistical probability of breakage."

2. Wind Load Analysis: For each glass unit type, each building elevation. The analysis shall clearly indicate that the statistical probability of breakage at the design wind pressure will not exceed the specified statistical probability of breakage.

C. Product Certificates: Signed by manufacturers of glass and glazing products certifying that products furnished comply with requirements.

D. Material Certificates: Submit glass treatment certificates signed by manufacturer of the heat-soaked glass products certifying that products furnished comply with requirements.

E. Product Test Reports: Submit product test reports for each type of glazing sealant and gasket indicated.

F. Warranties: Submit special warranties specified in this Section.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra lites of the respective types and quantities of glass as follows:

1. Exterior Units: As directed by Owner
   a.

B. Deliver in manufacturer's containers suitable for storing, clearly labeled as to type, size, and thickness. Include manufacturer's instructions for care and storage of glass. Store on the premises where directed.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has completed glazing similar in material, design, and extent to that indicated for Project and whose work has resulted in construction with a record of successful in-service performance.

B. Source Limitations for Glass and Glazing Accessories: Obtain glass and glazing accessories from one source for each product indicated below:

1. Primary glass.
2. Coated glass.
3. Heat-treated glass, including heat-strengthened, tempered, and heat-soaked glass.
4. Insulating glass.
5. Laminated glass.
6. Glazing gaskets.
7. Formed or "slumped" glass.

C. Fire-Rated Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire ratings indicated, based on testing according to NFPA 252.

D. Fire-Rated Window Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire ratings indicated, based on testing according to NFPA 257.

E. Safety Glass: Comply with the applicable requirements of the laws, codes, ordinances and regulations of Federal and Municipal authorities having jurisdiction. Wherever requirements conflict, the more stringent shall be required. Obtain approvals from all such authorities. As a minimum, provide

Category II materials complying with testing requirements in 16 CFR 1201 (Consumer Product Safety Commission "Safety Standard for Architectural Glazing Materials," as published in the Code of Federal Regulations) and ANSI Z97.1.

1. Subject to compliance with requirements, permanently mark safety glass with certification label of Safety Glazing Certification Council or another certification agency acceptable to authorities having jurisdiction. Locate permanent markings in one corner, and in the same location, of each glass lite in accordance with the requirements of the SGCC labeling guidelines. Markings shall have a nominal size of no greater than 1-inch (25.4-mm) in diameter, and be located with glass edge clearances, at the corner, by not more than 3/4-inch (19-mm) up and 3/4-inch (19-mm) over.

F. Glazing Publications: Comply with published recommendations of glass product manufacturers and organizations below, unless more stringent requirements are indicated. Refer to these publications for glazing terms not otherwise defined in this Section or in referenced standards.

1. GANA Publications: GANA's "Glazing Manual" and "Laminated Glass Design Guide."
2. IGMA Publications: IGMA TM-3000, "Vertical Glazing Guidelines."

G. Insulating-Glass Certification Program: Permanently marked either on spacers or on at least one component lite of units with appropriate certification label of the Insulating Glass Certification Council (IGCC) or of the Associated Laboratories, Inc. (ALI).

H. Mockups: Refer to **Section 08 41 13 "Aluminum-Framed Entrances and Storefronts,"** for requirements applicable to mockups.

I. Sample Installations: Refer to Section 08 41 13 “Aluminum Framed entrances and Storefronts” " for requirements applicable to sample installations.

1. Representatives of glass and glazing materials manufacturers, together with Contractor's field supervisor for glazing, shall be present during construction and field testing (if any) of sample installations.
2. Prepare sample installations where shown and as required to match approved shop drawings and the Contract Documents in all respects before proceeding with the Work.
3. Accepted sample installations may remain as a portion of the completed Work.

J. Pre-Construction Testing:

1. Bow and Warp Distortion (Flatness) Tolerance Testing:

a. Prior to the visual observation by the Architect and Owner of the preconstruction glass mockups, measure each mockup lite for bow and warp in accordance with ASTM C 1048. Measure the lites on a vertical plane with an aluminum straight edge or fishing line.

1) Measure the mockup glass lites for compliance with the bow and warp tolerances under Article "Heat-Treated Float Glass," Paragraph "Flatness Tolerances."

b. Document and record results for each glass lite. Tag each glass lite that falls outside of the maximum bow and warp limits and certify that these non-conforming glass lites will not be incorporated into the Work.

1) Provide written documentation of the bow and warp readings in fractions of an inch or millimeters for each mockup glass lite to the Owner and Architect at the preconstruction glass mockup meeting. Provide additional written documentation as requested by the Owner and Architect.

2. Roll Ripple Distortion (Flatness) Tolerance Testing:

a. Prior to the visual observation by the Architect and Owner of the preconstruction glass mockups, measure each monolithic lite in the mockup containing low emissivity coated, unfritted, heat-treated glass having a 1/4-inch- (6-mm-) thickness or greater using a LiteSentry or Osprey Series type optical scanning measurement device complying with ASTM C 1652 for digital grid scanning glass devices. **Measure each monolithic mockup lite having 100 percent full screen, frit coated monolithic heat-treated glass having a 1/4-inch- (6-mm-) thickness or greater using a trolley type scanning measurement device complying with ASTM C 1651.**

1) Measure the monolithic mockup glass lites for compliance with the flatness tolerances under Article "Heat-Treated Float Glass," Paragraph "Flatness Tolerances."

b. Document and record results for each glass lite. Tag each glass lite that falls outside of the maximum flatness limits and certify that these non-conforming glass lites will not be incorporated into the Work.

1) Provide written documentation of the flatness readings in fractions of an inch, in millimeters, and in millidiopters, for each mockup glass lite to the Owner and Architect at the preconstruction glass mockup meeting. Provide additional written documentation as requested by the Owner and Architect.

3. Color Tolerance Testing:

a. Prior to the visual observation by the Architect and Owner of the preconstruction glass mockups, measure each monolithic mockup glass unit using either an off-line, or on-line, spectrophotometer. Color measurement shall be taken from the uncoated side.

1) Tolerance limits for the color variation shall be as accepted on the visual mockup.

b. Document and record results for each glass unit. Tag each unit of glass that falls outside of the color variation limits and certify that these non-conforming glass units will not be incorporated into the Work.

K. Quality Control (Production) Testing: As a minimum, provide the following quality control (production) testing for the exterior glass units:

1. Bow and Warp Distortion (Flatness) Tolerance Testing:

a. During the production of the heat-treated glass lites, measure for bow and warp in accordance with ASTM C 1048. Measure the lites on a vertical plane with an aluminum straight edge or fishing line.

1) Measure the monolithic glass lites for compliance with the bow and warp tolerances under Article "Heat-Treated Float Glass," Paragraph "Flatness Tolerances," unless otherwise accepted by the Owner and Architect at the preconstruction glass mockup.

b. During glass production, and once an hour, randomly select a single heat-treated glass lite and measure it. Document and record results. Tag each glass lite that falls outside of the maximum bow and warp limits and certify that these non-conforming glass lites were not incorporated into the Work.

c. Provide written documentation of the bow and warp readings in fractions of an inch or millimeters for each tested glass lite to the Owner and Architect, if requested. Provide additional written documentation as requested by the Owner and Architect.

2. Roll Ripple Distortion (Flatness) Tolerance Testing:

a. During the production of the heat-treated glass lites, measure each low emissivity coated, unfritted, monolithic glass lite having a 1/4-inch- (6-mm-) thickness or greater using a LiteSentry or Osprey Series type optical scanning measurement device complying with ASTM C 1652 for digital grid scanning glass devices. **During the production of the 100 percent full screen, frit-coated monolithic heat-treated glass lites having a 1/4-inch- (6-mm-) thickness or greater, and at a frequency of at least once an hour, randomly select a monolithic single lite and measure it using a trolley type scanning measurement device complying with ASTM C 1651.**

1) Measure the monolithic glass lites for compliance with the flatness tolerances under Article "Heat-Treated Float Glass," Paragraph "Flatness Tolerances," unless otherwise accepted by the Owner and Architect at the preconstruction glass mockup.

b. Document and record results for each glass lite. Tag each glass lite that falls outside of the maximum flatness limits and certify that these non-conforming glass lites were not incorporated into the Work.

1) Provide written documentation of the flatness readings in fractions of an inch, in millimeters, and in millidiopters, for each glass lite to the Owner and Architect, if requested. Provide additional written documentation as requested by the Owner and Architect.

3. Color Tolerance Testing: During production, test monolithic coated and coated insulating glass units for color compliance as follows:

a. Establish a color target selected from the accepted pre-construction glass mockup unit(s) and perform quality control color control checks using either an off-line, or on-line, spectrophotometer. Examples of acceptable off-line devices include Minolta 2500d/2600d; examples of acceptable on-line devices include Benchmodel Spectrophotometers. Color measurement shall be taken from the uncoated side.
b. Frequency: Test a minimum of one unit every hour.
c. Document and record results for each glass unit. Tag each unit of glass that falls outside of the color variation limits and certify that these non-conforming glass units will not be incorporated into the Work.

4. Insulating Glass Unit Testing Requirements: During production, test insulating glass units as follows:

a. Butterfly Unit Adhesion Pull Testing:

1) Adhesion Criteria: Comply with the pass/fail requirements of the sealant manufacturer's published guidelines and/or sealant manufacturer's certification audit requirements/recommendations. Minimum pull back to 30 degrees from horizontal with no adhesive failure.
2) Frequency: Test one minimum 24-by-36-inch- (600 x 900-mm-) size unit each eight-hour shift and after each sealant drum change.

3) Test units shall be fabricated on the same production line and processing equipment and with the same spacers and sealant used in the production of the insulating glass units fabricated for the Project.

b. Desiccant Temperature Rise Testing:

1) Test Criteria: Comply with the desiccant manufacturer's written recommendations.
2) Frequency: Test a minimum of once every eight-hour shift and after each drum change.

c. Bow/Warp and Air Space Measurement Concave/Convex Testing:

1) Measure and record bow and warp once every hour on a vertical plane with an aluminum straight edge or with a laser.
2) Measure and record unit center air space a minimum of once an hour with a checking gage (FDR Designs, or equal) and visually inspect all units.

d. Skips and voids in the primary or secondary seals are prohibited and maximum gap at primary/secondary seal interface shall be 1 inch (25.4 mm) in length and 3/32 inch (2.38 mm) in width.
e. Document and record results. Provide additional documentation upon request by the Owner or Architect.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Protect glazing materials according to manufacturer's written instructions and as needed to prevent damage to glass and glazing materials from condensation, temperature changes, direct exposure to sun, or other causes.

B. For insulating-glass units that will be exposed to substantial altitude changes, comply with insulating-glass manufacturer's written recommendations for venting (using either breather or capillary tubes) and sealing.

1.7 FIELD CONDITIONS

A. Environmental Limitations: Do not proceed with glazing when ambient and substrate temperature conditions are outside limits permitted by glazing material manufacturers and when glazing channel substrates are wet from rain, frost, condensation, or other causes.

1.8 WARRANTY

A. Manufacturer's Special Warranty on Ceramic Frit-Coated-Glass Products: Written warranty, made out to Owner and signed by coated-glass manufacturer agreeing to furnish replacements for those coated-glass units whose coatings flake, peel, or crack within the specified warranty period indicated below. Upon notification of such deterioration within the warranty period, furnish replacement glass units for those glass units whose coatings have flaked, peeled or cracked at the convenience of the Owner.

1. Warranty Period: Five years from date of Substantial Completion.

B. Manufacturer's Special Warranty on Laminated Glass: Written warranty, made out to Owner and signed by laminated-glass manufacturer agreeing to furnish replacements for laminated-glass units that develop edge separation, delamination materially obstructing vision through glass, and blemishes exceeding those allowed by GANA standards within the specified warranty period indicated below. Upon notification of such deterioration within the warranty period, furnish replacement glass units for those glass units having edge separation, delamination, and blemishes at the convenience of the Owner.

1. Warranty Period: Five years from date of Substantial Completion.

C. Manufacturer's Special Warranty on Insulating Glass: Written warranty, made out to Owner and signed by insulating-glass manufacturer agreeing to furnish replacements for insulating-glass units whose hermetic seal has failed within specified warranty period indicated below. Evidence of failure is the obstruction of vision by dust, moisture, or film on interior surfaces of glass. Upon notification of such deterioration within the warranty period, furnish replacement glass units for failed glass units at the convenience of the Owner.

1. Warranty Period: 10 years from date of Substantial Completion.

D.

E. Manufacturer's Special Warranty on Building Integrated Photovoltaic Glazing Units: Written warranty, made out to Owner and signed by laminated-glass manufacturer agreeing to furnish replacements for laminated-glass units that develop edge separation, delamination materially obstructing vision through glass, and blemishes exceeding those allowed by GANA standards within the specified warranty period indicated below. Upon notification of such deterioration within the warranty period, furnish replacement glass units for those glass units having edge separation, delamination, and blemishes at the convenience of the Owner.

1. Warranty Period: 10 years from date of Substantial Completion

PART 2 - PRODUCTS

2.1 PRODUCTS AND MANUFACTURERS

A. Refer to **Finish Schedule on the Drawings** for the extent of glass types and locations. **Glass types indicated on the Drawings are keyed to the Part 3 Glass Schedule Articles at the end of this Section.** The Contractor shall confirm the levels of heat-treatment required for each glass type scheduled as contained in "Performance Requirements" and "Quality Assurance" Articles.

2.2 PERFORMANCE REQUIREMENTS

A. General: Provide and install watertight and airtight glazing systems capable of withstanding thermal movement and wind and impact loads without failure of any kind, including loss or breakage of glass, failure of seal or gaskets, exudation of glazing sealants, and excessive deterioration of glazing materials.

B. Glass Design: Glass thicknesses and heat treatments indicated are minimum requirements. Glazing details shown are for convenience of detailing only and are to be confirmed by the Contractor relative to cited standards and final framing details. Confirm glass thicknesses and heat treatments, verified by analysis, as required to meet the performance and testing requirements specified in **Section 08 44 13 "Glazed Aluminum Curtain Walls,"** Provide safety glazing where required by code.

C. Thermal and Optical Performance Properties: Provide insulating glass with performance properties specified based on manufacturer's published test data, as determined according to procedures indicated below:

1. For insulating-glass units, properties are based on units with lites 6 mm thick and a nominal 1/2 inch (13 mm) wide interspace.
2. Center-of-Glass U-Values: NFRC 100 methodology using LBL WINDOW 6.3 computer program, expressed as Btu/ sq. ft. x h x deg F (W/sq. m x K).
3. Solar Heat Gain Coefficient and Visible Transmittance: Center-of-glazing values, according to NFRC 200 and based on LBL WINDOW 6.3 computer program.
4. Visible Reflectance (Solar Optical) Properties: Center-of-glazing values, according to NFRC 300.

2.3 PRIMARY FLOAT GLASS

A. Float Glass: ASTM C 1036, Type I (transparent glass, flat), Quality q3 (glazing select); [**Class 1, clear**] **[Class 1, ultra clear low iron with visible light transmission of not less than 91 percent] [Class 2, tinted**] as indicated in schedules. Quality q3 shall apply regardless of thickness of glass.

1. Clear, Low Iron Glass: Where indicated in the schedules clear, low iron glass shall mean low iron products as follows:

   a. AGC Asahi Glass Co. Ltd.; Krystal Klear.
   b. Guardian Industries Corp.; UltraWhite.
   c. Pilkington North America; Optiwhite.
   d. PPG Industries, Inc.; Starphire.

2. In order to reduce the possibility of glass color range rejection, the supplier of float (primary) glass products shall provide glass for the entire Project from a single facility using stockpiled batch run materials from a single source for the entire Project.
3. Float Glass Quality Imperfection Limitations: In addition to the limitations included under ASTM C 1036, all glass shall be supplied meeting the following quality standards:

   a. Point blemishes - seeds/stones with distortion, stain spots, dirt, surface damage - shall be limited to 0.060 inch (1.52 mm) maximum separated by 12 inches (304.8 mm) minimum.
   b. Glass scratch/rubs shall be rejected if detectable at 10 feet (3048 mm).
   c. Water blow-off stains, tag residue, and handprints will not be permitted.

2.4 HEAT-TREATED FLOAT GLASS

A. General: Heat-treat glass where the need is determined by thermal stress analyses, by wind load analyses, and where required to meet safety glazing requirements.

B. Fabrication Process: By horizontal (roller-hearth) process with roll-wave distortion **parallel** to bottom edge of installed glass unit.

C.

D. Sizes and Cutting: Prior to heat treatment, cut glass to required sizes as determined by accurate measurement of openings to be glazed, making allowance for required edge clearances. Cut and process edges in accordance with glass manufacturer's recommendations. Do not cut or treat edges in the field.

E. Heat-Strengthened Glass: Provide glass complying with ASTM C 1048 Kind HS. Surface compression range shall be between 4,000 psi (27.6 MPa) and 7,000 psi (48.3 MPa) for 1/4 inch (6 mm) thick glass. **[Surface compression range shall be between 5,000 psi (34.5 MPa) and 8,000 psi (55.2 MPa) for 5/16 inch (7.93 mm) thick glass.]**

1. Heat-Strengthened Glass Quality Imperfection Limitations: In addition to the limitations included under ASTM C 1048, all glass shall be supplied meeting the following quality standards:

a. Chill cracks, roller marks, and picture framing shall not be permitted.
b. Tracking/cloud and heat dimples shall be rejected if detectable at 10 feet (3048 mm).

F. Fully Tempered Glass: Provide glass complying with ASTM C 1048 Kind FT and meeting the requirements of ANSI Z97.1. Surface compression shall be equal to or greater than 10,000 psi (69 MPa). After tempering, heat-soak 100 percent of all fabricated glass units to European Union Standard EN14179 to reduce the potential for inclusion related glass breakage. Statistical heat soaking shall not be permitted.

1. Tempered Glass Quality Imperfection Limitations: In addition to the limitations included under ASTM C 1048, all glass shall be supplied meeting the following quality standards:

a. Chill cracks, roller marks, and picture framing shall not be permitted.
b. Tracking/cloud and heat dimples shall be rejected if detectable at 10 feet (3048 mm).

G. Flatness Tolerances: All heat-treated glass shall be fabricated to the following flatness tolerances. Verification of compliance for overall bow and warp shall be in accordance with ASTM C 1048. Verification of compliance for flatness shall be via an optical scanning device such as LiteSentry or Osprey Series.

1. Overall Bow and Warp: Not greater than ½ of the maximum bow and warp tolerances in any direction as listed in ASTM C 1048 Table 2. Localized warp limited to 1/32 inch in 12 inches (0.79 mm in 304.8 mm).
2. Roll Ripple: The deviation from flatness at any peak (peak to valley deviation) shall not exceed 0.003 inches for 6 mm (0.0762 mm for 6 mm) thick glass in the glass center, with leading and trailing edge deviation not to exceed 0.008 inches for 6 mm (0.2032 mm for 6 mm) thick glass.

H. Millidiopter Criteria: Maximum +/- 120 millidiopters overall or the highest overall measurement from the approved visual mockup that is less than +- 120 millidiopter overall whichever is less when viewed outdoors.

2.5 CERAMIC-COATED GLASS

A. Ceramic-Coated Vision Glass: Float glass with ceramic coating applied by silk-screened process and complying with ASTM C 1048, Condition C (other coated glass), Type I (transparent glass, flat), Quality q3 (glazing select); and complying with Specification No. 95-1-31, "Specification for Decorative Architectural Flat Glass" in GANA's "Engineering Standards Manual"; and with other requirements specified in schedules.

B. Ceramic-Coated Spandrel Glass: ASTM C 1048, Condition B (spandrel glass, one-surface ceramic coated), Type I (transparent glass, flat), Quality q3 (glazing select), and complying with other requirements specified in schedules.

1. Factory apply opacifier of polyester film laminated to glass with solvent-based adhesive to coated second surface of lites, with resulting products complying with Specification No. 89-1-6 in GANA's "Engineering Standards Manual."
    a. Edge delete opacifier in structural silicone applications.

2.6 COATED FLOAT GLASS

A. General: Provide coated glass complying with requirements indicated in this Article, under Paragraph "Insulating Glass," and in schedules.

1. Sputter-Coated Float Glass: Float glass with the coating(s) specified in schedules, deposited by magnetron sputtered vacuum deposition process after manufacture and heat treatment (if any). Pyrolytic and wet chemical deposition glass coatings will not be permitted.
2. Coating Quality: The allowable range of defects in coatings applied to glass shall be as accepted through glass sample submissions. Installed coated glass products which are outside of the accepted sample range shall be subject to rejection by the Architect. **[In order to reduce the possibility of glass rejection, the supplier of coated glass products shall provide glass coating production runs for the entire Project from a single coating facility.]** All coated glass shall be provided from a single coating facility. The allowable range of defects are defined as follows:

    a. The vision glass area is defined as the field of glass which is greater than 1 inch (25.4 mm) from the glass unit edge.

        1) Pinholes: At an indoor viewing distance of 10 feet (3048 mm) for non-reflective and reflective low emissivity coatings:

            a) Pinholes greater than 1/16 inch (1.5 mm) in diameter shall not be permitted in 80 percent of the central portion of the vision glass area and separated by greater than or equal to 12 inches (300 mm). Pinholes larger than 3/32 inch (2.4 mm) are not allowed in the outer 20 percent of the perimeter vision glass area and separated by greater than or equal to 12 inches (300 mm);
            b) No more than two readily apparent blemishes are allowed in a 3 inch (75 mm) diameter circle and no more than five readily apparent blemishes are allowed in a 12 inch (305 mm) diameter circle.

        2) Scratches: At an indoor viewing distance of 10 feet (3048 mm) for non-reflective and reflective low emissivity coatings, and 15 feet (4572 mm) for reflective coatings:

            a) Scratches are allowed in 80 percent of the central glass area if not detectable at the viewing distance, and scratches less than or equal to 1 inch (25 mm) are allowed in the outer 20 percent area if not detectable at the viewing distance. Concentrated scratches or abraded areas are not allowed.
            b) Scuffs, rub marks, cup marks, or abraded areas shall not be permitted in any glass area.

        3) Reflectance and Transmission Inspection: When viewed outdoors against a bright uniform opaque background at a distance of 10 feet (3048 mm) for low emissivity coatings, color, reflectance and transmission will be permitted to have a slight variance subject to Architect's acceptance.

            a) Mottling and streaking of the coating shall not be permitted.
            b) Coating arcing will not be permitted.

c) Water blow-off stains will not be permitted.
d) Handprints will not be permitted.
e) Roller marks shall not be permitted.
f) Positive and negative air distortion shall not be permitted.
g) Tag residue shall not be permitted.

2.7 WIRED GLASS

A. Wired Glass: ASTM C 1036, Type II (patterned and wired glass, flat), Class 1 (clear), Quality q5 or q6 (glazing); 6.4 mm thick; of form, finish, mesh, and pattern indicated below:

1. Polished Wired Glass: Form 1 (wired, polished both sides), and as follows:

    a. Mesh 1 (M1)(diamond).
    b. Mesh 2 (M2) (square).
    c. Mesh 3 (M3) (parallel strand).

2. Patterned Wired Glass: Form 2 (patterned and wired), Mesh 1 (M1) (diamond).

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Polished Wired Glass: AGC Asahi Glass Co. Ltd.
2. Patterned Wired Glass: AGC Asahi Glass Co. Ltd.

2.8 PATTERNED GLASS

A. Patterned Glass: ASTM C 1036, Type II (patterned and wired glass, flat), Class 1 (clear), Quality q5 or q6 (glazing), form, finish, mesh, and pattern indicated in the Glass Schedule.

B. Tempered Patterned Glass: ASTM C 1048, Kind FT (fully tempered), Type II (patterned glass, flat), Class 1 (clear), Quality q5 or q6 (glazing), form, finish, mesh, and pattern indicated in the Glass Schedule.

2.9 BENT AND "SLUMPED" GLASS

A. Comply with ASTM C 1464, [**Kind BA for bent monolithic annealed glass**] [**Kind BFT for bent monolithic full tempered glass**] [**Kind BHS for bent monolithic heat-strengthened**] [**Kind BL for bent laminated**] for bent or "slumped" glass formed to the sizes shapes and profiles indicated using ASTM C 1036, Type 1, Quality Q3, [**Class 1, clear**] [**Class 1, clear, low iron**] [**Class 2, tinted**] glass and further processed to comply with [**ASTM C 1048 for fully tempered and heat-strengthened glass**] [**ASTM C 1172 for laminated glass**].

1. Manufacturer: Manufacturer is to have a minimum of 10 years' experience and successful fabrication and installation of 3-dimensional monolithic and laminated formed or "slumped" glass shapes. Manufacturers known to be capable of forming bent and "slumped" glass include the following:

    a. California Glass Bending.
    b. Cricursa, Cristales Curavados S.A.
    c. Dlubak Corporation.
    d. Cristacurva

2.10 LAMINATED GLASS

A. Laminated Glass: Comply with ASTM C 1172 for kinds of laminated glass indicated and other requirements specified, including those in the Glass Schedule.

B. Interlayer: Unless indicated otherwise, provide 0.060 inch (1.5 mm) thick polyvinyl butyral (PVB) sheet or ionoplast sheet interlayer material with a proven record of no tendency to bubble, discolor, or lose physical and mechanical properties after laminating glass lites and installation.

1. All interlayer furnished for the Project shall have been manufactured and fabricated in North American facilities.

C. Laminating Process: Prior to laminating, cut glass to required sizes and profiles as determined by accurate measurement of openings to be glazed, making allowance for required edge clearances. Cut and process edges in accordance with glass manufacturer's recommendations. Do not cut or treat edges in the field. Fabricate laminated glass to produce glass free of scuff vinyl markings, handprints, tag residue, and foreign substances such as lint, hair, vinyl shavings in the central glass area and the outer 20 percent area when viewed from a distance of 39 inches (1 meter) and 10 feet (3048 mm), respectively. Handprints, tag residue, scuff vinyl markings, and foreign substances must be separated by more than 12 inches (300 mm) if not detectable at less than the viewing distances. Delaminations, blow-ins, short interlayers, and air or gas pockets shall not be permitted in the central glass area. In the outer 20 percent area, delamination will not be permitted; blow-ins, air or gas pockets, and short interlayers shall be limited to a maximum dimension of 3/32 inch (2.38-mm) in diameter, 3/32 inch (2.38-mm) in diameter, and 1/16 inch (1.5-mm) long, respectively. Laminate units as follows:

1. Laminate lites with interlayer in autoclave with heat plus pressure.

2.11 INSULATING GLASS

A. Insulating-Glass Units: Preassembled units, with dehydrated entrapped air, consisting of sheets of glass hermetically sealed at all edges with a polyisobutylene primary and a **black** silicone secondary elastomeric sealant. The lites of glass shall be separated by dessicant containing**black colored**aluminum spacers. All insulating glass units shall be IGCC certified to comply with ASTM E 2190 and with requirements specified in this Article and in the Glass Schedule.

1. Provide Kind HS (heat-strengthened) float glass where needed to comply with "Performance Requirements" Article. Provide Kind FT (fully tempered) where safety glass is indicated.

B. Overall Unit Thickness and Thickness of Each Lite: Dimensions indicated in the Glass Schedule are nominal and the overall thicknesses of units are measured perpendicularly from outer surfaces of glass lites at unit's edge.

1. Minimum insulated unit make-up 3/8" outboard lite, ½" airspace, ¼" inboard lite.

2.

2.12 FIRE-RATED GLAZING PRODUCTS

A. Laminated Ceramic Glazing Material: Two lites of clear ceramic glazing material laminated together to produce a laminated lite of minimum 5/16 inch (8 mm) nominal thickness; polished on both surfaces; weighing 4 lb/sq. ft. (19.5 kg/sq. m); and as follows:

1. Fire-Protection Rating: As indicated for the assembly in which the glazing material is installed, and permanently labeled by a testing and inspecting agency acceptable to authorities having jurisdiction.
2. Polished on both surfaces, transparent.
3. Product: Provide one of the following:

   a. "FireLite Plus"; Nippon Electric Glass Co., Ltd. and distributed by Technical Glass Products.
   b. Pyran Platinum L; SaftiFirst div. of O'Keeffe's, Inc.
   c. Keralite FR-L; Vetrotech.

B. Laminated Glass with Intumescent Interlayers: Proprietary product in the form of multiple lites of Condition A (uncoated surfaces), Type I (transparent glass, flat), Class 1 (clear), Kind FT (fully tempered) float glass laminated with intumescent interlayers; and as follows:

1. Fire-Protection Rating: As indicated for the assembly in which the glazing material is installed, and permanently labeled by a testing and inspecting agency acceptable to authorities having jurisdiction.
2. Product: Subject to compliance with requirements, provide "PyroStop" distributed by Technical Glass Products.

2.13 GLAZING SEALANTS

A. General: Provide products of type indicated, complying with the following requirements:

1. VOC Content: For sealants used inside of the weatherproofing system, not more than 250 g/L when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Sealant shall have a VOC content of 250 g/L or less.
3. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. Gasket, Blocking, and Spacer Wet Glazing Materials: Silicone, compatible with and adherent to each material it will be in contact with, as recommended by the manufacturer to fulfill performance requirements.

C. Structural and Butt Glazing Sealants: Refer to Section 07 92 00 "Joint Sealants," Article "Elastomeric Joint Sealants," subparagraph "Structural Glazing."

D. Glazing Sealant for Fire-Resistive Glazing Products: Identical to product used in test assembly to obtain fire-protection rating.

2.14 GLAZING TAPES

A. Back-Bedding Mastic Glazing Tape: Preformed, butyl-based elastomeric tape with a solids content of 100 percent; nonstaining and nonmigrating in contact with nonporous surfaces; with or without spacer rod as recommended in writing by tape and glass manufacturers for application indicated; packaged on rolls with a release paper backing; and complying with ASTM C 1281 and AAMA 800 for products indicated below:

1. AAMA 806.3 tape, for glazing applications in which tape is subject to continuous pressure.
2. AAMA 807.3 tape, for glazing applications in which tape is not subject to continuous pressure.

2.15 GLAZING GASKETS

A. Lock-Strip Gaskets: Neoprene extrusions in size and shape indicated, fabricated into frames with molded corner units and zipper lock strips, complying with ASTM C 542, black.

B. Dense Compression Gaskets:

1. Neoprene: Continuous extruded neoprene with, cross sectional profile, physical properties, and tolerances as recommended by the window and curtain wall manufacturer, and as required, to comply with the performance requirements specified and shown all in compliance with the applicable provisions of ASTM C 864, Option II. [**Provide injection molded corners.**]
2. EPDM: Continuous extruded EPDM with cross sectional profile, physical properties, and tolerances as recommended by the window and curtain wall manufacturer, and as required, to comply with the performance requirements specified and shown all in compliance with the applicable provisions of ASTM C 864, Option II. [**Provide injection molded corners.**]
3. Silicone: Continuous extruded silicone with cross sectional profile, physical properties, and tolerances as recommended by the window and curtain wall manufacturer, and as required, to comply with the performance requirements specified and shown all in compliance with the applicable provisions of ASTM C 1115, Type C. [**Provide injection molded corners.**]
4. Thermoplastic Polyolefin Rubber: Continuous extruded thermoplastic polyolefin rubber with cross sectional profile, physical properties, and tolerances as recommended by the window and curtain wall manufacturer, and as required, to comply with the performance requirements specified and shown all in compliance with the applicable provisions of ASTM C 1115. [**Provide injection molded corners.**]
5. Any material indicated above.

C. Soft Compression Gaskets: Continuous extruded expanded foam with, cross sectional profile, physical properties, and tolerances as recommended by the window and curtain wall manufacturer, and as required, to comply with the performance requirements specified and shown all in compliance with the applicable provisions of ASTM C 509, Option II, Type II; provide the following:

1. Neoprene.
2. EPDM.
3. Silicone.
4. Thermoplastic polyolefin rubber.
5. Any material indicated above.

D. Continuous Structural Gaskets/Spacers: Continuous extruded silicone or silicone compatible rubber, with cross sectional profile, physical properties, and tolerances as recommended by the window and curtain wall manufacturer, and as required, to comply with the performance requirements specified and shown. Gaskets/spacers shall be tested for compatibility with silicone sealants and shall be subject to the acceptance of the sealant manufacturer.

2.16 MISCELLANEOUS GLAZING MATERIALS

A. General: Provide products of material, size, and shape complying with referenced glazing standard, requirements of manufacturers of glass and other glazing materials for application indicated, and with a proven record of compatibility with surfaces, and wet glazing materials, contacted in installation.

B. Cleaners, Primers, and Sealers: Types recommended by sealant or gasket manufacturer.

C. Setting Blocks: EPDM complying with ASTM C 864 (Option II), blocks, 85 +/- 5 Shore A durometer hardness, 1/16 inch (1.5 mm) less than the channel width, and length based on the face area of the glass unit to be supported in accordance with GANA standards and glass manufacturer recommendations, but not less than 4 inches (101.6 mm).

D. Setting Blocks: Silicone complying with ASTM C 1115 (Type C), blocks, 85 +/- 5 Shore A durometer hardness, 1/16 inch (1.5 mm) less than the channel width, and length based on the face area of the glass unit to be supported in accordance with GANA standards and glass manufacturer recommendations, but not less than 4 inches (101.6 mm).

E. Spacers: Elastomeric blocks or continuous extrusions with a Shore A durometer hardness of 40 to 60.

F. Edge Blocks: Silicone complying with ASTM C 1115 (Type C), blocks, 65 +/- 5 Shore A durometer hardness, minimum 4 inches (101.6 mm) long and sized to allow 1/8 inch (3.18 mm) clearance between edge of glass and block.

G. Edge Blocks: EPDM complying with ASTM C 864 (Option II), blocks, 65 +/- 5 Shore A durometer hardness, minimum 4 inches (101.6 mm) long and sized to allow 1/8 inch (3.18 mm) clearance between edge of glass and block.

H. Perimeter Insulation for Fire-Resistive Glazing: Identical to product used in test assembly to obtain fire-resistance rating.

2.17 FABRICATION OF GLASS AND OTHER GLAZING PRODUCTS

A. Fabricate glass and other glazing products in sizes required to glaze openings indicated for Project, with edge and face clearances, edge and surface conditions, and bite complying with written instructions of product manufacturer and referenced glazing standard, to comply with system performance requirements.

1. Edge and Surface Conditions: Comply with the recommendations of AAMA "Structural Properties of Glass" for "clean-cut" edges, except comply with manufacturer's recommendations when they are at variance therewith.

B. Cutting: Do not nip glass edges. Edges may be wheel cut or sawed and seamed at manufacturer's option. For glass to be cut at site, provide glass 2 inches (50.8 mm) larger than required in both dimensions, so as to facilitate cutting of clean cut edges without the necessity of seaming or nipping. Do not cut, seam, nip or abrade heat-treated glass.

C. Glass edges exposed to view and butt glazed edges shall be polished and arrissed.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine glass framing, with glazier and glass framing erector present, for compliance with the following:

1. Compliance with the specified manufacturing and installation tolerances, including those for size, squareness, and offsets at corners.
2. Presence and functioning of weep system.
3. Minimum required face or edge clearances.
4. Effective sealing between joints of glass-framing members.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean glazing stops, glazing channels, and rabbets which will be in contact with the glazing materials immediately before glazing. Loose particles present or resulting from fabrication and cleaning shall be removed by blowing out joints with oil-free compressed air, or by vacuuming joints. Remove protective coatings, oils from cutting and drilling operations, and residue on metallic surfaces with solvents that leave no residue. Do not allow solvent to air dry without wiping. Use only lint-free towels for wiping of surfaces. Wipe metal surfaces with IPA (isopropyl alcohol) unless otherwise required by compatibility and adhesion testing results.

1. Prime surfaces to receive glazing compounds. When priming, comply with wet glazing manufacturer's recommendations.

B. Inspect each glass unit immediately before installation. Do not install any units which are improperly sized or have damaged edges, scratches or abrasion or other evidence of damage. Remove labels from glass immediately after installation.

C. Seal vent (breather or capillary) tubes in insulating glass units in accordance with the insulating glass manufacturer's written recommendations.

3.3 GLAZING, GENERAL

A. Comply with combined written instructions of manufacturers of glass, sealants, gaskets, and other glazing materials, unless more stringent requirements are indicated, including those in referenced glazing publications.

1. All glass units shall be installed in accordance with the glass manufacturer's recommendations.

a. Unitized Shop-Glazed Structural Silicone Window and Curtain Wall Systems: Comply with the recommendations of the structural silicone and curtain wall framing manufacturers; where conflicts arise, the most stringent shall apply.

1) Structurally seal glass unit to mullions with specified two-part structural silicone sealant. Place and tool structural silicone beads to remove air pockets and bubbles; remove excess structural silicone from glass and metal substrates. Insert and shape weatherseal joint backer rods, or gaskets, into void between glass units and between glass units and framing to the proper depth to receive silicone weatherseal sealant. Place silicone weatherseal sealant into void and tool flush with adjacent exterior glass lite faces; remove excess sealant from glass and metal substrates.

b. Field Glazed Structural Silicone Window and Curtain Wall Units: Set full height continuous structural gaskets/spacers to vertical mullions. Set glass units with void between edge of units and head/sill channel, but with units fully within head/sill rebate so as to provide a proper bite. Align glass unit edges over vertical mullion continuous structural gasket/spacers and secure with manufacturer's recommended temporary cleats. Structurally seal glass unit to vertical mullions with specified one-part structural silicone sealant. Tool structural silicone flush in alignment to mullion face and perpendicular to face of interior glass lite; remove excess structural silicone from glass and metal substrates. After full cure of structural silicone sealant, remove temporary cleats. Any holes left in the vertical mullions which were caused by the temporary cleats shall be sealed immediately. Insert and shape weatherseal joint backer rods, or gaskets, into vertical void between glass units and at a proper depth to receive silicone weatherseal sealant. Place silicone weatherseal sealant into void and tool flush with adjacent exterior glass lite faces; remove excess sealant from glass and metal substrates.

c. Apply silicone heel beads to top of insulated glazing units.

B. Glazing channel dimensions, as indicated on Drawings, provide necessary bite on glass, minimum edge and face clearances, with reasonable tolerances. Adjust as required by Project conditions during installation.

C. Protect glass edges from damage during handling and installation. Remove damaged glass from Project site and legally dispose of off Project site. Damaged glass is glass with edge damage or other imperfections that, when installed, could weaken glass and impair performance and appearance.

D. Apply primers to surfaces indicated to receive glazing materials. Use primers as determined by preconstruction compatibility and adhesion testing.

E. Install setting blocks in sill rabbets, sized and located to comply with referenced glazing publications, unless more stringent requirements are recommended by glass manufacturer. Place blocks to allow water passage to weep holes. Set blocks in thin course of silicone sealant.

1. For Glass Units Less Than 72 inches (1830 mm): Locate setting blocks at sill one-quarter of the width in from each end of the glass, unless otherwise recommended by the glass manufacturer.
2. For Glass Units 72 inches (1830 mm) or Greater: Locate setting blocks at sill one-eighth of the width in from each end of the glass, but not less than 6 inches (150 mm), unless otherwise recommended by the glass manufacturer.

F. Do not exceed edge pressures stipulated by glass manufacturers for installing glass lites.

G. Provide spacers for glass lites where the length plus width is larger than 50 inches (1270 mm) as follows:

1. Locate spacers directly opposite each other on both inside and outside faces of glass. Install correct size and spacing to preserve required face clearances, unless gaskets and glazing tapes are used that have demonstrated ability to maintain required face clearances and to comply with system performance requirements.
2. Provide 1/8 inch (3 mm) minimum bite of spacers on glass and use thickness equal to sealant width. With glazing tape, use thickness slightly less than final compressed thickness of tape.

H. Provide edge blocking to prevent glass lites from moving sideways in glazing channel, sized and located to comply with the glass manufacturer's recommendations and the requirements in referenced glazing publications.

1. Edge blocking will not be required at structural glazed window and curtain walls unless specifically required by the glass manufacturer for the conditions shown.

I. Set glass lites with uniform pattern, draw, bow, and similar characteristics, producing the greatest possible degree of uniformity in appearance on the entire exterior wall elevation.

1. Set glass units with void between edge of units and glazing channel.
2. Shadow Box Enclosure Glazing: Remove any dirt, window and curtain wall debris, and construction debris, from interior portion of shadowbox enclosures. Where lubricants are recommended for the installation of glazing gaskets, use types which will not release volatiles, or leave visible deposits or residues, on inside of spandrel glass units or metal back panels.
3. Orient and install insulating glass units made up with one lite of low emissivity coated glass with the uncoated glass lite on the inboard (building) side.
4. Orient and install insulating glass units made up with one lite of tinted glass with the untinted glass lite on the inboard (building) side.

J. Where wedge-shaped gaskets are driven into one side of channel to pressurize gasket on opposite side, provide adequate anchorage so gasket cannot walk out when installation is subjected to movement.

K. Miter cut gaskets at corners and install gaskets in a manner recommended by gasket manufacturer to prevent corners from pulling away and join with sealant recommended by gasket manufacturer which will provide an airtight and watertight seal at the joint.

3.4 TAPE GLAZING

A. Position tapes on fixed stops so that, when compressed by glass, their exposed edges are flush with or protrude slightly above sightline of stops.

B. Install tapes continuously, but not necessarily in one continuous length. Do not stretch tapes to make them fit opening.

C. Where framing joints are vertical, cover these joints by applying tapes to heads and sills first and then to jambs. Where framing joints are horizontal, cover these joints by applying tapes to jambs and then to heads and sills.

D. Place joints in tapes at corners of opening with adjoining lengths butted together, not lapped. Seal joints in tapes with compatible sealant approved by tape manufacturer.

E. Do not remove release paper from tape until just before each glazing unit is installed.

F. Apply heel bead of elastomeric sealant.

G. Center glass lites in openings on setting blocks and press firmly against tape by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings.

H. Apply cap bead of elastomeric sealant over exposed edge of tape.

3.5 LOCK-STRIP GASKET GLAZING

A. Comply with ASTM C 716 and gasket manufacturer's written instructions. Use special tool to install and remove filler strips; lubricate in accordance with manufacturer's instructions. Provide supplementary wet seal and weep system, unless otherwise indicated.

3.6 PROTECTION AND CLEANING

A. Protect exterior glass from damage immediately after installation by attaching crossed streamers to framing held away from glass. Do not apply markers to glass surface. Remove nonpermanent labels, and clean surfaces.

B. Protect glass from contact with contaminating substances resulting from construction operations. If, despite such protection, contaminating substances do come into contact with glass, remove them immediately as recommended by glass manufacturer.

C. Examine glass surfaces adjacent to or below exterior concrete and other masonry surfaces at frequent intervals during construction, but not less than once a month, for build-up of dirt, scum, alkaline deposits, or stains; remove as recommended by glass manufacturer.

D. Remove and replace glass that is broken, chipped, cracked, abraded, or damaged in any way and from any source, including natural causes, accidents, and vandalism.

E. Wash glass on both exposed surfaces in each area of Project not more than four days before date scheduled for inspections that establish date of Substantial Completion. Wash glass as recommended by glass manufacturer.

3.7 GLASS SCHEDULE

END OF SECTION 08 8000

SECTION 08 8300

MIRRORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes mirrored glass with vinyl-backing safety film.

1.2 ACTION SUBMITTALS

A. Product Data: For each product indicated.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other Work.

C. Samples: As follows:

1. Mirrored Glass: 12 inches square, including safety backing and edge treatment on 2 adjoining edges.
2. Mirror clips.
3. Mirror Trim: 12 inches long.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Product certificates.

C. Preconstruction Test Report: For mirror mastic compatibility.

D. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs glass installers for this Project who are certified under the National Glass Association's Glazier Certification Program as Level 2 (Senior Glaziers) or Level 3 (Master Glaziers).

B. Glazing Publications: Comply with published recommendations in GANA's "Glazing Manual," unless more stringent requirements are indicated.

C. NAAMM's Publication: For silvered mirrored glass, comply with recommendations in NAAMM's "Mirrors, Handle with Extreme Care, Tips for the Professional on the Care and Handling of Mirrors."

D. Safety Glass: Category II materials complying with testing requirements in 16 CFR 1201.

E. Preconstruction Compatibility Test: Submit mirror mastic products to organic protective coating manufacturer for testing to determine compatibility of adhesive with mirrored glass coating.

1.5 DELIVERY, STORAGE, AND HANDLING

A. For silvered mirrored glass, comply with mirrored glass manufacturer's written instructions for shipping, storing, and handling mirrored glass as needed to prevent deterioration of silvering, damage to edges, and abrasion of glass surfaces and applied coatings. Store indoors, protected from moisture including condensation.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace mirrored glass units that deteriorate f.o.b. the nearest shipping point to Project site, within five years from date of Substantial Completion.

1. Deterioration of Silvered Mirrored Glass: Defects developed from normal use not caused by maintaining and cleaning mirrored glass contrary to manufacturer's written instructions. Defects include discoloration, black spots, and clouding of the silver film.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Products: Subject to compliance with requirements, provide one of the products specified.
2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 FLOAT GLASS

A. Annealed Float Glass: ASTM C 1036, Type I (transparent glass, flat).

1. Clear: Class 1 (clear), Quality q2 (mirror).

a. Thickness: 6 mm.

2.3 MIRRORED GLASS

A. Silvered Mirrored Glass:

1. Manufacturers:

a. American Mirror Company, Inc.
b. Carolina Mirror Company.
c. Donisi Mirror Company.
d. Gardner Glass Products.
e. Gilded Mirrors, Inc.
f. Lenoir Mirror Company.
g. Stroupe Mirror Co., Inc.
h. Sunshine Mirror.

i. Virginia Mirror Co., Inc.
j. VVP America, Inc.; Binswanger Mirror Products.
k. Walker Glass Co., Ltd.

2. Annealed Float Glass: Clear.
3. Silvering: Successive layers of chemically deposited silver, electrically or chemically deposited copper, and manufacturer's standard organic protective coating applied to second glass surface to produce coating system complying with FS DD-M-411.

B. Fabrication:

1. Cutouts: Fabricate cutouts for notches and holes in mirrored glass without marring visible surfaces. Locate and size cutouts so they fit closely around penetrations in mirrored glass.
2. Mirrored Glass Edge Treatment: Rounded polished.

a. Silvered Mirror Glass: Seal edges after edge treatment to prevent chemical or atmospheric penetration of glass coating.

C. Vinyl-Backed Safety Mirrored Glass: Apply vinyl backing with pressure-sensitive adhesive coating over glass coating as recommended by vinyl-backing manufacturer to produce a surface free of bubbles, blisters, and other imperfections. Use adhesives and vinyl backing compatible with mirrored glass as certified by organic coating manufacturer.

2.4 MISCELLANEOUS MATERIALS

A. Setting Blocks: Neoprene, 70 to 90 Shore A hardness.

B. Edge Sealer: Coating compatible with glass coating and approved by mirrored glass manufacturer for use in protecting against silver deterioration at mirrored glass edges.

C. Mirror Mastic: An adhesive setting compound, produced specifically for setting mirrored glass by spot application and not containing asbestos.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Qwikset Mirror Mastic by Palmer Products Corporation.
b. UltraBond by Gunther Mirror Mastics.

D. Mirror Mastic: An adhesive setting compound, produced specifically for setting mirrors and certified by both mirror manufacturer and mastic manufacturer as compatible with glass coating and substrates on which mirrors will be installed.

1. VOC Content: Not more than 70 g/L when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

E. Extruded-Aluminum Top and Bottom Trim: J-channels with return that produces glazing channel to accommodate mirrored glass thickness indicated.

1. Bottom Trim: J-channels formed with front leg and back leg not less than 3/8 and 7/8 inch in height, respectively, and a thickness of not less than 0.05 inch.

a. Products:

1) C. R. Laurence Co., Inc.; CRL Standard "J" Channel.
2) Sommer & Maca Industries, Inc.; Heavy Gauge Aluminum Shallow Nose "J" Moulding Lower Bar.

2. Top Trim: J-channels formed with front leg and back leg not less than 5/8 and 1 inch in height, respectively, and a thickness of not less than 0.062 inch.

a. Products

1) C. R. Laurence Co., Inc.; CRL Deep "J" Channel.
2) Sommer & Maca Industries, Inc.; Heavy Gauge Aluminum Deep Nose "J" Moulding Lower Bar.

3. Aluminum Finish: Satin anodized.

F. Fasteners: Fabricated of same basic metal and alloy as fastened metal.

G. Anchors and Inserts: Provide devices as required for mirror hardware installation. Provide toothed or lead-shield expansion-bolt devices for drilled-in-place anchors. Provide galvanized anchors and inserts for applications on inside face of exterior walls and where indicated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify compatibility with and suitability of substrates, including compatibility of mirror mastic with existing finishes or primers.

B. Install mirrored glass units to comply with written instructions of mirrored glass manufacturer and with referenced GANA and NAAMM publications. Mount mirrored glass accurately in place in a manner that avoids distorting reflected images.

C. Provide space for air circulation between back of mirrored glass units and face of mounting surface.

D. Mastic Spot Installation System:

1. Apply barrier coat to mirrored glass backing where approved in writing by manufacturers of mirrored glass and backing material.
2. Apply mastic in spots to comply with mastic manufacturer's written instructions for coverage and to allow air circulation between back of mirrored glass units and face of mounting surface.
3. After mastic is applied, align mirrored glass units and press into place while maintaining a minimum air space of 1/8 inch between back of mirrored glass and mounting surface.

E. For wall-mounted mirrored glass units, install permanent means of support at bottom and top edges with bottom support designed to withstand mirrored glass weight and top support designed to prevent mirrored glass from coming away from wall along top edges.

1. Attach mirror hardware securely to mounting surfaces with mechanical fasteners installed with anchors or inserts as applicable. Install fasteners so heads do not impose point loads on backs of mirrored glass units.

2. For continuous bottom supports, provide setting blocks 1/8 inch thick by 4 inches long at quarter points. For channels or other continuous supports in which water could be trapped, provide, between setting blocks, two slotted weeps not less than 1/4 inch wide by 3/8 inch long.
3. Where indicated, install bottom and top trim. Fabricate trim in single lengths to fit and cover top and bottom edges of mirrored glass units.

F. Protect mirrored glass from breakage and contaminating substances resulting from construction operations.

1. Do not permit edges of silvered mirrored glass to be exposed to standing water.
2. Maintain environmental conditions that will prevent silvered mirrored glass from being exposed to moisture from condensation or other sources for continuous periods of time.

END OF SECTION 08 8300

SECTION 08 9119

FIXED LOUVERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fixed, extruded-aluminum louvers.

1.2 DEFINITIONS

A. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section unless otherwise defined in this Section or in referenced standards.

B. Horizontal Louver: Louver with horizontal blades (i.e., the axes of the blades are horizontal).

C. Wind-Driven-Rain-Resistant Louver: Louver that provides specified wind-driven rain performance, as determined by testing according to AMCA 500-L.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.

B. Shop Drawings: For louvers and accessories. Include plans, elevations, sections, details, and attachments to other work. Show frame profiles and blade profiles, angles, and spacing.

1. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.
2. Show mullion profiles and locations.

C. Samples: For each type of metal finish required.

D. Delegated-Design Submittal: For louvers indicated to comply with structural and seismic performance requirements, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."

1.5 FIELD CONDITIONS

A. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain louvers from single source from a single manufacturer where indicated to be of same type, design, or factory-applied color finish.

2.2 PERFORMANCE REQUIREMENTS

A. Structural Performance: Louvers shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of louver components, noise or metal fatigue caused by louver-blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.

1. Wind Loads: Determine loads based on pressures as indicated on Drawings.

B. Seismic Performance: Louvers, including attachments to other construction, shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 .

1. Design earthquake spectral response acceleration, short period (Sds) for Project: Reference structural drawings.
2. Component Importance Factor: 1.0.

C. Louver Performance Ratings: Provide louvers complying with requirements specified, as demonstrated by testing manufacturer's stock units identical to those provided, except for length and width according to AMCA 500-L.

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces .

E. SMACNA Standard: Comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" for fabrication, construction details, and installation procedures.

2.3 FIXED, EXTRUDED-ALUMINUM LOUVERS

A. Horizontal, Wind-Driven-Rain-Resistant Louver :

1. Basis-of-Design Product: Subject to compliance with requirements, provide Construction Specialties, Inc.; Model DS-5700 or comparable product by one of the following:

    a. Airolite Company, LLC (The).
    b. Arrow United Industries; a division of Mestek, Inc.
    c. Greenheck Fan Corporation.
    d. Nystrom, Inc.
    e. Reliable Products, Inc.

2. Louver Depth: 5 inches.
3. Frame and Blade Nominal Thickness: Not less than 0.060 inch (1.52 mm) for blades and 0.080 inch (2.03 mm) for frames.
4. Louver Performance Ratings:

   a. Wind-Driven Rain Performance: Not less than 99 percent effectiveness when subjected to a rainfall rate of 3 inches (75 mm) per hour and a wind speed of 29 mph (13 m/s) at a core-area intake velocity of 98 fpm.

5. AMCA Seal: Mark units with AMCA Certified Ratings Seal.

2.4 LOUVER SCREENS

A. General: Provide screen at each exterior louver.

   1. Screen Location for Fixed Louvers: Interior face.
   2. Screening Type: Bird screening.

B. Secure screen frames to louver frames with machine screws with heads finished to match louver, spaced a maximum of 6 inches (150 mm) from each corner and at 12 inches (300 mm) o.c.

C. Louver Screen Frames: Fabricate with mitered corners to louver sizes indicated.

   1. Metal: Same type and form of metal as indicated for louver to which screens are attached.
   2. Finish: Same finish as louver frames to which louver screens are attached .
   3. Type: Rewirable frames with a driven spline or insert .

D. Louver Screening for Aluminum Louvers:

   1. Bird Screening: Aluminum, 1/2-inch- (13-mm-) square mesh, 0.063-inch (1.60-mm) wire.

2.5 MATERIALS

A. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063-T5, T-52, or T6.

B. Aluminum Sheet: ASTM B 209 (ASTM B 209M), Alloy 3003 or 5005 with temper as required for forming, or as otherwise recommended by metal producer for required finish.

C. Fasteners: Use types and sizes to suit unit installation conditions.

   1. Use hex-head or Phillips pan-head screws for exposed fasteners unless otherwise indicated.
   2. For fastening aluminum, use aluminum or 300 series stainless-steel fasteners.
   3. For color-finished louvers, use fasteners with heads that match color of louvers.

D. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.6 FABRICATION

A. Factory assemble louvers to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

B. Maintain equal louver blade spacing to produce uniform appearance.

C. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

1. Frame Type: Channel unless otherwise indicated.

D. Include supports, anchorages, and accessories required for complete assembly.

E. Provide vertical mullions of type and at spacings indicated, but not more than is recommended by manufacturer, or 72 inches (1830 mm) o.c., whichever is less.

1. Exposed Mullions: Where indicated, provide units with exposed mullions of same width and depth as louver frame. Where length of louver exceeds fabrication and handling limitations, provide interlocking split mullions designed to permit expansion and contraction.

F. Provide subsills made of same material as louvers or extended sills for recessed louvers.

G. Join frame members to each other and to fixed louver blades with fillet welds concealed from view unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

2.7 ALUMINUM FINISHES

A. Finish louvers after assembly.

B. High-Performance Organic Finish: Three -coat fluoropolymer finish complying with AAMA 2605 and containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

1. Color and Gloss: As indicated by manufacturer's designations .

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and openings, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

3.3 INSTALLATION

A. Locate and place louvers level, plumb, and at indicated alignment with adjacent work.

B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.

C. Form closely fitted joints with exposed connections accurately located and secured.

D. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

E. Protect unpainted galvanized and nonferrous-metal surfaces that are in contact with concrete, masonry, or dissimilar metals from corrosion and galvanic action by applying a heavy coating of bituminous paint or by separating surfaces with waterproof gaskets or nonmetallic flashing.

F. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required. Comply with Section 079200 "Joint Sealants" for sealants applied during louver installation.

3.4 ADJUSTING AND CLEANING

A. Clean exposed louver surfaces that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate during construction period.

B. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.

C. Restore louvers damaged during installation and construction so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.

   1. Touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

END OF SECTION 08 9119

SECTION 09 2116.23

GYPSUM BOARD SHAFT WALL ASSEMBLIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Shaft enclosures.
2. Chase enclosures.
3. Stair enclosures.
4. Horizontal enclosures.

1.2 ACTION SUBMITTALS

A. Product Data: For each gypsum board shaft-wall assembly indicated.

B. CALGreen Submittals:

1. Product Certificates for A5.405.1: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional. For the purposes of this item, "regional" is interpreted to mean within 500 miles of the project or within the State of California.
2. Product Certificates for Credit A5.405.1: For products and materials required to comply with requirements for regionally manufactured and regionally extracted and manufactured materials. Include statement indicating cost for each regionally manufactured material. For the purposes of this item "regional" is interpreted to mean within 500 miles of the project or within the State of California.
3. Section A5405.4 Recycled Content, Tier 1: use materials, equivalent in performance to virgin materials. Provide cost documentation showing value of recycled content using A5.405.4.2.

1.3 INFORMATIONAL SUBMITTALS

A. Fire-Test-Response Reports:

1. Include data substantiating that elevator entrances and other items that penetrate each gypsum board shaft-wall assembly do not negate fire-resistance rating.

B. Research/evaluation reports.

C. Acoustical-test-response reports.

1.4 QUALITY ASSURANCE

A. Fire-Resistance-Rated Assemblies: Provide materials and construction identical to those tested in assembly indicated according to ASTM E 119 by an independent testing and inspecting agency acceptable to authorities having jurisdiction.

B. STC-Rated Assemblies: For gypsum board shaft-wall assemblies indicated to have STC ratings, provide assembly materials and construction complying with requirements of assemblies whose STC ratings were determined according to ASTM E 90 and classified according to ASTM E 413 by a qualified independent testing agency.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: The design for gypsum board shaft-wall assemblies is based on products named on Drawings by design designation of a qualified testing and inspecting agency. Subject to compliance with requirements, provide the named product or a comparable product by one of the following:

1. American Gypsum Co.
2. G-P Gypsum Corp.
3. National Gypsum Company.
4. USG Corporation, Inc.

2.2 MATERIALS AND COMPONENTS

A. General: Comply with requirements of fire-resistance-rated assemblies indicated.

1. Provide panels in maximum lengths available to eliminate or minimize end-to-end butt joints.
2. Provide auxiliary materials complying with gypsum board shaft-wall assembly manufacturer's written recommendations.

B. Recycled Content of Steel Products: Provide products with average recycled content of steel products such that post-consumer recycled content plus one-half of pre-consumer recycled content is not less than 25 percent by weight.

C. Recycled Content of Gypsum Products: Provide gypsum panel products with recycled content such that post-consumer recycled content plus one-half of pre-consumer recycled content is not less than 40 percentby weight.

D. Low-Emitting Materials: Gypsum board shaft-wall assemblies shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

E. Steel Sheet Components: Metal complying with ASTM C 645 requirements.

1. Protective Coating: Manufacturer's standard corrosion-resistant zinc coating.

F. Studs: Manufacturer's standard profile for repetitive members and corner and end members and for fire-resistance-rated assembly indicated.

1. Depth: As indicated .
2. Minimum Base Metal Thickness: As indicated .

G. Track (Runner): Manufacturer's standard J-profile track with long-leg length as standard with manufacturer, but at least 2 inches , in depth matching studs.

1. Minimum Base Metal Thickness: As indicated .

H. Jamb Struts: Manufacturer's standard J-profile strut with long-leg length of 3 inches, in depth matching studs, and not less than 0.0341 inch thick.

I. Gypsum Shaftliner Board, Moisture- and Mold-Resistant Type X: ASTM C 1658/C 1658M; manufacturer's proprietary fire-resistive liner panels with moisture- and mold-resistant core and surfaces.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Georgia-Pacific Gypsum; "DensGlass Shaftliner" or a comparable product by one of the following:

a. CertainTeed Corp.
b. Lafarge North America, Inc.
c. National Gypsum Company.
d. PABCO Gypsum.
e. Temple-Inland Inc.
f. USG Corporation.

2. Thickness: 1 inch.
3. Long Edges: Double bevel.
4. Mold Resistance: ASTM D 3273, score of 10 as rated according to ASTM D 3274.

J. Gypsum Wallboard: ASTM C 1396, core type as required by fire-resistance-rated assembly indicated.

1. Edges: Tapered.

K. Accessories: Cornerbead, edge trim, and control joints of material and shapes specified in Section 09 29 00 "Gypsum Board" that comply with gypsum board shaft-wall assembly manufacturer's written recommendations for application indicated.

L. Gypsum Wallboard Joint-Treatment Materials: ASTM C 475 and as specified in Section 09 29 00 "Gypsum Board."

M. Steel Drill Screws: ASTM C 1002, unless otherwise indicated.

1. Use screws complying with ASTM C 954 for fastening panels to steel members from 0.033 to 0.112 inch thick.

N. Track (Runner) Fasteners: Power-driven fasteners of size and material required to withstand loading conditions imposed on shaft-wall assemblies without exceeding allowable design stress of track, fasteners, or structural substrates in which anchors are embedded.

1. Powder-Actuated Fasteners: Provide powder-actuated fasteners with capability to sustain, without failure, a load equal to 10times that imposed by shaft-wall assemblies, as determined by testing conducted by a qualified independent testing agency according to ASTM E 1190.

O. Acoustical Sealant: As specified in Section 09 29 00 "Gypsum Board."

1. Use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Adhesives shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

P. Sound Attenuation Blankets: ASTM C 665 for Type I, unfaced mineral-fiber-blanket insulation produced by combining thermosetting resins with mineral fibers manufactured from slag or rock wool.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Sprayed Fire-Resistive Materials: Coordinate with gypsum shaft-wall assemblies so both elements of Work remain complete and undamaged.

B. Install gypsum board shaft-wall assemblies to comply with requirements of fire-resistance-rated assemblies indicated, manufacturer's written installation instructions, and the following:

1. ASTM C 754 for installing steel framing.
2. Division Section 09 29 00 "Gypsum Board" for applying and finishing panels.

C. Do not bridge building expansion joints with shaft-wall assemblies; frame both sides of joints with furring and other support.

D. Install supplementary framing in gypsum board shaft-wall assemblies around openings and as required for blocking, bracing, and support of gravity and pullout loads of fixtures, equipment, services, heavy trim, furnishings, and similar items that cannot be supported directly by shaft-wall assembly framing.

1. At elevator hoistway door frames, provide jamb struts on each side of door frame.
2. Where handrails directly attach to gypsum board shaft-wall assemblies, provide galvanized steel reinforcing strip with 0.0312 inch minimum thickness of base (uncoated) metal, accurately positioned and secured behind at least 1 face-layer panel.

E. Integrate stair hanger rods with gypsum board shaft-wall assemblies by locating cavity of assemblies where required to enclose rods.

F. At penetrations in shaft wall, maintain fire-resistance rating of shaft-wall assembly by installing supplementary steel framing around perimeter of penetration and fire protection behind boxes containing wiring devices, elevator call buttons, elevator floor indicators, and similar items.

G. Isolate gypsum finish panels from building structure to prevent cracking of finish panels while maintaining continuity of fire-rated construction.

H. Install control joints to maintain fire-resistance rating of assemblies.

I. Seal gypsum board shaft walls with acoustical sealant at perimeter of each assembly where it abuts other work and at joints and penetrations within each assembly. Install acoustical sealant to withstand dislocation by air-pressure differential between shaft and external spaces; maintain an airtight and smoke-tight seal; and comply with manufacturer's written instructions or ASTM C 919, whichever is more stringent.

J. In elevator shafts where gypsum board shaft-wall assemblies cannot be positioned within 2 inches of the shaft face of structural beams, floor edges, and similar projections into shaft, install 1/2 or 5/8 inch thick, gypsum board cants covering tops of projections.

1. Slope cant panels at least 75 degrees from horizontal. Set base edge of panels in adhesive and secure top edges to shaft walls at 24 inches o.c. with screws fastened to shaft-wall framing.
2. Where steel framing is required to support gypsum board cants, install framing at 24 inches o.c. and extend studs from the projection to the shaft-wall framing.

END OF SECTION 09 2116.23

SECTION 09 2216

NON-STRUCTURAL METAL FRAMING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes non-load-bearing steel framing members for the following applications:

1. Interior framing systems (e.g., supports for partition walls, framed soffits, furring, etc.).
2. Interior suspension systems (e.g., supports for ceilings, suspended soffits, etc.).

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. CALGreen Submittals:

1. Product Certificates for A5.405.1: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional. For the purposes of this item, "regional" is interpreted to mean within 500 miles of the project or within the State of California.
2. Product Certificates for Credit A5.405.1: For products and materials required to comply with requirements for regionally manufactured and regionally extracted and manufactured materials. Include statement indicating cost for each regionally manufactured material. For the purposes of this item "regional" is interpreted to mean within 500 miles of the project or within the State of California.
3. Section A5405.4 Recycled Content, Tier 1: use materials, equivalent in performance to virgin materials. Provide cost documentation showing value of recycled content using A5.405.4.2.

1.3 QUALITY ASSURANCE

A. Fire-Test-Response Characteristics: Provide materials and construction identical to those tested in assembly indicated according to ASTM E 119 by a testing and inspection agency.

B. Sound Transmission Characteristics: Provide materials and construction identical to those tested in assembly indicated according to ASTM E 90 and classified according to ASTM E 413 by a testing and inspection agency.

PART 2 - PRODUCTS

2.1 NON-LOAD-BEARING STEEL FRAMING, GENERAL

A. Recycled Content of Steel Products: Provide products with average recycled content of steel products such that post-consumer recycled content plus one-half of pre-consumer recycled content is not less than 25 percent.

B. Framing Members, General: Comply with ASTM C 754 for conditions indicated.

1. Steel Sheet Components: Comply with ASTM C 645 requirements for metal, unless otherwise indicated.
2. Protective Coating: ASTM A 653/A 653M, G40 , hot-dip galvanized, unless otherwise indicated.

2.2 SUSPENSION SYSTEM COMPONENTS

A. Tie Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.0625 inch diameter wire, or double strand of 0.0475 inch diameter wire.

B. Hanger Attachments to Concrete:

1. Anchors: Fabricated from corrosion-resistant materials with holes or loops for attaching wire hangers and capable of sustaining, without failure, a load equal to 5 times that imposed by construction as determined by testing according to ASTM E 488 by an independent testing agency.

    a. Type: Post-installed, chemical anchor .

2. Powder-Actuated Fasteners: Suitable for application indicated, fabricated from corrosion-resistant materials with clips or other devices for attaching hangers of type indicated, and capable of sustaining, without failure, a load equal to 10 times that imposed by construction as determined by testing according to ASTM E 1190 by an independent testing agency.

C. Wire Hangers: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.162 inch diameter.

D. Carrying Channels: Cold-rolled, commercial-steel sheet with a base-metal thickness of 0.0538 inch and minimum 1/2 inch wide flanges.

1. Depth: As indicated on Drawings .

E. Furring Channels (Furring Members):

1. Cold-Rolled Channels: 0.0538 inch bare-steel thickness, with minimum 1/2 inch wide flanges, 3/4 inch deep.

F. Grid Suspension System for Ceilings: ASTM C 645, direct-hung system composed of main beams and cross-furring members that interlock.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Armstrong World Industries, Inc.; Drywall Grid Systems.
    b. Chicago Metallic Corporation; 640-C or 660-C Drywall Furring System.
    c. USG Corporation; Drywall Suspension System.

2.3 STEEL FRAMING FOR FRAMED ASSEMBLIES

A. Steel Studs and Runners: ASTM C 645.
   1. Minimum Base-Metal Thickness: As indicated on Drawings .
   2. Depth: As indicated on Drawings .

B. Slip-Type Head Joints: Where indicated, provide the following:

   1. Single Long-Leg Runner System: ASTM C 645 top runner with 2 inch deep flanges in thickness not less than indicated for studs, installed with studs friction fit into top runner and with continuous bridging located within 12 inches of the top of studs to provide lateral bracing.

C. Firestop Tracks: Top runner manufactured to allow partition heads to expand and contract with movement of the structure while maintaining continuity of fire-resistance-rated assembly indicated; in thickness not less than indicated for studs and in width to accommodate depth of studs.

   1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
   2. Products: Subject to compliance with requirements, provide one of the following:

      a. Fire Trak Corp.; Fire Trak .
      b. Metal-Lite, Inc.; The System.

D. Cold-Rolled Channel Bridging: 0.0538 inch bare-steel thickness, with minimum 1/2 inch wide flanges.

   1. Depth: 1-1/2 inches .
   2. Clip Angle: Not less than 1-1/2 by 1-1/2 inches, 0.068 inch thick, galvanized steel.

2.4 AUXILIARY MATERIALS

A. Fasteners for Metal Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten steel members to substrates.

B. Isolation Strip at Exterior Walls: Provide the following:

   1. Foam Gasket: Adhesive-backed, closed-cell vinyl foam strips that allow fastener penetration without foam displacement, 1/8 inch thick, in width to suit steel stud size.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Installation Standard: ASTM C 754, except comply with framing sizes and spacing indicated.

   1. Gypsum Board Assemblies: Also comply with requirements in ASTM C 840 that apply to framing installation.

3.2 INSTALLING SUSPENSION SYSTEMS

A. Isolate suspension systems from building structure where they abut or are penetrated by building structure to prevent transfer of loading imposed by structural movement.

B. Suspend hangers from building structure as follows:

1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structural or suspension system.

a. Splay hangers only where required to miss obstructions and offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.

2. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with locations of hangers required to support standard suspension system members, install supplemental suspension members and hangers in the form of trapezes or equivalent devices.

a. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced installation standards .

3. Do not connect or suspend steel framing from ducts, pipes, or conduit.

C. Fire-Resistance-Rated Assemblies: Wire tie furring channels to supports.

D. Seismic Bracing: Sway-brace suspension systems with hangers used for support .

E. Grid Suspension Systems: Attach perimeter wall track or angle where grid suspension systems meet vertical surfaces. Mechanically join main beam and cross-furring members to each other and butt-cut to fit into wall track.

F. Installation Tolerances: Install suspension systems that are level to within 1/8 inch in 12 feet measured lengthwise on each member that will receive finishes and transversely between parallel members that will receive finishes.

3.3 INSTALLING FRAMED ASSEMBLIES

A. Where studs are installed directly against exterior masonry walls or dissimilar metals at exterior walls, install isolation strip between studs and exterior wall.

B. Install studs so flanges within framing system point in same direction.

1. Space studs as follows:

a. Single-Layer Application: 16 inches o.c., unless otherwise indicated.
b. Multilayer Application: 16 inches o.c., unless otherwise indicated.
c. Tile backing panels: 16 inches o.c., unless otherwise indicated.

C. Install tracks (runners) at floors and overhead supports. Extend framing full height to structural supports or substrates above suspended ceilings, except where partitions are indicated to terminate at suspended ceilings. Continue framing around ducts penetrating partitions above ceiling.

1. Slip-Type Head Joints: Where framing extends to overhead structural supports, install to produce joints at tops of framing systems that prevent axial loading of finished assemblies.
2. Door Openings: Screw vertical studs at jambs to jamb anchor clips on door frames; install runner track section (for cripple studs) at head and secure to jamb studs.

a. Install two studs at each jamb, unless otherwise indicated.

b. Install cripple studs at head adjacent to each jamb stud, with a minimum 1/2 inch clearance from jamb stud to allow for installation of control joint in finished assembly.
c. Extend jamb studs through suspended ceilings and attach to underside of overhead structure.

3. Other Framed Openings: Frame openings other than door openings the same as required for door openings, unless otherwise indicated. Install framing below sills of openings to match framing required above door heads.
4. Fire-Resistance-Rated Partitions: Install framing to comply with fire-resistance-rated assembly indicated and support closures and to make partitions continuous from floor to underside of solid structure.

   a. Firestop Track: Where indicated, install to maintain continuity of fire-resistance-rated assembly indicated.

5. Sound-Rated Partitions: Install framing to comply with sound-rated assembly indicated.

D. Direct Furring:

1. Screw to wood framing.
2. Attach to concrete or masonry with stub nails, screws designed for masonry attachment, or powder-driven fasteners spaced 24 inches o.c.

E. Installation Tolerance: Install each framing member so fastening surfaces vary not more than 1/8 inch from the plane formed by faces of adjacent framing.

END OF SECTION 09 2216

SECTION 09 2400

CEMENT PLASTERING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Portland Cement Plaster Finishes: Acrylic based.
2. Metal lath and metal and plastic accessories.

B. Related Sections:

1. Section 05 40 00 "Cold-Formed Metal Framing" for load-bearing steel framing.

1.2 ACTION SUBMITTALS

A. Product Data: For each product indicated.

B. Samples: For each exposed finish and for each color and texture required.

1.3 INFORMATIONAL SUBMITTALS

A. Material Certificates: For aggregates.

1.4 QUALITY ASSURANCE

A. Fire-Test-Response Characteristics: Where indicated, provide assemblies identical to those tested for fire resistance per ASTM E 119 by UL or another testing and inspecting agency acceptable to authorities having jurisdiction.

1.5 PROJECT CONDITIONS

A. Environmental Requirements, General: Comply with requirements of referenced plaster application standards and recommendations of plaster manufacturer for environmental conditions before, during, and after plaster application.

PART 2 - PRODUCTS

2.1 LATH

A. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Expanded-Metal Lath: ASTM C 847.

1. Material: Zinc-coated (galvanized) steel sheet, structural quality, with coating complying with ASTM A 653/A 653M, G60 coating designation.
2. Diamond-Mesh Lath: Flat.

   a. Weight: 3.4 lb/sq. yd..

3. Rib Lath:

   a. Flat, rib depth of not more than 1/8 inch.

      1) Weight: 3.4 lb/sq. yd..

   b. Rib depth of 3/8 inch.

      1) Weight: 4 lb/sq. yd..

C. Paper Backing: Factory bonded to back of lath, complying with FS UU-B-790, Type I.

1. Vapor-Permeable Paper: Grade D, Style 2.
2. Vapor-Retardant Paper: Grade B, Style 1 with flame-spread index of 25 per ASTM E 84.

2.2 ACCESSORIES

A. General: ASTM C 1063. Coordinate depth of accessories with thicknesses and number of plaster coats required.

B. Metal Corner Reinforcement: Expanded, large-mesh, diamond-metal lath fabricated from zinc-alloy or welded-wire mesh fabricated from 0.0475 inch diameter, zinc-coated (galvanized) wire and specially formed to reinforce external corners of portland cement plaster on exterior exposures while allowing full plaster encasement.

1. Galvanized Steel: Minimum 0.0172 inch thick.

C. Cornerbeads: Small nose cornerbeads with expanded flanges of large-mesh diamond-metal lath allowing full plaster encasement.

1. Material: Galvanized steel.

D. Casing Beads: Square-edged style, with expanded flanges.

1. Material: Galvanized steel.

E. Curved Casing Beads: Square-edged style, fabricated from aluminum coated with clear plastic, preformed into curve of radius indicated.

F. Control Joints: Prefabricated with removable protective tape on plaster face of control joints.

1. Material: Galvanized steel.
2. Type: 2-piece, casing beads with back flanges formed to produce slip-joint action, adjustable for joint widths from 1/8 to 5/8 inch.

G. Foundation Sill (Weep) Screed: Manufacturer's standard profile designed for use at sill plate line to form plaster stop and prevent plaster from contacting damp earth, fabricated from zinc-coated (galvanized) steel sheet.

H. Lath Attachment Devices: Material and type required by ASTM C 1063 for installations indicated.

2.3 PLASTER MATERIALS

A. Base-Coat Cements: Plastic cement, ASTM C 150, Type I or II, except for limitations on insoluble residue, air entrainment, and additions subsequent to calcination and with maximum plasticizing agent content not exceeding 12 percent of total volume.

B. Acrylic-Based Finish Coat: Factory-mixed formulation of acrylic emulsion, colorfast mineral pigments, and fine aggregates specifically recommended by acrylic-based finish manufacturer for use over portland cement plaster base coats.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Bonsal, W. R. Co.
   b. Dryvit Systems, Inc.
   c. Parex Incorporated.
   d. Pleko Products, Inc.
   e. Quikrete Companies (The).
   f. Senergy, Inc.
   g. Sto Industries.
   h. Stuc-O-Flex International.
   i. Thoro System Products.

C. Lime: Special hydrated lime for finishing purposes, ASTM C 206, Type S; or special hydrated lime for masonry purposes, ASTM C 207, Type S.

D. Sand Aggregate for Base Coats: ASTM C 897.

E. Aggregate for Finish Coats: ASTM C 897 system, manufactured or natural sand, in color matching sample.

2.4 MISCELLANEOUS MATERIALS

A. Fiber for Base Coat: Alkaline-resistant glass or polypropylene fibers, 1/2 inch long, free of contaminates, manufactured for use in portland cement plaster.

B. Water for Mixing and Finishing Plaster: Potable.

C. Bonding Agent: ASTM C 932.

D. Acid-Etching Solution: Muriatic acid (10 percent solution of commercial hydrochloric acid) mixed 1 part to not less than 6 nor more than 10 parts water.

E. Dash-Coat Material: 2 parts portland cement to 3 parts fine sand, mixed with water to a mushy-paste consistency.

F. Asphalt-Saturated Felt: ASTM D 226, Type I (No. 15), nonperforated.

G. Line Wire: 0.0475 inch diameter, zinc-coated (galvanized), soft, annealed steel wire.

H. Steel Drill Screws:

1. ASTM C 1002 for fastening metal lath to wood or steel members less than 0.033 inch thick.
2. Steel drill screws complying with ASTM C 954 for fastening metal lath to steel members 0.033 to 0.112 inch thick.

I. Acoustical Sealant for Exposed and Concealed Joints: Nonsag, paintable, nonstaining, latex sealant complying with ASTM C 834 that effectively reduces airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E 90.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. ChemRex, Inc., Contech Brands; PL Acoustical Sealant.
   b. Pecora Corp.; AC-20 FTR Acoustical and Insulation Sealant.
   c. United States Gypsum Co.; SHEETROCK Acoustical Sealant.

2. Sealants shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.5 PLASTER MIXES AND COMPOSITIONS

A. General: Comply with ASTM C 926.

1. Base-Coat Mixes and Compositions: Adjust mix proportions within limits specified to attain workability.
2. Fiber: Not to exceeding 1 lb/cu. ft. of cementitious materials. Add to mixes according to fiber manufacturer's written instructions after other mix components have been mixed at least 2 minutes. Reduce aggregate quantities accordingly to maintain workability.

B. Three-Coat Work over Metal Lath:

1. Scratch and Brown Coat Mixes: Scratch, 1 part plastic cement, 1 part portland cement, 2-1/2 to 4 parts aggregate; brown, 1 part plastic cement, 1 part portland cement, 3 to 5 parts aggregate.

C. Two-Coat Work over Concrete Unit Masonry:

1. Base Coat Mix: 1 part plastic cement, 3 to 4 parts aggregate.

D. Acrylic-Based Finish Coat: Apply material as factory packaged; do not add other ingredients; comply with manufacturer's written instructions.

PART 3 - EXECUTION

3.1 LATH AND FURRING INSTALLATION, GENERAL

A. Standards: Comply with ML/SFA 920, "Guide Specifications for Metal Lathing and Furring," and ASTM C 1063.

B. Install supplementary framing, blocking, and bracing at terminations in work and for support of fixtures, equipment services, heavy trim, grab bars, handrails, furnishings, and similar work to comply with details indicated or, if not otherwise indicated, to comply with applicable written instructions of lath and furring manufacturer.

C. Isolation: Where lathing and metal support system abut building structure horizontally and where partition or wall abuts overhead structure, isolate from structural movement to prevent transfer of loading from building structure.

1. Frame both sides of control joints independently and do not bridge joints with furring and lathing or accessories.

D. Install additional framing, furring, runners, lath, and beads, as required to form openings and frames for other work as indicated. Coordinate support system for proper support of framed work that is not indicated to be supported independently of metal furring and lathing system.

3.2 LATHING

A. Install where plaster base coats are required. Provide appropriate type, configuration, and weight of metal lath selected from materials indicated that comply with referenced ML/SFA specifications and ASTM lathing installation standards.

1. Suspended and Furred Ceilings: Use flat, diamond-mesh lath.
2. Vertical Metal Framing and Furring: Use flat, diamond-mesh lath and cold-rolled channel stud framing.
3. Exterior Sheathed Wall Surfaces: Use self-furring, diamond-mesh lath.
4. Monolithic Surfaces: Use self-furring, diamond-mesh lath or vertical metal framing and furring as required for plaster thickness.

3.3 PREPARATIONS FOR PLASTERING

A. Protect contiguous Work from damage and deterioration caused by plastering with temporary covering and other provisions necessary.

B. Clean plaster bases and substrates for direct application of plaster, removing loose material and substances that may impair the Work.

C. Etch concrete and concrete unit masonry surfaces indicated for direct plaster application. Scrub with acid-etching solution on previously wetted surface and rinse thoroughly with clean water. Repeat application, if necessary, to obtain adequate suction and mechanical bond of plaster (where dash coat, bonding agent, or additive is not used).

D. Apply bonding agent on concrete and concrete unit masonry surfaces indicated for direct plaster application.

E. Apply dash coat on concrete surfaces indicated for direct plaster application. Moist-cure dash coat for at least 24 hours after application and before plastering.

F. Install temporary grounds and screeds to ensure accurate rodding of plaster to true surfaces; coordinate with scratch-coat work.

G. Refer to Division 06 Sections for installing permanent wood grounds.

H. Refer to Division 07 Sections for installing flashing.

I. Surface Conditioning: Immediately before plastering, dampen concrete and concrete unit masonry substrates, except where a bonding agent has been applied, to produce optimum suction for plastering.

3.4 PLASTERING ACCESSORIES INSTALLATION

A. General: Comply with referenced lathing and furring installation standards for provision and location of plaster accessories. Miter or cope accessories at corners; install with tight joints and in alignment. Attach accessories securely to plaster bases to hold accessories in place and in alignment during plastering.

1. External Corners: Install corner reinforcement at external corners.
2. Terminations of Plaster: Install casing beads, unless otherwise indicated.
3. Control Joints: Install at locations indicated or, if not indicated, at locations complying with the following criteria and approved by Architect:

   a. Where an expansion or contraction joint occurs in surface of construction directly behind plaster membrane.
   b. Distance between Control Joints: Not to exceed 18 feet in either direction or a length-to-width ratio of 2-1/2 to 1.
   c. Wall Areas: Not more than 144 sq. ft..
   d. Horizontal Surfaces: Not more than 100 sq. ft. in area.
   e. Where plaster panel sizes or dimensions change, extend joints full width or height of plaster membrane.

3.5 PLASTER APPLICATION

A. Plaster Application Standard: Comply with ASTM C 926.

1. Mixing: Mechanically mix cementitious and aggregate materials for plasters to comply with applicable referenced application standard and with recommendations of plaster manufacturer.
2. Do not use materials that are frozen, caked, lumpy, dirty, or contaminated by foreign materials.
3. Do not use excessive water in mixing and applying plaster materials.

B. Flat Surface Tolerances: Do not deviate more than plus or minus 1/8 inch in 10 feet from a true plane in finished plaster surfaces, as measured by a 10 foot straightedge placed at any location on surface.

C. Grout hollow-metal frames, bases, and similar work occurring in plastered areas, with base-coat plaster material, and before lathing where necessary. Except where full grouting is indicated or required for fire-resistance rating, grout at least 6 inches at each jamb anchor.

D. Sequence plaster application with installation and protection of other work so that neither will be damaged by installation of other.

E. Plaster flush with metal frames and other built-in metal items or accessories that act as a plaster ground, unless otherwise indicated. Where interior plaster is not terminated at metal frame by casing beads, cut base coat free from metal frame before plaster sets and groove finish coat at junctures with metal.

F. Corners: Make internal corners and angles square; finish external corners flush with cornerbeads on interior work, square and true with plaster faces on exterior work.

G. Number of Coats:

1. Metal Lath: Three coats.
2. Concrete Unit Masonry: Two coats.
3. Concrete, Cast-in-Place or Precast: Two coats when surface condition complies with ASTM C 926 for plaster bonded to solid base.

H. Finish Coats:

1. Float Finish: Apply finish coat to a minimum thickness of 1/8 inch to completely cover base coat, uniformly floated to a true even plane with fine-textured finish matching sample.
2. Trowel-Textured Finish: Apply finish coat with hand-troweled-textured finish matching sample.
3. Dash Finish: Machine-apply finish-coat plaster in two coats evenly and uniformly to produce textured finish matching sample.
4. Prepared Finish: Apply stucco finish coats, acrylic-based finish coats, and other factory-prepared finish coats according to manufacturer's written instructions.
5. Moist-cure plaster base and finish coats to comply with ASTM C 926, including written instructions for time between coats and curing in "Annex A2 Design Considerations."

3.6 CUTTING, PATCHING, AND CLEANING

A. Cut, patch, replace, repair, and point up plaster as necessary to accommodate other work. Repair cracks and indented surfaces. Point-up finish plaster surfaces around items that are built into or penetrate plaster surfaces. Repair or replace work to eliminate blisters, buckles, check cracking, dry outs, efflorescence, excessive pinholes, and similar defects. Repair or replace work as necessary to comply with required visual effects.

B. Remove temporary covering and other provisions made to minimize spattering of plaster on other work. Promptly remove plaster from door frames, windows, and other surfaces not to be plastered. Repair surfaces stained, marred or otherwise damaged during plastering work.

END OF SECTION 09 2400

SECTION 09 2900

GYPSUM BOARD

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Interior gypsum wallboard.
2. Tile backing panels.

1.2 ACTION SUBMITTALS

A. Product Data: For each product indicated.

1.3 QUALITY ASSURANCE

A. Fire-Test-Response Characteristics: For gypsum board assemblies with fire-resistance ratings, provide materials and construction identical to those tested in assembly indicated according to ASTM E 119 by an independent testing and inspecting agency acceptable to authorities having jurisdiction.

B. Sound Transmission Characteristics: For gypsum board assemblies with STC ratings, provide materials and construction identical to those tested in assembly indicated according to ASTM E 90 and classified according to ASTM E 413 by a qualified independent testing agency.

C. Mockups: Before finishing gypsum board assemblies, install mockups of at least 100 sq. ft. in surface area to demonstrate aesthetic effects and qualities of materials and execution.

1. Install mockups for the following applications:

    a. Surfaces indicated to receive nontextured paint finishes.

2. Simulate finished lighting conditions for review of mockups.
3. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Low-Emitting Materials: For ceiling and wall assemblies, provide materials and construction identical to those tested in assembly and complying with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.2 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
2. Products: Subject to compliance with requirements, provide one of the products specified.

2.3 PANELS, GENERAL

A. Recycled Content: Provide gypsum panel products with recycled content such that post-consumer recycled content plus one-half of pre-consumer recycled content constitutes a minimum of 40 percent by weight.

B. Regional Materials: Gypsum panel products shall be manufactured within 500 miles of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles of Project site.

C. Regional Materials: Gypsum panel products shall be manufactured within 500 miles of Project site.

2.4 PANEL PRODUCTS

A. Manufacturers:

1. BPB Gypsum. http://www.british-gypsum.com/
2. G-P Gypsum Corporation.
3. National Gypsum Company
4. Temple-Inland Forest Products Corp.http://www.templeinland.com/
5. USG Corporation, Inc.

B. Panel Size, General: Provide in maximum lengths and widths available that will minimize joints in each area and correspond with support system indicated.

C. Gypsum Wallboard: ASTM C 1396.

1. Type X: In thickness indicated and with long edges tapered.

D. Sag-Resistant Gypsum Wallboard: ASTM C 1396, manufactured to have more sag resistance than regular-type gypsum board, 1/2 inch thick, and with long edges tapered. Provide panels of 12-foot lengths.

E. Special Fire-Resistive Type: ASTM C 1396, having improved fire resistance over standard Type X, complying with requirements of fire-resistance-rated assemblies indicated, in thickness indicated, and with long edges tapered.

1. G-P Gypsum Corporation; Type 5. www.gp.com/gypsum
2. USG Corporation, Inc.; Firecode C. www.usg.com

F. Moisture and Mold Resistant Board: ASTM C 1396/C 1396M; with moisture- and mold-resistant core and facing surfaces.

1. Core: 5/8 inch.

2. Long Edges: Tapered.
3. Mold Resistance: ASTM D 3273, score of 10 as rated according to ASTM D 3274.

G. Tile Backing Panels:

1. Cementitious Backer Units: ANSI A118.9, in thickness indicated.

2.5 TRIM ACCESSORIES

A. Interior Trim: ASTM C 1047.

1. Cornerbead: Use at outside corners, unless otherwise indicated.
2. LC-Bead: Use at exposed panel edges.
3. L-Bead: Use where indicated .
4. U-Bead: Use where indicated .
5. Expansion (Control) Joint: Use where indicated .

2.6 JOINT TREATMENT MATERIALS

A. General: Comply with ASTM C 475.

B. Joint Tape:

1. Interior Gypsum Wallboard over Metal Studs: Paper.
2. Tile Backing Panels: As recommended by panel manufacturer.

C. Joint Compound for Interior Gypsum Wallboard: For each coat use formulation that is compatible with other compounds applied on previous or for successive coats.

1. Pre-filling: At open joints and damaged surface areas, use setting-type taping compound.
2. Embedding and First Coat: For embedding tape and first coat on joints, flanges of trim accessories, and fasteners, use setting-type taping compound.
3. Fill Coat: For second coat, use setting-type, sandable topping compound.
4. Finish Coat: For third coat, use drying-type, all-purpose compound.
5. Skim Coat: For final coat of Level 5 finish, use drying-type, all-purpose compound.

D. Joint Compound for Tile Backing Panels:

1. Cementitious Backer Units: As recommended by manufacturer.

2.7 AUXILIARY MATERIALS

A. General: Provide auxiliary materials that comply with referenced installation standards and manufacturer's written recommendations.

B. Acoustical Sealant for Exposed and Concealed Joints: Nonsag, paintable, nonstaining, latex sealant, with a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24), complying with ASTM C 834 that effectively reduces airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E 90.

1. Products:

a. OSI Sealants, Inc.; Pro-Series, SC 175 Acoustical Sound Sealant Non-Flammable - Latex. www.osisealants.com
b. Pecora Corporation; AC-20 + Silicone. www.pecora.com
c. Tremco, Incorporated; Tremflex 834. www.tremcosealants.com
d. United States Gypsum Co.; SHEETROCK Acoustical Sealant. www.usg.com

C. Steel Drill Screws: ASTM C 1002, unless otherwise indicated.

1. For fastening cementitious backer units, use screws of type and size recommended by panel manufacturer.

D. Isolation Strip at Exterior Walls:

1. Foam Gasket: Adhesive-backed, closed-cell vinyl foam strips that allow fastener penetration without foam displacement, 1/8 inch thick, in width to suit steel stud size.

E. Sound Attenuation Blankets: ASTM C 665, Type I (blankets without membrane facing) produced by combining thermosetting resins with mineral fibers manufactured from slag wool, or rock wool.

1. Fire-Resistance-Rated Assemblies: Comply with mineral-fiber requirements of assembly.

PART 3 - EXECUTION

3.1 PANEL PRODUCT INSTALLATION

A. Gypsum Board: Comply with ASTM C 840 and GA-216.

1. Space screws a maximum of 12 inches o.c. for vertical applications.
2. Space fasteners in panels that are tile substrates a maximum of 8 inches o.c.
3. On ceilings, apply sag-resistant gypsum panels before wall/partition board application to the greatest extent possible and at right angles to framing, unless otherwise indicated.
4. Single-Layer Fastening Methods: Apply gypsum panels to supports with steel drill screws.
5. Multilayer Fastening Methods: Fasten base layers and face layers separately to supports with screws .
6. Laminating to Substrate: Comply with gypsum board manufacturer's written recommendations and temporarily brace or fasten gypsum panels until fastening adhesive has set.

B. Tile Backing Panels:

1. Cementitious Backer Unit Application: ANSI A108.11.

3.2 FINISHING

A. Installing Trim Accessories: For trim with back flanges intended for fasteners, attach to framing with same fasteners used for panels. Otherwise, attach trim according to manufacturer's written instructions.

B. Finishing Gypsum Board Panels: Treat gypsum board joints, interior angles, edge trim, control joints, penetrations, fastener heads, surface defects, and elsewhere as required to prepare gypsum board surfaces for decoration.

1. Pre-fill open joints and damaged surface areas.

2. Apply joint tape over gypsum board joints, except those with trim having flanges not intended for tape.
3. Cementitious Backer Units: Finish according to manufacturer's written instructions.

C. Gypsum Board Finish Levels: Finish panels to levels indicated below, according to ASTM C 840, for locations indicated:

1. Level 1: Embed tape at joints in ceiling plenum areas, concealed areas, and where indicated, unless a higher level of finish is required for fire-resistance-rated assemblies and sound-rated assemblies.
2. Level 2: Embed tape and apply separate first coat of joint compound to tape, fasteners, and trim flanges where panels are substrate for tile and where indicated.
3. Level 3: Embed tape and apply separate first and fill coats of joint compound to tape, fasteners, and trim flanges where indicated.
4. Level 4: Embed tape and apply separate first, fill, and finish coats of joint compound to tape, fasteners, and trim flanges at panel surfaces that will be exposed to view, unless otherwise indicated.
5. Level 5: Embed tape and apply separate first, fill, and finish coats of joint compound to tape, fasteners, and trim flanges, and apply skim coat of joint compound over entire surface where indicated.

3.3 APPLYING TEXTURE FINISHES

A. Surface Preparation and Primer: Prepare and apply primer to gypsum panels and other surfaces receiving texture finishes. Apply primer to surfaces that are clean, dry, and smooth.

B. Texture Finish Application: Mix and apply finish using powered spray equipment, to produce a uniform texture matching approved mockup and free of starved spots or other evidence of thin application or of application patterns.

C. Prevent texture finishes from coming into contact with surfaces not indicated to receive texture finish by covering them with masking agents, polyethylene film, or other means. If, despite these precautions, texture finishes contact these surfaces, immediately remove droppings and overspray to prevent damage according to texture finish manufacturer's written recommendations.

END OF SECTION 09 2900

SECTION 09 3000

TILING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Ceramic mosaic tile.
2. Paver tile.
3. Glazed wall tile.
4. Stone thresholds installed as part of tile installations.
5. Waterproof membrane for thin-set tile installations.
6. Crack-suppression membrane for thin-set tile installations.
7. Joint sealants installed as part of tile installations.
8. Metal edge strips installed as part of tile installations.

B. Related Sections:

1. Section 09 29 00 "Gypsum Board" for tile backing panels.

1.2 ACTION SUBMITTALS

A. Product Data: For each product indicated.

B. CALgreen Submittals:

1. Product Data for Section 5.504.4.1: For sealants, adhesives and caulks, provide documentation including printed statement of VOC content showing compliance with SCAQMD Rule 1168 VOC limits and CCR Title 17 for aerosols.

2. Product Certificates for Section A5.405.1: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. For the purposes of this requirement, “regional” is interpreted to mean within 500 miles of the project location or within the State of California.
3. Section A5405.4 Recycled Content, Tier 1: use materials, equivalent in performance to virgin materials. Provide cost documentation showing value of recycled content using A5.405.4.2.

C. Shop Drawings: Show locations of each type of tile and tile pattern. Show widths, details, and locations of expansion, contraction, control, and isolation joints.

D. Samples:

1. Each type, composition, color, and finish of tile.
2. Assembled samples with grouted joints for each color grout and for each type, composition, color, and finish of tile.
3. For each color of joint sealant.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Building Code: Comply with applicable requirements of Alberta Building Code for combustible interior finishes.
2. Accessibility Requirements: Comply with applicable requirements of the Alberta Building Code for barrier free path of travel.
3. Surface Burning Characteristics: CAN/ULC-S102-M and CAN/ULC-S102.2-M; identify products with appropriate markings of applicable testing agency.

1.4 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Tile and Trim Units: Furnish quantity of full-size units equal to 3 percent of amount installed, for each type, composition, color, pattern, and size indicated.

1.5 WARRANTY

A. The Contractor warrants the work of this Section to be in accordance with the Contract Documents and free from faults and defects in materials and workmanship for a period of 25 years. The manufacturer of adhesives, mortars, grouts and other installation materials shall provide a written twenty five (25) year warranty, which covers materials and labor - reference LATICRETE Warranty Data Sheet 025.0 for complete details and requirements. For exterior facades over steel or wood framing, the manufacturer of adhesives, mortars, grouts and other installation materials shall provide a written ten (10) years warranty, which covers replacement of LATICRETE products only – reference LATICRETE Warranty Data Sheet 230.15 for complete details and requirements.

PART 2 - PRODUCTS

2.1 PRODUCTS, GENERAL

A. ANSI Ceramic Tile Standard: Provide tile that complies with ANSI A137.1 for types, compositions, and other characteristics indicated.

1. Provide tile complying with Standard grade requirements unless otherwise indicated.

B. ANSI Standards for Tile Installation Materials: Provide materials complying with ANSI A108.02, ANSI standards referenced in other Part 2 articles, ANSI standards referenced by TCA installation methods specified in tile installation schedules, and other requirements specified.

C. FloorScore Compliance: Tile for floors shall comply with requirements of FloorScore Standard.

D. Low-Emitting Materials: Tile flooring systems shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

E. Factory Blending: For tile exhibiting color variations within ranges, blend tile in factory and package so tile units taken from one package show same range in colors as those taken from other packages and match approved Samples.

F. Mounting: For factory-mounted tile, provide back- or edge-mounted tile assemblies as standard with manufacturer unless otherwise indicated.

1. Where tile is indicated for installation on exteriors or in wet areas, do not use back- or edge-mounted tile assemblies unless tile manufacturer specifies in writing that this type of mounting is suitable for installation indicated and has a record of successful in-service performance.

G. Factory-Applied Temporary Protective Coating: Where indicated under tile type, protect exposed surfaces of tile against adherence of mortar and grout by precoating with continuous film of petroleum paraffin wax, applied hot. Do not coat unexposed tile surfaces.

2.2 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply for product selection:

1. Basis-of-Design Product: The design for each tile type is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified.
2. Products: Subject to compliance with requirements, provide one of the products specified.
3. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.3 PERFORMANCE REQUIREMENTS

A. Static Coefficient of Friction: For tile installed on walkway surfaces, provide products with the following values as determined by testing identical products per ASTM C 1028:

1. Level Surfaces: Minimum 0.6.

2.4 TILE PRODUCTS

A. Manufacturers:
1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings.

B. ANSI Ceramic Tile Standard: Provide Standard grade tile that complies with ANSI A137.1, "Specifications for Ceramic Tile," for types, compositions, and other characteristics indicated.

2.5 ACCESSORY MATERIALS

A. Thresholds: Fabricate to provide transition between adjacent floor finishes.

1. Stainless Steel, as manufactured by Schluter Systems, of height required to protect edge of tile, and of maximum lengths to minimize running joints.
   a. Product: Schluter®-QUADEC
2. Rubber transitions at other locations as detailed on the drawings.

2.6 WATERPROOFING AND CRACK-SUPPRESSION MEMBRANES FOR THIN-SET TILE INSTALLATIONS

A. Waterproofing Membrane: LATICRETE® Hydro Ban as manufactured by LATICRETE International, Inc.

B. Epoxy Waterproofing Membrane: LATAPOXY® Waterproof Flashing Mortar as manufactured by LATICRETE International, Inc.

C. Crack Suppression Membrane: LATICRETE Blue 92 Anti-Fracture Membrane as manufactured by LATICRETE International, Inc.

2.7 SETTING AND GROUTING MATERIALS

A. Installation materials as manufactured by LATICRETE International, Inc., 1 LATICRETE Park North, Bethany, CT 06524-3423 USA. Phone 800-243-4788, www.laticrete.com; www.laticrete.com/green.

B. Sound Control Underlayment: LATICRETE 170 Sound & Crack Isolation Mat (Standard or PLUS Configurations) as manufactured by LATICRETE International, Inc.

C. Latex-Portland Cement Mortar for thick beds, screeds, leveling beds and scratch/plaster coats: LATICRETE 3701 Fortified Mortar Bed** as manufactured by LATICRETE International, Inc.

D. Self-Leveling Underlayment: LATICRETE 86 LatiLevel™ as manufactured by LATICRETE International, Inc.

E. Moisture Vapor Reduction: LATAPOXY 312 Vapor Reduction Membrane as manufactured by LATICRETE International, Inc.

F. Epoxy Adhesive: LATAPOXY 300 Adhesive as manufactured by LATICRETE International, Inc.

G. Latex Portland Cement Thin Bed Mortar: LATICRETE 254 Platinum as manufactured by LATICRETE International, Inc.

H. Sound & Crack Isolation Adhesive: LATICRETE 125 Sound & Crack Adhesive as manufactured by LATICRETE International, Inc.

I. Medium Bed Mortar: LATICRETE 255 MultiMax™ as manufactured by LATICRETE International, Inc.

J. Organic Adhesive: LATICRETE 15 Premium Mastic as manufactured by LATICRETE International, Inc.

K. Epoxy Grout (Industrial): LATICRETE SpectraLOCK 2000 IG as manufactured by LATICRETE International, Inc.

L. Epoxy Grout (Commercial/Residential): LATICRETE SpectraLOCK® PRO Premium Grout** as manufactured by LATICRETE International, Inc.

M. Latex Portland Cement Grout: LATICRETE PermaColor™ Grout as manufactured by LATICRETE International, Inc.

N. Expansion and Control Joint Sealant: LATICRETE Latasil™ as manufactured by LATICRETE International, Inc.

O. Roof Deck: LATICRETE Plaza & Deck System as manufactured by LATICRETE International, Inc.

P. Spot Bonding Epoxy Adhesive: LATAPOXY 310 Stone Adhesive (Standard or Rapid Grade) as manufactured by LATICRETE International, Inc.

2.8 MISCELLANEOUS MATERIALS

A. General: Provide manufacturer's standard chemically curing, elastomeric sealants of base polymer and characteristics indicated that comply with applicable requirements in Section 07 92 00 "Joint Sealants."

1. VOC Content: Not more than 250 g/L when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. One-Part, Mildew-Resistant Silicone: ASTM C 920; Type S; Grade NS; Class 25; Uses NT, G, A, and, as applicable to nonporous joint substrates indicated, O; formulated with fungicide, intended for in-service exposures of high humidity and extreme temperatures.

    a. Products:

        1) Dow Corning Corporation; Dow Corning 786.
        2) GE Silicones; Sanitary 1700.
        3) Pecora Corporation; Pecora 898 Sanitary Silicone Sealant.

3. Multipart, Pourable Urethane Sealant for Use T: ASTM C 920; Type M; Grade P; Class 25; Uses T, M, A, and, as applicable to joint substrates indicated, O.

    a. Products:

        1) Pecora Corporation; NR-200 Urexpan.
        2) Tremco, Inc.; THC-900.

    b. Color: As indicated in schedule on Drawings.

B. Trowelable Underlayments and Patching Compounds: Latex-modified, portland cement-based formulation provided or approved by manufacturer of tile-setting materials.

C. Grout Sealer: Manufacturer's standard silicone product for sealing grout joints that does not change color or appearance of grout.

PART 3 - EXECUTION

3.1 PREPARATION

A. Remove coatings, including curing compounds and other substances that contain soap, wax, oil, or silicone, that are incompatible with tile-setting materials.

B. Fill cracks, holes, and depressions with trowelable leveling and patching compound according to tile-setting material manufacturer's written instructions.

C. Remove protrusions, bumps, and ridges by sanding or grinding.

D. Blending: For tile exhibiting color variations, use factory blended tile or blend tiles at Project site before installing.

E. Field-Applied Temporary Protective Coating: Where indicated under tile type or needed to prevent grout from staining or adhering to exposed tile surfaces, precoat them with continuous film of temporary protective coating, taking care not to coat unexposed tile surfaces.

3.2 INSTALLATION, GENERAL

A. ANSI Tile Installation Standards: Comply with parts of ANSI A108 Series "Specifications for Installation of Ceramic Tile" that apply to types of setting and grouting materials and to methods indicated in ceramic tile installation schedules.

B. TCNA Installation Guidelines: TCNA's "Handbook for Ceramic Tile Installation." Comply with TCNA installation methods indicated in ceramic tile installation schedules.

C. Extend tile work into recesses and under or behind equipment and fixtures to form complete covering without interruptions, unless otherwise indicated. Terminate work neatly at obstructions, edges, and corners without disrupting pattern or joint alignments.

D. Accurately form intersections and returns. Perform cutting and drilling of tile without marring visible surfaces. Grind cut edges of tile abutting trim, finish, or built-in items. Fit tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap tile.

E. Jointing Pattern: Lay tile in grid pattern, unless otherwise indicated. Align joints when adjoining tiles on floor, base, walls, and trim are same size. Lay out tile work and center tile fields in both directions in each space or on each wall area. Adjust to minimize tile cutting. Provide uniform joint widths, unless otherwise indicated.

F. Movement Joints: Locate movement joints and other sealant-filled joints during installation of setting materials, mortar beds, and tile. Do not saw-cut joints after installing tiles.

1. Locate joints in tile surfaces directly above joints in concrete substrates.
2. Prepare joints and apply sealants to comply with requirements in Section 07 92 00 "Joint Sealants."

G. Grout tile to comply with requirements of ANSI A108.10, unless otherwise indicated.

1. For chemical-resistant epoxy grouts, comply with ANSI A108.6.

H. Install crack isolation membrane to comply with ANSI A118.10 and membrane manufacturer's written instructions for full floor coverage.

I. Install waterproofing to comply with ANSI A108.13 and waterproofing manufacturer's written instructions to produce waterproof membrane of uniform thickness bonded securely to substrate.

1. Do not install tile over waterproofing until waterproofing has cured and been tested to determine that it is watertight.

J. For installations indicated below, follow procedures in ANSI A108 Series tile installation standards for providing 95 percent mortar coverage.

1. Tile floors in wet areas.
2. Tile floors composed of tiles8 by 8 inches or larger.
3. Tile floors composed of rib-backed tiles.

K. Install tile on floors with the following joint widths:

1. 1/8 inch or as recommended by tile manufacturer.

L. Metal Edge Strips: Install at locations indicated or where exposed edge of tile flooring meets carpet, wood, or other flooring that finishes flush with top of tile.

M. Install tile on walls with the following joint widths:

1. Ceramic Mosaic Tile: 1/8 inch.
2. Glazed Wall Tile: 1/8 inch.

N. Apply grout sealer to cementitious grout joints in tile floors according to grout-sealer manufacturer's written instructions. As soon as grout sealer has penetrated grout joints, remove excess sealer and sealer that has gotten on tile faces by wiping with soft cloth.

3.3 FLOOR TILE INSTALLATION SCHEDULE

A. Interior floor installation on concrete; cement mortar bed (thickset) with cleavage membrane; TCNA F111.

1. Bond Coat/Thin-Set Mortar: Latex-portland cement mortar.
2. Grout: Polymer-modified sanded grout.

B. Interior floor installation on concrete; thin-set mortar; TCNA F113.

1. Thin-Set Mortar: Latex-portland cement mortar.
2. Grout: Polymer-modified sanded grout.

C. Interior floor installation on concrete; water-cleanable epoxy adhesive; TCNA F116.

1. Grout: Polymer-modified sanded grout.

D. Interior floor installation on waterproof crack-suppression membrane over concrete cement mortar bed (thickset); TCNA F121.

1. Bond Coat/Thin-Set Mortar: Latex-portland cement mortar.
2. Grout: Polymer-modified sanded grout.

E. Interior floor installation on waterproof crack-suppression membrane over concrete; thin-set mortar; TCNA F122.

1. Thin-Set Mortar: Latex-portland cement mortar.
2. Grout: Polymer-modified sanded grout.

3.4 WALL TILE INSTALLATION SCHEDULE

A. Interior wall installation with waterproof membrane over masonry or concrete; cement mortar bed (thickset); TCNA W201.

1. Bond Coat/Thin-Set Mortar: Latex-portland cement mortar.
2. Grout: Polymer-modified sanded grout.

B. Interior wall installation over masonry or concrete; thin-set mortar; TCNA W202.

1. Thin-Set Mortar: Latex-portland cement mortar.
2. Grout: Polymer-modified sanded grout.

C. Interior wall installation over masonry or concrete; cement mortar bed (thickset) bonded to substrate; TCNA W211.

1. Bond Coat/Thin-Set Mortar: Latex- portland cement mortar.
2. Grout: Polymer-modified sanded grout.

D. Interior wall installation with waterproof membrane over solid backing and solid anchorage for metal lath; cement mortar bed (thickset); TCNA W221.

1. Bond Coat/Thin-Set Mortar: Latex-portland cement mortar.
2. Grout: Polymer-modified sanded grout.

E. Interior wall installation; cement mortar bed (thickset); over metal studs; TCNA W241.

1. Bond Coat: Latex-portland cement mortar.
2. Grout: Polymer-modified sanded grout.

F. Interior wall installation; thin-set mortar; over gypsum board; TCNA W243.

1. Thin-Set Mortar: Latex-portland cement mortar.
2. Grout: Polymer-modified sanded grout.

G. Interior wall installation over glass-mat, water-resistant backer board; thin-set mortar; TCNA W245.

1. Thin-Set Mortar: Latex-portland cement mortar.
2. Grout: Polymer-modified sanded grout.

END OF SECTION 09 3000

SECTION 09 5113

ACOUSTICAL PANEL CEILINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes acoustical panels and exposed suspension systems for ceilings.

B. Products furnished, but not installed under this Section, include anchors, clips, and other ceiling attachment devices to be cast in concrete.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating costs for each product having recycled content.
2. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.
3. Laboratory Test Reports for Credit EQ 4: For ceiling systems and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. CALgreen Submittals:

1. Product Data for Section 5.504.4.1: For sealants, adhesives and caulking, provide documentation including printed statement of VOC content showing compliance with SCAQMD Rule 1168 VOC limits and CCR Title 17 for aerosols.
2. Product Data for Section 5.504.4.3: for paints and coatings, provide documentation that products comply with VOC limits of Air Resource Board Architectural Coatings Suggested Control Measure and CCAR Title 17 for aerosols.

D. Samples for Verification: For each component indicated and for each exposed finish required, prepared on Samples of size indicated below.

1. Acoustical Panel: Set of 6-inch- (150-mm-) square Samples of each type, color, pattern, and texture.
2. Exposed Suspension-System Members, Moldings, and Trim: Set of 6-inch- (150-mm-) long Samples of each type, finish, and color.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which suspension systems will be attached.
3. Size and location of initial access modules for acoustical panels.
4. Items penetrating finished ceiling including the following:

    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels..

5. Perimeter moldings.

B. Product Test Reports: For each acoustical panel ceiling, for tests performed by manufacturer and witnessed by a qualified testing agency .

C. Evaluation Reports: For each acoustical panel ceiling suspension system and anchor and fastener type, from ICC-ES.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For finishes to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Build mockup of typical ceiling area as shown on Drawings, or if not shown, as directed by Architect.
2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver acoustical panels, suspension-system components, and accessories to Project site in original, unopened packages and store them in a fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.

B. Before installing acoustical panels, permit them to reach room temperature and a stabilized moisture content.

C. Handle acoustical panels carefully to avoid chipping edges or damaging units in any way.

1.8 FIELD CONDITIONS

A. Environmental Limitations: Do not install acoustical panel ceilings until spaces are enclosed and weatherproof, wet work in spaces is complete and dry, work above ceilings is complete, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Acoustical ceiling shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

B. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: Comply with ASTM E 1264 for Class A materials.
2. Smoke-Developed Index: 50 or less.

2.2 ACOUSTICAL PANELS, GENERAL

A. Low-Emitting Materials: Acoustical panel ceilings shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Source Limitations: Obtain each type of acoustical ceiling panel and supporting suspension system from single source from single manufacturer.

C. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 20 percent.

D. Glass-Fiber-Based Panels: Made with binder containing no urea formaldehyde.

E. Acoustical Panel Standard: Provide manufacturer's standard panels of configuration indicated that comply with ASTM E 1264 classifications as designated by types, patterns, acoustical ratings, and light reflectances unless otherwise indicated.

1. Mounting Method for Measuring NRC: Type E-400; plenum mounting in which face of test specimen is 15-3/4 inches (400 mm) away from test surface according to ASTM E 795.

F. Acoustical Panel Colors and Patterns: Match appearance characteristics indicated for each product type.

1. Where appearance characteristics of acoustical panels are indicated by referencing pattern designations in ASTM E 1264 and not manufacturers' proprietary product designations, provide products selected by Architect from each manufacturer's full range that comply with requirements indicated for type, pattern, color, light reflectance, acoustical performance, edge detail, and size.

2.3 ACOUSTICAL PANELS

A. Reference Finish Legend in the Drawings for design selections.

2.4 METAL SUSPENSION SYSTEMS, GENERAL

A. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Metal Suspension-System Standard: Provide manufacturer's standard direct-hung metal suspension systems of types, structural classifications, and finishes indicated that comply with applicable requirements in ASTM C 635/C 635M.

1. High-Humidity Finish: Comply with ASTM C 635/C 635M requirements for "Coating Classification for Severe Environment Performance" where high-humidity finishes are indicated, or if not indicated, as directed by Architect.

C. Attachment Devices: Size for five times the design load indicated in ASTM C 635/C 635M, Table 1, "Direct Hung," unless otherwise indicated. Comply with seismic design requirements.

1. Anchors in Concrete: Anchors of type and material indicated below, with holes or loops for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to five times that imposed by ceiling construction, as determined by testing according to ASTM E 488 or ASTM E 1512 as applicable, conducted by a qualified testing and inspecting agency.

a. Type: Cast-in-place or postinstalled bonded anchors.
b. Corrosion Protection: Carbon-steel components zinc plated to comply with ASTM B 633, Class Fe/Zn 5 (0.005 mm) for Class SC 1 service condition.

D. Wire Hangers, Braces, and Ties: Provide wires complying with the following requirements:

1. Zinc-Coated, Carbon-Steel Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper.
2. Size: Select wire diameter so its stress at three times hanger design load (ASTM C 635/C 635M, Table 1, "Direct Hung") will be less than yield stress of wire, but provide not less than 0.106-inch- (2.69-mm-) diameter wire.

E. Hanger Rods and Flat Hangers: Mild steel, zinc coated or protected with rust-inhibitive paint.

F. Seismic Stabilizer Bars: Manufacturer's standard perimeter stabilizers designed to accommodate seismic forces.

G. Seismic Struts: Manufacturer's standard compression struts designed to accommodate seismic forces.

H. Seismic Clips: Manufacturer's standard seismic clips designed and spaced to secure acoustical panels in place.

2.5 METAL SUSPENSION SYSTEM

A. Reference Finish Legend in the Drawings for design selections.

2.6 METAL EDGE MOLDINGS AND TRIM

A. Roll-Formed, Sheet-Metal Edge Moldings and Trim: Type and profile indicated or, if not indicated, manufacturer's standard moldings for edges and penetrations that comply with seismic design requirements; formed from sheet metal of same material, finish, and color as that used for exposed flanges of suspension-system runners.

1. Provide manufacturer's standard edge moldings that fit acoustical panel edge details and suspension systems indicated and that match width and configuration of exposed runners unless otherwise indicated.
2. For circular penetrations of ceiling, provide edge moldings fabricated to diameter required to fit penetration exactly.

2.7 ACOUSTICAL SEALANT

A. Acoustical Sealant: Manufacturer's standard sealant complying with ASTM C 834 and effective in reducing airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E 90.

1. Exposed and Concealed Joints: Nonsag, paintable, nonstaining latex sealant.
2. Concealed Joints: Nondrying, nonhardening, nonskinning, nonstaining, gunnable, synthetic-rubber sealant.
3. Acoustical sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, including structural framing to which acoustical panel ceilings attach or abut, with Installer present, for compliance with requirements specified in this and other Sections that affect ceiling installation and anchorage and with requirements for installation tolerances and other conditions affecting performance of acoustical panel ceilings.

B. Examine acoustical panels before installation. Reject acoustical panels that are wet, moisture damaged, or mold damaged.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Measure each ceiling area and establish layout of acoustical panels to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width panels at borders, and comply with layout shown on reflected ceiling plans.

3.3 INSTALLATION

A. General: Install acoustical panel ceilings to comply with ASTM C 636/C 636M and seismic design requirements indicated, according to manufacturer's written instructions and CISCA's "Ceiling Systems Handbook."

B. Suspend ceiling hangers from building's structural members and as follows:

1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structure or of ceiling suspension system.
2. Splay hangers only where required to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
3. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension-system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices.
4. Secure wire hangers to ceiling-suspension members and to supports above with a minimum of three tight turns. Connect hangers directly either to structures or to inserts, eye screws, or other devices that are secure and appropriate for substrate and that will not deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
5. Secure flat, angle, channel, and rod hangers to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices that are secure and appropriate for both the structure to which hangers are attached and the type of hanger involved. Install hangers in a manner that will not cause them to deteriorate or fail due to age, corrosion, or elevated temperatures.
6. Do not support ceilings directly from permanent metal forms or floor deck. Fasten hangers to cast-in-place hanger inserts, post-installed mechanical or adhesive anchors, or power-actuated fasteners that extend through forms into concrete.
7. When steel framing does not permit installation of hanger wires at spacing required, install carrying channels or other supplemental support for attachment of hanger wires.
8. Do not attach hangers to steel deck tabs.
9. Do not attach hangers to steel roof deck. Attach hangers to structural members.
10. Space hangers not more than 48 inches (1200 mm) o.c. along each member supported directly from hangers unless otherwise indicated; provide hangers not more than 8 inches (200 mm) from ends of each member.
11. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards and publications.

C. Secure bracing wires to ceiling suspension members and to supports with a minimum of four tight turns. Suspend bracing from building's structural members as required for hangers, without attaching to permanent metal forms, steel deck, or steel deck tabs. Fasten bracing wires into concrete with cast-in-place or postinstalled anchors.

D. Install edge moldings and trim of type indicated at perimeter of acoustical ceiling area and where necessary to conceal edges of acoustical panels.

1. Apply acoustical sealant in a continuous ribbon concealed on back of vertical legs of moldings before they are installed.
2. Screw attach moldings to substrate at intervals not more than 16 inches (400 mm) o.c. and not more than 3 inches (75 mm) from ends, leveling with ceiling suspension system to a tolerance of 1/8 inch in 12 feet (3.2 mm in 3.6 m). Miter corners accurately and connect securely.
3. Do not use exposed fasteners, including pop rivets, on moldings and trim.

E. Install suspension-system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.

F. Install acoustical panels with undamaged edges and fit accurately into suspension-system runners and edge moldings. Scribe and cut panels at borders and penetrations to provide a neat, precise fit.

1. For square-edged panels, install panels with edges fully hidden from view by flanges of suspension-system runners and moldings.
2. For reveal-edged panels on suspension-system runners, install panels with bottom of reveal in firm contact with top surface of runner flanges.
3. For reveal-edged panels on suspension-system members with box-shaped flanges, install panels with reveal surfaces in firm contact with suspension-system surfaces and panel faces flush with bottom face of runners.
4. Paint cut edges of panel remaining exposed after installation; match color of exposed panel surfaces using coating recommended in writing for this purpose by acoustical panel manufacturer.

3.4 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:

1. Compliance of seismic design.

B. Acoustical panel ceiling hangers and anchors and fasteners will be considered defective if they do not pass tests and inspections.

3.5 CLEANING

A. Clean exposed surfaces of acoustical panel ceilings, including trim, edge moldings, and suspension-system members. Comply with manufacturer's written instructions for cleaning and touchup of minor finish damage. Remove and replace ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.

END OF SECTION 09 5113

SECTION 09 6536

STATIC-CONTROL RESILIENT FLOORING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Static-dissipative, vinyl composition floor tile and rubber sheet floor covering.
2. Conductive, solid vinyl floor tile.
3. This Section includes material designated RT-01, RT-02 on the Drawings.

B. Related Requirements:

1. Section 09 65 13 "Resilient Base and Accessories" for resilient base, reducer strips, and other accessories installed with static-control resilient flooring.

1.3 PREINSTALLATION MEETINGS

1. Review methods and procedures related to static-control resilient flooring including, but not limited to, the following:

   a. Examination and preparation of substrates to receive static-control resilient flooring.
   b. Installation including seamless installation techniques.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each type of static-control resilient flooring. Include floor-covering layouts, edges, columns, doorways, enclosing partitions, built-in furniture, cabinets, and cutouts.

1. Show details of special patterns.
2. Show locations of inscribed maintenance tiles.
3. Submit grounding diagram showing location of grounding strips and connections.

C. Samples for Initial Selection: For each type of static-control resilient flooring.

D. Samples for Verification: For each type of static-control resilient flooring, of size indicated below:

1. Floor Tile: 6-by-9-inch (150-by-230-mm) units.
2. Sheet Floor Covering: 6-by-9-inch (150-by-230-mm) sections of floor covering.

3. Heat-Welding Bead: Include manufacturer's standard-size Samples, but not less than 9 inches (230 mm) long, of each color required.

E. Seam Samples: For seamless-installation technique indicated and for each static-control resilient flooring product, color, and pattern required; with seam running lengthwise and in center of 6-by-9-inch (152-by-230-mm) Sample applied to a rigid backing and prepared by Installer for this Project.

F. Product Schedule: For static-control resilient flooring and resilient flooring RTXX

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for static-control resilient flooring.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For each type of static-control resilient flooring to include in maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Floor Tile: Furnish one box for every 50 boxes or fraction thereof, of each type, color, and pattern of floor tile installed.
2. Sheet Floor Covering: Furnish not less than 10 linear feet (3 linear m) for every 500 linear feet (150 linear m) or fraction thereof, in roll form and in full roll width for each color, pattern, and type of sheet floor covering installed.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs workers for this Project who are competent in techniques required by manufacturer for static-control resilient flooring and seaming method.

1. Engage an installer who employs workers for this Project who are trained or certified by manufacturer for installation techniques required.

B. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Build mockups for static-control resilient flooring including resilient base and accessories.

a. Size: Minimum 50 sq. ft. (9.3 sq. m) for each type, color, and pattern in locations directed by Architect.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Store static-control resilient flooring and installation materials in dry spaces protected from the weather, with ambient temperatures maintained within range recommended by manufacturer but not less than 50 deg F (10 deg C) or more than 90 deg F (32 deg C).

1. Floor Tile: Store on flat surfaces.
2. Sheet Floor Covering: Store rolls upright.

1.10 PROJECT CONDITIONS

A. Maintain ambient temperatures within range recommended by manufacturer, but not less than 70 deg F (21 deg C) or more than 85 deg F (29 deg C), in spaces to receive static-control resilient flooring during the following time periods:

1. 48 hours before installation.
2. During installation.
3. 48 hours after installation.

B. Until Substantial Completion, maintain ambient temperatures within range recommended by manufacturer, but not less than 55 deg F (13 deg C) or more than 95 deg F (35 deg C).

C. Close spaces to traffic during static-control resilient flooring installation.

D. Close spaces to traffic for 48 hours after static-control resilient flooring installation.

E. Install static-control resilient flooring after other finishing operations, including painting, have been completed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Static-Dissipative Properties: Provide static-control resilient flooring with static-control properties indicated as determined by testing identical products per test method indicated by an independent testing and inspecting agency.

1. Electrical Resistance: Test per ASTM F 150 with 100-V applied voltage ESD-STM-7.1.

   a. Average greater than 1 megohm and less than or equal to 1000 megohms when test specimens are tested surface to ground.
   b. Average greater than 1 megohm and less than or equal to 1000 megohms when installed floor coverings are tested surface to ground.

2. Static Generation: Less than 300 V when tested per AATCC-134 at 20 percent relative humidity with conductive footwear.
3. Static Decay: 5000 to zero V in less than 0.25 seconds when tested per FED-STD-101C/4046.1.

B. Conductive Properties: Provide static-control resilient flooring with static-control properties indicated as determined by testing identical products per test method indicated by an independent testing and inspecting agency.

1. Electrical Resistance: Test per ASTM F 150 with 500-V applied voltage ESD-STM-7.1 NFPA 99, Annex E UL 779.
    a. Average greater than 25,000 ohms and less than 1 megohm when test specimens and installed floor coverings are tested surface to surface (point to point).
    b. Average greater than 25,000 ohms with no single measurement less than 10,000 ohms when installed floor coverings are tested surface to ground.
2. Static Generation: Less than 100 V when tested per AATCC-134 at 20 percent relative humidity with conductive footwear.
3. Static Decay: 5000 to zero V in less than 0.03 seconds when tested per FED-STD-101C/4046.1.

C. Flooring products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

D. Fire-Test-Response Characteristics: As determined by testing identical products according to ASTM E 648 or NFPA 253 by a qualified testing agency.
1. Critical Radiant Flux Classification: Class I, not less than 0.45 W/sq. cm.

2.2 STATIC-DISSIPATIVE RESILIENT FLOOR COVERINGS

A. Static-Dissipative, Vinyl Composition Floor Tile RTXX: ASTM F 1066 (vinyl composition floor tile, nonasbestos formulated), Class 2 (through-pattern tile).
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    a. Armstrong World Industries, Inc.
2. Thickness: Not less than 0.125 inch (3.2 mm).
3. Size: 12 by 12 inches (305 by 305 mm).
4. Colors and Patterns: Refer to Drawings Finish Schedule.

2.3 CONDUCTIVE RESILIENT FLOOR COVERINGS

A. Conductive, Composite Vinyl Floor Tile RTXX: ASTM F 1303, Type II, Grade I, Class B (nonfoamed plastic backing).
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    a. Chilewich Contract.
2. Thickness: In manufacturer's standard thickness, but not less than 0.08 inch (2.0 mm).
3. Size: 18 **by 18 inches (305 by 305 mm)**.
4. Seaming Method: Standard.
5. Colors and Patterns: As indicated in Drawing Finish Schedule.

2.4 INSTALLATION MATERIALS

A. Trowelable Leveling and Patching Compounds: Latex-modified portland cement or blended hydraulic-cement-based formulation provided or approved by manufacturer for applications indicated.

B. Static-Control Adhesive: Provided or approved by manufacturer; type that maintains electrical continuity of floor-covering system to ground connection.

1. Adhesives shall have a VOC content of 50 g/L or less.
2. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

C. Grounding Strips: Provided or approved by manufacturer; type and size that maintains electrical continuity of floor-covering system to ground connection.

D. Seamless-Installation Accessories:

1. Heat-Welding Bead: Solid-strand product of manufacturer for heat welding seams.

   a. Color: Match floor covering.

2. Chemical-Bonding Compound: Product of manufacturer for chemically bonding seams.
3. Chemical-Bonding Compound shall have a VOC content of 510 g/L or less.
4. Chemical-Bonding Compound shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

E. Integral-Flash-Cove Base Accessories:

1. Cove Strip: 1-inch (25-mm) radius support strip provided or approved by manufacturer.
2. Cap Strip: Square metal, vinyl, or rubber cap provided or approved by manufacturer.
3. Corners: Metal inside and outside corners and end stops provided or approved by floor-covering manufacturer.

F. Maintenance Floor Tiles: Special floor tiles inscribed "Conductive floor. Do not wax."

G. Floor Polish: Provide protective, static-control liquid floor polish products as recommended by floor-covering manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, with Installer present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

B. Verify that finishes of substrates comply with tolerances and other requirements specified in other Sections and that substrates are free of cracks, ridges, depressions, scale, and foreign deposits that might interfere with adhesion or static-control characteristics of floor coverings.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Prepare substrates according to manufacturer's written instructions to ensure adhesion of static-control resilient flooring and electrical continuity of floor-covering systems.

B. Concrete Substrates: Prepare according to ASTM F 710.

1. Verify that substrates are dry and free of curing compounds, sealers, and hardeners.
2. Remove substrate coatings and other substances that are incompatible with floor-covering adhesives and that contain soap, wax, oil, or silicone, using mechanical methods recommended by manufacturer. Do not use solvents.
3. Alkalinity and Adhesion Testing: Perform tests recommended by manufacturer. Proceed with installation only after substrates pass testing.
4. Moisture Testing: Perform tests recommended by manufacturer. Proceed with installation only after substrates pass testing.

   a. Perform anhydrous calcium chloride test according to ASTM F 1869. Proceed with installation only after substrates have maximum moisture-vapor-emission rate of [**3 lb of water/1000 sq. ft. (1.36 kg of water/92.9 sq. m)**] <**Insert values**> in 24 hours.
   b. Perform relative-humidity test using in situ probes according to ASTM F 2170. Proceed with installation only after substrates have maximum [**75**] <**Insert number**> percent relative-humidity level measurement.

C. Access Flooring Panels: Remove protective film of oil or other coating using method recommended by access flooring manufacturer.

D. Fill cracks, holes, and depressions in substrates with trowelable leveling and patching compound and remove bumps and ridges to produce a uniform and smooth substrate.

E. Do not install static-control resilient flooring until it is same temperature as space where it is to be installed.

1. Move static-control resilient flooring and installation materials into spaces where they will be installed at least 48 hours in advance of installation.

F. Sweep and vacuum substrates to be covered by static-control resilient flooring immediately before installation.

3.3 INSTALLATION, GENERAL

A. Install static-control resilient flooring according to manufacturer's written instructions[**and with oversight by manufacturer's representative**].

B. Embed grounding strips in static-control adhesive. Extend grounding strips beyond perimeter of static-control resilient floor-covering surfaces to ground connections.

C. Scribe, cut, and fit static-control resilient flooring to butt neatly and tightly to vertical surfaces and permanent fixtures including built-in furniture, cabinets, pipes, outlets, and door frames.

D. Extend static-control resilient flooring into toe spaces, door reveals, closets, and similar openings. Extend static-control resilient flooring to center of door openings.

E. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on static-control resilient flooring as marked on substrates. Use chalk or other nonpermanent, nonstaining marking device.

F. Install static-control resilient flooring on covers for telephone and electrical ducts, and similar items in installation areas. Maintain overall continuity of color and pattern with pieces of static-control resilient flooring installed on covers. Tightly adhere static-control resilient flooring edges to substrates that abut covers and to cover perimeters.

G. Adhere static-control resilient flooring to substrates using a full spread of static-control adhesive applied to substrate to produce a completed installation without open cracks, voids, raising and puckering at joints, telegraphing of adhesive spreader marks, and other surface imperfections.

H. Seamless Installation:

1. Heat-Welded Seams: Comply with ASTM F 1516. Rout joints and heat weld with welding bead to permanently fuse sections into a seamless floor covering. Prepare, weld, and finish seams to produce surfaces flush with adjoining floor-covering surfaces.
2. Chemically Bonded Seams: Bond seams with chemical-bonding compound to permanently fuse sections into a seamless floor covering. Prepare seams and apply compound to produce tightly fitted seams without gaps, overlays, or excess bonding compound on floor-covering surfaces.

I. Integral-Flash-Cove Base: Cove static-control flooring [**6 inches (152 mm)**] [**to dimension indicated**] <**Insert dimension**> up vertical surfaces. Support static-control resilient flooring at horizontal and vertical junction with cove strip. Butt at top against cap strip.

1. Install metal corners at inside and outside corners.

3.4 FLOOR-TILE INSTALLATION

A. Comply with manufacturer's written instructions for installing floor tile.

B. Lay out floor tiles from center marks established with principal walls, discounting minor offsets, so floor tiles at opposite edges of room are of equal width. Adjust as necessary to avoid using cut widths that equal less than one-half floor tile at perimeter.

1. Lay floor tiles [**square with room axis**] [**at a 45-degree angle with room axis**] [**in pattern indicated**] <**Insert requirements**>.

C. Match floor tiles for color and pattern by selecting floor tiles from cartons in same sequence as manufactured and packaged if so numbered. Discard broken, cracked, chipped, or deformed floor tiles.

1. Lay static-dissipative, vinyl composition floor tiles [**with grain running in one direction**] [**with grain direction alternating in adjacent floor tiles (basket-weave pattern)**] [**in pattern of colors and sizes indicated**].

D. In each space where conductive, solid vinyl floor tile is installed, install maintenance floor tile identifying conductive floor tile in locations approved by Architect.

3.5 SHEET FLOOR-COVERING INSTALLATION

A. Comply with manufacturer's written instructions for installing sheet floor coverings.

B. Unroll sheet floor coverings and allow them to stabilize before cutting and fitting.

C. Lay out sheet floor coverings as follows:

1. Maintain uniformity of sheet floor-covering direction.
2. Minimize number of seams and place them in inconspicuous and low-traffic areas, at least 6 inches (152 mm) away from parallel joints in floor-covering substrates.
3. Match edges of floor coverings for color shading at seams.
4. Avoid cross seams.

3.6 FIELD QUALITY CONTROL

A. Testing: [**Owner will engage**] [**Engage**] a qualified testing agency to test electrical resistance of static-control resilient flooring for compliance with requirements.

1. Arrange for testing after static-control adhesives have fully cured and static-control resilient flooring has stabilized to ambient conditions and after ground connections are completed.
2. Arrange for testing of static-control resilient flooring [**before**] [**and**] [**after**] performing floor polish procedures.

B. Static-control resilient flooring will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.7 CLEANING AND PROTECTION

A. Comply with manufacturer's written instructions for cleaning and protection of static-control resilient flooring.

B. Perform the following operations immediately after completing static-control resilient flooring:

1. Remove static-control adhesive and other blemishes from exposed surfaces.
2. Sweep and vacuum surfaces thoroughly.
3. Damp-mop surfaces to remove marks and soil.

C. Protect static-control resilient flooring from mars, marks, indentations, and other damage from construction operations and placement of equipment and fixtures during remainder of construction period.

1. Do not wax static-control resilient flooring.
2. If recommended in writing by manufacturer, apply protective static-control floor polish formulated to maintain or enhance floor covering's electrical properties; ensure static-control resilient flooring surfaces are free from soil, static-control adhesive, and surface blemishes.

   a. Verify that both floor polish and its application method are approved by manufacturer and that floor polish will not leave an insulating film that reduces static-control resilient flooring's effectiveness for static control.

D. Cover static-control resilient flooring until Substantial Completion.

END OF SECTION 09 6536

SECTION 09 6813

TILE CARPETING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes modular, tufted carpet tile.

B. Related Requirements:
1. Section 096513 "Resilient Base and Accessories" for resilient wall base and accessories installed with carpet tile.
2. Section 096816 "Sheet Carpeting."

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review methods and procedures related to carpet tile installation including, but not limited to, the following:

a. Review delivery, storage, and handling procedures.
b. Review ambient conditions and ventilation procedures.
c. Review subfloor preparation procedures.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include manufacturer's written data on physical characteristics, durability, and fade resistance.
2. Include installation recommendations for each type of substrate.

B. LEED Submittals:

1. Product Data for Credit EQ 4.3:

a. For carpet tile, documentation indicating compliance with testing and product requirements of CRI's "Green Label Plus" program.
b. For installation adhesive, documentation including printed statement of VOC content.

2. Laboratory Test Reports for Credit EQ 4: For carpet and installation adhesives, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings: Show the following:

1. Columns, doorways, enclosing walls or partitions, built-in cabinets, and locations where cutouts are required in carpet tiles.

2. Carpet tile type, color, and dye lot.
3. Type of subfloor.
4. Type of installation.
5. Pattern of installation.
6. Pattern type, location, and direction.
7. Pile direction.
8. Type, color, and location of insets and borders.
9. Type, color, and location of edge, transition, and other accessory strips.
10. Transition details to other flooring materials.

D. Samples: For each of the following products and for each color and texture required. Label each Sample with manufacturer's name, material description, color, pattern, and designation indicated on Drawings and in schedules.

1. Carpet Tile: Full-size Sample.
2. Exposed Edge, Transition, and Other Accessory Stripping: 12-inch- long Samples.

E. Product Schedule: For carpet tile. Use same designations indicated on Drawings.

F. Sustainability: Provide the Statement of the Achievement Level the carpet has attained for Gold, 52 to 70 points, based on specific Sustainable Attribute Performance for all product stages according to ANSI/NSF 140.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Product Test Reports: For carpet tile, for tests performed by a qualified testing agency.

C. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For carpet tiles to include in maintenance manuals. Include the following:

1. Methods for maintaining carpet tile, including cleaning and stain-removal products and procedures and manufacturer's recommended maintenance schedule.
2. Precautions for cleaning materials and methods that could be detrimental to carpet tile.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Carpet Tile: Full-size units equal to 5 percent of amount installed for each type indicated, but not less than 10 sq. yd..

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is certified by the International Certified Floorcovering Installers Association at the Commercial II certification level.

B. Fire-Test-Response Ratings: Where indicated, provide carpet tile identical to those of assemblies tested for fire response according to NFPA 253 by a qualified testing agency.

C. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.

1. Build mockups at locations and in sizes shown on Drawings or directed by Architect.
2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Comply with CRI 104.

1.9 FIELD CONDITIONS

A. Comply with CRI 104 for temperature, humidity, and ventilation limitations.

B. Environmental Limitations: Do not deliver or install carpet tiles until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and ambient temperature and humidity conditions are maintained at occupancy levels during the remainder of the construction period.

C. Do not install carpet tiles over concrete slabs until slabs have cured and are sufficiently dry to bond with adhesive and concrete slabs have pH range recommended by carpet tile manufacturer.

D. Where demountable partitions or other items are indicated for installation on top of carpet tiles, install carpet tiles before installing these items.

1.10 WARRANTY

A. Special Warranty for Carpet Tiles: Manufacturer agrees to repair or replace components of carpet tile installation that fail in materials or workmanship within specified warranty period.

1. Warranty does not include deterioration or failure of carpet tile due to unusual traffic, failure of substrate, vandalism, or abuse.
2. Failures include, but are not limited to, more than 10 percent edge raveling, snags, runs, dimensional stability, excess static discharge, loss of tuft bind strength, loss of face fiber, zippering, backing resiliency loss and delamination.
3. Warranty Period: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CARPET TILE C20, C21

A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1. Tandus Flooring - Embossed Flannel #03146.

B. Color: As indicated on drawings.

C. Fiber Type: Antron Lumena Nylon.

D. Pile Characteristic: Patterned Loop pile.

E. Gage: 5/64.

F. Surface Pile Weight: 22 oz./sq. yd..

G. Size: 24 by 24 inches.

H. Primary Backing/Backcoating: Ethos.

I. Applied Soil-Resistance Treatment: Ensure.

J. Performance Characteristics: As follows:
1. Dimensional Tolerance: Within 1/32 inch of specified size dimensions, as determined by physical measurement.
2. Dimensional Stability: 0.2 percent or less according to ISO 2551 (Aachen Test).
3. Resistance to Insects: Comply with AATCC 24.
4. Colorfastness to Crocking: Not less than 4, wet and dry, according to AATCC 165.
5. Antimicrobial Activity: Not less than 2-mm halo of inhibition for gram-positive bacteria, not less than 1-mm halo of inhibition for gram-negative bacteria, and no fungal growth, according to AATCC 174.
6. Electrostatic Propensity: Less than 1.8 kV according to AATCC 134.

2.2 CARPET TILE C25

A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1. Shaw - Bon Jour 59411.

B. Color: As indicated on drawings

C. Fiber Type: Pet Polyester

D. Backing: Ecoworx Tile

E. Size: 24 by 24 inches.

F. Construction: Hobnail Thermal Bonded

G. Tufted Weight: 35.0

2.3 INSTALLATION ACCESSORIES

A. Trowelable Leveling and Patching Compounds: Latex-modified, hydraulic-cement-based formulation provided or recommended by carpet tile manufacturer.

B. C20, C21, C25 - Floating Installation System: Tandus Tape+
1. Level 1; Install at MVER ≤ 12.0 pounds
2. Levels 2 - 6; Install at MVER ≤ 8.0 pounds

C. Metal Edge/Transition Strips: Stainless steel of profile and width shown, of height required to protect exposed edge of carpet, and of maximum lengths to minimize running joints.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for maximum moisture content, alkalinity range, installation tolerances, and other conditions affecting carpet tile performance. Examine carpet tile for type, color, pattern, and potential defects.

B. Concrete Subfloors: Verify that concrete slabs comply with ASTM F 710 and the following:

1. Slab substrates are dry and free of curing compounds, sealers, hardeners, and other materials that may interfere with adhesive bond. Determine adhesion and dryness characteristics by performing bond and moisture tests recommended by carpet tile manufacturer.
2. Subfloor finishes comply with requirements specified in Section 033000 "Cast-in-Place Concrete" for slabs receiving carpet tile.
3. Subfloors are free of cracks, ridges, depressions, scale, and foreign deposits.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. General: Comply with CRI 104, Section 6.2, "Site Conditions; Floor Preparation," and with carpet tile manufacturer's written installation instructions for preparing substrates indicated to receive carpet tile installation.

B. Use trowelable leveling and patching compounds, according to manufacturer's written instructions, to fill cracks, holes, depressions, and protrusions in substrates. Fill or level cracks, holes and depressions 1/8 inch wide or wider and protrusions more than 1/32 inch unless more stringent requirements are required by manufacturer's written instructions.

C. Remove coatings, including curing compounds, and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, without using solvents. Use mechanical methods recommended in writing by carpet tile manufacturer.

D. Clean metal substrates of grease, oil, soil and rust, and prime if directed by adhesive manufacturer. Rough sand painted metal surfaces and remove loose paint. Sand aluminum surfaces, to remove metal oxides, immediately before applying adhesive.

E. Broom and vacuum clean substrates to be covered immediately before installing carpet tile.

3.3 INSTALLATION

A. General: Comply with CRI 104, Section 14, "Carpet Modules," and with carpet tile manufacturer's written installation instructions.

B. Installation Method:
1. C20, C21, C25 Floating installation with taped corners..

C. Maintain dye lot integrity. Do not mix dye lots in same area.

D. Cut and fit carpet tile to butt tightly to vertical surfaces, permanent fixtures, and built-in furniture including cabinets, pipes, outlets, edgings, thresholds, and nosings. Bind or seal cut edges as recommended by carpet tile manufacturer.

E. Extend carpet tile into toe spaces, door reveals, closets, open-bottomed obstructions, removable flanges, alcoves, and similar openings.

F. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on finish flooring as marked on subfloor. Use nonpermanent, nonstaining marking device.

G. Install pattern parallel to walls and borders.

H. Stagger joints of carpet tiles so carpet tile grid is offset from access flooring panel grid. Do not fill seams of access flooring panels with carpet adhesive; keep seams free of adhesive.

3.4 CLEANING AND PROTECTION

A. Perform the following operations immediately after installing carpet tile:

1. Remove surface blemishes using cleaner recommended by carpet tile manufacturer.
2. Remove yarns that protrude from carpet tile surface.
3. Vacuum carpet tile using commercial machine with face-beater element.

B. Protect installed carpet tile to comply with CRI 104, Section 16, "Protecting Indoor Installations."

C. Protect carpet tile against damage from construction operations and placement of equipment and fixtures during the remainder of construction period. Use protection methods indicated or recommended in writing by carpet tile manufacturer.

END OF SECTION 09 6813

SECTION 09 7713

STRETCHED-FABRIC WALL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes stretched fabric wall systems.

1.2 ACTION SUBMITTALS

A. Product Data: Submit product data for each type of frame and core material specified.

B. LEED Submittals: Submit the following in compliance with Section 01 81 13 "Sustainable Design Requirements":

1. LEED Criteria Worksheet for each component material of the product or assembly used in the installation of Work of this Section.
2. Product Data for Credit MR 4: For products having recycled content.
3. Product Certificates for Credit MR 5: For products and materials required to comply with requirements for regional materials.
4. Certificates for Credit MR 7: Chain-of-custody certificates indicating that wood-based products used in stretched-fabric systems comply with forest certification requirements.
5. Product Data for Credit IEQ 4.1: For installation adhesives.
6. Product Data for Credit IEQ 4.4: For composite wood products.

C. Shop Drawings: Submit shop drawings including attachment devices; seaming diagrams; and details at head, base, joints, corners and intersections with shelves, countertops, doors, electrical outlets and switches, thermostats, and other components. Indicate frame edge and core materials.

1. Include elevations showing panel sizes and direction of fabric weave.

D. Samples: Submit samples of the following products. Prepare Samples from the same material to be used for the Work.

1. Fabric: Full-width by 36 inch long Sample from dye lot to be used for the Work, with specified treatments applied. Show complete pattern repeat. Mark top and face of fabric.
2. Frame System: 12 inch long Sample showing edge profile and corner.
3. Core Material: 12 inch square Sample, each core type.
4. Portable mockup of complete installation, no larger than 36 by 36 inches. Show joints at seams.

1.3 INFORMATIONAL SUBMITTALS

A. Warranty: Special warranty specified in this Section.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: Submit maintenance instructions for stretched-fabric systems including fabric manufacturer's cleaning and stain-removal recommendations.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Engage a firm with a minimum of 5 years successful experience in the fabrication and erection of fabric wall panel units of similar sizes, shapes, and finishes to the units required for this Project, and which has ample production facilities to produce, furnish, and supply the units as required for this Project.

B. Sample Installations: Before installing stretched-fabric wall systems, install sample installations for each type of system and finish required to verify selections made under sample submittals and to demonstrate aesthetic affects and qualities of materials and workmanship. Install sample installations to comply with the following requirements, using materials indicated for the completed Work:

1. Install sample installations in the location and of the size indicated or, if not indicated, as directed by Architect.

   a. Include intersection at door opening.
   b. Include intersection at wall and ceiling.

2. Demonstrate the proposed range of aesthetic effects and workmanship.
3. Obtain Architect's approval of sample installations before starting installation of stretched-fabric systems.
4. Maintain sample installations during installation in an undisturbed condition as a standard for judging the completed Work.
5. Approved sample installations may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 DELIVERY AND STORAGE

A. Framing members, fabrics, and core materials shall be delivered to the job site and stored elevated above the floor in an enclosed space with proper ventilation and protection from damage.

B. Comply with fabric manufacturer's written instructions for minimum and maximum temperature and humidity requirements for storage.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Do not install stretched-fabric systems until wet-work in spaces is complete and dry, work above ceilings is complete, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

B. Field Measurements: Verify dimensions by field measurements.

C. Lighting during Installation: Provide not less than 50 fc on surface to be covered.

1.8 WARRANTY

A. Special Warranty: Provide a written warranty for a period of at least two years from date of substantial completion that the fabric installation shall remain dimensionally stable year round and will not sag or distort due to variances in temperature and humidity conditions. Further warranty that the grain and weave will be level and true and that all seams are plumb and true without sagging and equally spaced. If the fabric should sag due to climatic conditions, or if the fabric or seams are imperfect, the installing contractor will replace or repair, restretch and reinstall the fabric at his own expense. The Owner and/or Architect will be the determinant if the fabric is sagging, distorted or imperfect in any way.

PART 2 - PRODUCTS

2.1 SYSTEMS AND MANUFACTURERS

A. General: Subject to compliance with requirements, provide products by one of the following:

1. NOVAWALL® Systems, Inc.
2. Fabri-Trak Upholstered Wall System, Fabri-Trak Systems, Inc., Cranbury, NJ.

2.2 STRETCHED-FABRIC WALL SYSTEM COMPONENTS

A. Fabric: As indicated in the Drawings and specified under Section 09 72 00 "Wall Coverings." Fabrics shall be shop cut, stitched together, squared and trimmed to appropriate sizes. All sewing shall be perfectly straight, seams pressed flat. Provide appropriate lining on fabrics as required.

B. Edge Profile: Square.

C. Frame System: Extruded PVC or Extruded aluminum as follows:

1. SnapLoc 90; Stretchwall Products, Inc.
2. 10,000S 1" thick with Square Edge; Accutrack Systems, Inc.
3. Fabri-Trak 1 Inch Height SE; Fabri-Trak Systems, Inc.

2.3 CORE MATERIALS

A. Acoustical Infill: Standard acoustical infill manufactured from 1 inch thick unless otherwise indicated, 6 lb. density compressible fiberglass having an NRC value of 0.80.

B. Tackable Infill: Mineral-Fiber Board bearing a minimum density of 23 pcf, plus or minus 3 pcf, in thickness indicated, the following:

1. USG, Cloquet, MN plant; Micore.

C. Artwork Blocking: Untreated plywood, refer to Section 06 10 53 "Miscellaneous Rough Carpentry."

D. VOC Content for Core Mounting Adhesive: Not more than 70 g/L when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fabric, substrates, and conditions, with Installer present, for compliance with requirements, installation tolerances, and other conditions affecting performance of stretched-fabric systems.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Acclimatize Fabric: Before installation, allow fabric to adjust to and become stable at ambient temperature and humidity of spaces where it will be installed.

B. Install framing members at the areas indicated to receive fabric wall panels around the perimeter of each fabric panel. Install framing members wherever practical, in one continuous piece with smooth edges so as not to show irregularities. All framing members shall be installed, shimmed, plumbed, scribed and trued to align perfectly with adjacent surfaces. All framing members shall be installed in such a way as to prevent them from sagging or moving out of position after fabric has been stretched tightly over them.

C. Install core materials flush with face of stretched-fabric system track. Core shall be smooth and free from bumps and protrusions. Bond or fasten core materials to substrate by method recommended by stretched-fabric system manufacturer.

1. Install artwork blocking where indicated on the Drawings. Infill the areas between the artwork blocking and the framing members with acoustical infill core material.

D. Woof and warp yarns shall be stretched perfectly square and plumbed so that the fabric is not distorted and does not pucker or ripple. If sewn seams are required, they shall be squared with a plumb bob and must be true top to bottom without wavering. All fabrics shall be stretched and secured in such a way as not to show the fastening technique. All fabrics shall be blind fastened using manufacturer's proprietary fabric tensioning system framing on all sides of each wall area in and around cut-outs without the use of any gimp, trim, hand sewing, welts or batons. All fabric pattern and grains shall match horizontally and be perfectly level.

E. Fabric shall be removable in case of damage and easily replaceable without affecting adjacent surfaces.

3.3 INSTALLATION

A. Train Owner's permanent maintenance staff in the proper methods of maintaining, removing, installing, and replacing fabric material.

3.4 CLEANING AND PROTECTION

A. During installation, protect all existing work from damage. Remove all trimmings and other debris.

B. Immediately after the installation is completed, thoroughly clean all exposed surfaces and finished materials and restore all damaged surfaces to the complete satisfaction of the Owner and the Architect.

1. Vacuum all exposed fabric surfaces.
2. Trim and remove all loose threads.

END OF SECTION 09 7713

SECTION 09 9113

EXTERIOR PAINTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes surface preparation and the application of paint systems on exterior substrates.

B. Related Requirements:

1. Section 051200 "Structural Steel Framing" for shop priming of metal substrates with primers specified in this Section.
2. Section 099600 "High-Performance Coatings" for special-use coatings.
3. Section 099123 "Interior Painting" for surface preparation and the application of paint systems on interior substrates.

1.3 DEFINITIONS

Table 1. MPI gloss and sheen standards

Gloss Level	*Description*	*Gloss at 60°*	*Sheen at 60°*
Gloss Level 1	a traditional matte finish, flat	maximum 5 units	maximum 10 units
Gloss Level 2	a high side sheen flat, a velvet-like finish	maximum 10 units	10-35 units
Gloss Level 3	a traditional eggshell-like finish	10-25 units	10-35 units
Gloss Level 5	a traditional semi-gloss	35-70 units	
Gloss Level 6	a traditional gloss	70-85 units	

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product. Include preparation requirements and application instructions.

B. Samples for Initial Selection: For each type of topcoat product.

C. Samples for Verification: For each type of paint system and each color and gloss of topcoat.

1. Submit Samples on rigid backing, 8 inches (200 mm) square.
2. Step coats on Samples to show each coat required for system.

3. Label each coat of each Sample.
4. Label each Sample for location and application area.

D. CALgreen Submittals:

1. Product Data for Section 5.504.4.1: For sealants, adhesives and caulks, provide documentation including printed statement of VOC content showing compliance with SCAQMD Rule 1168 VOC limits and CCR Title 17 for aerosols.
2. Product Data for Section 5.504.4.3: for paints and coatings, provide documentation that products comply with VOC limits of Air Resource Board Architectural Coatings Suggested Control Measure and CCAR Title 17 for aerosols.
3. Product Certificates for Section A5.405.1: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. For the purposes of this requirement, "regional" is interpreted to mean within 500 miles of the project location or within the State of California.
4. Product data for Section A5.406.1, .2 and .3: submit documentation that materials have been selected for longevity, reduced maintenance and recyclability.
5. Section A5.405.4 Recycled Content, Tier 1: use materials, equivalent in performance to virgin materials. Provide cost documentation showing value of recycled content using A5.405.4.2.

E. Product List: For each product indicated, include the following:

1. Cross-reference to paint system and locations of application areas. Use same designations indicated on Drawings and in schedules.
2. VOC content.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Paint: 5 percent, but not less than 1 gal. (3.8 L) of each material and color applied.

1.6 QUALITY ASSURANCE

A. Mockups: Apply mockups of each paint system indicated and each color and finish selected to verify preliminary selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Architect will select one surface to represent surfaces and conditions for application of each paint system specified in Part 3.

   a. Vertical and Horizontal Surfaces: Provide samples of at least 100 sq. ft. (9 sq. m).
   b. Other Items: Architect will designate items or areas required.

2. Final approval of color selections will be based on mockups.

   a. If preliminary color selections are not approved, apply additional mockups of additional colors selected by Architect at no added cost to Owner.

3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F (7 deg C).

1. Maintain containers in clean condition, free of foreign materials and residue.
2. Remove rags and waste from storage areas daily.

1.8 FIELD CONDITIONS

A. Apply paints only when temperature of surfaces to be painted and ambient air temperatures are between 50 and 95 deg F (10 and 35 deg C).

B. Do not apply paints in snow, rain, fog, or mist; when relative humidity exceeds 85 percent; at temperatures less than 5 deg F (3 deg C) above the dew point; or to damp or wet surfaces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Benjamin Moore & Co. (Benjamin Moore).
2. Dunn Edwards
3. Glidden Professional (Glidden).
4. Sherwin-Williams Co. (Sherwin-Williams).
5. Vista Paint Corporation (Vista).

2.2 PAINT, GENERAL

A. Material Compatibility:

1. Provide materials for use within each paint system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
2. For each coat in a paint system, provide products recommended in writing by manufacturers of topcoat for use in paint system and on substrate indicated.

B. VOC Content: Provide materials that comply with VOC limits of authorities having jurisdiction.

C. Colors: As indicated in Finish Schedule.

2.3 BLOCK FILLERS

A. Block Filler, Latex, Interior/Exterior:

1. Benjamin Moore & Co. - 285 Latex Block Filler
2. Glidden Professional – 3010 Block Filler
3. Sherwin-Williams Co. – B25W25 Block Filler
4. Vista Paint Corporation – 040 Block Filler

2.4 PRIMERS/SEALERS

A. Primer, Alkali Resistant, Water Based:

1. Benjamin Moore & Co. - 023 Fresh Start Primer
2. Glidden Professional – 6001 HydroSealer
3. Sherwin-Williams Co. – A24W3000 Loxon Primer
4. Vista Paint Corporation – 4600 Uniprime II

B. Primer, Bonding, Water Based:

1. Benjamin Moore & Co. – 169 SuperSpec Masonry Primer
2. Glidden Professional – 3210 Gripper
3. Sherwin-Williams Co. – B28W300 Prep Rite Primer
4. Vista Paint Corporation – 188 Acrylic Primer

2.5 METAL PRIMERS

A. Primer, Alkyd Emulsion, Anti-Corrosive for Ferrous Metal:

1. Benjamin Moore & Co. - 790 Advance Primer
2. Glidden Professional – 205 Devran Primer
3. Sherwin-Williams Co. – B50WZ30 Galvite HS Primer
4. Vista Paint Corporation – 9600 Protec Metal Primer

B. Primer, Water-Based, for Galvanized:

1. Benjamin Moore & Co. – M04 Acrylic Metal Primer
2. Glidden Professional - 4020 Devflex Primer
3. Sherwin-Williams Co. – B66A50 DTM Bonding Primer
4. Vista Paint Corporation – 4800 Metal Pro Primer

C. Primer, Water-Based, for Aluminum:

1. Benjamin Moore & Co. – M04 Acrylic Metal Primer
2. Glidden Professional - 4020 Devflex Primer
3. Sherwin-Williams Co. – B66A50 DTM Bonding Primer
4. Vista Paint Corporation – 4800 Metal Pro Primer

2.6 WOOD PRIMERS

A. Primer, Latex for Exterior Wood:

1. Benjamin Moore & Co. – 023 Fresh Start Primer
2. Glidden Professional – 3210 Gripper
3. Sherwin-Williams Co. – B51 W20 PrepRite Pro Block
4. Vista Paint Corporation – 4200 Terminator II

2.7 WATER-BASED PAINTS

A. Latex, Exterior Flat (Gloss Level 1):

1. Benjamin Moore & Co. – 105 MoorLife Flat
2. Glidden Professional – 6201 Fortis 450 Flat
3. Sherwin-Williams Co. – K33 Duration Flat
4. Vista Paint Corporation – 2000 Duratone Flat

B. Latex, Exterior Velva Sheen (Gloss Level 2):

1. Benjamin Moore & Co. - 103 MoorGard Low Sheen
2. Glidden Professional - NA
3. Sherwin-Williams Co. – A89 Super Paint Satin
4. Vista Paint Corporation – 6200 Carefree Velva Sheen

C. Latex, Exterior Eggshell (Gloss Level 3):

1. Benjamin Moore & Co. - NA
2. Glidden Professional – 6403 Fortis 450 Satin
3. Sherwin-Williams Co. – K34 Duration Satin
4. Vista Paint Corporation – 8300 / 6300 Carefree Eggshell

D. Latex, Exterior Semi-Gloss (Gloss Level 5):

1. Benjamin Moore & Co. – 096 MoorGard Semi-Gloss
2. Glidden Professional – 6407 Fortis 450 Semi-Gloss
3. Sherwin-Williams Co. – B42 Metalatex Semi-Gloss
4. Vista Paint Corporation – 8400 / 6400 Carefree Semi-Gloss

E. Latex, Exterior, Gloss (Gloss Level 6):

1. Benjamin Moore & Co. – M28 Acrylic Gloss
2. Glidden Professional - NA
3. Sherwin-Williams Co. – A85 Super Paint Gloss
4. Vista Paint Corporation – 8500 Carefree Gloss

F. Light Industrial Coating, Exterior, Water-Based Alkyd Emulsion, Eggshell (Gloss Level 3):

1. Benjamin Moore & Co. - NA
2. Glidden Professional – 1502 Lifemaster Oil Eggshell
3. Sherwin-Williams Co. - NA
4. Vista Paint Corporation – 9700 Protec Satin

G. Light Industrial Coating, Exterior, Water-Based, Alkyd Emulsion, Semi-Gloss (Gloss Level 5):

1. Benjamin Moore & Co. - NA
2. Glidden Professional – 1506 Lifemaster Oil Semi-Gloss
3. Sherwin-Williams Co. - NA
4. Vista Paint Corporation – 9800 Protec Semi-Gloss

H. Light Industrial Coating, Exterior, Water-Based, Alkyd Emulsion, Gloss (Gloss Level 6):

1. Benjamin Moore & Co. - NA
2. Glidden Professional – 1508 Lifemaster Oil Gloss
3. Sherwin-Williams Co. - NA
4. Vista Paint Corporation – 9900 Protec Gloss

2.8 TEXTURED AND HIGH-BUILD COATINGS

A. Primer for Textured Coating, Latex, Flat: As recommended in writing by topcoat manufacturer.

1. Benjamin Moore & Co. - 023 All Purpose Primer
2. Glidden Professional – 6001 HydroSealer
3. Sherwin-Williams Co. – A24W3000 Loxon Primer
4. Vista Paint Corporation – 4600 Uniprime II

B. Intermediate Coat for Textured Coating, Latex, Flat: As recommended in writing by topcoat manufacturer.

1. Benjamin Moore & Co. - NA
2. Glidden Professional – 2221 Decraflex
3. Sherwin-Williams Co. - NA
4. Vista Paint Corporation – 1900 Weather Master

C. Textured Coating, Latex, Flat:

1. Benjamin Moore & Co. - NA
2. Glidden Professional – 2221 Decraflex
3. Sherwin-Williams Co. - NA
4. Vista Paint Corporation – 1900 Weather Master

D. Primer for Latex, Exterior, High Build: As recommended in writing by topcoat manufacturer.

1. Benjamin Moore & Co. - 023 Fresh Start Primer
2. Glidden Professional – 6001 HydroSealer
3. Sherwin-Williams Co. – A24W3000 Loxon Primer
4. Vista Paint Corporation – 4600 Uniprime II

E. Intermediate Coat for Latex, Exterior, High-Build: As recommended in writing by topcoat manufacturer.

1. Benjamin Moore & Co. - 056 Moorlastic Elastomeric
2. Glidden Professional – 2260 Decraflex 100% Acrylic Elasteromeric
3. Sherwin-Williams Co. – A5-400 Conflex XL Smooth
4. Vista Paint Corporation - 500 Solotex 100% Acrylic Elastomeric

F. Latex, Exterior, High-Build:

1. Benjamin Moore & Co. - 056 Moorlastic Elastomeric
2. Glidden Professional - 2260 Decraflex 100% Acrylic Elasteromeric
3. Sherwin-Williams Co. - A5-400 Conflex XL Smooth
4. Vista Paint Corporation - 500 Solotex 100% Acrylic Elastomeric

2.9 ALUMINUM PAINT

A. Aluminum Paint:

1. Benjamin Moore & Co. – 138 All Purpose Aluminum Paint
2. Glidden Professional – 18480 Aluminum Paint
3. Sherwin-Williams Co. – B59S-11 Silver Brite Aluminum Paint
4. Vista Paint Corporation – Sheffield Hi-Heat Aluminum Paint

2.10 FLOOR COATINGS

A. Sealer, Water Based, for Concrete Floors:

1. Benjamin Moore & Co. – P27 Clear Acrylic Sealer
2. Glidden Professional – 3214 Concrete Coatings Clear Acrylic Sealer
3. Sherwin-Williams Co. – H + C Concrete and Masonry Sealer
4. Vista Paint Corporation – Monochem 2900 Dex-Coat Clear

B. Floor Paint, Latex, Low Gloss (Maximum Gloss Level 3):

1. Benjamin Moore & Co. - 122 Latex Floor and Patio Enamel
2. Glidden Professional – 3018N Concrete Coatings Acrylic Floor Enamel
3. Sherwin-Williams Co. – A32W00251 Porch & Floor Satin
4. Vista Paint Corporation – 400 Acripoxy Low Gloss Acrylic

2.11 SOURCE QUALITY CONTROL

A. Testing of Paint Materials: Owner reserves the right to invoke the following procedure:

1. Owner will engage the services of a qualified testing agency to sample paint materials. Contractor will be notified in advance and may be present when samples are taken. If paint materials have already been delivered to Project site, samples may be taken at Project site. Samples will be identified, sealed, and certified by testing agency.
2. Testing agency will perform tests for compliance with product requirements.
3. Owner may direct Contractor to stop applying paints if test results show materials being used do not comply with product requirements. Contractor shall remove noncomplying paint materials from Project site, pay for testing, and repaint surfaces painted with rejected materials. Contractor will be required to remove rejected materials from previously painted surfaces if, on repainting with complying materials, the two paints are incompatible.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

B. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:

1. Concrete: 12 percent.
2. Masonry (Clay and CMU): 12 percent.
3. Wood: 15 percent.
4. Portland Cement Plaster: 12 percent.
5. Gypsum Board: 12 percent.

C. Portland Cement Plaster Substrates: Verify that plaster is fully cured.

D. Exterior Gypsum Board Substrates: Verify that finishing compound is sanded smooth.

E. Verify suitability of substrates, including surface conditions and compatibility with existing finishes and primers.

F. Proceed with coating application only after unsatisfactory conditions have been corrected.

1. Application of coating indicates acceptance of surfaces and conditions.

3.2 PREPARATION

A. Comply with manufacturer's written instructions and recommendations in "MPI Manual" applicable to substrates and paint systems indicated.

B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.

1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection.

C. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints and encapsulants.

1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce paint systems indicated.

D. Concrete Substrates: Remove release agents, curing compounds, efflorescence, and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces to be painted exceeds that permitted in manufacturer's written instructions.

E. Masonry Substrates: Remove efflorescence and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces or mortar joints exceeds that permitted in manufacturer's written instructions.

F. Steel Substrates: Remove rust, loose mill scale, and shop primer if any. Clean using methods recommended in writing by paint manufacturer.

1. SSPC-SP 2, "Hand Tool Cleaning."
2. SSPC-SP 3, "Power Tool Cleaning."
3. SSPC-SP 7/NACE No. 4, "Brush-off Blast Cleaning."
4. SSPC-SP 11, "Power Tool Cleaning to Bare Metal."

G. Shop-Primed Steel Substrates: Clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material as used for shop priming to comply with SSPC-PA 1 for touching up shop-primed surfaces.

H. Galvanized-Metal Substrates: Remove grease and oil residue from galvanized sheet metal by mechanical methods to produce clean, lightly etched surfaces that promote adhesion of subsequently applied paints.

I. Aluminum Substrates: Remove loose surface oxidation.

J. Wood Substrates:

1. Scrape and clean knots. Before applying primer, apply coat of knot sealer recommended in writing by topcoat manufacturer for exterior use in paint system indicated.
2. Sand surfaces that will be exposed to view, and dust off.
3. Prime edges, ends, faces, undersides, and backsides of wood.
4. After priming, fill holes and imperfections in the finish surfaces with putty or plastic wood filler. Sand smooth when dried.

K. Plastic Trim Fabrication Substrates: Remove dust, dirt, and other foreign material that might impair bond of paints to substrates.

3.3 APPLICATION

A. Apply paints according to manufacturer's written instructions and recommendations in "MPI Manual."

1. Use applicators and techniques suited for paint and substrate indicated.
2. Paint surfaces behind movable items same as similar exposed surfaces. Before final installation, paint surfaces behind permanently fixed items with prime coat only.
3. Paint both sides and edges of exterior doors and entire exposed surface of exterior door frames.
4. Paint entire exposed surface of window frames and sashes.
5. Do not paint over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
6. Primers specified in painting schedules may be omitted on items that are factory primed or factory finished if acceptable to topcoat manufacturers.

B. Tint undercoats same color as topcoat, but tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of same material are to be applied. Provide sufficient difference in shade of undercoats to distinguish each separate coat.

C. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.

D. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.

E. Painting Fire Suppression, Plumbing, HVAC, Electrical, Communication, and Electronic Safety and Security Work:

1. Paint the following work where exposed to view:

   a. Equipment, including panelboards.
   b. Uninsulated metal piping.
   c. Uninsulated plastic piping.
   d. Pipe hangers and supports.
   e. Metal conduit.
   f. Plastic conduit.
   g. Tanks that do not have factory-applied final finishes.

3.4 FIELD QUALITY CONTROL

A. Dry Film Thickness Testing: Owner may engage the services of a qualified testing and inspecting agency to inspect and test paint for dry film thickness.

1. Contractor shall touch up and restore painted surfaces damaged by testing.
2. If test results show that dry film thickness of applied paint does not comply with paint manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry film thickness that complies with paint manufacturer's written recommendations.

3.5 CLEANING AND PROTECTION

A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

B. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

C. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.

D. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

END OF SECTION 09 9113

SECTION 09 9123

INTERIOR PAINTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes surface preparation and field painting of exposed interior items and surfaces.

B. Paint exposed surfaces. If an item or a surface is not specifically mentioned, paint the item or surface the same as similar adjacent materials or surfaces. Painting includes field painting of exposed bare and covered pipes and ducts (including color coding), hangers, exposed steel and iron supports, and surfaces of mechanical and electrical equipment that do not have a factory-applied final finish.

C. Do not paint prefinished items, concealed surfaces, finished metal surfaces, operating parts, and labels.

1.2 DEFINITIONS

A. General: Standard coating terms defined in ASTM D 16 apply to this Section.
   1. Flat refers to a lusterless or matte finish with a gloss range below 15 when measured at an 85-degree meter.
   2. Eggshell refers to low-sheen finish with a gloss range between 20 and 35 when measured at a 60-degree meter.
   3. Semigloss refers to medium-sheen finish with a gloss range between 35 and 70 when measured at a 60-degree meter.

1.3 ACTION SUBMITTALS

A. Product Data: For each paint system indicated. Include block fillers and primers.

B. Samples for Verification: For each color and material to be applied, with texture to simulate actual conditions, on representative Samples of the actual substrate.

C. Samples for Initial Selection: For each type of topcoat product.

D. Samples for Verification: For each type of paint system and in each color and gloss of topcoat.

   1. Submit Samples on rigid backing, 8 inches square.
   2. Step coats on Samples to show each coat required for system.
   3. Label each coat of each Sample.
   4. Label each Sample for location and application area.

E. Product List: For each product indicated, include the following:

   1. Cross-reference to paint system and locations of application areas. Use same designations indicated on Drawings and in schedules.
   2. Printout of current "MPI Approved Products List" for each product category specified in Part 2, with the proposed product highlighted.
   3. VOC content.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Applicator.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements: VOC and durability requirements:
   1. ASTM C 6886 Standard Test Method for Specification of the Volatile Organic Compounds in Low VOC Content Waterborne Air Dry Coatings by Gas Chromatography.
   2. ASTM D 3960 Standard Practice for Determining Volatile Organic Compound.
   3. ASTM D 2486 Standard Test Method for Scrub Resistance of Interior Wall Paint.
   4. ASTM D 2805 Standard Test Method for Hiding Power of Paints by Reflectometry.
   5. ASTM D 4828 Standard Test Method for Practical Washability of Organic Coatings.

B. Applicator Qualifications: A firm or individual experienced in applying paints and coatings similar in material, design, and extent to those indicated for this Project, whose work has resulted in applications with a record of successful in-service performance.

C. Source Limitations: Obtain primers for each coating system from the same manufacturer as the finish coats.

D. Benchmark Samples (Mockups): Provide a full-coat benchmark finish sample for each type of coating and substrate required. Comply with procedures specified in PDCA P5.
   1. Wall Surfaces: Provide samples on at least 100 sq. ft.
   2. Small Areas and Items: Architect will designate items or areas required.
   3. Final approval of colors will be from benchmark samples.

1.6 PROJECT CONDITIONS

A. Apply waterborne paints only when temperatures of surfaces to be painted and surrounding air are between 50 and 90 deg.

B. Apply solvent-thinned paints only when temperatures of surfaces to be painted and surrounding air are between 45 and 95 deg.

C. Do not apply paint in snow, rain, fog, or mist; or when relative humidity exceeds 85 percent; or at temperatures less than 5 deg F above the dew point; or to damp or wet surfaces.
   1. Painting may continue during inclement weather if surfaces and areas to be painted are enclosed and heated within temperature limits specified by manufacturer during application and drying periods.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the products listed in other Part 2 articles.

B. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
   1. Color your World.

2. Para Paints.
3. Benjamin Moore & Co. (Benjamin Moore).
4. PPG Industries, Inc. (Pittsburgh Paints).
5. Sherwin-Williams Co. (Sherwin-Williams).

2.2 PAINT, GENERAL

A. Material Compatibility: Provide block fillers, primers, and finish-coat materials that are compatible with one another and with the substrates indicated under conditions of service and application, as demonstrated by manufacturer based on testing and field experience.

B. Material Quality: Provide manufacturer's best-quality paint material of the various coating types specified that are factory formulated and recommended by manufacturer for application indicated. Paint-material containers not displaying manufacturer's product identification will not be acceptable.
   1. Proprietary Names: Use of manufacturer's proprietary product names to designate colors or materials is not intended to imply that products named are required to be used to the exclusion of equivalent products of other manufacturers. Furnish manufacturer's material data and certificates of performance for proposed substitutions.

C. VOC Content of Field-Applied Interior Paints and Coatings: Provide products that comply with the following limits for VOC content, exclusive of colorants added to a tint base, when calculated according to 40 CFR 59, Subpart D (EPA Method 24); these requirements do not apply to paints and coatings that are applied in a fabrication or finishing shop:
   1. Flat Paints, Coatings, and Primers: VOC content of not more than 50 g/L.
   2. Nonflat Paints, Coatings, and Primers: VOC content of not more than 150 g/L.
   3. Anti-Corrosive and Anti-Rust Paints Applied to Ferrous Metals: VOC content not more than 250 g/L.
   4. Floor Coatings: VOC content not more than 100 g/L.
   5. Shellacs, Clear: VOC content not more than 730 g/L.
   6. Shellacs, Pigmented: VOC content not more than 550 g/L.
   7. Flat Topcoat Paints: VOC content of not more than 50 g/L.
   8. Nonflat Topcoat Paints: VOC content of not more than 50 g/L.
   9. Anti-Corrosive and Anti-Rust Paints Applied to Ferrous Metals: VOC content not more than 100 g/L.
   10. Floor Coatings: VOC content not more than 50 g/L.
   11. Shellacs, Clear: VOC content not more than 730 g/L.
   12. Shellacs, Pigmented: VOC content not more than 550 g/L.
   13. Primers, Sealers, and Undercoaters: VOC content of not more than 100 g/L.
   14. Dry-Fog Coatings: VOC content of not more than 150 g/L.
   15. Zinc-Rich Industrial Maintenance Primers: VOC content of not more than 100 g/L.
   16. Pre-Treatment Wash Primers: VOC content of not more than 420 g/L.

D. Chemical Components of Field-Applied Interior Paints and Coatings: Provide topcoat paints and anti-corrosive and anti-rust paints applied to ferrous metals that comply with the following chemical restrictions; these requirements do not apply to paints and coatings that are applied in a fabrication or finishing shop:
   1. Aromatic Compounds: Paints and coatings shall not contain more than 1.0 percent by weight of total aromatic compounds (hydrocarbon compounds containing one or more benzene rings).
   2. Restricted Components: Paints and coatings shall not contain any of the following:
      a. Acrolein.
      b. Acrylonitrile.
      c. Antimony.
      d. Benzene.
      e. Butyl benzyl phthalate.
      f. Cadmium.
      g. Di (2-ethylhexyl) phthalate.

h. Di-n-butyl phthalate.
i. Di-n-octyl phthalate.
j. 1,2-dichlorobenzene.
k. Diethyl phthalate.
l. Dimethyl phthalate.
m. Ethylbenzene.
n. Formaldehyde.
o. Hexavalent chromium.
p. Isophorone.
q. Lead.
r. Mercury.
s. Methyl ethyl ketone.
t. Methyl isobutyl ketone.
u. Methylene chloride.
v. Naphthalene.
w. Toluene (methylbenzene).
x. 1,1,1-trichloroethane.
y. Vinyl chloride.

E. Colors: As indicated on Finish Schedule by manufacturer's designations.

2.3 INTERIOR PRIMERS

A. Interior Gypsum Board Primer: Factory-formulated latex-based primer for interior application.

B. Interior Wood Primer for Acrylic-Enamel and Semigloss Alkyd-Enamel Finishes: Factory-formulated alkyd- or acrylic-latex-based interior wood primer.

C. Interior Ferrous-Metal Primer: Factory-formulated quick-drying rust-inhibitive alkyd-based metal primer.

D. Interior Zinc-Coated Metal Primer: Factory-formulated galvanized metal primer.

2.4 INTERIOR FINISH COATS

A. Interior Flat Acrylic Paint: Factory-formulated flat acrylic-emulsion latex paint for interior application.
   1. Benjamin Moore; Pristine Eco Spec WB Interior Waterborne Flat Finish 373: Applied at a dry film thickness of not less than 0.033 mm (1.3 mils).
   2. Pittsburgh Paints; 80-Line Wallhide Interior Wall Flat Latex Paint: Applied at a dry film thickness of not less than 0.030 mm (1.2 mils).
   3. Sherwin-Williams; SuperPaint Interior Latex Flat Wall Paint, A86 Series: Applied at a dry film thickness of not less than 0.038 mm (1.5 mils).

B. Interior Flat Latex-Emulsion Size: Factory-formulated flat latex-based interior paint.
   1. Benjamin Moore; Eco Spec WB Interior Waterborne Flat Finish 373: Applied at a dry film thickness of not less than 0.033 mm (1.3 mils).
   2. Pittsburgh Paints; 6-700 Series SpeedHide Ultra Interior Wall Flat Latex 100 Percent Acrylic: Applied at a dry film thickness of not less than 0.025 mm (1.0 mil).
   3. Sherwin-Williams; SuperPaint Flat Wall Paint A86 Series: Applied at a dry film thickness of not less than 0.038 mm (1.5 mils).

C. Interior Low-Luster Acrylic Enamel: Factory-formulated eggshell acrylic-latex interior enamel.
   1. Benjamin Moore; Eco Spec WB Interior Waterborne Eggshell 374: Applied at a dry film thickness of not less than 0.036 mm (1.4 mils).

2. Pittsburgh Paints; 89-Line Manor Hall Interior Eggshell Wall and Trim: Applied at a dry film thickness of not less than 0.036 mm (1.4 mils).
3. Sherwin-Williams; SuperPaint Interior Latex Satin Wall Paint A87 Series: Applied at a dry film thickness of not less than 0.041 mm (1.6 mils).

D. Interior Semigloss Acrylic Enamel: Factory-formulated semigloss acrylic-latex enamel for interior application.
1. Benjamin Moore; Eco Spec WB Interior Waterborne Semi-Gloss 376: Applied at a dry film thickness of not less than 0.036 mm (1.4 mils).
2. Pittsburgh Paints; 88-110 Satinhide Interior Enamel Wall & Trim Lo-Lustre Semi-Gloss Latex: Applied at a dry film thickness of not less than 0.028 mm (1.1 mils).
3. Sherwin-Williams; SuperPaint Interior Latex Semi-Gloss Enamel A88 Series: Applied at a dry film thickness of not less than 0.041 mm (1.6 mils).

E. Interior Semigloss Alkyd Enamel: Factory-formulated semigloss alkyd enamel for interior application.
1. Pittsburgh Paints; 27 Line Wallhide Low Odor Interior Enamel Wall and Trim Semi-Gloss Oil: Applied at a dry film thickness of not less than 0.038 mm (1.5 mils).
2. Sherwin-Williams; Classic 99 Interior Alkyd Semi-Gloss Enamel A-40 Series: Applied at a dry film thickness of not less than 0.043 mm (1.7 mils).

2.5 INTERIOR WOOD STAINS AND VARNISHES

A. Open-Grain Wood Filler: Factory-formulated paste wood filler applied at spreading rate recommended by manufacturer.
1. Pittsburgh Paints; none required.
2. Sherwin-Williams; Sher-Wood Fast-Dry Filler.
3. Sherwin-Williams; none recommended.

B. Interior Wood Stain: Factory-formulated alkyd-based penetrating wood stain for interior application applied at spreading rate recommended by manufacturer.
1. Pittsburgh Paints; 77-560 Rez Interior Semi-Transparent Oil Stain.
2. Sherwin-Williams; Wood Classics Interior Oil Stain A-48 Series.

C. Clear Sanding Sealer: Factory-formulated fast-drying alkyd-based clear wood sealer applied at spreading rate recommended by manufacturer.
1. Pittsburgh Paints; 6-10 SpeedHide Quick-Drying Interior Sanding Wood Sealer and Finish.
2. Sherwin-Williams; Wood Classics Fast Dry Sanding Sealer B26V43.

D. Interior Alkyd- or Polyurethane-Based Clear Satin Varnish: Factory-formulated alkyd- or polyurethane-based clear varnish.
1. Pittsburgh Paints; 77-7 Rez Varnish, Interior Satin Oil Clear.
2. Sherwin-Williams; Wood Classics Fast Dry Oil Varnish, Satin A66-300 Series.

E. Interior Waterborne Clear Satin Varnish: Factory-formulated clear satin acrylic-based polyurethane varnish applied at spreading rate recommended by manufacturer.
1. Pittsburgh Paints; 77-49 Rez Satin Acrylic Clear Polyurethane.
2. Sherwin-Williams; Wood Classics Waterborne Polyurethane Satin, A68 Series.

F. Interior Waterborne Clear Gloss Varnish: Factory-formulated clear gloss acrylic-based polyurethane varnish applied at spreading rate recommended by manufacturer.
1. Pittsburgh Paints; 77-45 Rez Full-Gloss Acrylic Clear Polyurethane.
2. Sherwin-Williams; Wood Classics Waterborne Polyurethane Gloss, A68 Series.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with procedures specified in PDCA P4.

B. Coordination of Work: Review other Sections in which primers are provided to ensure compatibility of the total system for various substrates. Notify Architect about anticipated problems when using the materials specified over substrates primed by others.

C. General: Remove hardware and hardware accessories, plates, machined surfaces, lighting fixtures, and similar items already installed that are not to be painted. If removal is impractical or impossible because of size or weight of the item, provide surface-applied protection before surface preparation and painting. After completing painting operations in each space or area, reinstall items removed using workers skilled in the trades involved.

D. Cleaning: Before applying paint or other surface treatments, clean substrates of substances that could impair bond of the various coatings. Remove oil and grease before cleaning.
   1. Schedule cleaning and painting so dust and other contaminants from the cleaning process will not fall on wet, newly painted surfaces.

E. Surface Preparation: Clean and prepare surfaces to be painted according to manufacturer's written instructions for each particular substrate condition and as specified. Provide barrier coats over incompatible primers or remove and reprime.
   1. Wood: Clean surfaces of dirt, oil, and other foreign substances with scrapers, mineral spirits, and sandpaper, as required. Sand surfaces exposed to view smooth and dust off.
      a. Scrape and clean small, dry, seasoned knots, and apply a thin coat of white shellac or other recommended knot sealer before applying primer. After priming, fill holes and imperfections in finish surfaces with putty or plastic wood filler. Sand smooth when dried.
      b. Prime, stain, or seal wood to be painted immediately on delivery. Prime edges, ends, faces, undersides, and back sides of wood, including cabinets, counters, cases, and paneling.
      c. If transparent finish is required, backprime with spar varnish.
      d. Backprime paneling on interior partitions where masonry, plaster, or other wet wall construction occurs on back side.
      e. Seal tops, bottoms, and cutouts of unprimed wood doors with a heavy coat of varnish or sealer immediately on delivery.
   2. Ferrous Metals: Clean ungalvanized ferrous-metal surfaces that have not been shop coated; remove oil, grease, dirt, loose mill scale, and other foreign substances. Use solvent or mechanical cleaning methods that comply with SSPC's recommendations.
      a. Blast steel surfaces clean as recommended by paint system manufacturer and according to SSPC-SP 6/NACE No. 3.
      b. Treat bare and sandblasted or pickled clean metal with a metal treatment wash coat before priming.
      c. Touch up bare areas and shop-applied prime coats that have been damaged. Wire-brush, clean with solvents recommended by paint manufacturer, and touch up with same primer as the shop coat.
   3. Galvanized Surfaces: Clean galvanized surfaces with nonpetroleum-based solvents so surface is free of oil and surface contaminants. Remove pretreatment from galvanized sheet metal fabricated from coil stock by mechanical methods.

F. Material Preparation: Mix and prepare paint materials according to manufacturer's written instructions.
   1. Maintain containers used in mixing and applying paint in a clean condition, free of foreign materials and residue.

2. Stir material before application to produce a mixture of uniform density. Stir as required during application. Do not stir surface film into material. If necessary, remove surface film and strain material before using.
3. Use only thinners approved by paint manufacturer and only within recommended limits.

G. General Application: Apply paint according to manufacturer's written instructions. Use applicators and techniques best suited for substrate and type of material being applied.
1. Paint colors, surface treatments, and finishes are indicated in the paint schedules.
2. Do not paint over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions detrimental to formation of a durable paint film.
3. Provide finish coats that are compatible with primers used.
4. The term "exposed surfaces" includes areas visible when permanent or built-in fixtures, grilles, convector covers, covers for finned-tube radiation, and similar components are in place. Extend coatings in these areas, as required, to maintain system integrity and provide desired protection.
5. Paint surfaces behind movable equipment and furniture the same as similar exposed surfaces. Before final installation of equipment, paint surfaces behind permanently fixed equipment or furniture with prime coat only.
6. Paint interior surfaces of ducts with a flat, nonspecular black paint where visible through registers or grilles.
7. Paint back sides of access panels and removable or hinged covers to match exposed surfaces.
8. Sand lightly between each succeeding enamel or varnish coat.

H. Scheduling Painting: Apply first coat to surfaces that have been cleaned, pretreated, or otherwise prepared for painting as soon as practicable after preparation and before subsequent surface deterioration.
1. The number of coats and film thickness required are the same regardless of application method. Do not apply succeeding coats until previous coat has cured as recommended by manufacturer. If sanding is required to produce a smooth, even surface according to manufacturer's written instructions, sand between applications.
2. Omit primer over metal surfaces that have been shop primed and touchup painted.
3. If undercoats, stains, or other conditions show through final coat of paint, apply additional coats until paint film is of uniform finish, color, and appearance. Give special attention to ensure that edges, corners, crevices, welds, and exposed fasteners receive a dry film thickness equivalent to that of flat surfaces.
4. Allow sufficient time between successive coats to permit proper drying. Do not recoat surfaces until paint has dried to where it feels firm, and does not deform or feel sticky under moderate thumb pressure, and until application of another coat of paint does not cause undercoat to lift or lose adhesion.

I. Application Procedures: Apply paints and coatings by brush, roller, spray, or other applicators according to manufacturer's written instructions.
1. Brushes: Use brushes best suited for type of material applied. Use brush of appropriate size for surface or item being painted.
2. Rollers: Use rollers of carpet, velvet-back, or high-pile sheep's wool as recommended by manufacturer for material and texture required.
3. Spray Equipment: Use airless spray equipment with orifice size as recommended by manufacturer for material and texture required.

J. Minimum Coating Thickness: Apply paint materials no thinner than manufacturer's recommended spreading rate to achieve dry film thickness indicated. Provide total dry film thickness of the entire system as recommended by manufacturer.

K. Mechanical and Electrical Work: Painting of mechanical and electrical work is limited to items exposed in equipment rooms and occupied spaces.

L. Mechanical items to be painted include, but are not limited to, the following:

1. Uninsulated metal piping.
2. Uninsulated plastic piping.
3. Pipe hangers and supports.
4. Tanks that do not have factory-applied final finishes.
5. Visible portions of internal surfaces of metal ducts, without liner, behind air inlets and outlets.
6. Duct, equipment, and pipe insulation having "all-service jacket" or other paintable jacket material.
7. Mechanical equipment that is indicated to have a factory-primed finish for field painting.

M. Electrical items to be painted include, but are not limited to, the following:
1. Switchgear.
2. Panelboards.
3. Electrical equipment that is indicated to have a factory-primed finish for field painting.

N. Prime Coats: Before applying finish coats, apply a prime coat, as recommended by manufacturer, to material that is required to be painted or finished and that has not been prime coated by others. Recoat primed and sealed surfaces where evidence of suction spots or unsealed areas in first coat appears, to ensure a finish coat with no burn-through or other defects due to insufficient sealing.

O. Pigmented (Opaque) Finishes: Completely cover surfaces as necessary to provide a smooth, opaque surface of uniform finish, color, appearance, and coverage. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections will not be acceptable.

P. Transparent (Clear) Finishes: Use multiple coats to produce a glass-smooth surface film of even luster. Provide a finish free of laps, runs, cloudiness, color irregularity, brush marks, orange peel, nail holes, or other surface imperfections.
1. Provide satin finish for final coats.

Q. Stipple Enamel Finish: Roll and redistribute paint to an even and fine texture. Leave no evidence of rolling, such as laps, irregularity in texture, skid marks, or other surface imperfections.

R. Completed Work: Match approved samples for color, texture, and coverage. Remove, refinish, or repaint work not complying with requirements.

S. Cleanup: At the end of each workday, remove empty cans, rags, rubbish, and other discarded paint materials from Project site.
1. After completing painting, clean glass and paint-spattered surfaces. Remove spattered paint by washing and scraping without scratching or damaging adjacent finished surfaces.

T. Protect work of other trades, whether being painted or not, against damage from painting. Correct damage by cleaning, repairing or replacing, and repainting, as approved by Architect.

U. Provide "Wet Paint" signs to protect newly painted finishes. After completing painting operations, remove temporary protective wrappings provided by others to protect their work. After work of other trades is complete, touch up and restore damaged or defaced painted surfaces. Comply with procedures specified in PDCA P1.

3.2 INTERIOR PAINT SCHEDULE

A. Gypsum Board: Provide the following finish systems over interior gypsum board surfaces:
1. Flat Acrylic Finish: Two finish coats over a primer.
   a. Primer: Interior gypsum board primer.
   b. Finish Coats: Interior flat acrylic paint.
2. Low-Luster Acrylic-Enamel Finish: Two finish coats over a primer.
   a. Primer: Interior gypsum board primer.

b. Finish Coats: Interior low-luster acrylic enamel.
3. Semigloss Acrylic-Enamel Finish: Two finish coats over a primer.
   a. Primer: Interior gypsum board primer.
   b. Finish Coats: Interior semigloss acrylic enamel.
4. Semigloss Alkyd-Enamel Finish: Two finish coats over a primer.
   a. Primer: Interior gypsum board primer.
   b. Finish Coats: Interior semigloss alkyd enamel.

B. Wood and Hardboard: Provide the following paint finish systems over new interior wood surfaces:
1. Low-Luster Acrylic-Enamel Finish: Two finish coats over a primer.
   a. Primer: Interior wood primer for acrylic-enamel and semigloss alkyd-enamel finishes.
   b. Finish Coats: Interior low-luster acrylic enamel.
2. Semigloss Acrylic-Enamel Finish: Two finish coats over a wood undercoater.
   a. Primer: Interior wood primer for acrylic-enamel and semigloss alkyd-enamel finishes.
   b. Finish Coats: Interior semigloss acrylic enamel.
3. Semigloss Alkyd-Enamel Finish: Two finish coats over a primer.
   a. Primer: Interior wood primer for acrylic-enamel and semigloss alkyd-enamel finishes.
   b. Finish Coats: Interior semigloss alkyd enamel.

C. Ferrous Metal: Provide the following finish systems over ferrous metal:
1. Flat Acrylic Finish: Two finish coats over a primer.
   a. Primer: Interior ferrous-metal primer.
   b. Finish Coats: Interior flat acrylic paint.
2. Low-Luster Acrylic-Enamel Finish: Two finish coats over a primer.
   a. Primer: Interior ferrous-metal primer.
   b. Finish Coats: Interior low-luster acrylic enamel.
3. Semigloss Acrylic-Enamel Finish: Two finish coats over a primer.
   a. Primer: Interior ferrous-metal primer.
   b. Finish Coats: Interior semigloss acrylic enamel.
4. Semigloss Alkyd-Enamel Finish: Two finish coats over a primer.
   a. Primer: Interior ferrous-metal primer.
   b. Finish Coats: Interior semigloss alkyd enamel.

D. Zinc-Coated Metal: Provide the following finish systems over interior zinc-coated metal surfaces:
1. Flat Acrylic Finish: Two finish coats over a primer.
   a. Primer: Interior zinc-coated metal primer.
   b. Finish Coats: Interior flat acrylic paint.
2. Low-Luster Acrylic-Enamel Finish: Two finish coats over a primer.
   a. Primer: Interior zinc-coated metal primer.
   b. Finish Coats: Interior low-luster acrylic enamel.
3. Semigloss Acrylic-Enamel Finish: Two finish coats over a primer.
   a. Primer: Interior zinc-coated metal primer.
   b. Finish Coats: Interior semigloss acrylic enamel.
4. Semigloss Alkyd-Enamel Finish: Two finish coats over a primer.
   a. Primer: Interior zinc-coated metal primer.
   b. Finish Coats: Interior semigloss alkyd enamel.

3.3 INTERIOR STAIN AND NATURAL-FINISH WOODWORK SCHEDULE

A. Stained Woodwork: Provide the following stained finishes over new interior woodwork:
1. Alkyd-Based Stain Satin-Varnish Finish: Two finish coats of alkyd-based clear satin varnish over a sealer coat and interior wood stain. Wipe wood filler before applying stain.
   a. Filler Coat: Open-grain wood filler.
   b. Stain Coat: Interior wood stain.
   c. Sealer Coat: Clear sanding sealer.

    d. Finish Coats: Interior alkyd- or polyurethane-based clear satin varnish.
2. Waterborne Stain Satin-Varnish Finish: Two finish coats of waterborne clear satin varnish over a sealer coat and waterborne interior wood stain. Wipe wood filler before applying stain.
    a. Filler Coat: Open-grain wood filler.
    b. Stain Coat: Interior wood stain.
    c. Sealer Coat: Clear sanding sealer.
    d. Finish Coats: Interior waterborne clear satin varnish.
3. Waterborne Stain Full-Gloss Varnish Finish: Two finish coats of waterborne clear full-gloss varnish over a sealer coat and interior wood stain. Wipe filler before applying stain.
    a. Filler Coat: Open-grain wood filler.
    b. Stain Coat: Interior wood stain.
    c. Sealer Coat: Clear sanding sealer.
    d. Finish Coats: Interior waterborne clear gloss varnish.
4. Alkyd-Based Stain Wax-Polished Finish: Three finish coats of paste wax over a sealer coat and alkyd-based interior wood stain.
    a. Stain Coat: Interior wood stain.
    b. Sealer Coat: Clear sanding sealer.
    c. Finish Coats: Paste wax.

B. Natural-Finish Woodwork: Provide the following natural finishes over new interior woodwork:
1. Alkyd-Based Satin-Varnish Finish: Two finish coats of alkyd-based clear satin varnish over a sanding sealer. Provide wood filler on open-grain wood before applying first varnish coat.
    a. Filler Coat: Open-grain wood filler.
    b. Sealer Coat: Clear sanding sealer.
    c. Finish Coats: Interior alkyd- or polyurethane-based clear satin varnish.
2. Waterborne Satin-Varnish Finish: Two finish coats of waterborne clear satin varnish over a sanding sealer. Wipe wood filler before applying stain.
    a. Filler Coat: Open-grain wood filler.
    b. Sealer Coat: Clear sanding sealer.
    c. Finish Coats: Interior waterborne clear satin varnish.
3. Waterborne Full-Gloss Varnish Finish: Two finish coats of waterborne clear full-gloss varnish over a sealer coat. Wipe filler before applying stain.
    a. Filler Coat: Open-grain wood filler.
    b. Sealer Coat: Clear sanding sealer.
    c. Finish Coats: Interior waterborne clear gloss varnish.
4. Wax-Polished Finish: Three finish coats of paste wax over a sanding-sealer first coat.
    a. Sealer Coat: Clear sanding sealer.
    b. Finish Coats: Paste wax.

END OF SECTION 09 9123

SECTION 09 9600

HIGH-PERFORMANCE COATINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes surface preparation and application of high-performance coating systems.

B. Related Requirements:

1. Section 051200 "Structural Steel Framing" for shop priming of metal substrates with primers specified in this Section.
2. Section 099113 "Exterior Painting" for special-use coatings and general field painting.
3. Section 099123 "Interior Painting" for special-use coatings and general field painting.

1.3 DEFINITIONS

A. Gloss Level 6: 70 to 85 units at 60 degrees, according to ASTM D 523.

B. Gloss Level 7: More than 85 units at 60 degrees, according to ASTM D 523.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include preparation requirements and application instructions.

B. Samples for Initial Selection: For each type of topcoat product indicated.

C. Samples for Verification: For each type of coating system and in each color and gloss of topcoat indicated.

1. Submit Samples on rigid backing, 8 inches square.
2. Step coats on Samples to show each coat required for system.
3. Label each coat of each Sample.
4. Label each Sample for location and application area.

D. Product List: For each product indicated, include the following:

1. Cross-reference to paint system and locations of application areas. Use same designations indicated on Drawings and in schedules.
2. Printout of current "MPI Approved Products List" for each product category specified in Part 2, with the proposed product highlighted.

3. VOC content.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Coatings: 5 percent, but not less than 1 gal. of each material and color applied.

1.6 QUALITY ASSURANCE

A. Mockups: Apply mockups of each coating system indicated to verify preliminary selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Architect will select one surface to represent surfaces and conditions for application of each coating system specified in Part 3.

a. Wall and Ceiling Surfaces: Provide samples of at least 100 sq. ft..
b. Other Items: Architect will designate items or areas required.

2. Final approval of color selections will be based on mockups.

a. If preliminary color selections are not approved, apply additional mockups of additional colors selected by Architect at no added cost to Owner.

3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F.

1. Maintain containers in clean condition, free of foreign materials and residue.
2. Remove rags and waste from storage areas daily.

1.8 FIELD CONDITIONS

A. Apply coatings only when temperature of surfaces to be coated and surrounding air temperatures are between 50 and 95 deg F.

B. Do not apply coatings when relative humidity exceeds 85 percent; at temperatures less than 5 deg F above the dew point; or to damp or wet surfaces.

C. Do not apply exterior coatings in snow, rain, fog, or mist.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Behr Process Corporation.
2. Benjamin Moore & Co.
3. Bennette Paint Mfg. Co., Inc.
4. Betonel Ltd.
5. BLP Mobile Paint Manufacturing Company, Inc.
6. Cloverdale Paint.
7. Color Wheel Paints & Coatings.
8. Columbia Paint & Coatings.
9. Conco Paints.
10. Coronado Paint.
11. Diamond Vogel Paints.
12. Dunn-Edwards Corporation.
13. Duron, Inc.
14. Euclid Chemical Company.
15. Farrell-Calhoun.
16. Frazee Paint.
17. General Paint.
18. Hirshfield's, Inc.
19. ICI Paints.
20. ICI Paints (Canada).
21. Insl-x.
22. Kelly-Moore Paints.
23. Kwal Paint.
24. M.A.B. Paints.
25. Microblend Technologies Inc.
26. Miller Paint.
27. Mills Paint.
28. PARA Paints.
29. Parex LaHabra Inc.
30. Parker Paint Mfg. Co. Inc.
31. PPG Architectural Finishes, Inc.
32. Pratt & Lambert.
33. Rodda Paint Co.
34. Scott Paint.
35. Sherwin-Williams Company (The).
36. Sico, Inc.
37. Vista Paint.
38. Zinsser.

2.2 HIGH-PERFORMANCE COATINGS, GENERAL

A. MPI Standards: Provide products that comply with MPI standards indicated and are listed in "MPI Approved Products List."

B. Material Compatibility:

1. Provide materials for use within each coating system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
2. For each coat in a coating system, provide products recommended in writing by manufacturers of topcoat for use in coating system and on substrate indicated.
3. Provide products of same manufacturer for each coat in a coating system.

C. VOC Content: Products shall comply with VOC limits of authorities having jurisdiction and, for interior coatings applied at project site, the following VOC limits, exclusive of colorants added to a tint base, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

1. Flat Paints and Coatings: 50 g/L.
2. Nonflat Paints and Coatings: 150 g/L.
3. Primers, Sealers, and Undercoaters: 200 g/L.
4. Anti-Corrosive and Anti-Rust Paints Applied to Ferrous Metals: 250 g/L.
5. Zinc-Rich Industrial Maintenance Primers: 340 g/L.
6. Pre-Treatment Wash Primers: 420 g/L.
7. Floor Coatings: 100 g/L.
8. Shellacs, Clear: 730 g/L.
9. Shellacs, Pigmented: 550 g/L.

D. Low-Emitting Materials: Interior coatings shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

E. Colors: As indicated in color schedule.

2.3 BLOCK FILLERS

A. Block Filler, Latex, Interior/Exterior: MPI #4.

B. Block Filler, Epoxy: MPI #116.

2.4 INTERIOR PRIMERS/SEALERS

A. Primer Sealer, Latex, Interior: MPI #50.

B. Wood-Knot Sealer: White shellac or other sealer recommended in writing by manufacturer for this purpose.

2.5 METAL PRIMERS

A. Primer, Zinc-Rich, Inorganic: MPI #19.

B. Primer, Zinc-Rich, Epoxy: MPI #20.

C. Primer, Rust-Inhibitive, Water Based: MPI #107.

D. Primer, Epoxy, Anti-Corrosive, for Metal: MPI #101.

E. Primer, Vinyl Wash: MPI #80.

2.6 EPOXY COATINGS

A. Epoxy, Gloss: MPI #77.

B. Epoxy-Modified Latex, Interior, Gloss (Gloss Level 6): MPI #115.

C. Epoxy, High-Build, Low Gloss: MPI #108.

D. Epoxy Deck Coating (Slip-Resistant): MPI #82.

2.7 POLYURETHANE COATINGS

A. Polyurethane, Two-Component, Pigmented, Gloss (Gloss Level 6): MPI #72.

B. Varnish, Aliphatic Polyurethane, Two-Component (Gloss Level 6 or 7): MPI #78.

2.8 SOURCE QUALITY CONTROL

A. Testing of Coating Materials: Owner reserves the right to invoke the following procedure:

1. Owner will engage the services of a qualified testing agency to sample coating materials. Contractor will be notified in advance and may be present when samples are taken. If coating materials have already been delivered to Project site, samples may be taken at Project site. Samples will be identified, sealed, and certified by testing agency.
2. Testing agency will perform tests for compliance with product requirements.
3. Owner may direct Contractor to stop applying paints if test results show materials being used do not comply with product requirements. Contractor shall remove noncomplying coating materials from Project site, pay for testing, and recoat surfaces coated with rejected materials. Contractor will be required to remove rejected materials from previously coated surfaces if, on recoating with complying materials, the two coatings are incompatible.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

1. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:

   a. Concrete: 12 percent.
   b. Masonry (Clay and CMU): 12 percent.
   c. Wood: 15 percent.
   d. Gypsum Board: 12 percent.

B. Gypsum Board Substrates: Verify that finishing compound is sanded smooth.

C. Plaster Substrates: Verify that plaster is fully cured.

D. Verify suitability of substrates, including surface conditions and compatibility with existing finishes and primers.

E. Proceed with coating application only after unsatisfactory conditions have been corrected.

1. Beginning coating application constitutes Contractor's acceptance of substrates and conditions.

3.2 PREPARATION

A. Comply with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual" applicable to substrates indicated.

B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.

1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection.

C. Clean substrates of substances that could impair bond of coatings, including dust, dirt, oil, grease, and incompatible paints and encapsulants.

1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce coating systems indicated.

D. Concrete Substrates: Remove release agents, curing compounds, efflorescence, and chalk. Do not coat surfaces if moisture content or alkalinity of surfaces to be coated exceeds that permitted in manufacturer's written instructions.

1. Clean surfaces with pressurized water. Use pressure range of 1500 to 4000 psi at 6 to 12 inches.
2. Abrasive blast clean surfaces to comply with SSPC-SP 7/NACE No. 4, "Brush-Off Blast Cleaning."

E. Masonry Substrates: Remove efflorescence and chalk. Do not coat surfaces if moisture content or alkalinity of surfaces or if alkalinity of mortar joints exceed that permitted in manufacturer's written instructions.

1. Clean surfaces with pressurized water. Use pressure range of 100 to 600 psi at 6 to 12 inches.

F. Steel Substrates: Remove rust, loose mill scale, and shop primer if any. Clean using methods recommended in writing by paint manufacturer.

G. Shop-Primed Steel Substrates: Clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material as used for shop priming to comply with SSPC-PA 1 for touching up shop-primed surfaces.

H. Galvanized-Metal Substrates: Remove grease and oil residue from galvanized sheet metal by mechanical methods to produce clean, lightly etched surfaces that promote adhesion of subsequently applied coatings.

I. Aluminum Substrates: Remove loose surface oxidation.

J. Wood Substrates:

1. Scrape and clean knots. Before applying primer apply coat of knot sealer recommended in writing by topcoat manufacturer for coating system indicated.
2. Sand surfaces that will be exposed to view and dust off.
3. Prime edges, ends, faces, undersides, and back sides of wood.
4. After priming, fill holes and imperfections in the finish surfaces with putty or plastic wood filler. Sand smooth when dried.

3.3 APPLICATION

A. Apply high-performance coatings according to manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual."

1. Use applicators and techniques suited for coating and substrate indicated.
2. Coat surfaces behind movable equipment and furniture same as similar exposed surfaces. Before final installation, coat surfaces behind permanently fixed equipment or furniture with prime coat only.
3. Coat back sides of access panels, removable or hinged covers, and similar hinged items to match exposed surfaces.
4. Do not apply coatings over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.

B. Tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of the same material are to be applied. Tint undercoats to match color of finish coat, but provide sufficient difference in shade of undercoats to distinguish each separate coat.

C. If undercoats or other conditions show through final coat, apply additional coats until cured film has a uniform coating finish, color, and appearance.

D. Apply coatings to produce surface films without cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections. Produce sharp glass lines and color breaks.

3.4 FIELD QUALITY CONTROL

A. Dry Film Thickness Testing: Owner will engage the services of a qualified testing and inspecting agency to inspect and test coatings for dry film thickness.

1. Contractor shall touch up and restore coated surfaces damaged by testing.
2. If test results show that dry film thickness of applied coating does not comply with coating manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry film thickness that complies with coating manufacturer's written recommendations.

3.5 CLEANING AND PROTECTION

A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

B. After completing coating application, clean spattered surfaces. Remove spattered coatings by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

C. Protect work of other trades against damage from coating operation. Correct damage by cleaning, repairing, replacing, and recoating, as approved by Architect, and leave in an undamaged condition.

D. At completion of construction activities of other trades, touch up and restore damaged or defaced coated surfaces.

3.6 EXTERIOR HIGH-PERFORMANCE COATING SCHEDULE

A. Steel Substrates:

1. Pigmented Polyurethane over Aromatic Urethane Zinc-Rich Primer and High-Build Epoxy System:

    a. Prime Coat: Primer, zinc-rich, aromatic urethane.
    b. Intermediate Coat: Epoxy, high-build, low gloss.
    c. Topcoat: Polyurethane, two-component, pigmented, semi- gloss (Gloss Level 5).

B. Galvanized-Metal Substrates:

1. Pigmented Polyurethane System:

    a. Prime Coat: Primer, epoxy, as recommended in writing by topcoat manufacturer.
    b. Intermediate Coat: Polyurethane, two-component, pigmented.
    c. Topcoat: Polyurethane, two-component, pigmented, semi-gloss (Gloss Level 5).

END OF SECTION 09 9600

SECTION 12 4813

ENTRANCE FLOOR MATS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Resilient entrance mats.
   2. This Section contains materials designated WM-01 on Drawings.

1.3 COORDINATION

A. Coordinate size and location of recesses in concrete to receive floor mats and frames.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for floor mats and frames.

B. Shop Drawings:

   1. Items penetrating floor mats and frames, including door control devices.
   2. Divisions between mat sections.
   3. Perimeter floor moldings.
   4. Custom Graphics: Scale drawing indicating colors.

C. Samples: For the following products, in manufacturer's standard sizes:

   1. Floor Mat: Assembled sections of floor mat.
   2. Tread Rail: Sample of each type and color.
   3. Frame Members: Sample of each type and color.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For floor mats and frames to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Resilient-Tile Entrance Mats: Full-size tile units equal to 2 percent of amount installed, but no fewer than 10 units.

PART 2 - PRODUCTS

2.1 ENTRANCE FLOOR MATS AND FRAMES, GENERAL

A. Structural Performance: Provide roll-up rail mats and frames capable of withstanding the following loads and stresses within limits and under conditions indicated:

1. Uniform floor load of 300 lbf/sq. ft. (14.36 kN/sq. m).
2. Wheel load of 350 lb (159 kg) per wheel.

B. Accessibility Standard: Comply with applicable provisions in the DOJ's "2010 ADA Standards for Accessible Design" and ICC A117.1.

2.2 RESILIENT ENTRANCE MATS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. 3M, or approved equal.

B. High traffic walk off mat.

1. Colors, Textures, and Patterns: Refer to Drawing Finish Schedule.
2. Mat Size: As indicated in Finish Plan.
3. Note: Provide flush installation with adjacent floor finishes.

2.3 FRAMES

A. Recessed Frames: Manufacturer's standard extrusion.

1. Extruded Aluminum: ASTM B 221 (ASTM B 221M), Alloy 6061-T6 or Alloy 6063-T5, T6, or T52.

   a. Color: Black.

2. Architectural Bronze: ASTM B 455, Alloy UNS No. C38500.

2.4 CONCRETE FILL AND GROUT MATERIALS

A. Provide concrete fill and grout equivalent in strength to cast-in-place concrete slabs for recessed mats and frames. Use aggregate no larger than one-third fill thickness.

2.5 FABRICATION

A. Floor Mats: Shop fabricate units to greatest extent possible in sizes indicated. Unless otherwise indicated, provide single unit for each mat installation; do not exceed manufacturer's recommended maximum sizes for units that are removed for maintenance and cleaning. Where joints in mats are necessary, space symmetrically and away from normal traffic lanes. Miter corner joints in framing elements with hairline joints or provide prefabricated corner units without joints.

B. Recessed Frames: As indicated, for permanent recessed installation, complete with corner pins or reinforcement and anchorage devices.

1. Fabricate edge-frame members in single lengths or, where frame dimensions exceed maximum available lengths, provide minimum number of pieces possible, with hairline joints equally spaced and pieces spliced together by straight connecting pins.

C. Surface-Mounted Frames: As indicated for permanent surface-mounted installation, complete with corner connectors, splice plates or connecting pins, and postinstalled expansion anchors.

D. Coat concealed surfaces of aluminum frames that contact cementitious material with manufacturer's standard protective coating.

2.6 ALUMINUM FINISHES

A. Mill finish.

B. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm or thicker.

C. Color Anodic Finish: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm or thicker.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and floor conditions for compliance with requirements for location, sizes, 3/8" finished recessed depth, and other conditions affecting installation of floor mats and frames.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install recessed mat frames and mats to comply with manufacturer's written instructions so that tops of mats will be flush with adjoining finished flooring. Set mats with tops at height recommended by manufacturer for most effective cleaning action; coordinate tops of mat surfaces with bottoms of doors that swing across mats to provide clearance between door and mat.

1. For installation in terrazzo flooring areas, allow for grinding and polishing of terrazzo without grinding surface of recessed frames. Coordinate with other trades as required.
2. Install necessary shims, spacers, and anchorages for proper location, and secure attachment of frames.
3. Install grout and fill around frames and, if required to set mat tops at proper elevations, in recesses under mats. Finish grout and fill smooth and level.

4. Delay setting mats until construction traffic has ended.

B. Install surface-type units to comply with manufacturer's written instructions; coordinate with entrance locations and traffic patterns.

1. Anchor fixed surface-type frame members to floor with devices spaced as recommended by manufacturer.

3.3 PROTECTION

A. After completing frame installation and concrete work, provide temporary filler of plywood or fiberboard in recesses and cover frames with plywood protective flooring. Maintain protection until construction traffic has ended and Project is near Substantial Completion.

END OF SECTION 12 4813

SECTION 13 0085

VISCOUS DAMPING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work in this Section includes preparation of shop drawings, test reports, designing, fabricating, testing, handling and shipping to the site of Viscous Damping Devices (VDDs).

1.2 RELATED SECTIONS

A. Section 05 12 00 – Structural Steel Framing

1.3 DEFINITIONS

A. Damper Unit: The Damper Unit is the energy dissipating element, incorporating the pressure vessel, piston rods, viscous medium, seals, and housing.

B. Force-Velocity Relationship: The relationship between the VDD force and the relative velocity of the ends of the VDD, as determined by testing specified in this Section.

C. Theoretical Output Relationship: The relationship between the VDD force and relative velocity of the ends of the VDD proposed to comply with the project requirements.

D. Viscous Damping Device (VDD): The VDD is defined as the complete assembly of VDD Components, from mounting bracket to mounting bracket.

E. VDD Components: The VDD components are the individual elements comprising the VDD, including the Damper Unit, clevis plates, spherical bearings, pins and fasteners necessary to connect the individual elements in accordance with the Contract Documents.

1.4 REFERENCES

A. Conform to the current editions of the following standards:
   1. ISO 9001 Quality Management Systems - Requirements

B. Refer to Article 1.2 – Related Sections for additional references not included in this section.

1.5 SUBMITTALS

A. See Section 01 3323 – Shop Drawings, Product Data & Samples.

B. Shop Drawings: Shop drawings shall include, but not be limited to fabrication drawings, installation drawings, setting diagrams, bolting templates and schedules. Submit prior to manufacture of item, allowing adequate time for review and approval. Submit shop drawings for:

1. Each VDD type, including any required prototypes, indicating dimensions, weights, and component material types.
2. All VDD Components, including mounting and connection hardware.
3. Method of corrosion protection for all VDD components.
4. Shop drawing re-submittals shall clearly identify all revisions to previous submittals.
    a. Heavy ink, clouded outlines (revision clouds) shall be drawn around revised areas of individual sheets.
    b. The City of Inglewood's Representative will not review information outside of revision clouds on resubmitted drawings.

C. Design Calculations: submit calculations bearing the seal of a Structural Engineer registered in the state of California. Calculations shall be included for all connections to the structure, considering localized effects on structural elements induced by the connection loads.

D. Product Data:
1. VDD: Product data shall include the manufacturer's product specifications, a list of production history for seismic dampers, and installation instructions. It shall also include any prototype test data used on previous projects that is being used to satisfy the requirements of Article 2.9.A – Prototype Testing.
2. Paint: Submit manufacturer's literature and data.

E. Certifications: Submit the following documents, written and signed by an approved independent testing agency.
1. Certification that all testing equipment has been checked for accuracy by appropriate standards for the purpose of this specification.
2. Certified mill test reports for all structural steel to be used within the VDDs.

F. Proposed Test Procedures: Submit annotated and drafted illustrations of proposed test apparatus and procedures for tests required by this Section. Such illustrations shall be submitted to the Engineer of Record prior to the commencement of any testing.

G. Test Reports: Submit the following reports, written and signed by an approved testing agency, for approval by the City of Inglewood's Representative.
1. Test Program Verification
2. Prototype VDD Test Reports: Submit test data for each prototype VDD tested within fourteen (14) days after completion of testing.
3. Production VDD Test Reports: Submit test data for each production VDD tested within fourteen (14) days after completion of the testing.
4. Final Test Report: Submit a final report summarizing test results for all prototype and production VDDs within fourteen (14) days after completion of all testing.

H. Operations and Maintenance Manual: Furnish the following information, at a minimum, in an Operations and Maintenance Manual:
1. Requirements contained under Article 1.9.
2. Procedure for removal and reinstallation of dampers.
3. Instructions for inspection and maintenance requirements and frequency. Inspections to be performed by a Structural Engineer registered in the State of California. Building finishes to be removed as necessary to provide adequate access to dampers for inspection and possible removal and replacement.
    a. Visual inspection of dampers in areas where a fire has occurred
    b. Visual inspection of dampers in an inverted chevron configuration in areas where standing water occurs to a height exceeding 2"
    c. Visual inspection of 100% of dampers two years after end of construction and every five years thereafter. The inspection interval may be relaxed to every ten years after a minimum of three inspections have occurred with written permission from the City of Inglewood's Representative.

d. Visual inspection of 10% of dampers after an earthquake having a peak ground acceleration, as measured or adjusted for a rock site (V_{s30} = 2500 ft/sec) within 5 miles of the building, exceeding 0.23g. The 10% of dampers selected for inspection shall be spatially distributed in both plan and elevation and shall include at least one damper of each damper type shown on the structural drawings.

e. Visual inspection of 100% of dampers after an earthquake having a peak ground acceleration, as measured or adjusted for a rock site (V_{s30} = 2500 ft/sec) within 5 miles of the building, exceeding 0.45g.

1.6 MANUFACTURER

A. VDD Manufacturers:

1. Taylor Devices, Inc.
   90 Taylor Drive
   North Tonawanda, NY 14120
   (716) 694-0800
   craigwinters@taylordevices.com
2. ITT Enidine, Inc.
   7 Center Drive
   Orchard Park, NY 14127
   (585) 313-9740
   Ben.eder@itt.com
3. Or equal.

1.7 QUALITY ASSURANCE

A. The VDD shall be manufactured under an established and maintained Quality Assurance Program, including written process specifications and procedures. The system must ensure that manufacturing, process, inspection and testing are accomplished in accordance with the following:

1. Manufacturing Control: Maintain a system that complies with the requirements of the International Standard Organization (ISO) 9001 model. Alternate programs may be considered acceptable after review and approval by the City of Inglewood's Representative.
2. Process Control: Maintain a system that includes, as a minimum, all of the following
   a. Specific raw material traceability
   b. Special process certification traceability
   c. Detailed manufacturing instructions that identify by operation and machine the work performed
   d. Inspection instructions
   e. In-process and final detail component inspection instructions with actual dimensions
3. Change Control: After initial design completion and approval, or initial hardware delivery, whichever occurs first, any change or substitution of material, dimensions, processes or other characteristics must be approved by the City of Inglewood's Representative prior to incorporation.
4. Calibration Control: All devices used to measure, gauge, test, inspect or otherwise examine items to determine compliance with specification and/or contractual requirements shall be calibrated to a measurement standard traceable to the National Institute of Standards and Technology (NIST), or approved equivalent.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Deliver production VDDs to the jobsite in protective packaging for freight and handling purposes.

B. Handling: Handle VDDs and components carefully to prevent damage, breaking, denting or scoring. Do not deliver damaged VDDs or components; replace with new.

C. Storage: Store VDDs in a clean, dry place. Protect from dirt, fumes, construction debris and physical damage.

1.9 WARRANTIES AND GUARANTEES

A. Furnish to the City of Inglewood a written guarantee for the damper units against all defects in materials and workmanship for 35 years from date of acceptance. Refer to Section 01 78 00, CLOSE-OUT SUBMITTALS, for submittal form.

PART 2 - PRODUCTS

2.1 PRODUCT LIFE AND MAINTENANCE

A. Damper Units: The Damper Units shall be maintenance-free and comply with Article 2.5.A - Output Tolerances when kept within the Operating Conditions specified in this Section for a life of thirty-five (35) years. Maintenance free shall mean that no refilling of viscous medium or replacement of any other parts shall be required.

B. Corrosion Protection: All materials subject to deterioration or corrosion when exposed to the environment shall be protected by means acceptable for the application. These methods shall include, but are not limited to coating, plating, or painting.

C. Installation: The VDDs shall be constructed such that installation, removal and replacement, if necessary, shall not require any special tools or methods.

2.2 VDD MATERIALS AND FABRICATION

A. Unless suitably protected against electrolytic corrosion, dissimilar materials shall not be used in contact with each other. Dissimilar metal joints shall not be permitted without a non-metallic separator or gasket of at least .06 inch thickness. The use of aluminum, aluminum alloys, magnesium, magnesium alloys, beryllium and beryllium alloys is prohibited.

B. The damper unit shall contain provisions to limit internal positive or negative pressures as may be caused by thermal expansion and/or contraction of the hydraulic medium and that would otherwise result in seal failure, leakage or damage to the VDD.

C. Non-filled cavities of the damper unit shall be sealed against external contamination and moisture and shall be constructed of materials protected against corrosion.

D. Only non-nutrient materials shall be used in the VDD.

E. All non-metallic packings, seals, wipers or gaskets shall be of non-age sensitive materials.

2.3 VDD COMPONENTS

A. Damper Unit components: All components of the Damper Units shall comply with the requirements of this section.
   1. Pressure Vessels: The pressure vessel components of the damper shall not be of tie-rod type construction, and shall not include externally supported heads or end caps.
   2. Castings: Castings shall be prohibited for pressure vessel parts or any other parts subjected to tensile or bending stresses, except for parts such as covers, handles, etc., the failure of which would not affect the structural integrity or performance characteristics of the unit.
   3. Piston Rods: Base metal shall be wrought or forged steel only and shall be either stainless steel or chrome plated.
   4. Viscous Medium: The viscous media used in the Damper Units shall be chemically inert, OSHA-approved, non-toxic, non-corrosive, non-flammable material. Petrochemical materials shall not be used.
   5. Seals: Under the requirements of Article 2.7 - Operating Conditions specified herein, the damper unit seals shall not leak or weep.
   6. Piston Rod Protection: The VDD shall be designed to prevent dusting, scratching, dinging or otherwise marring of the piston rod surface. Where a steel protective cover is used, it shall be fitted with an inspection hatch to allow easy inspection of the Damper Unit seals and piston rod.
   7. Reservoirs and Plumbing: External reservoirs, external plumbing and/or viscous medium level indicators are not permitted.

B. VDD Components other than the Damper Unit
   1. Spherical bearings shall have an inner ring with a spherical outer surface and an outer ring with a spherical inner surface. Bearings shall be fabricated with stainless or high alloy steel and may be of the lined type with non-metallic liners.
   2. Pins shall be machined and hardened to be compatible with design requirements of the clevis plates and spherical bearings.
   3. Clevis Plates shall be ASTM A36 minimum.

C. Finish requirements:
   1. The damper casing exterior surfaces shall either be nickel plated or painted with a primer coat. A finish coat of paint shall be applied on top of the nickel plating or primer coat.
      a. Primer paint: Fabricator's standard, with primer paint complying with VOC limitations of the Authority Having Jurisdiction. Coating thickness: 25 microns.
      b. Finish paint: In accordance with Section 09 9123 – Interior Painting. Coating thickness: 25 microns.

2.4 DESIGN REQUIREMENTS

A. Theoretical Output Relationship: The Damper Unit shall produce damping force output within the specified Output Tolerances, in both directions of travel, according to the following Theoretical Output Relationship:

   $F = C^*V^{\alpha}$ = damping force output from the Damper Unit (kips)
   C = Damper Unit damping coefficient (kip-sec/in)
   V = relative velocity between opposite ends of the Damper Unit (in/sec)
   α = alpha, Damper Unit velocity exponent (unitless)

B. Design Parameters: The Design Parameters for the VDD shall establish the Theoretical Output Relationship for the Damper Unit. The Design Parameters are as shown on the structural drawings.

C. Dimensions: The overall dimensions of the VDD shall be held to a minimum consistent with the requirements of this specification and shall be coordinated with the associated steel detailing on the structural drawings.

D. Length Adjustment: The VDD shall include provisions for overall length adjustment. The minimum length adjustment provided shall be ±0.25 inch from the neutral position. Slotted bolted holes shall not be used to provide the required length adjustment.

E. Total Stroke: The VDD shall have a total stroke sufficient to allow a complete cycle of displacement as shown on the on the structural drawings. The complete cycle of displacement shall be measured from the installed, at-rest position.

F. Articulation: The end attachments of the VDD shall allow for a minimum of ±20 degrees of free articulation about an axis parallel to the mounting pins and a minimum of ±3 degrees of free articulation in all other directions.

2.5 PERFORMANCE REQUIREMENTS

A. Output Tolerances: The output developed by the Damper Unit shall be within the following tolerances, when cycled about any point:
   1. Force Output: The Damper Unit force output shall not be less than 85% nor more than 115% of the value indicated by Article 2.4.A - Theoretical Output Relationship in either direction of travel.
   2. Cyclic Force Difference: The force output developed by the Damper Unit in one direction of travel shall not be less than 90% nor more than 110% of the force developed in the opposite direction of travel for a given piston-rod position, velocity and temperature.
   3. Cyclic Energy Dissipation: The area of the measured force versus displacement hysteresis loop shall not be less than 85% of the area of the theoretical hysteresis loop. The area of the theoretical hysteresis loop shall be determined using the measured force displacement signal for the test under consideration and Article 2.4.A - Theoretical Output Relationship.

B. Performance at Articulated Limits: The Damper Unit shall be designed to operate at the maximum articulated limits according to Article 2.6 - Design Limit States.

C. No Leakage: The Damper Units shall not leak the viscous medium externally under any circumstances whether under operating or non-operating conditions. The units shall show no visible evidence of external leakage when subjected to the greatest internal pressure corresponding to application of any of the requirements in Article 2.7 - Operating Conditions for 180 seconds.

2.6 DESIGN LIMIT STATES

A. VDD components shall be proportioned such that all component stresses are at or below the yield stress under application of any of the following:
   1. Simultaneous application of 2.0 times the design velocity and a lateral acceleration of 1g, at any piston-rod position, under any of the requirements in Article 2.7 - Operating Conditions.
   2. Application of internal pressure of 200 percent of maximum operating pressure, but not less than 20,000 psi.

2.7 OPERATING CONDITIONS

A. The VDDs shall be capable of performing according to Article 2.4.A - Theoretical Output Relationship when operating at the temperatures, installed duration, wind and seismic duty cycles, and other environmental conditions specified herein, without degradation of performance, within the requirements of Article 2.5.A - Output Tolerances.

1. Wind duty cycles: 0 to 0.15 inches amplitude at 0.73 Hz for 30,000 cycles per year.
2. Seismic duty cycles: 1 inch mean amplitude (2 inches peak amplitude) at 0.73 Hz for an average of 5 cycles per year.
3. Ambient operating temperature: Maximum and minimum ambient air temperatures ranging from +20°F to +130°F.
4. Atmospheric pressure: The unit shall operate at close to sea level pressure (760 ±50mm mercury).
5. Humidity: Relative humidity up to 100 percent, including condensation due to temperature change.
6. Other atmospheric elements: Any of the probable combinations of the following atmospheric elements: rain, snow, sleet, hail, ice, fog, smoke, wind, ozone, sunshine, sand and dust, and salt atmosphere.

2.8 SERIAL NUMBER ASSIGNMENT

A. Unique serial numbers shall be assigned to each VDD unit. The individual numbers shall be assigned according to the manufacturer's standard practice unless otherwise specified in the purchase order or contract.

2.9 TESTING

A. Prototype Testing

1. The purpose of this phase of testing is to verify the ability to produce Damper Units with a measured Force-Velocity Relationship that matches the Theoretical Output Relationship for the tested damper while subjected to the requirements of Article 2.7 - Operating Conditions. The City of Inglewood's Representative shall be given sufficient notice of when prototype testing is to occur so as to arrange for on-site structural observation at testing facility, if desired.
2. One Damper Unit for each damper type shall be tested in accordance with this Article. Tests shall be performed in the order listed.
3. Proof Load Testing
    a. An internal pressure equal to the largest pressure due to application of any of the conditions specified in Article 2.6 - Design Limit States shall be applied and maintained for 180 seconds.
4. Testing in accordance with Article 2.9.B.3.
5. Life Cycle Testing
    a. Wind Load Test: The prototype Damper Unit shall be subjected to 2,000 fully reversed cycles of ±0.15 inches (or ±0.3 inches for Damper Unit spanning two levels) at a frequency of 0.73 Hz.
    b. Full Stroke Test: The prototype Damper Unit shall be cycled through its full end-to-end displacement for a total of 120 cycles. The cyclic velocity is expected to be much slower than the maximum velocity and shall depend on the capacity of the approved testing apparatus. The test velocity shall be submitted to the City of Inglewood's Representative for approval prior to testing.
6. Theoretical Output Relationship Verification
    a. Testing Parameters: Tests shall be complete cycles of sinusoidal deformation for each peak test velocity and stroke. The peak velocity and displacement for each test shall be within ±10% of the required value below for each cycle of testing.

1) Ten fully reversed cycles at 0.25 times the design velocity and 0.25 times stroke.
2) Five fully reversed cycles at 0.5 times the design velocity and 0.5 times stroke.
3) Five fully reversed cycles at 0.75 times the design velocity and 0.75 times stroke.
4) Three fully reversed cycles at 1.0 times the design velocity and 0.75 times stroke.

b. Test Temperatures: Testing shall be performed at three ambient temperatures: room temperature (60°F to 75°F), 20°F, and 130°F. Prior to commencement of testing at each ambient temperature, the damper unit shall be conditioned at the ambient temperature for at least 4 hours. All cycles of testing shall be completed within 2 hours of removing the damper from the temperature controlled environment. All practically feasible means of maintaining the conditioned temperature of the damper units shall be employed during testing. Testing in this article need only be completed for one damper prototype per project, rather than for each damper prototype, where the manufacturer can show that all damper prototypes are (i) made of identical material and similar internal construction, (ii) have similar static and dynamic internal pressures, and (iii) are fabricated with identical processes and manufacturing quality control procedures. If only one damper prototype per project is tested in accordance with this article, all other damper prototypes need only be tested at room temperature.

7. Prototype Damper Unit used as production Damper Unit: Where a prototype Damper Unit is proposed to be used as production Damper Unit, it shall meet the requirements of Article 2.9.B following all testing described in this article. Reconditioning of the Damper Unit following testing in this article is permitted before testing in accordance with Article 2.9.B.
8. Damper units that are (i) of similar size, identical material, internal construction, and static and dynamic internal pressures and (ii) fabricated with identical internal processes and manufacturing quality control procedures and have been previously tested by an independent laboratory in the manner described above need not be tested for the above requirements provided that:
   a. All pertinent testing data are made available to, and are approved by, the City of Inglewood's Representative.
   b. The manufacturer can substantiate the similarity of the previously tested devices to the satisfaction of the design professional, and
   c. The submission of data from a previous testing program is approved in writing by the City of Inglewood's Representative.

B. Production Testing
1. The purpose of this phase of testing is to ensure quality control for the Damper Units. The City of Inglewood's Representative shall be given sufficient notice of when production testing is to occur so as to arrange for on-site structural observation at testing facility, if desired.
2. Proof Load Testing
   a. Proof Load Test: For each production Damper Unit, an internal pressure equal to the largest pressure due to application of Article 2.6.A.1 shall be applied and maintained for 180 seconds.
   b. High Level Proof Load Test: For one out of every fifty production Damper Units, or a minimum of one per damper type, an internal pressure equal to the largest pressure due to application of Article 2.6.A.2 shall be applied and maintained for 180 seconds.
3. Life Cycle Testing
   a. Full Stroke Test: One out of every fifty production Damper Units, or a minimum of two per damper type, shall be cycled through its full end-to-end displacement for a total of 30 cycles. The cyclic velocity is expected to be much slower than the maximum velocity and shall depend on the capacity of the approved testing

apparatus. The test velocity shall be submitted to the Engineer of Record for approval prior to testing.

4. Theoretical Output Relationship Verification: The following test shall be performed on each production Damper Unit.
   a. Testing Parameters: Tests shall be complete cycles of sinusoidal deformation for each peak test velocity and stroke. The peak velocity and displacement for each test shall be within ±10% of the required value below for each cycle of testing.
      1) Three fully reversed cycles at 0.75 times the design velocity and 0.75 times stroke.
   b. Test Temperature: Testing shall be performed at room temperature (60°F to 75°F). Prior to commencement of testing, the damper unit shall be conditioned at the ambient temperature for at least 4 hours. All cycles of testing shall be completed within 2 hours of removing the damper from the temperature controlled environment. All practically feasible means of maintaining the conditioned temperature of the damper units shall be employed during testing.

C. Test Acceptance Criteria: All of the following criteria shall be met for each tested Damper Unit for any of the Prototype or Production Tests.
   1. No evidence of external leakage before, during or after the testing program.
   2. No evidence of binding, yielding or permanent deformation in any part of the damper unit.
   3. No evidence of degradation of the seals in the damper unit.
   4. For each cycle of tests in Articles 2.9.A.5 and 2.9.B.3, the damper output shall fall within the requirements of Article 2.5.A - Output Tolerances.

D. Test Failures: The failure of any Damper Unit to satisfy the requirements of Article 2.9.C – Test Acceptance Criteria shall result in one of the following courses of action:
   1. Reject Damper Unit.
   2. Subject to approval by the City of Inglewood's Representative, repair Damper Unit and re-test.

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with the requirements of Section 05 12 00 – Structural Steel Framing.

END OF SECTION 13 0085

SECTION 21 0548

VIBRATION AND SEISMIC CONTROLS FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
1. Restraining braces.
2. Flexible piping connections.
3. Seismic restraints for isolated and non-isolated piping and equipment.
4. Seismic restraints are not required for the following:

    a. Piping less than 2-1/2 inch inside diameter and piping suspended by individual hangers 12 inches in length or less from the top of the pipe to the support structure.

5. The term g is the acceleration due to gravity and is equal to 386 inches/second (9.8 meters/second).

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: [**A**] [**B**] [**C**] [**D**] [**E**] [**F**].
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: [**I**] [**II**] [**III**].

    a. Component Importance Factor: [**1.0**] [**1.5**] <**Insert value**>.
    b. Component Response Modification Factor: [**1.5**] [**2.5**] [**3.5**] [**5.0**] <**Insert value**>.
    c. Component Amplification Factor: [**1.0**] [**2.5**] <**Insert value**>.

3. Design Spectral Response Acceleration at Short Periods (0.2 Second): <**Insert percent**>.
4. Design Spectral Response Acceleration at 1-Second Period: <**Insert percent**>.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Data:

a. Catalog cuts and data sheets on specific restraints to be utilized showing compliance with the specifications.
b. An itemized list showing the items of equipment or piping to be restrained, the restraint type or model number selected, and reference to specific drawings showing base and construction where applicable.
c. An itemized list of equipment and piping not isolated to be seismically restrained.
d. Seismic restraint calculations. Signed and sealed by a licensed Structural or Civil Engineers' stamp verifying design and calculations for seismic restraining system used.

2. Shop Drawings:

a. Equipment base construction for each piece of equipment, including dimensions, structural member sizes and support point locations.
b. Methods of suspension and support guides for piping.
c. Concrete and steel details for bases including anchor bolt locations.
d. Number and location of seismic restraints and anchors for each piece of equipment.
e. Specific details of restraints including anchor bolts for mounting and maximum loading at each location, for each piece of equipment and pipe.

3. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
b. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select seismic restraints.
2. Seismic-Restraint Details:

a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Welding certificates.

D. Qualification Data: For professional engineer and testing agency.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC NYC Building Code SMACNA guidelines for Seismic Piping Restraints for Mechanical systems and NFPA 13 unless requirements in this Section are more stringent.

C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 SEISMIC-RESTRAINT DEVICES

A. Shall be capable of safely accepting one-half (1/2) "g" external forces without failure. Shall maintain equipment and piping in a captive position. Shall not short circuit vibration isolation systems or transmit objectionable vibration or noise. Shall be provided on all equipment as required by referenced codes and standards. Calculations by registered Civil or Structural Engineer shall be submitted to verify snubber capacities for each isolated piece of equipment.

   1. Seismic Restraint Type V: Non isolated equipment to be field bolted (power shots not acceptable) to resist seismic forces.

B. The above systems shall replace the general mounting types in the standard isolation specification.

C. Curbs shall meet the following criteria:

   1. Curbs shall be rated for 1 "g" of acceleration.
   2. Curbs shall have NRCA approval.
   3. Curbs shall be welded to building steel or bolted to concrete decks to attain acceleration criteria.

D. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

E. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

F. Basis-of-Design Product: Subject to compliance with requirements, provide comparable product by one of the following:

   1. Amber/Booth Company, Inc.
   2. Kinetics Noise Control.
   3. Korfund Dynamics Corp.

4. Loos & Co.; Cableware Division.
5. Mason Industries.
6. Vibration Mountings, Inc.

G. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

H. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

I. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

J. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

K. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

L. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

M. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

2.2 FACTORY FINISHES

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.
2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
3. Baked enamel or powder coat for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

D. New piping shall be provided with seismic restraining system in accordance with guidelines as outlined below.

1. Lateral Bracing:

   a. Feed mains and cross mains:

      1) At 40 feet intervals.

   b. Branch lines 2-1/2 inches and larger at 40 feet intervals.
   c. Lateral sway bracing may be omitted on pipes individually supported by rods less than 6 inches long.
   d. Lateral braces shall be acceptable as longitudinal braces if within 24 inches of the center line of the piping braced longitudinally for lines that are 2-1/2 inches and larger.\Maximum distance between last brace and end of pipe is 20 feet.

2. Longitudinal Bracing:

   a. Feed and cross mains:

      1) At 80 feet intervals.

   b. Longitudinal braces shall be acceptable as lateral braces where install within 24 inches of piping braced laterally.
   c. Maximum distance between last brace and end of pipe is 40 feet.

3. Similar bracing shall be provided at every pipe turn.
4. Sway bracing is not required for branch lines except end sprinkler.

3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment Restraints:

1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

2. Install seismic-restraint devices using methods approved an agency acceptable to authorities having jurisdiction providing required submittals for component.
3. New equipment shall be bolted to foundation and braced to adjacent walls to allow for minimum 1.2 "g" of acceleration. Bolt points and diameter of inserts shall be submitted and verified as part of the contractor's submission for each piece of equipment and certified by a licensed Civil or Structural Engineer.
4. Structurally suspended overhead equipment isolated or non-isolated shall be four point independently braced with rigid seismic restraining system.

B. Piping Restraints:

1. Comply with requirements in MSS SP-127 and NFPA 13.
2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet.
4. Install Seismic Restraining System, (Type III): Taut for overhead suspended non-isolated equipment, piping and slack with 1/2 inch cable deflection for isolated system.
5. Seismically restrain all piping with (Type III) cable or rigid restraining system in accordance with guideline as outlined below.

   a. Piping to be braced laterally and longitudinally at 40 feet intervals and at turns of more than four (4) feet.

6. Where base anchoring is insufficient to resist seismic forces supplementary restraining such as seismic cable restraint system Type III shall be used above system's center of gravity to suitably resist "g" force levels.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install seismic-restraint devices using methods approved by agency acceptable to authorities having jurisdiction providing required submittals for component.

E. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

F. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

G. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

H. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in this section and Division 21 Section 21 1000"Water-Based Fire-Suppression Systems" for piping flexible connections.

END OF SECTION 21 0548

SECTION 21 1313

WET-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Piping materials.
2. Pipe joining materials.
3. Cover system for sprinkler piping.
4. Listed fire-protection valves.
5. Trim and drain valves.
6. Specialty valves:
    a. Sprinkler specialty pipe fittings.
7. Sprinklers.
8. Alarm devices.
9. Pressure gages.
10. Escutcheons.
11. Sleeves.
12. Sleeve seals.
13. Grout.

1.3 DEFINITIONS

A. High-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure higher than standard 175 psig, but not higher than 250 psig.

B. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175 psig maximum.

1.4 SYSTEM DESCRIPTIONS

A. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply through alarm valve. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device. Hose connections are included if indicated.

1.5 PERFORMANCE REQUIREMENTS

A. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.

B. High-Pressure Piping System Component: Listed for 250-psig minimum working pressure.

C. Delegated Design: Design sprinkler system(s), including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1. Available fire-hydrant flow test records indicate the following conditions:

   a. Date: <**Insert test date**>.
   b. Time: <**Insert time**> **[a.m.] [p.m.]**
   c. Performed by: <**Insert operator's name**> of <**Insert firm**>.
   d. Location of Residual Fire Hydrant R: <**Insert location**>.
   e. Location of Flow Fire Hydrant F: <**Insert location**>.
   f. Static Pressure at Residual Fire Hydrant R: <**Insert psig**>.
   g. Measured Flow at Flow Fire Hydrant F: <**Insert gpm**>.
   h. Residual Pressure at Residual Fire Hydrant R: <**Insert psig**>.

D. Sprinkler system design shall be approved by authorities having jurisdiction.

1. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.
2. Sprinkler Occupancy Hazard Classifications.

   a. Building Service Areas: Ordinary Hazard, Group 1.
   b. Electrical Equipment Rooms: Ordinary Hazard, Group 1.
   c. General Storage Areas: Ordinary Hazard, Group 1.
   d. Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
   e. Office and Public Areas: Light Hazard.

3. Minimum Density for Automatic-Sprinkler Piping Design:

   a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. area.
   b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft.area.
   c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. area.
   d. Special Occupancy Hazard: As determined by authorities having jurisdiction.

4. Maximum Protection Area per Sprinkler: Per UL listing.
5. Maximum Protection Area per Sprinkler:

   a. Office Spaces: 120 sq. ft.
   b. Storage Areas: 130 sq. ft.
   c. Mechanical Equipment Rooms: 130 sq. ft.
   d. Electrical Equipment Rooms: 130 sq. ft.
   e. Other Areas: According to NFPA 13 recommendations unless otherwise indicated.

6. Total Combined Hose-Stream Demand Requirement: According to NFPA 13 unless otherwise indicated:

   a. Light-Hazard Occupancies: 100 gpm for 30 minutes.
   b. Ordinary-Hazard Occupancies: 250 gpm for 60 to 90 minutes.
   c. Extra-Hazard Occupancies: 500 gpm for 90 to 120 minutes.

E. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

1.6 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For wet-pipe sprinkler systems. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

D. Coordination Drawings: Sprinkler systems, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Domestic water piping.
2. Compressed air piping.
3. HVAC hydronic piping.
4. Items penetrating finished ceiling include the following:

    a. Lighting fixtures.
    b. Air outlets and inlets.

E. Qualification Data: For qualified Installer and professional engineer.

F. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.

G. Welding certificates.

H. Fire-hydrant flow test report.

I. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."

J. Field quality-control reports.

K. Operation and Maintenance Data: For sprinkler specialties to include in emergency, operation, and maintenance manuals.

L. Submittals shall indicate M.E.A. approval with a Calendar Number.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.

a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.

B. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. NFPA Standards: Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:

1. NFPA 13, "Installation of Sprinkler Systems."
2. NFPA 13R, "Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height."
3. NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances."
4. NFPA 72E
5. Americans with Disabilities Act.

E. In NYC provide products with BS & A approval as required.

1.8 PROJECT CONDITIONS

A. Interruption of Existing Sprinkler Service: Do not interrupt sprinkler service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sprinkler service according to requirements indicated:

1. Notify Architect no fewer than two days in advance of proposed interruption of sprinkler service.
2. Do not proceed with interruption of sprinkler service without Architect's written permission.

1.9 COORDINATION

A. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

1.10 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.

B. Basis-of-Design Product: Subject to compliance with requirements, provide Wheatland or an equal product by one of the following:
1. Cerro.
2. Allied.

2.2 STEEL PIPE AND FITTINGS

A. Schedule 40, Black-Steel Pipe: ASTM A 53/A 53M, Type E , Grade B. Pipe ends may be factory or field formed to match joining method.

B. Schedule 10, Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10, plain end.

C. Cast-Iron Flanges: ASME 16.1, Class 125.

D. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.

E. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.

F. Grooved-Joint, Steel-Pipe Appurtenances:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Victaulic Company or an equal product by one of the following:

   a. Anvil International, Inc.
   b. Corcoran Piping System Co.
   c. National Fittings, Inc.
   d. Shurjoint Piping Products.
   e. Tyco Fire & Building Products LP.

2. Pressure Rating: **175 psig** minimum.
3. Galvanized and Uncoated, Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

G. Steel Pressure-Seal Fittings: UL 213, FM-approved, 175-psig pressure rating with steel housing, rubber O-rings, and pipe stop; for use with fitting manufacturers' pressure-seal tools.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Victaulic Company or an equal product by one of the following:

2.3 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free.

1. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
2. Class 250, Cast-Iron Flanges and Class 300, Steel Raised-Face Flanges: Ring-type gaskets.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

D. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

E. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F 493, solvent cement recommended by pipe and fitting manufacturer, and made for joining CPVC sprinkler pipe and fittings. Include cleaner or primer recommended by pipe and fitting manufacturer.

1. Use solvent cement that has a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Use adhesive primer that has a VOC content of 650 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. Plastic, Pipe-Flange Gasket, and Bolts and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.4 COVER SYSTEM FOR SPRINKLER PIPING

A. Basis-of-Design Product: Subject to compliance with requirements, provide DecoShield Systems, Inc. or an equal product by one of the following:

B. Description: System of support brackets and covers made to protect sprinkler piping.

C. Brackets: Glass-reinforced nylon.

2.5 LISTED FIRE-PROTECTION VALVES

A. General Requirements:

1. Valves shall be UL listed or FM approved.
2. Minimum Pressure Rating for Standard-Pressure Piping: 175 psig.
3. Minimum Pressure Rating for High-Pressure Piping: 250 psig.

B. Ball Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Victaulic Company or an equal product by one of the following:

   a. Anvil International, Inc.

2. Standard: UL 1091 except with ball instead of disc.

3. Valves NPS 1-1/2 and Smaller: Bronze body with threaded ends.
4. Valves NPS 2 and NPS 2-1/2: Bronze body with threaded ends or ductile-iron body with grooved ends.
5. Valves NPS 3: Ductile-iron body with grooved ends.
6. Grooved end shut-off valve shall be ball type, two-piece bronze body ASTM A584 with threaded or grooved end connections. Chrome-plated brass ball, 316 stainless steel stem, TFE seat, die-cast brass gearbox, pre-wired supervisory switches. Victaulic Series 728 Firelock®.

C. Bronze Butterfly Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Milwaukee Valve Company or an equal product by one of the following:

   a. Fivalco Inc.
   b. Global Safety Products, Inc.

2. Standard: UL 1091.
3. Pressure Rating: 175 psig.
4. Body Material: Bronze.
5. End Connections: Threaded.
6. Equal to Milwaukee BB-SC100, BBVSC100, BBVSCS02, threaded end, slow closing with position indicator less tamper switch, BB-SCS02 with tamper switch.

D. Iron Butterfly Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Victaulic Company or an equal product by one of the following:

   a. Anvil International, Inc.
   b. Fivalco Inc.
   c. Global Safety Products, Inc.
   d. Kennedy Valve; a division of McWane, Inc.
   e. Milwaukee Valve Company.
   f. NIBCO Inc.
   g. Shurjoint Piping Products.
   h. Tyco Fire & Building Products LP.

2. Standard: UL 1091.
3. Pressure Rating: 175 psig.
4. Body Material: Cast or ductile iron.
5. Style: Lug or wafer.
6. End Connections: Grooved.

E. Check Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Victaulic Company or an equal product by one of the following:
   a. Anvil International, Inc.
   b. Clow Valve Company; a division of McWane, Inc.
   c. Crane Co.; Crane Valve Group; Crane Valves.
   d. Crane Co.; Crane Valve Group; Stockham Division.
   e. Fire-End & Croker Corporation.
   f. Fivalco Inc.
   g. Globe Fire Sprinkler Corporation.
   h. Kennedy Valve; a division of McWane, Inc.

i. Milwaukee Valve Company.
j. Mueller Co.; Water Products Division.
k. NIBCO Inc.
l. Potter Roemer.
m. Reliable Automatic Sprinkler Co., Inc.
n. Shurjoint Piping Products.
o. Tyco Fire & Building Products LP.
p. Viking Corporation.

2. Standard: UL 312.
3. Pressure Rating: 250 psig minimum.
4. Type: Swing check.
5. Body Material: Cast iron.
6. End Connections: Flanged or grooved.
7. Two inch and smaller valves, except as noted, shall be threaded bronze, 175 psig wwp, equal to Milwaukee Fig. 509. 2-1/2 inch and larger, except as noted shall be flanged IBBM, 175 psig wwp and equal to Stockham Fig. G-940 for N.Y.C., elsewhere, Milwaukee Fig. F2974-FP.
8. Wafer type check valves equal to Anvil International Model F512 or grooved end spring-assisted check valves equal to Victaulic Series 717, 250# WWP UL, FMG, MEA approved (in NYC only) may be used.
9. Threaded bronze, swing type check valves, 175 psig wwp with composition or leather disc for air lines, equal to Stockham Fig. B-305B.

F. Bronze OS&Y Gate Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Milwaukee Valve Company or an equal product by one of the following:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Stockham Division.
c. NIBCO Inc.

2. Standard: UL 262.
3. Pressure Rating: 175 psig.
4. Body Material: Bronze.
5. End Connections: Threaded.
6. Equal to Kennedy Fig. 66.

G. Iron OS&Y Gate Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Milwaukee Valve Company or an equal product by one of the following:
a. Clow Valve Company; a division of McWane, Inc.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Hammond Valve.
e. Mueller Co.; Water Products Division.
f. NIBCO Inc.
g. Shurjoint Piping Products.
h. Tyco Fire & Building Products LP.

2. Standard: UL 262.
3. Pressure Rating: 250 psig minimum.
4. Body Material: Cast or ductile iron.
5. End Connections: Flanged or grooved.
6. 2-1/2 inch and larger, shall be flanged IBBM, OS&Y gate type.

a. floor and above: 175 psig wwp, equal to Milwaukee 2885-FP or NIBCO F-607-OTS.
b. floor and below : 300 psig wwp, equal to FIBCO F-697-0
c. floor and below: 500 psig wwp (M.E.A. up to 350 psig), equal to NIBCO F-667-0.
d. On suction side of pumps: 175 psig wwp, equal to Milwaukee 2885-FP or NIBCO F-607-OTS.

7. Valves 6 inch and larger: Valved bypass.

8. Valves 6 inch and larger: Valved bypass.

9. Seal valves in proper position and provide approved type metal signs indicating purpose of valve.

H. Indicating-Type Butterfly Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Victaulic Company or an equal product by one of the following:

a. Anvil International, Inc.
b. Fivalco Inc.
c. Global Safety Products, Inc.
d. Kennedy Valve; a division of McWane, Inc.
e. Milwaukee Valve Company.
f. NIBCO Inc.
g. Shurjoint Piping Products.
h. Tyco Fire & Building Products LP.

2. Standard: UL 1091.
3. Pressure Rating: 175 psig minimum.
4. Valves NPS 2 and Smaller:

a. Valve Type: Ball or butterfly.
b. Body Material: Bronze.
c. End Connections: Threaded.

5. Valves NPS 2-1/2 and Larger:

a. Valve Type: Butterfly.
b. Body Material: Cast or ductile iron.
c. End Connections: Flanged, grooved, or wafer.

I. NRS Gate Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide NIBCO Inc. or an equal product by one of the following:

a. American Cast Iron Pipe Company; Waterous Company Subsidiary.
b. American Valve, Inc.
c. Clow Valve Company; a division of McWane, Inc.
d. Crane Co.; Crane Valve Group; Stockham Division.
e. Kennedy Valve; a division of McWane, Inc.
f. Mueller Co.; Water Products Division.
g. Tyco Fire & Building Products LP.

2. Standard: UL 262.
3. Pressure Rating: [**250 psig minimum**] [**300 psig**].

4. Body Material: Cast iron with indicator post flange.
5. Stem: Nonrising.
6. End Connections: Flanged or grooved.
7. Equal to American Flow Control Series 2500.

J. Indicator Posts:

1. Basis-of-Design Product: Subject to compliance with requirements, provide NIBCO Inc. or an equal product by one of the following:
   a. Clow Valve Company; a division of McWane, Inc.
   b. Crane Co.; Crane Valve Group; Stockham Division.
   c. Kennedy Valve; a division of McWane, Inc.
   d. Mueller Co.; Water Products Division.
   e. Tyco Fire & Building Products LP.

2. Standard: UL 789.
3. Type: Horizontal for wall mounting.
4. Body Material: Cast iron with extension rod and locking device.
5. Operation: [**Wrench**] [**Hand wheel**].
6. Equal to NIBCO NIP-2AJ.

2.6 TRIM AND DRAIN VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating: 175 psig minimum.

B. Angle Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Milwaukee Valve Company No. 504 or an equal product by one of the following:

   a. Fire Protection Products, Inc.
   b. United Brass Works, Inc.

C. Ball Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Milwaukee Valve Company or an equal product by one of the following:
   a. Anvil International, Inc.
   b. Conbraco Industries, Inc.; Apollo Valves.
   c. Fire-End & Croker Corporation.
   d. Kennedy Valve; a division of McWane, Inc.
   e. NIBCO Inc.
   f. Potter Roemer.
   g. Tyco Fire & Building Products LP.
   h. Victaulic Company.
   i. Watts Water Technologies, Inc.

2. Grooved end shut-off valve shall be ball type, two-piece bronze body ASTM A584 with threaded or grooved end connections. Chrome-plated brass ball, 316 stainless steel stem, TFE seat, die-cast brass gearbox, pre-wired supervisory switches. Victaulic Series 728 FireLock®.

D. Globe Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Milwaukee Valve Company No. 502 or an equal product by one of the following:

   a. Fire Protection Products, Inc.
   b. United Brass Works, Inc.

2.7 SPECIALTY VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating:

   a. Standard-Pressure Piping Specialty Valves: 175 psig minimum.
   b. High-Pressure Piping Specialty Valves: 250 psig minimum.

3. Body Material: Cast or ductile iron.
4. Size: Same as connected piping.
5. End Connections: Flanged or grooved.

B. Alarm Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Victaulic Company or an equal product by one of the following:
   a. Globe Fire Sprinkler Corporation.
   b. Reliable Automatic Sprinkler Co., Inc.
   c. Tyco Fire & Building Products LP.
   d. Viking Corporation.

2. Standard: UL 193.
3. Design: For horizontal or vertical installation.
4. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gage and fill-line attachment with strainer.
5. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
6. Drip Cup Assembly: Pipe drain with check valve to main drain piping.
7. Flanged IBBM alarm check valve, equal to Reliable Model E or grooved end equal to Victaulic Series 751.

   a. With variable pressure trim, with retard chamber equal to Victaulic Series 752.
   b. With constant pressure trim.
   c. Alarm switches to actuate alarm panel, local alarm gong, remote fire alarm and to shut down ventilating equipment.
   d. Water motor gong equal to Victaulic Series 760.
   e. All required drains, gauges, testing apparatus, and accessories.
   f. Internal components of valve shall be replaceable without removing valve from the installed position.

C. Automatic (Ball Drip) Drain Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Potter-Roemer or an equal product by one of the following:

a. Fire End & Croker Company.
b. Reliable Automatic Sprinkler Co., Inc.
c. Tyco Fire & Building Products LP.

2. Standard: UL 1726.
3. Pressure Rating: 175 psig minimum.
4. Type: Automatic draining, ball check.
5. Size: NPS 3/4.
6. End Connections: Threaded.
7. Equal to Potter-Roemer No. 5982 (straight).

2.8 SPRINKLER SPECIALTY PIPE FITTINGS

A. Branch Outlet Fittings:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Victaulic Company or an equal product by one of the following:

   a. Anvil International, Inc.
   b. Shurjoint Piping Products.
   c. Tyco Fire & Building Products LP.

2. Standard: UL 213.
3. Pressure Rating: 175 psig minimum.
4. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
5. Type: Mechanical-T and -cross fittings.
6. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
7. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
8. Branch Outlets: Grooved, plain-end pipe, or threaded.

B. Flow Detection and Test Assemblies:

1. Basis-of-Design Product: Subject to compliance with requirements, provide AGF Manufacturing Inc. or an equal product by one of the following:
   a. Reliable Automatic Sprinkler Co., Inc.
   b. Tyco Fire & Building Products LP.
   c. Victaulic Company.

2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
3. Pressure Rating: 175 psig minimum.
4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

C. Branch Line Testers:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Potter Roemer or an equal product by one of the following:

   a. Elkhart Brass Mfg. Company, Inc.
   b. Fire-End & Croker Corporation.

2. Standard: UL 199.
3. Pressure Rating: 175 psig.
4. Body Material: Brass.
5. Size: Same as connected piping.
6. Inlet: Threaded.
7. Drain Outlet: Threaded and capped.
8. Branch Outlet: Threaded, for sprinkler.
9. Test Pipes: Valved test connections at the following locations and pipe them to discharge though proper orifice.

    a. At each waterflow alarm device. (Floor control assembly with PRV, test line shall be 2 inch minimum and drain riser shall be 3 inch minimum.)
    b. At the end of the most remote sprinkler branch pipe in the uppermost story.
    c. For each Dry Pipe and Pre-Action Sprinkler System: At the end of the most remote sprinkler branch on the uppermost level protected by the system.

        1) Test connections for dry pipe and pre-action systems shall consist of a 1 inch shut-off valve and a plug (or a capped nipple), at least one of which shall be brass.

    d. At other required locations.

D. Sprinkler Inspector's Test Fittings:

1. Basis-of-Design Product: Subject to compliance with requirements, provide AGF Manufacturing Inc or an equal product by one of the following:

    a.
    b. Tyco Fire & Building Products LP.
    c. Victaulic Company.
    d. Viking Corporation.

2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
3. Pressure Rating: 175 psig minimum.
4. Body Material: Cast- or ductile-iron housing with sight glass.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.
7. Where required, test pipe with sight glass, and calibrated orifice or Victaulic Style 720 Alarm Test module TestMaster II (option for PRV).
8. Where applicable, use a grooved end 90 degree elbow at fire department connection (Siamese) equal to Victaulic #10-DR.

E. Adjustable Drop Nipples:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Merit Manufacturing; a division of Anvil International, Inc. or an equal product by one of the following:

    a. CECA, LLC.
    b. Corcoran Piping System Co.

2. Standard: UL 2443.
3. Pressure Rating: 250 psig minimum.
4. Body Material: Steel pipe with EPDM-rubber O-ring seals.
5. Size: Same as connected piping.
6. Length: Adjustable.

7. Inlet and Outlet: Threaded.

F. Flexible, Sprinkler Hose Fittings:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Potter Roemer or an equal product by one of the following:

a. Fivalco Inc.
b. FlexHead Industries, Inc.
c. Gateway Tubing, Inc.

2. Standard: UL 2443.
3. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
4. Pressure Rating: 175 psig minimum.
5. Size: Same as connected piping, for sprinkler.

2.9 SPRINKLERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Reliable Automatic Sprinkler Co., Inc. or an equal product by one of the following:
1. Globe Fire Sprinkler Corporation.
2. Tyco Fire & Building Products LP.
3. Victaulic Company.
4. Viking Corporation.

B. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating for Automatic Sprinklers: 175 psig minimum.
3. Pressure Rating for High-Pressure Automatic Sprinklers: 300 psig.
4. On deluge systems, provide open type sprinkler heads.

C. Automatic Sprinklers **with Heat-Responsive Element:**

1. Early-Suppression, Fast-Response Applications: UL 1767.
2. Nonresidential Applications: UL 199.
3. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

D. Open Orifice Sprinklers: UL 199.

1. Characteristics:

a. Nominal 1/2-inch Orifice: With Discharge Coefficient K between 5.3 and 5.8.
b. Nominal 17/32-inch Orifice: With Discharge Coefficient K between 7.4 and 8.2.

E. Sprinkler Finishes:

1. Chrome plated.
2. Bronze.
3. Painted.

F. Special Coatings:

1. Wax.
2. Lead.
3. Corrosion-resistant paint.

G. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.

1. Ceiling Mounting: Concealed, flushed and recessed.
2. Sidewall Mounting: Concealed and recessed.

H. Sprinkler Guards:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Reliable Automatic Sprinkler Co., Inc. or an equal product by one of the following:

    a. Globe Fire Sprinkler Corp.
    b. Tyco Fire & Building Products LP.
    c. Victaulic Company.
    d. Viking Corporation.

2. Standard: UL 199.
3. Type: Wire cage with fastening device for attaching to sprinkler.

I. Standard Response Sprinklers (5.6 K-Factor Only):
1. Sprinklers shall be provided where noted and installed in accordance with their listing:
    a. Upright:
        1) Reliable Model G
        2) Victaulic Model V2703
    b. Pendent:
        1) Reliable Model G
        2) Victaulic Model V2707
    c. Sidewall:
        1) Reliable Model G
        2) Victaulic Model V3809
    d. Concealed:
        1) Reliable Model G4FR
        2) Victaulic Model V3801

J. Quick Response Sprinklers (5.6 K-Factor Only):
1. Sprinklers shall be provided where noted and installed in accordance with their listing.
    a. Upright:
        1) Reliable Model GFR (fusible link UL Listing only)
        2) Reliable Model F1FR (frangible bulb UL & FM listed)
        3) Victaulic Model V2704 (frangible bulb UL and FM listed)
    b. Pendent:
        1) Reliable Model GFR (fusible link UL listing only)
        2) Reliable Model F1FR (frangible bulb UL & FM listed)
        3) Victaulic Model V2708 (frangible bulb UL and FM listed)
    c. Sidewall:
        1) Reliable Model GFR (fusible link UL listing only)
        2) Reliable Model F1FR (frangible bulb UL & FM listed)
        3) Victaulic Model V2710 (frangible bulb UL and FM listed)
    d. Concealed:
        1) Reliable Model G4A (fusible link UL listing only)
        2) Victaulic Model V3802 (frangible bulb UL listing only)

2.10 ALARM DEVICES

A. Water-Flow Indicators:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Potter Electric Signal Company or an equal product by one of the following:
   a. McDonnell & Miller; ITT Industries.
   b. System Sensor; a Honeywell company.
   c. Viking Corporation.

2. Standard: UL 346.
3. Water-Flow Detector: Electrically supervised.
4. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
5. Type: Paddle operated.
6. Pressure Rating: 250 psig.
7. Design Installation: Horizontal or vertical.

B. Pressure Switches:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product by one of the following:

   a. AFAC Inc.
   b. Barksdale, Inc.
   c. Detroit Switch, Inc.
   d. Potter Electric Signal Company.
   e. System Sensor; a Honeywell company.
   f. Tyco Fire & Building Products LP.
   g. United Electric Controls Co.
   h. Viking Corporation.

2. Standard: UL 346.
3. Type: Electrically supervised water-flow switch with retard feature.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design Operation: Rising pressure signals water flow.
6. Closed circuit water flow indicators with two sets of S.P.D.T. contacts, equal to System Sensor WFD Series or Potter Electric Signal Co. model PS10 for water and PS40 for air piping 24 VAC for dry pipe sprinkler system and 24 VAC for preaction sprinkler system.

   a. Electrical connections shall be of rigid conduit type. No plug-in connectors will be permitted.

C. Valve Supervisory Switches:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product by one of the following:

   a. Fire-Lite Alarms, Inc.; a Honeywell company.
   b. Kennedy Valve; a division of McWane, Inc.
   c. Potter Electric Signal Company.
   d. System Sensor; a Honeywell company.

2. Standard: UL 346.

3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled valve is in other than fully open position.
6. Equal to OSY2, PSP1.

2.11 PRESSURE GAGES

A. Basis-of-Design Product: Subject to compliance with requirements, provide Ashcroft, Inc. or an equal product by one of the following:

1. AMETEK; U.S. Gauge Division.
2. Brecco Corporation.
3. WIKA Instrument Corporation.

B. Standard: UL 393.

C. Dial Size: 3-1/2- to 4-1/2-inch diameter.

D. Pressure Gage Range: 0 to 250 psig minimum.

E. Water System Piping Gage: Include "WATER" or "AIR/WATER" label on dial face.

2.12 ESCUTCHEONS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Elcen or an equal product by one of the following:

B. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.

C. One-Piece, Cast-Brass Escutcheons: Polished chrome-plated or rough-brass finish with set-screws.

D. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with chrome-plated finish.

E. One-Piece, Stamped-Steel Escutcheons: Chrome-plated finish with set-screw or spring clips.

F. Split-Casting, Cast-Brass Escutcheons: Polished chrome-plated or rough-brass finish with concealed hinge and set-screw.

G. Split-Casting Floor Plates: Cast brass with concealed hinge.

2.13 SLEEVES

A. Cast-Iron Wall Pipe Sleeves: Cast or fabricated of cast iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, standard weight, zinc coated, plain ends.

C. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set-screws.

D. Except where framed openings are provided in General Construction Work, provide No. 22 USSG galvanized sheet metal sleeves though interior floors, ceilings, walls, and partitions.
   1. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

E. Projecting flashing type sleeves though interior membrane waterproofed floors, except as noted. Sleeves shall be cast iron with integral flashing flange for built up membrane, with clamping ring, equal to Josam Series No. 26420 or to Smith No. 1760. For liquid membrane, furnish sleeves with integral or brazed 4 inch wide flange, equal to Josam Series No. 26420-47 and to Smith No. 1755.

F. Flush flashing type sleeves though membrane waterproofed walls, slabs with earth fill above and slabs on ground. Sleeves shall be cast iron with integral flashing flange and clamping ring for built up membrane, equal to Josam Series no. 26400 or/and Smith No. 1721. For liquid membrane sleeves shall be with integral or brazed 4 inch wide flange, equal to Josam series no. 26400-47 or Smith No. 1721. Sleeves shall be modified for wall or slab thickness.

G. Through elastomeric type waterproofing, galvanized cast iron sleeves with integral bottom flange, equal to Smith No. DX-9325.

   1. Exposed sleeves after packing shall be covered by close-fitting metal escutcheons on both sides of construction.

H. Generally, sleeves though foundations are by others. Provide additional sleeves required and cutting and patching to install same or to relocate existing sleeves.

2.14 SLEEVE SEALS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product by one of the following:

   1. Advance Products & Systems, Inc.
   2. Calpico, Inc.
   3. Metraflex, Inc.
   4. Pipeline Seal and Insulator, Inc.

B. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

   1. Sealing Elements: EPDM-rubber or NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   2. Pressure Plates: Stainless steel.
   3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.15 GROUT

A. Standard: ASTM C 1107, Grade B, posthardening and volume adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink, and recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.

B. Report test results promptly and in writing.

3.2 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.

1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect or Engineer before deviating from approved working plans.

B. Piping Standard: Comply with requirements for installation of sprinkler piping in NFPA 13.

C. Install seismic restraints on piping. Comply with requirements for seismic-restraint device materials and installation in NFPA 13.

D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install unions adjacent to each valve in pipes NPS 2 and smaller.

F. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

G. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.

H. Install sprinkler piping with drains for complete system drainage.

1. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes. Drain pipes or test pipes shall spill through building wall, over ejector pit, over sump pit, over mop sink, over anti-splash standpipe drain, on roof or as noted.

I. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.

J. Install alarm devices in piping systems.

K. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.

L. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.

M. Fill sprinkler system piping with water.

3.3 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

B. Install unions adjacent to each valve in pipes NPS 2 and smaller.

C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.

G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

H. Twist-Locked Joints: Insert plain end of steel pipe into plain-end-pipe fitting. Rotate retainer lugs one-quarter turn or tighten retainer pin.

I. Steel-Piping, Pressure-Sealed Joints: Join lightwall steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.

J. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.

K. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.

L. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.

M. Steel-Piping, Pressure-Sealed Joints: Join Schedule 5 steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.

N. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.

O. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.4 INSTALLATION OF COVER SYSTEM FOR SPRINKLER PIPING

A. Install cover system, brackets, and cover components for sprinkler piping according to manufacturer's "Installation Manual" and with NFPA 13 or NFPA 13R for supports.

3.5 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve. Fasten sign to yoke with brass chain.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Specialty Valves:

1. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
2. Alarm Valves: Include bypass check valve and retarding chamber drain-line connection.
3. Deluge Valves: Install in vertical position, in proper direction of flow, and in main supply to deluge system. Install trim sets for drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.

3.6 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels.

B. Install sprinklers into flexible, sprinkler hose fittings and install hose into bracket on ceiling grid.

3.7 ESCUTCHEON INSTALLATION

A. Install escutcheons for penetrations of walls, ceilings, and floors.

B. Escutcheons for New Piping:

1. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
2. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish.
3. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish.

4. Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated finish.
5. Bare Piping in Equipment Rooms: One piece, cast brass.
6. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

C. Escutcheons for Existing Piping:

1. Chrome-Plated Piping: Split casting, cast brass with chrome-plated finish.
2. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish.
3. Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish.
4. Bare Piping in Unfinished Service Spaces: Split casting, cast brass with polished chrome-plated finish.
5. Bare Piping in Equipment Rooms: Split casting, cast brass.
6. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.

3.8 SLEEVE INSTALLATION

A. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.

B. Sleeves are not required for core-drilled holes.

C. Permanent sleeves are not required for holes formed by removable PE sleeves.

D. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.

E. Install sleeves in new partitions, slabs, and walls as they are built.

F. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements for joint sealants in Division 07 Section "Joint Sealants."

G. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements for joint sealants in Division 07 Section "Joint Sealants."

H. =

I. Provide sleeves of cast iron or steel pipe through exterior walls, beams, interior machine room floors and interior sprinklered area floors, except as noted. Extend sleeves 3 inches to 6 inches above finished floor. Provide continuously welded center flange for sleeves though exterior walls, and floors of machine rooms and sprinklered areas.

J. Seal space outside of sleeves in concrete slabs and walls with grout.

K. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.

L. Install sleeve materials according to the following applications:

1. Sleeves for Piping Passing through Concrete Floor Slabs: Galvanized-steel pipe <Insert type.

2. Sleeves for Piping Passing through Interior Concrete Walls:
    a. Galvanized-steel-sheet sleeves for pipes NPS 6 and larger.

M. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestop materials and installations in Division 07 Section "Penetration Firestopping."

3.9 SLEEVE SEAL INSTALLATION

A. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.

B. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.10 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
4. Energize circuits to electrical equipment and devices.
5. Start and run excess-pressure pumps.
6. Coordinate with fire-alarm tests. Operate as required.
7. Coordinate with fire-pump tests. Operate as required.
8. Verify that equipment hose threads are same as local fire-department equipment.

C. Sprinkler piping system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Submit a copy of Department of Buildings/Plumbing Division On Site Inspection Report (New York projects only).

3.12 CLEANING

A. Clean dirt and debris from sprinklers.

B. Remove and replace sprinklers with paint other than factory finish.

3.13 PIPING APPLICATION

A. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.

B. Standard-pressure, wet-pipe sprinkler system, NPS 2 and smaller, shall be one of the following:

1. Standard-weight, Schedule 40, threaded, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Standard-weight, black-steel pipe with cut- or roll-]grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

C. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 to NPS 4, shall be[one of the following:

1. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Schedule 10, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.14 SPRINKLER SCHEDULE

A. Use sprinkler types in subparagraphs below for the following applications:

1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings: Recessed sprinklers.
3. Wall Mounting: Sidewall sprinklers.
4. Special Applications: Extended-coverage, flow-control, and quick-response sprinklers where indicated.

B. Provide sprinkler types in subparagraphs below with finishes indicated.

1. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
2. Flush Sprinklers: Bright chrome, with painted white escutcheon.
3. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
4. Pendent and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION 21 1313

SECTION 22 0500

COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
1. Piping materials and installation instructions common to most piping systems.
2. Transition fittings.
3. Dielectric fittings.
4. Mechanical sleeve seals.
5. Sleeves.
6. Escutcheons.
7. Grout.
8. Equipment installation requirements common to equipment sections.
9. Painting and finishing.
10. Concrete bases.
11. Supports and anchorages.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for rubber materials:
1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For the following:
   1. Transition fittings.
   2. Dielectric fittings.
   3. Mechanical sleeve seals.
   4. Escutcheons.

B. Welding certificates.

1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

1.7 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.
2. Where Basis of Design product is indicated, provide that item or a manufacturer listed or equal. For manufacturers not listed, submit substitution only at time of bid with complete comparison to specified item.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 22 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 150, cast-iron and steel flanges.
   2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux for potable water according to ASTM B 813.

E. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 TRANSITION FITTINGS

A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
   1. Manufacturers:
      a. Cascade Waterworks Mfg. Co.
      b. Dresser Industries, Inc.; DMD Div.
      c. Ford Meter Box Company, Incorporated (The); Pipe Products Div.
      d. JCM Industries.
      e. Smith-Blair, Inc.
      f. Viking Johnson.
   2. Aboveground Pressure Piping: Pipe fitting.

B. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.
   1. Manufacturers:
      a. Cascade Waterworks Mfg. Co.
      b. Fernco, Inc.
      c. Mission Rubber Company.

C. Adapters:
   1. Tile-cast iron adapters with extra heavy cast iron hub and spigot type, equal to Josam Series 88700.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F. Shall be listed under ASSE Standard No. 1079.
   1. Manufacturers:
      a. Capitol Manufacturing Co.
      b. Central Plastics Company.
      c. Eclipse, Inc.
      d. Epco Sales, Inc.
      e. Hart Industries, International, Inc.
      f. Watts Industries, Inc.; Water Products Div.
      g. Zurn Industries, Inc.; Wilkins Div.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
   1. Manufacturers:
      a. Capitol Manufacturing Co.
      b. Central Plastics Company.
      c. Epco Sales, Inc.
      d. Watts Industries, Inc.; Water Products Div.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
   1. Manufacturers:
      a. Advance Products & Systems, Inc.
      b. Calpico, Inc.
      c. Central Plastics Company.
      d. Pipeline Seal and Insulator, Inc.
   2. Separate companion flanges and steel bolts and nuts shall have 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.
   1. Manufacturers:
      a. Calpico, Inc.
      b. Lochinvar Corp.

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.
   1. Manufacturers:
      a. Perfection Corp.
      b. Precision Plumbing Products, Inc.
      c. Sioux Chief Manufacturing Co., Inc.
      d. Victaulic Co. of America.

2.6 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
   1. Manufacturers:
      a. Advance Products & Systems, Inc.
      b. Linkseal.
      c. Calpico, Inc.
      d. Metraflex Co.
      e. Pipeline Seal and Insulator, Inc.
   2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   3. Pressure Plates: Molded glass reinforced Nylon Polymer. Include two for each sealing element.
   4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   1. Under deck Clamp: Clamping ring with set screws.

2.8 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.
   1. Finish: Polished chrome-plated and rough brass.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
   1. Finish: Polished chrome-plated and rough brass.

E. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.

F. Split-Plate, Stamped-Steel Type: With set screw or spring clips, and chrome-plated finish.

G. One-Piece, Floor-Plate Type: Cast-iron floor plate.

H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.9 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
   2. Design Mix: 5000-psi, 28-day compressive strength.
   3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
   1. New Piping:
      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
      b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
      c. Insulated Piping: One-piece, stamped-steel type with spring clips.
      d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
      e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
      f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with rough-brass finish.
      g. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed or exposed-rivet hinge and set screw or spring clips.

h. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
i. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw or spring clips.
j. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

M. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
1. Seal space between pipe and sleeves through exterior walls and fire and smoke-rated walls and floors in accordance with local code and Fire Department requirements.
2. Fire rated construction: Space between pipe and sleeve shall not exceed one-half inch. Provide close fitting metal escutcheons on both sides of sleeves through fire-rated construction.
a. Sealant material shall be non-combustible and smoke-tight, equal to Nelson Flameseal system using ceramic fiber insulation plus putty. Install in accordance with manufacturer's recommendations.
b. Sealant material shall be non-combustible and smoke-tight.
3. Exterior walls: Seal watertight with oakum packing and caulked lead.

N. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
1. Cut sleeves to length for mounting flush with both surfaces.
a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
a. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
b. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
1) Seal space outside of sleeve fittings with grout.
4. Wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
5. Provide projecting flashing sleeve through interior membrane waterproofed floors, except as noted. Provide cast iron sleeve with integral flashing flange for built up membrane with clamping ring, equal to Smith No. 1760. Provide integral or brazed four-inch wide flange on sleeve for floors with liquid membrane waterproofing, equal to Smith No. 1755. Adjust sleeve height to floor construction with galvanized steel pipe nipples top and bottom extending two inches above finished floor.
6. Provide flush flashing type sleeve for installation through membrane-waterproofed walls, floors for floor outlet fixtures, slabs with earth fill above, and slabs on ground. Provide cast iron sleeve with integral flashing flange and clamping ring for floors with built up membrane, equal to Smith No. 1721. Provide sleeves with integral or brazed four-inch wide flange for floors with liquid membrane, equal to Smith No. DX-1721. Modify sleeve length for wall or slab thickness. Seal pipe watertight in sleeve with oakum packing and caulked lead joint.
7. Provide galvanized cast iron sleeve with integral bottom flange, through floors with elastomeric type waterproofing, equal to Smith No. DX-9325.
8. Provide No. 22 USSG galvanized iron U-shaped covers over water piping installed in floor fill. Surround covers and drainage and vent piping with a minimum of one-half inch of cement mortar.

O. Aboveground Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install steel "wall pipes" for sleeves 6 inches and larger in diameter.

3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
4. Provide continuously welded center flange in sleeve though exterior walls, interior floors of machine rooms and sprinklered areas and fireproof floors.

P. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Fire stopping" for materials.

Q. Verify final equipment locations for roughing-in.

R. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux for potable water, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:
1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.

2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.5 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section “Metal Fabrications” for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.6 GROUTING

A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 22 0500

SECTION 22 0516

EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal-bellows expansion joints.
2. Rubber expansion joints.
3. Flexible-hose expansion joints.
4. Drainage piping expansion joints.
5. Test tee expansion joints.
6. Pipe bends and loops.
7. Alignment guides and anchors.

1.3 DEFINITIONS

A. BR: Butyl rubber.

B. Buna-N: Nitrile rubber.

C. CR: Chlorosulfonated polyethylene synthetic rubber.

D. CSM: Chlorosulfonyl-polyethylene rubber.

E. EPDM: Ethylene-propylene-diene terpolymer rubber.

F. NR: Natural rubber.

1.4 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping system fluids, materials, working pressures, and temperatures.

B. Capability: Products shall absorb 200 percent of maximum axial movement between anchors.

1.5 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Delegated-Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and bends.
2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
3. Alignment Guide Details: Detail field assembly and attachment to building structure.
4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

C. Welding certificates.

D. Product Certificates: For each type of pipe expansion joint, signed by product manufacturer.

E. Maintenance Data: For pipe expansion joints to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. Steel Shapes and Plates: AWS D1.1, "Structural Welding Code - Steel."
2. Welding to Piping: ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 EXPANSION JOINTS

A. Flexible Hose Expansion Joints: Manufactured assembly with two flexible metal hose legs joined by long radius, 180 degree return bend or center section of flexible hose; with inlet and outlet elbow fittings, corrugated metal inner hoses, and braided outer

1. Basis-of-Design Product: Subject to compliance with requirements, provide Flex Hose Co.,Inc., or comparable product by one of the following:

a. Flexicraft Industries.
b. Flex-Pression, Ltd.
c. Mason Industries.
d. Metraflex, Inc.

2. Flexible Hose Expansion Joints for Copper Piping: Copper alloy fittings with solder joint end connections.

a. NPS 2 and Smaller: Bronze hoses and single braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.
b. NPS 2 1/2 to NPS 4: Stainless steel hoses and single braid, stainless steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings.

3. Flexible Hose Expansion Joints for Copper Piping: Copper alloy fittings with solder joint end connections.

a. NPS 2 and Smaller: Bronze hoses and double braid bronze sheaths with 700 psig at 70 deg F and 500 psig at 450 deg F ratings. Equal to Mason Industries type CPS
b. NPS 2 1/2 to NPS 4: Stainless steel hoses and double braid, stainless steel sheaths with 420 psig at 70 deg F and 315 psig at 450 deg F ratings.
c. NPS 2-1/2 to NPS 6: Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F and 145 psig at 600 deg F ratings. Equal to Mason Industries type FFL.
d. NPS 8 to NPS 12: Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F and 90 psig at 600 deg F ratings.

4. Flexible-Hose Expansion Joints for Steel Piping: Carbon-steel fittings with threaded end connections for NPS 2 and smaller and [**flanged**] [**weld**] end connections for NPS 2-1/2 and larger.

a. NPS 2 and Smaller: Stainless-steel hoses and double-braid, stainless-steel sheaths with 700 psig at 70 deg F and 515 psig at 600 deg F ratings.
b. NPS 2-1/2 to NPS 6: Stainless-steel hoses and double-braid, stainless-steel sheaths with 275 psig at 70 deg F and 200 psig at 600 deg F ratings.
c. NPS 8 and Larger: Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F and 120 psig at 600 deg F ratings.

5. Expansion joints for drainage piping:
a. **<Insert manufacturer's name.>**

2.2 MATERIALS FOR ANCHORS

A. Steel Shapes and Plates: ASTM A 36/A 36M.

B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex head.

C. Washers: ASTM F 844, steel, plain, flat washers.

D. Expansion Anchors

1. Smooth wall, non-self-drilling internal plug expansion type anchors constructed of AISC 12L14 steel and zinc plated in accordance with Fed. Spec. QQ-A-325 type 1, Class 3.
2. Do not exceed 1/4 of average values for a specific anchor size using 2000 PSIG concrete only, for maximum working loads.
3. Locate spacing and install anchors in accordance with the manufacturer's recommendations.
4. Expansion anchors shall be U.L listed and equal to Hilti HDI.

E. Chemical Fasteners: Insert-type-stud bonding system anchor for use with hardened portland cement concrete, and tension and shear capacities appropriate for application.

1. Bonding Material: ASTM C 881, Type IV, Grade 3, 2-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
2. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
3. Washer and Nut: Zinc-coated steel.

F. Concrete: Portland cement mix, 3000 psi minimum. Comply with requirements in Division 03 Section "Cast-in-Place Concrete" for formwork, reinforcement, and concrete.

G. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink, nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 EXPANSION-JOINT INSTALLATION

A. Install manufactured, nonmetallic expansion joints according to FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."

B. Install expansion joints of sizes matching size of piping in which they are installed.

C. Install alignment guides to allow expansion and to avoid end-loading and torsional stress.

D. Provide cast iron test tee expansion joints every 150 feet on vertical drainage and vent lines and where noted or required.

3.2 PIPE BEND AND LOOP INSTALLATION

A. Install pipe bends and loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Attach pipe bends and loops to anchors.

1. Steel Anchors: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer's written instructions.

3.3 SWING CONNECTIONS

A. Connect risers and branch connections to mains with at least **[five]** <**Insert number**> pipe fittings, including tee in main.

B. Connect risers and branch connections to terminal units with at least **[four]** <**Insert number**> pipe fittings, including tee in riser.

C. Connect mains and branch connections to terminal units with at least **[four]** <**Insert number**> pipe fittings, including tee in main.

3.4 ALIGNMENT-GUIDE INSTALLATION

A. Install guides on piping adjoining pipe expansion fittings and loops.

B. Attach guides to pipe and secure to building structure.

3.5 ANCHOR INSTALLATION

A. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.

C. Construct concrete anchors of poured-in-place concrete of dimensions indicated and include embedded fasteners.

D. Install pipe anchors according to expansion-joint manufacturer's written instructions if expansion joints are indicated.

E. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

END OF SECTION 22 0516

SECTION 22 0517

SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

2.2 STACK-SLEEVE FITTINGS

A. Basis of Design Product: Subject to compliance with requirements, provide Smith, Jay R. Mfg. Co. or comparable product by one of the following:

1. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.

B. Description: Manufactured, cast iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

A. Basis of Design Product: Subject to compliance with requirements, provide Link Seal or comparable product by one of the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.

B. Description: Modular sealing element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion resistant coating, of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

A. Basis of Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:

1. Presealed Systems.

B. Description: Manufactured plastic, sleeve type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve seal system installed, select sleeves of size large enough to provide 1 inch annular clear space between piping and concrete walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.

   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 1 inch above finished floor level.

3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Division 07 Section "Joint Sealants."

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Division 07 Section "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using grout, seal the space around outside of stack-sleeve fittings.

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:

    a. Piping Smaller Than NPS 6: Sleeve seal fittings.
    b. Piping NPS 6 and Larger: Galvanized steel pipe sleeves.

2. Exterior Concrete Walls below Grade:

    a. Piping Smaller Than NPS 6: Sleeve seal fittings.

        1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

    b. Piping NPS 6 and Larger: Cast iron wall sleeves with sleeve seal system Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

        1) Select sleeve size to allow for 1 inch annular clear space between piping and sleeve for installing sleeve seal system.

3. Concrete Slabs-on-Grade:

    a. Piping Smaller Than NPS 6: Sleeve seal fittings.

        1) Select sleeve size to allow for 1 inch annular clear space between piping and sleeve for installing sleeve seal system.

b. Piping NPS 6 and Larger: Cast iron wall sleeves with sleeve seal system.

1) Select sleeve size to allow for 1 inch annular clear space between piping and sleeve for installing sleeve seal system.

4. Concrete Slabs above Grade:

a. Piping Smaller Than NPS 6: Stack sleeve fittings.
b. Piping NPS 6 and Larger: Stack sleeve fittings.

5. Interior Partitions:

a. Piping Smaller Than NPS 6: Galvanized steel pipe sleeves.

END OF SECTION 22 0517

SECTION 22 0519

METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Thermometers.
   2. Pressure gages.
   3. Test plugs.

B. Related Sections:
   1. Division 22 Section 22 1113 "Facility Water Distribution Piping" for domestic and fire-protection water service meters outside the building.
   2. Division 22 Section 22 1116 and 221117 "Domestic Water Piping" for domestic and fire-protection water service meters inside the building.
   3. Division 23 Section 22 7000 "Natural-Gas System."

1.3 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

B. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated; include performance curves.

B. Shop Drawings: Schedule for thermometers and gages indicating manufacturer's number, scale range, and location for each.

C. Product Certificates: For each type of thermometer and gage, signed by product manufacturer.

1.5 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. NSF Compliance:
   1. Comply with NSF 61, "Drinking Water System Components – Health Effects; Sections 1 through 9" and Annex F & G for potable domestic water piping and components.

PART 2 - PRODUCTS

2.1 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
   1. Palmer - Wahl Instruments Inc.
   2. Trerice, H. O. Co.
   3. Weiss Instruments, Inc.
   4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Case: Chrome-plated brass, 7 inches long.

C. Tube: Red or blue reading, organic-liquid filled, with magnifying lens.

D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.

E. Window: Glass.

F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.

G. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.

H. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.2 DIRECT-MOUNTING, VAPOR-ACTUATED DIAL THERMOMETERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
   1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
   2. KOBOLD Instruments, Inc.
   3. Marsh Bellofram.
   4. Trerice, H. O. Co.
   5. Weiss Instruments, Inc.
   6. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Case: Liquid-filled type, drawn steel or cast aluminum 4-1/2-inchdiameter.

C. Element: Bourdon tube or other type of pressure element.

D. Movement: Mechanical, connecting element and pointer.

E. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.

F. Pointer: Red or other dark-color metal.

G. Window: Glass.

H. Ring: Stainless steel.

I. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.

J. Thermal System: Liquid- or mercury-filled bulb in copper-plated steel, aluminum, or brass stem for thermowell installation and of length to suit installation.

K. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

L. Equal to Trerice No. V80030 V80742 V80341R or V80342R.

2.3 REMOTE-MOUNTING, VAPOR-ACTUATED DIAL THERMOMETERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
1. AMETEK, Inc.; U.S. Gauge Div.
2. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
3. Marsh Bellofram.
4. Miljoco Corp.
5. Palmer - Wahl Instruments Inc.
6. REO TEMP Instrument Corporation.
7. Tel-Tru Manufacturing Company.
8. Trerice, H. O. Co.
9. Weiss Instruments, Inc.
10. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
11. Winters Instruments.

B. Case: Dry type, drawn steel or cast aluminum 4-1/2-inch diameter with holes for panel mounting.

C. Element: Bourdon tube or other type of pressure element.

D. Movement: Mechanical, connecting element and pointer.

E. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.

F. Pointer: Red or other dark-color metal.

G. Window: Glass.

H. Ring: Stainless steel.

I. Connector: Bottom union type.

J. Thermal System: Liquid- or mercury-filled bulb in copper-plated steel, aluminum, or brass stem for thermowell installation and of length to suit installation.

K. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

L. Copper Bulb with metal protective sheathed light wall flexible copper tubing or unsheathed extra heavy flexible copper tubing, equal to Trerice No. V80025. Copper bulb with metal protective sheathed flexible tubing, equal to Trerice no. V80341.

2.4 BIMETALLIC-ACTUATED DIAL THERMOMETERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
   1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
   2. Ernst Gage Co.
   3. Eugene Ernst Products Co.
   4. Trerice, H. O. Co.
   5. Weiss Instruments, Inc.
   6. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
   7. WIKA Instrument Corporation.

B. Description: Direct-mounting, bimetallic-actuated dial thermometers complying with ASME B40.3.

C. Case: Liquid-filled type, stainless steel with 5-inch diameter.

D. Element: Bimetal coil.

E. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.

F. Pointer: Red or other dark-color metal.

G. Window: Glass.

H. Ring: Stainless steel.

I. Connector: Adjustable angle type.

J. Stem: Metal, for thermowell installation and of length to suit installation.

K. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.6 THERMOWELLS

A. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
   1. AMETEK, Inc.; U.S. Gauge Div.
   2. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
   3. Ernst Gage Co.
   4. Trerice, H. O. Co.
   5. Weiss Instruments, Inc.
   6. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
   7. WIKA Instrument Corporation.
   8. Winters Instruments.

B. Manufacturers: Same as manufacturer of thermometer being used.

C. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.7 PRESSURE GAGES

A. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
   1. AMETEK, Inc.; U.S. Gauge Div.
   2. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
   3. Ernst Gage Co.
   4. Eugene Ernst Products Co.
   5. Trerice, H. O. Co.
   6. Weiss Instruments, Inc.
   7. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
   8. WIKA Instrument Corporation.
   9. Winters Instruments.

B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.
   1. Case: Liquid-filled type, drawn steel or cast aluminum 4-1/2-inch diameter.
   2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
   3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
   4. Movement: Mechanical, with link to pressure element and connection to pointer.
   5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
   6. Pointer: Red or other dark-color metal.
   7. Window: Glass.
   8. Ring: Stainless steel.
   9. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
   10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
   11. Range for Fluids under Pressure: Two times operating pressure.
   12. Equal to Ashcroft Type 1010 with brass pressure snubber and brass tee-handle cock.
   13. Equal to Ashcroft Duragauge Type 1379 with brass snubber and brass tee handle.

C. Remote-Mounting, Dial-Type Pressure Gages: ASME B40.100, indicating-dial type.
   1. Case: Dry type, drawn steel or cast aluminum, 4-1/2-inch diameter with holes for panel mounting.
   2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
   3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
   4. Movement: Mechanical, with link to pressure element and connection to pointer.
   5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
   6. Pointer: Red or other dark-color metal.
   7. Window: Glass.
   8. Ring: Stainless steel.
   9. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
   10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
   11. Range for Fluids under Pressure: Two times operating pressure.

D. Pressure-Gage Fittings:
   1. Valves: NPS 1/4 brass or stainless-steel needle type.
   2. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.8 TEST PLUGS

A. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
   1. Flow Design, Inc.
   2. MG Piping Products Co.
   3. National Meter, Inc.
   4. Trerice, H. O. Co.

5. Watts Industries, Inc.; Water Products Div.

B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

C. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

D. Core Inserts: One or two self-sealing rubber valves.
   1. Insert material for water service at 20 to 200 deg F shall be CR.
   2. Insert material for water service at minus 30 to plus 275 deg F shall be EPDM.

E. Test Kit: Furnish two test kit(s) containing one pressure gage and adaptor, two thermometer(s), and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.
   1. Pressure Gage: Small bourdon-tube insertion type with 2- to 3-inch-diameter dial and probe. Dial range shall be 0 to 200 psig.
   2. Low-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial ranges shall be 25 to 125 deg F.
   3. High-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch-diameter dial and tapered-end sensing element. Dial ranges shall be 0 to 220 deg F.
   4. Carrying case shall have formed instrument padding.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

A. Install liquid-in-glass, direct-mounting, vapor-actuated dial, remote-mounting, vapor-actuated dial, bimetallic-actuated dial thermometers in the outlet of each domestic, hot-water storage tank.

B. Install liquid-filled-case-type, bimetallic-actuated dial thermometers at suction and discharge of each pump.

C. Provide stainless steel separable socket in tank connections. On piping connection, provide in an oversized tee and nipple. Locate on each water heater, pre-heater, hot water tank, in outlet piping of each water heater and in outlet piping of each thermostatic tempering valve, hot water return piping, chilled water supply and return piping, and as noted.

D. Provide the following temperature ranges for thermometers:
   1. Domestic Hot Water: 30 to 180 deg F, with 2-degree scale divisions.
   2. Domestic Cold Water: 0 to 100 deg F, with 2-degree scale divisions.

3.2 GAGE APPLICATIONS

A. Install dry-case-type pressure gages for discharge of each pressure-reducing valve.

B. Install liquid-filled-case-type pressure gages at suction and discharge of each pump.

3.3 INSTALLATIONS

A. Install direct-mounting thermometers and adjust vertical and tilted positions.

B. Install remote-mounting dial thermometers on panel, with tubing connecting panel and thermometer bulb supported to prevent kinks. Use minimum tubing length.

C. Install thermowells with socket extending a minimum of 2 inches into fluid one-third of diameter of pipe to center of pipe and in vertical position in piping tees where thermometers are indicated.

D. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.

E. Install remote-mounting pressure gages on panel.

F. Install needle-valve and snubber fitting in piping for each pressure gage.

G. Install test plugs in tees in piping.

H. Install permanent indicators on walls or brackets in accessible and readable positions.

I. Install connection fittings for attachment to portable indicators in accessible locations.

J. Install thermometers and gages adjacent to machines and equipment to allow service and maintenance for thermometers, gages, machines, and equipment.

K. Adjust faces of thermometers and gages to proper angle for best visibility.

END OF SECTION 22 0519

SECTION 22 0523

GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Bronze angle valves.
2. Iron angle valves.
3. Bronze ball valves.
4. Steel ball valves.
5. Bronze lift check valves.
6. Bronze swing check valves.
7. Iron swing check valves.
8. Iron swing check valves with closure control.
9. Iron, grooved-end swing check valves.
10. Iron, center-guided check valves.
11. Iron, plate-type check valves.
12. Resilient wedge Iron gate valves.
13. Bronze globe valves.
14. Iron globe valves.
15. Lubricated plug valves.
16. Chainwheels.

B. Related Sections:
1. Division 22 plumbing piping Sections for specialty valves applicable to those Sections only.
2. Division 22 Section "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene diene terpolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: Nonrising stem.

E. PTFE: Polytetrafluoroethylene plastic.

F. OS&Y: Outside screw and yoke.

G. RS: Rising stem.

H. SWP: Steam working pressure.

1.4 SUBMITTALS

A. Product Data: For each type of valve indicated.

1.5 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:
1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
2. ASME B31.1 for power piping valves.
3. ASME B31.9 for building services piping valves.

C. NSF Compliance: NSF 61 for valve materials for potable-water service no lead content.

D. Dezincification: Silicon bronze lead-free copper alloys or dezincification resistant alloys that are comparable to or superior to commonly used bronze alloys containing lead.
1. Tested per ISO 6509 and examined according to ASTM E 3.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set angle, gate, and globe valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position.

B. Use the following precautions during storage:
1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Refer to valve schedule articles for applications of valves.

B. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

C. Bronze Valves: NPS 2 (DN 50) and smaller with threaded ends, unless otherwise indicated.

D. Ferrous Valves: NPS 2-1/2 (DN 65) and larger with flanged ends, unless otherwise indicated.

E. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

F. Valve Sizes: Same as upstream piping unless otherwise indicated.

G. Valve Actuator Types:
1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.
4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 5 plug valves, for each size square plug-valve head.
5. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

H. Valves in Insulated Piping: With 2-inch stem extensions and the following features:
1. Gate Valves: With rising stem.
2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation and memory stops that are fully adjustable after insulation is applied.
   a. Basis-of-Design Product: Subject to compliance with requirements, provide NIBCO Nib-seal handle extension or comparable product by one of the following:
      1) Conbraco Industries, Inc.; Appollo Div.
3. Butterfly Valves: With extended neck.

I. Valve-End Connections:
1. Flanged: With flanges according to ASME B16.1 for iron valves, ASME B16.5 for steel valves.
2. Grooved: With grooves according to AWWA C606.
3. Solder Joint: With sockets according to ASME B16.18.
4. Threaded: With threads according to ASME B1.20.1.

J. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE ANGLE VALVES

A. Class 125, Bronze Angle Valves with Nonmetallic Disc:
1. Provide NIBCO Model S-311-Y or T-311-Y or comparable product by one of the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Powell Valves.
   c. Watts.
2. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 200 psig.
   c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
   d. Ends: Threaded or solder..
   e. Stem: Copper-silicon bronze.
   f. Disc: PTFE or TFE.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron, bronze.

2.3 IRON ANGLE VALVES

A. Class 125, Cast-Iron Angle Valves:
   1. Provide NIBCO Model F-818-B or a comparable product by one of the following:
      a. Crane Co.; Crane Valve Group; Crane Valves.
      b. Powell Valves.
      c. Watts.
   2. Description:
      a. Standard: MSS SP-85, Type 2.
      b. CWP Rating: 200 psig.
      c. Body Material: ASTM A 126, gray iron with bolted bonnet.
      d. Ends: Flanged.
      e. Trim: Bronze.
      f. Disc: Bronze mounted.
      g. Packing and Gasket: Asbestos free.

2.4 BRONZE BALL VALVES

A. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:
   1. Basis-of-Design Product: Subject to compliance with requirements, provide NIBCO Model S-585-70 or a comparable product by one of the following:
      a. Conbraco Industries, Inc.; Apollo Div.
      b. Jamesbury, Inc.
   2. Description:
      a. Standard: MSS SP-110.
      b. SWP Rating: 150 psig.
      c. CWP Rating: 600 psig.
      d. Body Design: Two piece with threaded body packnut design (no threaded stem designs allowed) with adjustable stem packing.
      e. Body Material: Bronze ASTM B 584 Alloy C844.
      f. Ends: Threaded or solder.
      g. Seats: PTFE or TFE.
      h. Stem: Bronze.
      i. Ball: Chrome-plated brass.
      j. Port: Full.

B. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:
   1. Provide NIBCO Model S-585-70-66 or T-585-70-66 or a comparable product by one of the following:
      a. Conbraco Industries, Inc.; Apollo Div.
      b. Jamesbury, Inc.
      c. Watts.
   2. Description:
      a. Standard: MSS SP-110.
      b. SWP Rating: 150 psig.
      c. CWP Rating: 600 psig.
      d. Body Design: Two piece steel with threaded body packnut design (no threaded stem designs allowed) with adjustable stem packing.
      e. Body Material: Bronze ASTM B 584 Alloy C844.
      f. Ends: Threaded or Solder.
      g. Seats: PTFE or TFE.
      h. Stem: Stainless.
      i. Ball: Stainless steel, vented.
      j. Port: Full.

2.5 STEEL BALL VALVES

A. Class 15, Full-Port Steel Ball Valves:
1. Provide NIBCO Model F-515-CS-F-66-FS or a comparable product by one of the following:
   a. Conbraco Industries, Inc.; Apollo Div.
   b. Jamesbury, Inc.
   c. Watts.
2. Description:
   a. Standard: MSS SP-72.
   b. CWP Rating: 285 psig.
   c. Body Design: Split body.
   d. Body Material: Carbon steel ASTM A 216, type WCB.
   e. Ends: Flanged.
   f. Seats: PTFE or TFE.
   g. Stem: Stainless steel.
   h. Ball: Stainless steel, vented.
   i. Port: Full.

2.6 BRONZE LIFT CHECK VALVES

A. Class 125, Lift Check Valves with Nonmetallic Buna-N Disc:
1. Provide NIBCO Model S-480 or T-480 or a comparable product by one of the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Powell Valves.
   c. Watts.
2. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 200 psig.
   c. Body Design: Vertical flow.
   d. Body Material: ASTM B 584 Alloy C844, bronze.
   e. Ends: Threaded or Solder.
   f. Disc: Buna-N.

B. Class 125, Lift Check Valves with Nonmetallic TFE Disc:
1. Provide NIBCO Model S-480 or T-480 or a comparable product by one of the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Powell Valves.
   c. Watts.
2. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 200 psig.
   c. Body Design: Vertical flow.
   d. Body Material: ASTM B 584 Alloy C844, bronze.
   e. Ends: Threaded or Solder.
   f. Disc: PTFE, or TFE.

2.7 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Bronze Disc:
1. Provide NIBCO Model S-413-B or T-413-B or a comparable product by one of the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Powell Valves.
   c. Watts.
2. Description:

a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 200 psig.
c. Body Design: Y-pattern horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded or Solder.
f. Disc: Bronze.

B. Class 125, Bronze Swing Check Valves with Nonmetallic Buna-N Disc:
1. Provide NIBCO Model S-413-W or T-413-W or a comparable product by one of the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Powell Valves.
c. Watts.
2. Description:
a. Standard: MSS SP-80, Type 4.
b. CWP Rating: 200 psig.
c. Body Design: Y-pattern horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded or Solder.
f. Disc: Buna-N.

C. Class 125, Bronze Swing Check Valves with Nonmetallic TFE Disc:
1. Provide NIBCO Model S-413-Y or T-413-Y or a comparable product by one of the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Powell.
c. Watts.
2. Description:
a. Standard: MSS SP-80, Type 4.
b. CWP Rating: 200 psig.
c. Body Design: Y-pattern horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded or Solder.
f. Disc: PTFE or TFE.

2.8 IRON SWING CHECK VALVES

A. Class 125, Cast-Iron Swing Check Valves with Metal Seats:
1. Provide NIBCO Model F-918-B or a comparable product by one of the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Powell Valves.
c. Watts.
2. Description:
a. Standard: MSS SP-71, Type I.
b. CWP Rating: Body Design: Clear or full waterway.
c. Body Material: ASTM A 126, gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: Bronze.
f. Gasket: Asbestos free.

B. Class 150, Ductile-Iron Swing Check Valves with Metal Seats:
1. Provide NIBCO Model F-9138-31 or a comparable product by one of the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Powell, Wm. Co.
c. Watts.
2. Description:
a. Standard: MSS SP-71, Type I.

b. CWP Rating: 285 psig.
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A 395, ductile iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Seat Ring: Asbestos free.
h. Disc Holder: Bronze.
i. Disc: PTFE or TFE.
j. Gasket: Asbestos free.

C. Class 250, Iron Swing Check Valves with Metal Seats:
1. Provide NIBCO Model F-9138-31 or a comparable product by one of the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Powell, Wm. Co.
c. Watts.
2. Description:
a. Standard: MSS SP-71, Type I.
b. CWP Rating: 500 psig.
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Gasket: Asbestos free.

2.9 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Class 125, Iron Swing Check Valves with Lever- and Spring-Closure Control:
1. Provide NIBCO Model F-918-B-L&S or a comparable product by one of the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Powell, Wm. Co.
c. Watts.
2. Description:
a. Standard: MSS SP-71, Type I.
b. CWP Rating: 200 psig.
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Gasket: Asbestos free.
h. Closure Control: Factory-installed, exterior lever and spring.

B. Class 125, Iron Swing Check Valves with Lever- and Weight-Closure Control:
1. Provide NIBCO Model F-918-B-L&W or a comparable product by one of the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Powell, Wm. Co.
c. Watts.
2. Description:
a. Standard: MSS SP-71, Type I.
b. CWP Rating: 200 psig.
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Gasket: Asbestos free.
h. Closure Control: Factory-installed, exterior lever and weight.

2.10 IRON, GROOVED-END SWING CHECK VALVES

A. 250 CWP, Iron, Grooved-End Swing Check Valves:
   1. Provide NIBCO Model G-917-W or a comparable product by one of the following:
      a. Crane Co.; Crane Valve Group; Crane Valves.
      b. Powell, Wm. Co.
      c. Watts.
   2. Description:
      a. CWP Rating: 250 psig.
      b. Body Material: Gray iron.
      c. Seal: EPDM.
      d. Disc: Spring-operated, stainless steel with EPDM.

2.11 IRON, CENTER-GUIDED CHECK VALVES

A. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
   1. Provide NIBCO Model W-910-B or a comparable product by one of the following:
      a. Metraflex Co.
      b. Val-Matic Valve & Manufacturing Corp.
      c. Watts.
   2. Description:
      a. Standard: MSS SP-125.
      b. CWP Rating: 200 psig.
      c. Body Material: ASTM A 48, gray iron.
      d. Style: Compact wafer.
      e. Seat: Buna-N.

B. Class 125, Iron, Globe, Center-Guided Check Valves with Resilient Seat:
   1. Provide NIBCO Model F-910-B or a comparable product by one of the following:
      a. Metraflex.
      b. Val-Matic Valve & Manufacturing Corp.
      c. Watts.
   2. Description:
      a. Standard: MSS SP-125.
      b. CWP Rating: 200 psig.
      c. Body Material: ASTM A 48, gray iron.
      d. Style: Globe, spring loaded.
      e. Ends: Flanged.
      f. Seat: Buna-N.

C. Class 250, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
   1. Provide NIBCO Model W-960-B or a comparable product by one of the following:
      a. Metraflex Co.
      b. Val-Matic Valve & Manufacturing Corp.
      c. Watts.
   2. Description:
      a. Standard: MSS SP-125.
      b. CWP Rating: 400 psig.
      c. Body Material: ASTM A 48, gray iron.
      d. Style: Compact wafer, spring loaded.
      e. Seat: Buna-N.

D. Class 250, Iron, Globe, Center-Guided Check Valves with Resilient Seat:
   1. Provide NIBCO Model F-960-B or a comparable product by one of the following:
      a. Metraflex Co.

b. Val-Matic Valve & Manufacturing Corp.
c. Watts.

2. Description:
a. Standard: MSS SP-125.
b. CWP Rating: 400 psig.
c. Body Material: ASTM A 48, gray iron.
d. Style: Globe, spring loaded.
e. Ends: Flanged.
f. Seat: Buna-N.

2.12 IRON, PLATE-TYPE CHECK VALVES

A. Class 125, Iron, Dual-Plate Check Valves with Resilient Seat:

1. Provide NIBCO Model W-920-W or a comparable product by one of the following:
a. Metraflex Co.
b. Val-Matic Valve & Manufacturing Corp.
c. Watts.

2. Description:
a. Standard: ANSI B16.1.
b. CWP Rating: 200 psig.
c. Body Design: Wafer, spring-loaded plates.
d. Body Material: ASTM A 126, gray iron.
e. Seat: Buna-N.

2.13 IRON GATE VALVES

A. Class 125, Resilient seat NRS, Cast-Iron Gate Valves:

1. Provide NIBCO Model F-619 RW or a comparable product by one of the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Powell Valves.
c. Watts.

2. Description:
a. Standard: MSS SP-70, Type I.
b. CWP Rating: 200 psig.
c. Body Material: ASTM A 126, gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: Bronze.
f. Disc: Solid wedge.
g. Packing and Gasket: Asbestos free.

B. Class 250, Resilient wedge OS&Y, Cast-Iron Gate Valves:

1. Provide NIBCO Model F-607-RW or a comparable product by one of the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Powell Valves.
c. Watts.

2. Description:
a. Standard: AWWA C509 & 515.
b. CWP Rating: 250 psig.
c. Body Material: Ductile iron ASTM A 536.
d. Ends: Flanged.
e. Disc: Resilient wedge.
f. Packing and Gasket: Asbestos free.

2.14 BRONZE GLOBE VALVES

A. Class 125, Bronze Globe Valves with Bronze Disc:
   1. Provide NIBCO Model S-211-B or T-211-B or a comparable product by one of the following:
      a. Crane Co.; Crane Valve Group; Crane Valves.
      b. Powell Valves.
      c. Watts.
   2. Description:
      a. Standard: MSS SP-80, Type 1.
      b. CWP Rating: 200 psig.
      c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
      d. Ends: Threaded or solder.
      e. Stem and Disc: Copper-silicon bronze.
      f. Packing: Asbestos free.
      g. Handwheel: Malleable iron, bronze.

B. Class 125, Bronze Globe Valves with Nonmetallic Disc:
   1. Provide NIBCO Model S-211-Y or T-211-Y or a comparable product by one of the following:
      a. Crane Co.; Crane Valve Group; Crane Valves.
      b. Powell Valves.
      c. Watts.
   2. Description:
      a. Standard: MSS SP-80, Type 2.
      b. CWP Rating: 200 psig.
      c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
      d. Ends: Threaded or solder.
      e. Stem: Copper-silicon bronze.
      f. Disc: PTFE or TFE.
      g. Packing: Asbestos free.
      h. Handwheel: Malleable iron, bronze.

2.15 IRON GLOBE VALVES

A. Class 125, Iron Globe Valves:
   1. Provide NIBCO Model F-718-B or a comparable product by one of the following:
      a. Crane Co.; Crane Valve Group; Crane Valves.
      b. Powell Valves.
      c. Watts.
   2. Description:
      a. Standard: MSS SP-85, Type I.
      b. CWP Rating: 200 psig.
      c. Body Material: ASTM A 126, gray iron with bolted bonnet.
      d. Ends: Flanged.
      e. Trim: Bronze.
      f. Packing and Gasket: Asbestos free.

2.16 CHAINWHEELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Babbitt Steam Specialty Co.
   2. Roto Hammer Industries.
   3. Trumbull Industries.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
   1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
   2. Attachment: For connection to ball and gate valve stems.
   3. Sprocket Rim with Chain Guides: Ductile or cast iron, of type and size required for valve.
   4. Chain: Stainless steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully close. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for ball gate valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

F. Install check valves for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.
   2. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
   3. Lift Check Valves: With stem upright and plumb.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:
   1. Shutoff Service: Ball or gate valves.
   2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
   3. Throttling Service: Globe or angle valves.
   4. Pump-Discharge Check Valves:
      a. NPS 2 and Smaller: Bronze swing check valves with bronze or nonmetallic disc.
      b. NPS 2-1/2 and Larger for Domestic Water: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal or resilient-seat check valves.
      c. NPS 2-1/2 and Larger for Sanitary Waste and Storm Drainage: Iron swing check valves with lever and weight or spring.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:
   1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
   2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
   3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
   4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
   5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
   6. For Steel Piping, NPS 5 and Larger: Flanged ends.
   7. For Grooved-End Copper Tubing: Valve ends may be grooved.

3.5 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
   1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
   2. Bronze Angle Valves: Class 150, nonmetallic disc.
   3. Ball Valves: Two piece, full port, bronze with stainless-steel trim.
   4. Bronze Lift Check Valves: Class 125, nonmetallic TFE disc.
   5. Bronze Swing Check Valves: Class 150, nonmetallic TFE disc.
   6. Bronze Gate Valves: Class 150, RS.
   7. Bronze Globe Valves: Class 150, nonmetallicdisc.

B. Pipe NPS 2-1/2 and Larger:
   1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
   2. Iron Angle Valves: Class 250.
   3. Steel Ball Valves: Class 250, full-port.
   4. Iron Swing Check Valves: Class 150, metal seats.
   5. Iron Swing Check Valves with Closure Control: Class 125, lever and weight.
   6. Iron, Grooved-End Swing Check Valves: 300 CWP.
   7. Iron, Plate-Type Check Valves: Class 250; dual plate; resilient seat.
   8. Iron Gate Valves: Class 250, OS&Y.

3.6 SANITARY-WASTE VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
   1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.

2. Ball Valves: Two piece, full port, bronze with stainless-steel trim.
3. Bronze Swing Check Valves: Class 125, nonmetallic disc.
4. Bronze Gate Valves: Class 150, RS.

B. Pipe NPS 2-1/2 and Larger:
1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Steel Ball Valves: Class 150, full port.
3. Iron Swing Check Valves: Class 125, metal seats.
4. Iron Swing Check Valves with Closure Control: Class 125, lever and weight.
5. Iron, Grooved-End Swing Check Valves: 300 CWP.
6. Iron Gate Valves: Class 125, OS&Y.
7. Lubricated Plug Valves: Class 125, regular gland cylindrical, threaded, or flanged.

3.7 SHUT-OFF VALVES

A. On aluminum piping, provide cast aluminum No. SG70A alloy rising stem gate type with threaded ends and 18-8 stainless steel stem and disc, 100 psig wwp, equal to Powell No. 1876.

B. On stainless steel piping, provide type 316 stainless steel rising stem gate type with threaded ends, 200 psig wwp, equal to Powell No. 1832. For tubing, provide with stainless steel adapters.

END OF SECTION 22 0523

SECTION 22 0529

HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following hangers and supports for plumbing system piping and equipment:
   1. Steel pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Metal framing systems.
   4. Thermal-hanger shield inserts.
   5. Fastener systems.
   6. Equipment supports.
   7. Stainless steel hangers.

B. Related Sections include the following:
   1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
   2. Division 21 Section 21 1000 "Water-Based Fire-Suppression Systems" for pipe hangers for fire-suppression piping.
   3. Division 22 Section 22 0516 "Expansion Fittings and Loops for Plumbing Piping" for pipe guides and anchors.
   4. Division 22 Section 22 0548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for vibration isolation devices.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society for The Valve and Fittings Industry Inc.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes, including trapezes capable of supporting combined weight of supported systems, system contents, and test water.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

D. Where thermal movement of pipe occurs, hanger assembly should support pipe line in all operating conditions.

1.5 SUBMITTALS

A. Product Data: For the following:
  1. Steel pipe hangers and supports.
  2. Thermal-hanger shield inserts.
  3. Powder-actuated fastener systems.
  4. Stainless steel hangers.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:
  1. Trapeze pipe hangers. Include Product Data for components.
  2. Metal framing systems. Include Product Data for components.
  3. Equipment supports.

C. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel."

B. Welding: Qualify procedures and personnel according to the following:
  1. AWS D1.1, "Structural Welding Code--Steel."
  2. AWS D1.2, "Structural Welding Code--Aluminum."
  3. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
  4. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
  2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 STEEL PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

B. Manufacturers:
  1. AAA Technology & Specialties Co., Inc.
  2. Anvil International.
  3. B-Line Systems, Inc.; a division of Cooper Industries.

4. Grinnell Corp.
5. Flex Hose.
6. National Pipe Hanger Corporation.
7. PHS Industries, Inc.
8. Piping Technology & Products, Inc.
9. Tolco Inc.

C. Galvanized, Metallic Coatings: Pre-galvanized or hot dipped.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

E. Padded Hangers: Hanger with felt or fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping and pipe isolation due to dissimilar metal contact.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.4 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

B. Manufacturers:
1. B-Line Systems, Inc.; a division of Cooper Industries.
2. ERICO/Michigan Hanger Co.; ERISTRUT Div.
3. GS Metals Corp.
4. Power-Strut Div.; Tyco International, Ltd.
5. Thomas & Betts Corporation.
6. Tolco Inc.
7. Unistrut Corp.; Tyco International, Ltd.

C. Coatings: Manufacturer's standard finish unless bare metal surfaces are indicated.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.5 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig- minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Manufacturers:
1. Carpenter & Paterson, Inc.
2. ERICO/Michigan Hanger Co.
3. PHS Industries, Inc.
4. Pipe Shields, Inc.
5. Rilco Manufacturing Company, Inc.
6. Value Engineered Products, Inc.

C. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with vapor barrier.

D. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate.

E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

F. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

G. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened Portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
   1. Manufacturers:
      a. Hilti, Inc.
      b. ITW Ramset/Red Head.
      c. Masterset Fastening Systems, Inc.
      d. MKT Fastening, LLC.
      e. Powers Fasteners.

B. Mechanical-Expansion Anchors: Insert-wedge-type stainless steel, for use in hardened Portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
   1. Manufacturers:
      a. B-Line Systems, Inc.; a division of Cooper Industries.
      b. Empire Industries, Inc.
      c. Hilti, Inc.
      d. ITW Ramset/Red Head.
      e. MKT Fastening, LLC.
      f. Powers Fasteners.
   2. Expansion Anchors:
      a. Smooth wall, non-self-drilling internal plug expansion type anchors constructed of AISC 12L14 steel and zinc plated in accordance with Fed. Spec. QQ-A-325 type 1, Class 3.
      b. Do not exceed 1/4 of average values for a specific anchor size using 2000 PSIG concrete only, for maximum working loads.
      c. Locate spacing and install anchors in accordance with the manufacturer's recommendations.
      d. Expansion anchors shall be U.L. listed and equal to Hilti HDI.

2.7 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

2.8 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
   1. Properties: Nonstaining, noncorrosive, and nongaseous.
   2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use padded hangers for piping that is subject to scratching.

F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.
10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
11. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
16. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.

19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

I. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
   a. Inserts shall be steel, slotted type and factory-painted.
      1) Single rod shall be equal to Anvil International Fig. 281.
      2) Multi-rod shall be equal to Carpenter Patterson Series with end caps and closure strips.
      3) Clip form nails flush with inserts.
      4) Maximum loading including pipe, contents and covering shall not exceed 75% of rated insert capability.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.

c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

J. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

K. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
   a. Horizontal (MSS Type 54): Mounted horizontally.
   b. Vertical (MSS Type 55): Mounted vertically.
   c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

L. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.

M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

N. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

3.2 HANGER AND SUPPORT INSTALLATION

A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.

2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

C. Fiberglass Pipe Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.

D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.

E. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled fiberglass struts.

F. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

G. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

I. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

J. Install lateral bracing with pipe hangers and supports to prevent swaying.

K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

L. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.

N. Insulated Piping: Comply with the following:
   1. Attach clamps and spacers to piping.
      a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
      b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
      c. Do not exceed pipe stress limits according to ASME B31.9 for building services piping.
   2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
   3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
   4. Shield Dimensions for Pipe: Not less than the following:
      a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
      b. NPS 4: 12 inches long and 0.06 inch thick.
      c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   5. Pipes NPS 8 and Larger: Include wood inserts.

6. Insert Material: Length at least as long as protective shield.
7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

O. Suspended Horizontal Piping:
1. Support piping independently from structure using heavy iron-hinged type hangers, equal to Anvil International Clevis No. 260.
2. Provide electroplated solid-band hangers equal to Auto-Grip, for 2-inch and smaller pipe.
3. Provide trapeze hangers of angles, angles bolted back-to-back, or channels to parallel lines of piping.
4. Provide wall brackets for wall-supported piping, and furnish pipe saddles for floor-mounted piping.
5. Provide supports with recommended lining for glass piping.
6. Provide supports with felted lining for un-insulated copper piping.
7. Suspend piping from inserts or expansion anchors, using beam clips, steel fish plates, cantilever brackets or other accepted means. Beam clips shall be equal to Anvil International Figures 14, 87, or 134.
8. Suspend piping by rods with double nuts.
9. Provide additional steel framing as required and accepted where overhead construction does not permit fastening hanger rods in required locations.
10. Support branch fixture water piping in chases with copper-plated metal brackets, secured to studs, equal to Holdrite Nos. 102-18, 107-18, 102-26, or 101-26.

3.3 EQUIPMENT SUPPORTS

A. Mount on or support from accepted foundations and supports, all noted equipment and related piping.

B. Size, locate, and install noise and vibration isolation equipment in accordance with manufacturer's recommendations and after review.

C. Select noise and vibration isolation equipment for lowest operating speed of equipment to be isolated.

D. Ensure that lateral motion under equipment at start-up, shut-down or when unbalanced is no more than a maximum of 1/4 inch.

E. Provide corrosion resistant mounting systems when exposed to the elements and other corrosive environments. Provide hot dip galvanized metal parts of mountings (except springs and hardware). Provide cadmium-plated and neoprene-coated springs and cadmium-plated nuts and bolts.

F. Correct noise and vibration problems due to faulty equipment or poor workmanship, as directed, without additional charge to Owner.

G. Steel Spring Type:
1. Utilize bare stable springs without restraints.
2. Provide spring with diameter not less than 80% of loaded operating height of spring.
3. Design ends of spring so that they remain parallel during and after springs are loaded to their minimum specified deflections.
4. Provide springs with 50% travel from operating deflection before reaching solid height.
5. Provide spring mounts with 1/4 inch thick waffled neoprene acoustical pad bonded to underside of base plate.

H. Provide resiliently mounted equipment bases raised to operating height with a minimum of 2 inch of clearance at bottom of base prior to installing equipment.
1. Temporarily support bases on 2-inch thick (minimum) spacer blocks.
2. Adjust mountings to transfer load from spacer blocks to mountings; remove spacer blocks after equipment installation, but immediately prior to operation.

I. Concrete inertia blocks with adequate reinforcing steel will be provided under General Construction Work.

J. Neoprene-In-Shear Isolation Rails: Furnish for horizontal pumps, air compressors, and vacuum pumps when supplied with fractional horsepower motors.
   1. Provide top structural iron channel rails with tapped holes to accept machinery foundation bolts supported by properly loaded and located double deflection neoprene-in-shear mountings, equal to Type DNR - M.I.I.
   2. Provide mountings with 3/8 inch minimum static deflection and bolt holes for anchoring onto foundation equal to Type DNR - M.I.I.

K. Neoprene-In-Shear Supported Concrete Inertia Bases: Provide for horizontal pumps, jockey pumps, air compressors, and vacuum pumps when supplied with one horsepower to three horsepower motors.

L. Provide a minimum 6-inch thick concrete inertia block supported by double deflection neoprene-in-shear mountings, equal to Type ND - M.I.I., with form as noted for foundations. Bolt and grout equipment to concrete base. Provide minimum static deflection of __ inch.

M. Spring-Supported, Factory-Fabricated Inertia Bases: Provide for horizontal pumps (except fire pumps), bottom-supported vertical booster pumps, jockey pumps, rotary air compressors and vacuum pumps with five horsepower and larger motors.
   1. Provide concrete inertia block with factory-fabricated steel structural perimeter frame, set on roofing paper, with equipment anchor bolt templates and mounting brackets supplied by vibration control manufacturer.
   2. Provide and locate under brackets, spring supports with a minimum static deflection of 1 inch and with leveling device to raise entire isolation base 2 inch above foundation.
   3. Provide minimum thickness required for concrete inertia bases as follows:
      a. Motor Size 5 hp to 15 hp: 6 inch.
      b. Motor Size 20 hp to 50 hp: 8 inch.
   4. Provide assemblies, equal to Type KSL - M.I.I.

N. Spring supported factory fabricated structural steel bases: Provide for vertical booster pumps suspended from floor slab above and through penetration.
   1. Provide equipment rigidly bolted to spring supported reinforced structural base and isolated from suitable framed structural supports erected from floor slab.
   2. Provide reinforced structural steel base constructed with structural members having depth of section not less than 1/12 span between spring mountings and supplied by vibration control manufacturer.
   3. Provide a framed base to permit removal of any pump mounted on structural base.
   4. Provide structural supports erected from floor slab, sized and framed to accept spring mountings and supported loads.
   5. Piping in projected area of isolated structural pump base may be rigidly supported from isolated pump base.
   6. Provide spring mountings designed so that they are capable of supporting equipment at fixed elevation during installation, and adjusted to provide operating clearance in mountings of 1/4 inch, equal to Type SLR - M.I.I.

O. Center of gravity (C.G.) mounted spring inertia blocks: Provide for piston type air compressors five horsepower and larger.
   1. Equipment and its driving motor shall be integrally mounted on spring-supported concrete inertia blocks.
   2. Provide inertia blocks sized to provide sufficient mass so that dynamic movement of equipment block assembly will be less than 1/16 inch peak-to-peak at any connection flange. Form shall be as noted for foundations.
   3. Provide blocks and spring mountings arranged to accomplish dynamically symmetrical system with respect to total C.G. of spring assembly in all three major axes.

4. Provide steel spring mountings consisting of bare stable springs arranged in pendulum configuration with built-in adjustable side snubbers, leveling device and 1/4 inch thick neoprene acoustical base pad.
5. Provide mountings with a minimum static deflection corresponding to isolation efficiency of 90% at lowest equipment operating speed.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 painting Sections. Section "High-Performance Coatings."

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

D. Dip in epoxy primer, uncoated hangers, supports, rods, and inserts.

E. Epoxy primer shall be Sherwin Williams MIL-P53022B, or approved equal.

END OF SECTION 22 0529

SECTION 22 0548

VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
1. Isolation pads.
2. Isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Freestanding and restrained spring isolators.
5. Housed spring mounts.
6. Elastomeric hangers.
7. Spring hangers.
8. Spring hangers with vertical-limit stops.
9. Pipe riser resilient supports.
10. Resilient pipe guides.
11. Seismic snubbers.
12. Restraining braces and cables.
13. Flexible Connectors.
14. Steel and inertia, vibration isolation equipment bases.

1.3 DEFINITIONS

A. CBC: California Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers.

D. Life Safety and Hazardous Components - All systems involved with fire protection including sprinkler piping, fire pumps, jockey pumps, fire pump control panels, service water supply piping, water tanks, fire dampers and smoke exhaust systems and mechanical, electrical, plumbing or fire protection systems that support the operation of or are connected to emergency power equipment including all lighting, generators, transfer switches and transformers. Hazardous components include any pipe, vessel, duct or piece of equipment that contains flammable or toxic material.

E. Component – a part or element of an architectural, mechanical, electrical or structural system.

F. Positive Attachment – a cast in place anchor, a drill in wedge anchor, a chemical anchor, a double sided beam clamp loaded perpendicular to the beam or a welded or bolted connection to the structure.

G. Special Inspection – inspection of the materials, installation, fabrication or placement of components and anchorage.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:
   1. Values as specified from Project structural engineer and applicable code.

1.5 SUBMITTALS

A. Product Data: For the following:
   1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
   2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
      a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
      b. Annotate to indicate application of each product submitted and compliance with requirements.
   3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.
   4. Catalog cuts and data sheets on specific vibration isolators and restraints to be utilized showing compliance with specifications.
   5. An itemized list showing the items of equipment or piping to be isolated, the isolator type and model number selected, isolator loading and deflection, and reference to specific drawings showing base and construction where applicable.
   6. Seismic restraint calculations and structural or civil engineers stamp verifying design and calculations for seismic restraining system used.
   7. Drawings showing equipment base construction for each piece of equipment, including dimensions, structural member sizes and support point locations.
   8. Drawing showing methods of suspension, support guides for piping.
   9. Drawings showing methods for isolation of pipes piercing walls and slabs.
   10. Concrete and steel details for bases including anchor bolt locations.
   11. Number and location of seismic restraints and anchors for each piece of equipment.
   12. Specific details of restraints including anchor bolts for mounting and maximum loading at each location, for each piece of equipment and/or pipe.

B. Substitution of seismic control products is subject to Authority Having Jurisdiction.

C. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators, seismic restraints, and for designing vibration isolation bases.
   2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
   3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.
   4. Seismic-Restraint Details:

a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

D. Coordination Drawings: Show coordination of seismic bracing for plumbing piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

E. Welding certificates.

F. Qualification Data: For professional engineer.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the CBC unless requirements in this Section are more stringent.

C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproved by ICC-ES, or preapproved by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

E. It is the objective of this Specification to provide the necessary design for the seismic restraint and control of excessive noise and vibration in the buildings due to the operation of machinery or equipment, and/or due to interconnected piping. The installation of all vibration isolation units, and associated hangers and bases, shall be under the direct supervision of the vibration isolation manufacturer's representatives.

1. All vibration isolators shall have either known undeflected heights or calibration markings so that, after adjustment when carrying their load, the deflection under load can be verified, thus determining that the load is within the proper range of the device and that the correct degree of vibration isolation ins being provided according to the design.

2. All isolators shall operate in the linear portion of their load versus deflection curve. Load versus deflection curves shall be furnished by the manufacturer, and must be linear over a deflection range of not less than 50 percent above the design deflection.
3. The theoretical vertical natural frequency for each support point, based upon load per isolator and isolator stiffness, shall not differ from the design objectives for the equipment as whole by more than plus or minus 10 percent.
4. All neoprene mountings shall have a shore hardness of 30 to 60 plus or minus 5, after minimum aging of 20 days or corresponding oven aging.

1.7 MANUFACTURER RESPONSIBILITIES

A. Manufacturer of vibration isolation and seismic control equipment shall have the following responsibilities:
1. Determine vibration isolation and seismic restraint sizes and locations.
2. Provide piping and equipment isolation systems and seismic restraints as scheduled or specified.
3. Guarantee specified isolation system deflection.
4. Provide installation instructions, drawings and field supervision to assure proper installation and performance.
5. Purchased and/or fabricated equipment must be designed to safely accept external forces of one-half "G" load in any direction for all rigidly and resiliently supported equipment and piping without failure and permanent displacement of the equipment. Life safety equipment including, but not limited to, fire pumps, sprinkler piping, and machinery must be capable of safely accepting external forces up to one "G" load in any direction without permanent displacement of the supported equipment. Substitution of "Internally Isolated" mechanical equipment in lieu of the specified isolation of this Section must be approved for individual equipment units and is acceptable only if above accelerations are certified in writing by equipment manufacturer and stamped by a licensed civil or structural engineer.

1.8 CONTRACTOR RESPONSIBILITIES

A. The Contractor performing the work on equipment in the section shall have the following responsibilities.
1. Identify the components that are part of the Quality Assurance Plan.
2. All electrical components for standby or emergency power systems.
3. All flammable, combustible and highly toxic piping and their associated mechanical systems.
4. All ductwork containing hazardous materials.
5. All equipment using combustible or toxic energy sources.
6. Identify all Special inspection and Testing.
7. List control procedures within the contractor's organization including methods and frequency of reporting and their distribution.
8. List personnel and their qualifications exercising control over the seismic aspects of the project.
9. The Contractor shall bring to the Architect's attention prior to installation any conflicts with other trades which will result in unavoidable contact with the plumbing lines described herein due to inadequate space, etc.
10. The Contractor shall bring to the Architect's attention any discrepancies between the Specifications and field conditions, changes required due to the specific equipment selection, etc., prior to the installation.

PART 2 - PRODUCTS

2.1 GENERAL

A. All vibration isolation and seismic devices shall be the product of a single manufacturer. Products of the other manufacturers are acceptable provided their systems strictly comply with the design intent performance, deflection and structural design of the base manufacturer.

2.2 VIBRATION ISOLATORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Mason Industries or an equal product by one of the following:
   1. Amber/Booth Company, Inc.
   2. Kinetics Noise Control.
   3. International Seismic Application Technology (ISAT).
   4. Tolco (Nibco).
   5. Vibration Eliminator Co., Inc.
   6. Vibration Mountings & Controls, Inc.

B. Vibration Isolator Types:
   1. Type A: Spring isolators shall incorporate the following:
      a. Minimum diameter of 0.8 of the loaded operating height.
      b. Corrosion resistance where exposed to corrosive environment with:
         1) Springs cadmium plated or electro-galvanized.
         2) Hardware cadmium plated.
         3) All other metal parts hot-dip galvanized.
      c. Reserve deflection (from loaded to solid height) of 50 percent of rated deflection.
      d. Minimum 1/4 inch thick neoprene acoustical base pad on underside, unless designated otherwise.
      e. Designed and installed so that ends of springs remain parallel and all springs installed with adjustment bolts.
      f. Non-resonant with equipment forcing frequencies or support structure natural frequencies.
      g. Spring isolators to be Mason Type SLF, or approved equal.
      h. This isolator must be accompanied by seismic isolator Type II.
   2. Type B: Spring isolators shall be same as Type A, except:
      a. Provide built-in vertical limit stops with minimum 1/4 inch clearance under normal operation.
      b. Tapped holes in top plate for bolting to equipment when subject to wind load.
      c. Capable of supporting equipment at a fixed elevation during equipment erection. Installed and operating heights shall be identical.
      d. Adjustable and removable spring pack with separate neoprene pad isolation.
      e. Housing shall be designed to accept 1 G of acceleration.
      f. Mason Type SLR, or approved equal.
   3. Type C: Spring hanger rod isolators shall incorporate the following:
      a. Spring element seated on a steel washer within a neoprene cup incorporating a rod isolation bushing.
      b. Steel retainer box encasing the spring and neoprene cup.
      c. Requires seismic restraint Type III.
      d. Mason Type HS, or approved equal.
   4. Type E: Elastomer hanger rod isolators shall be incorporate the following:
      a. Molded unit type neoprene element with projecting bushing lining rod clearance hole.
      b. Neoprene element shall be minimum 1-3/4 inch thick.
      c. Steel retainer box encasing neoprene mounting.

d. Clearance between mounting hanger rod and neoprene bushing shall be minimum of 1/8 inch.
e. Requires seismic restraint Type III.
f. Mason Type HD, or approved equal.

5. Type F: Combination spring/elastomer hanger rod isolators to incorporate the following:
   a. Spring and neoprene isolator elements in a steel box retainer. Neoprene of double deflection type. Single deflection is unacceptable. Spring seated in a neoprene cup with extended rod bushing.
   b. Characteristics of spring and neoprene as describe in Type A and Type E isolators.
   c. Requires seismic restraint Type III.
   d. Mason Type 30N, or approved equal.
6. Type G: Pad type elastomer mountings to incorporate the following:
   a. 0.750 inch minimum thickness.
   b. 50 psi maximum loading.
   c. Ribbed or waffled design.
   d. 0.10 inch deflection per pad thickness.
   e. 1/16 inch galvanized steel plate between multiple layers or pad thickness.
   f. Suitable bearing plate to distribute load.
   g. Mason Type Super W, or approved equal.
7. Type H: Pad type elastomer mountings to incorporate the following:
   a. Laminate canvas duck and neoprene.
   b. Maximum loading 1000 psi.
   c. Suitable bearing plate to distribute load.
   d. Minimum thickness, 1/2 inch.
   e. Mason Type HL, or approved equal.
8. Type J: Rail type spring isolators:
   a. Rail type spring isolators shall provide steel members of sufficient strength to prevent flexure with equipment operation.
   b. Springs shall be the same as Type A with seismic restraint Type II or seismic restraint Type I or IV isolation.
   c. Mason Type ICS, or approved equal.
9. Type K: Pipe anchors:
   a. Vibration isolator manufacturer shall provide an all directional acoustical pipe anchor, consisting of a telescopic arrangement of two sizes of steel tubing separated by a minimum half inch thickness of heavy duty neoprene and duck or neoprene isolation material.
   b. Vertical restraints shall be provided by similar material arranged to prevent vertical travel in either direction.
   c. Allowable loads on the isolation material shall not exceed 500 psi and the design shall be balanced for equal resistance in any direction.
   d. Mason Type ADA, or approved equal.

2.3 FLEXIBLE CONNECTORS

A. Elastomer Type FC-1:
1. Manufactured of nylon tire cord and EPDM both molded and cured with hydraulic presses.
2. Straight connectors shall have two spheres reinforced with a molded-in external ductile iron ring between spheres.
3. Elbow shall be long radius reducing type.
4. Rated 250 psi at 170 degrees F dropping in a straight line to 170 psi at 250 degrees F for sizes 1-1/2 inch to 12 inch elbows. Elbows shall be rated no less than 90 percent of straight connections.
5. Sizes 10 inches to 12 inches to employ control cables with neoprene end fittings isolated from anchor plates by means of 1/2 inch bridge bearing neoprene bushings.
6. Minimum safety factor, 4 to 1 at maximum pressure ratings.
7. Submittals shall include test reports.

8. Mason Type MFTNC Superflex.

B. Flexible Stainless Hose, Type FC-2:
1. Braided flexible metal hose.
2. 2 inch pipe size and smaller with male nipple fittings.
3. 2-1/2 inch and larger pipe size with fixed steel flanges.
4. Suitable for operating pressure with 4 to 1 minimum safety factor.
5. Length as required or shown on drawings.
6. Mason Type BSS, or as approved.

2.4 VIBRATION ISOLATION EQUIPMENT BASES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Amber/Booth Company, Inc.
2. Kinetics Noise Control.
3. Mason Industries.
4. Vibration Eliminator Co., Inc.
5. Vibration Mountings & Controls, Inc.

B. Type B-1: Integral Structural Steel Base
1. Reinforced, as required, to prevent base flexure at start-up and misalignment of drive and driven units. Centrifugal fan bases complete with motor slide rails. Drilled for drive and driven unit mounting template.
2. Mason Type M, WF, or approved equal.

C. Type B-2: Concrete Inertia Base
1. Concrete inertia bases shall be formed in a structural steel perimeter base, reinforced as required to prevent flexure, misalignment of drive and driven unit or stress transferal into equipment. The base shall be complete with motor slide rails, pump base elbow supports, and complete with height saving brackets, reinforcing, equipment bolting provisions and isolators.
2. Minimum thickness of the inertia base shall be according to the following tabulation:

Motor Size		Minimum Thickness	
(hp)	(kW)	(in)	(mm)
5-15	(4-11)	6	(150)
20-50	(15-37)	8	(200)
60-75	(45-55)	10	(250)
100-250	(75-190)	12	(300)
300-500	(220-375)	18	(350)

3. Mason Type K, BMK, or approved equal.

2.5 SEISMIC-RESTRAINT DEVICES

A. Type I: Spring Incorporating Seismic Restraint
1. Shall comply with general characteristics of spring isolators.
2. Shall have vertical restraints and are capable of supporting equipment at fixed elevation during equipment erection. Vertical restraint shall be separate from equipment load support.
3. Shall incorporate seismic snubbing restraint in all directions at specified acceleration loadings.
4. System to be field bolted to structure with minimum capability to withstand external forces of 1.0 g.
5. Mason Type SSLR, or as approved

B. Basis-of-Design Product: Subject to compliance with requirements, provide a equal product by one of the following:
   1. ISAT (International Seismic Application Technology).
      a. Shall comply with general characteristics of spring isolators.
      b. Shall have vertical restraints and are capable of supporting equipment at fixed elevation during equipment erection. Vertical restraint shall be separate from equipment load support.
      c. Shall incorporate seismic snubbing restraint in all directions at specified acceleration loadings.
      d. System to be field bolted to structure with minimum capability to withstand external forces of 1.0 g edit per project requirements.
      e. Mason Type SSLR, or approved equal.

C. Type II: Stationary Seismic Restraint
   1. Each corner or side seismic restraint shall incorporate minimum 5/8" (16 mm) thick pad limit stops. Restraints shall be made of plate, structural members or square metal tubing in a welded assembly, incorporating resilient pads. Angle bumpers are not acceptable. System to be field bolted to deck with 1.0 g acceleration capacity.
   2. Seismic spring mountings as described above are an acceptable alternative providing all seismic loading requirements are met.
   3. Mason Industries Type Z-1011, Type Z-1225, or approved equal.

D. Type III: Cable Seismic Restraint,
   1. Metal cable type with approved end fastening devices to equipment and structure. System to be field bolted to deck or overhead structural members or deck with aircraft cable and clamps as per the seismic engineer of record.

E. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES an agency acceptable to authorities having jurisdiction.
   1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

F. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

G. Restraint Cables: ASTM A 603 galvanized or ASTM A 492 stainless-steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

H. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

I. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

J. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

K. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

L. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

M. Low VOC Adhesive Anchor Bolts: Adhesive anchor bolts are not permitted where seismic restraint is required. Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488 and meet the IBC/ASCE cracked concrete testing requirements. Anchors shall have a valid ICC-ESR number.

2.6 FACTORY FINISHES

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
   1. Powder coating on springs and housings.
   2. All hardware shall be galvanized. Hot-dip galvanized metal components for exterior use.
   3. Baked enamel or powder coat for metal components on isolators for interior use.
   4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment Restraints:

1. Install seismic snubbers on plumbing equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inches.
3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.
4. All equipment whether isolated or not, shall be bolted to structure to allow for minimum 1/2 G of acceleration. Bolt points and diameter of inserts shall be submitted and verified as part of the contractor's submission for each piece of equipment and certified by a licensed civil or structural engineer.
5. All structurally suspended overhead equipment isolated or non-isolated shall be four point independently braced within Type III seismic restraining system.
6. Where base anchoring is insufficient to resist seismic forces, supplementary restraining such as seismic restraint system Type III shall be used above systems center of gravity to suitably resist "G" force levels. Vertically mounted tanks may require this additional restraint.

B. Piping Restraints:
   1. Comply with requirements in MSS SP-127.
   2. Space lateral supports a maximum of 40 feet at turns of more than 4 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
   3. Brace a change of direction longer than 12 feet.
   4. Install Seismic Restraining System Type III: Taut for overhead suspended non-isolated equipment, piping and slack with 1/2 inch cable deflection for isolated systems.
   5. Seismically restrain all piping with Type III restraining system in accordance with guideline as outlined below.
   6. Seismic restraints are not required for the following (this does not apply to any life safety or high hazard equipment):
      a. Gas piping less than 1 inch I.D.
      b. Piping in Boiler and Mechanical Equipment rooms less than 1-1/4 inch I.D.
      c. All other piping less than 2-1/2 I.D.
      d. All piping suspended by individual hangers 12 inches in length or less from the top of the pipe to the bottom of the support for the hanger.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install seismic-restraint devices in accordance with the NYCBC Chapter 16.

E. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

F. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

G. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

H. Drilled-in Anchor Example:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.

4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.4 SEISMIC RESTRAINTS FOR NON-ISOLATED EQUIPMENT

A. All ceiling suspended piping not excluded by diameter or distance required from support: Seismic Restraint type III.

B. All ceiling mounted equipment: Seismic Restraint Type III.

C. All floor mounted equipment, including but not limited to tanks, domestic water heaters, etc.: Seismic Restraint Type V.

3.5 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in this section and Division 22 Section 22 1116 "Domestic Water Piping" for piping flexible connections.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:
1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. Air-Mounting System Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
10. Air-Mounting System Operational Test: Test the compressed-air leveling system.
11. Test and adjust air-mounting system controls and safeties.
12. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.7 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of sprint isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.8 PLUMBING VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE SCHEDULE

Type of Equipment	**Below Grade**		**Above Grade**	
	Isolation Type	**Deflection**	**Isolation Type**	**Deflection**
Air Compressor Tank Mounted up to 10 HP	D[(a)]	0.75 inches	B or SR Type I	1 inch[(b)]
Air Compressor Tank mounted or unitary AC unit over 10 HP	A-B(-2)	1 inch	B or SR Type I and Base Type B-2	2 inches
Boilers	D[(a)]	0.4 inch	B and Base Type B-1	1 inch[(b)]
Pumps up to 15 HP	D[(a)]-J	0.4 inch	B or SR Type I and Base Type J[(c)]	1 inch[(b)]
Pumps 20 HP and Higher	B or SR Type I and Base Type B-2	1 inch	B or SR Type I and Base Type B-2	2 inches[(b)]
All Piping in MER	Type I and SR Type III	1 inch	Type I and SR Type III	2 inches
Piping Flexible Connectors for Pumps	FC-1	--	FC-1	--

[(a)]There appears to be no Isolator Type 'D' listed (C → E). This should be a spring floor isolator or hanger; no base necessary.

[(b)]Greater static deflection may be necessary for floor spans in excess of 20ft.

[(c)]No Type 'J' Base listed; use concrete inertia base.

END OF SECTION 22 0548

SECTION 22 0553

IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Equipment labels.
   2. Warning signs and labels.
   3. Pipe labels.
   4. Stencils.
   5. Valve tags.
   6. Warning tags.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 QUALITY ASSURANCE

A. Comply with California Plumbing Code 601.2 and Table 6-1. For domestic water.

B. Comply with California Plumbing Code 601.2.4 for non-potable water outlets.

C. Comply with Low VOC requirements for adhesives for indoor applications.

1.5 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:
1. Material and Thickness: Stainless steel, 0.025-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless-steel rivets or self-tapping screws.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
6. For Non-Potable water, provide labels as required per CPC, Section 601.2

B. Plastic Labels for Equipment:
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black.
3. Background Color: White.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Low VOC Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Black.

C. Background Color: White.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction. For Non-Potable Water, PROVIDE PER CPC TABLE 6-1.

B. Pre-tensioned Pipe Labels: Pre-coiled, semi-rigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
   1. Factory fabricated, snap-on type pipe markers every 10 feet indicating system and direction of flow. The pipe markers shall be the weather-proof plastic type and shall not be used where surface temperature exceeds 180 deg F.
   2. The pipe markers shall be equal to Seton Name Plate Corporation "Setmark", with the following types:
      a. Smaller than 6 inch: Setmark SNA, completely encircling pipe.
      b. 6 inch and larger: Setmark STR, stainless steel spring fasteners.
      c. Adhesive type markers will not be permitted.

C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
   2. Lettering Size: At least 1-1/2 inches high.

2.4 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: 2 inch square Stainless steel, 0.025-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass wire-link or beaded chain.
   3. Equal to Seton Name Plate Corp.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
   1. Mount charts on walnut grained wood plaque with clear plastic laminations covering diagrams and/or lists.
   2. Mount charts, diagrams, and/or lists, in aluminum frame and glass.

3. Letter and number equipment, valves and controls to correspond with designations on metal tags and/or nameplates.
4. Fasten permanently in locations, as directed, with four brass screws.
5. Valve-tag schedule shall be included in operation and maintenance data.

2.5 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
   1. Size: Approximately 4 by 7 inches.
   2. Fasteners: Reinforced grommet and wire.
   3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
   4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment, and for gauges, meters, valve boxes, instruments, control devices, pilot lamps, transmitters, motor controllers, and panel-mounted equipment.

B. Locate equipment labels where accessible and visible.

C. Install non-potable labels as required by CPC, Section 601.2.

3.3 PIPE LABEL INSTALLATION

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations with direction of flow as follows:
   1. Near each valve and control device.
   2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
   3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
   4. At access doors, manholes, and similar access points that permit view of concealed piping.
   5. Near major equipment items and other points of origination and termination.
   6. Spaced at maximum intervals of 25 feet along each run. Reduce intervals to 10 feet in areas of congested piping and equipment.
   7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
   8. Where removable ceiling tiles are provided, install buttons, tabs, or markers to identify location of concealed work and/or valves. Submit for review.
   9. Install non-potable labels as required by CPC, Section 601.2.

B. Pipe Label Color Schedule (PROVIDE PER CPC TABLE 6-1 FOR LETTER SIZE.):
1. Domestic Cold Water Piping:
   a. Background Color: Green.
   b. Letter Color: White.
2. Domestic Hot Water Piping:
   a. Background Color: Green.
   b. Letter Color: White.
3. Domestic Hot Water Return Piping:
   a. Background Color: Green.
   b. Letter Color: White.
4. Fuel Gas piping:
   a. Background Color: Yellow.
   b. Letter Color: Black.
5. Sanitary Waste, Vent and Storm Drainage Piping:
   a. Background Color: Yellow.
   b. Letter Color: Black.
6. Non-potable water:
   a. Background Color: Yellow.
   b. Letter Color: Black.
   c. Provide the words "CAUTION: NON-POTABLE WATER, DO NOT DRINK."
7. Recycled water:
   a. Background Color: Purple.
   b. Letter Color: Per Los Angeles County Health Department.
   c. Provide the words "DANGER: RECYCLED WATER, DO NOT DRINK."

3.4 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
1. Valve-Tag Size and Shape:
   a. All systems: 1-1/2 inches round where easily readable.
   b. All systems: 2 inches round where installed above 7 feet in non-ceiling areas.
2. Valve-Tag Color:
   a. Correspond with pipe system background.
3. Letter Color:
   a. Correspond with pipe system background.

3.5 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 22 0553

SECTION 22 0700

PLUMBING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Insulation Materials:
      a. Cellular glass.
      b. Flexible elastomeric.
      c. Mineral fiber.
      d. Phenolic.
      e. Polyisocyanurate.
      f. Polyolefin.
      g. Polystyrene.
   2. Insulating cements.
   3. Adhesives.
   4. Mastics.
   5. Lagging adhesives.
   6. Sealants.
   7. Factory-applied jackets.
   8. Field-applied fabric-reinforcing mesh.
   9. Field-applied cloths.
   10. Field-applied jackets.
   11. Tapes.
   12. Securements.
   13. Corner angles.

B. Related Sections include the following:
   1. Division 21 Section 21 0700: "Fire-Suppression Systems Insulation."
   2. Division 23 Section "HVAC Insulation."
   3. Division 22 Section 22 0533 "Heat Racing For Plumbing Pipe."

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).

B. LEED Submittal:
   1. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of low VOC content.

C. Shop Drawings:

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties, equipment connections, and access panels.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.
8. Detail field application for each equipment type.

D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:
   1. Sample Sizes:
      a. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
      b. Sheet Form Insulation Materials: 12 inches square.
      c. Jacket Materials for Pipe: 12 inches long by NPS 2.
      d. Sheet Jacket Materials: 12 inches square.
      e. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

E. Qualification Data: For qualified Installer.

F. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

G. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

C. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Engineer. Use materials indicated for the completed Work.
   1. Piping Mockups:
      a. One 10-foot section of NPS 2 straight pipe.
      b. One each of a 90-degree threaded, welded, and flanged elbow.
      c. One each of a threaded, welded, and flanged tee fitting.
      d. One NPS 2 or smaller valve, and one NPS 2-1/2 or larger valve.

e. Four support hangers including hanger shield and insert.
f. One threaded strainer and one flanged strainer with removable portion of insulation.
g. One threaded reducer and one welded reducer.
h. One pressure temperature tap.
i. One mechanical coupling.

2. Equipment Mockups: One tank or vessel.
3. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
4. Notify Engineer seven days in advance of dates and times when mockups will be constructed.
5. Obtain Engineer's approval of mockups before starting insulation application.
6. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Engineer specifically approves such deviations in writing.
7. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
8. Demolish and remove mockups when directed.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 22 Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application and equipment Installer for equipment insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Cell-U-Foam Corporation; Ultra-CUF.
      b. Pittsburgh Corning Corporation; Foamglas Super K.
   2. Block Insulation: ASTM C 552, Type I.
   3. Special-Shaped Insulation: ASTM C 552, Type III.
   4. Board Insulation: ASTM C 552, Type IV.
   5. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
   6. Preformed Pipe Insulation with Factory-Applied ASJ ASJ-SSL: Comply with ASTM C 552, Type II, Class 2.
   7. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

G. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Armacell LLC; AP Armaflex.
      b. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

H. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Products: Subject to compliance with requirements, provide the following:
      a. CertainTeed Corp.; Duct Wrap.
      b. Johns Manville; Microlite.
      c. Knauf Insulation; Duct Wrap.
      d. Manson Insulation Inc.; Alley Wrap.
      e. Owens Corning; All-Service Duct Wrap.

I. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Johns Manville; HTB 23 Spin-Glas.
      b. Owens Corning; High Temperature Flexible Batt Insulations.

J. Mineral-Fiber, Preformed Pipe Insulation:
   1. Products: Subject to compliance with requirements, provide the following:
      a. Fibrex Insulations Inc.; Coreplus 1200.
      b. Johns Manville; Micro-Lok.
      c. Knauf Insulation; 1000(Pipe Insulation.
      d. Manson Insulation Inc.; Alley-K.
      e. Owens Corning; Fiberglas Pipe Insulation.
   2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

K. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied FSK jacket complying with ASTM C 1393, Type II or

Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide the following:
    a. CertainTeed Corp.; CrimpWrap.
    b. Johns Manville; MicroFlex.
    c. Knauf Insulation; Pipe and Tank Insulation.
    d. Manson Insulation Inc.; AK Flex.
    e. Owens Corning; Fiberglas Pipe and Tank Insulation.

L. Phenolic:
1. Products: Subject to compliance with requirements, provide the following:
    a. Kingspan Corp.; Koolphen K.
2. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.
3. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
4. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
5. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
    a. Preformed Pipe Insulation: ASJ.
    b. Board for Equipment Applications: ASJ.

M. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.
1. Products: Subject to compliance with requirements, provide the following:
    a. Apache Products Company; ISO-25.
    b. Dow Chemical Company (The); Trymer.
    c. Duna USA Inc.; Corafoam.
    d. Elliott Company; Elfoam.
2. Comply with ASTM C 591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F at 75 deg F after 180 days of aging.
3. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less for thickness up to 1-1/2 inches as tested by ASTM E 84.
4. Fabricate shapes according to ASTM C 450 and ASTM C 585.
5. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
    a. Pipe Applications: ASJ-SSL.
    b. Equipment Applications: ASJ-SSL.

N. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.
1. Products: Subject to compliance with requirements, provide the following:
    a. Nomaco Inc.; IMCOLOCK, IMCOSHEET, NOMALOCK, and NOMAPLY.
    b. RBX Corporation; Therma-cell.

O. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C 578, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed 0.26 Btu x in./h x sq. ft. x deg F after 180 days of aging. Fabricate shapes according to ASTM C 450 and ASTM C 585.
1. Products: Subject to compliance with requirements, provide the following:
    a. Dow Chemical Company (The); Styrofoam.
    b. Knauf Insulation; Knauf Polystyrene.

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Childers Products, Division of ITW; CP-97.
      b. Foster Products Corporation, H. B. Fuller Company; 81-27/81-93.
      c. Marathon Industries, Inc.; 290.
      d. Mon-Eco Industries, Inc.; 22-30.
      e. Vimasco Corporation; 760.
   2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Armacell LCC; 520 Adhesive.
      b. Foster Products Corporation, H. B. Fuller Company; 85-75.
   2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Childers Products, Division of ITW; CP-82.
      b. Marathon Industries, Inc.; 225.
   2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Childers Products, Division of ITW; CP-82.
      b. Marathon Industries, Inc.; 225.
   2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. PVC Jacket Adhesive: Compatible with PVC jacket.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Dow Chemical Company (The); 739, Dow Silicone.
   2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.3 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
   1. For indoor applications, use mastics that have a VOC content of Insert value g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Childers Products, Division of ITW; CP-35.

b. Foster Products Corporation, H. B. Fuller Company; 30-90.
c. ITW TACC, Division of Illinois Tool Works; CB-50.
d. Mon-Eco Industries, Inc.; 55-40.
2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
5. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
1. Products: Subject to compliance with requirements, provide the following:
a. Childers Products, Division of ITW; CP-10.
b. Foster Products Corporation, H. B. Fuller Company; 35-00.
c. ITW TACC, Division of Illinois Tool Works; CB-05/15.
d. Marathon Industries, Inc.; 550.
e. Mon-Eco Industries, Inc.; 55-50.
f. Vimasco Corporation; WC-1/WC-5.
2. Water-Vapor Permeance: ASTM F 1249, 3 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 200 deg F.
4. Solids Content: 63 percent by volume and 73 percent by weight.
5. Color: White.

2.4 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.
1. For indoor applications, use lagging adhesives that have a VOC content per LEED requirement when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Products: Subject to compliance with requirements, provide the following:
a. Childers Products, Division of ITW; CP-52.
b. Foster Products Corporation, H. B. Fuller Company; 81-42.
c. Marathon Industries, Inc.; 130.
d. Mon-Eco Industries, Inc.; 11-30.
e. Vimasco Corporation; 136.
3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment and pipe insulation.
4. Service Temperature Range: Minus 50 to plus 180 deg F.
5. Color: White.

2.5 SEALANTS

A. Joint Sealants:
1. Joint Sealants for Cellular-Glass, Phenolic, and Polyisocyanurate Products: Subject to compliance with requirements, provide the following:
a. Marathon Industries, Inc.; 405.
b. Mon-Eco Industries, Inc.; 44-05.
c. Pittsburgh Corning Corporation; Pittseal 444.
2. Joint Sealants for Polystyrene Products: Subject to compliance with requirements, provide the following:
a. Childers Products, Division of ITW; CP-70.
b. Foster Products Corporation, H. B. Fuller Company; 30-45/30-46.
c. Marathon Industries, Inc.; 405.
d. Mon-Eco Industries, Inc.; 44-05.
3. Materials shall be compatible with insulation materials, jackets, and substrates.
4. Permanently flexible, elastomeric sealant.

5. Service Temperature Range: Minus 100 to plus 300 deg F.
6. Color: White or gray.
7. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. FSK and Metal Jacket Flashing Sealants:
1. Products: Subject to compliance with requirements, provide the following:
    a. Marathon Industries, Inc.; 405.
    b. Mon-Eco Industries, Inc.; 44-05.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, Kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with Kraft-paper backing; complying with ASTM C 1136, Type II.
4. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
    a. Products: Subject to compliance with requirements, provide the following:
        1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
5. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
    a. Products: Subject to compliance with requirements, provide the following:
        1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
6. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
    a. Products: Subject to compliance with requirements, provide the following:
        1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

2.7 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
1. Products: Subject to compliance with requirements, provide the following:
    a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
    b. Compac Corp.; 104 and 105.
    c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
    d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
2. Width: 3 inches.

3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lb/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
      b. Compac Corp.; 110 and 111.
      c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
      d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.
   2. Width: 3 inches.
   3. Thickness: 6.5 mils.
   4. Adhesion: 90 ounces force/inch in width.
   5. Elongation: 2 percent.
   6. Tensile Strength: 40 lbf/inch in width.
   7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
      b. Compac Corp.; 120.
      c. Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF.
      d. Venture Tape; 3520 CW.
   2. Width: 2 inches.
   3. Thickness: 3.7 mils.
   4. Adhesion: 100 ounces force/inch in width.
   5. Elongation: 5 percent.
   6. Tensile Strength: 34 lbf/inch in width.

2.8 SECUREMENTS

A. Bands:
   1. Products: Subject to compliance with requirements, provide the following:
      a. Childers Products; Bands.
      b. PABCO Metals Corporation; Bands.
      c. RPR Products, Inc.; Bands.
   2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing or closed seal.
   3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing or closed seal.
   4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
   5. Copper clad annealed steel wire having a minimum 16 gauge thickness.
   6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
      a. Products: Subject to compliance with requirements, provide the following:
         1) AGM Industries, Inc.; RC-150.
         2) GEMCO; R-150.
         3) Midwest Fasteners, Inc.; WA-150.
         4) Nelson Stud Welding; Speed Clips.

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
   a. Products: Subject to compliance with requirements, provide the following:
      1) GEMCO.
      2) Midwest Fasteners, Inc.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

C. Wire: 0.062-inch soft-annealed, stainless steel 0.062-inch soft-annealed, galvanized steel.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. C & F Wire.
      b. Childers Products.
      c. PABCO Metals Corporation.
      d. RPR Products, Inc.

2.9 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105 or 5005; Temper H-14.

C. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or 316.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
   1. Verify that systems and equipment to be insulated have been tested and are free of defects.
   2. Verify that surfaces to be insulated are clean and dry.
   3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
   1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use de-mineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment and pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Replace normal insulation inside hanger shields with incompressible insulating block equal to Schuller T-12 Gold inside jacket. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield. Refer to Section 22 1116 “Domestic Water Piping” for shield sizes.

K. Apply adhesives, mastics, and sealants at manufacturer’s recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:
1. Draw jacket tight and smooth.

2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
   a. For below ambient services (i.e. cold water, chilled water, insulated storm water, and other frost protected services), apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above ambient services, do not install insulation to the following:
   1. Vibration-control devices.
   2. Testing agency labels and stamps.
   3. Nameplates and data plates.
   4. Manholes.
   5. Hand holes.
   6. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
   4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
   4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
  1. Comply with requirements in Division 07 Section "Penetration Fire stopping" fire stopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:
  1. Pipe: Install insulation continuously through floor penetrations.
  2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Fire stopping."

3.5 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

A. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
  1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
  2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
  3. Protect exposed corners with secured corner angles.
  4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
    a. Do not weld anchor pins to ASME-labeled pressure vessels.
    b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
    c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
    d. Do not over compress insulation during installation.
    e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
    f. Impale insulation over anchor pins and attach speed washers.
    g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
  5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
  6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch pre-stressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch pre-stressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
  7. Stagger joints between insulation layers at least 3 inches.
  8. Install insulation in removable segments on equipment access doors, manholes, hand holes, and other elements that require frequent removal for service and inspection.
  9. Bevel and seal insulation ends around manholes, hand holes, ASME stamps, and nameplates.
  10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
   1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
   2. Seal longitudinal seams and end joints.

3.6 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
   1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
   2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
   3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
   4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
   5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
   6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
   7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
   8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
   9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
   1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.

2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.7 CELLULAR-GLASS INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.8 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:
1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.9 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install preformed sections of same material as straight segments of pipe insulation when available.

2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.10 PHENOLIC INSULATION INSTALLATION

A. General Installation Requirements:
1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with 0.062-inch wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.

B. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets with vapor retarders on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

C. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:
1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

E. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.11 POLYISOCYANURATE INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
   2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
   3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:
   1. Install preformed pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.

C. Insulation Installation on Fittings and Elbows:
   1. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed sections of polyisocyanurate insulation to valve body.
   2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   3. Install insulation to flanges as specified for flange insulation application.

3.12 POLYOLEFIN INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:
   1. Install pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as pipe insulation.
   4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install mitered sections of polyolefin pipe insulation.
   2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install cut sections of polyolefin pipe and sheet insulation to valve body.

2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.13 POLYSTYRENE INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure each layer of insulation with tape or bands and tighten bands without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
   2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
   3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:
   1. Install preformed pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed section of polystyrene insulation to valve body.
   2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   3. Install insulation to flanges as specified for flange insulation application.

3.14 FINISHES

A. Equipment and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.
   1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
      a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.15 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:
   1. Inspect field-insulated equipment, randomly selected by Engineer, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
   2. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.16 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
   1. Drainage piping located in crawl spaces, only where noted.
   2. Underground piping.
   3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

C. Soundproof piping in walls and ceilings of as noted for insulation on respective service, except with a minimum 2 inch thick fiberglass, or as recommended by an acoustic consultant.

3.17 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Hot, Tempered, and Recirculated Hot and Tempered Water:
   1. NPS 1-1/4 and Smaller: Insulation shall be one of the following:
      a. Cellular Glass: 1 inches thick.
      b. Flexible Elastomeric: 1 inch thick.
      c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
      d. Phenolic: 1 inch thick.
      e. Polyisocyanurate: 1 inch thick.
      f. Polyolefin: 1 inch thick.
   2. NPS 2-1/2 and Larger: Insulation shall be one of the following:
      a. Cellular Glass: 1-1/2 inches thick.
      b. Flexible Elastomeric: 1 inch thick.
      c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
      d. Phenolic: 1 inch thick.
      e. Polyisocyanurate: 1 inch thick.
      f. Polyolefin: 1 inch thick.

3. For hot water piping with a temperature maintenance electric heating strip, the following insulation thickness apply:
    a. For 105 degrees F systems:
        1) 1/2 inch to 2 inches diameter, 1/2 inch thick.
        2) 2-1/2 inches to 4 inches diameter, 1 inch thick.
    b. For 120 degrees F systems:
        1) 1/2 inch to 1-1/2 inches diameter, 1/2 inch thick.
        2) 2 inches to 2-1/2 inches diameter, 1 inch thick.
        3) 3 inches and larger, 2 inches thick.
    c. For 140 degrees F systems:
        1) 1/2 inch to 3/4 inch diameter, 1/2 inch thick.
        2) 1 inch to 1-1/2 inches diameter, 1 inch thick.
        3) 2 inches to 2-1/2 inches diameter, 1-1/2 inches thick.
        4) 3 inches and larger, 2 inches thick.
4. Install insulation on hot water piping only after temperature maintenance heating strip has been tested.

B. Storm water and Overflow for Acoustic Requirements:
1. All Pipe Sizes: Insulation shall be one of the following:
    a. Cellular Glass: 1-1/2 inches thick.
    b. Flexible Elastomeric: 1 inch thick.
    c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
    d. Phenolic: 1 inch thick.
    e. Polyisocyanurate: 1 inch thick.
    f. Polyolefin: 1 inch thick.

C. Roof Drain and Overflow Drain Bodies:
1. All Pipe Sizes: Insulation shall be one of the following:
    a. Cellular Glass: 1-1/2 inches thick.
    b. Flexible Elastomeric: 1 inch thick.
    c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
    d. Phenolic: 1 inch thick.
    e. Polyisocyanurate: 1 inch thick.
    f. Polyolefin: 1 inch thick.

D. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:
1. All Pipe Sizes: Insulation shall be one of the following:
    a. Flexible Elastomeric: 1/2 inch thick.
    b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.
    c. Polyolefin: 1/2 inch thick.
    d. Pre-formed insulation for ADA traps and fittings, equal to Procap.

E. Sanitary Waste Piping Where Heat Tracing Is Installed:
1. All Pipe Sizes: Insulation shall be one of the following:
    a. Cellular Glass: 2 inches thick.
    b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-1/2 inches thick.
    c. Phenolic: 1-1/2 inches thick.
    d. Polyisocyanurate: 1-1/2 inches thick.

F. Condensate and Equipment Drain Water below 60 Deg F:
1. All Pipe Sizes: Insulation shall be one of the following:
    a. Cellular Glass: 1-1/2 inches thick.
    b. Flexible Elastomeric: 3/4 inch thick.
    c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.
    d. Phenolic: 1 inch thick.

e. Polyisocyanurate: 1 inch thick.
f. Polyolefin: 3/4 inch thick.

G. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F:
1. All Pipe Sizes: Insulation shall be one of the following:
a. Cellular Glass: 1-1/2 inches thick.
b. Flexible Elastomeric: 3/4 inch thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.
d. Phenolic: 1 inch thick.
e. Polyisocyanurate: 1 inch thick.
f. Polyolefin: 3/4 inch thick.

H. Hot Service Drains:
1. All Pipe Sizes: Insulation shall be one of the following:
a. Calcium Silicate: 1-1/2 inches thick.
b. Cellular Glass: 1-1/2 inches thick.
c. Mineral-Fiber, Preformed Pipe, Type I or II: 1 inch thick.

3.18 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Domestic Hot and Re-circulated Hot Water:
1. All Pipe Sizes: Insulation shall be one of the following:
a. Cellular Glass: 2 inches thick.
b. Flexible Elastomeric: 2 inches thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.
d. Phenolic: 2 inches thick.
e. Polyisocyanurate: 2 inches thick.
f. Polyolefin: 2 inches thick.

B. Sanitary Waste Piping Where Heat Tracing Is Installed:
1. All Pipe Sizes: Insulation shall be one of the following:
a. Cellular Glass: 2 inches thick.
b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.
c. Phenolic: 2 inches thick.
d. Polyisocyanurate: 2 inches thick.

3.19 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE

A. Loose-fill insulation, for belowground piping, is specified in Division 33 piping distribution Sections.

B. Sanitary Waste Piping, All Sizes, Where Heat Tracing Is Installed: Cellular glass, 2 inches thick.

3.20 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

3.21 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 22 0700

SECTION 22 1116

DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This section includes water distribution piping and related components inside the building for the domestic water piping system to 5 feet outside the building.
   1. Aboveground domestic and non-potable water pipes, tubes, fittings, and specialties.
   2. Encasement for piping.
   3. Transition fittings.
   4. Dielectric fittings.
   5. Flexible connectors.
   6. Escutcheons.
   7. Sleeves and sleeve seals.
   8. Wall penetration systems.

B. Related Section:
   1. Division 22 Section 22 1119 "Facility Water Distribution Piping" for water-service piping outside the building from source to the point where water-service piping enters the building.
   2. Division 22 Section 22 0523 "General Duty Valves for Plumbing Piping."
   3. Division 22 section 22 0553 "Identification for Plumbing pipes."

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Domestic water piping and support and installation shall withstand effects of earthquake motions determined according to ASCE/SEI 7.

1.4 SUBMITTALS

A. Product Data: For the following products:
   1. Specialty valves.
   2. Transition fittings.
   3. Dielectric fittings.
   4. Flexible connectors.
   5. Backflow preventers Vacuum breakers Backflow preventers and vacuum breakers.
   6. Escutcheons.
   7. Sleeves and sleeve seals.
   8. Water penetration systems.

B. Water Samples: Specified in "Cleaning" Article.

C. Coordination Drawings: For piping in equipment rooms and other congested areas, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
1. Fire-suppression-water piping.
2. Domestic water piping.
3. Non-Potable water.
4. HVAC hydronic piping.
5. Electrical conduits and cable trays.

D. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14 for potable domestic water piping and components. Include marking "NSF-pw" on piping.

C. Comply with NSF 61-G for potable domestic water piping and components.

D. Comply with California AB 1953 requirements.

E. Comply with 2010 California Plumbing code section 601.2 for non-potable water.

1.6 PROJECT CONDITIONS

A. Coordinate with Construction Manager for phased work

1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate with all other trades.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.
1. Cast-Copper Solder-Joint Fittings: ASME B16.18, pressure fittings.
2. Wrought-Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
3. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
4. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

2.3 SPECIALTY VALVES

A. Comply with requirements in Division 22 Section 22 0523 "General-Duty Valves for Plumbing Piping" for general-duty metal valves.

B. Comply with requirements in Division 22 Section 22 1119 "Domestic Water Piping Specialties" for balancing valves, drain valves, backflow preventers, and vacuum breakers.

2.4 TRANSITION FITTINGS

A. General Requirements:
  1. Same size as pipes to be joined.
  2. Pressure rating at least equal to pipes to be joined.
  3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Sleeve-Type Transition Coupling: AWWA C219.
  1. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
    a. Cascade Waterworks Manufacturing.
    b. Dresser, Inc.; Dresser Piping Specialties.
    c. Ford Meter Box Company, Inc. (The).
    d. JCM Industries.
    e. Romac Industries, Inc.
    f. Smith-Blair, Inc; a Sensus company.
    g. Viking Johnson; c/o Mueller Co.

2.5 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

B. Dielectric Unions:
  1. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
    a. Capitol Manufacturing Company.
    b. Central Plastics Company.
    c. EPCO Sales, Inc.
    d. Hart Industries International, Inc.
    e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
    f. Zurn Plumbing Products Group; Wilkins Water Control Products.
  2. Description:
    a. Pressure Rating: 250 psig at 180 deg F.
    b. End Connections: Solder-joint copper alloy and threaded ferrous.
  3. Shall be listed under ASSE Standard No. 1079.

C. Dielectric Flanges:
  1. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
    a. Capitol Manufacturing Company.
    b. Central Plastics Company.
    c. EPCO Sales, Inc.

d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Factory-fabricated, bolted, companion-flange assembly.
   b. Pressure Rating: 250 psig.
   c. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Kits:
1. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Central Plastics Company.
   d. Pipeline Seal and Insulator, Inc.
2. Description:
   a. Non-conducting materials for field assembly of companion flanges.
   b. Pressure Rating: 250 psig.
   c. Gasket: Neoprene or Phenolic.
   d. Bolt Sleeves: Phenolic or polyethylene.
   e. Washers: Phenolic with steel backing washers.

E. Dielectric Couplings:
1. Basis-of-Design Product: Subject to compliance with requirements, provide a or comparable product by one of the following:
   a. Calpico, Inc.
   b. Lochinvar Corporation.
2. Description:
   a. Galvanized-steel coupling.
   b. Pressure Rating: 300 psig at 225 deg F.
   c. End Connections: Female threaded.
   d. Lining: Inert and noncorrosive, thermoplastic.

F. Dielectric Nipples:
1. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
   a. Perfection Corporation; a subsidiary of American Meter Company.
   b. Precision Plumbing Products, Inc.
   c. Victaulic Company.
2. Description:
   a. Electroplated steel nipple complying with ASTM F 1545.
   b. Pressure Rating: 300 psig at 225 deg F.
   c. End Connections: Male threaded or grooved.
   d. Lining: Inert and noncorrosive, propylene.

2.6 FLEXIBLE CONNECTORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
1. Flex-Hose Co., Inc.
2. Flexicraft Industries.
3. Flex Pression, Ltd.
4. Flex-Weld, Inc.
5. Hyspan Precision Products, Inc.
6. Mason Industries Inc.
7. Mercer Rubber Co.

8. Metraflex, Inc.
9. Proco Products, Inc.

B. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
   1. Working-Pressure Rating: Minimum 200 psig.
   2. End Connections NPS 2 and Smaller: Threaded copper pipe or plain-end copper tube.
   3. End Connections NPS 2-1/2 and Larger: Flanged copper alloy.

C. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.
   1. Working-Pressure Rating: Minimum 200 psig.
   2. End Connections NPS 2 and Smaller: Threaded steel-pipe nipple.
   3. End Connections NPS 2-1/2 and Larger: Flanged steel nipple.
   4. Stainless steel or bronze metal flexible connectors with wire-braided jacket, and threaded or solder joint type ends, 150 psig wwp; equal to M.I.I Types BSS and BB.

D. Non-metallic flexible connectors constructed of wire- and fabric- reinforced Dacron and rubber hose and integrally cast flanged ends with steel back-up rings, 150 psig wwp; equal to M.I.I. Type MFTNC.

E. Short flexible connectors constructed on neoprene with floating steel flanges, twin sphere 150 psig wwp; equal to M.I.I Type MFTNC.

2.7 ESCUTCHEONS

A. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.

B. One Piece, Cast Brass: Polished, chrome-plated or rough-brass finish with setscrews.

C. One Piece, Deep Pattern: Deep-drawn, box-shaped brass with chrome-plated finish.

D. One Piece, Stamped Steel: Chrome-plated finish with setscrew or spring clips.

E. Split Casting, Cast Brass: Polished, chrome-plated or rough-brass finish with concealed hinge and setscrew.

F. Split Plate, Stamped Steel: Chrome-plated finish with concealed hinge, setscrew or spring clips.

G. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

H. Split-Casting Floor Plates: Cast brass with concealed hinge.

2.8 SLEEVES

A. Cast-Iron Wall Pipes: Fabricated of cast iron, and equivalent to ductile-iron pressure pipe, with plain ends and integral water stop unless otherwise indicated.

B. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc-coated, with plain ends.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   1. Under deck Clamp: Clamping ring with setscrews.

2.9 SLEEVE SEALS

A. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
   1. Advance Products & Systems, Inc.
   2. Calpico, Inc.
   3. Metraflex, Inc.
   4. Pipeline Seal and Insulator, Inc.

B. Description: Modular sealing element unit, designed for field assembly, used to fill annular space between pipe and sleeve.
   1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   2. Pressure Plates: Stainless steel.
   3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.10 WALL PENETRATION SYSTEMS

A. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
   1. SIGMA.

B. Description: Wall-sleeve assembly, consisting of housing and gland, gaskets, and pipe sleeve.
   1. Carrier-Pipe Deflection: Up to 5 percent without leakage.
   2. Housing: Ductile-iron casting with hub, water stop, anchor ring, and locking devices. Include gland, bolts, and nuts.
   3. Housing-to-Sleeve Gasket: EPDM rubber.
   4. Housing-to-Carrier-Pipe Gasket: AWWA C111, EPDM rubber.
   5. Pipe Sleeve: AWWA C151, ductile-iron pipe or ASTM A 53/A 53M, Schedule 40, zinc-coated steel pipe.

2.11 GROUT

A. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Non-shrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

D. Valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Comply with requirements in Division 22 Section 22 0519 "Meters and Gages for Plumbing Piping" for pressure gages and Division 22 Section 22 1119 "Domestic Water Piping Specialties" for drain valves and strainers.

E. Install shutoff valve immediately upstream of each dielectric fitting.

F. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements in Division 22 Section 22 1119 "Domestic Water Piping Specialties" for pressure-reducing valves.

G. Install seismic restraints on piping. Comply with requirements in Division 22 Section 22 0548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

H. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

I. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

J. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

K. Install piping adjacent to equipment and specialties to allow service and maintenance.

L. Install piping to permit valve servicing.

M. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure rating used in applications below unless otherwise indicated.

N. Install piping free of sags and bends.

O. Install fittings for changes in direction and branch connections.

P. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

Q. Install pressure gages on suction and discharge piping from each plumbing pump and packaged booster pump. Comply with requirements in Division 22 Section 22 0519 "Meters and Gages for Plumbing Piping" for pressure gages.

R. Install thermostats in hot-water circulation piping. Comply with requirements in Division 22 Section 22 1123 "Domestic Water Pumps" for thermostats.

S. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements in Division 22 Section 22 0519 "Meters and Gages for Plumbing Piping" for thermometers.

T. Install Backflow protection where required or indicated.

U. Install per 2010 California Plumbing code section 601.2

3.3 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

E. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.

F. Copper-Tubing Grooved Joints: Roll groove end of tube. Assemble coupling with housing, gasket, lubricant, and bolts. Join copper tube and grooved-end fittings according to AWWA C606 for roll-grooved joints.

G. Ductile-Iron-Piping Grooved Joints: Cut groove end of pipe. Assemble coupling with housing, gasket, lubricant, and bolts. Join ductile-iron pipe and grooved-end fittings according to AWWA C606 for ductile-iron-pipe, cut-grooved joints.

H. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

I. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.4 VALVE INSTALLATION

A. General-Duty Valves: Comply with requirements in Division 22 Section 22 0523 "General-Duty Valves for Plumbing Piping" for valve installations.

B. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use full port ball or gate valves for piping NPS 2 and smaller. Use gate valves for piping NPS 2-1/2 and larger.

C. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping. Drain valves are specified in Division 22 Section 22 1119 "Domestic Water Piping Specialties."
   1. Hose-End Drain Valves: At low points in water mains, risers, and branches.
   2. Stop-and-Waste Drain Valves: Instead of hose-end drain valves where indicated.

D. Install balancing valve in each hot-water circulation return branch and discharge side of each pump and circulator. Set balancing valves partly open to restrict but not stop flow. Use full port ball valves for piping NPS 2 and smaller and gate valves for piping NPS 2-1/2 and larger. Comply with requirements in Division 22 Section 22 1119 "Domestic Water Piping Specialties" for balancing valves.

E. Install calibrated balancing valves in each hot-water circulation return branch and discharge side of each pump and circulator. Set calibrated balancing valves partly open to restrict but not stop flow. Comply with requirements in Division 22 Section 22 1119 "Domestic Water Piping Specialties" for calibrated balancing valves.

3.5 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:
   1. NPS 1-1/2 and Smaller: Fitting-type coupling.
   2. NPS 2 and Larger: Sleeve-type coupling.

C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings or unions.

3.6 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric couplings unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.7 FLEXIBLE CONNECTOR INSTALLATION

A. Install flexible connectors in suction and discharge piping connections to each domestic water pump and in suction and discharge manifold connections to each domestic water booster pump.

B. Install bronze-hose flexible connectors in copper domestic water tubing.

C. Install stainless-steel-hose flexible connectors in steel domestic water piping.

D. Provide horizontal flexible connectors in piping from vibration isolation mounted equipment closely connected to an immovable mass (such as water meter, tank, etc) and as noted.

3.8 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Division 22 Section 22 0548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

B. Comply with requirements in Division 22 Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support products and installation.
1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:
    a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer than 100 Feet: MSS Type 43, adjustable roller hangers.
    c. Longer than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
1. Per 2010 California Plumbing Code table 3-2.
2. NPS 1 and NPS 1-1/4: 6 feet with 3/8-inch rod.
3. NPS 1-1/2 and NPS 2: 8 feet with 3/8-inch rod.
4. NPS 2-1/2: 9 feet with 1/2-inch rod.
5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
6. NPS 6: 10 feet with 5/8-inch rod.
7. NPS 8: 10 feet with 3/4-inch rod.

F. Install supports for vertical copper tubing every 10 feet.

G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/4 and Smaller: 7 feet with 3/8-inch rod.
2. NPS 1-1/2: 9 feet with 3/8-inch rod.
3. NPS 2: 10 feet with 3/8-inch rod.
4. NPS 2-1/2: 11 feet with 1/2-inch rod.
5. NPS 3 and NPS 3-1/2: 12 feet with 1/2-inch rod.
6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
7. NPS 6: 12 feet with 3/4-inch rod.
8. NPS 8 to NPS 12: 12 feet with 7/8-inch rod.

H. Install supports for vertical steel piping every 15 feet.

I. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

J. Support of Piping:

1. Provide resilient, spring, and neoprene-supported hangers with mounting that provide a minimum deflection of 7/8 inch for piping not provided with flexible connectors within 50 feet of connected motor-operated equipment.
2. Provide spring elements for pipe hanger mountings with first harmonic natural frequency of no less than 360 cycles per second.
3. Hanger rod isolators shall be equal to Type DNHS-M.I.I.

K. Vertical Pipe Riser Supports:
1. Provide piping connected to motor-operated equipment, within shafts with bearing plates and two layers of 1/4 inch thick ribbed or waffled neoprene pad.
2. Provide isolation pads loaded for maximum 50 psig and separated with steel plate, equal to Type W – M.I.I.

L. Cast iron shall be every 5 feet and at every fitting or joint, except for pipe lengths exceeding 5 feet then at intervals equal to pipe length.

M. Cast Iron: Every 5 feet and at every fitting or joint.

3.9 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment and machines to allow service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
1. Domestic Hot Water Booster Pumps: Hot-water suction and discharge piping.
2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
3. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Comply with requirements in Division 22 plumbing fixture Sections for connection sizes.
4. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

E. Connect non-potable water piping to water-service piping with shutoff valve, backflow device and connect to the following:
1. Any non-potable system or fixture.
2. Comply with 2010 California Plumbing Code section 601.2 for non-potable water.

3.10 ESCUTCHEON INSTALLATION

A. Install escutcheons for penetrations of walls, ceilings, and floors.

B. Escutcheons for Piping:
1. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
2. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, stamped steel with set screw.

3. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece or split casting, cast brass with polished chrome-plated finish.
4. Bare Piping in Unfinished Service Spaces: One piece, stamped steel with set screw.
5. Bare Piping in Equipment Rooms: One piece, stamped steel with set screw.
6. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.
7. Bare Piping in Equipment Rooms: Split casting, cast brass.
8. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.

3.11 SLEEVE INSTALLATION

A. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.

B. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.

C. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants" for joint sealants.

D. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants" for joint sealants.

E. For exterior wall penetrations below grade, seal annular space between sleeve and pipe using sleeve seals specified in this Section.

F. Seal space outside of sleeves in concrete slabs and walls with grout.

G. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.

H. Install sleeve materials according to the following applications:
   1. Sleeves for Piping Passing through Concrete Floor Slabs: Steel pipe.
   2. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Steel pipe Stack sleeve fittings.
      a. Extend sleeves 2 inches above finished floor level.
      b. For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Comply with requirements in Division 07 Section "Sheet Metal Flashing and Trim" for flashing.
   3. Sleeves for Piping Passing through Concrete Roof Slabs: Steel pipe.
   4. Sleeves for Piping Passing through Exterior Concrete Walls:
      a. Steel pipe sleeves for pipes smaller than NPS 6.
      b. Cast-iron wall pipe sleeves for pipes NPS 6 and larger.
      c. Install sleeves that are large enough to provide 1-inchannular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.
      d. Do not use sleeves when wall penetration systems are used.
   5. Sleeves for Piping Passing through Interior Concrete Walls:
      a. Steel pipe sleeves for pipes smaller than NPS 6.
      b. Galvanized-steel sheet sleeves for pipes NPS 6 and larger.

I. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire stop materials. Comply with requirements in Division 07 Section "Penetration Fire stopping" for fire stop materials and installations.

3.12 SLEEVE SEAL INSTALLATION

A. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.

B. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.13 WALL PENETRATION SYSTEM INSTALLATION

A. Install wall penetration systems in new, exterior concrete walls.

B. Assemble wall penetration system components with sleeve pipe. Install so that end of sleeve pipe and face of housing are flush with wall. Adjust locking devices to secure sleeve pipe in housing.

3.14 IDENTIFICATION

A. Identify system components. Comply with requirements in Division 22 0553 Section "Identification for Plumbing Piping and Equipment" for identification materials and installation.

B. Label pressure piping with system operating pressure.

3.15 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Piping Inspections:
1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
2. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
    a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
    b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
3. Re-inspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for re-inspection.
4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

C. Piping Tests:
1. Fill domestic water and non-potable piping. Check components to determine that they are not air bound and that piping is full of water.
2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.

3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
4. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
6. Prepare reports for tests and for corrective action required.

D. Domestic water and non-potable piping will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.16 ADJUSTING

A. Perform the following adjustments before operation:
1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
    a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide flow of hot water in each branch.
    b. Adjust calibrated balancing valves to flows indicated.
5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.17 CLEANING

A. Clean and disinfect potable and non-potable domestic water piping as follows:
1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
    a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
    b. Fill and isolate system according to either of the following:
        1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
        2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
    c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
    d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

B. Clean non-potable and domestic water piping as follows:
1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.

2. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:
   a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
   b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

C. Prepare and submit reports of purging and disinfecting activities.

D. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.18 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.

D. Aboveground domestic and non-potable water piping, NPS 2 and smaller, shall be one of the following:
   1. Hard copper tube, ASTM B 88, Type L wrought-copper solder-joint fittings.

E. Aboveground domestic and non-potable water piping, NPS 2-1/2 to NPS 4, shall be one of the following:
   1. Hard copper tube, ASTM B 88, Type L cast- copper solder-joint fittings.
   2. On pump discharge to roof: Cast bronze fittings, standard weight brazing joints or extra heavy threaded.

F. Aboveground domestic water piping, NPS 5 to NPS 8, shall be one of the following:
   1. Hard copper tube, ASTM B 88, Type L copper solder-joint fittings.

G. Unreduced Tank Pressure Piping:
   1. On Unreduced Tank Pressure Piping: Threaded malleable iron or extra heavy cast iron flanged fittings.

3.19 VALVE SCHEDULE

A. General:
   1. Shutoff: Use ball valves for piping NPS 2 and smaller. Use resilient seat gate valves with flanged ends for piping NPS 2-1/2 and larger.
   2. Throttling: Use ball or globe valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.
   3. Hot-Water Circulation Piping, Balancing: Calibrated Memory-stop balancing valves.
   4. Drain: Hose-end drain valves.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

C. Iron grooved-end valves may be used with grooved-end piping.

END OF SECTION 22 1116

SECTION 22 1124

DOMESTIC WATER PACKAGED BOOSTER PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Multiplex, variable-speed booster pumps.

1.3 DEFINITIONS

A. VFC: Variable-frequency controller(s).

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Booster pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the booster pump will remain in place without separation of any parts from the booster pump when subjected to the seismic forces specified and the booster pump will be fully operational after the seismic event."

1.5 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, and dimensions of individual components and profiles. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For booster pumps. Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.

C. Seismic Qualification Certificates: For booster pumps, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Operation and Maintenance Data: For booster pumps to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Comply with ASME B31.9 for piping.

C. UL Compliance for Packaged Pumping Systems:
1. UL 508, "Industrial Control Equipment."
2. UL 508A, "Industrial Control Panels."
3. UL 778, "Motor-Operated Water Pumps."
4. UL 1995, "Heating and Cooling Equipment."

D. Booster pumps shall be listed and labeled as packaged pumping systems by testing agency acceptable to authorities having jurisdiction.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Retain protective coatings and flange's protective covers during storage.

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 DOMESTIC HOT WATER MULTIPLEX PACKAGED BOOSTER PUMP

A. General:
1. Factory assembled and tested variable speed, constant pressure booster system, Weil Aquatronics/Grundfos or City of Los Angeles approved equal.
2. Entire package must be Underwriters Laboratories (UL) or ETL listed.
3. City of Los Angeles DBS approved (RR4682).
4. Manufacturer must be ISO 9001 certified and shall have thirty years manufacturing and pump application experience.
5. In addition, entire package shall be ANSI/NSF Standard 61 Annex G, and certified in compliance with the lead-free requirements of California AB1953.
6. Include current certifications with substitution request.
7. System shall be suitable for 120°F water temperature.

B. Pumps:
1. Grundfos model CRNE, vertical multistage diffuser type.
2. Pumps shall be certified to ANSI/NSF Standard 61 for drinking water system components.
3. Pump suction/discharge chamber, impellers, pump shaft, diffuser chambers, outer discharge sleeve, impeller seal rings, and seal ring retainers shall be constructed of 316 stainless steel.
4. Motor stool, and pump shaft coupling shall be constructed of cast iron.

5. Single silicon carbide mechanical shaft seal shall be of the cartridge design so that the seal may be replaced without removing motor.
6. Shaft journal and chamber bearings shall be tungsten carbide and bronze.

C. Motors:
1. Each motor shall be of the Integrated Variable Frequency Drive design consisting of a motor and a Variable Frequency Drive (VFD) built and tested as one unit by the same manufacturer.
2. The VFD shall be of the PWM (Pulse Width Modulation) design using current IGBT (Insulated Gate Bipolar Transistor) technology.
3. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of motor. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump control and to eliminate the need for motor de-rating.
4. The VFD shall have a minimum of two skip frequency bands which can be field adjustable.
5. The VFD shall have internal solid-state overload protection designed to trip within the range of 125-150% of rated current.
6. The integrated VFD motor shall include protection against input transients, phase imbalance, loss of AC line phase, over-voltage, under-voltage, VFD over-temperature, and motor over-temperature.
7. The integrated VFD motor shall have, as a minimum, the following input/output capabilities:
   a. Speed Reference Signal: 0-10 VDC, 4-20mA
   b. Digital remote on/off
   c. Fault Signal Relay (NC or NO)
8. The motor shall be Totally Enclosed Fan Cooled (TEFC) with a standard NEMA C-Face, Class F insulation with a Class B temperature rise.
9. Motor drive end bearings shall be adequately sized so that the minimum L10 bearing life is 17,500 hours at the minimum allowable continuous flow rate for the pump at full rated speed.

D. System Controller:
1. The pump system controller shall be a standard product developed and supported by the pump manufacturer.
2. The controller shall be microprocessor based. The controller user interface shall have a large display, minimum of 3-1/2" x 4-5/8", for easily viewing of system status parameters and for field programming of controller. Password protection of system settings shall be standard.
3. The controller shall display the following as status readings from single display on the controller:
   a. Current value of the control parameter, (usually discharge pressure).
   b. Latest current alarm, if any.
   c. System status with current operating mode and current value of control parameter.
   d. Status of all pumps with current operating mode and speed of pumps as percentage (%).
4. Pump system programming (field adjustable) shall include as a minimum the following:
   a. Qty (7) closed loop programmable setpoints (usually Constant Pressure setpoints)
   b. Qty (7) open loop programmable setpoints
   c. Pressure Transducer supply/range
   d. System time (reaction)
   e. Backup pump designation
   f. High system pressure shut-down
   g. Low suction pressure shutdown
   h. Low system pressure shutdown

i. Ethernet connection for field programming from a remote location

5. The system pressure set-point shall be capable of being automatically adjusted by using up to two external set-point influences in conjunction.
6. The system shall include an "Influence Function". Influence function allows user ability to determine relationship between the measuring parameter which is to influence the set-point and the desired influence as a percentage.
7. The controller shall be capable of receiving a remote analog set-point (4-20mA or 0-10 VDC) as well as a remote on/off (digital) signals.
8. The pump system controller shall store up to 24 warning and alarms in memory. The time, date and duration of each alarm shall be recorded. A potential-free relay shall be provided for alarm notification to the building management system. The controller shall display the following alarm conditions:
   a. High System Pressure
   b. Low system pressure
   c. Low suction pressure
   d. Individual pump failure
   e. VFD trip/failure
   f. Loss of sensor signal (4-20 mA)
   g. Loss of remote set-point signal (4-20mA)
   h. System power loss
9. The pump system controller shall be mounted in a NEMA 4 enclosure (NEMA 3R if cooling fan is required).
10. The entire control panel shall be UL 508 listed as an assembly.
11. The control panel shall include a main disconnect, circuit breakers for each pump and the control circuit and control relays for alarm functions.
12. Control panel options shall include, but not be limited to:
    a. Pump Run Lights
    b. Pump Alarm Lights
    c. System Fault Light
    d. Audible Alarm (80 db[A])
    e. Surge Arrestor
    f. Control Panel Internal Illumination
    g. Emergency/Normal Operation Switches
    h. Service Disconnect Switches
13. The controller shall be capable of using a redundant primary sensor to function as backup sensor to primary sensor.
14. The controller shall have a "Test Run" feature with settings of once every 24 hours, 48 hours or once a week for cycling pumps in periods of inactivity.
15. The controller shall be capable of providing power consumption and energy consumption information when used with integrated VFD motors connected through the field bus.
16. The controller shall be capable of providing a calculated flow rate.

E. Sequence of Operation:
1. The system controller shall operate equal capacity variable speed pumps to maintain a constant discharge pressure (system set-point). The system controller shall receive an analog signal [4-20mA] from the factory installed pressure transducer on the discharge manifold, indicating the actual system pressure. As flow demand increases the pump speed shall be increased to maintain the system set-point pressure. When the operating pump(s) reach 96% of full speed (adjustable), an additional pump will be started and will increase speed until the system set-point is achieved. All pumps in operation will be running at the same speed to maintain the system set-point. As flow demand decreases the pump speed shall be reduced while system set-point pressure is maintained. When all pumps in operation are running at low speed the system controller shall switch off pumps when fewer pumps are able to maintain system demand.
2. For no flow shut-down (periods of zero demand) an ASME bladder-type hydropneumatic tank shall be installed. The tank shall be piped to the discharge manifold or system piping downstream of the pump system. When zero flow is detected by the system controller, the

remaining pump(s) shall be switched off. When the system pressure falls to 50% of ON/OFF band below the system set-point (flow begins after shut-down), a pump shall be switched on, increasing speed to maintain the system set-point pressure.

F. Factory assembly:
1. The entire packaged pumping system shall be mounted on a 304 stainless steel fabricated skid.
2. Type 316 stainless steel discharge and suction headers, designed to attach to the system piping at either end of the manifold.
3. Each manifold shall include a liquid-filled pressure gauge.
4. Isolation valves shall be installed on the suction and discharge of each pump.
5. A check valve shall be installed on the discharge of each pump.

G. Testing and Warranty:
1. All systems shall be factory flow tested for performance and hydrostatic tested to 300 psi.
2. Provide a written guarantee covering all the equipment as well as the system performance for one year from date of start-up.
3. Factory trained engineer shall be provided for start-up and instruction of maintenance personnel.

H. Hydropneumatic tank:
1. The system shall include an ASME full acceptance pressure tank rated for scheduled working pressure, with NSF approved bladder, sized as scheduled.
2. Install on roof where shown on plans, or at highest fixture elevation.
3. Tank must be charged at the jobsite to a pressure equal to "system" pressure.

SCHEDULE

DHWP-1&2	
TYPE:	Duplex Variable Speed
MANUFACTURER:	Weil Aquatronics/Grundfos
MODEL NUMBER:	MPC-E2-CRNE 5-16-WA
SYSTEM FLOW CAPACITY:	62 GPM
SYSTEM PRESSURE BOOST:	149 PSIG
MINIMUM / MAXIMUM SUCTION PRESSURE:	26 PSIG / 35 PSIG *(please verify)*
RATED SYSTEM WORKING PRESSURE*:	300 PSIG
SUCTION AND DISCARGE MANIFOLD SIZE:	2" NPT AISI 316 Stainless Steel
PUMP CAPACITY / HEAD (EACH):	31 GPM / 345' TDH
MOTORS (EACH):	5 HP 3500 RPM
POWER SUPPLY:	460/3/60 *(please verify)*
TANK:	53 Gallon ASME 125 PSIG working pressure.
NOTES:	Certified Lead-Free (AB1953)

*Including shut-off pressure of pumps and maximum anticipated suction pressure.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for booster pumps to verify actual locations of piping connections before booster-pump installation.

3.2 INSTALLATION

A. Equipment Mounting: Install booster pumps on concrete base using elastomeric pads. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete."
   1. Minimum Deflection: 1/4 inch.
   2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
   3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   5. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Equipment Mounting: Install booster pumps using elastomeric pads elastomeric mount restrained spring isolators. Comply with requirements for vibration isolation devices specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."
   1. Minimum Deflection: 1/4 inch.

C. Support connected domestic-water piping so weight of piping is not supported by booster pumps.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in Division 22 Section "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect domestic-water piping to booster pumps. Install suction and discharge pipe equal to or greater than size of system suction and discharge headers.
   1. Install shutoff valves on piping connections to booster-pump suction and discharge headers. Install ball, butterfly, or gate valves same size as suction and discharge headers. Comply with requirements for general-duty valves specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
   2. Install union, flanged, or grooved-joint connections on suction and discharge headers at connection to domestic-water piping. Comply with requirements for unions and flanges specified in Division 22 Section "Domestic Water Piping."
   3. Install valved bypass, same size as and between piping, at connections to booster-pump suction and discharge headers. Comply with requirements for domestic-water piping specified in Division 22 Section "Domestic Water Piping."
   4. Install flexible connectors, same size as piping, on piping connections to booster-pump suction and discharge headers. Comply with requirements for flexible connectors specified in Division 22 Section "Domestic Water Piping."
   5. Install piping adjacent to booster pumps to allow service and maintenance.

3.4 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:
   1. Perform visual and mechanical inspection.
   2. Leak Test: After installation, charge booster pump and test for leaks. Repair leaks and retest until no leaks exist.
   3. Operational Test: After electrical circuitry has been energized, start booster pumps to confirm proper motor rotation and booster-pump operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Pumps and controls will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Provide video records of startup in maintenance procedures.

3.7 ADJUSTING

A. Adjust booster pumps to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust pressure set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting booster pump to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain booster pumps.

END OF SECTION 22 1123

SECTION 22 1316

SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following for soil, waste, and vent piping inside the building:
1. Pipe, tube, and fittings.
2. Special pipe fittings.

B. Related Sections include the following:
1. Division 22 Section 22 1329 "Sanitary Sewerage Pumps."
2. Division 22 Section 22 0548 "Vibration and Seismic controls for Plumbing, Piping and Equipment."
3. Division 22 Section 22 0529 "Hangers and Supports for Plumbing, Piping and Equipment."

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

C. PE: Polyethylene plastic.

D. TPE: Thermoplastic elastomer.

1.4 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
1. Soil, Waste, and Vent Piping: 10-foot head of water.
2. Sanitary Sewer, Force-Main Piping: 70 psig.

B. Seismic Performance: Soil, waste, and vent piping and support and installation shall be capable of withstanding the effects of seismic events determined according to ASCE 7, "Minimum Design Loads for Buildings and Other Structures."

1.5 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

B. LEED Submittal:
   1. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.

C. Shop Drawings:
   1. Design Calculations: Signed and sealed by a qualified professional engineer for selecting seismic restraints.
   2. Pipe routing fully coordinated with other trades.

D. Field quality-control inspection and test reports.

1.6 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Piping shall bear NSF listed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Basis-of-Design Product: Subject to compliance with requirements, provide or comparable product.

2.2 PIPING MATERIALS

A. Refer to Part 3 “Piping Applications” Article for applications of pipe, tube, fitting, and joining materials.

2.3 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.
   1. Standard, Shielded, Stainless-Steel Couplings: CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve.
      a. Manufacturers:
         1) ANACO.
         2) Husky.
         3) Fernco, Inc.
         4) Ideal Div.; Stant Corp.
         5) Mission Rubber Co.
         6) Tyler Pipe; Soil Pipe Div.
   2. Heavy-Duty, Shielded, Stainless-Steel Couplings: With stainless-steel shield, stainless-steel bands and tightening devices, and ASTM C 564, rubber sleeve.
      a. Basis-of-Design Product: Subject to compliance with requirements, provide or comparable product by one of the following:
         1) ANACO.

2) Husky.
3) Clamp-All Corp.
4) Ideal Div.; Stant Corp.
5) Mission Rubber Co.
6) Tyler Pipe; Soil Pipe Div.

C. Rigid, Unshielded Couplings: ASTM C 1461, sleeve-type, reducing- or transition-type mechanical coupling molded from ASTM C 1440, TPE material with corrosion-resistant-metal tension band and tightening mechanism on each end.
1. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
a. ANACO.

2.4 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade A or B, Standard Weight or Schedule 40, galvanized. Include ends matching joining method.

B. Drainage Fittings: ASME B16.12 threaded, cast-iron drainage pattern.

C. Pressure Fittings:
1. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
2. Malleable-Iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
3. Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, standard pattern.
4. Cast-Iron Flanges: ASME B16.1, Class 125.
5. Cast-Iron, Flanged Fittings: ASME B16.1, Class 125.

D. Grooved-Joint Systems:
1. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
a. Anvil International.
b. Star Pipe Products; Star Fittings Div.
c. Victaulic Company.
d. Ward Manufacturing, Inc.
2. Grooved-End, Steel-Piping Fittings: ASTM A 47/A 47M, malleable-iron casting; ASTM A 106, galvanized-steel pipe; or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
3. Grooved-End, Steel-Piping Couplings: AWWA C606, for steel-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.

2.5 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end, unless grooved or flanged ends are indicated.
1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Grooved-Joint Systems:
1. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:

a. Victaulic Company.
b. Anvil.
2. Grooved-End, Ductile-Iron Fittings: ASTM A 47/A 47M, malleable-iron castings or ASTM A 536, ductile-iron castings with dimensions matching pipe.
3. Grooved-End, Ductile-Iron-Piping Couplings: AWWA C606, for ductile-iron-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.

C. Flanges: ASME 16.1, Class 125, cast iron.

2.6 COPPER TUBE AND FITTINGS

A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.
1. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

B. Hard Copper Tube: ASTM B 88, Types L, water tube, drawn temper.
1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
2. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
3. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

2.7 SPECIAL PIPE FITTINGS

A. Flexible, Nonpressure Pipe Couplings: Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition pattern. Include shear ring, ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.
1. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
a. Dallas Specialty & Mfg. Co.
b. Fernco, Inc.
c. Logan Clay Products Company (The).
d. Mission Rubber Co.
e. NDS, Inc.
2. Sleeve Materials:
a. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
b. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
c. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

B. Shielded Non-pressure Pipe Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
1. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
a. Cascade Waterworks Mfg. Co.
b. Mission Rubber Co.

C. Rigid, Unshielded, Non-pressure Pipe Couplings: ASTM C 1461, sleeve-type reducing- or transition-type mechanical coupling molded from ASTM C 1440, TPE material with corrosion-resistant-metal tension band and tightening mechanism on each end.
1. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:

a. ANACO.

D. Pressure Pipe Couplings: AWWA C219 metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
1. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
a. Cascade Waterworks Mfg. Co.
b. Dresser, Inc.; DMD Div.
c. EBAA Iron Sales, Inc.
d. Ford Meter Box Company, Inc. (The); Pipe Products Div.
e. JCM Industries, Inc.
f. Romac Industries, Inc.
g. Smith-Blair, Inc.
h. Viking Johnson.
2. Center-Sleeve Material: Stainless steel.
3. Gasket Material: Natural or synthetic rubber.
4. Metal Component Finish: Corrosion-resistant coating or material.

E. Flexible Ball Joints: Ductile-iron fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include gasketed ball-joint section and ductile-iron gland, rubber gasket, and steel bolts.
1. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
a. EBAA Iron Sales, Inc.

F. Expansion Joints: Two or three-piece, ductile-iron assembly consisting of telescoping sleeve(s) with gaskets and restrained-type, ductile-iron, bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Select and assemble components for expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
1. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
a. EBAA Iron Sales, Inc.
b. Romac Industries, Inc.
c. Star Pipe Products; Star Fittings Div.

G. Wall-Penetration Fittings: Compound, ductile-iron coupling fitting with sleeve and flexing sections for up to 20-degree deflection, gaskets, and restrained-joint ends complying with AWWA C110 or AWWA C153. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
1. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
a. SIGMA Corp.

2.8 ENCASEMENT FOR UNDERGROUND METAL PIPING

A. Description: ASTM A 674 or AWWA C105, high-density, cross laminated PE film of 0.004-inch minimum thickness.

B. Form: Sheet or tube.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.

B. Aboveground, soil and waste piping NPS 4 and smaller shall be any of the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel heavy-duty shielded, stainless-steel and rigid, unshielded couplings; and hubless-coupling joints.
   3. Steel pipe, drainage fittings, and threaded joints.
   4. Stainless-steel pipe and fittings, gaskets, and gasketed joints.
   5. Copper DWV tube, copper drainage fittings, and soldered joints.
   6. Dissimilar Pipe-Material Couplings: Flexible, Shielded, Rigid, unshielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

C. Aboveground, soil and waste piping NPS 5 and larger shall be any of the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. Hubless cast-iron soil pipe and fittings; standard, and heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.
   3. Steel pipe, drainage fittings, and threaded joints.
   4. Dissimilar Pipe-Material Couplings: Flexible, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

D. Aboveground, vent piping NPS 4 and smaller shall be any of the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel heavy-duty shielded, stainless-steel and rigid, unshielded couplings; and hubless-coupling joints.
   3. Steel pipe, drainage fittings, and threaded joints.
   4. Stainless-steel pipe and fittings gaskets, and gasketed joints.
   5. Copper DWV tube, copper drainage fittings, and soldered joints.
      a. Option for Vent Piping, NPS 2-1/2 and NPS 3-1/2: Hard copper tube, Type M; copper pressure fittings; and soldered joints.
   6. Dissimilar Pipe-Material Couplings: Flexible, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.
   7. Galvanized steel piping for horizontal offsets of vent headers.

E. Aboveground, vent piping NPS 5 and larger shall be any of the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. Hubless cast-iron soil pipe and fittings; standard, and heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.
   3. Steel pipe, drainage fittings, and threaded joints.
   4. Dissimilar Pipe-Material Couplings: Flexible, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.
   5. Galvanized steel piping for horizontal offsets of vent headers.

F. Aboveground sanitary-sewage force mains NPS 1-1/2 and NPS 2] shall be any of the following:
   1. Hard copper tube, Type L]; copper pressure fittings; and soldered joints.
   2. Steel pipe, pressure fittings, and threaded joints.

G. Aboveground sanitary-sewage force mains NPS 2-1/2 to NPS 6 shall be any of the following:
   1. Hard copper tube, Type L; copper pressure fittings; and soldered joints.
   2. Steel pipe, pressure fittings, and threaded joints.
   3. Grooved-end steel pipe, grooved-joint system fittings and couplings, and grooved joints.

3.3 PIPING INSTALLATION

A. Sanitary sewer piping outside the building is specified in Division 22 Section "Facility Sanitary Sewers."

B. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."

C. Install seismic restraints on piping. Seismic-restraint devices are specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

D. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.

E. Install cleanout fitting with closure plug inside the building in sanitary force-main piping.

F. Install underground, steel, force-main piping. Install encasement on piping according to ASTM A 674 or AWWA C105.

G. Install underground, ductile-iron, force-main piping according to AWWA C600. Install buried piping inside the building between wall and floor penetrations and connection to sanitary sewer piping outside the building with restrained joints. Anchor pipe to wall or floor. Install thrust-block supports at vertical and horizontal offsets. Wrap all piping in mat foundation with ¼" minimum foam per authorities having jurisdiction.
   1. Install encasement on piping according to ASTM A 674 or AWWA C105.

H. Install underground, copper, force-main tubing according to CDA's "Copper Tube Handbook."
   1. Install encasement on piping according to ASTM A 674 or AWWA C105.

I. Install underground, ductile-iron, special pipe fittings according to AWWA C600.
   1. Install encasement on piping according to ASTM A 674 or AWWA C105.

J. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing."

K. Install wall-penetration fitting at each service pipe penetration through foundation wall. Make installation watertight.

L. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

M. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

N. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:
   1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
   2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow NPS 2 (DN80) and smaller at 1/4 inch per foot minimum 1 percent downward in direction of flow NPS 4 and larger at 1/8 inch per foot minimum.
   3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

O. Install engineered soil and waste drainage and vent piping systems as follows:
   1. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.

P. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

Q. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

R. Hubless piping shall be installed in a rigid, linear, and plumb system without any deflection at the joints either horizontally or vertically. The system shall be supported and secured to the building structure to prevent movement induced by a ten-foot head of water and its associated thrust forces.
   1. When horizontal hubless CI piping is suspended in excess of 18 inch by means of non-rigid hangers, provide sway bracing to prevent horizontal movement.
   2. For all horizontal hubless CI piping 5-inch and larger, provide sway bracing to prevent horizontal movement at every branch opening and change of direction by securing to building structure, or provide pipe clamps and rodding across coupling.

3.4 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."

B. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.

C. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

D. Grooved Joints: Assemble joint with keyed coupling, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

3.5 VALVE INSTALLATION

A. General valve installation requirements are specified in Division 22 Section 22 0519 "General-Duty Valves for Plumbing Piping."

B. Shutoff Valves: Install shutoff valve on each sewage pump discharge.
   1. Install gate or full-port ball valve for piping NPS 2 and smaller.
   2. Install gate valve for piping NPS 2-1/2 and larger.

C. Check Valves: Install non-slam swing check valve, between pump and shutoff valve, on each sewage pump discharge.

D. Backwater Valves: Install backwater valves in piping subject to sewage backflow.
   1. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.
   2. Floor Drains: Drain outlet backwater valves, unless drain has integral backwater valve.
   3. Install backwater valves in accessible locations.
   4. Backwater valve are specified in Division 22 Section 22 1319 "Sanitary Waste Piping Specialties."

3.6 HANGER AND SUPPORT INSTALLATION

A. Seismic-restraint devices are specified in Division 22 Section 22 0548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Pipe hangers and supports are specified in Division 22 Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment." Install the following:
   1. Vertical Piping: MSS Type 8 or Type 42, clamps.
   2. Install individual, straight, horizontal piping runs according to the following:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.
   3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install supports according to Division 22 Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
   2. NPS 3: 60 inches with 1/2-inch rod.
   3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
   4. NPS 6: 60 inches with 3/4-inch rod.
   5. NPS 8 to NPS 12: 60 inches with 7/8-inch rod.

G. Install supports for vertical cast-iron soil piping every 15 feet.

H. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4: 84 inches with 3/8-inch rod.
   2. NPS 1-1/2: 108 inches with 3/8-inch rod.
   3. NPS 2: 10 feet with 3/8-inch rod.
   4. NPS 2-1/2: 11 feet with 1/2-inch rod.
   5. NPS 3: 12 feet with 1/2-inch rod.
   6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
   7. NPS 6: 12 feet with 3/4-inch rod.
   8. NPS 8 to NPS 12: 12 feet with 7/8-inch rod.

I. Install supports for vertical steel piping every 15 feet.

J. Install hangers for stainless-steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 2: 84 inches with 3/8-inch rod.
   2. NPS 3: 96 inches with 1/2-inch rod.
   3. NPS 4: 108 inches with 1/2-inch rod.
   4. NPS 6: 10 feet with 5/8-inch rod.

K. Install supports for vertical stainless-steel piping every 10 feet.

L. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4: 72 inches with 3/8-inch rod.
   2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
   3. NPS 2-1/2: 108 inches with 1/2-inch rod.
   4. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
   5. NPS 6: 10 feet with 5/8-inch rod.
   6. NPS 8: 10 feet with 3/4-inch rod.

M. Install supports for vertical copper tubing every 10 feet.

N. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect drainage and vent piping to the following:
   1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
   2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
   3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
   4. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.

D. Connect force-main piping to the following:
   1. Sanitary Sewer: To exterior force main or sanitary manhole.
   2. Sewage Pumps: To sewage pump discharge.

3.8 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
   1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
   2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Re-inspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for re-inspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
4. Prepare reports for tests and required corrective action.

3.9 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

END OF SECTION 22 1316

SECTION 22 1329

SANITARY SEWAGE PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following sewage pumps and accessories for sanitary drainage piping systems in buildings:
   1. Sewage pump basin and cover.

B. Related Sections include the following:
   1. Division 22 Section "Sump Pumps" for applications in storm-drainage systems.

1.3 SUBMITTALS

A. Product Data: For each type and size of sewage pump specified. Include certified performance curves with operating points plotted on curves; and rated capacities of selected models, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Operation and Maintenance Data: For each sewage pump to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of sewage pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with pump manufacturer's written rigging instructions for handling.

1.6 COORDINATION

A. Coordinate size and location of concrete bases and pits. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
      a. Weil Pumps.
      b. Paco Rupp.
      c. Homa Pumps.
      d. Grundfos.

2.2 HEAVY DUTY SEWAGE EJECTORS:

A. Provide pumps as scheduled on plans.

B. Weil Series 2500, or approved equal

C. Pump casing, end bell and motor shell cast iron.

D. Impeller is cast iron non-clog type handling 2.5" solids.

E. Each sewage ejector pump shall be equipped with a full flow type check valve capable of passing a 2.5" spherical solid.

F. Motors:
   1. Four pole, air-filled, class F insulation, sealed grease-lubricated upper and lower heavy duty ball bearings.
   2. Solid AISI 304 stainless steel shaft.
   3. City of Los Angeles DBS approved

G. Basin and cover:
   1. Freestanding fabricated steel, size and openings per plans, complying with LAPC Section 94.710.8
   2. Bitumastic-coated interior and exterior.
   3. Bolt-down angle clips on bottom
   4. Hold-down tabs for guy wires and turnbuckles
   5. Matching cover, gas tight, with discharge, vent, inspection, and electrical openings.

H. Valves:
   1. Provide valve assembly for each pump discharge.
   2. Factory assembled, consisting of ball check valves and isolation valve.
   3. Discharge connection shall be oriented as shown on drawings.

I. Pilot controls:

1. Four pre-wired and tested, UL listed non-mercury float switches, complete with switch mounting plate.

J. Control Panel:
1. Factory pre-wired and tested, UL listed and UL508a labeled.
2. NEMA-1 enclosure.
3. Disconnects switches with lockout handles through door, magnetic starters with OL protection, Test-Off-Automatic selector switches, electric alternator, control circuit transformer, pump running lights, through-the-door reset buttons.
4. Contacts and terminals for remote alarm panel.
5. Float failure detection system shall include an "out-of-sequence" logic program that monitors all floats and a maximum run timer to protect against a stop float fail closed.

K. Remote-Mounted Alarm Panel:
1. Weil 8301 Fail-Safe alarm panel.
2. Factory pre-wired and tested, UL listed and UL508a labeled.
3. NEMA-4X (corrosion proof) enclosure.
4. POWER FAILURE indicator light.
5. LAG PUMP CALLED indicator light.
6. HIGH LEVEL indicator light.
7. Float failure indicator light.
8. 95 db Piezo buzzer to sound under any alarm condition. When alarm is silenced and a different alarm condition arises, alarm will sound again.
9. Combination pushbutton for silence/reset.
10. Lamp/Horn test pushbutton.
11. The indicator lights corresponding to the alarm conditions shall flash when the alarm condition occurs. The indicator light shall remaining flashing until alarm is acknowledged by pressing the SILENCE/RESET pushbutton. At that time the indicator light will go solid and remain in that state until the condition has been reset.
12. Furnish combination NO/NC dry contacts for each alarm condition.

L. Installation:
1. Basin to be cleaned thoroughly, with all water and debris removed prior to installing pumps.
2. Discharge piping shall extend through basin cover, and connect to valve assembly as shown on plans.
3. Electrical contractor to provide separate conduit for power cables.
4. Coordinate location and wiring of control and alarm panels with electrician.

M. Schedule:

	SE-1&2
MANUFACTURER:	Weil Pump Co.
MODEL:	2548
CAPACITY / HEAD (EACH):	300 GPM / 60' TDH
MOTOR:	7.5 HP / 1750 RPM
POWER SUPPLY:	460/3/60 *(please verify)*
BASIN SIZE:	72" x __'-__" high
REMARKS:	

N. Duplex Sewage Ejector Controls.
1. Factory pre-wired and tested, UL listed and UL508a labeled. Pump station control enclosure to be NEMA 1 double door front enclosure. Door hinge shall be sealed with a neoprene gasket and equipped with captive closing hardware. Control components shall be mounted on a removable steel back panel secured to the enclosure with collar studs.
2. All control devices shall be labeled to indicate function.
3. The panel shall bear a serialized U.L. label listed for "Enclosed Industrial Control Panel".

4. Provide step down transformer.
5. The control circuit for pump #2 shall be equipped with a time delay to prevent simultaneous motor starts.
6. Provide high water and pump failure alarm to send a signal to the building Automation System.
7. Provide wiring for remote monitoring by Building Automation System. Contractor to verify wire length. Similar to WEIL 8301 Fail Safe alarm panel. NEMA 4X corrosion proof. Lag pump called indicator light. Power failure indicator lights, 95db Piezo buzzer to sound under any alarm condition. When alarm is silenced and a different alarm condition arises, alarm will sound again. Combination push button for silence/reset. Lamp/horn test push button.
8. For normal operation, pump shall operate singly. When load exceeds capacity of one pump, pumps shall operate simultaneously. Pumps will also alternate on every cycle and be integral to the liquid level controller.
9. Provide a permanent brass or stainless steel corrosion resistant name plate attached to the control panel to include the following:
    a. Equipment serial number.
    b. Control panel short circuit rating.
    c. Supply voltage, phase and frequency.
    d. Current rating of the minimum conductor.
    e. Electrical wiring diagram number.
    f. Motor horsepower and full load current.
    g. Motor overload heater element.
    h. Motor circuit breaker trip current rating.
    i. Name, location, and telephone number of equipment manufacturer.

O. Level Sensors:
1. Encapsulated Float Switches for each level of operation sensed. Provide normally open contacts that close on water rise. Float switches to be Mercury free similar to Roto-Float with pipe clamp mounting brackets.
2. Suspend float switches and secure on stainless steel pipe in wet well and provide control cable connected to control panel.
    a. Provide explosion proof pumps with intrinsically safe relays.
    b. Provide a switch for each level sensed with simple relays to activate starters and alarms.
    c. Provide dry contacts for each switch to indicate when water levels drop.
3. Provide a minimum of 4 floats in basin.
    a. Sensor #1 mounted near the bottom of the wet pit (per manufacturers recommended minimum cover).
    b. Sensor #2 Lead pump on (see details).
    c. Sensor #3 Lag pump on (see details).
    d. Sensor #4 High water alarm (2-inches below inlet of effluent).

2.3 BUILDING AUTOMATION SYSTEM INTERFACE

A. Provide auxiliary contacts in pump controllers for interface to building automation system. Include the following:
1. On-off status of each pump.
2. Alarm status.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for plumbing piping to verify actual locations of sanitary drainage and vent piping connections before sewage pump installation.

3.2 INSTALLATION

A. Set submersible sewage pumps on basin and pit floors. Make direct connections to sanitary drainage piping.

B. Install sewage pump basins and connect to drainage and vent piping. Brace interior of basins according to manufacturer's written instructions to prevent distortion or collapse during concrete placement. Set basin cover and fasten to basin top flange. Install cover so top surface is flush with finished floor.

C. Install packaged, submersible sewage pump units and make direct connections to drainage and vent piping.

D. Support piping so weight of piping is not supported by pumps.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Division 22 Section "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to sewage pumps to allow service and maintenance.

C. Connect sanitary drainage and vent piping to pumps. Install discharge piping equal to or greater than size of pump discharge piping. Install vent piping equal to or greater than size of pump basin vent connection. Refer to Division 22 Section "Sanitary Drainage and Vent Piping."
   1. Install flexible connectors adjacent to pumps in discharge piping.
   2. Install check and shutoff valves on discharge piping from each pump. Install unions on pumps having threaded pipe connections. Install valves same size as connected piping. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves for sanitary waste piping.

D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Verify bearing lubrication.
   3. Disconnect couplings and check motors for proper direction of rotation.
   4. Verify that each pump is free to rotate by hand. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
   5. Verify that pump controls are correct for required application.
   6. Insert additional startup steps if any.

B. Start pumps without exceeding safe motor power:
   1. Start motors.
   2. Open discharge valves slowly.
   3. Check general mechanical operation of pumps and motors.

C. Test and adjust controls and safeties.

D. Remove and replace damaged and malfunctioning components.
   1. Pump Controls: Set pump controls for automatic start, stop, and alarm operation as required for system application.
   2. Set field-adjustable switches and circuit-breaker trip ranges as indicated, or if not indicated, for normal operation.

E. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project outside normal occupancy hours for this purpose.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps.

END OF SECTION 22 1329

SECTION 22 1413

STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following storm drainage piping inside the building:
   1. Pipe, tube, and fittings.
   2. Special pipe fittings.
   3. Enclosing existing storm drain piping in chiller room.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. LLDPE: Linear, low-density polyethylene plastic.

C. PE: Polyethylene plastic.

D. PVC: Polyvinyl chloride plastic.

E. TPE: Thermoplastic elastomer.

F. PVDF: Polyvinylidene Fluoride heat fusion plastic.

1.4 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working-pressure, unless otherwise indicated:
   1. Storm Drainage Piping: 10-foot head of water.
   2. Storm Drainage, Force-Main Piping: 50 psig.

B. Seismic Performance: Soil, waste, and vent piping and support and installation shall be capable of withstanding the effects of seismic events determined according to ASCE 7, "Minimum Design Loads for Buildings and Other Structures."

1.5 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

B. LEED Submittal:

1. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.

C. Shop Drawings:
1. Design Calculations: Signed and sealed by a qualified professional engineer for selecting seismic restraints.
2. Controlled-Flow Storm Drainage System: Include calculations, plans, and details.

D. Field quality-control inspection and test reports.

1.6 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Shall be NSF listed.

C. Double containment pipe to meet FDA requirements.

1.7 WARRANTY

A. Failures due to defective materials or workmanship for materials installed together, including piping, fittings, and mounting adapters.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.
1. Heavy-Duty, Shielded, Stainless-Steel Couplings: With stainless-steel shield, stainless-steel bands and tightening devices, and ASTM C 1540-2004, rubber sleeve.
    a. Manufacturers:
        1) ANACO.
        2) Clamp-All Corp.
        3) Ideal Div.; Stant Corp.
        4) Mission Rubber Co.
        5) Tyler Pipe; Soil Pipe Div.

C. Rigid, Unshielded Couplings: ASTM C 1461, sleeve-type, reducing- or transition-type mechanical coupling molded from ASTM C 1440, TPE material with corrosion-resistant-metal tension band and tightening mechanism on each end.
   1. Manufacturers:
      a. ANACO.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade A or B, Standard Weight or Schedule 40, galvanized. Include ends matching joining method.

B. Drainage Fittings: ASME B16.12, threaded, cast-iron drainage pattern.

C. Pressure Fittings:
   1. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
   2. Malleable-Iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
   3. Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, standard pattern.
   4. Cast-Iron Flanges: ASME B16.1, Class 125.
   5. Cast-Iron, Flanged Fittings: ASME B16.1, Class 125.

D. Grooved-Joint Systems:
   1. Manufacturers:
      a. Anvil International.
      b. Star Pipe Products; Star Fittings Div.
      c. Victaulic Co. of America.
      d. Ward Manufacturing, Inc.
   2. Grooved-End, Steel-Piping Fittings: ASTM A 47/A 47M, malleable-iron casting; ASTM A 106, galvanized-steel pipe; or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
   3. Grooved-End, Steel-Piping Couplings: AWWA C606, for steel-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.

2.4 ENCLOSURE OF EXISTING PIPING

A. Existing Storm drain piping in chiller room to be enclosed in 2 hour rated wall per authorities having jurisdiction requirements.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.

B. Aboveground storm drainage piping NPS 6 and smaller shall be any of the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. Hubless cast-iron soil pipe and fittings; standard, and heavy-duty shielded, stainless-steel couplings; and coupled joints.
   3. Galvanized steel pipe, drainage fittings, and threaded joints.

C. Aboveground, storm drainage piping NPS 8 and larger shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and coupled joints.
3. Steel pipe, drainage fittings, and threaded joints.
4. Dissimilar Pipe-Material Couplings: Flexible, Shielded, non-pressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

D. Aboveground storm drainage force mains NPS 2-1/2 and NPS 6 (DN 65 AND DN 150) shall be any of the following:
   1. Steel pipe, pressure fittings, and threaded joints.
   2. Grooved-end steel pipe, grooved-joint system fittings and couplings, and grooved joints.

3.2 PIPING INSTALLATION

A. Storm sewer and drainage piping outside the building are specified in Division 33 Section "Storm Utility Drainage Piping."

B. Basic piping installation requirements are specified in Division 22 Section 22 0500 "Common Work Results for Plumbing."

C. Install seismic restraints on piping. Seismic-restraint devices are specified in Division 22 Section 22 0548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

D. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers. Cleanouts are specified in Division 22 Section 22 1423 "Storm Drainage Piping Specialties."

E. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping.

F. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section 22 0500 "Common Work Results for Plumbing."

G. Install wall-penetration fitting system at each service pipe penetration through foundation wall. Make installation watertight.

H. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

I. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

J. Install storm drainage piping at the following minimum slopes, unless otherwise indicated:
   1. Building Storm Drain: 1 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
   2. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow.

K. Install force mains at elevations indicated.

L. Install engineered controlled-flow storm drainage piping in locations indicated.

M. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

N. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

O. Hubless piping shall be installed in a rigid, linear and plumb system without any deflection at the joints either horizontally or vertically. The system shall be supported and secured to the building structure to prevent movement induced by a ten-foot head of water and its associated thrust forces.
   1. When horizontal hubless CI piping is suspended in excess of 18 inch by means of non-rigid hangers, provide sway bracing to prevent horizontal movement.
   2. For all horizontal hubless CI piping 5-inch and larger, provide sway bracing to prevent horizontal movement at every branch opening and change of direction by securing to building structure, or provide pipe clamps and rodding across coupling.

3.3 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."

B. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

C. Hub-and-Spigot, Cast-Iron Soil Piping Calked Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.

D. Hubless Cast-Iron Soil Piping Coupled Joints: Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.

E. Grooved Joints: Cut groove ends of pipe and assemble grooved ends of pipes, grooved-end fittings, and grooved-end-piping couplings according to AWWA C606.

3.4 VALVE INSTALLATION

A. General valve installation requirements are specified in Division 22 Section 22 0523 "General-Duty Valves for Plumbing Piping."

B. Shutoff Valves: Install shutoff valve on each sump pump discharge.
   1. Install gate or full-port ball valve for piping NPS 2 and smaller.
   2. Install gate valve for piping NPS 2-1/2 and larger.

C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sump pump discharge.

D. Backwater Valves: Install backwater valves in piping subject to backflow.
   1. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.
   2. Install backwater valves in accessible locations.
   3. Backwater valve are specified in Division 22 Section 22 1423 "Storm Drainage Piping Specialties."

3.5 HANGER AND SUPPORT INSTALLATION

A. Seismic-restraint devices are specified in Division 22 Section 22 0548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Pipe hangers and supports are specified in Division 22 Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment." Install the following:
   1. Vertical Piping: MSS Type 8 or Type 42, clamps.
   2. Individual, Straight, Horizontal Piping Runs: According to the following:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.
   3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install supports according to Division 22 Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
   2. NPS 3: 60 inches with 1/2-inch rod.
   3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
   4. NPS 6: 60 inches with 3/4-inch rod.
   5. NPS 8 to NPS 12: 60 inches with 7/8-inch rod.
   6. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.

G. Install supports for vertical cast-iron soil piping every 15 feet.

H. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4: 84 inches with 3/8-inch rod.
   2. NPS 1-1/2: 108 inches with 3/8-inch rod.
   3. NPS 2: 10 feet with 3/8-inch rod.
   4. NPS 2-1/2: 11 feet with 1/2-inch rod.
   5. NPS 3: 12 feet with 1/2-inch rod.
   6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
   7. NPS 6: 12 feet with 3/4-inch rod.
   8. NPS 8 to NPS 12: 12 feet with 7/8-inch rod.

I. Install supports for vertical steel piping every 15 feet.

J. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

C. Connect force-main piping to the following:
1. Storm Sewer: To exterior force main or storm manhole.

3.7 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Test Procedure: Test storm drainage piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
5. Prepare reports for tests and required corrective action.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
4. Prepare reports for tests and required corrective action.

3.8 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

END OF SECTION 22 1413

SECTION 22 3400

DOMESTIC HOT WATER STORAGE TANK AND ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Division 221124, Domestic Water Packaged Booster Pumps.

1.2 SUMMARY

A. This Section includes the following fuel-fired water heaters:
  1. Commercial, high-efficiency, gas water heaters.
  2. Water heater accessories.

1.3 SUBMITTALS

A. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. LEED Submittal:
  1. Product Data for Prerequisite EA 2: Documentation indicating that units comply with ASHRAE/IESNA 90.1-2004, Section 7 – "Service Water Heating."

C. Shop Drawings: Diagram power, signal, and control wiring.

D. Product Certificates: For each type of commercial tank, signed by product manufacturer.

E. Manufacturer Seismic Qualification Certification: Submit certification that commercial water heaters, accessories, and components will withstand seismic forces defined in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment." Include the following:
  1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
     a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
  2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Source quality-control test reports.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For water heaters to include in emergency, operation, and maintenance manuals.

I. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain same type of water heaters through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of water heaters and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. ASHRAE/IESNA 90.1-2004Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004.

E. ASME Compliance:
   1. Where ASME-code construction is indicated, fabricate and label commercial water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
   2. Where ASME-code construction is indicated, fabricate and label commercial, finned-tube water heaters to comply with ASME Boiler and Pressure Vessel Code: Section IV.

F. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9" for all components that will be in contact with potable water.

1.5 COORDINATION

A. Coordinate size and location of concrete bases with Architectural and Structural Drawings.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-fired water heaters that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Structural failures including storage tank and supports.
      b. Faulty operation of controls.
      c. Deterioration of metals, metal finishes, and other materials beyond normal use.
   2. Warranty Period(s): From date of Substantial Completion:
      a. Commercial high efficiency water heater.
         1) Storage tank: 10 years.
         2) Controls and components: 3 years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
   2. See schedule on plans.

B. Commercial, High-Efficiency, Gas Water Heaters: Comply with ANSI Z21.10.3/CSA 4.3.
   1. Basis of Design Product: Subject to compliance with requirements. Provide A.O. Smith Cyclone, or a comparable product by one of the following:
      a. A. O. Smith, Water Products Company, BTH-500.
      b. Lochinvar SNA-500-125.
      c. PVI-800-N125
   2. Description: Manufacturer's proprietary design to provide at least **95** percent combustion efficiency at optimum operating conditions. Following features and attributes may be modified or omitted if water heater otherwise complies with requirements for performance.
   3. Storage-Tank Construction: ASME-code steel with 150-psig minimum working-pressure rating.
      a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
         1) NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
         2) NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
      b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
   4. Factory-Installed, Storage-Tank Appurtenances:
      a. Dip Tube: Provide unless cold-water inlet is near bottom of tank.
      b. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
      c. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
      d. Jacket: Steel with enameled finish.
      e. Combination Temperature and Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
   5. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for high-efficiency water heaters and for natural-gas fuel.
   6. Temperature Control: Adjustable thermostat.
   7. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
   8. Capacity and Characteristics:
      a. See Schedule on drawings.
      b. Electrical Characteristics:
         1) Volts: 120.
         2) Phase: Single.
         3) Hertz: 60.

2.2 WATER HEATER ACCESSORIES

A. Gas Shutoff Valves: ANSI Z21.15/CGA 9.1, manually operated. Furnish for installation in piping.

B. Gas Automatic Valves: ANSI Z21.21, appliance, electrically operated, on-off automatic valve.

C. Combination Temperature and Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select each relief valve with sensing element that extends into storage tank.
   1. Gas Water Heaters: ANSI Z21.22/CSA 4.4.
   2. Relief valves shall be equal to Watts.
      a. No. 40XL-7 1,000,000 BTU/hr.

D. Pressure Relief Valves: Include pressure setting less than working-pressure rating of water heater.
   1. Gas Water Heaters: ANSI Z21.22/CSA 4.4.
   2. ASME adjusted bronze body diaphragm pressure type with test lever, equal to Watts No. 174A.

E. Water Heater Mounting Brackets: Water heater manufacturer's factory-fabricated steel bracket for wall mounting and capable of supporting water heater and water.

F. Piping Manifold Kits: Water heater manufacturer's factory-fabricated inlet and outlet piping arrangement for multiple-unit installation. Include piping and valves for field assembly that is capable of isolating each water heater and of providing balanced flow through each water heater.

G. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1-2004 or ASHRAE 90.2-2004.

H. Combination Temperature and Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select each relief valve with sensing element that extends into storage tank.

I. Pressure Relief Valves: Include pressure setting less than working-pressure rating of water heater.

J. Tank Support: Manufacturer's factory-fabricated steel stand for floor mounting and capable of supporting water tank and water. Provide dimension that will support bottom of water heater a minimum of 18 inches above the floor. Provide seismic support.

K. Water Tank Mounting Brackets: Water tank Manufacturer's factory-fabricated steel bracket for wall mounting and capable of supporting water tank and water.

L. Piping Manifold Kits: Water tank Manufacturer's factory-fabricated inlet and outlet piping arrangement for multiple-unit installation. Include piping and valves for field assembly that is capable of isolating each water heater and of providing balanced flow through each water tank.

M. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1-2004 or ASHRAE 90.2-2004.

2.3 SOURCE QUALITY CONTROL

A. Test and inspect water storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test commercial water storage tanks before shipment to minimum of one and one-half times pressure rating.

C. Prepare test reports.

PART 3 - EXECUTION

3.1 WATER HEATER INSTALLATION

A. Install commercial water heaters and tank on concrete bases.
   1. Exception: Omit concrete bases for commercial water tank if installation on stand, bracket, suspended platform, or direct on floor is indicated.
   2. Concrete base construction requirements are specified in Division 22 Section 22 0500 "Common Work Results for Plumbing."

B. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain Manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
   1. Verify that the individual sections can fit though the access path and not exceed the floor and elevator load limitations.

C. Install seismic restraints for commercial water tanks. Anchor to substrate.

D. Install gas water heaters according to NFPA 54.

E. Install gas shutoff valves on gas supplies to gas water heaters without shutoff valves.

F. Install automatic gas valves on gas supplies to gas water heaters, if required for operation of safety control.

G. Install combination temperature and pressure relief valves in top portion of storage tanks, and at outlet of each tempering valve, at inlet to each hot water return pump, and as noted. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-tank, relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

H. Install water heater and tank drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water tank that do not have tank drains. Refer to Division 22 Section "Domestic Water Piping Specialties" for hose-end drain valves.

I. Install thermometer on outlet piping of water tanks. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

J. Install combination temperature and pressure relief valves in top portion of storage tanks, and at outlet of each tempering valve, at inlet to each hot water return pump, and as noted. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater, relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

K. Install water heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Division 22 Section "Domestic Water Piping Specialties" for hose-end drain valves.

L. Install thermometer on outlet piping of water heaters. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

M. Assemble and install inlet and outlet piping manifold kits for multiple water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each water heater. Include shutoff valve and thermometer in each water heater inlet and outlet, and throttling valve in each water heater outlet. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves and to Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

N. Install piping-type heat traps on inlet and outlet piping of water heater storage tanks without integral or fitting-type heat traps.

O. Fill water heater with water.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to water tanks to allow service and maintenance. Arrange piping for easy removal of water heaters.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
   1. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, confirm proper operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial water tanks. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 22 3400

SECTION 22 4000

PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 WORK IN THIS SECTION

A. Work in this Section includes the providing of labor, materials, equipment and services necessary for a complete and safe installation in accordance with the contract documents and all applicable codes and authorities having jurisdiction for the following:

1. Plumbing fixtures and trim, faucets, other fittings and related components.

1.3 SUMMARY

A. This Section includes the following conventional plumbing fixtures and related components:
1. Faucets for lavatories, sinks.
2. Flushometers.
3. Toilet seats.
4. Protective shielding guards.
5. Fixture supports.
6. Water closets and accessories.
7. Urinals and accessories.
8. Lavatories and accessories.
9. Mop receptors.
10.

B. Related Sections include the following:

1. Division 10 Section "Toilet, Bath, and Laundry Accessories."
2. Division 22 Section 22 1119 "Domestic Water Piping Specialties" for backflow preventers, floor drains, and specialty fixtures not included in this Section.
3. Division 31 Section 22 1113 "Facility Water Distribution Piping" for exterior plumbing fixtures and hydrants.

1.4 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.

C. Cast Polymer: Cast-filled-polymer-plastic material. This material includes cultured-marble and solid-surface materials.

D. Cultured Marble: Cast-filled-polymer-plastic material with surface coating.

E. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.

F. FRP: Fiberglass-reinforced plastic.

G. PMMA: Polymethyl methacrylate (acrylic) plastic.

H. PVC: Polyvinyl chloride plastic.

I. Solid Surface: Nonporous, homogeneous, cast-polymer-plastic material with heat-, impact-, scratch-, and stain-resistance qualities.

1.5 SUBMITTALS

A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Operation and Maintenance Data: For plumbing fixtures to include in emergency, operation, and maintenance manuals.

D. Warranty: Special warranty specified in this Section.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.
   1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90 480, "Architectural Barriers Act"; and Public Law 101 336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities; A117.1, "Specifications for making buildings and facilities accessible to and usable by physically handicapped people".

D. Regulatory Requirements: Comply with requirements in Public Law 102 486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.

E. NSF Standard: Comply with NSF 61, "Drinking Water System Components - Health Effects," for fixture materials that will be in contact with potable water.

F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

G. Comply with the following applicable standards and other requirements specified for plumbing fixtures:
1. Enameled, Cast Iron Fixtures: ASME A112.19.1M.
2. Porcelain Enameled, Formed Steel Fixtures: ASME A112.19.4M.
3. Slip Resistant Bathing Surfaces: ASTM F 462.
4. Solid Surface Material Lavatories and Sinks: ANSI/ICPA SS 1.
5. Stainless Steel Commercial, Handwash Sinks: NSF 2 construction.
6. Stainless Steel Residential Sinks: ASME A112.19.3.
7. Vitreous China Fixtures: ASME A112.19.2M.
8. Water Closet, Flush Valve, Tank Trim: ASME A112.19.5.
9. Water Closet, Flushometer Tank Trim: ASSE 1037.

H. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:
1. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
2. Backflow Protection Devices for Faucets with Hose Thread Outlet: ASME A112.18.3M.
3. Diverter Valves for Faucets with Hose Spray: ASSE 1025.
4. Faucets: ASME A112.18.1.
5. Hose Connection Vacuum Breakers: ASSE 1011.
6. Hose Coupling Threads: ASME B1.20.7.
7. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
8. NSF Potable Water Materials: NSF 61.
9. Pipe Threads: ASME B1.20.1.
10. Sensor Actuated Faucets and Electrical Devices: UL 1951.
11. Supply Fittings: ASME A112.18.1.
12. Brass Waste Fittings: ASME A112.18.2.

I. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:
1. Atmospheric Vacuum Breakers: ASSE 1001.
2. Brass and Copper Supplies: ASME A112.18.1.
3. Manual Operation Flushometers: ASSE 1037.
4. Brass Waste Fittings: ASME A112.18.2.
5. Sensor Operation Flushometers: ASSE 1037 and UL 1951.

J. Comply with the following applicable standards and other requirements specified for miscellaneous components:
1. Flexible Water Connectors: ASME A112.18.6.
2. Floor Drains: ASME A112.6.3.
3. Grab Bars: ASTM F 446.
4. Hose Coupling Threads: ASME B1.20.7.
5. Off Floor Fixture Supports: ASME A112.6.1M.
6. Pipe Threads: ASME B1.20.1.
7. Plastic Toilet Seats: ANSI Z124.5.
8. Supply and Drain Protective Shielding Guards: ICC A117.

1.7 WARRANTY

A. Special Warranties: Manufacturer's standard form in which manufacturer agrees to repair or replace components of whirlpools that fail in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
    a. Structural failures of unit shell.
    b. Faulty operation of controls, blowers, pumps, heaters, and timers.
    c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Period for Commercial Applications: Three year(s) from date of Substantial Completion.
3. Warranty Period for Residential Applications of Shells: Five years from date of Substantial Completion.
4. Warranty Period for Residential Applications of Electronic Controls: Five years from date of Substantial Completion.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Faucet Washers and O Rings: Equal to 10 percent of amount of each type and size installed.
   2. Faucet Cartridges and O Rings: Equal to 5 percent of amount of each type and size installed.
   3. Flushometer Valve, Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than 12 of each type.
   4. Provide hinged top wood or metal box, or individual metal boxes, with separate compartments for each type and size of extra materials listed above.
   5. Flushometer Tank, Repair Kits: Equal to 5 percent of amount of each type installed, but no fewer than 2 of each type.
   6. Water Closet Tank, Repair Kits: Equal to 5 percent of amount of each type installed.
   7. Toilet Seats: Equal to 5 percent of amount of each type installed.

PART 2 - PRODUCTS

2.1 LAVATORY FAUCETS

A. Basis of Design Product: Subject to compliance with requirements, provide product by one of the following:
   1. American Standard Companies, Inc.
   2. Bradley Corporation.
   3. Chicago Faucets.
   4. Delta Faucet Company.
   5. Grohe America, Inc.
   6. Kohler Co.

B. Description: Single control mixing valve. Include hot and cold water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
   1. Body Material: Commercial, solid brass.
   2. Finish: Polished chrome plate.
   3. Maximum Flow Rate: 0.5 gpm.
   4. Inlet(s): NPS 3/8 tubing, with NPS 1/2 male adaptor.
   5. Spout: Rigid type.
   6. Spout Outlet: Spray, 0.5 gpm.
   7. Operation: Sensor.
   8. Drain: Grid.
   9. Tempering Device: Thermostatic.

C. Type L Faucets: Refer to drawings.

D. Lavatory Supply Stops:
   1. 3/8 inch lockshield angle type stops with slow compression cartridge and loose key, equal to Chicago Faucets No 1005 CP, except as noted.

2.2 SINK FAUCETS

A. Sink Faucets (Refer to Drawings):
   1. Basis of Design Product: Subject to compliance with requirements, provide product by one of the following:
      a. American Standard Companies, Inc.
      b. Chicago Faucets.
      c. Kohler Co.
      d. Speakman Company.
      e. T & S Brass and Bronze Works, Inc.

B. Mop Sink (Refer to Drawings):
   1. Wall mounted combination faucet with integral stops, wall brace, pail hook, 3/4 inch hose thread end, and vacuum breaker, equal to Speakman No. SC 5811 RCP modified with 30 inch plain end rubber hose with wall bracket.

2.3 FLUSHOMETERS

A. Flushometers (Refer to Drawings):
   1. Basis of Design Product: Subject to compliance with requirements, provide product by one of the following:
      a. American Standard.
      b. Kohler.
      c. Sloan Valve Company.
      d. Zurn Plumbing Products Group; Commercial Brass Operation.
   2. Description: Flushometer for water closet type fixture. Include brass body with corrosion resistant internal components, non hold open feature, control stop with check valve, vacuum breaker, copper or brass tubing, and polished chrome plated finish on exposed parts.
      a. Internal Design: Diaphragm operation.
      b. Style: Exposed.
      c. Inlet Size: NPS 1.
      d. Trip Mechanism: Battery operated sensor actuator.
      e. Consumption: 3.0 gal./flush.
      f. Tailpiece Size: NPS 1 1/2 and standard length to top of bowl.

2.4 TOILET SEATS

A. Toilet Seats, <**Insert drawing designation**>:

   1. Basis-of-Design Product: Subject to compliance with requirements, provide <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:

      a. American Standard Companies, Inc.
      b. Beneke.
      c. Church Seats.
      d. Eljer.
      e. Kohler Co.
      f. Olsonite Corp.
      g. Beneke.
      h. Church Seats.
      i. Kohler Co.
      j. Olsonite Corp.

2. Description: Toilet seat for water-closet-type fixture.
    a. Material: Molded, solid plastic with antimicrobial agent.
    b. Configuration: Open front without cover.
    c. Size: Elongated.
    d. Hinge Type: CK, check, SS, self sustaining.
    e. Class: Heavy duty commercial.
    f. Color: White.

B. White heavy solid plastic White heavy solid plastic elongated type seats with integral molded brass or stainless steel check hinges, equal to Olsonite No. 1050CC open front and back, Olsonite No. 10CC open front. For Baby bowl, provide Olsonite No. 126CC.

C. Provide seats with covers, for rooms with bathtubs or showers, equal to Olsonite No. 46.

2.5 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:
1. Basis of Design Product: Subject to compliance with requirements, provide product by one of the following:
    a. Engineered Brass Co.
    b. Insul Tect Products Co.; a Subsidiary of MVG Molded Products.
    c. McGuire Manufacturing Co., Inc.
    d. Plumberex Specialty Products Inc.
    e. TCI Products.
    f. TRUEBRO, Inc.
    g. Zurn Plumbing Products Group; Tubular Brass Plumbing Products Operation.
2. Description: Manufactured plastic wraps for covering plumbing fixture hot water supply and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

B. Protective Shielding Piping Enclosures,:
1. Basis of Design Product: Subject to compliance with requirements, or a comparable product by one of the following:
    a. TRUEBRO, Inc.
2. Description: Manufactured plastic enclosure for covering plumbing fixture hot and cold water supplies and trap and drain piping. Comply with ADA requirements.
3. Description: Manufactured plastic enclosure for covering plumbing fixture hot and cold water supplies and trap and drain piping. Comply with ADA requirements.
    a. Elkay.

2.6 FIXTURE SUPPORTS

A. Basis of Design Product: Subject to compliance with requirements, provide by one of the following:
1. Josam Company.
2. MIFAB Manufacturing Inc.
3. Smith, Jay R. Mfg. Co.
4. Tyler Pipe; Wade Div.
5. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.
6. Zurn Plumbing Products Group; Specification Drainage Operation.

B. Water Closet Supports:
1. Description: Combination carrier designed for accessible mounting height of wall mounting, water closet type fixture. Include single or double, vertical or horizontal, hub and spigot or hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and

fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

2. Concealed adjustable extra heavy cast iron combination drainage fitting and chair carriers with an adjustable base anchored to slab using all base support holes, rear anchor foot assembly for stud walls, adjustable cast iron outlet nipple and/or coupling, neoprene gasket and steel supporting bolts with chrome plated washers and cap nuts, equal to Smith Series No. 100, No. 200, No. 400, or No. 500 for siphon jet.
   a. For blowout, use Smith Series No. 300, or No. 400.
   b. For residential, use Smith Series No. 500.
3. Set bowls for physically handicapped with top of seat 17 to 19 inches above floor and provide carrier, equal to Smith No. 600. For blowout, use Smith No. 620.

C. Urinal Supports:
1. Description: Type I, urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture for wall mounting, urinal type fixture. Include steel uprights with feet.
2. Accessible Fixture Support: Include rectangular steel uprights.
3. Concealed adjustable iron chair carrier with bearing plate and steel supporting bolts. For block walls, equal to Smith No. 637. For stud walls, equal to Smith No. 637 M31 with 3 inch x 1 inch rectangular uprights welded to base.
4. Type: On stud walls, concealed adjustable iron chair carrier, equal to Smith No. 635 M31 with 3 inch x 1 inch rectangular uprights welded to base, a plate for through bolts and steel supporting bolts with chrome plated washers and cap nuts.

D. Lavatory Supports:
1. Description: Type II, lavatory carrier with concealed arms and tie rod for wall mounting, lavatory type fixture. Include steel uprights with feet.
2. Accessible Fixture Support: Include rectangular steel uprights.
3. For Type lavatory, adjustable iron concealed arm wall carriers, chrome plated cast brass threaded escutcheons for slab type lavatories, mounted on block walls, equal to Smith No. 720 E (slab type), No. 720 (splash type).
4. For Type lavatory, concealed adjustable iron uprights with concealed arm chair carriers, chrome plated cast brass threaded escutcheons for slab type lavatories.
   a. For stud walls, supports equal to Smith No. 700 E M31 700 M31 with 3 inch x 1 inch rectangular uprights welded to base.
5. For Type wheel chair lavatory, concealed adjustable iron uprights with concealed arm chair carriers. For block walls, equal to Smith No. 700 27. For stud walls, provide units equal to Smith No. 700 27 M31 with 3 inch x 1 inch rectangular uprights welded to base.
6. 18 inch x 4 inch steel support plate on chair carrier leg and through bolts with chrome plated washers and cap nuts, equal to Smith No. KW to support mixing valve.
7. Fasten mixing valve support bracket with through bolts, and chrome plated washers and cap nuts to 18 inch x 4 inch built in steel backing plate, equal to Smith No. 825 modified (tile walls), No. 826 modified.
8. 18-inch x 4-inch steel support plate on chair carrier leg and through bolts with chrome plated washers and cap nuts, equal to Smith No. KW to support mixing valve.
9. Fasten mixing valve support bracket with through bolts, and chrome plated washers and cap nuts to 18-inch x 4-inch built-in steel backing plate, equal to Smith No. 825 modified (tile walls), No. 826 modified.

2.7 WATER CLOSETS

A. Fixtures, Basis of Design Product: Subject to compliance with requirements, provide American Standard Companies, Inc. or a comparable product by one of the following:
1. American Standard Companies, Inc.
2. Crane Plumbing, L.L.C./Fiat Products.

3. Delta Faucet Company.
4. Eljer.
5. Kohler Co. Kingston.
6. TOTO USA, Inc.
7. Zurn Plumbing Products Group, Commercial Brass Operation.
    a. Type WCE & HWCE (Refer to Drawings):

2.8 URINALS

A. Urinals, High Efficiency (Refer to Drawings):
   1. Description: Wall mounted back outlet, vitreous china fixture designed for 1/8th gallon per flush flushometer valve operation.
      a. Type: Washout flushing action.
      b. Strainer: Vandal resistant outlet strainer.
      c. Design Consumption: 1/8 gal/flush.
      d. Color: White.
      e. Supply Spud Size: NPS ¾.
      f. Outlet Size: NPS 2.
      g. Flushometer: Handicapped accessible when installed 17" from finished floor.
      h. Color: [**White**] <**Insert color**>.
      i. Drain: Separate removable dome strainer.
      j. Design Consumption: [**Not applicable**] <**Insert rate**>.
      k. Supply: NPS 1/2.
      l. Outlet Size: NPS 1-1/2.
      m. Drain Piping: NPS 1-1/2 chrome-plated, cast-brass P-trap; 0.045-inch-thick tubular brass waste to wall; and wall escutcheon.
      n. Flushing Device: Fixture manufacturer's standard, with washdown pipe, matching fixture.
      o. Fixture Support: Sink <**Insert designation**> chair carrier.

2.9 LAVATORIES

A. Fixtures, Basis of Design Product: Subject to compliance with requirements, provide American Standard Companies, Inc. or a comparable product by one of the following:
   1. American Standard Companies, Inc.
   2. Crane Plumbing, L.L.C./Fiat Products.
   3. Eljer Co.
   4. Kohler Co.
   5. TOTO USA, Inc.
   6. Zurn Plumbing Products Group; Commercial Brass Operation
   7. (Refer to Drawings)

B. Lavatories for the handicapped: Traps, supplies and straight stops run close to wall to clear knees. Provide offset grid drain with 1 1/4 inch tail piece. Insulate hot water and trap if more than six inches from wall. Provide protective Shielding Guard(s) for ADA Fixtures where none exists and as required.
   1. TOTO USA
   2. Brasscraft.
   3. Chicago Faucet Co.
   4. Eljer Co.
   5. Jameco.
   6. Kohler Co.

   7. Basis-of-Design Product: Subject to compliance with requirements, provide <**Insert**
      a. Supplies: NPS 1/2 copper tubing with ball, gate, or globe valves.

1) Dimensions: <**Insert dimensions.**>

b. Avonite, Inc.

2.10 TOILET ACCESSORIES

A. By general construction contractor.

2.11 SERVICE SINKS

A. Fixtures, Basis of Design Product: Subject to compliance with requirements, provide Fiat Products, Inc. or a comparable product by one of the following:
1. Acorn Engineering Company.
2. Crane Plumbing, LLC/Fiat Products.
3. Florestone Products Co., Inc.
4. Kohler Co.
5. Stern Williams Co.
6. (Refer to Drawings)

B. Faucets, Basis of Design Product: Subject to compliance with requirements, provide Speakman or a comparable product by one of the following:
1. Chicago Faucet Co.
2. T & S Brass and Bronze Works, Inc.
3. Zurn Plumbing Products Group.
4. (Refer to Drawings)

C. Waste outlets:
1. Type MS
a. Description: Three (3) inch waste outlet with removable stainless steel grid strainer plate.

2.12 FIXTURE CONNECTION SCHEDULE

A. Sizes of branch piping shall be not less than listed below. Actual connection sizes shall be as required by connection on fixtures.

B. Water closets: Drain: 4 inch, vent: 2 inch, CW: 1 inch.

C. Urinals: Drain: 2 inch, vent: 1½ inch, CW: ¾ inch.

D. Lavatories: Drain: 1½ inch, vent: 1½ inch, CW: 3/8 inch, HW: 3/8 inch.

E. Service sinks: Drain: 3 inch, vent: 1½ inch, CW: ½ inch, HW: ½ inch.

F. Mop receptors: Drain: 3 inch, vent: 1½ inch, Underground: 2 inch, CW: 3/4 inch, HW: 3/4

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.

B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. Install off floor supports, affixed to building substrate, for wall mounting fixtures.
   1. Use carrier supports with waste fitting and seal for back outlet fixtures.
   2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
   3. Use chair type carrier supports with rectangular steel uprights for accessible fixtures.
   4. Lag fixture carrier base plates or feet to slab with lead expansion shields and insert bolts in all bolt holes.
   5. Where wall hung water closets are supported adjacent to stud walls, provide rear anchor foot assembly bolted to slab.

C. Install back outlet, wall mounting fixtures onto waste fitting seals and attach to supports.

D. Install floor mounting fixtures on closet flanges or other attachments to piping or building substrate.

E. Install wall mounting fixtures with tubular waste piping attached to supports.

F. Install floor mounting, back outlet water closets attached to building floor substrate and wall bracket and onto waste fitting seals.

G. Install counter mounting fixtures in and attached to casework.

H. Install fixtures level and plumb according to roughing in drawings.

I. Install water supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
   1. Exception: Use ball, gate, or globe valves if supply stops are not specified with fixture. Valves are specified in Division 22 Section "General Duty Valves for Plumbing Piping."

J. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

K. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

L. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.

M. Install tanks for accessible, tank type water closets with lever handle mounted on wide side of compartment.

N. Install toilet seats on water closets.

O. Install faucet spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

P. Install water supply flow control fittings with specified flow rates in fixture supplies at stop valves.

Q. Install faucet flow control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

R. Install traps on fixture outlets.
   1. Exception: Omit trap on fixtures with integral traps.
   2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

S. Install disposer in outlet of each sink indicated to have disposer. Install switch where indicated or in wall adjacent to sink if location is not indicated.

T. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 Section "Common Work Results for Plumbing."

U. Seal joints between fixtures and walls, floors, and countertops using sanitary type, one part, mildew resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.

B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.

D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

E. Install fresh batteries in sensor-operated mechanisms.

3.5 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.

C. Replace washers and seals of leaking and dripping faucets and stops.

D. Install fresh batteries in sensor operated mechanisms.

3.6 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:

1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
2. Remove sediment and debris from drains.

B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.7 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 4000

SECTION 22 7000

NATURAL FUEL GAS SYSTEMS - PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Valves.
5. Pressure regulators.
6. Gas meters.
7. Dielectric fittings.
8. Sleeves.
9. Mechanical sleeves.
10. Escutcheons.
11. Pressure gauges.
12. Low pressure switches.
13. Labeling and identification.
14. Grout.
15. Electronic Natural Gas Leak Detection Equipment.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

1.4 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:
1. Piping and Valves: 125 psig minimum unless otherwise indicated.
2. Service Regulators: 125 psig minimum unless otherwise indicated.
3. Minimum Operating Pressure of Service Meter: 125 psig.

B. Natural-Gas System Pressure within Buildings:

1. Welded medium pressure piping and valves at 5 psig.

2. Threaded low pressure piping and valves at 7 to 14 inches water column.

1.5 SUBMITTALS

A. Shop Drawings Provide product data for each type of the following:
1. Piping
2. Fittings
3. Joints.
4. Piping specialties
5. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
6. Pressure regulators. Indicate pressure ratings and capacities.
7. Service meters including supports
8. Dielectric fittings.
9. Mechanical sleeve seals.
10. Escutcheons.
11. Supports

B. Seismic-Design Submittal: Provide for natural-gas piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
1. Detail fabrication and assembly of seismic restraints.
2. Design Calculations: Calculate requirements for selecting seismic restraints.

C. Coordination Drawings: Plans and details, drawn to 3/8 scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.

D. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.

E. Qualification Data: For qualified professional engineer.

F. Welding certificates.

G. Field quality-control reports.

H. Operation and Maintenance Data: For gas valves pressure regulators and service meters to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Refer to section 22 0500.

B. Reference Standards:
1. NFPA No. 54 National Fuel Gas Code – latest edition.
2. California Plumbing Code 2010.
3. Published Specifications' standards, tests or recommended methods of trade, industry or governmental organizations.
4. Compressed Gas Association (CGA).

5. Underwriters Laboratory.
6. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
7. Pipe Welding Qualifications: Qualify procedures and operators according to ASME IX Boiler and Pressure Vessel Code 1980.
8. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

1.8 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

1.9 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Division 08 Section "Access Doors and Frames."

C. Provide valved gas piping for heating, ventilating and air conditioning equipment to within ten (10) feet of equipment connections.

D. Provide sub-meters with remote metering to the Building Management System.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Exterior wall sleeves:
1. Innerlinks.
2. Thunderline.

B. Steel pipe and fittings:
1. Crane Co.
2. National Tube Co.
3. Republic Steel Co.
4. Allied Steel.

C. Fittings:
1. Crane Co.
2. Tube Turn.

3. Walworth.
4. Allied Steel.

D. Gas vent terminals:
1. Acme Scales Co., Inc.
2. Richards Manufacturing.
3. UPSCo., Inc.

E. Hangers and supports:
1. Anvil International.
2. Michigan Hanger (Erico).
3. PSI Corp.
4. B-Line.
5. Carpenter & Patterson, Inc.

F. Paint:
1. Sherwin Williams.
2. Pittsburgh Plate Glass Co.
3. Pratt & Lambert.

G. Valves:
1. Plug Valves, (Gas Cocks):
a. Conbraco Industries.
b. A.Y. McDonald Mfg. Co.
c. Crane Co.
d. DeZurik Healy Co.
e. Nordstrom Valves, Inc.
f. Walworth Co.

H. Pressure Gauges:
1. Treice Co.
2. U.S. Gage.
3. Weiss.

2.2 PIPING

A. Inside steel piping:
1. For low pressure 0.5 PSIG or less use standard weight black steel pipe with 150 PSIG threaded malleable iron fittings for piping 2 inch and smaller.
2. For low pressure 0.5 PSIG or less use steel welding fittings for piping 2-1/2 inch and larger.
a. All in accordance with ANSI Z223.1 of 1974 (NFPA-54) and Keyspan requirement whichever is more stringent.
3. For pressure (0.5 PSIG to 3 PSIG) use black steel pipe and steel welding fittings for piping 4 in. and larger and threaded for piping under 4 in.
4. For pressure above 3 PSIG, all piping shall be welded.

2.3 GAS VENT TERMINALS

A. ¾ in. and one (1) in. aluminum threaded vent terminal with 16 x 16 mesh 0.018 gauge stainless steel screen.

B. 1¼ in. to 4 in. standard pipe threaded elbow with 12 x 12 mesh stainless steel screen.
1. Equal to Upsco Inc.

C. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
   1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
   2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
   3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
   4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
      a. Material Group: 1.1.
      b. End Connections: Threaded or butt welding to match pipe.
      c. Lapped Face: Not permitted underground.
      d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
      e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.
   5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
      a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.
   6. Mechanical Couplings:
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Dresser Piping Specialties; Division of Dresser, Inc.
         2) Smith-Blair, Inc.
      b. Steel flanges and tube with epoxy finish.
      c. Buna-nitrile seals.
      d. Steel bolts, washers, and nuts.
      e. Coupling shall be capable of joining steel pipe to steel pipe.
      f. Steel body couplings installed underground on pipe shall be factory equipped with anodes.

D. Corrugated, Stainless-Steel Tubing: Comply with ANSI/IAS LC 1.

2.4 PIPING SPECIALTIES

A. Appliance Flexible Connectors:
   1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
   2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
   3. Corrugated stainless-steel tubing with polymer coating.
   4. Operating-Pressure Rating: 0.5 psig.
   5. End Fittings: Zinc-coated steel.
   6. Threaded Ends: Comply with ASME B1.20.1.
   7. Maximum Length: 72 inches.

B. Weatherproof Gas Vent Terminal Caps: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

C. ¾ in. and one (1) in. aluminum threaded vent terminal with 16 x 16 mesh 0.018 gauge stainless steel screen.

D. 1¼ in. to 4 in. standard pipe threaded elbow with 12 x 12 mesh stainless steel screen.
   1. Equal to Upsco Inc.

2.5 PIPE AND TUBING JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural fuel gas.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.6 VALVES

A. Manual Shut-off Valves Inside Building

B. General Requirements for Metallic Valves, NPS 2and Smaller: Comply with ASME B16.33.
1. CWP Rating: 125 psig.
2. Threaded Ends: Comply with ASME B1.20.1.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
4. Tamperproof Feature: Locking feature for valves where required by Con. Ed.
5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.
7. Threaded cast iron body, 125 PSIG wog
   a. Equal to Nordstrom Fig. 114.

C. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.
1. CWP Rating: 125 psig.
2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
3. Tamperproof Feature: Locking feature for valves where required by Con. Ed.
4. Service Mark: Initials "WOG" shall be permanently marked on valve body.
5. 2½ in. to 4-in.: Flanged cast iron body lubricated tapered plug type, 175 PSIG wog.
   a. Equal to Nordstrom Fig. 115.
6. 6 in. and larger: Flanged cast iron body lubricated tapered plug type, 200 PSIG wog, worm gear operated.
   a. Equal to Nordstrom Fig. 165.

D. Provide 2 wrenches for each size used.
1. Attach wrench to each valve.

E. Ball Valves
1. On local branches three inches and smaller, provide threaded three piece full port wafer-type ball valve with bronze body, ball stem, Teflon seats, and level handles, 300 PSIG wog.
   a. Equal to Contromatics No. C-1111-AA.

F. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
1. 2 inch and smaller: Threaded brass ball valves with full port TFE sears and blowout proof stem, 600 psig wog.
   a. Equal to NIBCO N: T-FP-600.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. BrassCraft Manufacturing Company; a Masco company.
   b. Conbraco Industries, Inc.; Apollo Div.
   c. Lyall, R. W. & Company, Inc.
   d. McDonald, A. Y. Mfg. Co.
   e. NIBCO.
   f. Perfection Corporation; a subsidiary of American Meter Company.

3. Body: Bronze, complying with ASTM B 584.
4. Ball: Chrome-plated bronze.
5. Stem: Bronze; blowout proof.
6. Seats: Reinforced TFE; blowout proof.
7. Packing: Threaded-body packnut design with adjustable-stem packing.
8. Ends: Threaded, flared, or socket.
9. CWP Rating: 600 psig.
10. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
11. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

G. Check Valves:
1. Provide bronze body swing disc check valve.
   a. Equal to Eclipse Series 1000.

H. Bronze Plug Valves: MSS SP-78.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hammond
   b. Lee Brass Company.
   c. McDonald, A. Y. Mfg. Co.
   d. NIBCO
2. Body: Bronze, complying with ASTM B 584.
3. Plug: Bronze.
4. Ends: Threaded, socket, or flanged.
5. Operator: Square head or lug type with tamperproof feature where indicated.
6. Pressure Class: 125 psig.
7. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

I. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. McDonald, A. Y. Mfg. Co.
   b. Mueller Co.; Gas Products Div.
   c. Xomox Corporation; a Crane company.
2. Body: Cast iron, complying with ASTM A 126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
6. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig.
9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

J. Cast Lubricated Plug Valves Inside Building:
1. 2-inch and smaller: Cast iron body, threaded, equal to Nordstrom Valves, Inc. Figure 114.
2. 2½ inch to 4-inch: Flanged cast iron body lubricated tapered plug type, 175 PSIG wog, equal to Nordstrom Valves, Inc. Figure 115.
3. 6 inch and larger: Flanged cast iron body lubricated tapered plug type, 200 PSIG wog, worm gear operated, equal to Nordstrom Valves, Inc. Figure 165.
4. Valves 2 ½ inch and larger shall be flanged.

5. Provide 2 wrenches for each size used.
6. Attach wrench to each valve.
7. Gas Cocks:
    a. Gas cocks shall be for use only as manual gas shut-off valves at each piece of gas burning equipment; shall be of the plug type, bronze construction with check, nut and washer bottom and tee handle.
    b. Gas cocks shall be Figure 10596 as manufactured by A.Y. McDonald Mfg. Co., or Series 52 as manufactured by Conbraco Industries, Inc.
    c. Gas cocks shall only be used on piping 1 inch and smaller.

K. Valve Boxes:
1. Cast-iron, two-section box.
2. Top section with cover with "GAS" lettering.
3. Bottom section with base to fit over valve and barrel a minimum of 5 inches in diameter.
4. Adjustable cast-iron extensions of length required for depth of bury.
5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

2.7 EARTHQUAKE VALVES

A. Earthquake Valves: Comply with ASCE 25.
1. Provide Pacific Seismic Products or comparable product by one of the following:
    a. Pacific Seismic Products, Inc.
    b. KOSO valves.
    c. Strand Earthquake valves.
2. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
3. Maximum Operating Pressure:
4. Cast-aluminum body with stainless-steel internal parts.
5. Nitrile-rubber, reset-stem o-ring seal.
6. Valve position, open or closed, indicator.
7. Composition valve seat with clapper held by spring or magnet locking mechanism.
8. Level indicator.
9. End Connections: Threaded for valves NPS ¾ 2 and smaller; flanged for valves NPS 2-1/2 and larger.

2.8 PRESSURE REGULATORS

A. General Requirements:
1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Service Pressure Regulators: Comply with ANSI Z21.80.
1. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following CGA approved products:
    a. Pietro Fiorentini.
    b. Sensus.
    c. American Meter Company.
2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.

6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
11. Maximum Inlet Pressure: 60 psig.

C. Line Pressure Regulators: Comply with ANSI Z21.80.
   1. Provide Eclipse or comparable product by one of the following:
      a. Pietro Fiorentini.
      b. Sensus.
      c. American Meter Company.
   2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
   3. Springs: Zinc-plated steel; interchangeable.
   4. Diaphragm Plate: Zinc-plated steel.
   5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
   6. Orifice: Aluminum; interchangeable.
   7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
   8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
   9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
   10. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
   11. Maximum Inlet Pressure: 1 psig.

D. Appliance Pressure Regulators: Comply with ANSI Z21.18.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Maxitrol Co. or comparable product by one of the following:
      a. Canadian Meter Company Inc.
      b. Eaton Corporation; Controls Div.
      c. Harper Wyman Co.
      d. Maxitrol Company.
      e. SCP, Inc.
   2. Body and Diaphragm Case: Die-cast aluminum.
   3. Springs: Zinc-plated steel; interchangeable.
   4. Diaphragm Plate: Zinc-plated steel.
   5. Seat Disc: Nitrile rubber.
   6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
   7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
   8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
   9. Maximum Inlet Pressure: 5 psig.

2.9 DIELECTRIC FITTINGS

A. Dielectric Unions:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Capitol Manufacturing Company.
      b. Central Plastics Company.
      c. Hart Industries International, Inc.

d. McDonald, A. Y. Mfg. Co.
e. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
f. Wilkins; Zurn Plumbing Products Group.

2. Minimum Operating-Pressure Rating: 150 psig.
3. Combination fitting of copper alloy and ferrous materials.
4. Insulating materials suitable for natural gas.
5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

B. Dielectric Flanges:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Capitol Manufacturing Company.
   b. Central Plastics Company.
   c. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
   d. Wilkins; Zurn Plumbing Products Group.
2. Minimum Operating-Pressure Rating: 150 psig.
3. Combination fitting of copper alloy and ferrous materials.
4. Insulating materials suitable for natural gas.
5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

C. Dielectric-Flange Kits:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Advance Products & Systems, Inc.
   b. Calpico Inc.
   c. Central Plastics Company.
   d. Pipeline Seal and Insulator, Inc.
2. Minimum Operating-Pressure Rating: 150 psig.
3. Companion-flange assembly for field assembly.
4. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or PE bolt sleeves, phenolic washers, and steel backing washers.
5. Insulating materials suitable for natural gas.
6. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

2.10 SLEEVES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

2.11 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
1. Manufacturers: Subject to compliance with requirements, provide a comparable product by one the following:
   a. Link Seal.
   b. Advance Products & Systems, Inc.
   c. Calpico Inc.

d. Metra-flex.
e. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe and sleeve.
3. Pressure Plates: Molded glass reinforced Nylon Polymer.
4. Connecting Bolts and Nuts: Stainless steel with length required to secure pressure plates to sealing elements. Include one nut and bolt for each sealing element.

2.12 MECHANICAL GAS SLEEVES

A. Carbon steel, zinc chromate bolts and nuts with corrosion inhibiting coating.

B. Seal material EPDM, black in color.

C. Pressure pates of reinforced nylon polymer.

D. Equal to Thunderline Link Seal Model 'C'.

2.13 ESCUTCHEONS

A. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to fit around pipe or tube, and OD that completely covers opening.

B. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Escutcheons: With set screw.
   1. Finish: Polished chrome-plated or rough brass.

D. Split-Casting, Cast-Brass Escutcheons: With concealed hinge and set screw.
   1. Finish: Polished chrome-plated or rough brass.

E. One-Piece, Stamped-Steel Escutcheons: With set screw or spring clips and chrome-plated finish.

F. Split-Plate, Stamped-Steel Escutcheons: With concealed hinge, set screw or spring clips, and chrome-plated finish.

G. One-Piece, Floor-Plate Escutcheons: Cast-iron floor plate.

H. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.

2.14 PRESSURE GAUGES

A. 4½ in. diameter, black enamel coated steel case ring with shatterproof glass, ½ in. bronze bellows with brass socket, blow out on back of case, ¼ in. bottom outlet connection, similar to Trerice No. 860 or Weksler Instruments Corp. No. BL14-PWE4-LWXX with 0 to 27 in. of water column dial, brass pressure snubber and brass tee-handle cock.

B. Locate pressure gauges on inlet and outlet of gas booster pressure pump, at farthest point in system and as noted.

2.15 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   1. Characteristics: Post-hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
   2. Design Mix: 5000-psi, 28-day compressive strength.
   3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to NFPA 54 Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with NFPA 54 Fuel Gas Code requirements for prevention of accidental ignition.

3.3 INSTALLATION

A. Install piping free from traps and with drain pocket consisting of nipple and cap at low points for inside building and drip pot for underground piping.

B. Install shut-off valves at connection to each piece of equipment. Provide union or right and left nipple and coupling at equipment side of individual shut-off valve.

C. Install gas meter in a well ventilated and accessible location. Gas meter room (3 hr. rated enclosure) with explosion-proof fixtures.

D. Threaded Joints:
   1. Make-up joints with U.L. listed gas resistant Teflon tape or Teflon paste, suited for gas piping.

E. Provide a two elbow-swing on all branches taken from a riser.

F. Provide valve tags for piping systems indicating the operating system pressure.

G. Color code piping at different pressures within the gas meter room. Paint fifteen (15) to five (5) psi system brown and reduced pressure piping yellow.

H. Welders must be qualified in accordance with either API 1104 or A.S.M.E. IX Boiler and Pressure Vessel Code and as required by local code.

I. Provide sign on the exterior of the gas meter door shall be provided with bold lettering at least 1 in. high and properly spaced with lettering and background in contrasting colors reading "Gas Meter Room - No Storage Permitted."

J. Support horizontal gas piping as follows:
   1. ½ in. - 6 ft. on center.
   2. ¾ in. or 1 in. - 8 ft. on center.
   3. 1¼ in. or larger - 10 ft. on center.
   4. Vertical piping at every floor.

3.4 INDOOR PIPING INSTALLATION

A. Comply with NFPA 54 Fuel Gas Code for installation and purging of natural-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Install escutcheons at penetrations of interior walls, ceilings, and floors.
   1. New Piping:
      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
      b. Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
      c. Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
      d. Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.
      e. Piping in Unfinished Service Spaces: One-piece, cast-brass type with rough-brass finish.
      f. Piping in Equipment Rooms: One-piece, cast-brass type.
      g. Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

L. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

M. Verify final equipment locations for roughing-in.

N. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

O. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
   1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

P. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

Q. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

R. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.
   1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
   2. Prohibited Locations:
      a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
      b. Do not install natural-gas piping in solid walls or partitions.

S. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

T. Connect branch piping from top or side of horizontal piping.

U. Install unions in pipes NPS 2and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

V. Do not use natural-gas piping as grounding electrode.

W. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

X. Install pressure gage upstream and downstream from each line regulator. Pressure gages are specified in Division 23 Section "Meters and Gages for HVAC Piping."

3.5 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

C. Install earthquake valves aboveground in buildings according to listing.

3.6 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:
1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:
1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

G. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

H. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.7 HANGER AND SUPPORT INSTALLATION

A. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

B. Comply with requirements for pipe hangers and supports specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

C. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.
5. NPS 4and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

D. Install hangers for horizontal, corrugated stainless-steel tubing with the following maximum spacing and minimum rod sizes:
1. NPS 3/8: Maximum span, 48 inches; minimum rod size, 3/8 inch
2. NPS 1/2: Maximum span, 72 inches; minimum rod size, 3/8 inch.

3. NPS 3/4 and Larger: Maximum span, 96 inches; minimum rod size, 3/8 inch.

3.8 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.9 LABELING AND IDENTIFYING

A. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment" for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.10 PAINTING

A. Comply with building owner's painting requirements for painting interior and exterior natural-gas piping.

B. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
   1. Latex Over Alkyd Primer System: MPI INT 5.1Q.
      a. Prime Coat: Alkyd anticorrosive metal primer.
      b. Intermediate Coat: Interior latex matching topcoat.
      c. Topcoat: Interior latex flat.
      d. Color: Gray.

C. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
   1. Test, inspect, and purge natural gas according to NFPA 54 and authorities having jurisdiction.
   2. Test for leaks using electronic Gas Detectors.

C. Pressure Tests:
   1. Per local code.

2. Test low pressure systems up to 0.5 PSIG with air at 3 PSIG for a minimum of one hour.
3. Test medium pressure systems up to 3 PSIG with air at 100 PSIG for a minimum of four hours.
4. Test high pressure systems (3 PSIG-15 PSIG) with air at 100 PSIG for a minimum of four hours.

D. Controlled Inspection:
1. Perform radiography test on all welds in gas service and at gas meter and piping where operating pressures exceed 3 PSIG and where required by the local utility company or code. Radiography shall be performed in accordance with API 1104 or A.S.M.E. Section IX Boiler and Pressure Vessel Code and as required by local code.

E. Purge all piping after pressure test and all appliances after piping has been purged.

F. Natural-gas piping will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

3.12 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain earthquake valves.

END OF SECTION 22 7000

SECTION 23 0500

COMMON WORK RESULTS FOR HVAC

1.1 UTILITY CONNECTIONS

A. Arrange for and pay utility costs for work of this Division.

B. Included:
1. Connection to utility company mains.
2. Connection to on-site piping mains.
3. Payment of service charges.
4. Provisions for temporary utilities.
5. (Others as required.)

1.2 JOB CONDITIONS

A. Examine all drawings and specifications in a manner to be fully cognizant of all work required under this Division.

B. Adjoining work of other Divisions shall be examined for interferences and conditions affecting this Division.

C. Examine site related work and surfaces before starting work of any Section.

1. Report to Owner, in writing, conditions which will prevent proper provision of this work.
2. Beginning work of any Section without reporting unsuitable conditions to Owner constitutes acceptance of conditions by Contractor.
3. Perform any required removal, repair or replacement of this work caused by unsuitable conditions at no additional cost to Owner.

D. Connections to existing work.

1. Verification of existing:

   a. Before submitting bid, become thoroughly familiar with actual existing conditions and systems at the building, and of the existing installations to which connections must be made, including any necessary alterations, and existing building engineering practices and requirements. The intent of the work is shown on the drawings and described herein, and no consideration will be granted by reason of lack of familiarity on the part of the contractor with actual physical conditions, requirements, and practices at the site.

2. Install new work and connect to existing work with minimum interference to existing facilities.
3. Temporary shutdowns of existing services:

   a. At no additional charges.
   b. At times not to interfere with normal operation of existing facilities.
   c. Only with written consent of Owner.

4. Maintain continuous operation of existing facilities as required with necessary temporary connections between new and existing work.
5. Restore existing disturbed work to original condition.

E. Removal and relocation of existing work.

1. Disconnect, remove or relocate material, equipment, plumbing fixtures, piping and other work noted and required by removal or changes in existing construction.
2. Where existing pipes, conduits and/or ducts which are to remain prevent installation of new work as indicated, relocate, or arrange for relocation, of existing pipes, conduits and/or ducts.
3. Provide new material and equipment required for relocated equipment.
4. Plug or cap active piping or ductwork behind or below finish.
5. Do not leave long dead-end branches. Cap or plug as close as possible to active line.
6. Remove unused piping, ductwork and material.
7. Dispose of removed fixtures and equipment as directed.
8. Turn over removed fixtures and equipment to Owner as directed.

F. Special Traffic Requirements:

1. Maintain emergency and service entrances useable to pedestrian, truck, and ambulance traffic at all times.
2. Where trenches are cut, provide adequate bridging for above mentioned traffic.
3. (Other paragraphs as required).

G. If asbestos insulation is found when working in existing areas, immediately stop work and notify Owner. Do not restart work until advised in writing by Owner that it is safe to do so following abatement, encapsulation, etc.

1.3 CLEARANCE FROM ELECTRICAL EQUIPMENT

A. Piping or ductwork:

1. Prohibited in:

   a. Electric rooms and closets.
   b. Telephone rooms and closets.
   c. Elevator machine rooms.
   d. Electric switchboard room.

2. Prohibited above an area within 5 ft. of:

   a. Transformers.
   b. Motor control centers.
   c. Standby power plant.
   d. Bus ducts.

1.4 SUBMITTALS

A. Submit the following items as hereinafter specified:

1. Names and qualifications of test and balance agencies.
2. Layout Drawings.
3. Coordinated Drawings.
4. As-built Record Drawings (Submitted to Client).
5. Record Files (Submitted to Client).
6. Operating and Maintenance Manuals.
7. Welding certificates.

8. Equipment and material submittals as required by sections within this division.

B. Items shall comply with the requirements as hereinafter specified.

C. Submit shop drawings, product data, samples and certificates of compliance required by contract documents.

1. See Division 1, Submittals for reference of minimum requirements, if not stated hereinbelow.

D. For all equipment requiring MEA numbers by City of New York, numbers shall be included within the equipment submittals.

E. Schedule of submittals, as agreed to by the Engineer, will set the basis of the minimum required submittals. Submittals shall be provided by the Contractor promptly and in accordance with the Schedule of submittals and in such sequence as to cause no delay in work or in work of any other divisions.

F. Resubmission Requirements:

1. In addition to Division 1 requirements, make any corrections or change in Submittals required. Resubmit for review until no exceptions are taken or a resubmission is not required.
2. Shop Drawings and Product Data:

   a. Revise initial drawings or data, and resubmit as specified for initial submittal.
   b. Indicate any changes which have been made other than those requested.

3. Samples: Submit new samples as required for initial submittal.
4. Clearly identify resubmittal by original submittal date, number and revision number and indicate all changes from previous submittal.
5. If more than two submissions are required (initial submittal and one resubmittal) based on rejection or lack of compliance by submittal, then the Contractor shall:

   a. Arrange for additional reviews by the Design Engineers.
   b. Pay all costs for such additional reviews.

G. Corrections or comments made on the shop drawings during review do not relieve the Contractor from compliance with requirements of the drawings and specifications. Shop drawing checking by the Engineer is only for review of general conformance with the design concept of the project and general compliance with the information given in the contract documents. The Contractor is responsible for:

1. Confirming and correlating all quantities and dimensions.
2. Selecting fabrication processes and techniques of construction.
3. Coordinating his work with that of all other trades.
4. Performing his work in a safe and satisfactory manner.

H. Substitutions:
1. See Division 1, Substitutions.
2. The bid shall include products per paragraph 2.01 MANUFACTURERS. Engineer will consider formal requests for substitution of products in place of those specified only if these are submitted with the bid for evaluation and in accordance with all conditions specified hereafter.
3. Requests for substitutions after award of contract shall be considered only in case of product unavailability. Product unavailability shall be verified in writing by manufacturer.
4. Submit separate request for each substitution at time of bid, or at appropriate time thereafter in the event of non-availability of item included in bid. Support each request with:

a. Complete data substantiating compliance of proposed substitution with requirements stated in Contract documents.
b. Data relating to changes in construction schedule.
c. Any effect of substitution on other Work in this and other Divisions, and any other related contracts, and changes required in other work or products.

5. Contractor shall be responsible at no extra cost to Owner for any changes resulting from proposed substitutions which affect work of other Sections or Divisions, or related contracts.
6. Claims for additional costs caused by substitution which may subsequently become apparent shall be met by the Contractor.
7. Substitutions will not be considered for acceptance when acceptance will require revision of Contract Documents, unless Contractor bears cost of redesign.
8. Where any redesign of electrical, mechanical or other work is required due to substitution, arrangement or equipment layout other than herein specified or shown:

   a. Arrange for required redesign by Engineer.
   b. Pay all costs for such redesign.
   c. Contractor shall perform such redesign.
   d. Produce detailed plans at no extra cost to Owner.
   e. All subject to Owner's approval.

9. Substitute products shall not be ordered or installed without prior written approval/acceptance by Owner.
10. Engineer will have sole discretion to determine acceptability of proposed substitutions and reserves the right to reject any such substitution.
11. Approval of substitutions shall not relieve Contractor from full compliance with requirements of Contract documents.
12. Coordinate with division submittal procedures and substitutions. If necessary, add the following sub-paragraphs:
    a. General Contractor shall request individual layout drawings from mechanical and electrical trades, per Section 23 0500 and Section 26 0500.
    b. Contractor shall assure that each mechanical and electrical trade has coordinated work with other trades. Stamp each layout submittal and sign to certify that these layouts have been coordinated.

I. Layout (Shop) Drawings:

1. Submit Layout Drawings indicating work within mechanical rooms areas containing boilers, chillers, cooling towers, air handlers or pumps, areas containing acoustically lined ductwork, food service areas and for any areas. See Division 1 specification sections for additional requirements on layout drawings.
2. Layout Drawings for mechanical rooms shall be at a scale of 3/8"=1'-0".
3. Prepare layout shop drawings for all areas.
4. From the layout drawings, prepare and submit Coordinated Drawings as herein specified below.

J. Coordinated Drawings:

1. This Contractor shall prepare coordinated drawings which shall show work of all trades including, but not limited to:
   a. Items noted in the Supplemental General conditions.
   b. Coordinated Ductwork with penetrations at floors, walls, ceiling and roof.
   c. Piping, including:

      1) HVAC, plumbing and fire protection.

2) Minor Piping such as drains, air vents, condensate piping, etc.
3) Sleeves and penetrations.
4) Expansion devices, anchors, guides and hangers.

d. Mechanical Equipment.
e. Supports and suspension devices.
f. Ductwork/Piping high points and low points.
g. Electrical Equipment.
h. Main Electrical conduits and bus ducts.
i. Equipment support and suspension devices including hangers, supports and bracing.
j. Structural and architectural constraints including:

1) Beams, braces, trusses, flanges, constraints, walls, openings ratings, doors, wall types, glazing.

k. Show location of:
1) Valves.
2) Chemical Treatment.
3) Piping specialties.
4) Dampers.
5) Access doors.
6) Control and electrical panels.
7) Disconnect switches
8) Others as required.

2. Drawings shall indicate coordination with work in other Divisions which must be incorporated in mechanical spaces, including, but not limited to:

a. Swimming pool equipment and piping.
b. Irrigation equipment and piping.
c. Elevator equipment.
d. Building vacuum cleaning systems.
e. Pneumatic tube system.
f. Cable trays not furnished under Division 26.
g. Computer equipment.
h. (Others as required).

3. Provide sections and elevations for all mechanical rooms, mechanical areas, areas with routed duct mains, areas with routed piping mains, and areas adjacent to the existing structure.
4. Preparation of drawings:

a. Prepare reproducible CADD drawings.
b. Submit to other trades for review of space allocated to all trades.
c. Revise drawings to compensate for requirements of existing conditions and conditions created by other trades.

5. Final prepared drawings shall show that other trades affected have made reviews and signed, by each trade, at completion of coordination.
6. Coordinated shop drawings shall be for all areas.
7. Contractor is to assure that each trade has coordinated work with other trades, prior to submittal.

K. As-built (Record) Drawings:

1. Provide after installation is complete. Final signoff and Owner acceptance will not occur prior to submission of As-built drawings to Owner.

2. Indicate as-built conditions and all revisions that occurred subsequent to "Coordinated Drawings" submittal, fully illustrating all revisions made by all trades in the course of work.
3. Dimension physical locations of ductwork, and piping with reference elevations and distances above finished floors, below beams, from wall faces, underground (invert elevations) and from column lines.
4. Exact location, type and function of concealed valves, dampers, controllers, piping, air vents, piping drains and isolators.
5. Indicate all equipment sizes and capacities and tag numbers.
6. Provide drawing on reproducible CADD mylar.
7. These drawings shall be for as-built record purposes for the Owner's use and are not considered shop drawings.

L. Record Files:

1. Provide 5 (five) electronic file copies of the As-built CADD drawings in the media (CDROM, Disks, Tape, etc.) of Owner's choice.
2. Include hard copy and electronic copy of file naming convention, layering standards, drawing index and file descriptions.
3. Electronic files shall be modifiable and shall include all associated referenced background files.

M. Operating Instructions, Maintenance Manuals and Parts Lists:

1. Before requesting acceptance of work, submit one set for review by Owner.
2. After review, furnish five printed and bound sets.
3. Include:

   a. Manufacturer's name, model number, service manual, spare-parts list, and descriptive literature for all components, cross referenced and numbered on Record Drawings and in accordance with Title 24 as required.
   b. Maintenance instructions.
   c. Listing of possible breakdown and repairs.
   d. Instruction for starting, operation and programming.
   e. Detailed and simplified one line, color coded flow and wiring diagram.
   f. Field test report, including:

      1) Instrument set points.
      2) Normal operating valves.

   g. Name, address and phone number of contractors equipment suppliers and service agencies.
   h. Assemble manufacturer's equipment manuals in chronological order, following the specification alpha-numeric system, in heavy duty 3-ring binders clearly titled on the spine and front cover with appropriate index dividers.

N. Quantity of Submittals Required.

1. Layout (Shop) Drawings and Coordinated Drawings:

   a. Submit two prints.
   b. Upon review, prints and electronic copy will be annotated and returned. Prints will be retained by the Engineer.

2. Product Data (brochures):

   a. Submit two copies of product data.

b. Five copies will be returned.
c. If comments are required, they will be returned with each copy.
d. One copy will be retained by the Engineer.

1.5 RELATED WORK AND REQUIREMENTS

A. Requirements of General Conditions and Division No.1 apply to all work in this division.

B. Carefully check the documents of each section with those of other sections and Divisions. Ascertain the requirements of any interfacing materials or equipment being furnished and/or installed by those sections and Divisions, and provide the proper installation and/or required interface.

C. As a minimum requirement and condition, the Contractor shall provide CADD generated drawings (for the purpose of Layout Drawings, Coordinated Drawings, As-built Drawings and Record Drawings) with a proven layering standard. Deviation from this requirement shall be:

1. At the sole discretion of the Engineer.
2. Submitted as a substitution within the specified time frame.

D. Related work specified elsewhere:

1. Providing temporary heat.
2. Providing finish painting, including pipe stenciling.
3. Access doors.
4. Trench covers and frames.
5. Providing chimney cleanout door and thimble.
6. Cutting and patching, except as noted in "AIA Document A201" and "Supplementary Conditions for Mechanical and Electrical Work.
7. Excavating and backfilling under building.
8. Excavating and backfilling.
9. Louvers in doors.
10. Undercut doors.
11. Wall louvers and screens.
12. Plenums other than sheet metal.
13. Flashing.
14. Shaft gratings.
15. Equipment platforms.
16. Pipe heat tracing system.

1.6 QUALITY ASSURANCE

A. All equipment and accessories to be the product of a manufacturer regularly engaged in its manufacture.

B. Supply all equipment and accessories new and free from defects.

C. Supply all equipment and accessories in compliance with the applicable standards and with all applicable national, state and local codes.

D. All items of a given type shall be the products of the same manufacturer.

E. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

F. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

1.7 REFERENCE STANDARDS

A. Published codes, specifications, standards, tests or recommended methods of trade, industry or governmental organizations apply to work in this Division where cited below:

1. AABC: Associated Air Balance Council.
2. ADC: Air Diffuser Council.
3. AMCA: Air Moving and Conditioning Association.
4. ANSI: American National Standards Institute.
5. ARI: Air-Conditioning and Refrigeration Institute.
6. ASHRAE: American Society of Heating, Refrigerating and Air Conditioning Engineers.
7. ASME: American Society of Mechanical Engineers.
8. ASSE: American Society of Sanitary Engineers.
9. ASTM: American Society for Testing and Materials.
10. AWS: American Welding Standards.
11. FM: Factory Mutual.
12. Local Utility Authorities.
13. National, State and Local Codes of all authorities having jurisdiction.
14. NEMA: National Electrical Manufacturer's Association.
15. NFPA: National Fire Protection Association.
16. OSHA: Occupational Safety and Health Act.
17. PDI: Plumbing and Drainage Institute.
18. State Energy Code having jurisdiction
19. UBC: Uniform Building Code.
20. UL: Underwriters' Laboratories, Inc.
21. UMC: Uniform Mechanical Code.
22. UPC: Uniform Plumbing Code.

B. In addition to complying with all other legal requirements, comply with current provisions of governing codes and regulations in effect during progress of the Work, and with the following:

1. Drawings and specification requirements shall govern where they exceed Code and Regulation requirements.
2. Where requirements between governing Codes and Regulations vary, the more restrictive provisions shall apply.
3. Nothing contained in Contract Documents shall be construed as authority or permission to disregard or violate legal requirements. The Contractor shall immediately draw the attention of the Owner to any such conflicts noted in the Contract Documents.

1.8 DESCRIPTION OF BID DOCUMENTS

A. Specifications:

1. Specifications, in general, describe quality and character of materials and equipment.
2. Specifications are of simplified form and include incomplete sentences.

3. Words or phrases such as "The Contractor shall," "shall be," "furnish," provide," "a," "an," "the," and "all" etc. have been omitted for brevity.

B. Drawings:
1. Drawings in general are diagrammatic and indicate scope, sizes, routing, locations, connections to equipment and methods of installation, but not necessarily offsets, obstructions or structural conditions. Locations on drawings may be distorted for purposes of clearness and legibility.
2. Contractor to provide additional offsets, fittings, hangers, supports, valves, drains as required for construction and coordination with work of other trades.
3. Scaled and figured dimensions are approximate and are for estimating purposes only, but shall be followed with sufficient accuracy to coordinate with other work and structural limitations.
4. Before proceeding with work, check and verify all dimensions and carefully check space requirements with other Work to ensure that all equipment and materials can be installed in spaces allotted.
5. Assume all responsibility for fitting of materials and equipment to other parts of equipment and structure.
6. The Contractor is responsible for installing the work in such a manner that it will conform to the structure and architectural elements, avoid obstructions, maintain headroom, leave adequate clearance for proper maintenance and repairs, and provide clearances and access required by codes.
7. Make adjustments that may be necessary or requested in order to resolve space problems, preserve headroom, and avoid architectural openings, structural members and work of other trades.
8. Above items to be performed at no additional cost to the Owner.

C. If any part of Specifications or Drawings appears unclear or contradictory, consult with Owner and/or Engineer for interpretation and decision as early as possible during bidding period. Do not proceed with such work without Owner's and or Engineer's decision.

D. Typical details, where shown on the drawings, apply to each and every item of the project where such items are applicable. Typical details are not repeated in full on the plans, and are diagrammatic only, but with the intention that such details shall be incorporated in full.

1.9 TEMPORARY FACILITIES

A. See division 1 for temporary facilities required.

1. Temporary water supply for construction per Specifications for Plumbing Work..
2. Temporary toilet facilities:

   a. Provide, where directed by Owner, temporary toilet facilities for use of all workman on project.
   b. Conform to requirements of all authorities having jurisdiction.
   c. Connect water to temporary water lines and drainage to sewer.
   d. Temporary toilets will be maintained by General Contractor who will pay for water consumed.
   e. At completion of job, or when directed by Owner, remove temporary toilet facilities and piping.

1.10 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces.

1.11 SPECIAL TOOLS

A. Furnish to Owner at completion of work:

1. One set of any special tools required to operate, adjust, dismantle or repair equipment furnished under any section of this Division.
2. "Special tools": those not normally found in possession of mechanics or maintenance personnel.
3. One pressure grease gun for each type of grease required.
    a. With adapters to fit all lubricating fittings on equipment.
    b. Include lubricant for lubricated plug valves.
4. Tag each item and cross reference in Maintenance Manual.
5. Turn over to Owner's representative or temporarily secure to unit at Owner's instruction.

1.12 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

C. Check dimensions of access route through the site from delivery point to final location. Where necessary, ship in crated sections of size to permit passing through available space. Dismantle and/or reassemble, reprovision and retest equipment too large to pass through available access route to final location in one piece.

D. Ship equipment in original packages, to prevent damaging or entrance of foreign matter.

E. Handle and ship in accordance with manufacturer's recommendations.

F. Provide protective coverings during construction.

G. Replace at no expense to Owner, equipment or material damaged during storage or handling, as directed by Owner..

H. Tag all items with weatherproof tag, identifying equipment by name and purchase order number.

I. Include packing and shipping lists.

J. Special requirements as specified in individual sections.

1.13 PROTECTION OF MATERIALS

A. Protect from damage, water, dust, etc., material, equipment and apparatus provided under this Division, both in storage and installed, until Notice of Completion has been filed.

B. Provide temporary storage facilities for material and equipment.

C. Arrange with Owner for storage facilities for materials and equipment.

D. Material, equipment or apparatus damaged because of improper storage or protection will be rejected.

1. Remove from site and provide new, duplicate, material equipment or apparatus in replacement of that rejected.

E. Cover motors and other moving machinery to protect from dirt and water during construction.

F. Protect premises and work of other Divisions from damage arising out of installation of work of this Division.

1. Repair or replace, as directed by Owner, materials and parts of premises which become damaged as result of installation of work of this Division.
2. Remove replaced parts from premises.

1.14 REVIEW OF CONSTRUCTION

A. Work may be reviewed at any time by representatives of owner.

B. Advise owner in writing that work is ready for review at following times:
1. Prior to backfilling buried work.
2. Prior to concealment of work in walls and above ceilings.
3. When all requirements of Contract have been completed.

C. Neither backfill nor conceal work without Owner's consent.

1.15 SCHEDULE OF WORK

A. Arrange work to conform to schedule of construction established or required to comply with Contract Documents.

B. In scheduling, anticipate means of installing equipment through available openings in structure.

C. Confirm in writing to Owner, within 30 days of signing of contract, anticipated number of days required to perform test, balance, and acceptance testing of mechanical systems:

1. This phase must occur after completion of mechanical systems, including all control calibration and adjustment, and requires substantial completion of the building, including closure, ceilings, lighting, partitioning, etc.
2. Submit for approval at this time, names and qualifications of test and balancing agencies to be used.

D. Arrange with Owner schedule for work in each area.

E. Unless otherwise directed by Owner perform work during normal working hours.

F. Work delays:

1. In case noisy work interferes with Owner's operations, Owner may require work to be stopped and performed at some other time, or after normal working hours.

2. Submit, with bid proposal, schedule of hourly rates and overtime premiums.

1.16 NOISE REDUCTION

A. Cooperate in reducing objectionable noise or vibration caused by mechanical systems.

1. To extent of adjustments to specified and installed equipment and appurtenances.

B. Correct noise problems caused by failure to install work in accordance with Contract Documents. Include labor and materials required as result of such failure.

1.17 PERMITS, LICENSES, AND INSPECTIONS

A. Permits and Licenses:

1. Secure required permits and licenses including payments of all charges and fees.

B. Inspections:

1. Obtain certificates of final inspection approval from authorities having jurisdiction, and submit to Owner before acceptance of the Work.
2. Obtain inspections during the Work as required to allow timely progress of these and other trades.

1.18 GUARANTEE

A. Guarantee all materials, equipment, apparatus and workmanship to be free of defective materials and faulty workmanship for period of one year from date of filing of Notice of Completion, unless extended guarantee periods are specified in individual sections.

B. Furnish guarantee covering all work in accordance with general requirements of the Contract.

C. Provide new materials, equipment, apparatus and labor to replace that determined by Owner to be defective or faulty.

D. This guarantee also applies to services such as Instructions, Adjusting, Testing, Noise, Balancing, etc.

E. Equipment manufacturers shall include extended warranty to give full coverage during warranty period, unless longer period is specified.

1.19 PRELIMINARY OPERATION

A. Any portion of the system or equipment shall be placed in operation at the request of the Owner prior to the final completion and acceptance of the work. Such operation shall be under the direct supervision of the Contractor.

B. Preliminary operation thereof shall not be construed as acceptance of any part of the Work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Division 23 Sections where articles and subparagraphs introduce lists, the following requirements apply for product selection:

1. Contractor's Options:

   a. For products specified only by reference standard, select product meeting that standard, by any manufacturer.
   b. For products specified by naming several products or manufacturers, select any one of products and manufacturers named which complies with Specifications.
   c. For products specified by naming one product or manufacturer, use that product or manufacturer only.
   d. Wherever catalog numbers and specific brands or trade names are used, they are used to establish standards of quality, utility and appearance required.

B. Submission of equipment of manufacturers' other than those specified shall detail equality and difference, item by item.

2.2 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

2.3 ACCESS DOORS

A. Size for proper access, adjusting and maintenance:

1. 12 in. x 12 in. minimum for valves, trap primers, shock absorbers, etc.
2. 24 in. x 24 in. for man access to concealed fans, coils, etc., unless indicated otherwise.
3. Access door types as appropriate for receiving surface in accordance with Access Doors Section, Division 8.

B. Supply as required by work in this Division.

C. Turn over for setting under trade installing surface on which panels are installed. Direct location and setting, after review by Owner.

D. Manufacturers:

1. Access doors:

   a. Karp Associates, Inc.
   b. Higgins Mfg. Co.
   c. Inryco, Inc.: Milcor.

d. Walsh-Spencer Co.

E. Locate and set after review.

F. Doors in fire-rated construction:

1. Insulated door panel and frame.

   a. Frame: 16 gauge steel.
   b. Panel: 20 gauge steel.
   c. 2 in. thick fire rated insulation.

2. Conform to requirements of regulating agencies.
3. Rating: UL 1 1/2 hour "B" label, 250°F rating.
4. Continuous hinge with stainless steel pin.
5. Automatic panel closer.
6. Interior latch release.
7. Finish:

   a. Self-latching.
   b. Direct action knurled knob.
   c. Flush screwdriver operated.
   d. Key-operated cylinder lock with two keys.
   e. Knurled knob and mortise cylinder. Cylinder replaceable with cylinder for master keying system.
   f. Similar to Karp Type KRP-150 FR.

G. Doors: Shop-painted 1 coat zinc chromate primer.

2.4 ACCESS TILE IDENTIFICATION

A. Buttons, tabs, and markers: to identify location of concealed work.

B. Submit for review.

2.5 MISCELLANEOUS METAL WORK

A. Access Platforms:

1. Under General Construction Work.
2. Provide removable gratings, toeplates and guard rails: suitable for minimum 100 lb per sq.ft. floor loading.
3. Supports:

   a. Welded structural steel.
   b. Cross-braced on 4 sides.
   c. Welded to baseplates for anchor bolting to concrete piers.

4. Provide access platforms for equipment, where indicated or required by authorities having jurisdiction. Submit shop drawings with details of construction and method of attachment.
5. In accordance with OSHA regulations.
6. Grating similar to:

a. Steel: Irving "X-Bar".
b. Aluminum: Irving "X-Bar".
c. Fiberglass: Ryerson Duradek I-5000.

B. Ladders:

1. Under General Construction Work.
2. Under General Construction Work except at Cooling Towers.

   a. See Section 23 6500: Cooling Towers,

3. Galvanized structural steel.
4. 18 in. wide.
5. 2 1/2 in. x 1/2 in. side rails.
6. 3/4 in. diameter rungs 12 in. on center.
7. In accordance with OSHA regulations.

C. Gratings in Shafts:

1. Under General Construction Work.
2. Suitable for minimum 100 lb per sq.ft. floor loading.
3. Support on structural steel members.
4. Submit shop drawings with details of construction and method of attachment.
5. Grating similar to:

   a. Steel: Irving "X-Bar".
   b. Aluminum: Irving "X-Bar".
   c. Fiberglass: Ryerson Duradek I-5000.

D. Trench Covers, or Gratings and Frames:

1. Under General Construction Work.
2. Covers:

   a. Galvanized checkered steel with:
   b. Galvanized expanded and perforated steel with:

      1) Flush drop-type lift handles.
      2) Means for securing to frame for easy removal.

   c. 3 ft. long.
   d. 1/4 in. thick.

3. Gratings: steel similar to Irving Grating.
4. Frames: 2 in. x 2 in. x 1/4 in. galvanized welded angle iron with welded stops and lugs for anchoring into concrete.
5. Turn over for setting under General Construction work.

E. Guards and Railings:

1. Furnish guards and railings as indicated and/or as required by Authorities having jurisdiction.
2. Provide OSHA approved guards for belt drives and rotating equipment.
3. Guards removable with:

   a. Frames: No. 18 USSG steel.

b. Fronts: No. 20 USSG galvanized perforated steel with:

1) Covered test openings to permit rpm readings without removal.

c. Supports: galvanized steel angles or channels, braced to maintain clearances of moving parts.
d. Clearance for motor adjustment.

4. Railings: removable of 1¼ in. pipe and rail fittings.

2.6 PAINTING

A. Manufacturers:

1. Sherwin-Williams.
2. Pittsburgh Plate Glass Co.
3. Pratt and Lambert.
4. Rust-Oleum.

B. Materials:

1. Best grade for its purpose.
2. Deliver in original sealed containers.
3. Apply in accordance with manufacturers instructions.
4. Heat resistant paint for hot piping, equipment and materials.
5. Colors as selected.

PART 3 - EXECUTION

3.1 HVAC DEMOLITION

A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
c. Insulated Piping: One-piece, stamped-steel type with spring clips.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
f. Bare Piping at Ceiling Penetrations in Finished Spaces: [**One-piece**] [**Split-casting**] [**One-piece or split-casting**], cast-brass type with polished chrome-plated finish.
g. Bare Piping at Ceiling Penetrations in Finished Spaces: [**One-piece, stamped-steel type**] [**Split-plate, stamped-steel type with concealed hinge**] [**One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge**] and set screw.
h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with [**polished chrome-plated**] [**rough-brass**] finish.
i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with [**concealed**] [**exposed-rivet**] [**concealed or exposed-rivet**] hinge and [**set screw**] [**spring clips**] [**set screw or spring clips**].
j. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with **set screw**.
l. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

2. Existing Piping: Use the following:

   a. Chrome-Plated Piping: Split-casting, cast-brass type with chrome-plated finish.
   b. Insulated Piping: Split-plate, stamped-steel type with concealed hinge and spring clips.
   c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
   e. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
   f. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
   g. Bare Piping in Unfinished Service Spaces: Split-casting, cast-brass type with [**polished chrome-plated**] [**rough-brass**] finish.
   h. Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with [**concealed**] [**exposed-rivet**] [**concealed or exposed-rivet**] hinge and set screw or spring clips.
   i. Bare Piping in Equipment Rooms: Split-casting, cast-brass type.
   j. Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
   k. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.

M. Sleeves are not required for core-drilled holes.

N. Permanent sleeves are not required for holes formed by removable PE sleeves.

O. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

P. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inchesabove finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide 1/4-inchannular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

   a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
   b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
   c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inchesabove finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.

      1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

Q. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inchannular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inchesin diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inchesand larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

R. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inchannular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

S. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

T. Verify final equipment locations for roughing-in.

U. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.3 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
3. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
4. PVC Nonpressure Piping: Join according to ASTM D 2855.

J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

K. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

L. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

M. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.4 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.

2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

E. Access to Valves and Equipment.

1. Access shall be possible where valves, expansion joints, fire dampers, motors, filters, control devices, and any other equipment requiring access for servicing, repairs, or maintenance are located in walls, chases, and/or above ceilings.
2. Definition of Accessible:

   a. Valves and dampers may be operated.
   b. Control devices may be adjusted.
   c. Fire dampers may be reset.
   d. Equipment access panels may be opened.
   e. Normal maintenance work such as replacement of filters, lubrication of bearings, etc., may be performed readily within arm's reach of access opening.
   f. It shall not be necessary to crawl through furred ceiling space to perform such operations.

3. Group concealed valves, expansion joints, controls, dampers and equipment requiring service access, so as to be freely accessible through access doors and to minimize the number of access doors required.
4. Relocate piping equipment and accessories as required, at no extra cost to afford proper maintenance access.
5. For access into ductwork see Section 23 3300: Air Duct Accessories.
6. Coordinate location of access panels with applicable trades installing walls or ceiling.

   a. Coordinate panel locations with lights and other architectural features.
   b. Submit proposed panel locations to Owner for review.

7. Access doors or panels will be installed by the trade furnishing surface on which panels are installed.
8. Arrange for location and marking of removable tiles in splined ceilings where access panels are not installed.
9. Existing Structures:

   a. When installation requires access openings through existing construction, provide necessary panels, and arrange for respective trades to provide openings and framing which may be required.
   b. Restore adjoining existing surfaces to original condition after new access panels have been installed.

3.6 PAINTING

1. Colors coordinated by Mechanical Contractor as directed by Owner.

B. Painting under this Division:

1. Interior of ductwork as far back as visible from outside: flat black.
2. Uncoated hangers, supports, rods and inserts: dip in zinc chromate primer.
3. Factory prime coat for following except as noted.

a. Pumps.
b. Fans.
c. Motors.
d. Equipment.
e. Chillers
f. Cooling Tower

4. Marred surfaces of prime coated equipment and piping: spot prime coat to match adjacent coat.
5. Shop prime coat for following, except as noted:

a. Structural frames.
b. Platforms.
c. Ladders.
d. Railings.
e. Tanks.

C. General:

1. Labor, materials and equipment necessary for field painting.
2. Protect flooring and equipment with drip cloths.
3. Paint and materials stored in location where directed.
4. Oily rags and waste removed from building every night.
5. Furnish each space containing stored painting materials with approved 2½ gallon fire extinguisher.
6. Wire brush and clean off all oil, dirt and grease areas to be painted before paint is applied.
7. Mixing:

a. Mixed and strained as required by manufacturer.
b. Use thinners only in accordance with manufacturers recommendation.
c. Follow printed instructions on paint containers. If none are available, instructions shall be obtained in writing from manufacturer.

8. Workmanship:

a. No painting or finishing shall be done with:

1) Dust laden air.
2) Unsuitable weather conditions.
3) Space temperature below 60°F.

b. Pipes being painted: containing no heat and to remain cold until paint is dried.
c. Paint spread: uniform and proper film thickness showing no runs, sags, crawls or other defects.
d. Finished surfaces shall be uniform in sheen, color, and texture.
e. All coats to be thoroughly dry before succeeding coats are applied, minimum 24 hrs. between coats.
f. Priming undercoat: slightly different color for inspection purposes.

9. Exposed, uninsulated, ungalvanized sheet metal other than stainless steel and aluminum: Two coats of aluminum paint or alkyd paint color as directed.
10. Exposed, uninsulated, galvanized sheet metal in finished space including mechanical equipment rooms:

a. One coat galvanized iron primer.
b. Two coats alkyd oil paint, color as directed.

11. Exposed, insulated piping and equipment covering:

    a. One coat primer sealer.
    b. Two coats alkyd oil paint, color as directed.

12. Finned tube radiation: One coat factory or field applied coat of heat resisting paint.
13. Paint following with two coats alkyd oil paint, color as directed:

    a. Exposed steel and metal work not furnished with factory-painted finish.
    b. Structural steel supports for piping ductwork and equipment.
    c. Exposed, uninsulated piping.

14. Exposed, uninsulated aluminum sheet metal in finished space:

    a. One coat zinc chromate primer.

15. No paint on exposed, uninsulated stainless steel sheet metal in finished space.

D. Finish painting:

1. Consisting of two finished coats of high gloss medium or long alkyd paint over prime coat.
2. Submit color shade for approval.
3. Piping continuously painted in all exposed areas.
4. Color coding per Section 23 0553: Mechanical Identification for HVAC piping and equipment

E. Interior of ductwork as far back as visible from outside: flat black.

F. Uncoated hangers, supports, rods and inserts: dip in zinc chromate primer.

G. Factory finish:

1. Steel air outlets in acoustical tile ceilings: baked white enamel.
2. Aluminum air outlets: anodized.
3. Exposed fan coil units: baked enamel.
4. Unit ventilators and unit heaters: baked enamel.

H. Factory prime coat, except as noted:
1. Pumps.
2. Fans.
3. Motors.
4. Equipment.
5. Chillers
6. Cooling tower

I. Marred surfaces of prime coated equipment and piping: spot prime coat to match adjacent coat.

J. Shop prime coat for following except as noted:

1. Structural frames.
2. Platforms.
3. Ladders.
4. Railings.
5. Tanks.

3.7 CONCRETE WORK

A. On concrete floors, install equipment on concrete housekeeping pads:

1. Pads 4 in. high unless otherwise noted.
2. Extend 6 in. minimum beyond equipment base, all sides.
3. Concrete work, including forming and reinforcing, under Division 03
   a. Coordinate size and location with General Contractor.
   b. Furnish and locate anchors and anchor bolts.

4. Curbs for field erected plenums similar.

B. Miscellaneous Concrete Items:
1. Concrete work, including forming and reinforcing, under Division 03 (or insert specific Section number for this project.)
2. Concrete for:

   a. Anchor and thrust blocks.
   b. Underground tank hold down slabs.
   c. Pipe trenches.

3. Refer to details on drawings.

C. Provide foundations for:

1. Pumps.
2. Fans.
3. Air handling units and floor mounted plenums
4. Refrigeration equipment.
5. Boilers.
6. Air Compressors.
7. Floor mounted control panels.
8. Motors.
9. Heat exchangers.
10. Convertors.
11. Chillers

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.9 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.10 GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.11 EXCAVATION AND BACKFILL

A. Excavate, backfill and restore surfaces inside building.

B. Excavate, backfill and restore surfaces inside and outside building.

C. Excavate, backfill and restore surfaces to 5 ft. outside building.

D. Excavation:

1. In accordance with requirements of Division 2.
2. Minimum depth, unless otherwise indicated:

    a. Metallic pipe: 24 in.
    b. Non-metallic pipe: 30 in.
    c. Below frost line.

3. If rock encountered:

    a. Excavate to 6 in. below bottom of piping.
    b. Refill with well tamped sand and gravel.

4. Bank excavated materials adjacent to trench as directed.
5. Bank supports:

    a. Sheet-piling, shoring or otherwise properly supported.

6. Install and maintain barricades, signs and lights.

7. Keep excavation free of water with attended pumping equipment.
8. No extra compensation:

    a. For quicksand, hardpan, or other material encountered in excavating.
    b. Except rock on unit price basis.

9. Remove bog or other swampy conditions encountered in excavating to 1 ft. below bottom of piping.

    a. Backfill with well tamped sand, finely crushed stone or gravel.

E. Installation of Underground Piping:

1. On solid undisturbed ground.

    a. Provide firm bed of sand for pipes with any form of protective covering.

2. On concrete or brick piers or cradles:

    a. Unsuitable ground, as directed.
    b. Trench crossings.
    c. Crossing excavation adjacent to building wall or foundations.

3. Bottom of trenches:

    a. Tamped hard.
    b. Graded for required pitch.
    c. Shaped to give uniform support to lower third of full length of pipe.
    d. Recesses excavated for bells and joints.

4. Support and protect piping so it remains in place without settling or damage during and from backfilling.

    a. Replace damaged pipe.

5. Under building:

    a. Temporarily support from below during installation and construction.
    b. Encase in concrete as detailed on Drawings.
    c. Permanently support with U rod hangers.

        1) Ends bent over reinforcing bars in construction above.
        2) Rod materials:

            a) Everdur 651 Alloy.
            b) Double-dipped galvanized steel.

        3) Minimum diameter of rods for following pipe sizes:

Up to 2 in.	3/8 in.
2 ½ to 4 in.	½ in.
5 and 6 in.	5/8 in.
8 and 10 in.	¾ in.

12 to 16 in.	7/8 in.

4) Paint hangers with heavy coat of bitumen solution paint.

F. Backfilling:

1. Immediately after piping installed, inspected, tested and accepted:
2. Remove sheet piling and bracing.
3. Backfill around piping with special care to solidly fill voids without damage to piping.
4. Backfill material.

   a. In accordance with the requirements of Division 02.
   b. Clean loam, clay, sand, gravel or lightweight aggregate:

      1) Sand only up to 6 in. above top of piping with any form of protective covering.
      2) Remainder to be excavated earth free from frozen materials, lumps of clay, rocks, cinders, slag, ashes, organic materials, building or other debris, or refuse.

   c. Install granular pipe insulation around pipe as specified in Section 23 0700: Piping Insulation.

5. Backfill:

   a. Up to 2 ft. above pipe, hand fill in 4 in. layers.
   b. Remainder, fill in 6 in. layers.
   c. Tamp and puddle each layer before placing next layer.
   d. No stones larger than 2 in. diameter allowed in fill up to 2 ft. above piping.
   e. No stones larger than 4 in. diameter allowed in fill above.
   f. Backfill in manner to prevent future settlement, in accordance with Division 2.
   g. Backfill to required compaction; per ASTM D-1557-587:
      1) 95% under building slabs.
      2) 90% outside of building.

G. Restore existing surfaces disturbed or damaged by excavation and backfilling, including, but not limited to:

1. Turf.
2. Plants.
3. Concrete walks.
4. Asphaltic paving.
5. All other surface improvements.

H. Dispose of acceptable surplus excavation on site as directed.

I. Remove surplus and unsuitable excavated materials from site as directed.

3.12 CUTTING AND PATCHING

A. All carpentry, cutting and patching to be done under trades doing that work.

B. Provide all carpentry, cutting and patching required for proper installation of material and equipment specified in this Division.

C. Do not cut or drill structural members without consent of Owner.

D. All cutting and repairing shall conform to Title 21 of California Administrative Code.

3.13 CUTTING THROUGH CELLULAR FLOORING

A. Cut openings for reception of work:

1. In accordance with manufacturer's recommendations and approval.
2. Not to interrupt continuity of electrical raceways.

3.14 WATER PROOFING

A. Under General Construction Work.

B. Where any work pierces waterproofing, installation shall be subject to review.

1. Provide all necessary sleeves, caulking, flashing and flashing fittings required to make openings absolutely watertight.

C. Flashing:

1. 6 lb. lead.
2. 16 oz. lead coated copper.
3. No.22 USSG aluminum.
4. Fittings for piping through roof:

    a. Galvanized cast iron bottom recess roof type.
    b. Similar to Josam No. 26440 or No. 26450.

D. Provide weather protection canopies, hoods or enclosures over out-of-door equipment which could be damaged by exposure to weather.

1. This requirement applies to:

    a. Damper operators.
    b. Damper bearings.
    c. Controls.
    d. Instruments.
    e. **[Others]**.

2. See other sections in this Division for application of this requirement to motors, drives, ducts, and fans, etc.
3. Identify items under such covers if entirely enclosed.

3.15 CLEANING AND ADJUSTING

A. Brush and clean work prior to concealing, painting and acceptance. Perform in stages if directed.

B. Painted or exposed work soiled or damaged: clean and repair to match adjoining work before final acceptance.

C. Remove debris from inside and outside of materials and equipment.

D. Flush out piping after installation.

E. Clean piping systems as described in Division 23, Section Hydronic Piping.

F. Adjust valves and automatic control devices.

G. Traps, wastes and supplies: unobstructed.

3.16 FIELD QUALITY CONTROL

A. Tests:

1. Perform as specified in individual sections, and as required by authorities having jurisdiction.
2. Duration as noted.

B. Provide required labor, material, equipment, and connections.

C. Furnish written report and certification that tests have been satisfactorily completed.

D. Repair or replace defective work, as directed.

E. Pay for restoring or replacing damaged work due to tests, as directed.

F. Pay for restoring or replacing damaged work of others, due to tests, as directed.

3.17 TRAINING

A. Provide training by qualified manufacturers' representatives for equipment as specified in this Division.

B. Training to include:

1. Site-specific training.
2. Minimum hours as specified in each Section.
3. Training materials (minimum six sets).
4. Videotapes (2 copies) of each training session upon completion.

C. Each training session to be scheduled with Owner at least 30 days in advance.

END OF SECTION 23 0500

SECTION 23 0519

METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

1.2 SUMMARY

A. Section Includes:

1. Thermometers.
2. Gages.
3. Test plugs.
4. Flowmeters.
5. Thermal-energy meters.

B. Related Sections:

1. Division 23 Section "Steam and Condensate Heating Piping" for steam and condensate meters.
2. Division 23 Section "Facility Natural-Gas Piping" for gas meters.

1.3 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

B. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated; include performance curves and installation instructions.

B. Shop Drawings: Schedule for [**thermometers**] [**gages**] [**flowmeters**] [**and**] [**thermal-energy meters**] indicating manufacturer's number, scale range, and location for each.

C. Product Certificates: For each type of [**thermometer**] [**gage**] [**flowmeter**] [**and**] [**thermal-energy meter**], signed by product manufacturer.

D. Operation and Maintenance Data: For [**flowmeters**] [**and**] [**thermal-energy meters**] to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Comply with applicable portions of American Society of Mechanical Engineers (ASME) and Instrument Society of America (ISA) standards pertaining to construction an installation of meters and gauges.

B. Design Criteria: The drawings indicate types, sizes, capacities, ranges, profiles, connections, and dimensional requirements of meters and gauges and are based on the specific manufacturer types and models indicated. Meters and gauges having equal performance characteristics by other manufacturers may be considered, provided that deviations do not change the design concept or intended performance as judged by the Architect.

1.6 EXTRA MATERIALS

A. Furnish extra materials described below to match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Provide six spare pressure gauges for use with valved pressure gauge outlets.
2. Provide six spare thermometers for use with pressure-temperature test stations.

PART 2 - PRODUCTS

2.1 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Moeller Instrument Co.
2. Palmer - Wahl Instruments Inc.
3. Taylor Instrument Process Control Div.
4. Trerice, H. O. Co.
5. Weiss Instruments, Inc.
6. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
7. **<Insert manufacturer's name.>**

B. Case: **[Die-cast aluminum] [Die-cast aluminum or brass] [Brass] [Chrome-plated brass]**, **[7 inches] [9 inches]** **<Insert other>** long.

C. Tube: Red or blue reading organic-liquid filled, with magnifying lens.

D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.

E. Window: **[Glass] [Glass or plastic] [Plastic] <Insert other>**.

F. Connector: **[Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device] [Rigid, straight type] [Rigid, angle type]**.

G. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of stem length to suit installation pipe size.

1. Below NPS 4 (DN 100): 3 1/2 inch (88 mm) stem, elbow mounted.
2. NPS 4 – NPS 8 (DN 100 – DN 200): 3 1/2 inch (88 mm) stem.
3. NPS 10 – NPS 14 (DN 250 – DN 350): 6 inch (150 mm) stem.
4. NPS 16 – NPS 20 (DN 400 – DN 500): 9 inch (225 mm) stem.

5. NPS 24 (DN 600): 12 inch (300 mm) stem.
6. Over NPS 24 (DN 600): Stem length equal to 50% pipe diameter.

H. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.2 PLASTIC-CASE, LIQUID-IN-GLASS THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ernst Gage Co.
2. Eugene Ernst Products Co.
3. Marsh Bellofram.
4. Miljoco Corp.
5. Trerice, H. O. Co.
6. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
7. Winters Instruments.
8. **<Insert manufacturer's name.>**

B. Case: Plastic, [**7 inches**] [**9 inches**] <**Insert other**> long.

C. Tube: Red or blue reading, organic-liquid filled, with magnifying lens.

D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.

E. Window: Glass or plastic.

F. Connector: [**Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device**] [**Rigid, straight type**] [**Rigid, angle type**].

G. Stem: Metal, for thermowell installation and of stem length to suit installation pipe size:

1. Below NPS (DN 100): 3 1/2 inch (88 mm) stem, elbow mounted.
2. NPS 4 – NPS 8 (DN 100 – DN 200): 3 1/2 inch (88 mm) stem.
3. NPS 10 – NPS 14 (DN 250 – DN 350): 6 inch (150 mm) stem.
4. NPS 16 – NPS 20 (DN 400 – DN 500): 9 inch (225 mm) stem.
5. NPS 24 (DN 600): 12 inch (300 mm) stem.
6. Over NPS 24 (DN 600): Stem length equal to 50% pipe diameter.

H. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.3 DUCT-TYPE, LIQUID-IN-GLASS THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Miljoco Corp.
2. Palmer - Wahl Instruments Inc.
3. Trerice, H. O. Co.
4. Weiss Instruments, Inc.
5. **<Insert manufacturer's name.>**

B. Case: [**Die-cast aluminum**] [**Metal or plastic**], [**7 inches**] <**Insert other**> long.

C. Tube: Red or blue reading, organic filled, with magnifying lens.

D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.

E. Window: **[Glass or plastic]** **<Insert other>**.

F. Connector: **[Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device]** **[Rigid, angle type]**.

G. Stem: Metal, for installation in mounting bracket and of length to suit installation.

H. Mounting Bracket: Flanged fitting for attachment to duct and made to hold thermometer stem.

I. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.4 DIRECT-MOUNTING, VAPOR-ACTUATED DIAL THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
2. KOBOLD Instruments, Inc.
3. Marsh Bellofram.
4. Moeller Instrument Co.
5. Taylor Instrument Process Control Div.
6. Trerice, H. O. Co.
7. Weiss Instruments, Inc.
8. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
9. **<Insert manufacturer's name.>**

B. Case: **[Dry]** **[Liquid-filled]** type, **[drawn steel or cast aluminum]** **[metal or plastic]** **[plastic]**, **[4-1/2-inch]** **[5-inch]** **[6-inch]** **<Insert other>** diameter.

C. Element: Bourdon tube or other type of pressure element. Brass, bronze bushed, recalibrator type.

D. Movement: Mechanical, connecting element and pointer.

E. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.

F. Pointer: Red[**or other dark-color**] metal.

G. Window: **[Glass]** **[Glass or plastic]** **[Plastic]** **<Insert other>**.

H. Ring: **[Chrome plated metal]** **[Brass]** **[Stainless steel]** **[Plastic]**.

I. Connector: **[Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device]** **[Rigid, bottom type]** **[Rigid, back type]**.

J. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem for thermowell installation and of length to suit installation pipe size:

1. Below NPS 4 (DN 100): 3 1/2 inch (88 mm) stem, elbow mounted.
2. NPS 4 – NPS 8 (DN 100 – DN 200): 3 1/2 inch (88 mm) stem.
3. NPS 10 – NPS 14 (DN 250 – DN 350): 6 inch (150 mm) stem.

4. NPS 16 – NPS 20 (DN 400 – DN 500): 9 inch (225 mm) stem.
5. NPS 24 (DN 600): 12 inch (300 mm) stem.
6. Over NPS 24 (DN 600): Stem length equal to 50% pipe diameter.

K. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.5 REMOTE-MOUNTING, VAPOR-ACTUATED DIAL THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AMETEK, Inc.; U.S. Gauge Div.
2. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
3. Marsh Bellofram.
4. Moeller Instrument Co.
5. Palmer - Wahl Instruments Inc.
6. Taylor Instrument Process Control Div.
7. Trerice, H. O. Co.
8. Weiss Instruments, Inc.
9. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
10. **<Insert manufacturer's name.>**

B. Case: Dry type, [**drawn steel or cast aluminum**] <**Insert other**>, [**4-1/2-inch**] [**6-inch**] <**Insert other**> diameter with [**holes**] <**Insert other**> for panel mounting.

C. Element: Bourdon tube or other type of pressure element. Brass, bronze brushed, recalibrator type.

D. Movement: Mechanical, connecting element and pointer.

E. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.

F. Pointer: Red[**or other dark-color**] metal.

G. Window: [**Glass**] [**Glass or plastic**] [**Plastic**] <**Insert other**>.

H. Ring: [**Black aluminum**] [**Brass**] [**Stainless steel**].

I. Connector: [**Bottom**] [**Back**] union type. Connecting tubing shall be double braided bronze armor over copper capillary.

J. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem for thermowell installation and of length to suit installation pipe size:

1. Below NPS 4 (DN 100): 3 1/2 inch (88 mm) stem, elbow mounted.
2. NPS 4 – NPS 8 (DN 100 – DN 200): 3 1/2 inch (88 mm) stem.
3. NPS 10 – NPS 14 (DN 250 – DN 350): 6 inch (150 mm) stem.
4. NPS 16 – NPS 20 (DN 400 – DN 500): 9 inch (225 mm) stem.
5. NPS 24 (DN 600): 12 inch (300 mm) stem.
6. Over NPS 24 (DN 600): Stem length equal to 50% pipe diameter.

K. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

L. For use in locations where temperature sensing bulb is located more than **[5 feet (1.5 m)]** <**Inset number**>.

2.6 BIMETALLIC-ACTUATED DIAL THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
2. Ernst Gage Co.
3. Eugene Ernst Products Co.
4. Marsh Bellofram.
5. Moeller Instrument Co.
6. Palmer - Wahl Instruments Inc.
7. Taylor Instrument Process Control Div.
8. Trerice, H. O. Co.
9. Weiss Instruments, Inc.
10. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
11. **<Insert manufacturer's name.>**

B. Description: Direct-mounting, bimetallic-actuated dial thermometers complying with ASME B40.3.

C. Case: [**Dry**] [**Liquid-filled**] type, stainless steel with [**3-inch**] [**5-inch**] diameter.

D. Element: Bimetal coil.

E. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.

F. Pointer: Red[**or other dark-color**] metal.

G. Window: [**Glass**] [**Glass or plastic**] [**Plastic**] <**Insert other**>.

H. Ring: Stainless steel.

I. Connector: [**Adjustable angle**] [**Rigid, back**] [**Rigid, bottom**] <**Insert other**> type. Dial may be rotated 360° and then stem turned 180° for readability.

J. Stem: Metal, for thermowell installation and of length to suit installation pipe size.

1. Below NPS 4 (DN 100): 3 1/2 inch (88 mm) stem, elbow mounted.
2. NPS 4 – NPS 8 (DN 100 – DN 200): 3 1/2 inch (88 mm) stem.
3. NPS 10 – NPS 14 (DN 250 – DN 350): 6 inch (150 mm) stem.
4. NPS 16 – NPS 20 (DN 400 – DN 500): 9 inch (225 mm) stem.
5. NPS 24 (DN 600): 12 inch (300 mm) stem.
6. Over NPS 24 (DN 600): Stem length equal to 50% pipe diameter.

K. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.7 THERMOWELLS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AMETEK, Inc.; U.S. Gauge Div.

2. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
3. Ernst Gage Co.
4. Marsh Bellofram.
5. Moeller Instrument Div.
6. Palmer - Wahl Instruments Inc.
7. Taylor Instrument Process Control Div.
8. Trerice, H. O. Co.
9. Weiss Instruments, Inc.
10. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
11. **<Insert manufacturer's name.>**

B. Manufacturers: Same as manufacturer of thermometer being used.

C. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer. Provide with separable brass socket connection, cap and chain.

2.8 PRESSURE GAGES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AMETEK, Inc.; U.S. Gauge Div.
2. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
3. Ernst Gage Co.
4. Eugene Ernst Products Co.
5. Marsh Bellofram.
6. Moeller Instrument Co.
7. Palmer - Wahl Instruments Inc.
8. Taylor Instrument Process Control Div.
9. Trerice, H. O. Co.
10. Weiss Instruments, Inc.
11. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
12. **<Insert manufacturer's name.>**

B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.

1. Case: [**Dry**] [**Liquid-filled**] type, [**drawn steel or cast aluminum**] [**metal or plastic**] [**plastic**], [**4-1/2-inch**] [**6-inch**] <**Insert other**> diameter.
2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
4. Movement: Mechanical, stainless steel, with link to pressure element and connection to pointer.
5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
6. Pointer: Red[**or other dark-color**] metal.
7. Window: [**Glass**] [**Glass or plastic**] [**Plastic**] <**Insert other**>.
8. Ring: [**Metal**] [**Brass**] [**Stainless steel**] [**Metal or plastic**] [**Plastic**].
9. Accuracy: Grade [**A, plus or minus 1 percent of middle half**] [**B, plus or minus 2 percent of middle half**] [**C, plus or minus 3 percent of middle half**] [**D, plus or minus 5 percent of whole**] scale.
10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
11. Range for Fluids under Pressure: Two times operating pressure.

C. Remote-Mounting, Dial-Type Pressure Gages: ASME B40.100, indicating-dial type.

1. Case: Dry type, **[drawn steel or cast aluminum]** **<Insert other>**, **[4-1/2-inch]** **[6-inch]** **<Insert other>** diameter with **[holes]** **<Insert other>** for panel mounting.
2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
4. Movement: Mechanical, stainless steel, with link to pressure element and connection to pointer.
5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
6. Pointer: Red[**or other dark-color**] metal.
7. Window: **[Glass]** **[Glass or plastic]** **[Plastic]** **<Insert other>**.
8. Ring: **[Metal]** **[Brass]** **[Stainless steel]** **[Metal or plastic]** **[Plastic]**.
9. Accuracy: Grade **[A, plus or minus 1 percent of middle half]** **[B, plus or minus 2 percent of middle half]** **[C, plus or minus 3 percent of middle half]** **[D, plus or minus 5 percent of whole]** scale.
10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
11. Range for Fluids under Pressure: Two times operating pressure.
12. For use with sensing lines up to 25 ft (630 mm) in length.

D. Pressure-Gage Fittings:

1. Valves: NPS 1/4 brass or stainless-steel needle type.
2. Syphons: NPS 1/4 coil of brass tubing with threaded ends.
3. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.9 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Flow Design, Inc.
2. MG Piping Products Co.
3. National Meter, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Co.
6. Trerice, H. O. Co.
7. Watts Industries, Inc.; Water Products Div.
8. **<Insert manufacturer's name.>**

B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

C. Minimum Pressure and Temperature Rating: **[500 psig at 200 deg F]** **<Insert other>**.

D. Core Inserts: One or two self-sealing rubber valves.

1. Insert material for air, water, oil, or gas service at 20 to 200 deg F shall be CR.
2. Insert material for air or water service at minus 30 to plus 275 deg F shall be EPDM.

E. Test Kit: Furnish **[one]** **<Insert other>** test kit(s) containing one pressure gage and adaptor, **[one]** **[two]** thermometer(s), and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.

1. Pressure Gage: Small bourdon-tube insertion type with **[2- to 3-inch-]** **<Insert other>** diameter dial and probe. Dial range shall be **[0 to 200 psig]** **<Insert other>**.

2. Low-Range Thermometer: Small bimetallic insertion type with [**1- to 2-inch-**] **<Insert other>** diameter dial and tapered-end sensing element. Dial ranges shall be [**25 to 125 deg F**] **<Insert other>**.
3. High-Range Thermometer: Small bimetallic insertion type with [**1- to 2-inch-**] **<Insert other>** diameter dial and tapered-end sensing element. Dial ranges shall be [**0 to 220 deg F**] **<Insert other>**.
4. Carrying case shall have formed instrument padding.

2.10 WAFER-ORIFICE FLOWMETERS

A. Manufacturers: Subject to compliance with requirements:

1. ABB, Inc.; ABB Instrumentation.
2. Armstrong Pumps, Inc.
3. Badger Meter, Inc.; Industrial Div.
4. Bell & Gossett; ITT Industries.
5. Meriam Instruments Div.; Scott Fetzer Co.
6. **<Insert manufacturer's name.>**

B. Description: Differential-pressure-design orifice insert for installation between pipe flanges; with calibrated flow-measuring element, separate flowmeter, hoses or tubing, valves, fittings, and conversion chart compatible with flow-measuring element, flowmeter, and system fluid.

C. Construction: Cast-iron body, brass valves with integral check valves and caps, and calibrated nameplate.

D. Pressure Rating: [**300 psig**] **<Insert other>**.

E. Temperature Rating: [**250 deg F**] **<Insert other>**.

F. Range: Flow range of flow-measuring element and flowmeter shall cover operating range of equipment or system served.

G. Permanent Indicators: Suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch- diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.

1. Scale: Gallons per minute.
2. Accuracy: Plus or minus 1 percent between 20 and 80 percent of range.

H. Portable Indicators: Differential-pressure type calibrated for connected flowmeter element and having two 12-foot hoses in carrying case.

1. Scale: Gallons per minute.
2. Accuracy: Plus or minus 2 percent between 20 and 80 percent of range.

I. Operating Instructions: Include complete instructions with each flowmeter.

2.11 VENTURI FLOWMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Armstrong Pumps, Inc.

2. Badger Meter, Inc.; Industrial Div.
3. Bailey-Fischer & Porter Co.
4. Flow Design, Inc.
5. Gerand Engineering Co.
6. Hyspan Precision Products, Inc.
7. Leeds & Northrup.
8. McCrometer, Inc.
9. Preso Meters Corporation.
10. Victaulic Co. of America.
11. **<Insert manufacturer's name.>**

B. Description: Differential-pressure design for installation in piping; with calibrated flow-measuring element, separate flowmeter, hoses or tubing, valves, fittings, and conversion chart compatible with flow-measuring element, flowmeter, and system fluid.

C. Construction: Bronze, brass, or factory-primed steel, as noted below; with brass fittings and attached tag with flow conversion data.

1. NPS 1/2 (DN 15) through NPS 2 (DN 50): Bronze or brass.
2. NPS 2 1/2 (DN 65) through NPS 8 (DN 200): Factory primed cast steel.
3. NPS 10 (DN 250) and larger: Factory primed fabricated steel.

D. Pressure Rating: **[250 psig]** <**Insert other**>.

E. Temperature Rating: **[250 deg F]** <**Insert other**>.

F. End Connections for NPS 2 and Smaller: Threaded.

G. End Connections for NPS 2-1/2 and Larger: Flanged.

H. Range: Flow range of flow-measuring element and flowmeter shall cover operating range of equipment or system served.

I. Permanent Indicators: Suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch- diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.

1. Scale: Gallons per minute.
2. Accuracy: Plus or minus 1 percent between 20 and 80 percent of range.

J. Portable Indicators: Differential-pressure type calibrated for connected flowmeter element and having two 12-foot hoses in carrying case.

1. Scale: Gallons per minute.
2. Accuracy: Plus or minus 2 percent between 20 and 80 percent of range.

K. Operating Instructions: Include complete instructions with each flowmeter.

2.12 TURBINE FLOWMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Badger Meter, Inc.; Industrial Div.
2. Bailey-Fischer & Porter Co.

3. Data Industrial Corp.
4. Engineering Measurements Company.
5. ERDCO Engineering Corp.
6. Fischer, George Inc.
7. Hoffer Flow Controls, Inc.
8. ISTEC Corporation.
9. Midwest Instruments & Controls Corp.
10. ONICON Incorporated.
11. SeaMetrics Inc.
12. Sponsler Company, Inc.
13. Thermo Measurement Ltd.
14. Venture Measurement.
15. <**Insert manufacturer's name.**>

B. Description: Insertion type for inserting turbine into piping and measuring flow directly in gallons per minute.

C. Construction: Bronze or stainless-steel body; with plastic turbine or impeller and integral direct-reading scale.

D. Pressure Rating: [**150 psig**] <**Insert other**> minimum.

E. Temperature Rating: [**180 deg F**] <**Insert other**> minimum.

F. Display: Visual instantaneous rate of flow[**, with register to indicate total volume in gallons**].

G. Accuracy: Plus or minus 2-1/2 percent.

2.13 VORTEX-SHEDDING FLOWMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Bailey-Fischer & Porter Co.
2. Engineering Measurements Company.
3. ISTEC Corporation.
4. MCO/Eastech, Inc.
5. Schlumberger Limited; Measurement Div.
6. Venture Measurement.
7. <**Insert manufacturer's name.**>

B. Description: Inline type for installing between pipe flanges and measuring flow directly in gallons per minute.

C. Construction: Stainless-steel body; with integral transmitter and direct-reading scale.

D. Pressure Rating: [**1000 psig**] <**Insert other**> minimum.

E. Temperature Rating: [**500 deg F**] <**Insert other**> minimum.

F. Display: Visual instantaneous rate of flow[**, with register to indicate total volume in gallons**].

G. Integral Transformer: For low-voltage power operation.

H. Accuracy: Plus or minus 7/10 percent for liquids and 1-1/4 percent for gases.

2.14 PITOT-TUBE FLOWMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Dieterich Standard Inc.
2. Meriam Instruments Div.; Scott Fetzer Co.
3. Preso Meters Corporation.
4. Taco, Inc.
5. Veris Industries.
6. **<Insert manufacturer's name.>**

B. Description: Insertion-type, differential-pressure design for inserting probe into piping and measuring flow directly in gallons per minute.

C. Construction: Stainless-steel probe of length to span inside of pipe; with integral transmitter and direct-reading scale.

D. Pressure Rating: [**150 psig**] <**Insert other**> minimum.

E. Temperature Rating: [**250 deg F**] <**Insert other**> minimum.

F. Display: Visual instantaneous rate of flow[**, with register to indicate total volume in gallons**].

G. Integral Transformer: For low-voltage power connection.

H. Accuracy: Plus or minus 1 percent for liquids and gases.

2.15 FLOW INDICATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Brooks Instrument Div.; Emerson Electric Co.
2. Dwyer Instruments, Inc.
3. Ernst Gage Co.
4. Eugene Ernst Products Co.
5. McCrometer, Inc.
6. OPW Engineered Systems; Dover Corp.
7. Penberthy, Inc.
8. **<Insert manufacturer's name.>**

B. Description: Instrument for installation in piping systems for visual verification of flow.

C. Construction: Bronze or stainless-steel body; with sight glass and [**plastic pelton-wheel**] <**Insert other**> indicator, and threaded or flanged ends.

D. Pressure Rating: [**125 psig**] <**Insert other**>.

E. Temperature Rating: [**200 deg F**] <**Insert other**>.

F. End Connections for NPS 2 and Smaller: Threaded.

G. End Connections for NPS 2-1/2 and Larger: Flanged.

2.16 INSERTION-TURBINE, THERMAL-ENERGY METER SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Data Industrial Corp.
2. ONICON Incorporated.
3. Thermo Measurement Ltd.
4. **<Insert manufacturer's name.>**

B. Description: Flow sensor,[**strainer,**] two temperature sensors, transmitter, meter, and connecting wiring.

C. Flow Sensor: Insertion-type turbine or paddle-wheel element with corrosion-resistant-metal body and transmitter.

1. Pressure Rating: [**125 psig**] <**Insert other**>.
2. Temperature Range: [**40 to 250 deg F**] <**Insert other**>.

D. Meter: Solid-state integrating type[**with integral battery pack**].

1. Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units.
2. Accuracy: Plus or minus [**1**] <**Insert other**> percent.
3. Battery Pack: Five-year lithium battery.

E. Strainer: Full size of main line piping.

2.17 INLINE-TURBINE, THERMAL-ENERGY METER SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Engineering Measurements Company.
2. Hoffer Flow Controls, Inc.
3. ISTEC Corporation.
4. Thermo Measurement Ltd.
5. Venture Measurement.
6. **<Insert manufacturer's name.>**

B. Description: Flow sensor,[**strainer,**] two temperature sensors, transmitter, meter, and connecting wiring.

C. Flow Sensor: Turbine-type water meter with corrosion-resistant-metal body and transmitter.

1. Pressure Rating: [**150-psig**] <**Insert other**> minimum working-pressure rating.
2. Temperature Range: [**40 to 250 deg F**] <**Insert other**>.

D. Meter: Solid-state integrating type[**with integral battery pack**].

1. Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units.
2. Accuracy: Plus or minus [**1**] <**Insert other**> percent.
3. Battery Pack: Five-year lithium battery.

E. Strainer: Full size of main line piping.

2.18 ULTRASONIC, THERMAL-ENERGY METER SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Controlotron Corporation.
2. Engineering Measurements Company.
3. Mesa Laboratories, Inc.; Nusonics Div.
4. **<Insert manufacturer's name.>**

B. Description: Flow sensor, two temperature sensors, transmitter, meter, and connecting wiring.

C. Flow Sensor: Strap-on or integral ultrasonic type with transmitter.

D. Meter: Solid-state integrating type[**with integral battery pack**].

1. Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units.
2. Accuracy: Plus or minus **[1]** <**Insert other**> percent.
3. Battery Pack: Five-year lithium battery.

E. Strainer: Full size of main line piping.

2.19 DIFFERENTIAL PERSSURE INDICATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ITT Barton.
2. Meriam Instrument Co.
3. Rosemount Engineering Co.
4. <**Insert manufacturer's name**>.

B. Description: Pressure sensor, two pressure sensors, meter and connecting tubing.

C. **[Die cast aluminum]** <**Insert material**>, **[6 inch (152 mm)]** <**Insert number**> diameter.

D. Pressure Connections: Brass, NPS 1/4 (DN 8), bottom outlet type, unless otherwise indicated.

E. Pressure-Element Assemblies: Stainless steel bellows and torque tube; self-draining.

F. Movement: Jeweled rotary type with zero and range adjustment screws.

G. Manifold: Stainless steel with carbon steel tubing.

H. Scale: Uniform, calibrated in psig (kPa).

I. Accuracy: 1/2 of 1 percent of full scale range.

J. Pressure Rating: **[500 psig (3450 kPa)]** <**Insert number**>.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

A. Install liquid-in-glass thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler and chiller.
3. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
4. Inlet and outlet of each cooling tower.
5. Chilled water and heating water lines at exit of equipment rooms.
6. Return main for each circuit of hat water systems.
7. .
8. Condensate discharge line from condensate coolers.
9. Other locations as noted on drawings.

B. Install direct-mounting, vapor-actuated dial thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler and chiller.
3. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
4. Inlet and outlet of each hydronic heat exchanger.
5. Inlet and outlet of each cooling tower.
6. Chilled water and heating water lines at exit of equipment rooms.
7. Return main for each circuit of hat water systems.
8. Condenser water line from condenser generator after by-pass, for absorption refrigeration units.
9. Other locations as noted on drawings.

C. Install remote-mounting, vapor-actuated dial thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler and chiller.
3. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
4. Inlet and outlet of each hydronic heat exchanger.
5. .
6. Inlet and outlet of each cooling tower.
7. Chilled water and heating water lines at exit of equipment rooms.
8. Return main for each circuit of hat water systems.
9. Outside air, return air and mixed air ducts.
10. Other locations as noted on drawings.

D. Install bimetallic-actuated dial thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler and chiller.
3. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
4. Inlet and outlet of each hydronic heat exchanger.
5. Inlet and outlet of each hydronic heat-recovery unit.
6. Inlet and outlet of each thermal storage tank.
7. Inlet and outlet of each condenser.
8. Inlet and outlet of each cooling tower.
9. Chilled water and heating water lines at exit of equipment rooms.
10. Return main for each circuit of hat water systems.
11. Condenser water line from condenser generator after by-pass, for absorption refrigeration units.

12. Outlet of steam condenser hot well, for turbine driven refrigeration units.
13. Condensate discharge line from condensate coolers.
14. Other locations as noted on drawings.

E. Install **[dry]** **[liquid-filled]**-case-type, **[vapor]** **[bimetallic]**-actuated dial thermometers at suction and discharge of each pump.

F. Provide the following temperature ranges for thermometers:

1. Heating Hot Water: **[30 to 240 deg F, with 2-degree scale divisions]** **[50 to 400 deg F, with 5-degree scale divisions]** **<Insert other>**.
2. Condenser Water: **[0 to 160 deg F, with 2-degree scale divisions]** **[30 to 240 deg F, with 2-degree scale divisions]** **<Insert other>**.
3. Chilled Water: **[0 to 100 deg F, with 2-degree scale divisions]** **[0 to 160 deg F, with 2-degree scale divisions]** **<Insert other>**.
4. Air Ducts: **[Minus 40 to plus 110 deg F, with 2-degree scale divisions]** **[30 to 240 deg F, with 2-degree scale divisions]** **[50 to 400 deg F, with 5-degree scale divisions]** **<Insert other>**.
5. **<Insert services.>**

3.2 GAGE APPLICATIONS

A. Install dry-case-type pressure gages at first stage inlet of pressure reducing valve stations and at discharge of each pressure-reducing valve.

B. Install **[dry]** **[liquid-filled]**-case-type pressure gages at chilled- and condenser-water inlets and outlets of chillers.

C. Install **[dry]** **[liquid-filled]**-case-type pressure gages at suction and discharge of each pump, between shut-off valve and pump. Provide compound type gauge if subject to negative pressure.

D. Install **[dry]** **[liquid-filled]**-case-type pressure gauges at inlets and outlets of hot water boilers.

E. Install **[dry]** **[liquid-filled]**-case-type pressure gauges at inlets and outlets of heat exchanger circuits.

F. Install **[dry]** **[liquid-filled]**-case-type pressure gauges at condenser water **[inlet]** **[inlet and outlet]** of cooling tower.

G. Install dry-case-type pressure gauges at steam inlets to **[absorption chillers]** **[turbine-drive chillers]** **[and heat exchangers]**.

H. Install dry-case-type pressure gauges in steam piping at exit of equipment rooms.

I. Install 8 inch (200 mm) diameter dry-case-type pressure gauge at main steam header in boiler room.

J. Install **[dry]** **[liquid-filled]**-case-type compound type pressure gauges at turbine tank drain outlets.

K. Install pressure gauges at other locations as noted on the drawings.

L. Pressure gauge ranges shall be selected so that normal system operating pressures occur at the center portion of the scale range.

3.3 INSTALLATIONS

A. Install direct-mounting thermometers and adjust vertical and tilted positions.

B. Install remote-mounting dial thermometers on panel, with tubing connecting panel and thermometer bulb supported to prevent kinks. Use minimum tubing length.

C. Install thermowells with socket extending [**a minimum of 2 inches into fluid**] [**one-third of diameter of pipe**] [**to center of pipe**] and in vertical position in piping tees where thermometers are indicated.

D. Duct Thermometer Support Flanges: Install in wall of duct where duct thermometers are indicated. Attach to duct with screws.

E. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.

F. Install remote-mounting pressure gages on panel.

G. Install needle-valve and snubber fitting in piping for each pressure gage for fluids (except steam).

H. Install needle-valve and syphon fitting in piping for each pressure gage for steam.

I. Install test plugs in tees in piping.

J. Install flow indicators, in accessible positions for easy viewing, in piping systems.

K. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters as prescribed by manufacturer's written instructions.

L. Install flowmeter elements in accessible positions in piping systems.

M. Install differential-pressure-type flowmeter elements with at least minimum straight lengths of pipe upstream and downstream from element as prescribed by manufacturer's written instructions.

N. Install wafer-orifice flowmeter elements between pipe flanges.

O. Install permanent indicators on walls or brackets in accessible and readable positions.

P. Install connection fittings for attachment to portable indicators in accessible locations.

Q. Install flowmeters at discharge of hydronic system pumps and at inlet of hydronic air coils.

R. Assemble components and install thermal-energy meters.

S. Mount meters on wall if accessible; if not, provide brackets to support meters.

T. Install pressure-temperature test stations adjacent to each bulb for controllers, remote temperature indication and recording thermometers, and at other points where noted on drawings.

U. Install valved outlets for pressure gauges at cooling and heating water supply and return for coil assemblies, for other equipment not noted to receive permanent pressure gauges, and at other points where noted on drawings.

3.4 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance for meters, gages, machines, and equipment.

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.

D. Connect thermal-energy-meter transmitters to meters.

3.5 ADJUSTING

A. Calibrate meters according to manufacturer's written instructions, after installation.

B. Adjust faces of meters and gages to proper angle for best visibility.

END OF SECTION 23 0519

SECTION 23 0529

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

1.2 SUMMARY

A. This Section includes the following hangers and supports for HVAC system piping and equipment:

1. Steel pipe hangers and supports.
2. Trapeze pipe hangers.
3. Fiberglass pipe hangers.
4. Metal framing systems.
5. Fiberglass strut systems.
6. Thermal-hanger shield inserts.
7. Fastener systems.
8. Pipe stands.
9. Equipment supports.

B. Related Sections include the following:

1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-protection piping.
3. Division 23 Section "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
4. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for vibration isolation devices.
5. Division 23 Section(s) "[**Metal Ducts**] [**Metal Ducts" and "Nonmetal Ducts**] [**Nonmetal Ducts**]" for duct hangers and supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society for The Valve and Fittings Industry Inc.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Design seismic-restraint hangers and supports for piping and equipment[**and obtain approval from authorities having jurisdiction**].

D. Where thermal movement in pipe line occurs, hanger assembly shall support pipe line in all operating conditions.

1.5 SUBMITTALS

A. Product Data: Manufacturer's catalog data, including load ratings, dimensions and installation instructions, for the following:

1. Steel pipe hangers and supports.
2. Fiberglass pipe hangers.
3. Thermal-hanger shield inserts.
4. Powder-actuated fastener systems.

B. Shop Drawings:[**Signed and sealed by a qualified professional engineer.**] Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers. Include Product Data for components.
2. Metal framing systems. Include Product Data for components.
3. Fiberglass strut systems. Include Product Data for components.
4. Pipe stands. Include Product Data for components.
5. Equipment supports.

C. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to [**AWS D1.1, "Structural Welding Code--Steel."**] [**AWS D1.3, "Structural Welding Code--Sheet Steel."**] [**AWS D1.4, "Structural Welding Code--Reinforcing Steel."**] [**ASME Boiler and Pressure Vessel Code: Section IX.**]

B. Welding: Qualify procedures and personnel according to the following:

1. AWS D1.1, "Structural Welding Code--Steel."
2. AWS D1.2, "Structural Welding Code--Aluminum."
3. AWS D1.3, "Structural Welding Code--Sheet Steel."
4. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
5. ASME Boiler and Pressure Vessel Code: Section IX.

C. Codes and Standards: Provide pipe hangers and supports conforming to the following:

1. American Society of Mechanical Engineering:

   a. B31.1 Power Piping.
   b. B31.2 Fuel Gas Piping.
   c. B31.5 Refrigerating Piping and Heat Transfer Components.
   d. B31.9 Building Services Piping.

2. American Society for Testing and Materials (ASTM):

   a. A36 Standard Specification for Carbon Structural Steel.
   b. A123 Standard Specification for Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products.
   c. A307 Standard Specification for Carbon Steel Bolts and Studs, 60000 PSI Tensile Strength.
   d. A575 Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades.
   e. D695 Compressive Properties of Rigid Plastics.
   f. D790 Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
   g. F708 Standard Practice for Design and Installation of Rigid Pipe.

3. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS):

   a. SP58 Pipe Hangers and Supports - Materials, Design and Manufacture.
   b. SP69 Pipe Hangers and Supports – Selection and Application.
   c. SP89 Pipe Hangers and Supports – Fabrication and Installation Practices.
   d. SP90 Guidelines on Terminology for Pipe Hangers and Supports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 STEEL PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

B. Manufacturers:

   1. AAA Technology & Specialties Co., Inc.
   2. Bergen-Power Pipe Supports.
   3. B-Line Systems, Inc.; a division of Cooper Industries.
   4. Carpenter & Paterson, Inc.
   5. Empire Industries, Inc.
   6. ERICO/Michigan Hanger Co.
   7. Globe Pipe Hanger Products, Inc.
   8. Grinnell Corp.
   9. GS Metals Corp.
   10. National Pipe Hanger Corporation.
   11. PHD Manufacturing, Inc.
   12. PHS Industries, Inc.
   13. Piping Technology & Products, Inc.
   14. Tolco Inc.

15. **<Insert manufacturer's name.>**

C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.4 FIBERGLASS PIPE HANGERS

A. Clevis-Type, Fiberglass Pipe Hangers: Similar to MSS Type 1, steel pipe hanger except hanger is made of fiberglass and continuous-thread rod and nuts are made of **[polyurethane]** **[polyurethane or stainless steel]** **[stainless steel]** **<Insert other>**.

1. Manufacturers:

a. B-Line Systems, Inc.; a division of Cooper Industries.
b. Champion Fiberglass, Inc.
c. Cope, T. J., Inc.; Tyco International, Ltd.
d. Seasafe, Inc.
e. Unistrut Corp.; Tyco International, Ltd.
f. Wesanco, Inc.
g. **<Insert manufacturer's name.>**

B. Strap-Type, Fiberglass Pipe Hangers: Made of fiberglass loop with stainless-steel continuous-thread rod, nuts, and support hook.

1. Manufacturers:

a. Plasti-Fab, Inc.
b. **<Insert manufacturer's name.>**

2.5 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

B. Manufacturers:

1. B-Line Systems, Inc.; a division of Cooper Industries.
2. ERICO/Michigan Hanger Co.; ERISTRUT Div.
3. GS Metals Corp.
4. Power-Strut Div.; Tyco International, Ltd.
5. Thomas & Betts Corporation.
6. Tolco Inc.
7. Unistrut Corp.; Tyco International, Ltd.

8. **<Insert manufacturer's name.>**

C. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.6 FIBERGLASS STRUT SYSTEMS

A. Description: Shop- or field-fabricated pipe-support assembly, similar to MFMA-3, made of fiberglass channels and other components.

B. Manufacturers:

1. B-Line Systems, Inc.; a division of Cooper Industries.
2. Champion Fiberglass, Inc.
3. Cope, T. J., Inc.; Tyco International Ltd.
4. Seasafe, Inc.
5. **<Insert manufacturer's name.>**

2.7 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig- minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Manufacturers:

1. Carpenter & Paterson, Inc.
2. ERICO/Michigan Hanger Co.
3. PHS Industries, Inc.
4. Pipe Shields, Inc.
5. Rilco Manufacturing Company, Inc.
6. Value Engineered Products, Inc.
7. **<Insert manufacturer's name.>**

C. Insulation-Insert Material for Cold Piping: **[Water-repellent treated, ASTM C 533, Type I calcium silicate] [Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass] [ASTM C 552, Type II cellular glass]** with vapor barrier.

D. Insulation-Insert Material for Hot Piping: **[Water-repellent treated, ASTM C 533, Type I calcium silicate] [Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass] [ASTM C 552, Type II cellular glass]**.

E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

F. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

G. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.8 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Manufacturers:

a. Hilti, Inc.
b. ITW Ramset/Red Head.
c. Masterset Fastening Systems, Inc.
d. MKT Fastening, LLC.
e. Powers Fasteners.
f. **<Insert manufacturer's name.>**

B. Mechanical-Expansion Anchors: Insert-wedge-type [**zinc-coated**] [**stainless**] steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Manufacturers:

a. B-Line Systems, Inc.; a division of Cooper Industries.
b. Empire Industries, Inc.
c. Hilti, Inc.
d. ITW Ramset/Red Head.
e. MKT Fastening, LLC.
f. Powers Fasteners.
g. **<Insert manufacturer's name.>**

2.9 PIPE STAND FABRICATION

A. Pipe Stands, General: Shop or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod-roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

1. Manufacturers:

a. ERICO/Michigan Hanger Co.
b. MIRO Industries.
c. **<Insert manufacturer's name.>**

C. Low-Type, Single-Pipe Stand: One-piece [**plastic**] [**stainless-steel**] base unit with plastic roller, for roof installation without membrane penetration.

1. Manufacturers:

a. MIRO Industries.
b. **<Insert manufacturer's name.>**

D. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.

1. Manufacturers:

   a. ERICO/Michigan Hanger Co.
   b. MIRO Industries.
   c. Portable Pipe Hangers.
   d. **<Insert manufacturer's name.>**

2. Base: [**Plastic**] [**Stainless steel**].
3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.

1. Manufacturers:

   a. Portable Pipe Hangers.
   b. **<Insert manufacturer's name.>**

2. Bases: One or more plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe support made from structural-steel shape, continuous-thread rods, and rollers for mounting on permanent stationary roof curb.

2.10 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

2.11 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

C. Hanger Rods: ASTM A 575, hot rolled Steel, ANSI B1.1 threads, continuously threaded, with electro-galvanized finish.

D. Steel Pipe Columns: ASTM A 53, Schedule 40, black steel.

E. Bolts and Nuts: ASTM A 307, Grade A, regular hexagon-head type.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Metal Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

C. Fiberglass Pipe Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.

D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.

E. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled fiberglass struts.

F. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

G. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

H. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Division 07 Section "Roof Accessories" for curbs.

I. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

J. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

K. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

L. Install lateral bracing with pipe hangers and supports to prevent swaying.

M. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, [**NPS 2-1/2**] <**Insert other**> and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

N. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

O. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.

P. Insulated Piping: Comply with the following:

1. Attach clamps and spacers to piping.

   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate insulation.
6. Inserts of length at least as long as protective shield.
7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

Q. Outdoor Piping: Pipe hangers, supports and hardware including screws, bolts, nuts, and washers, located outdoors shall be hot-dip galvanized in accordance with ASTM A123.

R. Miscellaneous Steel: Provide miscellaneous framing, steel members, beams, brackets, etc. for support of work in Division, unless specifically included in other Divisions.

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for [**trapeze pipe hangers**] [**and**] [**equipment supports**].

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1M procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to [**1-1/2 inches**] <**Insert other**>.

3.5 PAINTING

A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 [**painting Sections.**] [**Section "High-Performance Coatings."**]

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel [**pipe hangers and supports**] [**metal trapeze pipe hangers**] [**and**] [**metal framing systems**] and attachments for general service applications.

F. Use [**stainless-steel pipe hangers**] [**and**] [**fiberglass pipe hangers**] [**and**] [**fiberglass strut systems**] and [**stainless-steel**] [**or**] [**corrosion-resistant**] attachments for hostile environment applications.

G. Use copper-plated pipe hangers and [**copper**] [**or**] [**stainless-steel**] attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 1050 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.

14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange or carbon-steel plate and with U-bolt to retain pipe.
16. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 24, if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.

9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

P. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.

Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

R. Use [**powder-actuated fasteners**] [**or**] [**mechanical-expansion anchors**] instead of building attachments where required in concrete construction.

S. Supports of wire rope, wood, chain, strap perforated bar or any other makeshift device shall not be permitted.

END OF SECTION 23 0529

SECTION 23 0548

VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Isolation pads.
2. Isolation mounts.
3. Restrained elastomeric isolation mounts.
4. [**Freestanding**] [**Restrained**] [**Freestanding and restrained**] spring isolators.
5. Housed spring mounts.
6. Elastomeric hangers.
7. Spring hangers.
8. Spring hangers with vertical-limit stops.
9. Pipe riser resilient supports.
10. Resilient pipe guides.
11. [**Freestanding**] [**Restrained**] [**Freestanding and restrained**] air-mounting system.
12. Restrained vibration isolation roof-curb rails.
13. Seismic snubbers.
14. Restraining braces and cables.
15. [**Steel**] [**Inertia**] [**Steel and inertia**], vibration isolation equipment bases.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

D. ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers.

E. Life Safety and Hazardous Components - All systems involved with fire protection including sprinkler piping, fire pumps, jockey pumps, fire pump control panels, service water supply piping, water tanks, fire dampers and smoke exhaust systems and mechanical, electrical, plumbing or fire protection systems that support the operation of or are connected to emergency power equipment including all lighting, generators, transfer switches and transformers. Hazardous components include any pipe, vessel, duct or piece of equipment that contains flammable or toxic material.

F. Component – a part or element of an architectural, mechanical, electrical or structural system.

G. Positive Attachment – a cast in place anchor, a drill in wedge anchor, a chemical anchor, a double sided beam clamp loaded perpendicular to the beam or a welded or bolted connection to the structure.

H. Special Inspection – inspection of the materials, installation, fabrication or placement of components and anchorage.

1.4 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Values as specified from Project structural engineer and applicable code.

B. Seismic-Restraint Loading:

1. Values as specified from Project structural engineer and applicable code.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

    a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by [**an evaluation service member of ICC-ES**] [**OSHPD**] [**an agency acceptable to authorities having jurisdiction**].
    b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.
4. Catalog cuts and data sheets on specific vibration isolators and restraints to be utilized showing compliance with specifications.
5. An itemized list showing the items of equipment or piping to be isolated, the isolator type and model number selected, isolator loading and deflection, and reference to specific drawings showing base and construction where applicable.
6. Seismic restraint calculations and structural or civil engineers stamp verifying design and calculations for seismic restraining system used.
7. Drawings showing equipment base construction for each piece of equipment, including dimensions, structural member sizes and support point locations.
8. Drawing showing methods of suspension, support guides for piping.
9. Drawings showing methods for isolation of pipes piercing walls and slabs.
10. Concrete and steel details for bases including anchor bolt locations.
11. Number and location of seismic restraints and anchors for each piece of equipment.
12. Specific details of restraints including anchor bolts for mounting and maximum loading at each location, for each piece of equipment and or pipe.

B. Substitution of seismic control products is subject to Office of State Architect (O.S.A.) approval (California projects only).

C. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic[**and wind**] forces required to select vibration isolators, seismic[**and wind**] restraints, and for designing vibration isolation bases.

    a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Division 22 Sections for equipment mounted outdoors.

2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.
4. Seismic[**- and Wind**]-Restraint Details:

    a. Design Analysis: To support selection and arrangement of seismic[**and wind**] restraints. Include calculations of combined tensile and shear loads.
    b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
    c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Division 22 Sections for equipment mounted outdoors.
    d. Preapproval and Evaluation Documentation: By [**an evaluation service member of ICC-ES**] [**OSHPD**] [**an agency acceptable to authorities having jurisdiction**], showing maximum ratings of restraint items and the basis for approval (tests or calculations).

D. Coordination Drawings: Show coordination of seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

E. Welding certificates.

F. Qualification Data: For [**professional engineer**] [**and**] [**testing agency**].

G. Air-Mounting System Performance Certification: Include natural frequency, load, and damping test data[**performed by an independent agency**].

H. Field quality-control test reports.

I. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

E. It is the objective of this Specification to provide the necessary design for the seismic restraint and control of excessive noise and vibration in the buildings due to the operation of machinery or equipment, and/or due to interconnected piping. The installation of all vibration isolation units, and associated hangers and bases, shall be under the direct supervision of the vibration isolation manufacturer's representatives.

1. All vibration isolators shall have either known undeflected heights or calibration markings so that, after adjustment when carrying their load, the deflection under load can be verified, thus determining that the load is within the proper range of the device and that the correct degree of vibration isolation ins being provided according to the design.
2. All isolators shall operate in the linear portion of their load versus deflection curve. Load versus deflection curves shall be furnished by the manufacturer, and must be linear over a deflection range of not less than 50 percent above the design deflection.
3. The theoretical vertical natural frequency for each support point, based upon load per isolator and isolator stiffness, shall not differ from the design objectives for the equipment as whole by more than plus or minus 10 percent.
4. All neoprene mountings shall have a shore hardness of 30 to 60 plus or minus 5, after minimum aging of 20 days or corresponding oven aging.

1.7 MANUFACTURER RESPONSIBILITIES

A. Manufacturer of vibration isolation and seismic control equipment shall have the following responsibilities:

1. Determine vibration isolation and seismic restraint sizes and locations.
2. Provide piping and equipment isolation systems and seismic restraints as scheduled or specified.
3. Guarantee specified isolation system deflection.
4. Provide installation instructions, drawings and field supervision to assure proper installation and performance.
5. Purchased and/or fabricated equipment must be designed to safely accept external forces of **[one-half] [edit value as required for project]** "G" load in any direction for all rigidly and resiliently supported equipment and piping without failure and permanent displacement of the equipment. Life safety equipment including, but not limited to, fire pumps, sprinkler piping, and machinery must be capable of safely accepting external forces up to **[one] [edit value as required for project]** "G" load in any direction without permanent displacement of the supported equipment. Substitution of "Internally Isolated" mechanical equipment in lieu of the specified isolation of this Section must be approved for individual equipment units and is acceptable only if above accelerations are certified in writing by equipment manufacturer and stamped by a licensed civil or structural engineer.

1.8 CONTRACTOR RESPONSIBILITIES

A. The Contractor performing the work on equipment in the section shall have the following responsibilities.

1. Identify the components that are part of the Quality Assurance Plan.
2. All electrical components for standby or emergency power systems.
3. All flammable, combustible and highly toxic piping and their associated mechanical systems.
4. All ductwork containing hazardous materials.
5. All equipment using combustible or toxic energy sources.
6. Identify all Special inspection and Testing.
7. List control procedures within the contractor's organization including methods and frequency of reporting and their distribution.
8. List personnel and their qualifications exercising control over the seismic aspects of the project.
9. Purchased and/or fabricated equipment must be designed to safely accept external forces of **[one] [edit value as required for project]** g load in any direction for all rigidly and resiliently supported life safety or hazardous equipment components, piping and ductwork without failure and permanent displacement of the equipment.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Amber/Booth Company, Inc.
2. Kinetics Noise Control.
3. Mason Industries.
4. Vibration Eliminator Co., Inc.
5. Vibration Mountings & Controls, Inc.
6. <**Insert manufacturer's name**>.

B. Vibration Isolator Types:

1. Type A: Spring isolators shall incorporate the following:

    a. Minimum diameter of 0.8 of the loaded operating height.
    b. Corrosion resistance where exposed to corrosive environment with:

        1) Springs cadmium plated or electro-galvanized.
        2) Hardware cadmium plated.
        3) All other metal parts hot-dip galvanized.

    c. Reserve deflection (from loaded to solid height) of 50 percent of rated deflection.
    d. Minimum 1/4 inch thick neoprene acoustical base pad on underside, unless designated otherwise.
    e. Designed and installed so that ends of springs remain parallel and all springs installed with adjustment bolts.
    f. Non-resonant with equipment forcing frequencies or support structure natural frequencies.
    g. Spring isolators to be Mason Type SLF, or as approved.
    h. This isolator must be accompanied by seismic isolator Type II.

2. Type B: Spring isolators shall be same as Type A, except:

a. Provide built-in vertical limit stops with minimum 1/4 inch clearance under normal operation.
b. Tapped holes in top plate for bolting to equipment when subject to wind load.
c. Capable of supporting equipment at a fixed elevation during equipment erection. Installed and operating heights shall be identical.
d. Adjustable and removable spring pack with separate neoprene pad isolation.
e. Housing shall be designed to accept 1 G of acceleration.
f. Mason Type SLR, or as approved.

3. Type C: Spring hanger rod isolators shall incorporate the following:

a. Spring element seated on a steel washer within a neoprene cup incorporating a rod isolation bushing.
b. Steel retainer box encasing the spring and neoprene cup.
c. Requires seismic restraint Type III.
d. Mason Type HS, or as approved.

4. Type E: Elastomer hanger rod isolators shall be incorporate the following:

a. Molded unit type neoprene element with projecting bushing lining rod clearance hole.
b. Neoprene element shall be minimum 1-3/4 inch thick.
c. Steel retainer box encasing neoprene mounting.
d. Clearance between mounting hanger rod and neoprene bushing shall be minimum of 1/8 inch.
e. Requires seismic restraint Type III.
f. Mason Type HD, or as approved.

5. Type F: Combination spring/elastomer hanger rod isolators to incorporate the following:

a. Spring and neoprene isolator elements in a steel box retainer. Neoprene of double deflection type. Single deflection is unacceptable. Spring seated in a neoprene cup with extended rod bushing.
b. Characteristics of spring and neoprene as describe in Type A and Type E isolators.
c. Requires seismic restraint Type III.
d. Mason Type 30N, or as approved.

6. Type G: Pad type elastomer mountings to incorporate the following:

a. 0.750 inch minimum thickness.
b. 50 psi maximum loading.
c. Ribbed or waffled design.
d. 0.10 inch deflection per pad thickness.
e. 1/16 inch galvanized steel plate between multiple layers or pad thickness.
f. Suitable bearing plate to distribute load.
g. Mason Type Super W, or as approved.

7. Type H: Pad type elastomer mountings to incorporate the following:

a. Laminate canvas duck and neoprene.
b. Maximum loading 1000 psi.
c. Suitable bearing plate to distribute load.
d. Minimum thickness, 1/2 inch.
e. Mason Type HL, or as approved.

8. Type J: Rail type spring isolators:

a. Rail type spring isolators shall provide steel members of sufficient strength to prevent flexure with equipment operation.
b. Springs shall be the same as Type A with seismic restraint Type II or seismic restraint Type I isolation.
c. Mason Type ICS, or equal.

9. Type K: Pipe anchors:

a. Vibration isolator manufacturer shall provide an all directional acoustical pipe anchor, consisting of a telescopic arrangement of two sizes of steel tubing separated by a minimum half inch thickness of heavy duty neoprene and duck or neoprene isolation material.
b. Vertical restraints shall be provided by similar material arranged to prevent vertical travel in either direction.
c. Allowable loads on the isolation material shall not exceed 500 psi and the design shall be balanced for equal resistance in any direction.
d. Mason Type ADA, or as approved.

2.2 AIR-MOUNTING SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Kinetics Noise Control.
2. Mason Industries.
3. Vibration Eliminator Co., Inc.
4. <**Insert manufacturer's name**>.

B. Air Mounts <**Insert drawing designation**>: Freestanding, single or multiple, compressed-air bellows.

1. Assembly: Upper and lower steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows.
2. Maximum Natural Frequency: 3 Hz.
3. Operating Pressure Range: 25 to 100 psig.
4. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
5. Leveling Valves: Minimum of 3 required to maintain leveling within plus or minus 1/8 inch.

C. Restrained Air Mounts <**Insert drawing designation**>: Housed compressed-air bellows.

1. Assembly: Upper and lower steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows and spring, with angle-iron frame having vertical-limit stops and channel-section top with leveling adjustment and attachment screws.
2. Maximum Natural Frequency: 3 Hz.
3. Operating Pressure Range: 25 to 100 psig.
4. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
5. Leveling Valves: Minimum of 3 required to maintain leveling within plus or minus 1/8 inch.

2.3 VIBRATION ISOLATION EQUIPMENT BASES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Amber/Booth Company, Inc.
2. Kinetics Noise Control.
3. Mason Industries.
4. Vibration Eliminator Co., Inc.

5. Vibration Mountings & Controls, Inc.
6. **<Insert manufacturer's name>**.

B. Type B-1: Integral Structural Steel Base

1. Reinforced, as required, to prevent base flexure at start-up and misalignment of drive and driven units. Centrifugal fan bases complete with motor slide rails. Drilled for drive and driven unit mounting template.
2. Mason Type M, WF, or as approved.

C. Type B-2: Concrete Inertia Base

1. Concrete inertia bases shall be formed in a structural steel perimeter base, reinforced as required to prevent flexure, misalignment of drive and driven unit or stress transferal into equipment. The base shall be complete with motor slide rails, pump base elbow supports, and complete with height saving brackets, reinforcing, equipment bolting provisions and isolators.
2. Minimum thickness of the inertia base shall be according to the following tabulation:

Motor Size		Minimum Thickness	
(hp)	(kW)	(in)	(mm)
5-15	(4-11)	6	(150)
20-50	(15-37)	8	(200)
60-75	(45-55)	10	(250)
100-250	(75-190)	12	(300)
300-500	(220-375)	18	(350)

3. Mason Type K, BMK, or as approved.

D. Type B-3: Curb Mounted Base

1. Curb mounted rooftop equipment shall be mounted on spring isolation curbs that directly sit on roof construction and are flashed and incorporated into roof's membrane waterproofing system.
2. All spring locations shall have removable waterproof covers to allow for spring adjustment and/or removal.
3. All spring mounts shall be as Isolator Type B.
4. Curb and spring mounting shall be capable of withstanding 110mph wind and 1.0 g seismic loads for life safety or hazardous components.
5. Curbs shall be Mason Type CMAB or RSC (depending on deflection required), or approved equal.

E. Type B-4: Vaneaxial Fan Built-Up Casing Floating Base

1. The vaneaxial fan casing, coils, filter assembly and inlet/discharge silencers shall be erected on top of a poured-in-place, reinforced concrete floating floor supported on Mason Industries Type EAFM 2" (50 mm) high mounting system, or as approved.
2. The mountings shall be oriented in the floating floor base for the weight and weight distribution of the supported equipment (casing, coils, filter silencers) on the floating floor.
3. The plywood form shall be Type AC exterior grade, 2" (12 mm), thick. Isolation mounts shall be 2" (50 mm), thick and shall be selected and oriented to provide deflections not exceeding 0.3" (7.5 mm) or 10 Hz frequency.
4. The fans shall be resiliently spring supported, and as described elsewhere, from concrete piers erected from the structural slab and isolated from the floating floor.
5. The design and installation of the vaneaxial fan built-up casing floating floor and fan isolation shall be coordinated with the vibration control vendor such that there will be no short circuit of the floating built-up casing base and the building structure.
6. Requires seismic restraint type II for life safety or hazardous components.

2.4 SEISMIC-RESTRAINT DEVICES

A. Type I: Spring Incorporating Seismic Restraint

1. Shall comply with general characteristics of spring isolators.
2. Shall have vertical restraints and are capable of supporting equipment at fixed elevation during equipment erection. Vertical restraint shall be separate from equipment load support.
3. Shall incorporate seismic snubbing restraint in all directions at specified acceleration loadings.
4. System to be field bolted to structure with minimum capability to withstand external forces of [1.0 g] [edit per project requirements].
5. Mason Type SSLR, or as approved

B. Type II: Stationary Seismic Restraint

1. Each corner or side seismic restraint shall incorporate minimum 5/8" (16 mm) thick pad limit stops. Restraints shall be made of plate, structural members or square metal tubing in a welded assembly, incorporating resilient pads. Angle bumpers are not acceptable. System to be field bolted to deck with 1.0 g acceleration capacity.
2. Seismic spring mountings as described above are an acceptable alternative providing all seismic loading requirements are met.
3. Mason Industries Type Z-1011, Type Z-1225, or as approved.

C. Type III: Cable Seismic Restraint,

1. Metal cable type with approved end fastening devices to equipment and structure. System to be field bolted to deck or overhead structural members or deck with aircraft cable and clamps as per SMACNA guidelines.

D. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by [**an evaluation service member of ICC-ES**] [**OSHPD**] [**an agency acceptable to authorities having jurisdiction**].

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least [**four**] <**Insert number**> times the maximum seismic forces to which they will be subjected.

E. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

F. Restraint Cables: [**ASTM A 603 galvanized**] [**ASTM A 492 stainless**]-steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

G. Hanger Rod Stiffener: [**Steel tube or steel slotted-support-system sleeve with internally bolted connections**] [**Reinforcing steel angle clamped**] to hanger rod.

H. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

I. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

J. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

K. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

L. Adhesive Anchor Bolts: **Adhesive anchor bolts are not permitted where seismic restraint is required**. Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.5 FLEXIBLE CONNECTORS

A. Elastomer Type FC-1:

1. Manufactured of nylon tire cord and EPDM both molded and cured with hydraulic presses.
2. Straight connectors shall have two spheres reinforced with a molded-in external ductile iron ring between spheres.
3. Elbow shall be long radius reducing type.
4. Rated 250 psi at 170 degrees F dropping in a straight line to 170 psi at 250 degrees F for sizes 1-1/2 inch to 12 inch elbows. Elbows shall be rated no less than 90 percent of straight connections.
5. Sizes 10 inches to 12 inches to employ control cables with neoprene end fittings isolated from anchor plates by means of 1/2 inch bridge bearing neoprene bushings.
6. Minimum safety factor, 4 to 1 at maximum pressure ratings.
7. Submittals shall include test reports.
8. Mason Type MFTNC Superflex.

B. Flexible Stainless Hose, Type FC-2:

1. Braided flexible metal hose.
2. 2 inch pipe size and smaller with male nipple fittings.
3. 2-1/2 inch and larger pipe size with fixed steel flanges.
4. Suitable for operating pressure with 4 to 1 minimum safety factor.
5. Length as required or shown on drawings.
6. Mason Type BSS, or as approved.

2.6 FACTORY FINISHES

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.
2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
3. Baked enamel or powder coat for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and seismic[**- and wind**]-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic[**- and wind**]-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by [**an evaluation service member of ICC-ES**] [**OSHPD**] [**an agency acceptable to authorities having jurisdiction**].

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

B. Equipment Restraints:

1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
3. Install seismic-restraint devices using methods approved by [**an evaluation service member of ICC-ES**] [**OSHPD**] [**an agency acceptable to authorities having jurisdiction**] providing required submittals for component.

C. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of [**40 feet**] <**Insert dimension**> o.c., and longitudinal supports a maximum of [**80 feet**] <**Insert dimension**> o.c.
3. Brace a change of direction longer than 12 feet.

D. Install cables so they do not bend across edges of adjacent equipment or building structure.

E. Install seismic-restraint devices using methods approved by [**an evaluation service member of ICC-ES**] [**OSHPD**] [**an agency acceptable to authorities having jurisdiction**] providing required submittals for component.

F. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

I. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Division 22 Section "Hydronic Piping" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: [**Owner will engage**] [**Engage**] a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least [**four**] <**Insert number**> of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.

6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. Air-Mounting System Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
10. Air-Mounting System Operational Test: Test the compressed-air leveling system.
11. Test and adjust air-mounting system controls and safeties.
12. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust air-spring leveling mechanism.

D. Adjust active height of spring isolators.

E. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems. Refer to Division 01 Section "Demonstration And Training."

3.8 HVAC VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE SCHEDULE

A. As scheduled on drawings.

1. Equipment Location: <**Insert room number**>.
2. Pads:
   a. Material: [**Neoprene**] [**Rubber**] [**Hermetically sealed compressed fiberglass**].
   b. Thickness: <**Insert inches**>.
   c. Number of Pads: <**Insert number**> thick.
3. Isolator Type: <**Insert generic name or designation used in Part 2**>.
4. Base Type: <**Insert generic name or designation used in Part 2**>.
5. Minimum Deflection: <**Insert inches**>.
6. Component Importance Factor: [**1.0**] [**1.5**].
7. Component Response Modification Factor: [**1.5**] [**2.5**] [**3.5**] [**5.0**].
8. Component Amplification Factor: [**1.0**] [**2.5**].

Equipment	Base Type	Isolator Type	Minimum Static Deflection (inches)	Seismic Restraint Type (if part of life safety or hazardous component)
Roof Mounted Air Handling Units	B-3	A	1.0	II
Floor Mounted Centrifugal Fans	B-1	A	1.0	II
Floor Mounted Tubular Fans	--	A	1.0	II
Ceiling Suspended Fan vent Sets	B-1	C	1.0	III
Ceiling Suspended Tubular Fans	--	C	1.0	III
Pumps	B-2	A	1.0	II
Generators	--	B	1.0	I
Cooling Towers	B-1	B	2.0	I

END OF SECTION 23 0548

SECTION 23 0553

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.
5. Stencils.
6. Valve tags.
7. Access Tile Identification.
8. Warning tags.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated, manufacturer's catalog data, including size, color and materials.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 QUALITY ASSURANCE

A. Comply with ASME A 13.1 "Scheme for the Identification of Piping Systems."

1.5 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: [**Brass, 0.032-inch**] [**Stainless steel, 0.025-inch**] [**Aluminum, 0.032-inch**] [**or**] [**anodized aluminum, 0.032-inch**] minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless-steel [**rivets**] [**rivets or self-tapping screws**] [**self-tapping screws**].
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, [**1/16 inch**] [**1/8 inch**] <**Insert dimension**> thick, and having predrilled holes for attachment hardware.
2. Letter Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.
3. Background Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel [**rivets**] [**rivets or self-tapping screws**] [**self-tapping screws**].
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, [**1/16 inch**] [**1/8 inch**] <**Insert dimension**> thick, and having predrilled holes for attachment hardware.

B. Letter Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.

C. Background Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel [**rivets**] [**rivets or self-tapping screws**] [**self-tapping screws**].

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to [**partially cover**] [**cover full**] circumference of pipe and to attach to pipe without fasteners or adhesive.

1. NPS 5 (DN 125) and smaller: Attach to pipe without fasteners or adhesive.
2. NPS 6 (DN 150) and larger: Attach to pipe with stainless steel spring fasteners.

C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches high.

D. Maximum Temperature: Able to withstand temperatures up to 180 deg F (83 deg C).

2.4 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, [**1/16 inch**] [**1/8 inch**] <**Insert dimension**> thick, and having predrilled holes for attachment hardware.

B. Letter Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.

C. Background Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel [**rivets**] [**rivets or self-tapping screws**] [**self-tapping screws**].

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches high.

2.5 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.

1. Stencil Material: [**Aluminum**] [**Brass**] [**Fiberboard**] [**Fiberboard or metal**] <**Insert material**>.
2. Stencil Paint: Exterior, gloss, [**alkyd enamel**] [**acrylic enamel**] <**Insert paint type**> black unless otherwise indicated. Paint may be in pressurized spray-can form.
3. Identification Paint: Exterior, [**alkyd enamel**] [**acrylic enamel**] <**Insert paint type**> in colors according to ASME A13.1 unless otherwise indicated.

2.6 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: [**Brass, 0.032-inch**] [**Stainless steel, 0.025-inch**] [**Aluminum, 0.032-inch**] [**or**] [**anodized aluminum, 0.032-inch**] minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass [**wire-link or beaded chain; or S-hook**] [**wire-link chain**] [**beaded chain**] [**S-hook**].

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.7 ACCESS TILE IDENTIFICATION

A. Buttons, tabs, and markers: To identify location of concealed work.

B. Type: As approved by Architect.

2.8 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: [**3 by 5-1/4 inches minimum**] [**Approximately 4 by 7 inches**] <**Insert size**>.
2. Fasteners: [**Brass grommet and wire**] [**Reinforced grommet and wire or string**].
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Division 09 Section "[**Interior Painting**] [**High-Performance Coatings**]."

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels [**with painted, color-coded bands or rectangles**] [**, complying with ASME A13.1,**] on each piping system.

1. Identification Paint: Use for contrasting background.
2. Stencil Paint: Use for pipe marking.

C. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of [**50 feet**] <**Insert dimension**> along each run. Reduce intervals to [**25 feet**] <**Insert dimension**> in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

D. Pipe Label Color Schedule:

1. Chilled-Water Piping:

    a. Background Color: **[Black] [Blue] [Green] [Red] [White] [Yellow] <Insert color>**.
    b. Letter Color: **[Black] [Blue] [Red] [White] [Yellow] <Insert color>**.

2. Condenser-Water Piping:

    a. Background Color: **[Black] [Blue] [Green] [Red] [White] [Yellow] <Insert color>**.
    b. Letter Color: **[Black] [Blue] [Red] [White] [Yellow] <Insert color>**.

3. Heating Water Piping:

    a. Background Color: **[Black] [Blue] [Red] [White] [Yellow] <Insert color>**.
    b. Letter Color: **[Black] [Blue] [Red] [White] [Yellow] <Insert color>**.

4. Refrigerant Piping:

    a. Background Color: **[Black] [Blue] [Green] [Red] [White] [Yellow] <Insert color>**.
    b. Letter Color: **[Black] [Blue] [Red] [White] [Yellow] <Insert color>**.

5. Chemical Feed Piping:

    a. Background Color: **[Black] [Blue] [Green] [Red] [White] [Yellow] <Insert color>**.
    b. Letter Color: **[Black] [Blue] [Red] [White] [Yellow] <Insert color>**.

6. Vent and Relief Piping:

    a. Background Color: **[Black] [Blue] [Green] [Red] [White] [Yellow] <Insert color>**.
    b. Letter Color: **[Black] [Blue] [Red] [White] [Yellow] <Insert color>**.

7. City Water Piping:

    a. Background Color: **[Black] [Blue] [Green] [Red] [White] [Yellow] <Insert color>**.
    b. Letter Color: **[Black] [Blue] [Red] [White] [Yellow] <Insert color>**.

3.4 DUCT LABEL INSTALLATION

A. Install **[plastic-laminated] [self-adhesive]** duct labels with permanent adhesive on air ducts in the following color codes:

    1. **[Blue] <Insert color>**: For cold-air supply ducts.
    2. **[Yellow] <Insert color>**: For hot-air supply ducts.
    3. **[Green] <Insert color>**: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
    4. ASME A13.1 Colors and Designs: For hazardous material exhaust.

B. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 1 inch high is needed for proper identification because of distance from normal location of required identification.

C. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of **[50 feet] <Insert dimension>** in each space where ducts are exposed or concealed by removable ceiling system.

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:

   a. Chilled Water: **[1-1/2 inches]** [**2 inches**], **[round]** **[square]** <**Insert shape**>.
   b. Condenser Water: **[1-1/2 inches]** [**2 inches**], **[round]** **[square]** <**Insert shape**>.
   c. Refrigerant: **[1-1/2 inches]** [**2 inches**], **[round]** **[square]** <**Insert shape**>.
   d. Hot Water: **[1-1/2 inches]** [**2 inches**], **[round]** **[square]** <**Insert shape**>.
   e. Gas: **[1-1/2 inches]** [**2 inches**], **[round]** **[square]** <**Insert shape**>.
   f. Chemical Feed: **[11/2 inches]** [**2 inches**], **[round]** **[square]** <**Insert shape**>.
   g. Vent and Relief: **[1-1/2 inches]** [**2 inches**], **[round]** **[square]** <**Insert shape**>.
   h. City Water: **[1-1/2 inches]** [**2 inches**], **[round]** **[square]** <**Insert shape**>.

2. Valve-Tag Color:

   a. Chilled Water: **[Natural]** **[Green]** <**Insert color**>.
   b. Condenser Water: **[Natural]** **[Green]** <**Insert color**>.
   c. Refrigerant: **[Natural]** **[Green]** <**Insert color**>.
   d. Hot Water: **[Natural]** **[Green]** <**Insert color**>.
   e. Gas: **[Natural]** **[Yellow]** <**Insert color**>.
   f. Chemical Feed: **[Natural]** **[Green]** <**Insert color**>.
   g. Vent and Relief: **[Natural]** **[Green]** <**Insert color**>.
   h. **[**City Water: **[Natural]** **[Green]** <**Insert color**>.

3. Letter Color:

   a. Chilled Water: **[Black]** **[White]** <**Insert color**>.
   b. Condenser Water: **[Black]** **[White]** <**Insert color**>.
   c. Refrigerant: **[Black]** **[White]** <**Insert color**>.
   d. Hot Water: **[Black]** **[White]** <**Insert color**>.
   e. Gas: **[Black]** **[White]** <**Insert color**>.
   f. Chemical Feed: **[Black]** **[White]** <**Insert color**>.
   g. Vent and Fill: **[Black]** **[White]** <**Insert color**>.
   h. City Water: **[Black]** **[White]** <**Insert color**>.

3.6 ACCESS TILE IDENTIFICATION

A. Install buttons, tabs, or markers, where removable ceiling tiles are provided, to identify location of:

1. Valves.
2. Volume dampers.
3. Terminal Units.
4. Other concealed equipment requiring access.

3.7 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 23 0553

SECTION 23 0593

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

1.2 SUMMARY

A. This Section includes the providing of labor, materials, equipment, and services necessary for complete testing, adjusting, balancing (TAB) **[and Controlled Inspections]** of all heating, ventilating and air conditioning systems in accordance with the contract documents and all applicable codes and authorities having jurisdiction, for the following:
   1. Air Systems: Balancing of air distribution systems including supply, return and exhaust systems, condensing units, all fan-coils and related equipment for:
      a. Constant-volume air systems.
      b. Dual-duct systems.
      c. Variable-air-volume systems.
      d. Terminal devices for HVAC systems.
   2. Hydronic Piping Systems: Testing and balancing, including pumps, chillers, boilers, heat exchangers, coils, and all related equipment for:
      a. Constant-flow systems.
      b. Variable-flow systems.
      c. Primary-secondary systems.
   3. HVAC equipment quantitative-performance settings.
   4. Space pressurization testing and adjusting.
   5. Vibration measuring.
   6. Sound level measuring.
   7. Indoor-air quality measuring.
   8. Existing systems TAB.
      a. Recording flow of existing air and water systems which are to remain.
      b. Rebalancing and adjusting of existing systems.
   9. Verifying that automatic control devices are functioning properly.
   10. Reporting results of activities and procedures specified in this Section.
   11. Required Controlled Inspection, including Equipment Use Permits.

1.3 DEFINITIONS

A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.

C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.

D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

E. NC: Noise criteria.

F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

G. RC: Room criteria.

H. Report Forms: Test data sheets for recording test data in logical order.

I. Smoke-Control System: An engineered system that uses fans to produce airflow and pressure differences across barriers to limit smoke movement.

J. Smoke-Control Zone: A space within a building that is enclosed by smoke barriers and is a part of a zoned smoke-control system.

K. Stair Pressurization System: A type of smoke-control system that is intended to positively pressurize stair towers with outdoor air by using fans to keep smoke from contaminating the stair towers during an alarm condition.

L. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

M. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

N. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

O. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

P. TAB: Testing, adjusting, and balancing.

Q. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

R. Test: A procedure to determine quantitative performance of systems or equipment.

S. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.4 SUBMITTALS

A. LEED Submittals:
   1. Air Balance Report for Prerequisite EQ 1: Documentation of work performed for ASHRAE 62.1-latest edition, Section 7.2.2 - "Air Balancing."
   2. TAB Report for Prerequisite EQ 1: Documentation of work performed for ASHRAE/IESNA 90.1-latest edition, Section 6.7.2.3 - "System Balancing."

B. Qualification Data: Within [**15**] [**30**] [**45**] days from Contractor's Notice to Proceed, submit [**2**] [**4**] [**6**] copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article. Contractor shall also submit Form TR 1 listing person designated to perform controlled inspection so as not to impede the obtaining of required building permits.

C. Contract Documents Examination Report: Within [**15**] [**30**] [**45**] days from Contractor's Notice to Proceed, submit [**2**] [**4**] [**6**] copies of the Contract Documents review report as specified in Part 3.

D. Strategies and Procedures Plan: Within [**30**] [**60**] [**90**] days from Contractor's Notice to Proceed, submit [**2**] [**4**] [**6**] copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.

E. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.

F. Sample Report Forms: Submit two sets of sample TAB report forms.

G. Warranties specified in this Section.

H. At least fifteen (15) days prior to starting field work, submit three (3) copies of report forms filled out, including design flow values, installed equipment pressure drops and required air flow for air terminals. Submit a complete list of instruments proposed to be used, organized in appropriate categories and include data sheets for each. Indicate each manufacturer and model number, description and use when needed to further identify instrument, size or capacity range and latest calibration date.
   1. Architect/Engineer will review submittals for compliance with Contract Documents, and will return one set marked to indicate discrepancies noted between data shown and Contract Documents, additional, or more accurate, instruments required and requests for recalibration of specific instruments.
   2. Submit proposed method of balancing variable air volume systems to account for system diversity.

1.5 QUALITY ASSURANCE

A. TAB Firm Qualifications: Engage a TAB firm certified by [**AABC**] [**NEBB**] [**TABB**] [**AABC, NEBB, or TABB**].

   1. Furnish documentation that TAB firm is a member of one of the noted entities and that it has satisfactorily balanced at least three systems of comparable type and size of this project. Include list of such projects. TAB contractor shall be a certified member of the Testing Adjusting and Balancing Bureau (TABB) or the National Environmental Balancing Bureau (NEBB).
   2. The controlled inspection shall be performed by an independent registered professional engineer who is covered by both professional liability insurance and general comprehensive liability insurance acceptable to the Architect.

B. TAB Conference: Meet with Owner's and Architect's representatives on approval of TAB strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of TAB team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide seven days' advance notice of scheduled meeting time and location.
   1. Agenda Items: Include at least the following:
      a. Submittal distribution requirements.
      b. The Contract Documents examination report.
      c. TAB plan.
      d. Work schedule and Project-site access requirements.
      e. Coordination and cooperation of trades and subcontractors.

f. Coordination of documentation and communication flow.

C. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:
1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard forms from [**AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems."**] [**NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."**] [**SMACNA's TABB "HVAC Systems - Testing, Adjusting, and Balancing."**] [**TAB firm's forms approved by Architect.**] [**TABB "Contractors Certification Manual."**]

E. Instrumentation Type, Quantity, and Accuracy: As described in [**AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems**] [**NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification**]."

F. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.
1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

G. ASHRAE Compliance: Applicable requirements in the latest edition of ASHRAE 62.1-, Section 7.2.2 - "Air Balancing."

H. ASHRAE/IESNA 90.1 Latest Edition Compliance: Applicable requirements in the latest edition of ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

I. Controlled Inspection: Shall be performed by an independent, licensed, registered professional engineer who is covered by both professional liability insurance and general liability insurance acceptable to the Engineer.

1.6 PROJECT CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.7 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.8 WARRANTY

A. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:
1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
2. Systems are balanced to optimum performance capabilities within design and installation limits.

B. Special Guarantee: Provide a guarantee on [**NEBB**] [**TABB**] forms stating that [**NEBB**] [**TABB**] will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee shall include the following provisions:
1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
1. Contract Documents are defined in the General and Supplementary Conditions of Contract.
2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine Project Record Documents described in Division 01 Section "Project Record Documents."

D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

K. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.

L. Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

M. Examine strainers for clean screens and proper perforations.

N. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

O. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

P. Examine system pumps to ensure absence of entrained air in the suction piping.

Q. Examine equipment for installation and for properly operating safety interlocks and controls.

R. Examine automatic temperature system components to verify the following:
   1. Dampers, valves, and other controlled devices are operated by the intended controller.
   2. Dampers and valves are in the position indicated by the controller.
   3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
   4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
   5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
   6. Sensors are located to sense only the intended conditions.
   7. Sequence of operation for control modes is according to the Contract Documents.
   8. Controller set points are set at indicated values.
   9. Interlocked systems are operating.
   10. Changeover from heating to cooling mode occurs according to indicated values.

S. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values. Submit report recommending addition and/or relocation of balancing devices, including, but not limited to, volume dampers, balancing valves, flow metering devices for air and water, and pressure and temperature measuring points.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:

1. Permanent electrical power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.
9. Ensure that special equipment such as computers, laboratory equipment, and electronic equipment are in full operation.

C. Dummy Loads: [**Include if applicable**]
1. When operation testing is performed before final computer, laboratory and other equipment are installed, provide temporary electric heat loads in rooms, at no extra cost to Owner. Capacity of heating devices shall be such as to equal full heat gain in rooms, with exact capacity and location as directed by the Architect. Provide heating devices, wiring, connecting fittings compatible with electric circuits, operating and safety controls and other devices, as required. Other heating mediums than electrical may be proposed for approval by Architect.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in [**ASHRAE 111**] [**AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems"**] [**NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems"**] [**SMACNA's TABB "HVAC Systems - Testing, Adjusting, and Balancing"**] and this Section.
1. Comply with requirements in the latest edition of ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

D. Take and report testing and balancing measurements in [**inch-pound (IP)**] [**metric (SI)**] [**inch-pound (IP) and metric (SI)**] units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

E. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling unit components.

L. Check for proper sealing of air duct system.

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
   1. Measure fan static pressures to determine actual static pressure as follows:
      a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
      b. Measure static pressure directly at the fan outlet or through the flexible connection.
      c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
      d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
   2. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
      a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.
   3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, under final balanced conditions.
   4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.
   5. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
   6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
   1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.

a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
2. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure terminal outlets and inlets without making adjustments.
1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.
1. Adjust each outlet in same room or space to within plus or minus 5 percent of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 PROCEDURES FOR DUAL-DUCT SYSTEMS

A. Verify that the cooling coil is capable of full-system airflow, and set mixing boxes at full-cold airflow position for fan volume.

B. Measure static pressure in both hot and cold ducts at the end of the longest duct run to determine that sufficient static pressure exists to operate mixing-box controls and to overcome resistance in the ducts and outlets downstream from mixing box.
1. If insufficient static pressure exists, increase the airflow at the fan.

C. Test and adjust the constant-volume mixing boxes as follows:
1. Verify both hot and cold operations by adjusting the thermostat and observing the air temperature and volume changes.
2. Verify sufficient inlet static pressure before making volume adjustments.
3. Adjust mixing box to indicated airflows within specified tolerances. Measure the airflow by Pitot-tube traverse readings, totaling the airflow of the outlets; or by measuring static pressure at mixing-box taps if provided by box manufacturer.

D. Remeasure static pressure in both hot and cold ducts at the end of the longest duct run to determine that sufficient static pressure exists to operate mixing-box controls and to overcome resistance in the ducts and outlets downstream from mixing box.

E. Adjust variable-air-volume, dual-duct systems in the same way as constant-volume dual-duct systems, and adjust each mixing-box maximum- and minimum-airflow settings.

3.7 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Set outside-air dampers at minimum, and return- and exhaust-air dampers at a position that simulates full-cooling load.

2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
3. Measure total system airflow. Adjust to within +10% of indicated airflow.
4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.
   a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.
7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
8. Record the final fan performance data.

C. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Balance systems similar to constant-volume air systems.
2. Set terminal units and supply fan at full-airflow condition.
3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
4. Readjust fan airflow for final maximum readings.
5. Measure operating static pressure at the sensor that controls the supply fan, if one is installed, and verify operation of the static-pressure controller.
6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.
7. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.
   a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.
8. Measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.

D. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.
2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.
3. Set terminal units at full-airflow condition.
4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.

5. Adjust terminal units for minimum airflow.
6. Measure static pressure at the sensor.
7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.

3.8 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
   1. Open all manual valves for maximum flow.
   2. Check expansion tank liquid level.
   3. Check makeup-water-station pressure gage for adequate pressure for highest vent.
   4. Check flow-control valves for specified sequence of operation and set at indicated flow.
   5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
   6. Set system controls so automatic valves are wide open to heat exchangers.
   7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
   8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.9 PROCEDURES FOR HYDRONIC SYSTEMS

A. Measure water flow at pumps. Use the following procedures, except for positive-displacement pumps:
   1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
   2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
   3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
   4. Report flow rates that are not within plus or minus 5 percent of design.

B. Set calibrated balancing valves, if installed, at calculated presettings.

C. Measure flow at all stations and adjust, where necessary, to obtain first balance.
   1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

D. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

E. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
   1. Determine the balancing station with the highest percentage over indicated flow.
   2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
   3. Record settings and mark balancing devices.

F. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

G. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.10 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.11 PROCEDURES FOR PRIMARY-SECONDARY-FLOW HYDRONIC SYSTEMS

A. Balance the primary system crossover flow first, then balance the secondary system.

3.12 PROCEDURES FOR STEAM SYSTEMS

A. Measure and record upstream and downstream pressure of each piece of equipment.

B. Measure and record upstream and downstream steam pressure of pressure-reducing valves.

C. Check the setting and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record the final setting.

D. Check the settings and operation of each safety valve. Record settings.

E. Verify the operation of each steam trap.

3.13 PROCEDURES FOR HEAT EXCHANGERS

A. Measure water flow through all circuits.

B. Adjust water flow to within specified tolerances.

C. Measure inlet and outlet water temperatures.

D. Measure inlet steam pressure.

E. Check the setting and operation of safety and relief valves. Record settings.

3.14 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
   1. Manufacturer, model, and serial numbers.
   2. Motor horsepower rating.

3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.15 PROCEDURES FOR CHILLERS

A. Balance water flow through each evaporator and condenser to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
2. If water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
4. Power factor if factory-installed instrumentation is furnished for measuring kilowatt.
5. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatt.
6. Capacity: Calculate in tons of cooling.
7. If air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.16 PROCEDURES FOR COOLING TOWERS

A. Shut off makeup water for the duration of the test, and verify that makeup and blowdown systems are fully operational after tests and before leaving the equipment. Perform the following tests and record the results:
1. Measure condenser-water flow to each cell of the cooling tower.
2. Measure entering- and leaving-water temperatures.
3. Measure wet- and dry-bulb temperatures of entering air.
4. Measure wet- and dry-bulb temperatures of leaving air.
5. Measure condenser-water flow rate recirculating through the cooling tower.
6. Measure cooling tower pump discharge pressure.
7. Adjust water level and feed rate of makeup-water system.

3.17 PROCEDURES FOR BOILERS

A. If hydronic, measure entering- and leaving-water temperatures and water flow.

B. If steam, measure entering-water temperature and flow and leaving steam pressure, temperature, and flow.

3.18 PROCEDURES FOR HEAT-TRANSFER COILS

A. Water Coils: Measure the following data for each coil:
1. Entering- and leaving-water temperature.

2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

B. Refrigerant Coils: Measure the following data for each coil:
1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

3.19 PROCEDURES FOR TEMPERATURE MEASUREMENTS

A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

C. Measure outside-air, wet- and dry-bulb temperatures.

3.20 PROCEDURES FOR COMMERCIAL KITCHEN HOODS

A. Measure, adjust, and record the airflow of each kitchen hood. For kitchen hoods designed with integral makeup air, measure and adjust the exhaust and makeup airflow. Measure airflow by duct Pitot-tube traverse. If a duct Pitot-tube traverse is not possible, provide an explanation in the report of the reason(s) why and also the reason why the method used was chosen.
1. Install welded test ports in the sides of the exhaust duct for the duct Pitot-tube traverse. Install each test port with a threaded cap that is liquid tight.

B. After balancing is complete, do the following:
1. Measure and record the static pressure at the hood exhaust-duct connection.
2. Measure and record the hood face velocity. Make measurements at multiple points across the face of the hood. Perform measurements at a maximum of 12 inches between points and between any point and the perimeter. Calculate the average of the measurements recorded. Verify that the hood average face velocity complies with the Contract Documents and governing codes.
3. Check the hood for capture and containment of smoke using a smoke emitting device. Observe the smoke pattern. Make adjustments to room airflow patterns to achieve optimum results.

C. Visually inspect the hood exhaust duct throughout its entire length in compliance with authorities having jurisdiction. Begin at the hood connection and end at the point it discharges outdoors. Report findings.
1. Check duct slopes as required.
2. Verify that duct access is installed as required.
3. Verify that point of termination is as required.
4. Verify that duct air velocity is within the range required.
5. Verify that duct is within a fire-rated enclosure.

D. Report deficiencies.

3.21 PROCEDURES FOR LABORATORY FUME HOODS

A. Before performing laboratory fume hood testing, measure, adjust and record the supply airflow and airflow patterns of each supply air outlet that is located in the same room as the hood. Adjust the air outlet flow pattern to minimize turbulence and to achieve the desired airflow patterns at the face and inside the hood. Verify that adequate makeup air is available to achieve the indicated flow of the hood.

B. Measure, adjust, and record the airflow of each laboratory fume hood by duct Pitot-tube traverse with the laboratory fume hood sash in the design open position.

1. For laboratory fume hoods installed in variable exhaust systems, measure, adjust, and record the hood exhaust airflow at maximum and at minimum airflow conditions.
2. For laboratory fume hoods designed with integral makeup air, measure, adjust, and record the exhaust and makeup airflow.
3. Special filter systems for hoods shall be tested for proper operation and adjusted to maintain constant air flow through the system regardless of filter resistance. Flow shall be tested under not less than five different resistances representing clean, 25 percent, 50 percent, 75 percent and 100 percent dirt loading. Variations in airflow shall not be sufficient to adversely affect hood performance.

C. For laboratory fume hoods that are connected to centralized exhaust systems using automatic dampers, adjust the damper controller to obtain the indicated exhaust airflow.

D. After balancing is complete, do the following:

1. Measure and record the static pressure at the hood duct connection with the hood operating at indicated airflow.
2. Measure and record the face velocity across the open sash face area. Measure the face velocity at each point in a grid pattern. Perform measurements at a maximum of 12 inches between points and between any point and the perimeter of the opening.
   a. For laboratory fume hoods designed to maintain a constant face velocity at varying sash positions, also measure and record the face velocity at 50 and 25 percent of the design open sash position.
   b. Calculate and report the average face velocity by averaging all velocity measurements.
   c. Calculate and report the exhaust airflow by multiplying the calculated average face velocity by the sash open area. Compare this quantity with the exhaust airflow measured by duct Pitot-tube traverse. Report differences.
   d. If the average face velocity is less than the indicated face velocity, retest the average face velocity and adjust hood baffles, fan drives, and other parts of the system to provide the indicated average face velocity.
3. Check each laboratory fume hood for the capture and containment of smoke by using a hand-held emitting device. Observe the capture and containment of smoke flow pattern across the open face and inside the hood. Make adjustments necessary to achieve the desired results.

E. With the room and laboratory fume hoods operating at indicated conditions, perform an "as-installed" performance test of the laboratory fume hood according to ASHRAE 110. Test **[each]** **<insert number>** laboratory fume hood(s) and document the test results.

3.22 PROCEDURES FOR EXHAUST HOODS

A. Measure, adjust, and record the airflow of each exhaust hood. Measure airflow by duct Pitot-tube traverse. If a duct Pitot-tube traverse is not possible, explain why, in the report, and explain the test method used.

B. After balancing is complete, do the following:

1. Measure and record the static pressure at the hood exhaust-duct connection.

2. Check the hood for capture and containment of smoke using a smoke emitting device. Observe the smoke pattern. Make adjustments to achieve optimum results.

3.23 PROCEDURES FOR SPACE PRESSURIZATION MEASUREMENTS AND ADJUSTMENTS

A. Before testing for space pressurization, observe the space to verify the integrity of the space boundaries. Verify that windows and doors are closed and applicable safing, gaskets, and sealants are installed. Report deficiencies and postpone testing until after the reported deficiencies are corrected.

B. Measure, adjust, and record the pressurization of each room, each zone, and each building by adjusting the supply, return, and exhaust airflows to achieve the indicated conditions.

C. Measure space pressure differential where pressure is used as the design criteria, and measure airflow differential where differential airflow is used as the design criteria for space pressurization.
1. For pressure measurements, measure and record the pressure difference between the intended spaces at the door with all doors in the space closed. Record the high-pressure side, low-pressure side, and pressure difference between each adjacent space.
2. For applications with cascading levels of space pressurization, begin in the most critical space and work to the least critical space.
3. Test room pressurization first, then zones, and finish with building pressurization.

D. To achieve indicated pressurization, set the supply airflow to the indicated conditions and adjust the exhaust and return airflow to achieve the indicated pressure or airflow difference.

E. For spaces with pressurization being monitored and controlled automatically, observe and adjust the controls to achieve the desired set point.
1. Compare the values of the measurements taken to the measured values of the control system instruments and report findings.
2. Check the repeatability of the controls by successive tests designed to temporarily alter the ability to achieve space pressurization. Test overpressurization and underpressurization, and observe and report on the system's ability to revert to the set point.
3. For spaces served by variable-air-volume supply and exhaust systems, measure space pressurization at indicated airflow and minimum airflow conditions.

F. In spaces that employ multiple modes of operation, such as normal mode and emergency mode or occupied mode and unoccupied mode, measure, adjust, and record data for each operating mode.

G. Record indicated conditions and corresponding initial and final measurements. Report deficiencies.

3.24 PROCEDURES FOR VIBRATION MEASUREMENTS

A. Use a vibration meter meeting the following criteria:
1. Solid-state circuitry with a piezoelectric accelerometer.
2. Velocity range of 0.1 to 10 inches per second.
3. Displacement range of 1 to 100 mils.
4. Frequency range of at least 0 to 1000 Hz.
5. Capable of filtering unwanted frequencies.

B. Calibrate the vibration meter before each day of testing.
1. Use a calibrator provided with the vibration meter.
2. Follow vibration meter and calibrator manufacturer's calibration procedures.

C. Perform vibration measurements when other building and outdoor vibration sources are at a minimum level and will not influence measurements of equipment being tested.
   1. Turn off equipment in the building that might interfere with testing.
   2. Clear the space of people.

D. Perform vibration measurements after air and water balancing and equipment testing is complete.

E. Clean equipment surfaces in contact with the vibration transducer.

F. Position the vibration transducer according to manufacturer's written instructions and to avoid interference with the operation of the equipment being tested.

G. Measure and record vibration on rotating equipment over 3 hp.

H. Measure and record equipment vibration, bearing vibration, equipment base vibration, and building structure vibration. Record velocity and displacement readings in the horizontal, vertical, and axial planes.
   1. Pumps:
      a. Pump Bearing: Drive end and opposite end.
      b. Motor Bearing: Drive end and opposite end.
      c. Pump Base: Top and side.
      d. Building: Floor.
      e. Piping: To and from the pump after flexible connections.
   2. Fans and HVAC Equipment with Fans:
      a. Fan Bearing: Drive end and opposite end.
      b. Motor Bearing: Drive end and opposite end.
      c. Equipment Casing: Top and side.
      d. Equipment Base: Top and side.
      e. Building: Floor.
      f. Ductwork: To and from equipment after flexible connections.
      g. Piping: To and from equipment after flexible connections.
   3. Chillers and HVAC Equipment with Compressors:
      a. Compressor Bearing: Drive end and opposite end.
      b. Motor Bearing: Drive end and opposite end.
      c. Equipment Casing: Top and side.
      d. Equipment Base: Top and side.
      e. Building: Floor.
      f. Piping: To and from equipment after flexible connections.

I. For equipment with vibration isolation, take floor measurements with the vibration isolation blocked solid to the floor and with the vibration isolation floating. Calculate and report the differences.

J. Inspect, measure, and record vibration isolation.
   1. Verify that vibration isolation is installed in the required locations.
   2. Verify that installation is level and plumb.
   3. Verify that isolators are properly anchored.
   4. For spring isolators, measure the compressed spring height, the spring OD, and the travel-to-solid distance.
   5. Measure the operating clearance between each inertia base and the floor or concrete base below. Verify that there is unobstructed clearance between the bottom of the inertia base and the floor.

3.25 PROCEDURES FOR SOUND-LEVEL MEASUREMENTS

A. Perform sound-pressure-level measurements with an octave-band analyzer complying with ANSI S1.4 for Type 1 sound-level meters and ANSI S1.11 for octave-band filters. Comply with requirements in ANSI S1.13, unless otherwise indicated.

B. Calibrate sound meters before each day of testing. Use a calibrator provided with the sound meter complying with ANSI S1.40 and that has NIST certification.

C. Use a microphone that is suitable for the type of sound levels measured. For areas where air velocities exceed 100 fpm, use a windscreen on the microphone.

D. Perform sound-level testing after air and water balancing and equipment testing are complete.

E. Close windows and doors to the space.

F. Perform measurements when the space is not occupied and when the occupant noise level from other spaces in the building and outside are at a minimum.

G. Clear the space of temporary sound sources so unrelated disturbances will not be measured. Position testing personnel during measurements to achieve a direct line-of-sight between the sound source and the sound-level meter.

H. Take sound measurements at a height approximately 48 inches above the floor and at least 36 inches from a wall, column, and other large surface capable of altering the measurements.

I. Take sound measurements in dBA and in each of the 8 unweighted octave bands in the frequency range of 63 to 8000 Hz.

J. Take sound measurements with the HVAC systems off to establish the background sound levels and take sound measurements with the HVAC systems operating.
   1. Calculate the difference between measurements. Apply a correction factor depending on the difference and adjust measurements.

K. Perform sound testing at <**Insert number**> locations on Project for each of the following space types. For each space type tested, select a measurement location that has the greatest sound level. If testing multiple locations for each space type, select at least one location that is near and at least one location that is remote from the predominant sound source.
   1. Private office.
   2. Open office area.
   3. Conference room.
   4. Auditorium/large meeting room/lecture hall.
   5. Classroom/training room.
   6. Patient room/exam room.
   7. Sound or vibration sensitive laboratory.
   8. Hotel room/apartment.
   9. Each space with a noise criterion of RC or NC 25 or lower.
   10. Each space with an indicated noise criterion of RC or NC 35 and lower that is adjacent to a mechanical equipment room or roof mounted equipment.
   11. Inside each mechanical equipment room.
   12. **<Insert other spaces.>**

3.26 PROCEDURES FOR STAIR-TOWER PRESSURIZATION SYSTEM MEASUREMENTS AND ADJUSTMENTS

A. Before testing, observe the stair tower to verify that construction is complete. Verify the following:
  1. Walls and ceiling are free of unintended openings and are capable of achieving a pressure boundary.
  2. Firestopping and sealants are installed.
  3. Doors, door closers, and door gaskets are installed and adjusted.
  4. If applicable, window installation is complete.

B. Measure and record wind speed and direction, outside-air temperature, and relative humidity on each test day.

C. Test each stair tower as a single system. If multiple fans serve a single stair tower, operate the fans together.

D. Air Balance:
  1. Open the doors indicated to be open and measure, adjust, and record the airflow of each:
    a. Stair-tower fan.
    b. Air outlet supplying the stair tower.
  2. For ducted systems, measure the fan airflow by duct Pitot-tube traverse.

E. Pressurization Test:
  1. After air balancing is complete, perform stair-tower pressurization tests.
  2. Establish a consistent procedure for recording data throughout the entire test. Set the stair-tower side of the doors as the reference point and the floor side of the doors with positive pressure when higher than the stair tower, and negative pressure when lower than the stair tower.
  3. With the HVAC systems operating in their normal mode of operation and the stair-tower pressurization systems off, measure and record the following:
    a. Pressure difference across each stair-tower door with all doors in the stairwell closed.
    b. Force necessary to open each door, using a spring-type scale.
  4. With the HVAC systems operating and the stair-tower pressurization system activated, perform the following:
    a. Place building HVAC systems in their normal operating mode including equipment not used to implement smoke control, such as air-handling units, toilet exhaust fans, fan coil units, and similar equipment.
    b. Measure and record the pressure difference across each stair-tower door with all doors in the stair tower closed. Adjust the stair-tower pressure relief to prevent overpressurization.
    c. Use a spring scale to measure and record the force needed to open the door closest to the fan. With the initial door held in the open position, measure and record the pressure difference across each remaining closed stair-tower door.
    d. Open additional doors (up to the number indicated) one at a time, and measure and record the pressure difference across each remaining closed stair-tower door after the opening of each additional door.
    e. Open the doors indicated to be open and measure and record the direction and velocity through each of the open doors by a traverse of every 1 sq. ft. grid of door opening.
    f. Calculate the average of the door velocity measurements. Compare the average velocity to the Contract Documents and governing code requirements.
  5. Repeat the pressurization tests with the smoke-control systems and the HVAC systems operating.
  6. Criteria for Acceptance:
    a. The opening force on any door shall not exceed 30 lbf.
    b. Code requirements.
    c. **<Insert velocity, pressure, and other criteria.>**

F. Operational Tests:

1. Check the proper activation of the stair-tower pressurization system(s) in response to all means of activation, both automatic and manual.
2. Verify that each initiating occurrence produces the proper system response under each of the following modes of operation:
   a. Normal.
   b. Alarm.
   c. Manual override of normal mode and alarm.
   d. Return to normal.
3. Verify that the smoke detector at the stair pressurization fan inlet de-energizes the fan and closes the damper at the fan.
4. If standby power is provided for stair pressurization systems, test to verify that the stair pressurization systems operate while on both normal and standby power.
5. Conduct additional tests required by authorities having jurisdiction.

G. Prepare a complete report of observations, measurements, and deficiencies.

3.27 PROCEDURES FOR SMOKE-CONTROL SYSTEM TESTING

A. Before testing smoke-control systems, verify that construction is complete and verify the integrity of each smoke-control zone boundary. Verify that windows and doors are closed and that applicable safing, gasket, and sealants are installed. Report deficiencies and postpone testing until after the reported deficiencies are corrected.

B. Measure and record wind speed and direction, outside-air temperature, and relative humidity on each test day.

C. Measure, adjust, and record airflow of each smoke-control system with all fans that are a part of the system operating as intended by the design.

D. Measure, adjust, and record the airflow of each fan. For ducted systems, measure the fan airflow by duct Pitot-tube traverse.

E. After air balancing is complete, perform the following pressurization testing for each smoke-control zone as indicated on the plans.

F. Operational Tests:
1. Check the proper activation of each zoned smoke-control system in response to all means of activation, both automatic and manual.
2. Check automatic activation in response to fire alarm signals received from the building's fire alarm and detection system. Initiate a separate alarm for each means of activation to ensure that the proper operation of the correct zoned smoke-control system occurs.
3. Check and record the proper operation of fans, dampers, and related equipment as indicated on the plans for each separate zone of the smoke-control system.

G. Conduct additional tests required by authorities having jurisdiction. Unless required by authorities having jurisdiction, perform testing without the use of smoke or products that simulate smoke.

H. Prepare a complete report of observations, measurements, and deficiencies.

3.28 PROCEDURES FOR INDOOR-AIR QUALITY MEASUREMENTS

A. After air balancing is complete and with HVAC systems operating at indicated conditions, perform indoor-air quality testing.

B. Observe and record the following conditions for each HVAC system:
   1. The distance between the outside-air intake and the closest exhaust fan discharge, cooling tower, flue termination, or vent termination.
   2. Specified filters are installed. Check for leakage around filters.
   3. Cooling coil drain pans have a positive slope to drain.
   4. Cooling coil condensate drain trap maintains an air seal.
   5. Evidence of water damage.
   6. Insulation in contact with the supply, return, and outside air is dry and clean.

C. Measure and record indoor conditions served by each HVAC system. Make measurements at multiple locations served by the system if required to satisfy the following:
   1. Most remote area.
   2. One location per floor.
   3. One location for every 5000 sq. ft..

D. Measure and record the following indoor conditions for each location two times at two-hour intervals, and in accordance with ASHRAE 113:
   1. Temperature.
   2. Relative humidity.
   3. Air velocity.
   4. Concentration of carbon dioxide (ppm).
   5. Concentration of carbon monoxide (ppm).
   6. Nitrogen oxides (ppm).
   7. Formaldehyde (ppm).

3.29 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
   1. Measure and record the operating speed, airflow, and static pressure of each fan.
   2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
   3. Check the refrigerant charge.
   4. Check the condition of filters.
   5. Check the condition of coils.
   6. Check the operation of the drain pan and condensate drain trap.
   7. Check bearings and other lubricated parts for proper lubrication.
   8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished.
   1. New filters are installed.
   2. Coils are clean and fins combed.
   3. Drain pans are clean.
   4. Fans are clean.
   5. Bearings and other parts are properly lubricated.
   6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
   1. Compare the indicated airflow of the renovated work to the measured fan airflows and determine the new fan, speed, filter, and coil face velocity.
   2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.

3. If calculations increase or decrease the airflow and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated airflow and water flow rates. If 5 percent or less, equipment adjustments are not required.
4. Air balance each air outlet.

3.30 TEMPERATURE-CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Check free travel and proper operation of control devices such as damper and valve operators.

F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.

G. Check the interaction of electrically operated switch transducers.

H. Check the interaction of interlock and lockout systems.

I. Check main control supply-air pressure and observe compressor and dryer operations.

J. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.

K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.31 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:
1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 5 to plus 10 percent.
2. Air Outlets and Inlets: 0 to minus 10 percent.
3. Heating-Water Flow Rate: 0 to minus 10 percent.
4. Cooling-Water Flow Rate: 0 to minus 5 percent.

3.32 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.33 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
   1. Include a list of instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to certified field report data, include the following:
   1. Pump curves.
   2. Fan curves.
   3. Manufacturers' test data.
   4. Field test reports prepared by system and equipment installers.
   5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:
   1. Title page.
   2. Name and address of TAB firm.
   3. Project name.
   4. Project location.
   5. Architect's name and address.
   6. Engineer's name and address.
   7. Contractor's name and address.
   8. Report date.
   9. Signature of TAB firm who certifies the report.
   10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
   11. Summary of contents including the following:
       a. Indicated versus final performance.
       b. Notable characteristics of systems.
       c. Description of system operation sequence if it varies from the Contract Documents.
   12. Nomenclature sheets for each item of equipment.
   13. Data for terminal units, including manufacturer, type size, and fittings.
   14. Notes to explain why certain final data in the body of reports varies from indicated values.
   15. Test conditions for fans and pump performance forms including the following:
       a. Settings for outside-, return-, and exhaust-air dampers.
       b. Conditions of filters.
       c. Cooling coil, wet- and dry-bulb conditions.
       d. Face and bypass damper settings at coils.
       e. Fan drive settings including settings and percentage of maximum pitch diameter.
       f. Inlet vane settings for variable-air-volume systems.
       g. Settings for supply-air, static-pressure controller.
       h. Other system operating conditions that affect performance.

E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
   1. Quantities of outside, supply, return, and exhaust airflows.
   2. Water and steam flow rates.
   3. Duct, outlet, and inlet sizes.
   4. Pipe and valve sizes and locations.
   5. Terminal units.
   6. Balancing stations.
   7. Position of balancing devices.

F. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:
   1. Unit Data: Include the following:
      a. Unit identification.
      b. Location.
      c. Make and type.
      d. Model number and unit size.
      e. Manufacturer's serial number.
      f. Unit arrangement and class.
      g. Discharge arrangement.
      h. Sheave make, size in inches, and bore.
      i. Sheave dimensions, center-to-center, and amount of adjustments in inches.
      j. Number of belts, make, and size.
      k. Number of filters, type, and size.
   2. Motor Data:
      a. Make and frame type and size.
      b. Horsepower and rpm.
      c. Volts, phase, and hertz.
      d. Full-load amperage and service factor.
      e. Sheave make, size in inches, and bore.
      f. Sheave dimensions, center-to-center, and amount of adjustments in inches.
   3. Test Data (Indicated and Actual Values):
      a. Total airflow rate in cfm.
      b. Total system static pressure in inches wg.
      c. Fan rpm.
      d. Discharge static pressure in inches wg.
      e. Filter static-pressure differential in inches wg.
      f. Preheat coil static-pressure differential in inches wg.
      g. Cooling coil static-pressure differential in inches wg.
      h. Heating coil static-pressure differential in inches wg.
      i. Outside airflow in cfm.
      j. Return airflow in cfm.
      k. Outside-air damper position.
      l. Return-air damper position.
      m. Vortex damper position.

G. Apparatus-Coil Test Reports:
   1. Coil Data:
      a. System identification.
      b. Location.
      c. Coil type.
      d. Number of rows.
      e. Fin spacing in fins per inch o.c.
      f. Make and model number.
      g. Face area in sq. ft..
      h. Tube size in NPS.
      i. Tube and fin materials.
      j. Circuiting arrangement.
   2. Test Data (Indicated and Actual Values):
      a. Airflow rate in cfm.
      b. Average face velocity in fpm.
      c. Air pressure drop in inches wg.
      d. Outside-air, wet- and dry-bulb temperatures in deg F.
      e. Return-air, wet- and dry-bulb temperatures in deg F.
      f. Entering-air, wet- and dry-bulb temperatures in deg F.
      g. Leaving-air, wet- and dry-bulb temperatures in deg F.
      h. Water flow rate in gpm.

i. Water pressure differential in feet of head or psig.
j. Entering-water temperature in deg F.
k. Leaving-water temperature in deg F.
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig.
n. Refrigerant suction temperature in deg F.
o. Inlet steam pressure in psig.

H. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:
1. Unit Data:
a. System identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Fuel type in input data.
g. Output capacity in Btuh.
h. Ignition type.
i. Burner-control types.
j. Motor horsepower and rpm.
k. Motor volts, phase, and hertz.
l. Motor full-load amperage and service factor.
m. Sheave make, size in inches, and bore.
n. Sheave dimensions, center-to-center, and amount of adjustments in inches.
2. Test Data (Indicated and Actual Values):
a. Total airflow rate in cfm.
b. Entering-air temperature in deg F.
c. Leaving-air temperature in deg F.
d. Air temperature differential in deg F.
e. Entering-air static pressure in inches wg.
f. Leaving-air static pressure in inches wg.
g. Air static-pressure differential in inches wg.
h. Low-fire fuel input in Btuh.
i. High-fire fuel input in Btuh.
j. Manifold pressure in psig.
k. High-temperature-limit setting in deg F.
l. Operating set point in Btuh.
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btuh.

I. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:
1. Unit Data:
a. System identification.
b. Location.
c. Coil identification.
d. Capacity in Btuh.
e. Number of stages.
f. Connected volts, phase, and hertz.
g. Rated amperage.
h. Airflow rate in cfm.
i. Face area in sq. ft..
j. Minimum face velocity in fpm.
2. Test Data (Indicated and Actual Values):

a. Heat output in Btuh.
b. Airflow rate in cfm.
c. Air velocity in fpm.
d. Entering-air temperature in deg F.
e. Leaving-air temperature in deg F.
f. Voltage at each connection.
g. Amperage for each phase.

J. Fan Test Reports: For supply, return, and exhaust fans, include the following:
1. Fan Data:
    a. System identification.
    b. Location.
    c. Make and type.
    d. Model number and size.
    e. Manufacturer's serial number.
    f. Arrangement and class.
    g. Sheave make, size in inches, and bore.
    h. Sheave dimensions, center-to-center, and amount of adjustments in inches.
2. Motor Data:
    a. Make and frame type and size.
    b. Horsepower and rpm.
    c. Volts, phase, and hertz.
    d. Full-load amperage and service factor.
    e. Sheave make, size in inches, and bore.
    f. Sheave dimensions, center-to-center, and amount of adjustments in inches.
    g. Number of belts, make, and size.
3. Test Data (Indicated and Actual Values):
    a. Total airflow rate in cfm.
    b. Total system static pressure in inches wg.
    c. Fan rpm.
    d. Discharge static pressure in inches wg.
    e. Suction static pressure in inches wg.

K. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
1. Report Data:
    a. System and air-handling unit number.
    b. Location and zone.
    c. Traverse air temperature in deg F.
    d. Duct static pressure in inches wg.
    e. Duct size in inches.
    f. Duct area in sq. ft..
    g. Indicated airflow rate in cfm.
    h. Indicated velocity in fpm.
    i. Actual airflow rate in cfm.
    j. Actual average velocity in fpm.
    k. Barometric pressure in psig.

L. Air-Terminal-Device Reports:
1. Unit Data:
    a. System and air-handling unit identification.
    b. Location and zone.
    c. Test apparatus used.
    d. Area served.
    e. Air-terminal-device make.
    f. Air-terminal-device number from system diagram.

g. Air-terminal-device type and model number.
h. Air-terminal-device size.
i. Air-terminal-device effective area in sq. ft..

2. Test Data (Indicated and Actual Values):
   a. Airflow rate in cfm.
   b. Air velocity in fpm.
   c. Preliminary airflow rate as needed in cfm.
   d. Preliminary velocity as needed in fpm.
   e. Final airflow rate in cfm.
   f. Final velocity in fpm.
   g. Space temperature in deg F.

M. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
1. Unit Data:
   a. System and air-handling unit identification.
   b. Location and zone.
   c. Room or riser served.
   d. Coil make and size.
   e. Flowmeter type.
2. Test Data (Indicated and Actual Values):
   a. Airflow rate in cfm.
   b. Entering-water temperature in deg F.
   c. Leaving-water temperature in deg F.
   d. Water pressure drop in feet of head or psig.
   e. Entering-air temperature in deg F.
   f. Leaving-air temperature in deg F.

N. Packaged Chiller Reports:
1. Unit Data:
   a. Unit identification.
   b. Make and model number.
   c. Manufacturer's serial number.
   d. Refrigerant type and capacity in gal..
   e. Starter type and size.
   f. Starter thermal protection size.
   g. Compressor make and model number.
   h. Compressor manufacturer's serial number.
2. Water-Cooled Condenser Test Data (Indicated and Actual Values):
   a. Refrigerant pressure in psig.
   b. Refrigerant temperature in deg F.
   c. Entering-water temperature in deg F.
   d. Leaving-water temperature in deg F.
   e. Entering-water pressure in feet of head or psig.
   f. Water pressure differential in feet of head or psig.
3. Evaporator Test Reports (Indicated and Actual Values):
   a. Refrigerant pressure in psig.
   b. Refrigerant temperature in deg F.
   c. Entering-water temperature in deg F.
   d. Leaving-water temperature in deg F.
   e. Entering-water pressure in feet of head or psig.
   f. Water pressure differential in feet of head or psig.
4. Compressor Test Data (Indicated and Actual Values):
   a. Suction pressure in psig.
   b. Suction temperature in deg F.
   c. Discharge pressure in psig.
   d. Discharge temperature in deg F.

e. Oil pressure in psig.
f. Oil temperature in deg F.
g. Voltage at each connection.
h. Amperage for each phase.
i. Kilowatt input.
j. Crankcase heater kilowatt.
k. Chilled-water control set point in deg F.
l. Condenser-water control set point in deg F.
m. Refrigerant low-pressure-cutoff set point in psig.
n. Refrigerant high-pressure-cutoff set point in psig.

5. Refrigerant Test Data (Indicated and Actual Values):
   a. Oil level.
   b. Refrigerant level.
   c. Relief valve setting in psig.
   d. Unloader set points in psig.
   e. Percentage of cylinders unloaded.
   f. Bearing temperatures in deg F.
   g. Vane position.
   h. Low-temperature-cutoff set point in deg F.

O. Compressor and Condenser Reports: For refrigerant side of unitary systems, stand-alone refrigerant compressors, air-cooled condensing units, or water-cooled condensing units, include the following:
1. Unit Data:
   a. Unit identification.
   b. Location.
   c. Unit make and model number.
   d. Compressor make.
   e. Compressor model and serial numbers.
   f. Refrigerant weight in lb.
   g. Low ambient temperature cutoff in deg F.
2. Test Data (Indicated and Actual Values):
   a. Inlet-duct static pressure in inches wg.
   b. Outlet-duct static pressure in inches wg.
   c. Entering-air, dry-bulb temperature in deg F.
   d. Leaving-air, dry-bulb temperature in deg F.
   e. Condenser entering-water temperature in deg F.
   f. Condenser leaving-water temperature in deg F.
   g. Condenser-water temperature differential in deg F.
   h. Condenser entering-water pressure in feet of head or psig.
   i. Condenser leaving-water pressure in feet of head or psig.
   j. Condenser-water pressure differential in feet of head or psig.
   k. Control settings.
   l. Unloader set points.
   m. Low-pressure-cutout set point in psig.
   n. High-pressure-cutout set point in psig.
   o. Suction pressure in psig.
   p. Suction temperature in deg F.
   q. Condenser refrigerant pressure in psig.
   r. Condenser refrigerant temperature in deg F.
   s. Oil pressure in psig.
   t. Oil temperature in deg F.
   u. Voltage at each connection.
   v. Amperage for each phase.
   w. Kilowatt input.
   x. Crankcase heater kilowatt.
   y. Number of fans.

z. Condenser fan rpm.
aa. Condenser fan airflow rate in cfm.
bb. Condenser fan motor make, frame size, rpm, and horsepower.
cc. Condenser fan motor voltage at each connection.
dd. Condenser fan motor amperage for each phase.

P. Cooling Tower or Condenser Test Reports: For cooling towers or condensers, include the following:
1. Unit Data:
a. Unit identification.
b. Make and type.
c. Model and serial numbers.
d. Nominal cooling capacity in tons.
e. Refrigerant type and weight in lb.
f. Water-treatment chemical feeder and chemical.
g. Number and type of fans.
h. Fan motor make, frame size, rpm, and horsepower.
i. Fan motor voltage at each connection.
j. Sheave make, size in inches, and bore.
k. Sheave dimensions, center-to-center, and amount of adjustments in inches.
l. Number of belts, make, and size.
m. Pump make and model number.
n. Pump manufacturer's serial number.
o. Pump motor make and frame size.
p. Pump motor horsepower and rpm.
2. Pump Test Data (Indicated and Actual Values):
a. Voltage at each connection.
b. Amperage for each phase.
c. Water flow rate in gpm.
3. Water Test Data (Indicated and Actual Values):
a. Entering-water temperature in deg F.
b. Leaving-water temperature in deg F.
c. Water temperature differential in deg F.
d. Entering-water pressure in feet of head or psig.
e. Leaving-water pressure in feet of head or psig.
f. Water pressure differential in feet of head or psig.
g. Water flow rate in gpm.
h. Bleed water flow rate in gpm.
4. Air Data (Indicated and Actual Values):
a. Duct airflow rate in cfm.
b. Inlet-duct static pressure in inches wg.
c. Outlet-duct static pressure in inches wg.
d. Average entering-air, wet-bulb temperature in deg F.
e. Average leaving-air, wet-bulb temperature in deg F.
f. Ambient wet-bulb temperature in deg F.

Q. Heat-Exchanger/Converter Test Reports: For steam and hot-water heat exchangers, include the following:
1. Unit Data:
a. Unit identification.
b. Location.
c. Service.
d. Make and type.
e. Model and serial numbers.
f. Ratings.
2. Steam Test Data (Indicated and Actual Values):
a. Inlet pressure in psig.

b. Condensate flow rate in lb/h.
3. Primary Water Test Data (Indicated and Actual Values):
a. Entering-water temperature in deg F.
b. Leaving-water temperature in deg F.
c. Entering-water pressure in feet of head or psig.
d. Water pressure differential in feet of head or psig.
e. Water flow rate in gpm.
4. Secondary Water Test Data (Indicated and Actual Values):
a. Entering-water temperature in deg F.
b. Leaving-water temperature in deg F.
c. Entering-water pressure in feet of head or psig.
d. Water pressure differential in feet of head or psig.
e. Water flow rate in gpm.

R. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:
1. Unit Data:
a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model and serial numbers.
f. Water flow rate in gpm.
g. Water pressure differential in feet of head or psig.
h. Required net positive suction head in feet of head or psig.
i. Pump rpm.
j. Impeller diameter in inches.
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.
n. Amperage for each phase.
o. Full-load amperage and service factor.
p. Seal type.
2. Test Data (Indicated and Actual Values):
a. Static head in feet of head or psig.
b. Pump shutoff pressure in feet of head or psig.
c. Actual impeller size in inches.
d. Full-open flow rate in gpm.
e. Full-open pressure in feet of head or psig.
f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final water flow rate in gpm.
j. Voltage at each connection.
k. Amperage for each phase.

S. Boiler Test Reports:
1. Unit Data:
a. Unit identification.
b. Location.
c. Service.
d. Make and type.
e. Model and serial numbers.
f. Fuel type and input in Btuh.
g. Number of passes.
h. Ignition type.

i. Burner-control types.
j. Voltage at each connection.
k. Amperage for each phase.

2. Test Data (Indicated and Actual Values):
   a. Operating pressure in psig.
   b. Operating temperature in deg F.
   c. Entering-water temperature in deg F.
   d. Leaving-water temperature in deg F.
   e. Number of safety valves and sizes in NPS.
   f. Safety valve settings in psig.
   g. High-limit setting in psig.
   h. Operating-control setting.
   i. High-fire set point.
   j. Low-fire set point.
   k. Voltage at each connection.
   l. Amperage for each phase.
   m. Draft fan voltage at each connection.
   n. Draft fan amperage for each phase.
   o. Manifold pressure in psig.

T. Vibration Measurement Reports:
1. Date and time of test.
2. Vibration meter manufacturer, model number, and serial number.
3. Equipment designation, location, equipment, speed, motor speed, and motor horsepower.
4. Diagram of equipment showing the vibration measurement locations.
5. Measurement readings for each measurement location.
6. Calculate isolator efficiency using measurements taken.
7. Description of predominant vibration source.

U. Sound Measurement Reports: Record sound measurements on octave band and dBA test forms and on an NC or RC chart indicating the decibel level measured in each frequency band for both "background" and "HVAC system operating" readings. Record each tested location on a separate NC or RC chart. Record the following on the forms:
1. Date and time of test. Record each tested location on its own NC curve.
2. Sound meter manufacturer, model number, and serial number.
3. Space location within the building including floor level and room number.
4. Diagram or color photograph of the space showing the measurement location.
5. Time weighting of measurements, either fast or slow.
6. Description of the measured sound: steady, transient, or tonal.
7. Description of predominant sound source.

V. Indoor-Air Quality Measurement Reports for Each HVAC System:
1. HVAC system designation.
2. Date and time of test.
3. Outdoor temperature, relative humidity, wind speed, and wind direction at start of test.
4. Room number or similar description for each location.
5. Measurements at each location.
6. Observed deficiencies.

W. Instrument Calibration Reports:
1. Report Data:
   a. Instrument type and make.
   b. Serial number.
   c. Application.
   d. Dates of use.
   e. Dates of calibration.

3.34 INSPECTIONS

A. Initial Inspection:
1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.
2. Randomly check the following for each system:
a. Measure airflow of at least 10 percent of air outlets.
b. Measure water flow of at least 5 percent of terminals.
c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
d. Measure sound levels at two locations.
e. Measure space pressure of at least 10 percent of locations.
f. Verify that balancing devices are marked with final balance position.
g. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:
1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by [**Owner**] [**Architect**].
2. TAB firm test and balance engineer shall conduct the inspection in the presence of [**Owner**] [**Architect**].
3. [**Owner**] [**Architect**] shall randomly select measurements documented in the final report to be rechecked. The rechecking shall be limited to either 10 percent of the total measurements recorded, or the extent of measurements that can be accomplished in a normal 8-hour business day.
4. If the rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.
7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.35 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

3.36 RECORD OF EXISTING AIRFLOW

A. Prior to demolition of existing work, measure and record existing air flows in main supply, return and exhaust ducts of each system. Make pitot tube traverse in sections of existing ducts which are to remain, or as near as practicable. Use these recorded measurements to rebalance existing duct systems after completion of new systems.

3.37 RECORD OF EXISTING WATER FLOW RATES

A. Prior to demolition of existing work, measure and record existing flow rates in chilled water, heating water and condenser water systems.

B. Procedure: Make flow meter readings. Where no flow meters are installed in existing systems, measure and record differential pressures across pumps, coils, heat exchangers, and differential temperatures across coils, heat exchangers, boilers, chillers, cooling towers, etc. In sections of existing piping systems which are to remain, or as near as practicable, use these recorded measurements to rebalance existing water systems after completion of new systems.

3.38 CONTROLLED INSPECTION

A. The following items are to be inspected and tested in accordance with the applicable sections of the New York City Building code but shall not be limited to items described:

Item	Code Section
Smoke Test:	27-868
Eng/Installer Ventilation Certification:	27-779
Fuel Burning/Storage:	27-794
Noise Control Tests:	27-768, 769, 770
Refrigeration System:	27-781
Final Inspection:	Directive 14

B. Test all smoke and fire protection devices and systems related to the ventilating systems to verify that they are functioning properly. Where possible, this test shall be carried out at the same time as the Fire Department Inspector's inspection.
   1. In case of fusible link fire dampers, spot check as many dampers as necessary to be fully convinced of the acceptability of the installation.

END OF SECTION 23 0593

SECTION 23 0700

HVAC INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Insulation Materials:

   a. Calcium silicate.
   b. Cellular glass.
   c. Flexible elastomeric.
   d. Mineral fiber.
   e. Phenolic.
   f. Polyisocyanurate.
   g. Polyolefin.
   h. Polystyrene.

2. Fire-rated insulation systems.
3. Insulating cements.
4. Adhesives.
5. Mastics.
6. Lagging adhesives.
7. Sealants.
8. Factory-applied jackets.
9. Field-applied fabric-reinforcing mesh.
10. Field-applied cloths.
11. Field-applied jackets.
12. Tapes.
13. Securements.
14. Corner angles.

B. Related Sections:

1. Division 21 Section "Fire-Suppression Systems Insulation."
2. Division 22 Section "Plumbing Insulation."
3. Division 23 Section "Metal Ducts" for duct liners.
4. Division 33 Section "Underground Hydronic Energy Distribution" for loose-fill pipe insulation in underground piping outside the building.

5. Division 33 Section "Underground Steam and Condensate Distribution Piping" for loose-fill pipe insulation in underground piping outside the building.

1.3 DEFINITIONS

A. Exposed: Indoor ducts, piping or equipment located in mechanical equipment rooms and in areas in which they will be visible without removing ceilings or opening access panels.

B. Concealed: Indoor ducts, piping or equipment which are not exposed.

C. Outdoor: Ducts, piping or equipment which are exposed to the weather.

D. Underground: Ducts, piping or equipment which are buried; whereas ducts, piping or equipment located in a trench below grade are considered concealed.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).

B. LEED Submittal:

1. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.

C. Shop Drawings:

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties, equipment connections, and access panels.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.
8. Detail field application for each equipment type.

D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.

1. Sample Sizes:

a. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
b. Sheet Form Insulation Materials: 12 inches square.
c. Jacket Materials for Pipe: 12 inches long by NPS 2.
d. Sheet Jacket Materials: 12 inches square.
e. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

E. Schedule:

1. List of work that will be insulated and a description of insulation materials and finishing procedures.
2. A certificate indicating compliance with all applicable codes.

F. Qualification Data: For qualified Installer.

G. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

H. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Insulation Materials: All products shall carry ISO 9000 certification or guarantee to meet the ISO quality standards.

C. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.
3. Flame proofing treatments which are subject to deterioration from moisture or humidity are not acceptable.

D. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.

1. Piping Mockups:

   a. One 10-foot section of NPS 2 straight pipe.
   b. One each of a 90-degree threaded, welded, and flanged elbow.
   c. One each of a threaded, welded, and flanged tee fitting.
   d. One NPS 2 or smaller valve, and one NPS 2-1/2 or larger valve.
   e. Four support hangers including hanger shield and insert.
   f. One threaded strainer and one flanged strainer with removable portion of insulation.
   g. One threaded reducer and one welded reducer.
   h. One pressure temperature tap.
   i. One mechanical coupling.

2. Ductwork Mockups:

   a. One 10-foot section each of rectangular and round straight duct.

b. One each of a 90-degree mitered round and rectangular elbow, and one each of a 90-degree radius round and rectangular elbow.
c. One rectangular branch takeoff and one round branch takeoff from a rectangular duct. One round tee fitting.
d. One rectangular and round transition fitting.
e. Four support hangers for round and rectangular ductwork.

3. Equipment Mockups:

a. One chilled-water pump and one heating-hot-water pump.
b. One tank or vessel.

4. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
5. Notify Architect seven days in advance of dates and times when mockups will be constructed.
6. Obtain Architect's approval of mockups before starting insulation application.
7. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
8. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
9. Demolish and remove mockups when directed.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Before preparing piping and ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Calcium Silicate:

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Industrial Insulation Group (The); Thermo-12 Gold.
    b. Johns Manville; Thermo-12 Gold
    c. Pabco Gold, Inc.
    d. **<Insert manufacturer's name; product name or designation.>**

2. Thermal Conductivity (k-value) at 300°F (151°C) mean temperature is 0.40 Btu x in./hr. x ft. x degree F. (0.064 W/m x K) or less.
3. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
4. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
5. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

G. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Cell-U-Foam Corporation; Ultra-CUF.
    b. Pittsburgh Corning Corporation; Foamglas Super K.
    c. **<Insert manufacturer's name; product name or designation.>**

2. Thermal Conductivity (k-value) at 75°F (24°C) mean temperature is 0.27 Btu x in./hr. x ft. x degree F. (0.04 W/m x K) or less.
3. Block Insulation: ASTM C 552, Type I.
4. Special-Shaped Insulation: ASTM C 552, Type III.
5. Board Insulation: ASTM C 552, Type IV.
6. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
7. Preformed Pipe Insulation with Factory-Applied **[ASJ]** **[ASJ-SSL]**: Comply with ASTM C 552, Type II, Class 2.
8. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

H. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Aeroflex USA Inc.; Aerocel.
   b. Armacell LLC; AP Armaflex.
   c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.
   d. **<Insert manufacturer's name; product name or designation.>**

2. Thermal Conductivity (k-value) at 75°F (24°C) mean temperature is 0.27 Btu x in./hr. x ft. x degree F. (0.04 W/m x K) or less. Water absorption not be more than 0.2% by volume.

I. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type [I] [**II with factory-applied vinyl jacket**] [**III with factory-applied FSK jacket**] [**III with factory-applied FSP jacket**]. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. CertainTeed Corp.; Duct Wrap.
   b. Johns Manville; Microlite.
   c. Knauf Insulation; Duct Wrap.
   d. Manson Insulation Inc.; Alley Wrap.
   e. Owens Corning; All-Service Duct Wrap.
   f. **<Insert manufacturer's name; product name or designation.>**

2. Thermal Conductivity (k-value) at 75°F (24°C) mean temperature is 0.29 Btu x in./hr. x ft. x degree F. (0.043 W/m x K) or less.

J. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Johns Manville; HTB 23 Spin-Glas.
   b. Owens Corning; High Temperature Flexible Batt Insulations.
   c. **<Insert manufacturer's name; product name or designation.>**

2. Thermal Conductivity (k-value) at 75°F (24°C) mean temperature is 0.23 Btu x in./hr. x ft. x degree F. (0.033 W/m x K) or less.

K. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation [**without factory-applied jacket**] [**with factory-applied ASJ**] [**with factory-applied FSK jacket**]. For equipment applications, provide insulation [**without factory-applied jacket**] [**with factory-applied ASJ**] [**with factory-applied FSK jacket**]. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. CertainTeed Corp.; Commercial Board.
   b. Fibrex Insulations Inc.; FBX.
   c. Johns Manville; 800 Series Spin-Glas.
   d. Knauf Insulation; Insulation Board.

e. Manson Insulation Inc.; AK Board.
f. Owens Corning; Fiberglas 700 Series.
g. **<Insert manufacturer's name; product name or designation.>**

2. Thermal Conductivity (k-value) at 75°F (24°C) mean temperature is 0.23 Btu x in./hr. x ft. x degree F. (0.033 W/m x K) or less.

L. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Fibrex Insulations Inc.; FBX.
b. Johns Manville; 1000 Series Spin-Glas.
c. Owens Corning; High Temperature Industrial Board Insulations.
d. Rock Wool Manufacturing Company; Delta Board.
e. Roxul Inc.; Roxul RW.
f. Thermafiber; Thermafiber Industrial Felt.
g. **<Insert manufacturer's name; product name or designation.>**

2. Thermal Conductivity (k-value) at 75°F (24°C) mean temperature is 0.23 Btu x in./hr. x ft. x degree F. (0.033 W/m x K) or less.

M. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Fibrex Insulations Inc.; Coreplus 1200.
b. Johns Manville; Micro-Lok.
c. Knauf Insulation; 1000 Pipe Insulation.
d. Manson Insulation Inc.; Alley-K.
e. Owens Corning; Fiberglas Pipe Insulation.
f. **<Insert manufacturer's name; product name or designation.>**

2. Thermal Conductivity (k-value) at 75°F (24°C) mean temperature is 0.23 Btu x in./hr. x ft. x degree F. (0.033 W/m x K) or less.
3. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, [**without factory-applied jacket**] [**with factory-applied ASJ**] [**with factory-applied ASJ-SSL**]. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
4. Type II, 1200 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, [**without factory-applied jacket**] [**with factory-applied ASJ**] [**with factory-applied ASJ-SSL**]. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

N. Mineral-Fiber, Pipe Insulation Wicking System: Preformed pipe insulation complying with ASTM C 547, Type I, Grade A, with absorbent cloth factory applied to the entire inside surface of preformed pipe insulation and extended through the longitudinal joint to outside surface of insulation under insulation jacket. Factory apply a white, polymer, vapor-retarder jacket with self-sealing adhesive tape seam and evaporation holes running continuously along the longitudinal seam, exposing the absorbent cloth.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Knauf Insulation; Permawick Pipe Insulation.
b. Owens Corning; VaporWick Pipe Insulation.

c. **<Insert manufacturer's name; product name or designation.>**

2. Thermal Conductivity (k-value) at 75°F (24°C) mean temperature is 0.23 Btu x in./hr. x ft. x degree F. (0.033 W/m x K) or less.

O. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied [**ASJ**] [**FSK jacket**] complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following:

a. CertainTeed Corp.; CrimpWrap.
b. Johns Manville; MicroFlex.
c. Knauf Insulation; Pipe and Tank Insulation.
d. Manson Insulation Inc.; AK Flex.
e. Owens Corning; Fiberglas Pipe and Tank Insulation.
f. **<Insert manufacturer's name; product name or designation.>**

P. Phenolic:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Kingspan Corp.; Koolphen K.
b. **<Insert manufacturer's name; product name or designation.>**

2. Thermal Conductivity (k-value) at 75°F (24°C) mean temperature is 0.22 Btu x in./hr. x ft. x degree F. (0.031 W/m x K) or less.
3. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.
4. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
5. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
6. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.

a. Preformed Pipe Insulation: [**None**] [**ASJ**].
b. Board for Duct and Plenum Applications: [**None**] [**ASJ**].
c. Board for Equipment Applications: [**None**] [**ASJ**].

Q. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Apache Products Company; ISO-25.
b. Dow Chemical Company (The); Trymer.
c. Duna USA Inc.; Corafoam.
d. Elliott Company; Elfoam.
e. **<Insert manufacturer's name; product name or designation.>**

2. Comply with ASTM C 591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F at 75 deg F after 180 days of aging.
3. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less for thickness up to 1-1/2 inches as tested by ASTM E 84.

4. Fabricate shapes according to ASTM C 450 and ASTM C 585.
5. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.

    a. Pipe Applications: [**None**] [**ASJ**] [**ASJ-SSL**] [**PVDC**] [**PVDC-SSL**].
    b. Equipment Applications: [**None**] [**ASJ**] [**ASJ-SSL**] [**PVDC**] [**PVDC-SSL**].

R. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Armacell LLC; Tubolit.
    b. Nomaco Inc.; IMCOLOCK, IMCOSHEET, NOMALOCK, and NOMAPLY.
    c. RBX Corporation; Therma-cell.
    d. <**Insert manufacturer's name; product name or designation.**>

2. Thermal Conductivity (k-value) at 75°F (24°C) mean temperature is 0.25 Btu x in./hr. x ft. x degree F. (0.035 W/m x K) or less.

S. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C 578, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed 0.26 Btu x in./h x sq. ft. x deg F after 180 days of aging. Fabricate shapes according to ASTM C 450 and ASTM C 585.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Dow Chemical Company (The); Styrofoam.
    b. Knauf Insulation; Knauf Polystyrene.
    c. <**Insert manufacturer's name; product name or designation.**>

2.2 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F. Comply with ASTM C 656, Type II, Grade 6. tested and certified to provide a [**1**] [**2**]-hour fire rating by a NRTL acceptable to authority having jurisdiction.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Johns Manville; Super Firetemp M.
    b. <**Insert manufacturer's name; product name or designation.**>

B. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a [**1**] [**2**]-hour fire rating by a NRTL acceptable to authority having jurisdiction.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. CertainTeed Corp.; FlameChek.
    b. Johns Manville; Firetemp Wrap.
    c. Nelson Firestop Products; Nelson FSB Flameshield Blanket.
    d. Thermal Ceramics; FireMaster Duct Wrap.
    e. 3M; Fire Barrier Wrap Products.
    f. Unifrax Corporation; FyreWrap.
    g. Vesuvius; PYROSCAT FP FASTR Duct Wrap.
    h. <**Insert manufacturer's name; product name or designation.**>

2.3 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Insulco, Division of MFS, Inc.; Triple I.
b. P. K. Insulation Mfg. Co., Inc.; Super-Stik.
c. **<Insert manufacturer's name; product name or designation.>**

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

1. Products: Subject to compliance with requirements, provide one of the following:

a. P. K. Insulation Mfg. Co., Inc.; Thermal-V-Kote.
b. **<Insert manufacturer's name; product name or designation.>**

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Insulco, Division of MFS, Inc.; SmoothKote.
b. P. K. Insulation Mfg. Co., Inc.; PK No. 127, and Quik-Cote.
c. Rock Wool Manufacturing Company; Delta One Shot.
d. **<Insert manufacturer's name; product name or designation.>**

2.4 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Products, Division of ITW; CP-97.
b. Foster Products Corporation, H. B. Fuller Company; 81-27/81-93.
c. Marathon Industries, Inc.; 290.
d. Mon-Eco Industries, Inc.; 22-30.
e. Vimasco Corporation; 760.
f. **<Insert manufacturer's name; product name or designation.>**

2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Products, Division of ITW; CP-96.
b. Foster Products Corporation, H. B. Fuller Company; 81-33.
c. **<Insert manufacturer's name; product name or designation.>**

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Aeroflex USA Inc.; Aeroseal.
b. Armacell LCC; 520 Adhesive.
c. Foster Products Corporation, H. B. Fuller Company; 85-75.
d. RBX Corporation; Rubatex Contact Adhesive.
e. **<Insert manufacturer's name; product name or designation.>**

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Products, Division of ITW; CP-82.
b. Foster Products Corporation, H. B. Fuller Company; 85-20.
c. ITW TACC, Division of Illinois Tool Works; S-90/80.
d. Marathon Industries, Inc.; 225.
e. Mon-Eco Industries, Inc.; 22-25.
f. **<Insert manufacturer's name; product name or designation.>**

2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 deg F.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Products, Division of ITW; CP-96.
b. Foster Products Corporation, H. B. Fuller Company; 97-13.
c. **<Insert manufacturer's name; product name or designation.>**

G. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Products, Division of ITW; CP-82.
b. Foster Products Corporation, H. B. Fuller Company; 85-20.
c. ITW TACC, Division of Illinois Tool Works; S-90/80.
d. Marathon Industries, Inc.; 225.
e. Mon-Eco Industries, Inc.; 22-25.
f. **<Insert manufacturer's name; product name or designation.>**

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

H. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Dow Chemical Company (The); 739, Dow Silicone.
    b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
    c. P.I.C. Plastics, Inc.; Welding Adhesive.
    d. Speedline Corporation; Speedline Vinyl Adhesive.
    e. **<Insert manufacturer's name; product name or designation.>**

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.5 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of <**Insert value**> g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Childers Products, Division of ITW; CP-35.
    b. Foster Products Corporation, H. B. Fuller Company; 30-90.
    c. ITW TACC, Division of Illinois Tool Works; CB-50.
    d. Marathon Industries, Inc.; 590.
    e. Mon-Eco Industries, Inc.; 55-40.
    f. Vimasco Corporation; 749.
    g. **<Insert manufacturer's name; product name or designation.>**

2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Childers Products, Division of ITW; CP-30.
    b. Foster Products Corporation, H. B. Fuller Company; 30-35.
    c. ITW TACC, Division of Illinois Tool Works; CB-25.
    d. Marathon Industries, Inc.; 501.
    e. Mon-Eco Industries, Inc.; 55-10.
    f. **<Insert manufacturer's name; product name or designation.>**

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
3. Service Temperature Range: 0 to 180 deg F.
4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Products, Division of ITW; Encacel.
   b. Foster Products Corporation, H. B. Fuller Company; 60-95/60-96.
   c. Marathon Industries, Inc.; 570.
   d. Mon-Eco Industries, Inc.; 55-70.
   e. **<Insert manufacturer's name; product name or designation.>**

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
5. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Products, Division of ITW; CP-10.
   b. Foster Products Corporation, H. B. Fuller Company; 35-00.
   c. ITW TACC, Division of Illinois Tool Works; CB-05/15.
   d. Marathon Industries, Inc.; 550.
   e. Mon-Eco Industries, Inc.; 55-50.
   f. Vimasco Corporation; WC-1/WC-5.
   g. **<Insert manufacturer's name; product name or designation.>**

2. Water-Vapor Permeance: ASTM F 1249, 3 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 200 deg F.
4. Solids Content: 63 percent by volume and 73 percent by weight.
5. Color: White.

2.6 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of <**Insert value**> g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Products, Division of ITW; CP-52.
   b. Foster Products Corporation, H. B. Fuller Company; 81-42.
   c. Marathon Industries, Inc.; 130.
   d. Mon-Eco Industries, Inc.; 11-30.
   e. Vimasco Corporation; 136.
   f. **<Insert manufacturer's name; product name or designation.>**

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation.
4. Service Temperature Range: Minus 50 to plus 180 deg F.
5. Color: White.

2.7 SEALANTS

A. Joint Sealants:

1. Joint Sealants for Cellular-Glass, Phenolic, and Polyisocyanurate Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Products, Division of ITW; CP-76.
   b. Foster Products Corporation, H. B. Fuller Company; 30-45.
   c. Marathon Industries, Inc.; 405.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Pittsburgh Corning Corporation; Pittseal 444.
   f. Vimasco Corporation; 750.
   g. **<Insert manufacturer's name; product name or designation.>**

2. Joint Sealants for Polystyrene Products: Subject to compliance with requirements, [**provide the following**] [**provide one of the following**] [**available products that may be incorporated into the Work include, but are not limited to, the following**]:

   a. Childers Products, Division of ITW; CP-70.
   b. Foster Products Corporation, H. B. Fuller Company; 30-45/30-46.
   c. Marathon Industries, Inc.; 405.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Vimasco Corporation; 750.
   f. **<Insert manufacturer's name; product name or designation.>**

3. Materials shall be compatible with insulation materials, jackets, and substrates.
4. Permanently flexible, elastomeric sealant.
5. Service Temperature Range: Minus 100 to plus 300 deg F.
6. Color: White or gray.
7. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Products, Division of ITW; CP-76-8.
   b. Foster Products Corporation, H. B. Fuller Company; 95-44.
   c. Marathon Industries, Inc.; 405.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Vimasco Corporation; 750.
   f. **<Insert manufacturer's name; product name or designation.>**

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Products, Division of ITW; CP-76.
b. **<Insert manufacturer's name; product name or designation.>**

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.
6. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.8 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

   a. Products: Subject to compliance with requirements, provide one of the following:

      1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
      2) **<Insert manufacturer's name; product name or designation.>**

6. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

   a. Products: Subject to compliance with requirements, provide one of the following:

      1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
      2) **<Insert manufacturer's name; product name or designation.>**

7. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

   a. Products: Subject to compliance with requirements, provide one of the following:

      1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
      2) **<Insert manufacturer's name; product name or designation.>**

8. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.9 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch for covering pipe and pipe fittings.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Vimasco Corporation; Elastafab 894.
   b. **<Insert manufacturer's name; product name or designation.>**

B. Woven Glass-Fiber Fabric for Duct and Equipment Insulation: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. inch for covering equipment.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Products, Division of ITW; Chil-Glas No. 5.
   b. **<Insert manufacturer's name; product name or designation.>**

C. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch, in a Leno weave, for duct, equipment, and pipe.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Foster Products Corporation, H. B. Fuller Company; Mast-A-Fab.
   b. Vimasco Corporation; Elastafab 894.
   c. **<Insert manufacturer's name; product name or designation.>**

2.10 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.
   b. **<Insert manufacturer's name; product name or designation.>**

2.11 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Johns Manville; Zeston.
   b. P.I.C. Plastics, Inc.; FG Series.
   c. Proto PVC Corporation; LoSmoke.
   d. Speedline Corporation; SmokeSafe.

e. **<Insert manufacturer's name; product name or designation.>**

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: **[White] [Color-code jackets based on system. Color as selected by Architect]**.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

   a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

5. Factory-fabricated tank heads and tank side panels.

D. Metal Jacket:

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Products, Division of ITW; Metal Jacketing Systems.
   b. PABCO Metals Corporation; Surefit.
   c. RPR Products, Inc.; Insul-Mate.
   d. **<Insert manufacturer's name; product name or designation.>**

2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.

   a. **[Sheet and roll stock ready for shop or field sizing] [Factory cut and rolled to size]**.
   b. Finish and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier for Indoor Applications: **[1-mil- thick, heat-bonded polyethylene and kraft paper] [3-mil- thick, heat-bonded polyethylene and kraft paper] [2.5-mil- thick Polysurlyn]**.
   d. Moisture Barrier for Outdoor Applications: **[3-mil- thick, heat-bonded polyethylene and kraft paper] [2.5-mil- thick Polysurlyn]**.
   e. Factory-Fabricated Fitting Covers:

      1) Same material, finish, and thickness as jacket.
      2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      3) Tee covers.
      4) Flange and union covers.
      5) End caps.
      6) Beveled collars.
      7) Valve covers.
      8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

   a. **[Sheet and roll stock ready for shop or field sizing] [Factory cut and rolled to size]**.
   b. Material, finish, and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier for Indoor Applications: **[1-mil- thick, heat-bonded polyethylene and kraft paper] [3-mil- thick, heat-bonded polyethylene and kraft paper] [2.5-mil- thick Polysurlyn]**.
   d. Moisture Barrier for Outdoor Applications: **[3-mil- thick, heat-bonded polyethylene and kraft paper] [2.5-mil- thick Polysurlyn]**.
   e. Factory-Fabricated Fitting Covers:

      1) Same material, finish, and thickness as jacket.
      2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      3) Tee covers.

4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricated fitting covers only if factory-fabricated fitting covers are not available.

E. Underground Direct-Buried Jacket: 125-mil- thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Pittsburgh Corning Corporation; Pittwrap.
b. Polyguard; Insulrap No Torch 125.
c. **<Insert manufacturer's name; product name or designation.>**

F. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with **[white]** **[stucco-embossed]** aluminum-foil facing.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Polyguard; Alumaguard 60.
b. **<Insert manufacturer's name; product name or designation.>**

G. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Dow Chemical Company (The), Saran 540 Vapor Retarder Film.
b. **<Insert manufacturer's name; product name or designation.>**

H. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Dow Chemical Company (The), Saran 560 Vapor Retarder Film.
b. **<Insert manufacturer's name; product name or designation.>**

I. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
b. **<Insert manufacturer's name; product name or designation.>**

2.12 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
   b. Compac Corp.; 104 and 105.
   c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
   d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
   e. **<Insert manufacturer's name; product name or designation.>**

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
   b. Compac Corp.; 110 and 111.
   c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
   d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.
   e. **<Insert manufacturer's name; product name or designation.>**

2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
   b. Compac Corp.; 130.
   c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
   d. Venture Tape; 1506 CW NS.
   e. **<Insert manufacturer's name; product name or designation.>**

2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
    b. Compac Corp.; 120.
    c. Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF.
    d. Venture Tape; 3520 CW.
    e. **<Insert manufacturer's name; product name or designation.>**

2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Dow Chemical Company (The); Saran 540 Vapor Retarder Tape.
    b. **<Insert manufacturer's name; product name or designation.>**

2. Width: 3 inches.
3. Film Thickness: 4 mils.
4. Adhesive Thickness: 1.5 mils.
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch in width.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Dow Chemical Company (The); Saran 560 Vapor Retarder Tape.
    b. **<Insert manufacturer's name; product name or designation.>**

2. Width: 3 inches.
3. Film Thickness: 6 mils.
4. Adhesive Thickness: 1.5 mils.
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch in width.

2.13 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Childers Products; Bands.
    b. PABCO Metals Corporation; Bands.
    c. RPR Products, Inc.; Bands.
    d. **<Insert manufacturer's name; product name or designation.>**

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type [**304**] [**316**] [**304 or Type 316**]; 0.015 inch thick, [**1/2 inch**] [**3/4 inch**] wide with [**wing seal**] [**closed seal**] [**wing or closed seal**].
3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, [**1/2 inch**] [**3/4 inch**] wide with [**wing seal**] [**closed seal**] [**wing or closed seal**].
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, [**0.106-inch-**] [**0.135-inch-**] diameter shank, length to suit depth of insulation indicated.

   a. Products: Subject to compliance with requirements, provide one of the following:

      1) AGM Industries, Inc.; CWP-1.
      2) GEMCO; CD.
      3) Midwest Fasteners, Inc.; CD.
      4) Nelson Stud Welding; TPA, TPC, and TPS.
      5) **<Insert manufacturer's name; product name or designation.>**

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, [**0.106-inch-**] [**0.135-inch-**] diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

   a. Products: Subject to compliance with requirements, provide one of the following:

      1) AGM Industries, Inc.; CWP-1.
      2) GEMCO; Cupped Head Weld Pin.
      3) Midwest Fasteners, Inc.; Cupped Head.
      4) Nelson Stud Welding; CHP.
      5) **<Insert manufacturer's name; product name or designation.>**

3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

   a. Products: Subject to compliance with requirements, provide one of the following:

      1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series T.
      2) GEMCO; Perforated Base.
      3) Midwest Fasteners, Inc.; Spindle.
      4) **<Insert manufacturer's name; product name or designation.>**

   b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   c. Spindle: [**Copper- or zinc-coated, low carbon steel**] [**Aluminum**] [**Stainless steel**], fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
   d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, provide one of the following:

1) GEMCO; Nylon Hangers.
2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.
3) **<Insert manufacturer's name; product name or designation.>**

b. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
c. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, provide one of the following:

1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series TSA.
2) GEMCO; Press and Peel.
3) Midwest Fasteners, Inc.; Self Stick.
4) **<Insert manufacturer's name; product name or designation.>**

b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
c. Spindle: **[Copper- or zinc-coated, low carbon steel]** **[Aluminum]** **[Stainless steel]**, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
d. Adhesive-backed base with a peel-off protective cover.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, **[galvanized-steel]** **[aluminum]** **[stainless-steel]** sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. Products: Subject to compliance with requirements, provide one of the following:

1) AGM Industries, Inc.; RC-150.
2) GEMCO; R-150.
3) Midwest Fasteners, Inc.; WA-150.
4) Nelson Stud Welding; Speed Clips.
5) **<Insert manufacturer's name; product name or designation.>**

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. Products: Subject to compliance with requirements, provide one of the following:

1) GEMCO.
2) Midwest Fasteners, Inc.
3) **<Insert manufacturer's name.>**

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

D. Wire: **[0.080-inch nickel-copper alloy]** **[0.062-inch soft-annealed, stainless steel]** **[0.062-inch soft-annealed, galvanized steel]**.

1. Manufacturers: Subject to compliance with requirements, provide one of the following:

   a. C & F Wire.
   b. Childers Products.
   c. PABCO Metals Corporation.
   d. RPR Products, Inc.
   e. **<Insert manufacturer's name.>**

2.14 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105 or 5005; Temper H-14.

C. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type [**304**] [**316**] [**304 or 316**].

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at [**2 inches**] [**4 inches**] o.c.

   a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

1. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Pipe: Install insulation continuously through floor penetrations.
3. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.5 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

A. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for **[100]** **[50]** <**Insert percentage**> percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

   a. Do not weld anchor pins to ASME-labeled pressure vessels.
   b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
   c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
   d. Do not overcompress insulation during installation.
   e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
   f. Impale insulation over anchor pins and attach speed washers.
   g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.

7. Stagger joints between insulation layers at least 3 inches.
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.

C. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch- diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
2. Fabricate boxes from [**galvanized steel**] [**aluminum**] [**stainless steel**], at least [**0.040 inch**] [**0.050 inch**] [**0.060 inch**] thick.
3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

D. Insulation Installation and Cooling Coil Drain Pans in Field-Fabricated Units.

1. Provide cellular glass insulation 3 inches (75 mm) thick under entire bottom of drain pan.
2. Insulation shall be imbedded in a flexible vapor barrier sealant and bedding compound of type recommended by manufacturers.

3.6 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less

than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.7 CALCIUM SILICATE INSULATION INSTALLATION

A. Insulation Installation on Boiler Breechings and Ducts:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation material.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging

adhesive and press on one layer of glass cloth. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

B. Insulation Installation on Straight Pipes and Tubes:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

C. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
4. Finish flange insulation same as pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
3. Finish fittings insulation same as pipe insulation.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

3.8 CELLULAR-GLASS INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.9 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.10 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

E. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for **[100]** **[50]** <**Insert percentage**> percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
d. Do not overcompress insulation during installation.
e. Impale insulation over pins and attach speed washers.
f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

F. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for **[100]** **[50]** <**Insert percentage**> percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not overcompress insulation during installation.
   e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by

removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.11 PHENOLIC INSULATION INSTALLATION

A. General Installation Requirements:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with 0.062-inch wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.

B. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets with vapor retarders on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

C. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.12 POLYISOCYANURATE INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.

C. Insulation Installation on Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of polyisocyanurate insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.13 POLYOLEFIN INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of polyolefin pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install cut sections of polyolefin pipe and sheet insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.14 POLYSTYRENE INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation with tape or bands and tighten bands without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed section of polystyrene insulation to valve body.

2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.15 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

E. Where PVDC jackets are indicated, install as follows:

1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap factory-presized jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
3. Continuous jacket can be spiral wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. The 33-1/2-inch- circumference limit allows for 2-inch- overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.16 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Division 07 Section "Penetration Firestopping."

3.17 FINISHES

A. Duct, Equipment, and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.

1. Flat Acrylic Finish: [**Two**] <**Insert number**> finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

    a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.18 FIELD QUALITY CONTROL

A. Testing Agency: [**Owner will engage**] [**Engage**] a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to [**one**] <**Insert number**> location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
2. Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to [**one**] <**Insert number**> location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
3. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to [**three**] <**Insert number**> locations of straight pipe, [**three**] <**Insert number**> locations of threaded fittings, [**three**] <**Insert number**> locations of welded fittings, [**two**] <**Insert number**> locations of threaded strainers, [**two**] <**Insert number**> locations of welded strainers, [**three**] <**Insert number**> locations of threaded valves, and [**three**] <**Insert number**> locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.19 BOILER BREECHING INSULATION SCHEDULE

A. Round, exposed breeching and connector insulation shall be[**one of**] the following:

1. Calcium Silicate: 4 inches thick.
2. High-Temperature Mineral-Fiber Blanket: 3 inches thick and 3-lb/cu. ft. nominal density.
3. High-Temperature Mineral-Fiber Board: 3 inches thick and [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.

B. Round, concealed breeching and connector insulation shall be[**one of**] the following:

1. Calcium Silicate: 4 inches thick.
2. High-Temperature Mineral-Fiber Blanket: 3 inches thick and 3-lb/cu. ft. nominal density.
3. High-Temperature Mineral-Fiber Board: 3 inches thick and [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.

C. Rectangular, exposed breeching and connector insulation shall be[**one of**] the following:

1. Calcium Silicate: 4 inches thick.
2. High-Temperature Mineral-Fiber Blanket: 3 inches thick and 3-lb/cu. ft. nominal density.
3. High-Temperature Mineral-Fiber Board: 3 inches thick and [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.

D. Rectangular, concealed breeching and connector insulation shall be[**one of**] the following:

1. Calcium Silicate: 4 inches thick.
2. High-Temperature Mineral-Fiber Blanket: 3 inches thick and 3-lb/cu. ft. nominal density.
3. High-Temperature Mineral-Fiber Board: 3 inches thick and [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.

3.20 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in nonconditioned space.
4. Indoor, exposed return located in nonconditioned space.
5. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
6. Indoor, exposed, Type I, commercial, kitchen hood exhaust.
7. Indoor, concealed oven and warewash exhaust.
8. Indoor, exposed oven and warewash exhaust.
9. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
10. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
11. Outdoor, concealed supply and return.
12. Outdoor, exposed supply and return.
13. Any ductwork where ductwork air temperature exceeds 85°F.

B. Items Not Insulated:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

3.21 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, round and flat-oval, supply-air duct insulation shall be[**one of**] the following:

1. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
2. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
3. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
5. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

B. Concealed, round and flat-oval, return-air duct insulation shall be[**one of**] the following:

1. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
2. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
3. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
5. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

C. Concealed, round and flat-oval, outdoor-air duct insulation shall be[**one of**] the following:

1. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
2. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
3. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
5. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

D. Concealed, round and flat-oval, exhaust-air duct insulation shall be[**one of**] the following:

1. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
2. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
3. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
5. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

E. Concealed, rectangular, supply-air duct insulation shall be[**one of**] the following:

1. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.

2. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
3. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
5. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

F. Concealed, rectangular, return-air duct insulation shall be[**one of**] the following:

1. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
2. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
3. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
5. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

G. Concealed, rectangular, outdoor-air duct insulation shall be[**one of**] the following:

1. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
2. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
3. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
5. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

H. Concealed, rectangular, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be[**one of**] the following:

1. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
2. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
3. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
5. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

I. Concealed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated [**blanket**] [**board**] [**blanket or board**]; thickness as required to achieve 2-hour fire rating.

J. Concealed, supply-air plenum insulation shall be[**one of**] the following:

1. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
2. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
3. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
5. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

K. Concealed, return-air plenum insulation shall be[**one of**] the following:

1. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.

2. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
3. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
5. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

L. Concealed, outdoor-air plenum insulation shall be[**one of**] the following:

1. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
2. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
3. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.

M. Concealed, exhaust-air plenum insulation shall be[**one of**] the following:

1. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
2. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
3. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.

N. Exposed, round and flat-oval, supply-air duct insulation shall be[**one of**] the following:

1. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
2. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
3. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
5. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

O. Exposed, round and flat-oval, return-air duct insulation shall be[**one of**] the following:

1. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
2. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
3. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
5. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

P. Exposed, round and flat-oval, outdoor-air duct insulation shall be[**one of**] the following:

1. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
2. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
3. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
5. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

Q. Exposed, round and flat-oval, exhaust-air duct insulation shall be[**one of**] the following:

1. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
2. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
3. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
5. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

R. Exposed, rectangular, supply-air duct insulation shall be[**one of**] the following:

1. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
2. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
3. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
5. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

S. Exposed, rectangular, return-air duct insulation shall be[**one of**] the following:

1. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
2. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
3. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
5. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

T. Exposed, rectangular, outdoor-air duct insulation shall be[**one of**] the following:

1. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
2. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
3. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
5. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

U. Exposed, rectangular, exhaust-air duct insulation shall be[**one of**] the following:

1. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
2. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
3. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
5. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

V. Exposed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated [**blanket**] [**board**] [**blanket or board**]; thickness as required to achieve 2-hour fire rating.

W. Exposed, supply-air plenum insulation shall be[**one of**] the following:

1. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.

2. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
3. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
5. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

X. Exposed, return-air plenum insulation shall be[**one of**] the following:

1. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
2. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
3. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
5. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

Y. Exposed, outdoor-air plenum insulation shall be[**one of**] the following:

1. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
2. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
3. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.

Z. Exposed, exhaust-air plenum insulation shall be[**one of**] the following:

1. Mineral-Fiber Blanket: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
2. Mineral-Fiber Board: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
3. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.

3.22 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.

B. Concealed, round and flat-oval, supply-air duct insulation shall be[**one of**] the following:

1. Mineral-Fiber Blanket: [**2 inches**] [**3 inches**] <**Insert thickness**> and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
2. Mineral-Fiber Board: [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
3. Phenolic: [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.

C. Concealed, round and flat-oval, return-air duct insulation shall be[**one of**] the following:

1. Mineral-Fiber Blanket: [**2 inches**] [**3 inches**] <**Insert thickness**> and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
2. Mineral-Fiber Board: [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
3. Phenolic: [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.

D. Concealed, round and flat-oval, outdoor-air duct insulation shall be[**one of**] the following:

1. Mineral-Fiber Blanket: [**2 inches**] [**3 inches**] <**Insert thickness**> and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
2. Mineral-Fiber Board: [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
3. Phenolic: [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.

E. Concealed, rectangular, supply-air duct insulation shall be[**one of**] the following:

1. Mineral-Fiber Blanket: [**2 inches**] [**3 inches**] <**Insert thickness**> and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
2. Mineral-Fiber Board: [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
3. Phenolic: [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.

F. Concealed, rectangular, return-air duct insulation shall be[**one of**] the following:

1. Mineral-Fiber Blanket: [**2 inches**] [**3 inches**] <**Insert thickness**> and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
2. Mineral-Fiber Board: [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
3. Phenolic: [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.

G. Concealed, supply-air plenum insulation shall be[**one of**] the following:

1. Mineral-Fiber Blanket: [**2 inches**] [**3 inches**] <**Insert thickness**> and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
2. Mineral-Fiber Board: [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
3. Phenolic: [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.

H. Concealed, return-air plenum insulation shall be[**one of**] the following:

1. Mineral-Fiber Blanket: [**2 inches**] [**3 inches**] <**Insert thickness**> and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
2. Mineral-Fiber Board: [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
3. Phenolic: [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.

I. Exposed, round and flat-oval, supply-air duct insulation shall be[**one of**] the following:

1. Mineral-Fiber Blanket: [**2 inches**] [**3 inches**] <**Insert thickness**> and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
2. Mineral-Fiber Board: [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
3. Phenolic: [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.

J. Exposed, round and flat-oval, return-air duct insulation shall be[**one of**] the following:

1. Mineral-Fiber Blanket: [**2 inches**] [**3 inches**] <**Insert thickness**> and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
2. Mineral-Fiber Board: [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
3. Phenolic: [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.

K. Exposed, rectangular, supply-air duct insulation shall be[**one of**] the following:

1. Mineral-Fiber Blanket: [**2 inches**] [**3 inches**] <**Insert thickness**> and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
2. Mineral-Fiber Board: [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
3. Phenolic: [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.

L. Exposed, rectangular, return-air duct insulation shall be[**one of**] the following:

1. Mineral-Fiber Blanket: [**2 inches**] [**3 inches**] <**Insert thickness**> and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
2. Mineral-Fiber Board: [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
3. Phenolic: [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.

M. Exposed, supply-air plenum insulation shall be[**one of**] the following:

1. Mineral-Fiber Blanket: [**2 inches**] [**3 inches**] <**Insert thickness**> and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
2. Mineral-Fiber Board: [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
3. Phenolic: [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.

N. Exposed, return-air plenum insulation shall be[**one of**] the following:

1. Mineral-Fiber Blanket: [**2 inches**] [**3 inches**] <**Insert thickness**> and [**0.75-lb/cu. ft.**] [**1.5-lb/cu. ft.**] [**3-lb/cu. ft.**] nominal density.
2. Mineral-Fiber Board: [**2 inches**] [**3 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
3. Phenolic: [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.

3.23 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.

C. Chillers: Insulate cold surfaces on chillers, including, but not limited to, evaporator bundles, [**condenser bundles,**] [**heat-recovery bundles,**] suction piping, compressor inlets, tube sheets, water boxes, nozzles and other areas recommended by the manufacturers with[**one of**] the following:

1. Cellular Glass: [**2 inches**] <**insert thickness**> thick.
2. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
3. Mineral-Fiber Board: [**1 inch**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Mineral-Fiber Pipe and Tank: [**1 inch**] <**Insert thickness**> thick.
5. Phenolic: [**1 inch**] <**Insert thickness**> thick.
6. Polyisocyanurate: [**1 inch**] <**Insert thickness**> thick.
7. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

D. Chilled-water pump insulation shall be[**one of**] the following:

1. Cellular Glass: [**3 inches**] <**Insert thickness**> thick.
2. Mineral-Fiber Board: [**2 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
3. Phenolic: [**2 inches**] <**Insert thickness**> thick.
4. Polyisocyanurate: [**1-1/2 inches**] <**Insert thickness**> thick.

E. Heating-hot-water pump insulation shall be[**one of**] the following:

1. Calcium Silicate: [**3 inches**] <**Insert thickness**> thick.
2. Cellular Glass: [**3 inches**] <**Insert thickness**> thick.
3. Mineral-Fiber Board: [**2 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.

F. Heat-recovery pump insulation shall be[**one of**] the following:

1. Cellular Glass: [**2 inches**] <**Insert thickness**> thick.
2. Mineral-Fiber Board: [**2 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
3. Phenolic: [**1 inch**] <**Insert thickness**> thick.
4. Polyisocyanurate: [**1-1/2 inches**] <**Insert thickness**> thick.

G. Chilled-water expansion/compression tank insulation shall be[**one of**] the following:

1. Cellular Glass: [**1-1/2 inches**] <**Insert thickness**> thick.
2. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
3. Mineral-Fiber Board: [**1 inch**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Mineral-Fiber Pipe and Tank: [**1 inch**] <**Insert thickness**> thick.
5. Phenolic: [**1 inch**] <**Insert thickness**> thick.
6. Polyisocyanurate: [**1 inch**] <**Insert thickness**> thick.
7. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

H. Condenser-water expansion/compression tank insulation shall be[**one of**] the following:

1. Cellular Glass: [**1-1/2 inches**] <**Insert thickness**> thick.
2. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
3. Mineral-Fiber Board: [**1 inch**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Mineral-Fiber Pipe and Tank: [**1 inch**] <**Insert thickness**> thick.
5. Phenolic: [**1 inch**] <**Insert thickness**> thick.
6. Polyisocyanurate: [**1 inch**] <**Insert thickness**> thick.
7. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

I. Heating-hot-water expansion/compression tank insulation shall be[**one of**] the following:

1. Calcium Silicate: [**2 inches**] <**Insert thickness**> thick.
2. Cellular Glass: [**1-1/2 inches**] <**Insert thickness**> thick.
3. Mineral-Fiber Board: [**1 inch**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Mineral-Fiber Pipe and Tank: [**1 inch**] <**Insert thickness**> thick.

J. Chilled-water air-separator insulation shall be[**one of**] the following:

1. Cellular Glass: [**2 inches**] <**Insert thickness**> thick.
2. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.

3. Mineral-Fiber Board: [**1 inch**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Mineral-Fiber Pipe and Tank: [**1 inch**] <**Insert thickness**> thick.
5. Phenolic: [**1 inch**] <**Insert thickness**> thick.
6. Polyisocyanurate: [**1 inch**] <**Insert thickness**> thick.
7. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

K. Condenser-water air-separator insulation shall be[**one of**] the following:

1. Cellular Glass: [**2 inches**] <**Insert thickness**> thick.
2. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
3. Mineral-Fiber Board: [**1 inch**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Mineral-Fiber Pipe and Tank: [**1 inch**] <**Insert thickness**> thick.
5. Phenolic: [**1 inch**] <**Insert thickness**> thick.
6. Polyisocyanurate: [**1 inch**] <**Insert thickness**> thick.
7. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

L. Heating-hot-water air-separator insulation shall be[**one of**] the following:

1. Calcium Silicate: [**3 inches**] <**Insert thickness**> thick.
2. Cellular Glass: [**3 inches**] <**Insert thickness**> thick.
3. Mineral-Fiber Board: [**2 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Mineral-Fiber Pipe and Tank: [**2 inches**] <**Insert thickness**> thick.

M. Heat-recovery air-separator insulation shall be[**one of**] the following:

1. Cellular Glass: [**2 inches**] <**Insert thickness**> thick.
2. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
3. Mineral-Fiber Board: [**1 inch**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
4. Mineral-Fiber Pipe and Tank: [**1 inch**] <**Insert thickness**> thick.
5. Phenolic: [**1 inch**] <**Insert thickness**> thick.
6. Polyisocyanurate: [**1 inch**] <**Insert thickness**> thick.
7. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

N. Piping system filter-housing insulation shall be[**one of**] the following:

1. Cellular Glass: [**3 inches**] <**Insert thickness**> thick.
2. Mineral-Fiber Board: [**2 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
3. Mineral-Fiber Pipe and Tank: [**2 inches**] <**Insert thickness**> thick.

O. Outdoor, aboveground, heated, fuel-oil storage tank insulation shall be[**one of**] the following:

1. Cellular Glass: [**3 inches**] <**Insert thickness**> thick.
2. Mineral-Fiber Board: [**2 inches**] <**Insert thickness**> thick and [**2-lb/cu. ft.**] [**3-lb/cu. ft.**] [**6-lb/cu. ft.**] nominal density.
3. Mineral-Fiber Pipe and Tank: [**2 inches**] <**Insert thickness**> thick.
4. Polyisocyanurate: [**1-1/2 inches**] <**Insert thickness**> thick.

3.24 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.25 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:

a. Cellular Glass: [**1-1/2 inches**] <**Insert thickness**> thick.
b. Flexible Elastomeric: [**3/4 inch**] [**1 inch**] <**Insert thickness**> thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I: [**1/2 inch**] [**1 inch**] <**Insert thickness**> thick.
d. Phenolic: [**1 inch**] <**Insert thickness**> thick.
e. Polyisocyanurate: [**1 inch**] <**Insert thickness**> thick.
f. Polyolefin: [**3/4 inch**] [**1 inch**] <**Insert thickness**> thick.

B. Chilled Water and Brine, 40 Deg F and below:

1. [**NPS 1**] <**Insert pipe size**> and Smaller: Insulation shall be[**one of**] the following:

a. Cellular Glass: [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
b. Mineral-Fiber, [**Preformed Pipe, Type I**] [**Pipe Insulation Wicking System**] [**Preformed Pipe, Type I or Pipe Insulation Wicking System**]: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
c. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick.
d. Polyisocyanurate: [**1 inch**] [**1-1/2 inches**] <**Insert thickness**> thick.

2. [**NPS 1 1/4 to NPS 4**] <**Insert pipe size range**>: Insulation shall be[**one of**] the following:

a. Cellular Glass: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick.
b. Mineral-Fiber, [**Preformed Pipe, Type I**] [**Pipe Insulation Wicking System**] [**Preformed Pipe, Type I or Pipe Insulation Wicking System**]: [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
c. Phenolic: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick.
d. Polyisocyanurate: [**1 inch**] [**1-1/2 inches**] <**Insert thickness**> thick.

3. [**NPS 5**] <**Insert pipe size**> and Larger: Insulation shall be[**one of**] the following:

a. Cellular Glass: [**2 inches**] [**3 inches**] <**Insert thickness**> thick.
b. Mineral-Fiber, [**Preformed Pipe, Type I**] [**Pipe Insulation Wicking System**] [**Preformed Pipe, Type I or Pipe Insulation Wicking System**]: [**2 inches**] [**3 inches**] <**Insert thickness**> thick.
c. Phenolic: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick.
d. Polyisocyanurate: [**1-1/2 inches**] <**Insert thickness**> thick.

C. Chilled Water and Brine, above 40 Deg F:

1. [**NPS 4**] <**Insert pipe size**> and Smaller: Insulation shall be[**one of**] the following:

   a. Cellular Glass: [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
   b. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
   c. Mineral-Fiber, [**Preformed Pipe, Type I**] [**Pipe Insulation Wicking System**] [**Preformed Pipe, Type I or Pipe Insulation Wicking System**]: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
   d. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick.
   e. Polyisocyanurate: [**1 inch**] [**1-1/2 inches**] <**Insert thickness**> thick.
   f. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

2. [**NPS 5**] <**Insert pipe size**> and Larger: Insulation shall be[**one of**] the following:

   a. Cellular Glass: [**2 inches**] [**3 inches**] <**Insert thickness**> thick.
   b. Mineral-Fiber [**Preformed Pipe, Type I**] [**Pipe Insulation Wicking System**] [**Preformed Pipe, Type I or Pipe Insulation Wicking System**]: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick.
   c. Phenolic: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick.
   d. Polyisocyanurate: [**1-1/2 inches**] <**Insert thickness**> thick.

D. Condenser-Water Supply and Return:

1. [**NPS 4**] <**Insert pipe size**> and Smaller: Insulation shall be[**one of**] the following:

   a. Cellular Glass: [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
   b. Flexible Elastomeric: [**1 inch**] <**Insert thickness**> thick.
   c. Mineral-Fiber, Preformed Pipe, Type I: [**1 inch**] [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
   d. Phenolic: [**1 inch**] [**1-1/2 inches**] <**Insert thickness**> thick.
   e. Polyisocyanurate: [**1 inch**] [**1-1/2 inches**] <**Insert thickness**> thick.
   f. Polyolefin: [**1 inch**] <**Insert thickness**> thick.

2. [**NPS 5**] <**Insert pipe size**> and Larger: Insulation shall be[**one of**] the following:

   a. Cellular Glass: [**2 inches**] [**3 inches**] <**Insert thickness**> thick.
   b. Mineral-Fiber, Preformed Pipe, Type I: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick.
   c. Phenolic: [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick.
   d. Polyisocyanurate: [**1-1/2 inches**] <**Insert thickness**> thick.

E. Heating-Hot-Water Supply and Return, 200 Deg F and below:

1. [**NPS 2**] <**Insert pipe size**> and Smaller: Insulation shall be[**one of**] the following:

   a. Cellular Glass: [**1-1/2 inches**] [**2 inches**] <**Insert thickness**> thick.
   b. Mineral-Fiber, Preformed Pipe, Type I: [**1 inch**] [**2 inches**] <**Insert thickness**> thick.
   c. Phenolic: [**1 inch**] [**1-1/2 inches**] [**2 inches**] [**3 inches**] <**Insert thickness**> thick.
   d. Polyisocyanurate: [**1 inch**] [**1-1/2 inches**] <**Insert thickness**> thick.

2. [**NPS 2 1/2**] <**Insert pipe size**> and Larger: Insulation shall be[**one of**] the following:

   a. Cellular Glass: [**2 inches**] [**3 inches**] <**Insert thickness**> thick.

b. Mineral-Fiber, Preformed Pipe, Type I: **[1-1/2 inches]** **[2 inches]** **[3 inches]** <**Insert thickness**> thick.
c. Phenolic: **[1-1/2 inches]** **[2 inches]** **[3 inches]** <**Insert thickness**> thick.
d. Polyisocyanurate: **[1-1/2 inches]** <**Insert thickness**> thick.

F. Heating-Hot-Water Supply and Return, above 200 Deg F:

1. **[NPS 2]** <**Insert pipe size**> and Smaller: Insulation shall be[**one of**] the following:

a. Calcium Silicate: **[2 inches]** **[3 inches]** <**Insert thickness**> thick.
b. Cellular Glass: **[2 inches]** **[3 inches]** <**Insert thickness**> thick.
c. Mineral-Fiber, Preformed Pipe, Type I or II: **[1-1/2 inches]** **[2 inches]** <**Insert thickness**> thick.

2. **[NPS 2 1/2]** <**Insert pipe size**> and Larger: Insulation shall be[**one of**] the following:

a. Calcium Silicate: **[3 inches]** **[4 inches]** <**Insert thickness**> thick.
b. Cellular Glass: **[3 inches]** **[4 inches]** <**Insert thickness**> thick.
c. Mineral-Fiber, Preformed Pipe, Type I or II: **[3 inches]** **[4 inches]** <**Insert thickness**> thick.

G. Refrigerant Suction and Hot-Gas Piping:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:

a. Cellular Glass: **[1-1/2 inches]** <**Insert thickness**> thick.
b. Flexible Elastomeric: **[1 inch]** <**Insert thickness**> thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I: **[1 inch]** <**Insert thickness**> thick.
d. Phenolic: **[1 inch]** <**Insert thickness**> thick.
e. Polyisocyanurate: **[1 inch]** <**Insert thickness**> thick.
f. Polyolefin: **[1 inch]** <**Insert thickness**> thick.

H. Refrigerant Suction and Hot-Gas Flexible Tubing:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:

a. Flexible Elastomeric: **[1 inch]** <**Insert thickness**> thick.
b. Polyolefin: **[1 inch]** <**Insert thickness**> thick.

I. Hot Service Drains:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:

a. Calcium Silicate: **[1-1/2 inches]** <**Insert thickness**> thick.
b. Cellular Glass: **[1-1/2 inches]** <**Insert thickness**> thick.
c. Mineral-Fiber, Preformed Pipe, Type I or II: **[1 inch]** <**Insert thickness**> thick.

J. Hot Service Vents:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:

a. Calcium Silicate: **[1-1/2 inches]** <**Insert thickness**> thick.
b. Cellular Glass: **[1-1/2 inches]** <**Insert thickness**> thick.
c. Mineral-Fiber, Preformed Pipe, Type I or II: **[1 inch]** <**Insert thickness**> thick.

K. Engine Exhaust Piping:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:

a. Calcium Silicate: [**4 inches**] [**4 1/2 inches**] <**Insert thickness**> thick.
b. Cellular Glass: [**4 inches**] [**4 1/2 inches**] <**Insert thickness**> thick.
c. Mineral-Fiber, Preformed Pipe, Type I or II: [**4 inches**] [**4 1/2 inches**] <**Insert thickness**> thick.

3.26 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Chilled Water and Brine:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:

a. Cellular Glass: [**3 inches**] <**Insert thickness**> thick.
b. Flexible Elastomeric: [**3 inches**] <**Insert thickness**> thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I: [**3 inches**] <**Insert thickness**> thick.
d. Phenolic: [**2 inches**] <**Insert thickness**> thick.
e. Polyisocyanurate: [**2 inches**] <**Insert thickness**> thick.
f. Polyolefin: [**3 inches**] <**Insert thickness**> thick.
g. Polystyrene: [**2 inches**] <**Insert thickness**> thick.

B. Condenser-Water Supply and Return:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:

a. Cellular Glass: [**2 inches**] <**Insert thickness**> thick.
b. Flexible Elastomeric: [**2 inches**] <**Insert thickness**> thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I: [**2 inches**] <**Insert thickness**> thick.
d. Phenolic: [**2 inches**] <**Insert thickness**> thick.
e. Polyisocyanurate: [**2 inches**] <**Insert thickness**> thick.
f. Polyolefin: [**2 inches**] <**Insert thickness**> thick.
g. Polystyrene: [**2 inches**] <**Insert thickness**> thick.

C. Heating-Hot-Water Supply and Return, 200 Deg F and below:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:

a. Cellular Glass: [**3 inches**] <**Insert thickness**> thick.
b. Mineral-Fiber, Preformed Pipe Insulation, Type I: [**2 inches**] <**Insert thickness**> thick.
c. Phenolic: [**2 inches**] <**Insert thickness**> thick.
d. Polyisocyanurate: [**2 inches**] <**Insert thickness**> thick.

D. Heating-Hot-Water Supply and Return, above 200 Deg F:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:

a. Calcium Silicate: [**3 inches**] <**Insert thickness**> thick.
b. Cellular Glass: [**3 inches**] <**Insert thickness**> thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I or II: [**2 inches**] <**Insert thickness**> thick.

E. Refrigerant Suction and Hot-Gas Piping:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:

    a. Cellular Glass: [**2 inches**] <**Insert thickness**> thick.
    b. Flexible Elastomeric: [**2 inches**] <**Insert thickness**> thick.
    c. Mineral-Fiber, Preformed Pipe Insulation, Type I: [**2 inches**] <**Insert thickness**> thick.
    d. Phenolic: [**2 inches**] <**Insert thickness**> thick.
    e. Polyisocyanurate: [**2 inches**] <**Insert thickness**> thick.
    f. Polyolefin: [**2 inches**] <**Insert thickness**> thick.
    g. Polystyrene: [**2 inches**] <**Insert thickness**> thick.

F. Refrigerant Suction and Hot-Gas Flexible Tubing:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:

    a. Flexible Elastomeric: [**2 inches**] <**Insert thickness**> thick.
    b. Polyolefin: [**2 inches**] <**Insert thickness**> thick.

G. Hot Service Drains:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:

    a. Calcium Silicate: [**1-1/2 inches**] <**Insert thickness**> thick.
    b. Cellular Glass: [**1-1/2 inches**] <**Insert thickness**> thick.
    c. Mineral-Fiber, Preformed Pipe Insulation, Type I: [**1 inch**] <**Insert thickness**> thick.

H. Hot Service Vents:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:

    a. Calcium Silicate: [**1-1/2 inches**] <**Insert thickness**> thick.
    b. Cellular Glass: [**1-1/2 inches**] <**Insert thickness**> thick.
    c. Mineral-Fiber, Preformed Pipe Insulation, Type II: [**1 inch**] <**Insert thickness**> thick.

I. Fuel Oil Piping, Heated:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:

    a. Cellular Glass: [**2 inches**] <**Insert thickness**> thick.
    b. Mineral-Fiber, Preformed Pipe Insulation, Type I: [**2 inches**] <**Insert thickness**> thick.

J. Engine Exhaust Piping:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:

    a. Calcium Silicate: [**4 inches**] [**4 1/2 inches**] <**Insert thickness**> thick.
    b. Cellular Glass: [**4 inches**] [**4 1/2 inches**] <**Insert thickness**> thick.
    c. Mineral-Fiber, Preformed Pipe, Type I or II: [**4 inches**] [**4 1/2 inches**] <**Insert thickness**> thick.

3.27 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE

A. Loose-fill insulation, for belowground piping, is specified in Division 33 piping distribution Sections.

B. Chilled Water, All Sizes: Cellular glass, [**2 inches**] <**Insert thickness**> thick.

C. Condenser-Water Supply and Return, All Sizes: Cellular glass, [**2 inches**] <**Insert thickness**> thick.

D. Heating-Hot-Water Supply and Return, All Sizes, 200 Deg F and below: Cellular glass, [**3 inches**] <**Insert thickness**> thick.

E. Heating-Hot-Water Supply and Return, All Sizes, above 200 Deg F:

1. Calcium Silicate: [**3 inches**] <**Insert thickness**> thick.
2. Cellular Glass: [**3 inches**] <**Insert thickness**> thick.

3.28 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Ducts and Plenums, Concealed:

1. None.
2. [**PVC**] [**PVC, Color-Coded by System**]: [**20 mils**] [**30 mils**] thick.
3. Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch**] [**0.020 inch**] [**0.024 inch**] [**0.032 inch**] [**0.040 inch**] thick.
4. Painted Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch**] [**0.020 inch**] [**0.024 inch**] [**0.032 inch**] thick.
5. Stainless Steel, Type [**304**] [**316**] [**304 or 316**], [**Smooth 2B Finish**] [**Corrugated**] [**Stucco Embossed**]: [**0.010 inch**] [**0.016 inch**] [**0.020 inch**] [**0.024 inch**] thick.
6. <**Insert jacket type.**>

D. Ducts and Plenums, Exposed:

1. None.
2. [**PVC**] [**PVC, Color-Coded by System**]: [**20 mils**] [**30 mils**] thick.
3. Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch**] [**0.020 inch**] [**0.024 inch**] [**0.032 inch**] [**0.040 inch**] thick.
4. Painted Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch**] [**0.020 inch**] [**0.024 inch**] [**0.032 inch**] thick.
5. Stainless Steel, Type [**304**] [**316**] [**304 or 316**], [**Smooth 2B Finish**] [**Corrugated**] [**Stucco Embossed**]: [**0.010 inch**] [**0.016 inch**] [**0.020 inch**] [**0.024 inch**] thick.
6. <**Insert jacket type.**>

E. Equipment, Concealed:

1. None.
2. [**PVC**] [**PVC, Color-Coded by System**]: [**20 mils**] [**30 mils**] thick.
3. Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch**] [**0.020 inch**] [**0.024 inch**] [**0.032 inch**] [**0.040 inch**] thick.
4. Painted Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch**] [**0.020 inch**] [**0.024 inch**] [**0.032 inch**] thick.
5. Stainless Steel, Type [**304**] [**316**] [**304 or 316**], [**Smooth 2B Finish**] [**Corrugated**] [**Stucco Embossed**]: [**0.010 inch**] [**0.016 inch**] [**0.020 inch**] [**0.024 inch**] thick.
6. <**Insert jacket type.**>

F. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:

1. None.
2. **[PVC]** **[PVC, Color-Coded by System]**: **[20 mils]** **[30 mils]** thick.
3. Aluminum, **[Smooth]** **[Corrugated]** **[Stucco Embossed]**: **[0.016 inch]** **[0.020 inch]** **[0.024 inch]** **[0.032 inch]** **[0.040 inch]** thick.
4. Painted Aluminum, **[Smooth]** **[Corrugated]** **[Stucco Embossed]**: **[0.016 inch]** **[0.020 inch]** **[0.024 inch]** **[0.032 inch]** thick.
5. Stainless Steel, Type **[304]** **[316]** **[304 or 316]**, **[Smooth 2B Finish]** **[Corrugated]** **[Stucco Embossed]**: **[0.010 inch]** **[0.016 inch]** **[0.020 inch]** **[0.024 inch]** thick.
6. **<Insert jacket type.>**

G. Equipment, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:

1. None.
2. **[Painted]**Aluminum, **[Smooth]** **[Stucco Embossed]** with **[1-1/4-Inch- Deep Corrugations]** **[2-1/2-Inch- Deep Corrugations]** **[4-by-1-Inch Box Ribs]**: **[0.032 inch]** **[0.040 inch]** thick.
3. Stainless Steel, Type **[304]** **[316]** **[304 or 316]**, **[Smooth]** **[Stucco Embossed]**, with **[1-1/4-Inch-Deep Corrugations]** **[2-1/2-Inch- Deep Corrugations]** **[4-by-1-Inch Box Ribs]**: **[0.020 inch]** **[0.024 inch]** thick.
4. **<Insert jacket type.>**

H. Piping, Concealed:

1. None.
2. **[PVC]** **[PVC, Color-Coded by System]**: **[20 mils]** **[30 mils]** thick.
3. Aluminum, **[Smooth]** **[Corrugated]** **[Stucco Embossed]**: **[0.016 inch]** **[0.020 inch]** **[0.024 inch]** **[0.032 inch]** **[0.040 inch]** thick.
4. Painted Aluminum, **[Smooth]** **[Corrugated]** **[Stucco Embossed]**: **[0.016 inch]** **[0.020 inch]** **[0.024 inch]** **[0.032 inch]** thick.
5. Stainless Steel, Type **[304]** **[316]** **[304 or 316]**, **[Smooth 2B Finish]** **[Corrugated]** **[Stucco Embossed]**: **[0.010 inch]** **[0.016 inch]** **[0.020 inch]** **[0.024 inch]** thick.
6. **<Insert jacket type.>**

I. Piping, Exposed:

1. None.
2. **[PVC]** **[PVC, Color-Coded by System]**: **[20 mils]** **[30 mils]** thick.
3. Aluminum, **[Smooth]** **[Corrugated]** **[Stucco Embossed]**: **[0.016 inch]** **[0.020 inch]** **[0.024 inch]** **[0.032 inch]** **[0.040 inch]** thick.
4. Painted Aluminum, **[Smooth]** **[Corrugated]** **[Stucco Embossed]**: **[0.016 inch]** **[0.020 inch]** **[0.024 inch]** **[0.032 inch]** thick.
5. Stainless Steel, Type **[304]** **[316]** **[304 or 316]**, **[Smooth 2B Finish]** **[Corrugated]** **[Stucco Embossed]**: **[0.010 inch]** **[0.016 inch]** **[0.020 inch]** **[0.024 inch]** thick.
6. **<Insert jacket type.>**

3.29 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Rectangular Ducts and Plenums, Concealed:

1. None.

2. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with [**white**] [**stucco-embossed**] aluminum-foil facing.
   a. Products: Subject to compliance with requirements, provide one of the following:
      1) Polyguard; Alumaguard 60.
      2) <Insert manufacturer's name; product name or designation.>

D. Rectangular Ducts and Plenums, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:
1. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with [**white**] [**stucco-embossed**] aluminum-foil facing.
   a. Products: Subject to compliance with requirements, provide one of the following:
      1) Polyguard; Alumaguard 60.
      2) <Insert manufacturer's name; product name or designation.>

E. Rectangular Ducts and Plenums, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:
1. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with [**white**] [**stucco-embossed**] aluminum-foil facing.
   a. Products: Subject to compliance with requirements, provide one of the following:
      1) Polyguard; Alumaguard 60.
      2) <Insert manufacturer's name; product name or designation.>

F. Round Ducts and Plenums, Concealed:

1. None.
2. [**PVC**] [**PVC, Color-Coded by System**]: [**20 mils**] [**30 mils**] thick.
3. Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch**] [**0.020 inch**] [**0.024 inch**] [**0.032 inch**] [**0.040 inch**] thick.
4. Painted Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch**] [**0.020 inch**] [**0.024 inch**] [**0.032 inch**] thick.
5. Stainless Steel, Type [**304**] [**316**] [**304 or 316**], [**Smooth 2B Finish**] [**Corrugated**] [**Stucco Embossed**]: [**0.010 inch**] [**0.016 inch**] [**0.020 inch**] [**0.024 inch**] thick.
6. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with [**white**] [**stucco-embossed**] aluminum-foil facing.
   a. Products: Subject to compliance with requirements, provide one of the following:
      1) Polyguard; Alumaguard 60.
      2) <Insert manufacturer's name; product name or designation.>
7. <**Insert jacket type.**>

G. Round Ducts, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:

1. Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch**] [**0.020 inch**] [**0.024 inch**] [**0.032 inch**] [**0.040 inch**] thick.
2. Painted Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch**] [**0.020 inch**] [**0.024 inch**] [**0.032 inch**] thick.
3. Stainless Steel, Type [**304**] [**316**] [**304 or 316**], [**Smooth 2B Finish**] [**Corrugated**] [**Stucco Embossed**]: [**0.010 inch**] [**0.016 inch**] [**0.020 inch**] [**0.024 inch**] thick.

4. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with **[white]** **[stucco-embossed]** aluminum-foil facing.
    a. Products: Subject to compliance with requirements, provide one of the following:
        1) Polyguard; Alumaguard 60.
        2) <Insert manufacturer's name; product name or designation.>
5. <**Insert jacket type.**>

H. Round Ducts, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:

1. [**Painted**]Aluminum, [**Smooth**] [**Stucco Embossed**] with [**1-1/4-Inch- Deep Corrugations**] [**2-1/2-Inch- Deep Corrugations**] [**4-by-1-Inch Box Ribs**]: [**0.032 inch**] [**0.040 inch**] thick.
2. Stainless Steel, Type [**304**] [**316**] [**304 or 316**], [**Smooth**] [**Stucco Embossed**], with [**1-1/4-Inch- Deep Corrugations**] [**2-1/2-Inch- Deep Corrugations**] [**4-by-1-Inch Box Ribs**]: [**0.020 inch**] [**0.024 inch**] thick.
3. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with [**white**] [**stucco-embossed**] aluminum-foil facing.
    a. Products: Subject to compliance with requirements, provide one of the following:
        1) Polyguard; Alumaguard 60.
        2) <Insert manufacturer's name; product name or designation.>
4. <**Insert jacket type.**>

I. Equipment, Concealed:

1. None.
2. [**PVC**] [**PVC, Color-Coded by System**]: [**20 mils**] [**30 mils**] thick.
3. Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch**] [**0.020 inch**] [**0.024 inch**] [**0.032 inch**] [**0.040 inch**] thick.
4. Painted Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch**] [**0.020 inch**] [**0.024 inch**] [**0.032 inch**] thick.
5. Stainless Steel, Type [**304**] [**316**] [**304 or 316**], [**Smooth 2B Finish**] [**Corrugated**] [**Stucco Embossed**]: [**0.010 inch**] [**0.016 inch**] [**0.020 inch**] [**0.024 inch**] thick.
6. <**Insert jacket type.**>

J. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:

1. [**Painted**]Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**] [**with Z-Shaped Locking Seam**]: [**0.016 inch**] [**0.020 inch**] [**0.024 inch**] [**0.032 inch**] [**0.040 inch**] thick.
2. Stainless Steel, Type [**304**] [**316**] [**304 or 316**], [**Smooth 2B Finish**] [**Corrugated**] [**Stucco Embossed**] [**with Z-Shaped Locking Seam**]: [**0.010 inch**] [**0.016 inch**] [**0.020 inch**] [**0.024 inch**] thick.
3. <**Insert jacket type.**>

K. Equipment, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:

1. [**Painted**]Aluminum, [**Smooth**] [**Stucco Embossed**] with [**1-1/4-Inch- Deep Corrugations**] [**2-1/2-Inch- Deep Corrugations**] [**4-by-1-Inch Box Ribs**]: [**0.032 inch**] [**0.040 inch**] thick.
2. Stainless Steel, Type [**304**] [**316**] [**304 or 316**], [**Smooth**] [**Stucco Embossed**], with [**1-1/4-Inch- Deep Corrugations**] [**2-1/2-Inch- Deep Corrugations**] [**4-by-1-Inch Box Ribs**]: [**0.020 inch**] [**0.024 inch**] thick.
3. <**Insert jacket type.**>

L. Piping, Concealed:

1. None.
2. **[PVC]** **[PVC, Color-Coded by System]**: **[20 mils]** **[30 mils]** thick.
3. Aluminum, **[Smooth]** **[Corrugated]** **[Stucco Embossed]**: **[0.016 inch]** **[0.020 inch]** **[0.024 inch]** **[0.032 inch]** **[0.040 inch]** thick.
4. Painted Aluminum, **[Smooth]** **[Corrugated]** **[Stucco Embossed]**: **[0.016 inch]** **[0.020 inch]** **[0.024 inch]** **[0.032 inch]** thick.
5. Stainless Steel, Type **[304]** **[316]** **[304 or 316]**, **[Smooth 2B Finish]** **[Corrugated]** **[Stucco Embossed]**: **[0.010 inch]** **[0.016 inch]** **[0.020 inch]** **[0.024 inch]** thick.
6. **<Insert jacket type.>**

M. Piping, Exposed:

1. PVC: **[20 mils]** **[30 mils]** **[40 mils]** thick.
2. **[Painted]**Aluminum, **[Smooth]** **[Corrugated]** **[Stucco Embossed]** **[with Z-Shaped Locking Seam]**: **[0.016 inch]** **[0.020 inch]** **[0.024 inch]** **[0.032 inch]** **[0.040 inch]** thick.
3. Stainless Steel, Type **[304]** **[316]** **[304 or 316]**, **[Smooth 2B Finish]** **[Corrugated]** **[Stucco Embossed]** **[with Z-Shaped Locking Seam]**: **[0.010 inch]** **[0.016 inch]** **[0.020 inch]** **[0.024 inch]** thick.
4. **<Insert jacket type.>**

3.30 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 23 0700

SECTION 23 0800

COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

1.2 SUMMARY

A. Section includes commissioning process requirements for HVAC&R and associated controls systems, assemblies, and equipment.

B. Related Sections:

1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements as well as the Commissioning Plan, found as an Appendix to that Specification.

1.3 DEFINITIONS

A. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

B. CxA: Commissioning Authority.

C. EOR: Engineer of Record

D. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.

E. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.4 ALLOWANCES

A. Labor, instrumentation, tools, and equipment costs for technicians for the performance of commissioning testing are covered by the "Schedule of Allowances" Article in Division 01 Section "Allowances."

1.5 UNIT PRICES

A. Commissioning testing allowance may be adjusted up or down by the "List of Unit Prices" Article in Division 01 Section "Unit Prices" when actual man-hours are computed at the end of commissioning testing.

1.6 CONTRACTOR'S RESPONSIBILITIES

A. Perform commissioning tests at the direction of the CxA.

B. Document equipment installation and startup activities as defined by the manufacturer and provide such documentation to the CxA prior to the start of commissioning tests.

C. Attend Commissioning Meetings during construction as designated by the CxA

D. Attend construction phase controls coordination meeting.

E. Attend testing, adjusting, and balancing review and coordination meeting.

F. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as called out in the installation specifications.
   1. Provide the CxA with sample training curricula for review and approval a minimum of **four (4) weeks** prior to the scheduled training.
   2. Provide EOR and CxA copies of O&M Manuals for review a minimum of **four weeks** prior to submission for substantial completion.

G. Provide information requested by the CxA for final commissioning documentation.

H. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

I. Provide site and equipment specific operating manuals detailing all manufacturer recommended maintenance procedures, spares lists,

1.7 CxA'S RESPONSIBILITIES

A. Provide Project-specific commissioning checklists and commissioning process test procedures for actual HVAC&R systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.

B. Develop and coordinate the Commissioning Plan.

C. Schedule and conduct Commissioning Meetings during construction as necessary to coordinate commissioning activities within the project delivery team.

D. Direct commissioning testing.

E. Verify testing, adjusting, and balancing of Work are complete.

F. Provide test data, inspection reports, and certificates in Systems Manual.

1.8 COMMISSIONING DOCUMENTATION

A. Provide the following information to the CxA for inclusion in the commissioning plan:

   1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
   2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.

3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC&R systems, assemblies, equipment, and components to be verified and tested.
4. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.
5. Certificate of readiness certifying that HVAC&R systems, subsystems, equipment, and associated controls are ready for testing.
6. Test and inspection reports and certificates.
7. Corrective action documents.
8. Verification of testing, adjusting, and balancing reports.

1.9 SUBMITTALS

A. Certificates of readiness.

B. Certificates of calibration for all test equipment used

C. Certificates of completion and completed checklists for installation, prestart, and startup activities for each piece of commissioned equipment prior to the start of commissioning testing activities.

D. Marked up “As-Built” documentation showing locations valve numbers, connection points, and sizes of installed equipment, piping, ductwork and other ancillary equipment.

E. Operations and Maintenance Manuals

F. Training information, including all curricula, manuals, visual aides and trainer qualifications for each piece of equipment so called out in the installation specifications. Information shall be submitted for approval to the CxA a no later than **three (3) weeks** prior to proposed training.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

A. Certify that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.2 Testing AND BALANCING VERIFICATION

A. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, and certificates to the CxA.

B. Notify the CxA at least [**10**] <**Insert number**> days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.

C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CxA.

1. The CxA will notify testing and balancing [**Contractor**] [**Subcontractor**] [**10**] <**Insert number**> days in advance of the date of field verification. Notice will not include data points to be verified.
2. The testing and balancing [**Contractor**] [**Subcontractor**] shall use the same instruments (by model and serial number) that were used when original data were collected.
3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.
4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.3 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the HVAC&R [**Contractor**] [**Subcontractor**], testing and balancing [**Contractor**] [**Subcontractor**], and HVAC&R Instrumentation and Control [**Contractor**] [**Subcontractor**] shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. Where ever possible, actual conditions will be created to test sequences of operations. The CxA may direct that set points be altered for simulation when creating actual conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.4 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. Boiler Testing and Acceptance Procedures: Testing requirements are specified in Division 23 boiler Sections. Provide submittals, test data, inspector record, and boiler certification to the CxA.

B. HVAC&R Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls." Assist the CxA with preparation of testing plans.

C. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment requirements are specified in Division 23 piping Sections. HVAC&R [**Contractor**] [**Subcontractor**] shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:

1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
2. Description of equipment for flushing operations.
3. Minimum flushing water velocity.
4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.
5. The plan shall be provided to the CxA for review a minimum of **one (1)** week prior to scheduled cleaning and flushing activities. Plan shall be approved prior to the commencement of such activity.
6. The contractor shall confirm in writing the date and time of the start of flushing activity to the CxA **48 hours** prior start.

D. Energy Supply System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of [**oil**] [**gas**] [**coal**] [**steam**] [**hot-water**] [**and**] [**solar**] systems and equipment at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

E. Refrigeration System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of chillers, cooling towers, refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

F. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.

G. Vibration and Sound Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.

H. <**Insert HVAC systems**>.

END OF SECTION 23 0800

SECTION 23 2123

HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Separately coupled, base-mounted, end-suction centrifugal pumps.
   2. Separately coupled, vertical-mounted, double-suction centrifugal pumps.

1.3 DEFINITIONS

A. Buna-N: Nitrile rubber.

B. EPT: Ethylene propylene terpolymer.

C. HI: Hydraulic Institute.

1.4 SUBMITTALS

A. Product Data: Include certified performance curves and rated capacities, power requirement, operating characteristics, furnished specialties, final impeller dimensions, material specifications, and accessories for each type of product indicated. Indicate pump's operating point on curves, including NPSH curves.

B. Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
   1. Wiring Diagrams: Power, signal, and control wiring.

C. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain hydronic pumps through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of hydronic pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. UL Compliance: Comply with UL 778 for motor-operated water pumps.

E. Pump Performance: Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25% of midpoint of published maximum efficiency curve.

F. Pump tests: Manufacturer shall test pumps in the shop prior to shipment. For identical pumps, only one pump of each specified capacity need to be tested. Tests shall be in accordance with the Hydraulic Institute Test Code.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

B. Store pumps in dry location.

C. Retain protective covers for flanges and protective coatings during storage.

D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

E. Comply with pump manufacturer's written rigging instructions.

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Mechanical Seals: **[One]** <**Insert number**> mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 GENERAL

A. Factory assembled, packaged and motor.

B. Centrifugal: Single stage, unless otherwise noted.

C. Statically and dynamically balance rotating parts.

D. Pumps to operate at 1750 rpm unless specified otherwise.

E. Pump and motor capacities:
   1. Minimum as scheduled on Drawings.
   2. Suitable for parallel operation.
   3. Motor to operate over entire head capacity range of pump without exceeding horsepower rating.
   4. Motors shall be "High-Efficiency" type specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

F. Pump characteristics:
   1. Pump curve shall rise continuously from maximum capacity to shutoff.
   2. Shutoff head shall be approximately 10% greater than design head.
   3. Operation shall be at or near peak efficiency.
   4. Capable of operating at 25% beyond design capacity in gpm without exceeding break off point.
   5. Impeller diameter: Maximum 90% difference between maximum and minimum of published impeller diameter.
   6. Scheduled maximum NPSH required to apply over full operating range of pump.

G. Tested and guaranteed to withstand 1 1/2 times specified working pressures.

H. Pumps to be suitable for handling fluids at scheduled temperatures.

I. Abrasive Separator: Except as noted, provide seal flush piping connections with stainless steel abrasive separator.

2.3 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

A. [**Available**]Manufacturers:
   1. Armstrong Pumps Inc.
   2. Aurora Pump; Division of Pentair Pump Group.
   3. Bell & Gossett; Div. of ITT Industries.
   4. Buffalo Pumps, Inc.; an Ampco Pittsburgh Co.
   5. Burks Pumps; Div. of Crane Pumps & Systems.
   6. Deming Pumps; Div. of Crane Pumps & Systems.
   7. PACO Pumps.
   8. Peerless Pump Co.; a member of the Sterling Fluid Systems Group.
   9. Weinman; Div. of Crane Pumps & Systems.
   10. **<Insert manufacturer's name.>**

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal. Rate pump for [**125-psig**] [**175-psig**] [**250-psig**] minimum working pressure and a continuous water temperature of [**200 deg F**] [**225 deg F**] [**250 deg F**].

C. Pump Construction:

1. Casing: Radially split, cast iron, with[**replaceable bronze wear rings,**] threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and [**threaded companion-flange**] [**flanged**] connections.[**Provide integral mount on volute to support the casing, and attached piping to allow removal and replacement of impeller without disconnecting piping or requiring the realignment of pump and motor shaft.**]
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
3. Pump Shaft: [**Steel**] [**Stainless steel**].
4. Shaft Sleeve: Renewable [**hardened stainless steel**] [**ceramic coated stainless steel of minimum 600 Brinell hardness**].
5. Mechanical Seal: Babbit filled carbon rotating ring against a tungsten carbide stationary seat held by a stainless steel spring, and [**Buna-N**] [**EPT**] bellows and gasket. Water flush design to provide flush across face of mechanical seal.
6. Packed Seal: Heavy duty stuffing box, with a minimum of four rings of asbestos free graphite-impregnated braided yarn with bronze split lantern rings between center two graphite rings, and bronze packing gland. Provide water seal piping.
7. Pump Bearings: Grease-lubricated ball bearings contained in cast-iron hosing with grease fittings, suitable for in-service lubrication. Rated life of bearings not less than 80,000 hours.

D. Shaft Coupling: Molded rubber insert and interlocking spider capable of absorbing vibration. [**Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor**] [**EPDM coupling sleeve for variable-speed applications**].

E. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

F. Baseplate: Cast iron or rolled steel, factory fabricated with raised lip and drain tappings. Fabricate to mount pump casing, coupling guard, and motor.

G. Motor: Single speed, with [**permanently lubricated**] [**grease-lubricated**] ball bearings, unless otherwise indicated; secured to baseplate, with adjustable alignment. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

H. Capacities and Characteristics: As scheduled on drawings.

2.4 SEPARATELY COUPLED, BASE-MOUNTED, DOUBLE-SUCTION CENTRIFUGAL PUMPS

A. Manufacturers:
1. Armstrong Pumps Inc.
2. Aurora Pump; Division of Pentair Pump Group.
3. Bell & Gossett; Div. of ITT Industries.
4. PACO Pumps.
5. Peerless Pump Co., a member of the Sterling Fluid Systems Group.

B. Description: Factory-assembled and -tested, centrifugal, impeller-between-bearings, separately coupled, double-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal. Rate pump for [**125-psig**] [**175-psig**] [**250-psig**] minimum working pressure and a continuous water temperature of [**200 deg F**] [**225 deg F**] [**250 deg F**].

C. Pump Construction:
1. Casing: [**Radially**] [**Horizontally**] split, cast iron, with[**replaceable bronze wear rings,**] threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and ASME B16.1, Class [**125**] [**250**] flanges.[**Casing supports shall allow removal and replacement of impeller without disconnecting piping.**]

2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. Trim impeller to match specified performance.
3. Pump Shaft: Stainless steel.
4. Shaft Sleeve: Renewable [**hardened stainless steel**] [**ceramic coated stainless steel of minimum 600 Brinell hardness**].
5. Mechanical Seal: Babbit filled carbon rotating ring against a tungsten carbide stationary seat held by a stainless steel spring, and [**Buna-N**] [**EPT**] bellows and gasket. Water flush design to provide flush across face of mechanical seal.
6. Packed Seal: Heavy duty stuffing box, with a minimum of four rings of asbestos free graphite-impregnated braided yarn with bronze split lantern rings between center two graphite rings, and bronze packing gland. Provide water seal piping.
7. Pump Bearings: Grease-lubricated ball bearings contained in cast-iron housing with grease fittings. Suitable for in-service lubrication. Rated life of bearings not less than 80,000 hours.

D. Shaft Coupling: Molded rubber insert and interlocking spider capable of absorbing vibration. [**Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor**] [**EPDM coupling sleeve for variable-speed applications**].

E. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

F. Baseplate: Cast or rolled steel, factory fabricated with raised lip and drain tappings. Fabricate to mount pump casing, coupling guard, and motor.

G. Motor: Single speed, with grease-lubricated ball bearings, unless otherwise indicated; secured to mounting frame, with adjustable alignment. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

H. Capacities and Characteristics: As scheduled on drawings.

2.5 SEPARATELY COUPLED, VERTICAL-MOUNTED, DOUBLE-SUCTION CENTRIFUGAL PUMPS

A. Manufacturers:
1. Armstrong Pumps Inc.
2. Aurora Pump; Division of Pentair Pump Group.
3. Bell & Gossett; Div. of ITT Industries.
4. Buffalo Pumps, Inc.; an Ampco Pittsburgh Co.
5. Fairbanks Morse; Division of Pentair Pump Group.
6. PACO Pumps.
7. Peerless Pump Co., a member of the Sterling Fluid Systems Group.

B. Description: Factory-assembled and -tested, centrifugal, impeller-between-bearings, separately coupled, double-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted vertically. Rate pump for [**125-psig**] [**175-psig**] [**250-psig**] minimum working pressure and a continuous water temperature of [**200 deg F**] [**225 deg F**] [**250 deg F**].

C. Pump Construction:
1. Casing: Radially split, cast iron, with[**replaceable bronze wear rings,**] threaded gage tappings at inlet and outlet, drain plug at bottom of volute, mounting support, and ASME B16.1, Class [**125**] [**250**] flanges.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. Trim impeller to match specified performance.
3. Pump Shaft: Stainless steel.

4. Shaft Sleeve: Renewable [**hardened stainless steel**] [**ceramic coated stainless steel of minimum 600 Brinell hardness**].
5. Mechanical Seal: Babbit filled carbon rotating ring against a tungsten carbide stationary seat held by a stainless steel spring, and [**Buna-N**] [**EPT**] bellows and gasket. Water flush design to provide flush across face of mechanical seal.
6. Packed Seal: Heavy duty stuffing box, with a minimum of four rings of asbestos free graphite-impregnated braided yarn with bronze split lantern rings between center two graphite rings, and bronze packing gland. Provide water seal piping.
7. Pump Bearings: Grease-lubricated ball bearings contained in cast-iron housing with grease fittings. Suitable for in-service lubrication. Rated life of bearings not less than 80,000 hours.

D. Shaft Coupling: Molded rubber insert and interlocking spider capable of absorbing vibration.

E. Motor: Single speed, with grease-lubricated ball bearings, unless otherwise indicated; secured to casing. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

F. Capacities and Characteristics: As scheduled on drawings.

2.6 PUMP SPECIALTY FITTINGS

A. Suction Diffuser: Angle pattern, [**175-psig**] [**300-psig**] pressure rating, [**cast**] [**ductile**]-iron body and end cap, pump-inlet fitting; with bronze startup and bronze or stainless-steel permanent strainers; bronze or stainless-steel straightening vanes; drain plug; and factory-fabricated support.

B. Triple-Duty Valve: Angle or straight pattern, [**175-psig**] [**300-psig**] pressure rating, [**cast**] [**ductile**]-iron body, pump-discharge fitting; with drain plug and bronze-fitted shutoff, balancing, and check valve features. Brass gage ports with integral check valve, and orifice for flow measurement.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONCRETE BASES

A. Install pumps on concrete bases of dimensions required for pumps and controllers. Refer to Division 23 Section "Common Work Results for HVAC" And see Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.

2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Cast-in-place concrete materials and placement requirements are specified in Division 03.

3.3 PUMP INSTALLATION

A. Comply with [**HI 1.4**] [**HI 2.4**].

B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping. Provide supports under elbows on pump suction and discharge lines [**8**] <**Insert number**> inches and over.

D. Install continuous-thread hanger rods and [**elastomeric hangers**] [**spring hangers**] [**spring hangers with vertical-limit stop**] of sufficient size to support pump weight. Vibration isolation devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Fabricate brackets or supports as required. Hanger and support materials are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

E. Suspend vertically mounted, in-line centrifugal pumps independent of piping. Install pumps with motor and pump shafts vertical. Use continuous-thread hanger rods and [**elastomeric hangers**] [**spring hangers**] [**spring hangers with vertical-limit stop**] of sufficient size to support pump weight. Vibration isolation devices are specified in Division 21 Section "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment." Hanger and support materials are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment/Hangers and Supports for HVAC Piping and Equipment."

F. Set base-mounted pumps on concrete foundation. Disconnect coupling before setting. Do not reconnect couplings until alignment procedure is complete.
1. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches between pump base and foundation for grouting.
2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.

G. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

3.4 ALIGNMENT

A. Align pump and motor shafts and piping connections after setting on foundation, grout has been set and foundation bolts have been tightened, and piping connections have been made.

B. Comply with pump and coupling manufacturers' written instructions.

C. Adjust pump and motor shafts for angular and offset alignment by methods specified in [**HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation**] [**HI 2.1-2.5, " Vertical Pumps for Nomenclature, Definitions, Application and Operation**]."

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.5 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles. Decrease to pump nozzles from line size with long radium reducing elbows or reducers.

E. Install [silent spring loaded **check valve and throttling**] [**triple-duty**] valve on discharge side of pumps.

F. Install [**Y-type strainer**] [**suction diffuser**] and shutoff valve on suction side of pumps.

G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

H. Install pressure gages on pump suction and discharge, at integral pressure-gage tapping.

I. Install check valve and gate or ball valve on each condensate pump unit discharge.

J. Provide drains from baseplates and stuffing boxes, piped to spill over floor drains.

K. Provide vent valves and drain on pump casings.

L. Pipe up flush filter for mechanical seals, with bypass line from pump discharge to external gland connection and filter or cyclone separator in line.

M. Install electrical connections for power, controls, and devices.

N. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

O. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Check piping connections for tightness.
   3. Clean strainers on suction piping.
   4. Perform the following startup checks for each pump before starting:
      a. Verify bearing lubrication.
      b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
      c. Verify that pump is rotating in the correct direction.

5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
6. Start motor.
7. Open discharge valve slowly.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION

SECTION 23 2300

REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

1.2 SUMMARY

A. This Section includes refrigerant piping, valves and refrigerant accessories used for air-conditioning applications.

1.3 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-22:

1. Suction Lines for Air-Conditioning Applications: 185 psig.
2. Suction Lines for Heat-Pump Applications: 325 psig.
3. Hot-Gas and Liquid Lines: 325 psig.

B. Line Test Pressure for Refrigerant R-134a:

1. Suction Lines for Air-Conditioning Applications: 115 psig.
2. Suction Lines for Heat-Pump Applications: 225 psig.
3. Hot-Gas and Liquid Lines: 225 psig.

C. Line Test Pressure for Refrigerant R-407C:

1. Suction Lines for Air-Conditioning Applications: 230 psig.
2. Suction Lines for Heat-Pump Applications: 380 psig.
3. Hot-Gas and Liquid Lines: 380 psig.

D. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig.
2. Suction Lines for Heat-Pump Applications: 535 psig.
3. Hot-Gas and Liquid Lines: 535 psig.

1.4 SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:

1. Thermostatic expansion valves.

2. Solenoid valves.
3. Hot-gas bypass valves.
4. Filter dryers.
5. Strainers.
6. Pressure-regulating valves.
7. Receivers.
8. Miscellaneous specialties and accessories

B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.

1. Shop Drawing Scale: **[1/4 inch equals 1 foot]** **<Insert value>**.
2. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

C. Product Data: Catalog cuts giving general assembly of specialties and data including load capacity.

D. Welding certificates.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals, including assembly views, instructions for changing cartridges, and spare parts list.

1.5 SYSTEM DESCRIPTION

A. Where more than one piping system material is specified ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, dielectric unions, and couplings for servicing are consistently provided.

B. Provide pipe hangers and supports in accordance with ASTM unless indicated otherwise.

C. Refrigerant Charging (Packed Angle) Valve: Use in liquid line between receiver shut-off valve and expansion valve.

D. Pressure Relief Valves: Install on ASME receivers. Discharge piped to outdoors.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.7 PRODUCT STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed. Dehydrated and charge components such as piping and receivers, seal prior to shipment, and maintain seal until connected into system.

1.8 COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.9 QUALIFICATIONS

A. Design piping system under direct supervision of a Professional Engineer experienced in design of this work and licensed in the state where the Project is located.

1.10 MAINTENANCE MATERIALS

A. Provide two refrigeration oil test kits each containing everything required to conduct one test.

B. Provide two filter-dryer cartridges of each type.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Copper Tube: [**ASTM B 88, Type K or L**] [**ASTM B 280, Type ACR**].

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Brazing Filler Metals: AWS A5.8, BCuP silver/phosphorus/copper alloy with melting range 1190 to 1480 deg F.

E. Flexible Connectors:

1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch- long assembly.
4. Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 deg F.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; Type, Grade, and wall thickness as selected in Part 3 piping applications articles.

B. Wrought-Steel Fittings: ASTM A 234/A 234M, for welded joints.

C. Steel Flanges and Flanged Fittings: ASME B16.5, steel, including bolts, nuts, and gaskets, bevel-welded end connection, and raised face.

D. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

E. Flanged Unions:

1. Body: Forged-steel flanges for NPS 1 to NPS 1-1/2 and ductile iron for NPS 2 to NPS 3. Apply rust-resistant finish at factory.
2. Gasket: Fiber asbestos free.
3. Fasteners: Four plated-steel bolts, with silicon bronze nuts. Apply rust-resistant finish at factory.
4. End Connections: Brass tailpiece adapters for solder-end connections to copper tubing.
5. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch- long assembly.
6. Pressure Rating: Factory test at minimum 400 psig.
7. Maximum Operating Temperature: 330 deg F.

F. Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, stainless-steel-wire-reinforced protective jacket
2. End Connections:

   a. NPS 2 and Smaller: With threaded-end connections.
   b. NPS 2-1/2 and Larger: With flanged-end connections.

3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch- long assembly.
4. Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 deg F.

2.3 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:

1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.
5. End Connections: Socket, union, or flanged.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.
8. With positive backseating.

B. Packed-Angle Valves:

1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem with backseating.
4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.

5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, or flanged.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg F.

C. Check Valves:

1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, or flanged.
7. Maximum Opening Pressure: 0.50 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 300 deg F.

D. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring or soldered.
5. Working Pressure Rating: 500 psig.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

1. Body and Bonnet: Plated steel, copper, or brass.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded or soldered.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and [**24**] [**115**] [**208**]-V ac coil.
6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 deg F.
8. Manual Operator: Steam shall permit manual operation in case of coil failure.
9. Coil Assembly: UL listed, replaceable, with molded electromagnetic coil, moisture and fungus proof, with surge protector, color coded lead wired, and integral junction box [**with pilot light**].

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL. Factory sealed and stamped with ASME UV and National Board Certification NB, and ASHRAE 15.

1. Body and Bonnet: Ductile iron and steel or brass, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat Disc: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig.
6. Maximum Operating Temperature: 240 deg F.

G. Thermostatic Expansion Valves: Comply with ARI 750.

1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Internal or external equalizer.
3. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.

4. Packing and Gaskets: Non-asbestos.
5. Capillary and Bulb: Copper tubing, replaceable type filled with refrigerant charge; remote sensing bulb.
6. Suction Temperature: **[40 deg F]** **<Insert temperature>**.
7. Superheat: **[Adjustable]** **[Nonadjustable]**.
8. Reverse-flow option (for heat-pump applications).
9. End Connections: Socket, flare, or threaded union.
10. Working Pressure Rating: **[700 psig]** **[450 psig]** **<Insert value>**.
11. Selection: Evaluate refrigerant pressure drop through system to determine available pressure drop across valve. Select valve for maximum load at design operating pressure and minimum 10 deg F superheat. Select valve to avoid being undersized at full load and excessively oversized at part load.

H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.

1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
5. Seat: Polytetrafluoroethylene.
6. Equalizer: **[Internal]** **[External]**.
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and **[24]** **[115]** **[208]**-V ac coil.
8. End Connections: Socket.
9. Set Pressure: **<Insert psig.>**
10. Throttling Range: Maximum 5 psig.
11. Working Pressure Rating: 500 psig.
12. Maximum Operating Temperature: 240 deg F.

I. Straight-Type Strainers:

1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg F.

J. Angle-Type Strainers:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

K. Moisture/Liquid Indicators: UL listed.

1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm **[with removable element]** and plastic cap.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.

7. Maximum Operating Temperature: 240 deg F.

L. Replaceable-Core Filter Dryers: Comply with ARI 730 and UL listed.

1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: **[2 psig]** <**Insert value**>.
8. Rated Flow: <**Insert tons.**>
9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 240 deg F.

M. Permanent Filter Dryers: Comply with ARI 730 and UL listed.

1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: **[2 psig]** <**Insert value**>.
8. Rated Flow: <**Insert tons.**>
9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 240 deg F.

N. Mufflers:

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or flare.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

O. Receivers: Comply with ARI 495 and UL listed. ASME tested and stamped if over 6" internal diameter.

1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
2. Comply with UL 207; listed and labeled by an NRTL.
3. Body: Welded steel with corrosion-resistant coating.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

P. Liquid Accumulators: Comply with ARI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

Q. Pressure Regulators:
1. Body: Brass.
2. Diaphragm: Stainless steel, [**direct acting**] [**pilot operated with remote pressure pilot**].
3. Adjustable over [**0 to 80**] psig range.
4. Working Pressure Rating: 400 psig (2760 kPa).
5. Maximum Operating Temperature: 240 deg F (116 deg C).

2.4 REFRIGERANTS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.
5. **<Insert manufacturer's name.>**

C. ASHRAE 34, R-22: Monochlorodifluoromethane.

D. ASHRAE 34, R-134a: Tetrafluoroethane.

E. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.

F. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-22

A. Suction Lines [**NPS 1-1/2 and Smaller**] **<Insert pipe size range>** for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

B. Suction Lines [**NPS 4 and Smaller**] [**NPS 2 to NPS 4**] **<Insert pipe size range>** for Conventional Air-Conditioning Applications: Copper, Type [**ACR**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.

D. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type [**ACR**] [**K**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

E. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]:

1. [**NPS 1-1/2 and Smaller**] **<Insert pipe size range>**: Copper, Type [**ACR**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.
2. [**NPS 2 to NPS 3**] **<Insert pipe size range>**: Copper, Type K, drawn-temper tubing and wrought-copper fittings with brazed joints.

3. [**NPS 4**] <**Insert pipe size**>: Copper, Type [**ACR**] [**K**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

F. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

G. Safety-Relief-Valve Discharge Piping: Copper, Type [**ACR**] [**K**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

H. Safety-Relief-Valve Discharge Piping:

1. [**NPS 1-1/2 and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.
2. [**NPS 2 to NPS 3**] <**Insert pipe size range**>: Copper, Type K, drawn-temper tubing and wrought-copper fittings with brazed joints.
3. [**NPS 4**] <**Insert pipe size**>: Copper, Type [**ACR**] [**K**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

3.2 PIPING APPLICATIONS FOR REFRIGERANT R-134a

A. Suction Lines [**NPS 1-1/2 and Smaller**] <**Insert pipe size range**> for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper and wrought-copper fittings with brazed joints.

B. Suction Lines [**NPS 4 and Smaller**] [**NPS 2 to NPS 4**] <**Insert pipe size range**> for Conventional Air-Conditioning Applications: Copper, Type [**ACR**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.

D. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type [**ACR**] [**K**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

E. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]:

1. [**NPS 1-1/2 and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [**K**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.
2. [**NPS 2 to NPS 4**] <**Insert pipe size**>: Copper, Type [**ACR**] [**K**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

F. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

G. Safety-Relief-Valve Discharge Piping: Copper, Type [**ACR**] [**K**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

H. Safety-Relief-Valve Discharge Piping:

1. [**NPS 1-1/2 and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.
2. [**NPS 2 to NPS 4**] <**Insert pipe size**>: Copper, Type [**ACR**] [**K**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

3.3 PIPING APPLICATIONS FOR REFRIGERANT R-407C

A. Suction Lines [**NPS 1-1/2 and Smaller**] <**Insert pipe size range**> for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.

B. Suction Lines [**NPS 2 to NPS 4**] <**Insert pipe size range**> for Conventional Air-Conditioning Applications: Copper, Type [**ACR**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

D. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type [**ACR**] [**K**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

E. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]:

1. [**NPS 1 and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.
2. [**NPS 1-1/4 to NPS 2**] <**Insert pipe size range**>: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.
3. [**NPS 4**] <**Insert pipe size**>: Copper, Type [**ACR**] [**K**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

F. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

G. Safety-Relief-Valve Discharge Piping: Copper, Type [**ACR**] [**K**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

H. Safety-Relief-Valve Discharge Piping:

1. [**NPS 1 and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.
2. [**NPS 1-1/4 to NPS 2**] <**Insert pipe size range**>: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.
3. [**NPS 4**] <**Insert pipe size**>: Copper, Type [**ACR**] [**K**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

3.4 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines [**NPS 1-1/2 and Smaller**] <**Insert pipe size range**> for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.

B. Suction Lines [**NPS 2 to NPS 3-1/2**] <**Insert pipe size range**> for Conventional Air-Conditioning Applications: Copper, Type [**ACR**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Suction Lines [**NPS 4**] <**Insert pipe size range**> for Conventional Air-Conditioning Applications: Copper, Type [**ACR**] [**K**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

D. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type [**ACR**] [**L**], annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

E. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

F. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type [**ACR**] [**K**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

G. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]: Copper, Type [**ACR**] [**K**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

H. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]:

1. [**NPS 5/8 and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [**L**], annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.
2. [**NPS 3/4 to NPS 1**] <**Insert pipe size range**>: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.
3. [**NPS 1-1/4 to NPS 2**] <**Insert pipe size range**>: Copper, Type [**ACR**] [**K**] [**L**], drawn-temper tubing and wrought-copper fittings with Alloy brazed joints.

I. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**] [**NPS 2 to NPS 4**] <**Insert pipe size range**>: Schedule 40, black-steel and wrought-steel fittings with welded joints.

J. Safety-Relief-Valve Discharge Piping: Copper, Type [**ACR**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

K. Safety-Relief-Valve Discharge Piping: Copper, Type K, drawn-temper tubing and wrought-copper fittings with brazed joints.

L. Safety-Relief-Valve Discharge Piping: Copper, Type [**ACR**] [**K**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

M. Safety-Relief-Valve Discharge Piping: Copper, Type [**ACR**] [**K**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

N. Safety-Relief-Valve Discharge Piping:

1. [**NPS 5/8 and Smaller**] <**Insert pipe size range**>: Copper, Type [**ACR**] [**L**], annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.
2. [**NPS 3/4 to NPS 1 and Smaller**] <**Insert pipe size range**>: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.
3. [**NPS 1-1/4 to NPS 2**] <**Insert pipe size range**>: Copper, Type [**ACR**] [**K**] [**L**], drawn-temper tubing and wrought-copper fittings with brazed joints.

O. Safety-Relief-Valve Discharge Piping [**NPS 2 to NPS 4**] <**Insert pipe size range**>: Schedule 40, black-steel and wrought-steel fittings with welded joints.

3.5 VALVE AND SPECIALTY APPLICATIONS

A. Install [**diaphragm packless**] [**packed-angle**] valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at compressor inlet and outlet, at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Install check valves on condenser liquid lines on multiple condenser systems.

E. Except as otherwise indicated, install [**diaphragm packless**] [**packed-angle**] valves on inlet and outlet side of filter dryers.

F. Install a full-sized, three-valve bypass around filter dryers.

G. Install Solenoid Valves as Follows:

1. Upstream from each expansion valve and hot gas by-pass valve.
2. In liquid line of systems operating with single pump-out or pump down compressor control.
3. In liquid line of single or multiple evaporator systems, including split circuit coils.
4. In oil bleeder lines from flooded evaporators to stop flow of oil and refrigerant into the suction line when system shuts down.
5. Install solenoid valves in horizontal lines with at top.

H. Install thermostatic expansion valves as close as possible to distributors on evaporators.

1. Install valve so diaphragm case is warmer than bulb.
2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

I. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

J. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

1. Use line size indicators in main liquid line leaving condenser and on leaving side of liquid solenoid valves.
2. If receiver is provided, install indicator in liquid line leaving receiver.

K. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:

1. Solenoid valves.
2. Thermostatic expansion valves.
3. Hot-gas bypass valves.
4. Compressor.
5. On steel piping systems install strainer in suction line.
6. Install a shut-off valve on each side of strainers.

L. Install filter dryers in liquid line between compressor and thermostatic expansion valve for each solenoid valves[**, and in the suction line at the compressor**].

1. Permanent Filter-Driers: Use [**in low temperature systems**][**, and in systems utilizing hermetic compressors**].
2. Replaceable Cartridge Filter-Driers: Use [**vertically in liquid line adjacent to receivers**][**, and for each solenoid valve**].

M. Install receivers sized to accommodate pump-down charge.

N. Install flexible connectors at right angles to axial movement of compressor, parallel to crankshaft.

3.6 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping and specialties in accordance with ASHRAE 15 and manufacturers instructions.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Refer to Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operation" for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Install piping to allow for expansion and contraction without stressing pipe, joints, or connects equipment.

M. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 08 Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

N. Install refrigerant piping in protective conduit where installed belowground.

O. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

P. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

Q. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

R. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:

1. Shot blast the interior of piping.
2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.

S. Install pipe sleeves at penetrations in exterior walls and floor assemblies.

T. Seal penetrations through fire and smoke barriers according to Division 07 Section "Penetration Firestopping."

U. Insulate piping[**and equipment**].

V. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

W. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.

X. Seal pipe penetrations through exterior walls according to Division 07 Section "Joint Sealants" for materials and methods.

Y. Identify refrigerant piping and valves according to Division 23 Section "Identification for HVAC Piping and Equipment."

3.7 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

F. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.

H. Welded Joints: Construct joints according to AWS D10.12/D10.12M.

I. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.8 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment." Install in accordance with ASTM and M55.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.
2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.
4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8 inch.
5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
7. NPS 2-1/2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
8. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.
9. NPS 4: Maximum span, 12 feet; minimum rod size, 1/2 inch.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
2. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
3. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
4. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2 inch.

E. Support multifloor vertical runs with riser clamps, at least at each floor.

F. Install hangers within 12 inches of each horizontal elbow.

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.

3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.

    a. Fill system with nitrogen to the required test pressure.
    b. System shall maintain test pressure at the manifold gage throughout duration of test.
    c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    d. Remake leaking joints using new materials, and retest until satisfactory, no leakage, results are achieved.

3.10 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.11 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 23 2300

SECTION 23 2500

HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

1.2 SUMMARY

A. This Section includes the following HVAC water-treatment systems:
   1. Chemical treatment test equipment.
   2. HVAC water-treatment chemicals.
   3. Makeup water softeners.

1.3 DEFINITIONS

A. EEPROM: Electrically erasable, programmable read-only memory.

B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

C. RO: Reverse osmosis.

D. TDS: Total dissolved solids.

E. UV: Ultraviolet.

F. NTU: Nephelometric turbidity units

G. uS/cm: Microsiemens per centimeter

1.4 PERFORMANCE REQUIREMENTS

A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment.

B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Closed hydronic systems, including low temperature, medium and high temperature hot-water heating chilled water dual-temperature water and glycol cooling and/or heating, shall have the following water qualities:

1. pH: Maintain a value within 9.0 to 10.5.
2. Turbidity: Maintain a value less than 15 .
3. Boron: Maintain a value within 100 to 200 ppm.
4. Chemical Oxygen Demand: Maintain a maximum value of 100 > ppm.
5. Soluble Copper: Maintain a maximum value of 0.20 > ppm.
6. TDS: Maintain a maximum value of 3000 > ppm.
7. Ammonia: Maintain a maximum value of 5 ppm.
8. Free Caustic Alkalinity: Maintain a maximum value of 20 > ppm.
9. Microbiological Limits:
    a. Total Aerobic Plate Count: Maintain a maximum value of 1000 > organisms/ml.
    b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/ml.
    c. Nitrate Reducers: Maintain a maximum value of 100 organisms/ml.
    d. Sulfate Reducers: Maintain a maximum value of 0 < organisms/ml.
    e. Iron Bacteria: Maintain a maximum value of 0 organisms/ml.
10. Treatment:
    a. Low temperature hot water, closed cooling and chilled water -Mixture of sodium nitrite, borax and molybdate with other copper alloy inhibitor; non-oxidizing, non cationic biocide.
    b. Glycol dual temperature – Buffered phosphate based corrosion inhibitor with copper alloy inhibitor in deionized water.
    c. Medium and high temperature hot water – Softened and deaerated makeup water treated with catalyzed, filming forming oxygen scavenger; neutralizing amine, polymeric dispersant and copper alloy inhibitor for treatment of system water.

1.5 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for the following products:
1. Bypass feeders.
2. Water meters.
3. Inhibitor injection timers.
4. pH controllers.
5. Chemical solution tanks.
6. Injection pumps.
7. Chemical test equipment.
8. Chemical material safety data sheets.
9. Water softeners and demineralizers.

B. Shop Drawings: Pretreatment and chemical, and ozone-generator biocide , and UV-irradiation biocide treatment equipment showing tanks, maintenance space required, and piping connections to HVAC systems. Include plans, elevations, sections, details, and attachments to other work.
1. Record actual locations of equipment and piping, including sampling points and locations of chemical injectors.
2. Wiring Diagrams: Power and control wiring.

C. Field quality-control test reports to indicate inhibitor levels, pH, conductivity, equipment conditions, chemical inventory and water usage data.

D. Manufacturer Seismic Qualification Certification: Submit certification that water softeners/demineralizers, RO equipment, water filtration units, and components will withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Operation and Maintenance Data: For sensors, injection pumps, water softeners/demineralizers,, RO equipment,, water filtration units,, and controllers to include in emergency, operation, and maintenance manuals.

F. Other Informational Submittals:
1. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in the "Performance Requirements" Article above.
2. Water Analysis: Illustrate water quality available at Project site.
3. Passivation Confirmation Report: Verify passivation of galvanized-steel surfaces, and confirm this observation in a letter to Architect.
4. Certification of compliance: Submit certificate of compliance from authority having jurisdiction indicating approval of chemicals and their proposal disposal.

1.6 QUALITY ASSURANCE

A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider with certified water technologists, capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.7 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion, scale formation, and biological growth for cooling, chilled-water piping, heating, hot-water piping, heating, steam and condensate piping, steam and condensate system for humidifier and cooking appliance applications, condenser-water piping, and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion, and shall include the following:
1. Initial makeup and system water analysis with HVAC water-treatment recommendations.
2. Startup assistance for Contractor to flush the systems, clean with disinfectant detergents, and initially fill systems with required chemical treatment prior to operation.
3. Minimum 4 hours of on-site training of plant engineers to use water treatment equipment, to handle and administer treatment chemicals.
4. Monthly,Biweekly,Weekly, field service and consultation.
5. Customer report charts and log sheets.
6. Laboratory technical analysis.
7. Analyses and reports of all chemical items concerning safety and compliance with government regulations.
8. Summary review reports with graphs every six months.

1.8 PIPING INITIAL CLEANING

A. See Division 23, Section "Hydronic Piping" Part 3 – Execution – for initial cleaning and flushing of piping systems.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ampion Corp.
   2. Anderson Chemical Co, Inc.
   3. Aqua-Chem, Inc.; Cleaver-Brooks Div.
   4. Barclay Chemical Co.; Water Management, Inc.
   5. Boland Trane Services
   6. GE Betz.
   7. GE Osmonics.
   8. H-O-H Chemicals, Inc.
   9. Cascade Water Services, Inc.
   10. Olin Water Service
   11. ONDEO Nalco Company.
   12. Watcon, Inc.

2.2 MANUAL CHEMICAL-FEED EQUIPMENT

A. Bypass Filter Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch fill opening in the top, and NPS 3/4 bottom inlet and top side outlet. Quarter turn cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.
   1. Capacity: 2 gal., 5 gal., 10 gal.(38L).
   2. Minimum Working Pressure: 125 psig, 175 psig.
   3. Filter Bag Kit with internal stainless steel support strainer.

2.3 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Water Meter:
   1. AWWA C700, displacement type, magnetic-drive, totalization meter.
   2. Body: Bronze.
   3. Maximum Temperature: 120 F (49 C)
   4. Minimum Working-Pressure Rating: 150 psig.
   5. Maximum Pressure Loss at Design Flow: 3 psig.
   6. Registration: Gallons or cubic feet.
   7. End Connections: Threaded.
   8. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow.

B. Water Meter:
   1. AWWA C701, turbine-type, totalization meter.
   2. Body: Bronze.
   3. Maximum Temperature: 120 F (49 C)
   4. Minimum Working-Pressure Rating: 100 psig.
   5. Maximum Pressure Loss at Design Flow: 3 psig.

6. Registration: Gallons or cubic feet.
7. End Connections: Threaded.
8. Control: Low-voltage signal capable of transmitting 1000 feet.

C. Water Meter:
1. AWWA C701, turbine-type, totalization meter.
2. Body: Bronze, Epoxy-coated cast iron.
3. Maximum Temperature: 120 F (49 C)
4. Minimum Working-Pressure Rating: 150 psig.
5. Maximum Pressure Loss at Design Flow: 3 psig.
6. Registration: Gallons or cubic feet.
7. End Connections: Flanged.
8. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow.

D. Inhibitor Injection Timers:
1. Microprocessor-based controller with LCD display in NEMA 4X, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation and Control for HVAC."
2. Programmable timers with infinite adjustment over full range, and mounted in cabinet with hand-off-auto switches and status lights.
3. Test switch.
4. Hand-off-auto switch for chemical pump.
5. Illuminated legend to indicate feed when pump is activated.
6. Programmable lockout timer with indicator light. Lockout timer to deactivate the pump and activate alarm circuits.
7. LCD makeup totalizer to measure amount of makeup and bleed-off water from two water meter inputs.
8. Timer mode includes: Choice of percent timer, water meter timer, limit timer and 28-day programmable timer.

E. pH Integral Controller:
1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 14 units. Incorporate solid-state integrated circuits and digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation and Control for HVAC."
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal pH indication.
5. High or low pH alarm light, trip points field adjustable; with silence switch.
6. Hand-off-auto switch for acid pump.
7. Internal adjustable hysteresis or deadband.

F. TDS/Conductivity Integral Controller:
1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 5000 micromhos. Incorporate solid-state integrated circuits and digital LCD display in NEMA 4X, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation and Control for HVAC."
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal conductance indication.
5. High or low conductance alarm light, trip points field adjustable; with silence switch.
6. Hand-off-auto switch for solenoid bleed-off valve.
7. Bleed-off valve activated indication.
8. Internal adjustable hysteresis or deadband.
9. Bleed Valves:

a. Cooling Systems: Forged-brass body, globe pattern, general-purpose with motorized ball valve.
b. Steam Boilers: Motorized ball valve, steel body, and TFE seats and seals with needle valve upstream for flow regulation.

G. ORP/Oxidation Reduction Potential Integral Controller
1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 14 units. Incorporate solid-state integrated circuits and digital LCD display in NEMA 4X, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation and Control for HVAC."
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal ORP indication.
5. High or low ORP alarm light, trip points field adjustable; with silence switch.
6. Hand-off-auto switch for acid pump.
7. Internal adjustable hysteresis or deadband.
8. 0-120 minutes limit timer lockout on output relay

H. Biocide Feeder Integral Timer:
1. Microprocessor-based controller with digital LCD display in NEMA 4X, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation and Control for HVAC."
2. 24-hour timer with 28-day skip feature to permit activation any hour of day.
3. Precision, solid-state, bleed-off lockout timer and clock-controlled biocide pump timer. Prebleed and bleed lockout timers.
4. Solid-state alternator to enable use of two different formulations.
5. 24-hour display of time of day.
6. 28-day display of day of week.
7. Battery backup so clock is not disturbed by power outages.
8. Hand-off-auto switches for biocide pumps.
9. Biocide A and Biocide B pump running indication.

I. Chemical Solution Tanks:
1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
2. Molded cover with recess for mounting pump.
3. Capacity: 30 gal., 50 gal., 120 gal..

J. Chemical Solution Injection Pumps:
1. Self-priming, positive-displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Metal and thermoplastic construction.
4. Built-in relief valve.
5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

K. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A 269, Type 304, stainless steel for steam boiler injection assemblies.

L. Injection Assembly:
1. Quill: Minimum NPS 1/2 with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
2. Ball Valve: Three, Two,-piece, stainless steel as described in "Stainless-Steel Pipes and Fittings" Article below; and selected to fit quill.

3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
4. Assembly Pressure/Temperature Rating: Minimum 600 psig at 200 deg F.
5. Materials of construction: Stainless steel 316, Nickel alloy, Carpenter 20, PVC

M. Fail-Safes and Alarms
1. Corrosion safety interlock: Alarm indication, lock-out all chemical feed, open bleed-off valve to flush corrosive water from system.
2. PH interlock: Alarm indication, lock-out all chemical feed, open bleed-off valve to reduce total dissolved solids in cooling tower water.
3. Flow interlock (on loss of flow): Alarm indication, lock-out all control outputs and chemical feeds.

N. Low Level Alarms
1. Low level alarm system to monitor chemical solution level in inhibitor, ph modifier (acid or alkali), biocide, and dispersant drums.
2. Alarm probes, suitable for use in 55 gal (207 L) drum and connected with flexible cable.
3. Signal output suitable for remote alarm function in addition to local alarm.

2.4 CHEMICAL TREATMENT TEST EQUIPMENT

A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounting cabinet for testing pH, TDS, inhibitor, chloride, alkalinity, phosphate, silica and hardness; sulfite, diethylhydorxylamine, hydroquinone, ketoximes Select appropriate oxygen scavenger and testable polymer tests for high-pressure boilers, and oxidizing biocide test for open cooling systems.

B. Sample Cooler:
1. Tube: Sample.
   a. Size: NPS 1/4 tubing.
   b. Material: ASTM A 666, Type 316 stainless steel.
   c. Pressure Rating: Minimum 2000 psig.
   d. Temperature Rating: Minimum 850 deg F.
2. Shell: Cooling water.
   a. Material: ASTM A 666, Type 304 stainless steel.
   b. Pressure Rating: Minimum 250 psig.
   c. Temperature Rating: Minimum 450 deg F.
3. Capacities and Characteristics:
   a. Tube: Sample.
      1) Flow Rate: 0.25 gpm >.
      2) Entering Temperature: 400 deg F
      3) Leaving Temperature: 88 deg F
      4) Pressure Loss: 6.5 psig .
   b. Shell: Cooling water.
      1) Flow Rate: 3 gpm >.
      2) Entering Temperature: 70 deg F.
      3) Pressure Loss: 1.0 psig.

C. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons in accordance with ASTM D2688. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.
1. Two -station rack for closed-loop systems.
2. Four -station rack for open systems.

2.5 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment, and that can attain water quality specified in Part 1 "Performance Requirements" Article.

B. Water Softener Chemicals:
1. Mineral: High-capacity, sulfonated-polystyrene 8% cross linked with divinylbenzene ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock. Resin exchange capacity minimum 30,000 grains/cu. ft. of calcium carbonate of resin when regenerated with 15 lb of salt.
2. Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock and granulated forms are not acceptable.

2.6 HVAC MAKEUP WATER SOFTENER

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Alamo Water Treatment; Ecodyne Water Treatment, Inc.
2. Columbia Water Conditioning Systems, Inc.
3. CSI; a division of Chandler Systems, Inc.
4. Culligan International.
5. CUNO Incorporated.
6. Diamond Water Conditioning.
7. Diamond Water Systems, Inc.
8. Environmental Dynamics Corporation.
9. Hungerford & Terry, Inc.
10. Kinetico Incorporated.
11. Marlo Incorporated.
12. Parker Boiler Company.
13. Plymouth Products, Inc.
14. Rainsoft Div.; Aquion Partners L. P.
15. Water King.

B. Description: Twin mineral tanks and one brine tank, factory mounted on skid.

C. Fabricate supports and attachments to tanks with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure as recommended in writing by manufacturer.

D. Mineral Tanks:
1. Fabricate and label steel filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Fabricate and label FRP filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, if indicated.
3. Pressure Rating: 100 psig, 125 psig, 150 psig, > minimum.
4. Wetted Components: Suitable for water temperatures from 40 to at least 100 deg F .
5. Freeboard: 50 percent, minimum, for backwash expansion above the normal resin bed level.
6. Support Legs or Skirt: Constructed of structural steel, welded or bonded to tank before testing and labeling.
7. Finish: Hot-dip galvanized on exterior and epoxy lined interior of tank after fabrication.
8. Upper Distribution System: Single-point type, fabricated from galvanized-steel pipe and fittings.
9. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from PVC pipe and fittings with individual, fine-slotted, nonclogging PE strainers; arranged for even-flow distribution through resin bed.

E. Controls: Automatic; factory mounted on mineral tanks and factory wired.
   1. Adjustable duration of regeneration steps.
   2. Push-button start and complete manual operation override.
   3. Pointer on pilot-control valve shall indicate cycle of operation.
   4. Means of manual operation of pilot-control valve if power fails.
   5. Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:
      a. Slow opening and closing, non-slam operation.
      b. Diaphragm guiding on full perimeter from fully open to fully closed.
      c. Isolated dissimilar metals within valve.
      d. Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
      e. Float-operated brine valve to automatically measure the correct amount of brine to the softener and refill with fresh water.
      f. Sampling cocks for soft water.
   6. Flow Control: Automatic control of backwash and flush rates over variations in operating pressures that do not require field adjustments. Equip mineral tanks with automatic-reset-head water meter that electrically activates cycle controller to initiate regeneration at preset total in gallons, and automatically resets after regeneration to preset total in gallons for next service run. Include alternator to regenerate one mineral tank with the other in service.

F. Brine Tank: Combination measuring and wet-salt storing system.
   1. Tank and Cover Material: Fiberglass a minimum of 3/16 inch thick; or molded PE a minimum of 3/8 inch thick.
   2. Brine Valve:. Float operated and plastic fitted for automatic control of brine withdrawn and freshwater refill.
   3. Size: Large enough for at least four regenerations at full salting.

G. Factory-Installed Accessories:
   1. Piping, valves, tubing, and drains.
   2. Sampling cocks.
   3. Main-operating-valve position indicators.
   4. Water meters.

H. Water Test Kit: Include water hardness and brine salinity test kit in wall-mounting enclosure for water softener.

I. Capacities and Characteristics:
   1. Continuous Service Flow Rate: at 15-psig pressure loss.
   2. Peak Service Flow Rate: at 25-psig pressure loss.
   3. Water Consumption:
   4. Water Demand: hours/day.
   5. Electrical Characteristics:

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INITIAL CLEANING OF SYSTEM

A. Prior to operation, clean system as specified in Section 23 0500 Common Work Results for HVAC.

3.3 INSTALLATION

A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

B. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Refer to Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for seismic restraints.

C. Install water testing equipment on wall near water chemical application equipment.

D. Install interconnecting control wiring for chemical treatment controls and sensors.

E. Mount sensors and injectors in piping circuits.

F. Bypass Feeders: Install in closed hydronic systems, including hot-water heating, chilled water,, and equipped with the following:
1. Install bypass feeder in a bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
2. Install side stream filter in a bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
3. Install water meter in makeup water supply.
4. Install test-coupon assembly in bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
5. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below feeder /filter inlet.
6. Install a swing check on inlet after the isolation valve.
7. Install a flow meter at outlet of filter.

G. Install automatic chemical-feed equipment for steam boiler and steam condensate systems and include the following:
1. Install makeup water softener.
2. Install water meter in makeup water supply.
3. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.
   a. Pumps shall operate for timed interval when contacts close at water meter in makeup water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.
4. Install test equipment and furnish test-kit to Owner.
5. Install RO unit for makeup water.
6. Install TDS/conductivity controller with sensor and bleed valves.
   a. Bleed valves shall cycle to maintain maximum TDS/conductivity concentration.
7. Install inhibitor injection timer with injection pumps and solution tanks.
   a. Pumps shall operate for timed interval on contact closure at water meter in makeup water supply connection. Injection pump shall discharge into main steam supply header.

H. Install automatic chemical-feed equipment for condenser, fluid-cooler spray, water and include the following:
1. Install makeup water softener.

2. Install water meter in makeup water supply.
3. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.
   a. Pumps shall operate for timed interval on contact closure at water meter in makeup water supply connection. Injection pump shall discharge into condenser water piping as shown on drawings.
4. Install test equipment and provide test-kit to Owner. Install test-coupon assembly in bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
5. Install TDS controller with sensor and bleed valves.
   a. Bleed valves shall cycle to maintain maximum TDS concentration.
6. Install pH, conductivity and orp sensors with integral controller, injection pumps and solution tanks.
   a. Injector pumps shall operate to maintain required pH and orp.
7. Install biocide feeder alternating timer with two sets of injection pumps and solution tanks.
   a. Injection pumps shall operate to feed biocide on an alternating basis.
8. Install ozone generator with diffusers in cooling tower side stream water piping.
   a. Ozone generator shall operate continuously with condenser-water flow.
9. Install UV-irradiation lamps in condenser-water piping.
   a. UV lights shall operate continuously with condenser-water flow.

I. Install corrosion resistant drip pan, a minimum of 3 in (75 mm) high, under tanks and pumps. Intent is to contain minor leaks.

J. Install water softener equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.

K. Install seismic restraints for tanks and floor-mounting accessories and anchor to building structure. Refer to Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for seismic restraints.

L. Install brine lines and fittings furnished by equipment manufacturer but not factory installed.

M. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.

N. Install water-testing sets on wall adjacent to water softeners.

3.4 RO UNIT INSTALLATION

A. Install RO unit and storage tank on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor RO unit and storage tank with pumps to substrate.

B. Install seismic restraints for tanks and floor-mounting accessories and anchor to building structure. Refer to Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for seismic restraints.

C. Install interconnecting piping and controls furnished by equipment manufacturer but not factory installed.

D. Install water testing sets on wall adjacent to RO unit.

3.5 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Division 23 Section "Common Work Results for HVAC."

D. Install unions, shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Division 23 Section "General-Duty Valves for HVAC Piping."

E. Refer to Division 22 Section "Domestic Water Piping Specialties" for backflow preventers required in makeup water connections to potable-water systems.

F. Confirm applicable electrical requirements in Division 26 Sections for connecting electrical equipment.

G. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

H. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing. Install and retrieve corrosion coupons every 90 days to generate quarterly reports on corrosion rates of steel and copper with photographic images of the coupons.

C. Tests and Inspections:
   1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
   2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
   3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.
   4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
   5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
   7. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.

8. Repair leaks and defects with new materials and retest piping until no leaks exist.

D. Remove and replace malfunctioning units and retest as specified above.

E. Sample boiler water at one-week intervals after boiler startup for a period of five weeks, and prepare test report advising Owner of changes necessary to adhere to Part 1 "Performance Requirements" Article for each required characteristic. Sample boiler water at four, six, eight,-week intervals following the testing noted above to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section.

F. At four, six, eight,-week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis advising Owner of changes necessary to adhere to Part 1 "Performance Requirements" Article.

G. Comply with ASTM D 3370 and with the following standards:
1. Silica: ASTM D 859.
2. Steam System: ASTM D 1066.
3. Acidity and Alkalinity: ASTM D 1067.
4. Iron: ASTM D 1068.
5. Water Hardness: ASTM D 1126.
6. Chloride: ASTM D4458
7. Copper: ASTM D1688
8. pH: ASTM D5464

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment. Refer to Division 01 Section "Demonstration and Training."

B. Training: Provide a minimum of 4 hours of training on handling and testing of treatment chemicals with "how-to-use" self-contained breathing apparatus video that details exact operating procedures of equipment.

END OF SECTION 23 2500

SECTION 23 3113

METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Duct liner.
5. Sealants and gaskets.
6. Hangers and supports.
7. Seismic-restraint devices.

B. Related Sections:

1. Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Division 23 Section "Nonmetal Ducts" for fibrous-glass ducts, thermoset fiber-reinforced plastic ducts, thermoplastic ducts, PVC ducts, and concrete ducts.
3. Division 23 Section "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
4. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports[**and seismic restraints**] shall withstand the effects of gravity[**and seismic**] loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" **[and] [ASCE/SEI 7.] [SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."**]

1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. LEED Submittals:

1. Product Data for Prerequisite EQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
3. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1, Section 6.4.4.2.2 - "Duct Leakage Tests."
4. Duct-Cleaning Test Report for Prerequisite EQ 1: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 - "Ventilation System Start-Up."
5. Product Data for Credit EQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
6. Laboratory Test Reports for Credit EQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment[**, seismic restraints,**] and vibration isolation.

D. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations **including analysis data signed and sealed by the qualified professional engineer responsible for their preparation** for selecting hangers and supports[**and seismic restraints**.

E. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:

    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Perimeter moldings.

F. Welding certificates.

G. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to [**AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.**] [**AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.**] [**AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.**]

B. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Manufacturers: Subject to compliance with requirements, [**provide products by one of the following**] [**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:

a. Lindab Inc.
b. McGill AirFlow LLC.
c. SEMCO Incorporated.
d. Sheet Metal Connectors, Inc.
e. Spiral Manufacturing Co., Inc.
f.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than [60 Inches] <**Insert dimension**> in Diameter: Flanged.

D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 FLUSH FLAT SEAM RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class, except use sheet metal 2 gauge numbers heavier than required for classification with normal standing seam construction.

B. Transverse Joints: Fabricate joints in accordance with transverse joint detail shown on drawings. Provide all joints and seams, smooth, and alighted with no projections. In other aspects conform to SMACNA's "HVAC Duct Construction Standards" for applicable sealing requirements, duct-support intervals and other provisions.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Install ducts with longitudinal seams at lop of ducts.

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Rectangular Duct Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Reinforcing: Install vertical stays for interval reinforcement at transverse joints and at 2 foot intervals along run of duct, as follows:

1. Ducts up to 60 inches wide: Provide 1 vertical stay at mid-point of duct.
2. Ducts 61 inches to 90 inches wide: Provide 2 vertical stays at third points of duct.
3. Ducts over 90 inches wide: Provide 3 vertical stays at quarter points of duct.
4. Vertical Stays: 10 USSG galvanized steel, free of burrs and rough edges, with both ends bent and fastened to the top and bottom of ducts.

2.4 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: [G60] [G90].
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. PVC-Coated, Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: [G60] [G90].
2. Minimum Thickness for Factory-Applied PVC Coating: 4 mils thick[**on sheet metal surface of ducts and fittings exposed to corrosive conditions, and minimum** 1 mil **thick on opposite surface**].
3. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL 181, Class 1.

D. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

E. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

F. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

G. Factory- or Shop-Applied Antimicrobial Coating:

1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
5. Shop-Applied Coating Color: [**Black**] [**White**].
6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

H. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

I. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.5 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Manufacturers: Subject to compliance with requirements, **provide products by one of the following** :

   a. CertainTeed Corporation; Insulation Group.
   b. Johns Manville.
   c. Knauf Insulation.
   d. Owens Corning.
   e. Maximum Thermal Conductivity:

      1) Type I, Flexible: [0.27 Btu x in./h x sq. ft. x deg F] > at 75 deg F mean temperature.
      2) Type II, Rigid: [0.23 Btu x in./h x sq. ft. x deg F] at 75 deg F mean temperature.

2. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. **Solvent**-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
b. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

1. Manufacturers: Subject to compliance with requirements, **provide products by one of the following:**

a. Armacell LLC.
b. Rubatex International, LLC

2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
b. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Natural-Fiber Duct Liner: 85 percent cotton, 10 percent borate, and 5 percent polybinding fibers, treated with a microbial growth inhibitor and complying with NFPA 90A or NFPA 90B.

1. Manufacturers: Subject to compliance with requirements, **provide products by one of** The manufacturer:

a. Bonded Logic, Inc.
b. Reflectix Inc.

2. Maximum Thermal Conductivity: [0.24 Btu x in./h x sq. ft. x deg F] at 75 deg F mean temperature when tested according to ASTM C 518.
3. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to ASTM E 84; certified by an NRTL.
4. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
b. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, [0.106-inch-] [0.135-inch-] diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick **galvanized steel** with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

E. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

   a. Fan discharges.
   b. Intervals of lined duct preceding unlined duct.
   c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.

   a. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23 percent.

10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.6 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: As per manufacturer's written instructions.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.

6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
10. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
11. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
9. VOC: Maximum 395 g/L.
10. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
11. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
12. Service: Indoor or outdoor.
13. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.7 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.8 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:

1. Cooper B-Line, Inc.; a division of Cooper Industries.
2. Ductmate Industries, Inc.
3. Hilti Corp.
4. Kinetics Noise Control.
5. Loos & Co.; Cableware Division.
6. Mason Industries.
7. TOLCO; a brand of NIBCO INC.
8. Unistrut Corporation; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by [**an evaluation service member of the ICC Evaluation Service the Office of Statewide Health Planning and Development for the State of California**.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least [**four**] times the maximum seismic forces to which they will be subjected.

C. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

D. Restraint Cables: **ASTM A 603, galvanized**-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

E. Hanger Rod Stiffener: **Steel tube or steel slotted-support-system sleeve with internally bolted connections** to hanger rod.

F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round[**and flat-oval**] ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. **Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."**

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

A. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.

B. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of [20 feet] [12 feet] in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings. Locate access panel on top or sides of duct a minimum of 1-1/2 inches from bottom of duct.

C. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

3.4 INSTALLATION OF DUCTS OUTDOORS

A. Ducts shall be made completely watertight.

B. Construct ducts as follows to assure water run-off.

1. Arrange standing seams so as not to act as dams.
2. Erect ducts with longitudinal seams at bottom of duct.
3. Slope entire top of duct down towards side.
4. Provide vertical struts within duct to bow tap panels of duct into convex shape.
5. Erect ducts with mastic sealant within sheet metal joints.

3.5 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.7 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with **[SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."**] **[ASCE/SEI 7.]**

1. Space lateral supports a maximum of [40 feet] o.c., and longitudinal supports a maximum of [80 feet] o.c.
2. Brace a change of direction longer than 12 feet.

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by **an evaluation service member of the ICC Evaluation Service, the Office of Statewide Health Planning and Development for the State of California**.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre stressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.8 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.9 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:

   a. Ducts with a Pressure Class Higher Than 3-Inch wg: Test representative duct sections, totaling no less than 25 percent of total installed duct area for each designated pressure class.
   b. Supply Ducts with a Pressure Class of 2-Inch wg, 3-Inch wg Inch wg] : Test representative duct sections[**, selected by Architect from sections installed,**] totaling no less than [**50**] [**100**] percent of total installed duct area for each designated pressure class.
   c. Return Ducts with a Pressure Class of 2-Inch wg, 3-Inch wg 4-Inch wg: Test representative duct sections totaling no less than **100** percent of total installed duct area for each designated pressure class.

   d. Exhaust Ducts with a Pressure Class of 2-Inch wg, 3-Inch wg [4-Inch wg]: Test representative duct sections **100** percent of total installed duct area for each designated pressure class.

   e. Outdoor Air Ducts with a Pressure Class of 2-Inch wg3-Inch wg 4-Inch wg: Test representative duct sections, **100** percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give [**seven**] days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

   a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.11 DUCT CLEANING

A. Clean **new and existing** duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Division 23 Section "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.12 START UP

A. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

3.13 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

1. Underground Ducts: Concrete-encased, **galvanized sheet steel PVC-coated, galvanized sheet steel with thicker coating on duct exterior**.

B. Supply Ducts:

1. Ducts Connected to Fan Coil Units, and Terminal Units:

a. Pressure Class: Positive [1-inch wg] [2-inch wg]
b. Minimum SMACNA Seal Class: [**A**] [**B**] [**C**].
c. SMACNA Leakage Class for Rectangular: [**12**] [**24**] .
d. SMACNA Leakage Class for Round and Flat Oval: [**12**] [**24**]

2. Ducts Connected to Constant-Volume Air-Handling Units :

a. Pressure Class: Positive [2-inch wg] [3-inch wg]
b. Minimum SMACNA Seal Class: [**A**] [**B**].
c. SMACNA Leakage Class for Rectangular: [**6**] [**12**] [**24**] >.
d. SMACNA Leakage Class for Round and Flat Oval: [**6**] [**12**] [**24**] .

3. Ducts Connected to Variable-Air-Volume Air-Handling Units :

a. Pressure Class: Positive [3-inch wg] [4-inch wg]
b. Minimum SMACNA Seal Class: [**A**] [**B**].
c. SMACNA Leakage Class for Rectangular: [**3**] [**6**] <
d. SMACNA Leakage Class for Round and Flat Oval: [**3**] [**6**] .

4. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive [2-inch wg] [3-inch wg] [4-inch wg]
b. Minimum SMACNA Seal Class: [**A**] [**B**].
c. SMACNA Leakage Class for Rectangular: [**3**] [**6**] [**12**]
d. SMACNA Leakage Class for Round and Flat Oval: [**3**] [**6**] [**12**]

C. Return Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive or negative [1-inch wg] [2-inch wg] .
b. Minimum SMACNA Seal Class: [**A**] [**B**] [**C**].
c. SMACNA Leakage Class for Rectangular: [**12**] [**24**] .
d. SMACNA Leakage Class for Round and Flat Oval: [**12**] [**24**] .

2. Ducts Connected to Air-Handling Units :

a. Pressure Class: Positive or negative [2-inch wg] [3-inch wg] .
b. Minimum SMACNA Seal Class: [**A**] [**B**].
c. SMACNA Leakage Class for Rectangular: [**6**] [**12**] [**24**] .
d. SMACNA Leakage Class for Round and Flat Oval: [**6**] [**12**] [**24**] .

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative [2-inch wg] [3-inch wg] [4-inch wg] .
b. Minimum SMACNA Seal Class: **[A]** [**B**].
c. SMACNA Leakage Class for Rectangular: **[3]** **[6]** **[12]** .
d. SMACNA Leakage Class for Round and Flat Oval: **[3]** **[6]** **[12]** .

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

a. Pressure Class: Negative [1-inch wg] [2-inch wg] [3-inch wg] .
b. Minimum SMACNA Seal Class: [**A**] [**B**] [**C**] if negative pressure, and A if positive pressure.
c. SMACNA Leakage Class for Rectangular: [**12**] [**24**] .
d. SMACNA Leakage Class for Round and Flat Oval: [**6**] [**12**] [**24**] .

2. Ducts Connected to Air-Handling Units :

a. Pressure Class: Positive or negative [2-inch wg] [3-inch wg] .
b. Minimum SMACNA Seal Class: [**A**] [**B**] if negative pressure, and A if positive pressure.
c. SMACNA Leakage Class for Rectangular: [**6**] [**12**] [**24**] .
d. SMACNA Leakage Class for Round and Flat Oval: [**3**] [**6**] [**12**] [**24**] .

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative [2-inch wg] [3-inch wg] [4-inch wg] .
b. Minimum SMACNA Seal Class: [**A**] [**B**] if negative pressure, and A if positive pressure.
c. SMACNA Leakage Class for Rectangular: [**6**] [**12**] [**24**] .
d. SMACNA Leakage Class for Round and Flat Oval: [**3**] [**6**] [**12**] [**24**]

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units

a. Pressure Class: Positive or negative [1-inch wg] [2-inch wg]
b. Minimum SMACNA Seal Class: **[A]** **[B]** [**C**].
c. SMACNA Leakage Class for Rectangular: [**12**] [**24**]
d. SMACNA Leakage Class for Round and Flat Oval: [**6**] [**12**] [**24**] .

2. Ducts Connected to Air-Handling Units :

a. Pressure Class: Positive or negative [2-inch wg] [3-inch wg]
b. Minimum SMACNA Seal Class: [**A**] [**B**].
c. SMACNA Leakage Class for Rectangular: [**6**] [**12**] [**24**] .
d. SMACNA Leakage Class for Round and Flat Oval: [**3**] [**6**] [**12**] [**24**]

F. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: **[Galvanized steel]** [**Carbon steel coated with zinc-chromate primer**] [**Galvanized steel or carbon steel coated with zinc-chromate primer**].
2. PVC-Coated Ducts:

a. Exposed to Airstream: Match duct material.
b. Not Exposed to Airstream: **[Galvanized]** [**Match duct material**].

3. Supply Air Ducts: [**Fibrous glass, Type I**] [**Flexible elastomeric**] [**Natural fiber**], [1 inch] [1-1/2 inches] [2 inches] thick.

4. Return Air Ducts: **[Fibrous glass, Type I]** **[Flexible elastomeric]** **[Natural fiber]**, [1 inch] [1-1/2 inches] [2 inches] thick.
5. Exhaust Air Ducts: **[Fibrous glass, Type I]** **[Flexible elastomeric]** **[Natural fiber]**, [1 inch] thick.
6. Supply Fan Plenums: **[Fibrous glass, Type II]** **[Flexible elastomeric]** **[Natural fiber]**, [1 inch] [1-1/2 inches] [2 inches] thick.
7. Return- and Exhaust-Fan Plenums: **[Fibrous glass, Type II]** **[Flexible elastomeric]** **[Natural fiber]**, [2 inches] thick.
8. Transfer Ducts: **[Fibrous glass, Type I]** **[Flexible elastomeric]** **[Natural fiber]**, [1 inch] [1-1/2 inches] [2 inches] thick.

G. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

   a. Velocity 1000 fpm or Lower:

      1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
      2) Mitered Type RE 4 without vanes.

   b. Velocity 1000 to 1500 fpm:

      1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
      2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
      3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

   c. Velocity 1500 fpm or Higher:

      1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
      2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
      3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

   a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
   c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

   a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

      1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.

2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
4) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, [12 Inches] and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, [14 Inches] <**Insert dimension**> and Larger in Diameter: [**Standing seam**] [**Welded**].

H. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   b. Rectangular Main to Round Branch: Spin in.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

   a. Velocity 1000 fpm or Lower: 90-degree tap.
   b. Velocity 1000 to 1500 fpm: Conical tap.
   c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 23 3113

SECTION 23 3600

AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Variable air volume single-duct air terminal units.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories.

B. LEED Submittal:
   1. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, materials used in fabrication, method of field assembly, components, and location and size of each field connection.
   1. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished.
   2. Wiring Diagrams: Power, signal, and control wiring and differentiate between factory-installed and field-installed wiring.
   3. Include catalog performance ratings which indicate air flow, static pressure and NC designation.
   4. Include a schedule listing discharge and radiated sound power levels, for each unit, of second to sixth octave band at inlet static pressure of 1 to 4 in. w.g. 250 to 1000 Pa. NC data alone will not be acceptable.

D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Ceiling suspension assembly members.
   2. Method of attaching hangers to building structure.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

E. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Instructions for resetting minimum and maximum air volumes.
   2. Instructions for adjusting software set points.

3. Directions for resetting constant volume regulators.
4. Parts list for each type of air terminal unit and troubleshooting maintenance guide.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air terminal units and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

E. Air terminal units shall be certified under AIR Standard 880-94 certification program and carry the ARI seal.

F. Air terminal unit lining shall meet UL 181 and NFPA 90A standards.

G. Fan-Powered air terminal units:
   1. Manufacturer shall provide proof that the proposed units have been tested under the airflows and static pressures shown on the project schedule, in a certified laboratory as per ANSI S1.31 standard, following ARI 880, and comply with the maximum sound power levels indicated below.
      a. Maximum radiated sound power level of fan powered boxes shall not be greater than any of the following octave band limits.

Maximum Fan Powered Box Sound Power Levels
Db re: 10^{-12} Watts
Tested in Accordance with ARI 880

Octave Band: Center Freq. (Hz):	2 125	3 250	4 500	5 1k	6 2k	7 4k
Unit Located Over NC-35 Space:	70	61	58	55	52	49
Unit Located Over NC-40 Space:	74	66	63	60	57	54

1.5 COORDINATION

A. Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Air terminal units shall be equipped with pressure independent direct digital controls supplied by the Control Contractor and mounted at the factory by the terminal unit manufacturer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 VARIABLE AIR VOLUME SINGLE DUCT AIR TERMINAL UNITS

A. Manufacturers:
   1. Price.
   2. Krueger.
   3. Titus.
   4. Trane co. (The); Worldwide Applied systems Group.

B. Configuration: Volume-damper assembly inside unit casing with control components located inside a protective metal enclosure.

C. Casing: 0.034-inch (0.85-mm) galvanized steel.
   1. Casing Lining: 1-inch- (25-mm-) thick, coated, fibrous-glass duct liner complying with ASTM C 1071; secured with adhesive. Cover liner with nonporous foil and perforated metal.
   2. Casing Lining: Adhesive attached, ¾-inch- (19-mm-) thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame spread index of 24 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
   3. Air Inlets: Round stub connections of S-slip and drive connections for duct attachments.
   4. Air Outlet: S-slip and drive connections.
   5. Access: Removable panels for access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket.
   6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
   1. Maximum Damper Leakage: ARI 880 rated, 2 percent of nominal airflow at 3-inch wg (750-Pa) inlet static pressure.

E. Attenuator Section: 0.034-inch (0.85-mm) galvanized steel sheet metal.
   1. Lining: 1-inch- (25-mm-) thick, coated, fibrous-glass duct liner complying with ASTM C 1071; secured with adhesive. Cover liner with nonporous foil and perforated metal.
   2. Lining: Adhesive attached, 3/4-inch- (19-mm-) thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.

F. Hot-Water Heating Coil: Copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig (1380 kPa); and factory installed.

G. Pneumatic Controls: Damper operator, cross flow type, velocity controllers and thermostat shall be compatible with temperature controls specified in Division 23 Section "Instrumentation and Control for HVAC."
   1. Pneumatic Damper Operator: 8- to 13-psig (55- to 90-kPa)spring range.

2. Velocity Controllers: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor. Locate velocity sensors in air inlet and air outlet.
3. Thermostat: Wall-mounting pneumatic type with appropriate mounting hardware.

H. Electronic Controls: Bidirectional damper operator and microprocessor-based thermostat with integral airflow transducer and room sensor shall be compatible with temperature controls specified in Division 23 Section "Instrumentation and Control for HVAC." And shall have the following features:
1. Damper Actuator: 24 V, powered closed, powered open.
2. Velocity controller: cross flow type, factory calibrated to minimum and maximum air volumes, field adjustable at thermostat; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor. Locate velocity sensors in air inlet and air outlet.
3. Thermostat: Wall-mounting electronic type with the flowing features:
    a. Proportional, plus integral control of room temperature.
    b. Time-proportional reheat-coil control.
    c. Temperature set-point display in Fahrenheit and Celsius.
    d. Auxiliary switch shall energize heating control circuit.
    e. Changeover thermistor shall reverse action.

I. DDC Controls: Single- package unitary controller and actuator specified in Division 23 Section "Instrumentation and Control for HVAC."

J. DDC Controls: Bidirectional damper operators and microprocessor-based controller and room sensor shall be compatible with temperature controls specified in Division 23 Section "Instrumentation and Control for HVAC" and shall have the following features:
1. Damper Actuator: 24 V, powered closed, spring return open, powered open.
2. Terminal Unit Controller: Pressure-independent, variable-air-volume controller with electronic airflow transducer with multipoint cross flow type velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:
    a. Proportional, plus integral control of room temperature.
    b. Time-proportional reheat-coil control.
    c. Occupied and unoccupied operating mode.
    d. Remote reset of airflow or temperature set points.
    e. Adjusting and monitoring with portable terminal.
    f. Communication with temperature-control system specified in Division 23Section "Instrumentation and Control for HVAC."
3. Room Sensor: Wall mounting, with temperature set-point adjustment and access for connection of portable operator terminal.

K. Control Sequence:
1. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg (60- and 750- Pa) inlet static pressure.
2. Control modulating damper to maintain vary supply air flow to maintain room temperature.
3. Wall mounting thermostat with temperature set-point adjustment.

2.3 SOURCE QUALITY CONTROL

A. Identification: Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

B. Verification of Performance: Rate air terminal units according to ARI 880.

C. Noise Levels at noted capacities: Units tested in accordance with ASHRAE Standard 36B or ADC, with ratings tabulated for inlet pressure of 3 in, 1 3/4 in, 1 1/2 in, and minimum static pressure.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

B. Provide sound lining downstream of units for a minimum of 5 ft. or as recommended by unit manufacturer to maintain scheduled NC levels.

C. Maintain sufficient clearance for normal service and maintenance.

D. Coordinate access through ceilings with respective trades.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air terminal units to allow service and maintenance.

C. Hot-Water Piping: In addition to requirements in Division 23 Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

D. Connect ducts to air terminal units according to Division 23 Section "Metal Ducts"

E. Ground units with electric heating coils according to Division 26 Section "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

G. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect test, and adjust field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units, controls and equipment, and retest as specified above.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions and do the following:
      a. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
      b. Verify that controls and control enclosure are accessible.
      c. Verify that control connections are complete.
      d. Verify that nameplate and identification tag are visible.
      e. Verify that controls respond to inputs as specified.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air terminal units. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 23 3600

SECTION 23 3713

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

1.2 SUMMARY

A. Section Includes:

1. Round ceiling diffusers.
2. Rectangular and square ceiling diffusers.
3. Perforated diffusers.
4. Louver face diffusers.
5. Linear bar diffusers.
6. Linear slot diffusers.
7. Ceiling-integral continuous diffusers.
8. Light troffer diffusers.
9. Round induction diffusers.
10. Linear floor diffuser plenums.
11. Drum louvers.
12. Modular core supply grilles.
13. Continuous tubular diffusers.
14. Adjustable bar [**registers**] [**grilles**] [**registers and grilles**].
15. Security [**registers**] [**grilles**] [**registers and grilles**].
16. Fixed face [**registers**] [**grilles**] [**registers and grilles**].
17. Linear bar grilles.
18. Underfloor air diffusers.

B. Related Sections:

1. Division 08 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
2. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.

C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

E. Source quality-control reports.

1.4 QUALITY ASSURANCE

A. Test and rate performance of air outlets and inlets in accordance with ADC Equipment Test code 1062 and ASHRAE 70.

B. Install diffusers, registers, and grilles according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating System."

PART 2 - PRODUCTS

2.1 GENERAL

A. Manufacturer shall examine application of each air inlet and outlet and guarantee that each will provide comfort space conditions without drafts or noise at noted capacities.

B. Noise Level: Noise levels at rated capacities shall not exceed criteria specifies under 1.4 "Quality Assurance."

C. All outlets shall be suitable for operation at 5 percent more and at 25 percent less than noted capacities.

D. Air inlets and outlets for surface mounting shall have a concealed mounting frame, with no mounting screws visible in face frame of outlet and/or plastic frame, unless otherwise noted.

E. Scheduled air outlets shall be as manufactured by the listed manufacturer and shall, to the greatest extent possible, all be manufactured by the same manufacturer.

F. The contractor and vender shall be jointly responsible for all quantity and neck size take-offs and coordination of mounting details with the ceiling, wall, or floor mounting in which it is installed.

G. Air distribution devices shall have unit mounted opposed blade volume dampers operable from the face of the air distribution devices.

H. Diffusers in the same room shall all be the same size and type, except as otherwise indicated.

I. Contractor shall provide all required blank offs for directional pattern throws.

2.2 CEILING DIFFUSERS

A. Round Ceiling Diffuser <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Anemostat Products; a Mestek company.
   b. Carnes.
   c. Hart & Cooley Inc.
   d. Metalaire, Inc.
   e. Price Industries.
   f. Titus.
   g. Tuttle & Bailey.
   h. <**Insert manufacturer's name**>.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: [**Steel**] [**Aluminum**].
4. Finish: [**Baked enamel, white**] [**Baked enamel, color selected by Architect**] [**Anodized aluminum**] <**Insert finish**>.
5. Face Style: [**Four**] [**Three**] [**Two**] cone.
6. Mounting: Duct connection.
7. Pattern: [**Fully adjustable**] [**Two-position horizontal**].
8. Dampers: Radial opposed blade .
9. Accessories:

   a. Equalizing grid.
   b. Plaster ring.
   c. Safety chain.
   d. Wire guard.
   e. Sectorizing baffles.
   f. Operating rod extension.

B. Rectangular and Square Ceiling Diffusers <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Anemostat Products; a Mestek company.
   b. Carnes.
   c. Hart & Cooley Inc.
   d. Krueger.
   e. Metalaire, Inc.
   f. Price Industries.
   g. Titus.
   h. Tuttle & Bailey.
   i. <**Insert manufacturer's name**>.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: [**Steel**] [**Aluminum**].
4. Finish: [**Baked enamel, white**] [**Baked enamel, color selected by Architect**] [**Anodized aluminum**] <**Insert finish**>.
5. Face Size: [**24 by 24 inches**] [**20 by 20 inches**] [**12 by 12 inches**] <**Insert dimensions**>.
6. Face Style: [**Three cone**] [**Four cone**] [**Plaque**].
7. Mounting: [**Surface**] [**T-bar**] [**Snap in**] [**Spline**] [**Mounting panel**].

8. Pattern: **[Fixed] [Two position] [Adjustable]**.
9. Dampers: Radial opposed blade.
10. Accessories:

    a. Equalizing grid.
    b. Plaster ring.
    c. Safety chain.
    d. Wire guard.
    e. Sectorizing baffles.
    f. Operating rod extension.

C. Perforated Diffuser <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Anemostat Products; a Mestek company.
    b. Carnes.
    c. Hart & Cooley Inc.
    d. Krueger.
    e. Titus.
    f. Tuttle & Bailey.
    g. Warren Technology.
    h. <**Insert manufacturer's name**>.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Steel backpan and pattern controllers, with **[steel] [aluminum]** face.
4. Finish: **[Baked enamel, white] [Baked enamel, color selected by Architect] [Anodized aluminum]** <**Insert finish**>.
5. Face Size: **[12 by 12 inches] [24 by 12 inches] [36 by 12 inches] [48 by 12 inches] [16 by 16 inches] [20 by 20 inches] [24 by 24 inches] [36 by 24 inches] [48 by 24 inches]** <**Insert dimensions**>.
6. Duct Inlet: **[Round] [Square]**.
7. Face Style: **[Flush] [Drop extended]**.
8. Mounting: **[Surface] [T-bar] [Snap in] [Spline] [Mounting panel]**.
9. Pattern Controller: **[Fixed with curved blades at inlet] [Adjustable with louvered pattern modules at inlet] [None]**.
10. Dampers: Opposed blade.
11. Accessories:

    a. Equalizing grid.
    b. Plaster ring.
    c. Safety chain.
    d. Wire guard.
    e. Sectorizing baffles.
    f. Operating rod extension.

D. Louver Face Diffuser <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Anemostat Products; a Mestek company.
    b. Carnes.
    c. Titus.

d. Tuttle & Bailey.
e. **<Insert manufacturer's name>**.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: **[Steel] [Aluminum]**.
4. Finish: **[Baked enamel, white] [Baked enamel, color selected by Architect] [Anodized aluminum] <Insert finish>**.
5. Face Size: **<Insert inches>**.
6. Mounting: **[Surface] [Surface with beveled frame] [T-bar] [Snap in] [Spline] [Mounting panel]**.
7. Pattern: **[One-way] [Two-way] [Two-way corner] [Three-way] [Four-way] [Adjustable] <Insert pattern>** core style.
8. Dampers: Radial opposed blade.
9. Accessories:

a. Square to round neck adaptor.
b. Adjustable pattern vanes.
c. Throw reducing vanes.
d. Equalizing grid.
e. Plaster ring.
f. Safety chain.
g. Wire guard.
h. Sectorizing baffles.
i. Operating rod extension.

2.3 LINEAR SLOT OUTLETS

A. Linear Bar Diffuser **<Insert drawing designation>**:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anemostat Products; a Mestek company.
b. Carnes.
c. Hart & Cooley Inc.
d. Krueger.
e. Titus.
f. Tuttle & Bailey.
g. **<Insert manufacturer's name>**.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: **[Steel] [Aluminum] [Stainless steel]**.
4. Finish: **[Baked enamel, white] [Baked enamel, color selected by Architect] <Insert finish>**.
5. Narrow Core Spacing Arrangement: 1/8-inch- thick blades spaced 1/4 inch apart, **[zero] [15]**-degree deflection.
6. Wide Core Spacing Arrangement: 1/8-inch- thick blades spaced 1/2 inch apart, **[zero] [15]**-degree deflection.
7. Wide Core Spacing Arrangement: 3/16-inch- thick blades spaced 1/2 inch apart, **[zero] [15] [30]**-degree deflection.
8. Pencil-Proof Core Spacing Arrangement: 3/16-inch- thick blades spaced 7/16 inch apart, **[zero] [15] [30]**-degree deflection.
9. **[One] [Two]**-Way Deflection Vanes: Extruded construction fixed louvers with removable core.
10. Frame: **[1-1/4 inches] [1 inch] [3/4 inch] [1/2 inch] [3/16 inch]** wide.
11. Mounting Frame: **[Filter] <Insert frame size and style>**.
12. Mounting: **[Concealed bracket] [Spring clip]**.
13. Damper Type: Adjustable opposed-blade assembly.

14. Accessories: **[Plaster frame] [Directional vanes] [Alignment pins] [Core clips] [Blank-off strips]**.

B. Linear Slot Diffuser <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Anemostat Products; a Mestek company.
   b. Carnes.
   c. Hart & Cooley Inc.
   d. Krueger.
   e. Metalaire, Inc.
   f. Price Industries.
   g. Titus.
   h. Tuttle & Bailey.
   i. <**Insert manufacturer's name**>.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material - Shell: **[Steel] [Aluminum]**, **[insulated] [noninsulated]**.
4. Material - Pattern Controller and Tees: Aluminum.
5. Finish - Face and Shell: **[Baked enamel, black]** <**Insert finish**>.
6. Finish - Pattern Controller: **[Baked enamel, black]** <**Insert finish**>.
7. Finish - Tees: **[Baked enamel, white] [Baked enamel, color selected by Architect]** <**Insert finish**>.
8. Slot Width: **[1/2 inch] [3/4 inch] [1 inch] [1-1/2 inches]**.
9. Number of Slots: **[One] [Two] [Three] [Four]** <**Insert number**>.
10. Length: **[24 inches] [30 inches] [36 inches] [48 inches] [60 inches]** <**Insert Length**>.
11. Accessories: **[Plaster frame] [T-bar slot] [Center notch] [T-bar on inlet side] [T-bar on both sides] [T-bar clip on one side] [T-bar clips on both sides] [Blank-off strips]**.

C. Ceiling-Integral Continuous Diffuser <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Anemostat Products; a Mestek company.
   b. Carnes.
   c. Hart & Cooley Inc.
   d. Krueger.
   e. Metalaire, Inc.
   f. Price Industries.
   g. Titus.
   h. Tuttle & Bailey.
   i. <**Insert manufacturer's name**>.

2. Slot Width: **[1 inch] [1-1/2 inches] [2 inches] [2-1/2 inches] [3 inches]**.
3. Section Length: **[12 feet]** <**Insert dimension**>.
4. Straight and curved sections as required to accommodate layout.
5. Mitered tees and corners.
6. Pattern Controllers: **[24 inches]** <**Insert dimension**> o.c.
7. Material: Aluminum, extruded, heavy wall.
8. Finishes:

   a. Exterior: Standard white.

b. Interior: Standard black.

9. Throw: [**Standard**] [**High**].
10. Mounting: [**Ceiling**] [**Sidewall**].
11. Plenum: Internally Insulated.
12. Other Features:

a. Painted interior.
b. Blank-offs.

D. Light Troffer Diffuser <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anemostat Products; a Mestek company.
b. Carnes.
c. Hart & Cooley Inc.
d. Krueger.
e. Metalaire, Inc.
f. Price Industries.
g. Titus.
h. Tuttle & Bailey.
i. <**Insert manufacturer's name**>.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Steel[**with external insulation**].
4. Finish: [**None**] [**Black enamel on visible surfaces**] <**Insert finish**>.
5. Slot Width: [**1/2 inch**] [**3/4 inch**] [**1 inch**] [**1-1/2 inches**].
6. Number of Sides: [**One**] [**Two**]; air passages isolated from lamp compartment.
7. Length: [**24 inches**] [**36 inches**] [**48 inches**].
8. Pattern: [**Fixed**] [**Adjustable**].
9. Inlet: [**Top**] [**Side**].
10. Inlet Size: [**5 inches**] [**6 inches**] [**8 inches**].
11. Suitable for operation at 15 percent more and 50 percent less than noted capacities.

2.4 REGISTERS AND GRILLES

A. Adjustable Bar Register <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anemostat Products; a Mestek company.
b. Carnes.
c. Hart & Cooley Inc.
d. Krueger.
e. Metalaire, Inc.
f. Price Industries.
g. Titus.
h. Tuttle & Bailey.
i. <**Insert manufacturer's name**>.

2. Material: [**Steel**] [**Aluminum**] [**Stainless steel**].

3. Finish: **[Baked enamel, white]** **[Baked enamel, color selected by Architect]** <**Insert finish**>.
4. Face Blade Arrangement: **[Horizontal]** **[Vertical]** spaced **[3 inches]** **[1-1/2 inches]** **[3/4 inch]** **[1/2 inch]** apart.
5. Core Construction: **[Integral]** **[Removable]**.
6. Rear-Blade Arrangement: **[Horizontal]** **[Vertical]** spaced **[3/4 inch]** **[1/2 inch]** apart.
7. Frame: **[1-1/4 inches]** **[1 inch]** wide.
8. Mounting Frame: **[Filter]** <**Insert frame size and style**>.
9. Mounting: **[Countersunk screw]** **[Concealed]** **[Lay in]**.
10. Damper Type: **[Adjustable opposed blade]** **[NRTL listed, opposed blade, spring closing, and with fusible link for 160 deg F]**.
11. Accessories:

    a. **[Front]** **[Rear]**-blade gang operator.
    b. Filter.

B. Adjustable Bar Grille <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Anemostat Products; a Mestek company.
    b. Carnes.
    c. Hart & Cooley Inc.
    d. Krueger.
    e. Metalaire, Inc.
    f. Price Industries.
    g. Titus.
    h. Tuttle & Bailey.
    i. <**Insert manufacturer's name**>.

2. Material: **[Steel]** **[Aluminum]** **[Stainless steel]**.
3. Finish: **[Baked enamel, white]** **[Baked enamel, color selected by Architect]** <**Insert finish**>.
4. Face Blade Arrangement: **[Horizontal]** **[Vertical]** spaced **[3 inches]** **[1-1/2 inches]** **[3/4 inch]** **[1/2 inch]** apart.
5. Core Construction: **[Integral]** **[Removable]**.
6. Rear-Blade Arrangement: **[Horizontal]** **[Vertical]** spaced **[3/4 inch]** **[1/2 inch]** apart.
7. Frame: **[1-1/4 inches]** **[1 inch]** wide.
8. Mounting Frame: **[Filter]** <**Insert frame size and style**>.
9. Mounting: **[Countersunk screw]** **[Concealed]** **[Lay in]**.

C. Security Register <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Anemostat Products; a Mestek company.
    b. Carnes.
    c. Hart & Cooley Inc.
    d. Krueger.
    e. Metalaire, Inc.
    f. Price Industries.
    g. Titus.
    h. Tuttle & Bailey.
    i. <**Insert manufacturer's name**>.

2. Security Level: [**Maximum**] [**Medium**] [**Minimum**] [**and suicide deterrent**].
3. Application: [**Ducted return**] [**Air transfer**] [**Barrier**].
4. Material: [**Steel**] [**Aluminum**].
5. Material Thickness: [**0.19 inch**] <**Insert dimension**>.
6. Finish: [**Baked enamel, white**] [**Baked enamel, color selected by Architect**] <**Insert finish**>.
7. Face Arrangement:

    a. Shape: [**Square**] [**Rectangular**] [**Round**].
    b. Design: [**Fixed bar**] [**Perforated**] [**Lattice**].
    c. Frame: [**Yes**] [**No**].
    d. Deflection: [**Zero**] [**38**] degrees.
    e. Core: [**None**] [**Louvered**].
    f. 3/16-inch- thick, front lattice plate with 2-by-2-inch- square holes and 1-inch frets, 0.135-inch wire mesh, and 1/4-inch- thick backer plate.
    g. 3/16-inch- thick, perforated faceplate with 5/16-inch- diameter holes spaced 7/16 inch o.c., staggered at 60 degrees.
    h. 1-1/2-inch bars and mandrel tubes and rods with [**zero**] [**15**]-degree deflection in 1-1/4-by-1-1/4-by-3/16-inch angle border.
    i. 1-3/8-inch bars and double mandrel tubes with [**zero**] [**15**]-degree deflection in 1-3/4-inch angle border.

8. Damper Operation: [**None**] [**Face operated**] [**Rear operated**].
9. Damper Type: [**Adjustable opposed blade**] [**NRTL listed, opposed blade, spring closing, and with fusible link for 160 deg F**].
10. Wall Sleeve: [**3/16 inch welded to face**] [**1/8 inch welded to face**] [**Mechanically fastened to border**].
11. Mounting: [**1-by-1-by-3/16-inch retaining angle frame**] [**1-1/4-by-1-1/4-by-3/16-inch retaining angle frame**] [**1-1/4-by-1-1/4-by-3/16-inch cast-in-place frame and tamperproof machine screws**].

D. Security Grille <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Anemostat Products; a Mestek company.
    b. Carnes.
    c. Hart & Cooley Inc.
    d. Krueger.
    e. Metalaire, Inc.
    f. Price Industries.
    g. Titus.
    h. Tuttle & Bailey.
    i. <**Insert manufacturer's name**>.

2. Security Level: [**Maximum**] [**Medium**] [**Minimum**] [**and suicide deterrent**].
3. Application: [**Ducted return**] [**Air transfer**] [**Barrier**].
4. Material: [**Steel**] [**Aluminum**].
5. Material Thickness: [**0.19 inch**] <**Insert dimension**>.
6. Finish: [**Baked enamel, white**] [**Baked enamel, color selected by Architect**] <**Insert finish**>.
7. Face Arrangement:

    a. Shape: [**Square**] [**Rectangular**] [**Round**].
    b. Design: [**Fixed bar**] [**Perforated**] [**Lattice**].
    c. Frame: [**Yes**] [**No**].
    d. Deflection: [**Zero**] [**38**] degrees.

e. Core: **[None] [Louvered]**.
f. 3/16-inch- thick, front lattice plate with 2-by-2-inch- square holes and 1-inch frets, 0.135-inch wire mesh, and 1/4-inch- thick backer plate.
g. 3/16-inch- thick perforated faceplate with 5/16-inch- diameter holes spaced 7/16 inch o.c., staggered at 60 degrees.
h. 1-1/2-inch bars and mandrel tubes and rods with [**zero**] [**15**]-degree deflection in 1-1/4-by-1-1/4-by-3/16-inch angle border.
i. 1-3/8-inch bars and double mandrel tubes with [**zero**] [**15**]-degree deflection in 1-3/4-inch angle border.

8. Wall Sleeve: [**3/16 inch welded to face**] [**1/8 inch welded to face**] [**Mechanically fastened to border**].
9. Mounting: [**1-by-1-by-3/16-inch retaining angle frame**] [**1-1/4-by-1-1/4-by-3/16-inch retaining angle frame**] [**1-1/4-by-1-1/4-by-3/16-inch cast-in-place frame and tamperproof machine screws**].

E. Fixed Face Register <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anemostat Products; a Mestek company.
b. Carnes.
c. Hart & Cooley Inc.
d. Krueger.
e. Metalaire, Inc.
f. Price Industries.
g. Titus.
h. Tuttle & Bailey.
i. <**Insert manufacturer's name**>.

2. Material: [**Steel**] [**Aluminum**].
3. Finish: [**Baked enamel, white**] [**Baked enamel, color selected by Architect**] <**Insert finish**>.
4. Face Arrangement: [**1/2-by-1/2-by-1/2-inch grid**] [**Perforated**] core.
5. Core Construction: [**Integral**] [**Removable**].
6. Frame: [**1-1/4 inches**] [**1 inch**] wide.
7. Mounting Frame: [**Filter**] <**Insert frame size and style**>.
8. Mounting: [**Countersunk screw**] [**Concealed**] [**Lay in**].
9. Damper Type: [**Adjustable opposed blade**] [**NRTL listed, opposed blade, spring closing, and with fusible link for 160 deg F**].
10. Accessory: Filter.

F. Fixed Face Grille <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anemostat Products; a Mestek company.
b. Carnes.
c. Hart & Cooley Inc.
d. Krueger.
e. Titus.
f. Tuttle & Bailey.
g. <**Insert manufacturer's name**>.

2. Material: **[Steel] [Aluminum]**.
3. Finish: **[Baked enamel, white]** **[Baked enamel, color selected by Architect]** **<Insert finish>**.
4. Face Arrangement: **[1/2-by-1/2-by-1/2-inch grid]** **[Perforated]** core.
5. Core Construction: **[Integral] [Removable]**.
6. Frame: **[1-1/4 inches]** **[1 inch]** wide.
7. Mounting Frame: **[Filter]** **<Insert frame size and style>**.
8. Mounting: **[Countersunk screw]** **[Concealed]** **[Lay in]**.
9. Accessory: Filter.

G. Linear Bar Grille **<Insert drawing designation>**:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Anemostat Products; a Mestek company.
   b. Carnes.
   c. Hart & Cooley Inc.
   d. Krueger.
   e. Metalaire, Inc.
   f. Price Industries.
   g. Titus.
   h. Tuttle & Bailey.
   i. **<Insert manufacturer's name>**.

2. Material: **[Steel] [Aluminum]**.
3. Finish: **[Baked enamel, white]** **[Baked enamel, color selected by Architect]** **<Insert finish>**.
4. Face Arrangement: **[1/2-by-1/2-by-1/2-inch grid]** **[Perforated]** core.
5. Distribution plenum.

   a. Internal insulation.
   b. Inlet damper.

6. Frame: **[1-1/4 inches]** **[1 inch]** wide.
7. Mounting Frame: **[Filter]** **<Insert frame size and style>**.
8. Mounting: **[Countersunk screw]** **[Concealed]** **[Lay in]**.
9. Damper Type: **[Adjustable opposed blade]** **[NRTL listed, opposed blade, spring closing, and with fusible link for 160 deg F]**.

2.5 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

D. Carefully install all ceiling mounted air distribution devices back pan insulation and vapor barrier. Where pre-molded insulation and vapor barrier is not furnished as an accessory to the air distribution device by the manufacturer the Contractor is responsible for field installation of insulation and vapor barrier for ceiling air distribution device back pans.

E. All visible interior surfaces of all grilles and air device accessories and components visible through the face of the outlet shall be factory painted flat black.

F. Install a manual volume damper in the branch duct to the air distribution device or at the conical bell-mouth spin-in fitting for connection of round flexible duct to the rectangular duct for balancing purposes.

G. Provide all required blank off for directional pattern.

H. Diffusers Utilizing a Plenum Box: Provide plenum box fabricated of 24 USBG galvanized steel, with internal surfaces lined with minimum 1/2 inch thick duct liner as specified under Division 23 Section "Metal Ducts."

I. Install return and exhaust registers with blades oriented to prevent sight though outlets.

J. Transfer Grilles: Provide 2 grilles, one on each side of wall with connecting sheet metal collar.

K. Transfer Ducts: Provide 2 grilles, one at each end of duct.

L. Air Handling Type Lighting Fixtures:

1. Furnish, install, connect, and balance all air boots for lighting fixtures, as required.
2. Remove air slot covering strip before mounting air boots to lighting fixtures.
3. Install flexible duct connections from branch duct to fixture air boot.
4. Balance and adjust slot air pattern with directional control blades.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 3713

SECTION 23 5216

BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

1.2 SUMMARY

A. This Section includes packaged, factory-fabricated and -assembled, gas-fired, finned copper **water-tube** boilers, trim, and accessories for generating **hot water**.

1.3 SUBMITTALS

A. Product Data: Include performance data, operating characteristics, dimensions, size and location of connections, furnished specialties, and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.

1. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.

    a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
    b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.

2. Wiring Diagrams: Power, signal, and control wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that boiler, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
    b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Source quality-control test reports.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For boilers to include in emergency, operation, and maintenance manuals.

G. Warranty: Special warranty specified in this Section.

H. Other Informational Submittals:

1. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

D. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."

E. UL Compliance: Test boilers for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment." Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

F. Emissions: Meet or exceed Air Quality Management District (AQMD) requirements.

1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.6 WARRANTY

A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents. Installing contractor shall provide one year of warranty parts and labor.

B. Special Warranty: Submit a written warranty, executed by the contractor for the heat exchanger.

1. Warranty Period: Manufacturer's standard, but not less than 10 years from date of Substantial Completion on the heat exchanger. Warranty shall be non-prorated and not limited to thermal shock. Additional 21 year thermal shock warranty on heat exchanger

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. RBI (a Mestek company) – Futera II Series
2. Fulton Boiler Works, Inc. – Pulse
3. Raypack.
4. Lochinvar Corporation. – Power Fin Series

B. Available Manufacturers: Manufacturer shall be a company specializing in manufacturing the products specified in this section with minimum five (5) years experience. Subject to compliance with requirements, manufacturers offering boilers that may be incorporated into the Work include, but are not limited to, the following:

C. Design: Boilers shall be CSA design certified and shall not release any condensate during operation. Boilers shall be designed for operation with natural or propane and have a CSA certified input rating as noted on the drawings, and a thermal efficiency rating of 85%.

D. Service Access: The boilers shall be provided with access covers for easily accessing all serviceable components. The boilers shall not be manufactured with large enclosures, which are difficult to remove and reinstall. All accesses must seal completely as not to disrupt the sealed combustion process. All gas train components and blower motor must be accessible and able to adjust without the removal of covers or cabinet components.

E. Indicating Lights: Each boiler shall include a diagnostic control panel indicating power on, operator, high limit, low water, low air, trial for ignition, main burner, flame failure, and inlet/outlet temperatures incorporated into the boiler. Access to the controls shall be through a control access door leaving diagnostic panel intact and not disrupted.

2.2 MANUFACTURED UNITS

A. Combustion Chamber: The combustion chamber shall be constructed of stainless steel. An access door shall be provided for ease of service and inspection of the heat exchanger. Chamber shall be air-cooled and not require additional insulation.

B. Heat Exchanger: The heat exchanger shall be inspected and bear the A.S.M.E. Section IV seal of approval. The heat exchanger shall be a four-pass heat exchanger with a maximum working pressure of 160 psi. The heat exchanger's vertical design shall provide equal amounts of heat transfer throughout the entire heating surface. Each heat exchanger shall have copper tubes, with an integral copper finned tube of 7/8" I.D., .064" minimum wall thickness, 7 fins per inch, with a fin height of 3/8". Each end of the water tubes shall be strength rolled into the header. The heat exchanger shall be gasket less. Each individual tube can be retubed without the disturbance of the surrounding tubes. A pressure relief valve of 50 lb/sq in shall be equipped with the boiler and factory mounted. The headers shall be of cast iron construction.

C. Jackets: 18 gauge galvanized steel with factory applied baked enamel. Brushed stainless steel (optional).

C. Gas Burner: The burner shall be constructed of low alloy steel and nickel-plated. The burner flame shall burn vertically and be of the power type with a forced draft fan. Burner shall fire to produce a full 360° flame pattern to provide equal distribution of heat throughout the entire heat exchanger. The burner shall be easily removed for maintenance without disruption of any other major component of the boiler. A window view port shall be provided for visual inspection of the flame during firing.

D. Rated Capacity: The boiler shall be capable of operating at rated capacity with pressures as low as 5" W.C. at the inlet to the burner pressure regulator.

G. The burner shall be capable of 85% efficiency without exceeding a NOx reading above 9 ppm.

H. The burner and gas train shall be provided with the following trim and features:

1. Burner Firing: 2 Stage
2. Burner Ignition: Intermittent spark
3. Safety Controls: Energize ignition, limit time for establishing flame, prevent opening of gas valve until pilot flame is proven, stop gas flow on ignition failure, and allow gas valve to open.
4. Flue Gas Collector: Enclosed combustion chamber with integral combustion air blower and single venting connection.
5. Gas Train: Manual gas valves (2), redundant main gas valves (solenoid/diaphragm, motorized), firing valve, 'B' valve, pilot gas pressure regulator, and automatic pilot gas valve. All components to be factory mounted.
6. Safety Devices: Optional high/low gas pressure switches, air flow switch, and blocked flue detection switch. All safeties to be factory mounted.

A. Safety Relief Valve: ASME rated, factory set to protect boiler and piping as per schedule/drawings.

B. Gauge: Combination water pressure and temperature shipped loose for field installation. Inlet/outlet temperature gauges to be an integral part of the front boiler control panel to allow for consistent easy monitoring of temperatures factory mounted and wired.

C. Low Water Cutoff and Outlet Flow Switch: Prevent burner operation when water falls below a safe level or when water flow is low. Flow switch shall be factory mounted and wired. Provision for installation of a low water cut off shall be provided.

D. Operating Controls: Boiler shall be provided with a Honeywell RM7800 series digital flame safe guard. The flame safeguard shall be capable of prepurge cycles.

E. Operating Temperature Control: Shall be a manual probe type controller adjustable from 120°F to 240°F, 49°C to 116°C. Control shall be factory mounted and sense the inlet temperature of the boiler through a dry well.

F. High Limit: Temperature control with manual reset limits boiler water temperature in series with the operating control. High limit shall be factory mounted and sense the outlet temperature of the boiler through a dry well.

G. PROVIDE THE FOLLOWING STANDARD TRIM:

1. Cast iron headers
2. Low air pressure switch
3. Blocked flue detection switch
4. Flow switch (factory mounted and wired)
5. Operating aquastat
6. Temperature/pressure gauge
7. Manual reset high limit
8. Air inlet filter
9. Inlet/outlet thermometers (factory mounted and wired)
10. FM and CSD-1 gas train

H. PROVIDE THE FOLLOWING JOB SPECIFIC TRIM AND FEATURES

1. Bronze fitted circulator provided by the manufacturer (shipped loose)
2. CSD-1 controls
3. Probe type low water cut off, manual reset (shipped loose)
4. Motorized gas valves
5. Diagnostic keyboard display for RM7800 series control
6. Barometric damper (if required)
7. Bronze headers
8. Outdoor installation (if required)

2.3 CONTROLS

A. Refer to Division 23 Section "Instrumentation and Control for HVAC."

B. Boiler operating controls and circuits, grounded, to operate on 120 V, 60 Hz, shall include the following devices and features:

1. Control transformer.
2. Set-Point Adjust: Set points shall be adjustable.

3. Operating Pressure Control: Factory wired and mounted to cycle burner.
4. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.

C. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.

1. High Cutoff:. **Automatic** reset stops burner if operating conditions rise above maximum boiler design **temperature**.
2. Low-Water Cutoff Switch: **Float and electronic** probe shall prevent burner operation on low water. Cutoff switch shall be **automatic**-reset type.
3. Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.
4. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

2.4 MOTORS

A. Boiler Blower Motor: Open drip-proof motors where satisfactorily housed or remotely located during operation. There shall be no requirement to remove gas train components to remove the blower motor. Blower motor *shall not* exceed 3/4 HP and *not* require more than 12 amps

2.5 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 26 Sections.

B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. House in NEMA 250, Type [**1**] enclosure.
2. Wiring shall be numbered and color-coded to match wiring diagram.
3. Install factory wiring outside of an enclosure in a [**metal**]raceway.
4. Field power interface shall be to **circuit breaker**.
5. Provide branch power circuit to each motor and to controls **circuit breaker**.
6. Provide each motor with overcurrent protection.

2.6 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

B. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

C. Allow Owner access to source quality-control testing of boilers. Notify Architect 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

A. Install boilers level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results for HVAC," and concrete materials and installation requirements are specified in Division 03.

B. Vibration Isolation: Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

C. Install gas-fired boilers according to NFPA 54.

D. Assemble and install boiler trim.

E. Install electrical devices furnished with boiler but not specified to be factory mounted.

F. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to boiler to allow service and maintenance.

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Division 23 Section "Common Work Results for HVAC,"

E. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.

F. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

G. Connect steam and condensate piping to supply-, return-, and blowdown-boiler tappings with shutoff valve and union or flange at each connection.

H. Install piping from safety relief valves to nearest floor drain.

I. Install piping from safety valves to drip-pan elbow and to nearest floor drain.

J. Boiler Venting:

1. Install flue venting kit and combustion-air intake.
2. Connect full size to boiler connections. **Comply with requirements in Division 23 Section "Breechings, Chimneys, and Stacks."**

K. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

L. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

   a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and [**water temperature**] [**steam pressure**].
   b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Remove and replace malfunctioning units and retest as specified above.

D. Occupancy Adjustments: When requested within **12 months of date of Substantial Completion**, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **two** visits to Project during other than normal occupancy hours for this purpose.

E. Performance Tests:

1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
3. Perform field performance tests to determine capacity and efficiency of boilers.

   a. Test for full capacity.

b. Test for boiler efficiency at **low fire 20, 40, 60, 80, 100**

4. Repeat tests until results comply with requirements indicated.
5. Provide analysis equipment required to determine performance.
6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
7. Notify Architect in advance of test dates.
8. Document test results in a report and submit to Architect.

3.5 DEMONSTRATION

A. **Engage a factory-authorized service representative to train** , **Train** Owner's maintenance personnel to adjust, operate, and maintain boilers. **Video training sessions.** Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 23 5216

SECTION 23 6416

CENTRIFUGAL WATER CHILLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

B. Related Work in the Following Sections apply to this Section:
1. Common Motor Requirements for HVAC Equipment
2. Vibration and Seismic Controls for HVAC Piping and Equipment
3. Hydronic Piping
4. Refrigerant Piping
5. Identification for HVAC Piping and Equipment
6. HVAC Insulation
7. Instrumentation and Control for HVAC
8. Variable Frequency Motor Controllers
9. Commissioning of HVAC.

1.2 SUMMARY

A. Section Includes:

1. Packaged, water-cooled, electric-motor-driven centrifugal chillers.
2. Packaged, portable refrigerant recovery units.
3. Heat-exchanger, brush-cleaning system.
4. Motor controllers.
5. Charge of refrigerant and oil.
6. Accessories.

B. Related Section:

1. Division 28 Section "Refrigerant Detection and Alarm" for refrigerant monitors, alarms, supplemental breathing apparatus, and ventilation equipment interlocks.

1.3 DEFINITIONS

A. BAS: Building automation system.

B. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.

C. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.

D. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and referenced to ARI standard rating conditions.

E. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.

F. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and intended for operating conditions other than the ARI standard rating conditions.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Centrifugal chillers shall withstand the effects of earthquake motions determined according to [**ASCE/SEI 7**] <**Insert requirement**>.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]." REMOVE, note if you decide to keep this the whole isolation rail will need to be redesigned.

B. Condenser-Fluid Temperature Performance:

1. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of [**60 deg F**] [**55 deg F**] [**40 deg F**] <**Insert temperature**> and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
2. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of [**65 deg F**] [**60 deg F**] [**55 deg F**] <**Insert temperature**>.
3. Make factory modifications to standard chiller design if necessary to comply with performance indicated.

C. Site Altitude: Chiller shall be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.

D. Performance Tolerance: Comply with the following in lieu of ARI 550/590:

1. Allowable Capacity Tolerance: [**Zero**] <**Insert number**> percent.
2. Allowable IPLV/NPLV Performance Tolerance: [**Zero**] <**Insert number**> percent.

1.5 SUBMITTALS

A. Product Data: For each type of product indicated. Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.

1. Performance at ARI standard conditions and at conditions indicated.
2. Performance at ARI standard unloading conditions.
3. Minimum evaporator flow rate.
4. Refrigerant capacity of chiller.
5. Oil capacity of chiller.
6. Fluid capacity of evaporator, condenser[**, and heat-reclaim condenser**].
7. Characteristics of safety relief valves.
8. Minimum entering condenser-fluid temperature.

9. Performance at varying capacities with constant design condenser-fluid temperature. Repeat performance at varying capacities for different condenser-fluid temperatures from design to minimum in **[5 deg F]** <**Insert temperature**> increments.

B. LEED Submittal:

1. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, load distribution, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

D. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural supports.
2. Piping roughing-in requirements.
3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.

E. Certificates: For certification required in "Quality Assurance" Article.

F. Seismic Qualification Certificates: For chillers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

G. Source quality-control reports.

H. Startup service reports.

I. Operation and Maintenance Data: For each chiller to include in emergency, operation, and maintenance manuals. Include start-up instructions, maintenance data, parts lists, controls, accessories, and troubleshooting guide.

J. Warranty: Sample of special warranty.

1.6 CODES AND STANDARDS

A. American Society of Mechanical Engineers (ASME):

1. Boiler and Pressure Vessel Code, Section VIII, Division 1, “Rules for Construction of Pressure Vessels.”
2. Boiler and Pressure Vessel Code, Section IX, “Welding and Brazing Qualifications.”
3. B31.1, “Power Piping.”

4. B31.5, "Refrigeration Piping and Heat Transfer Components."

B. Air-Conditioning and Refrigeration Institute (ARI):

1. Standard 550/590, "Performance Rating of Water Chilling Packages Using the Vapor Compression Cycle."
2. Standard 575, "Method of Measuring Machinery Sound Within an Equipment Space."

C. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

1. Standard 15, "Safety Standard for Refrigeration Systems."
2. Standard 147, "Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment and Systems."
3. Standard 90.1, "Energy Standard for Buildings Except Low-Rise Residential Buildings."

D. National Fire Protection Association (NFPA)

1. Standard 70, National Electrical Code (NEC)

E. American Gear Manufacturers Association (AGMA)

F. American National Standards Institute (ANSI)

G. American Society for Testing and Materials (ASTM)

H. Institute of Electrical and Electronics Engineers (IEEE)

I. National Electrical Manufacturers Association (NEMA)

J. Underwriters Laboratories (UL)

K. Occupational Safety & Health Act (OSHA)

1.7 QUALITY ASSURANCE

A. ARI Certification: Certify chiller according to ARI 550 certification program.

B. ARI Rating: Rate chiller performance according to requirements in ARI 550/590.

C. ASHRAE Compliance:

1. ASHRAE 15 for safety code for mechanical refrigeration.
2. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.

D. ASHRAE/IESNA Compliance: Applicable requirements in the latest edition of ASHRAE/IESNA 90.1.

E. ASME Compliance: Fabricate and label chillers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1[**, as applicable to chiller design**]. For chillers charged with R-134a refrigerant, include an ASME U-stamp and nameplate certifying compliance.

F. Comply with NFPA 70.

G. Comply with requirements of UL and UL Canada, and include label by a qualified testing agency showing compliance.

H. Green Seal Compliance: Signed by [**manufacturer**] [**Green Seal**] certifying compliance with GS-31.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Ship chillers from the factory fully charged with refrigerant.

B. Charge each chiller with nitrogen if refrigerant is shipped in containers separate from chiller.

C. Ship each oil-lubricated chiller with a full charge of oil.

1. Ship oil [**factory installed in chiller**] [**in containers separate from chiller**].

D. Package chiller for export shipping in totally enclosed [**bagging**] [**crate**] [**crate with bagging**].

E. Ship chillers from the factory fully assembled and tested, or as specified herein.

F. Ship each chiller with a firmly attached metal nameplate indicating name of manufacturer, model number, equipment type and refrigerant used.

G. Reject any damaged chiller equipment upon arrival at site. Replace damaged equipment or material at no cost to Owner.

H. Store chiller equipment to prevent damage, and protect from weather, dirt, fumes, water and construction debris. Provide a clean, dry space for storage if one is not available at the site.

I. Handle chiller equipment according to the manufacturer's rigging and installation instructions for unloading and transporting into the final location.

1.9 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.

1. Extended warranties include, but are not limited to, the following:

   a. Complete chiller including refrigerant and oil charge.
   b. Complete compressor and drive assembly including refrigerant and oil charge.
   c. Refrigerant charge.
   d. Parts **and labor**.
   e. Loss of refrigerant charge for any reason. Verify available warranties and warranty periods with manufacturers listed in Part 2 articles. Confirm with Owner the desired duration.

2. Warranty Period: **Five** years from date of Substantial Completion.
3. Chiller manufacturer shall provide a whole unit parts, labor and refrigerant warranty for a period of 5, years from start-up. The chiller manufacturer shall provide an original factory warranty

certificate for each chiller listing as a minimum chiller model, serial number, and warranty information as specified. Payment shall not be released until the owner receives original certificates. Warrantee coverage is per the factory, not local sales offices.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Are all subject to compliance with requirements of the specification & plans. Retain option in paragraph below if manufacturer's name and model number are indicated in schedules or plans on Drawings; delete option and insert manufacturer's name and model number if not included on Drawings.

B. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:

1. Trane; a division of American Standard.
2. YORK International Corporation, a Johnson Controls Company
3. Carrier Corporation; a United Technologies company

2.2 MANUFACTURED UNIT

A. Description: Factory-assembled and -tested chiller complete with compressor, compressor motor, compressor motor controller, **[lubrication system**]evaporator, condenser, **[heat-reclaim condenser as indicated,**]controls, interconnecting unit piping and wiring, and indicated accessories.

1. Disassemble chiller into major assemblies as required by the installation after factory testing and before packaging for shipment.
2. For chillers with dual compressors, provide each compressor with a dedicated motor and motor controller, and provide for continued operation when either compressor-drive assembly fails or is being serviced.

B. Seismic Fabrication Requirements:
1. Fabricate chiller mounting base with reinforcement strong enough to resist chiller movement during a seismic event when chiller is anchored to field support structure.

C. The centrifugal chillers on this project will be applied using a variable water-flow primary pumping system. The chilled water evaporators must be selected by the chiller manufacturer to allow trouble free chiller operation with a reduced chilled water flow rate of 58 % of the design chilled water flow rate. The manufacturer shall submit certified selections showing this capability.
1. The chilled water controller of each chiller shall include variable water-flow compensation capability to allow the chiller to respond quickly to accelerating or decelerating water. The variable water-flow control algorithm shall automatically adjust the control gain so that large changes in water-flow rate can be tolerated. The variable water-flow compensation capability shall allow control of the leaving chilled water temperature to within +/- 0.5F at a water flow rate change of 25% per minute and to within +/- 2F at a water flow rate change of 50% per minute. This option shall include factory mounted transducers to read the differential evaporator water pressure (psid) and condenser water pressure (psid).

D. The chiller unit controller must display the following data on the chiller control panel display:
1. Evaporator differential pressure (psid)

2. Condenser differential pressure (psid)
3. Evaporator water flow rate (GPM)
4. Condenser water flow rate (GPM)
5. Evaporator capacity (Tons)

2.3 COMPRESSOR-DRIVE ASSEMBLY

A. Description: Single-stage or multistage, variable-displacement, centrifugal-type compressor driven by an electric motor.

1. Where indicated, provide oil-free compressor technology using a permanent magnet synchronous motor, magnetic bearings, integral variable frequency controller, and digital electronic controls.

B. Compressor:

1. Casing: Cast iron, precision ground.
2. Impeller: High-strength cast aluminum or cast-aluminum alloy on carbon- or alloy-steel shaft.

C. Drive: **Direct-drive, hermetic** or **Gear-drive, hermetic** or **Gear-drive, open** design using an electric motor as the driver.

1. Gear Drives: For chillers with gear drives, provide single- or double-helical gear design continuously coated with oil while chiller is operating. Gears shall comply with American Gear Manufacturer Association standards. Temperature rise of gears shall not exceed 70 deg F above ambient at full load.
2. Drive Coupling: For chillers with open drives, provide flexible disc with all-metal construction and no wearing parts to ensure long life without the need for lubrication.
3. Seals: Seal drive assembly to prevent refrigerant leakage.

D. Compressor Motor:

1. Continuous-duty, squirrel-cage, induction-type, two-pole motor with energy efficiency required to suit chiller energy efficiency indicated.
2. Factory mounted, aligned, and balanced as part of compressor assembly before shipping.
3. Motor shall be of sufficient capacity to drive compressor throughout entire operating range without overload and with sufficient capacity to start and accelerate compressor without damage.
4. For chillers with open drives, provide motor with [**open-dripproof**] [**weather-protected, Type I**] [**weather-protected, Type II**] [**totally enclosed**] enclosure.
5. Provide motor with thermistor or RTD in [**single motor winding**] [**each of three-phase motor windings**] to monitor temperature and report information to chiller control panel.
6. Provide motor with thermistor or RTD to monitor bearing temperature and report information to chiller control panel.
7. Provide open-drive motor with internal electric heater, internally powered from chiller power supply.
8. Provide lifting lugs or eyebolts attached to motor.
9. Heat rejected by the chiller to be stated on the chiller data sheets. Open motor chillers shall provide additional capacity and the associated air handling equipment to offset their heat rejection. See the attached calculation for open motor heat based on chiller capacity.

E. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range. Operating speed shall be below the first critical speed.

1. Overspeed Test: 25 percent above design operating speed.

F. Service: Easily accessible for inspection and service.

1. Compressor's internal components shall be accessible without having to remove compressor-drive assembly from chiller.
2. Provide lifting lugs or eyebolts attached to casing.

G. Economizers: For multistage chillers, provide interstage economizers.

H. Capacity Control: Modulating, variable-inlet, guide-vane assembly combined with hot-gas bypass, if necessary, to achieve performance indicated.

1. Maintain stable operation that is free of surge, cavitation, and vibration throughout range of operation. Configure to achieve most energy-efficient operation possible.
2. Operating Range: From 100 to **[15]** **[10]** **[5]** **[zero]** <**Insert number**> percent of design capacity.
3. Condenser-Fluid Unloading Requirements over Operating Range: **[Constant-design entering condenser-fluid temperature]** **[Drop-in entering condenser-fluid temperature of 2.5 deg F for each 10 percent in capacity reduction]** <**Insert conditions**>.
4. Chillers with variable frequency controllers shall modulate compressor speed with variable-inlet, guide-vane control to achieve optimum energy efficiency.
5. Provide external electric guide-vane operator and linkage.
6. Seal points where guide-vane operating mechanism passes through the compressor casing to prevent refrigerant leakage.

I. Oil Lubrication System: Consisting of oil reservoir pump, filtration, **[heater,]**cooler, factory-wired power connection, motor controllers and controls.

1. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, coastdown, and standby conditions including power failure.
2. **[Manufacturer's standard method]** **[Thermostatically controlled oil heater properly sized]** to remove refrigerant from oil.
3. **[Oil filter]** **[Dual oil filers, one redundant,]** shall be the easily replaceable cartridge type, minimum 0.5-micron efficiency, with means of positive isolation while servicing.
4. **[Refrigerant]** **[Water]** **[Refrigerant- or water]**-cooled oil cooler.
5. Factory-installed and pressure-tested piping with isolation valves and accessories.
6. Oil compatible with refrigerant and chiller components.
7. Positive visual indication of oil level.
8. Oil flow must be proven for compressor to run.
9. Oil pump shall be submerged in the oil reservoir to assure a positive oil supply.

2.4 REFRIGERATION

A. Refrigerant:

1. Type: **R-134a; ASHRAE 34, Class A1** or **R-123 or R-134a; ASHRAE 34, Class A1 or Class B1**
2. Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.

B. Refrigerant Flow Control: Manufacturer's standard refrigerant flow-control device satisfying performance requirements indicated.

C. Pressure Relief Device:

1. Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. For Chillers Using R-123: **[Rupture disc constructed of frangible carbon] [Spring-loaded, pressure relief valve; single- or multiple-reseating type]**.
3. For Chillers Using R-134a: ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger. Condenser shall have dual valves with one being redundant and configured to allow either valve to be replaced without loss of refrigerant.

D. Refrigerant Transfer: Provide service valves and other factory-installed accessories required to facilitate transfer of refrigerant from chiller to a remote refrigerant storage and recycling system. Comply with requirements in ASHRAE 15 and ASHRAE 147.

E. Refrigerant Isolation for Chillers Using R-134a: Factory install [**positive shutoff, manual**]isolation valves in the compressor discharge line to the condenser and the refrigerant liquid line leaving the condenser to allow for isolation and storage of full refrigerant charge in the chiller condenser shell.[**In addition, provide isolation valve on suction side of compressor from evaporator to allow for isolation and storage of full refrigerant charge in the chiller evaporator shell.**]

F. Purge System:

1. For chillers operating at subatmospheric pressures (using R-123 refrigerant), factory install an automatic purge system for collection and return of refrigerant and lubricating oil and for removal of noncondensables including, but not limited to, water, water vapor, and noncondensable gases.
2. System shall be a thermal purge design, refrigerant or air cooled, equipped with a carbon filter that includes an automatic regeneration cycle.
3. Factory wire to chiller's main power supply and system complete with controls, piping, and refrigerant valves to isolate the purge system from the chiller.
4. Construct components of noncorrodible materials.
5. Controls shall interface with chiller control panel to indicate modes of operation, set points, data reports, diagnostics, and alarms.
6. Efficiency of not more when rated according to ARI 580.
7. Operation independent of chiller per ASHRAE 147.

G. Positive-Pressure System:

1. For chillers operating at subatmospheric pressures (using R-123 refrigerant), factory install an automatic positive-pressure system.
2. During nonoperational periods, positive-pressure system shall automatically maintain a positive pressure for atmosphere in the refrigerant pressure vessel of not less than (adjustable) up to a pressure that remains within the vessel design pressure limits.
3. System shall be factory wired and include controller, electric heat, pressure transmitter, or switch.

2.5 EVAPORATOR

A. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from condenser.

B. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.

C. Designed to prevent liquid refrigerant carryover from entering compressor.

D. Provide evaporator with sight glass or other form of positive visual verification of liquid-refrigerant level.

E. Tubes:

1. Individually replaceable from either end and without damage to tube sheets and other tubes.
2. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
3. Material: **[Copper]** **[Copper-nickel alloy]** **[Stainless steel]** **[Titanium]** **[Copper, copper-nickel alloy, stainless steel, or titanium]** <**Insert material**>.
4. Nominal OD: **[Manufacturer's choice]** **[3/4 inch]** **[1 inch]** **[3/4 or 1 inch]**.
5. Internal Finish: **[Enhanced]** **[Smooth]** **[Enhanced or smooth]**.

F. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.

G. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.

H. Water Box:

1. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
2. **[Standard]** **[Marine]** type for water box with piping connections. Standard type for water box without piping connections.
3. Provide water boxes **[and marine water-box covers**]with lifting lugs or eyebolts.
4. **[Hinged]** **[Davited]** **[Hinged or davited]** water boxes.
5. **[Hinged]** **[Davited]** **[Hinged or davited]** marine water-box covers.
6. Nozzle Pipe Connections: **[Welded, ASME B16.5, flat-face flange]** **[Welded, ASME B16.5, raised-face flange]** **[Grooved for mechanical-joint coupling]** **[Grooved with mechanical-joint coupling and flange adapter]**.
7. Thermistor or RTD temperature sensor factory installed in each nozzle.
8. Fit each water box with **[3/4-inch]** **[1-inch]** **[3/4- or 1-inch]** <**Insert size**> drain connection at low point and vent connection at high point, each with threaded plug.

I. Additional Corrosion Protection:

1. Electrolytic corrosion-inhibitor anode.
2. Coat wetted surfaces with a corrosion-resistant finish.
3. Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

2.6 CONDENSER

A. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from evaporator.

B. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.

C. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.

D. Provide condenser with sight glass or other form of positive visual verification of refrigerant charge and condition.

E. Tubes:

1. Individually replaceable from either end and without damage to tube sheets and other tubes.
2. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.

3. Material: **[Copper]** **[Copper-nickel alloy]** **[Stainless steel]** **[Titanium]** **[Copper, copper-nickel alloy, stainless steel, or titanium]** <**Insert material**>.
4. Nominal OD: **[Manufacturer's choice]** **[3/4 inch]** **[1 inch]** **[3/4 or 1 inch]**.
5. Internal Finish: **[Enhanced]** **[Smooth]** **[Enhanced or smooth]**.

F. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.

G. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.

H. Water Box:

1. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
2. **[Standard]** **[Marine]** type for water box with piping connections. Standard type for water box without piping connections.
3. Provide water boxes **[and marine water-box covers**]with lifting lugs or eyebolts.
4. **[Hinged]** **[Davited]** **[Hinged or davited]** water boxes.
5. **[Hinged]** **[Davited]** **[Hinged or davited]** marine water-box covers.
6. Nozzle Pipe Connections: **[Welded, ASME B16.5, flat-face flange]** **[Welded, ASME B16.5, raised-face flange]** **[Grooved for mechanical-joint coupling]** **[Grooved with mechanical-joint coupling and flange adapter]**.
7. Thermistor or RTD temperature sensor factory installed in each nozzle.
8. Fit each water box with **[3/4-inch]** **[1-inch]** **[3/4- or 1-inch]** <**Insert size**> drain connection at low point and vent connection at high point, each with threaded plug.

I. Additional Corrosion Protection:

1. Electrolytic corrosion-inhibitor anode.
2. Coat wetted surfaces with a corrosion-resistant finish.
3. Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

2.7 HEAT-RECLAIM CONDENSER

A. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from evaporator and condenser.

B. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.

C. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.

D. Tubes:

1. Individually replaceable from either end and without damage to tube sheets and other tubes.
2. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
3. Material: **[Copper]** **[Copper-nickel alloy]** **[Stainless steel]** **[Titanium]** **[Copper, copper-nickel alloy, stainless steel, or titanium]** <**Insert material**>.
4. Nominal OD: **[Manufacturer's choice]** **[3/4 inch]** **[1 inch]** **[3/4 or 1 inch]**.
5. Minimum Wall Thickness: **[Manufacturer's choice]** **[0.025 inch]** **[0.028 inch]** **[0.035 inch]** <**Insert value**>.
6. External Finish: Manufacturer's standard.
7. Internal Finish: **[Enhanced]** **[Smooth]** **[Enhanced or smooth]**.

E. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.

F. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.

G. Water Box:

1. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
2. [**Standard**] [**Marine**] type for water box with piping connections. Standard type for water box without piping connections.
3. Provide water boxes [**and marine water-box covers**]with lifting lugs or eyebolts.
4. [**Hinged**] [**Davited**] [**Hinged or davited**] water boxes.
5. [**Hinged**] [**Davited**] [**Hinged or davited**] marine water-box covers.
6. Nozzle Pipe Connections: [**Welded, ASME B16.5, flat-face flange**] [**Welded, ASME B16.5, raised-face flange**] [**Grooved for mechanical-joint coupling**] [**Grooved with mechanical-joint coupling and flange adapter**].
7. Thermistor or RTD temperature sensor factory installed in each nozzle.
8. Fit each water box with [**3/4-inch**] [**1-inch**] [**3/4- or 1-inch**] <**Insert size**> drain connection at low point and vent connection at high point, each with threaded plug.

H. Additional Corrosion Protection:

1. Electrolytic corrosion-inhibitor anode.
2. Coat wetted surfaces with a corrosion-resistant finish.
3. Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

2.8 INSULATION

A. Closed-cell, flexible elastomeric thermal insulation complying with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

1. Thickness: [**3/4 inch**] [**1-1/2 inches**] <**Insert thickness**>.

B. Adhesive: As recommended by insulation manufacturer.

C. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.

1. Apply adhesive to 100 percent of insulation contact surface.
2. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
3. Seal seams and joints to provide a vapor barrier.
4. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
5. Provide removable insulations covers for water boxes.

2.9 ELECTRICAL

A. Factory installed and wired, and functionally tested at factory before shipment.

B. Single-point, field-power connection to **circuit breaker.** Minimum withstand rating shall be as required by electrical power distribution system, but not less than **65,000 Amps**.

1. Branch power circuit to each motor, electric heater, dedicated electrical load, and controls[**with disconnect switch or circuit breaker**].

    a. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
    b. NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.

2. NEMA ICS 2-rated motor controller for auxiliary motors, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller for each variable-speed motor furnished.
3. Control-circuit transformer with primary and secondary side fuses.

C. Terminal blocks with numbered [**and color-coded**]wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.

D. Factory-installed wiring outside of enclosures shall be in metal raceway except make terminal connections with not more than a 24-inch length of [**liquidtight**] [**flexible metallic**] [**liquidtight or flexible metallic**] conduit.

E. Factory install and wire capacitor bank for the purpose of power factor correction to [**0.95**] <**Insert value**> at all operating conditions.

1. If capacitors are mounted in a dedicated enclosure, use same NEMA enclosure type as motor controller. Provide enclosure with service entrance knockouts and bushings for conduit.
2. Capacitors shall be non-PCB dielectric fluid, metallized electrode design, low loss with low-temperature rise. The kVAr ratings shall be indicated and shall not exceed the maximum limitations set by NFPA 70. Provide individual cells as required.
3. Provide each cell with current-limiting replaceable fuses and carbon-film discharge resistors to reduce residual voltage to less than 50 V within one minute after de-energizing.
4. Provide a ground terminal and a terminal block or individual connectors for phase connection.

2.10 MOTOR CONTROLLER

A. Enclosure: [**Factory installed, unit mounted**] [**Factory furnished, field mounted**], [**NEMA 250**] [**NEMA ICS 6**], [**Type 1**] [**Type 4**] [**Type 4X**] [**Type 12**] <**Insert type**>, with hinged full-front access door[**with lock and key or padlock and key**].

B. Control Circuit: Obtained from [**integral control power transformer**] <**Insert source of control power**> with a control power [**transformer**] [**source**] of enough capacity to operate connected control devices.

C. Overload Relay: Shall be sized according to UL 1995 or shall be an integral component of chiller control microprocessor.

D. Across-the-Line Controller: NEMA ICS 2, Class A, full voltage, nonreversing; include isolation switch and current-limiting fuses.

E. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed transition.

F. Autotransformer Reduced-Voltage Controller: NEMA ICS 2, closed transition; include isolation switch and current-limiting fuses.

G. Solid-State, Reduced-Voltage Controller: NEMA ICS 2.

1. Surge suppressor in solid-state power circuits providing three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
2. Visual indication of motor and control status, including the following conditions:

   a. Controller on.
   b. Overload trip.
   c. Loss of phase.
   d. Starter fault.

H. Accessories: Devices shall be factory installed in controller enclosure unless otherwise indicated.

1. Externally Operated[**, Door-Interlocked**] Disconnect: [**Fused disconnect switch**] [**Nonfused disconnect switch**] [**Circuit breaker**]. Minimum withstand rating shall be as required by electrical power distribution system, but not less than [**42,000**] [**65,000**] <**Insert value**> A.
2. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
3. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
4. Control Relays: Time-delay relays.
5. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
6. Number-of-Starts Counter: Numerical readout on face of enclosure.
7. Meters: Panel type, [**2-1/2 inches**] [**4-1/4 inches**] with [**90**] [**120**] [**270**]-degree scale and [**1**] [**2**] percent accuracy. Where indicated, provide transfer device with an off position. Meters shall indicate the following:

   a. Ammeter: Output current for each phase, with current sensors rated to suit application.
   b. Voltmeter: Output voltage for each phase.
   c. Frequency Meter: Output frequency.
   d. Real-time clock with current time and date.
   e. Total run time.
   f. <**Insert features**>.

8. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

   a. Selectable, digital display of the following:

      1) Phase Currents, Each Phase: Plus or minus 1 percent.
      2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
      3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
      4) Three-Phase Real Power: Plus or minus 2 percent.
      5) Three-Phase Reactive Power: Plus or minus 2 percent.
      6) Power Factor: Plus or minus 2 percent.
      7) Frequency: Plus or minus 0.5 percent.
      8) Integrated Demand with Demand Interval Selectable from Five to 60 Minutes: Plus or minus 2 percent.
      9) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

   b. Mounting: Display and control unit flush or semirecessed in instrument compartment door.

9. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
10. Power Protection: Chiller shall shut down within six cycles of power interruption.

2.11 VARIABLE FREQUENCY CONTROLLER

A. Motor controller shall be factory mounted and wired on the chiller to provide a single-point, field-power termination to the chiller and its auxiliaries.

B. Description: NEMA ICS 2; listed and labeled as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.

C. Enclosure: Unit mounted, NEMA 250, [**Type 1**] [**Type 4**] [**Type 4x**] [**Type 12**], with hinged full-front access door with lock and key.

D. Integral Disconnecting Means: [**Door-interlocked,**]NEMA AB 1, instantaneous-trip circuit breaker with lockable handle. Minimum withstand rating shall be as required by electrical power distribution system, but not less than [**42,000**] [**65,000**] <**Insert value**> A.

E. Technology: Pulse width modulated (PWM) output with insulated gate bipolar transistors (IGBT); suitable for variable torque loads.

F. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.

1. Rectifier section shall be a full-wave diode bridge that changes fixed-voltage, fixed-frequency, ac line power to a fixed dc voltage. Silicon controller rectifiers, current source inverters, and paralleling of devices are unacceptable. Rectifier shall be insensitive to phase rotation of the ac line.
2. Regulator shall provide full digital control of frequency and voltage.
3. Inverter section shall change fixed dc voltage to variable-frequency, variable ac voltage, for application to a squirrel-cage motor. Inverter shall produce a sine-coded, pulse width modulated (PWM) output wave form and shall conduct no radio-frequency interference back to the input power supply.

G. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.

H. Operating Requirements:

1. Input AC Voltage Tolerance: [**460-V ac, plus 10 percent or 506 V maximum**] <**Insert voltage and tolerance**>.
2. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
3. Capable of driving full load, without derating, under the following conditions:

   a. Ambient Temperature: 0 to 50 deg C.
   b. Relative Humidity: Up to [**90**] [**95**] percent (noncondensing).
   c. Altitude: [**3300 feet**] [**6600 feet**].

4. Minimum Efficiency: 96 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 95 percent without harmonic filter, 98 percent with harmonic filter.
6. The VSD design shall include as standard integrated active rectification control system to limit total demand distortion (TDD) in current at the VSD to less than or equal to 5-percent. If active

filters are used to meet less than or equal to 5% TDD, then the losses associated with the filter shall be included in the chiller performance on the selection.

7. Overload Capability: 1.05 times the full-load current for 7 seconds.
8. Starting Torque: As required by compressor-drive assembly.
9. Speed Regulation: Plus or minus 1 percent.
10. Isolated control interface to allow controller to follow control signal over a 10:1 speed range.
11. To avoid equipment resonant vibrations, provide critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
12. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.

I. Internal Adjustability Capabilities:

1. Minimum Output Frequency: 6 Hz.
2. Maximum Output Frequency: 60 Hz.
3. Acceleration: 2 seconds to a minimum of 60 seconds.
4. Deceleration: 2 seconds to a minimum of 60 seconds.
5. Current Limit: 30 percent to a minimum of 100 percent of maximum rating.

J. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:

1. Overtemperature.
2. Short circuit at controller output.
3. Ground fault at controller output. Variable frequency controller shall be able to start a grounded motor.
4. Open circuit at controller output.
5. Input undervoltage.
6. Input overvoltage.
7. Loss of input phase.
8. Reverse phase.
9. AC line switching transients.
10. Instantaneous overload, line to line or line to ground.
11. Sustained overload exceeding 100 percent of controller rated current.
12. Starting a rotating motor.

K. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.

L. Automatic Reset and Restart: Capable of [**three**] <**Insert number**> restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Controller shall be capable of automatic restart on phase-loss and overvoltage and undervoltage trips.

M. Visual Indication: On face of controller enclosure or chiller control enclosure; indicating the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.
7. Motor speed (percent).
8. Fault or alarm status (code).
9. DC-link voltage.
10. Motor output voltage.

11. Input kilovolt amperes.
12. Total power factor.
13. Input kilowatts.
14. Input kilowatt-hours.
15. Three-phase input voltage.
16. Three-phase output voltage.
17. Three-phase input current.
18. Three-phase output current.
19. Three-phase input voltage total harmonic distortion.
20. Three-phase input current total harmonic distortion.
21. Output frequency (Hertz).
22. Elapsed operating time (hours).
23. Diagnostic and service parameters.

N. Operator Interface: At controller or chiller control panel; with start-stop and auto-manual selector with manual-speed-control potentiometer.

O. Control Signal Interface:

1. Electric Input Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4-20 mA) and six programmable digital inputs.

P. Active Harmonic Distortion Filter: Factory mounted and wired to limit total voltage and current distortion to [**5**] <**Insert number**> percent.

Q. Input Line Conditioning: <**Insert requirements**>.

R. Cooling: [**Air**] [**Refrigerant**] [**Water**] [**Air, refrigerant, or water**] cooled.

S. Accessories: Devices shall be factory installed in controller enclosure unless otherwise indicated.

1. Control Relays: Auxiliary and adjustable time-delay relays.

T. Chiller Capacity Control Interface: Equip chiller with adaptive control logic to automatically adjust the compressor motor speed and the compressor pre-rotation inlet vane position independently to achieve maximum part-load efficiency in response to sensor inputs that are integral to the chiller controls.

2.12 CONTROLS

A. Control: Standalone and microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.

B. Enclosure: Unit mounted, NEMA 250, [**Type 1**] [**Type 4**] [**Type 4x**] [**Type 12**] <**Insert type**>, hinged or lockable; factory wired with a single-point, field-power connection and a separate control circuit.

C. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units selectable through the interface, display the following information:

1. Date and time.
2. Operating or alarm status.
3. Fault history with not less than last 10 faults displayed.
4. Set points of controllable parameters.
5. Trend data.

6. Operating hours.
7. Number of chiller starts.
8. Outdoor-air temperature or space temperature if required for chilled-water reset.
9. Entering- and leaving-fluid temperatures of evaporator and condenser.
10. Difference in fluid temperatures of evaporator and condenser.
11. Fluid flow of evaporator and condenser.
12. Fluid pressure drop of evaporator and condenser.
13. Refrigerant pressures in evaporator and condenser.
14. Refrigerant saturation temperature in evaporator and condenser shell.
15. Compressor refrigerant suction and discharge temperature.
16. Compressor bearing temperature.
17. Motor bearing temperature.
18. Motor winding temperature.
19. Oil temperature.
20. Oil discharge pressure.
21. Phase current.
22. Percent of motor rated load amperage.
23. Phase voltage.
24. Demand power (kilowatts).
25. Energy use (kilowatt-hours).
26. Power factor.
27. For chillers equipped with variable frequency controllers and harmonic filters, include the following:

    a. Output voltage and frequency.
    b. Voltage total harmonic distortion for each phase.
    c. Supply current total demand distortion for each phase.
    d. Inlet vane position.
    e. Controller internal ambient temperature.
    f. Heatsink temperature.

28. Purge suction temperature if purge system is provided.
29. Purge elapsed time if purge system is provided.
30. <**Insert status display items**>.

D. Control Functions:

1. Manual or automatic startup and shutdown time schedule.
2. Entering and leaving chilled-water temperatures, control set points, and motor load limits. Evaporator fluid temperature shall be reset based on [**return-water**] [**outdoor-air**] [**space**] temperature.
3. Current limit and demand limit.
4. Condenser-fluid temperature.
5. External chiller emergency stop.
6. Variable evaporator flow.
7. Thermal storage.
8. Heat reclaim.
9. <**Insert control functions**>.

E. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:

1. Low evaporator [**pressure**] [**temperature**] [**pressure or temperature**]; high condenser pressure.
2. Low evaporator fluid temperature.
3. Low oil differential pressure.
4. High or low oil pressure.

5. High oil temperature.
6. High compressor-discharge temperature.
7. Loss of condenser-fluid flow.
8. Loss of evaporator fluid flow.
9. Motor overcurrent.
10. Motor overvoltage.
11. Motor undervoltage.
12. Motor phase reversal.
13. Motor phase failure.
14. Sensor- or detection-circuit fault.
15. Processor communication loss.
16. Motor controller fault.
17. Extended compressor surge.
18. Excessive air-leakage detection for chillers using R-123 refrigerant.
19. High motor temperature.
20. **<Insert manually reset safety controls>**.

F. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.

G. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.

H. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.

I. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer[**and a notebook computer**].

J. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display chiller status and alarms.

1. Hardwired Points:

    a. Monitoring: On-off status, [**common trouble alarm**] [**electrical power demand (kilowatts)**] [**electrical power consumption (kilowatt-hours)**] [**power factor**] **<Insert monitoring point>**.
    b. Control: On-off operation, [**chilled-water, discharge temperature set-point adjustment**] [**electrical power demand limit**] **<Insert control point>**.

2. [**ASHRAE 135 (BACnet)**] [**LonTalk**] [**Modbus**] [**Industry-accepted, open-protocol**] **<Insert type of interface>** communication interface with the BAS shall enable the BAS operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the BAS.

2.13 FINISH

A. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:

1. Provide at least one coat of primer with a total dry film thickness of at least 2 mils.
2. Provide at least two coats of [**alkyd-modified, vinyl enamel**] [**epoxy**] [**polyurethane**] finish with a total dry film thickness of at least 4 mils.
3. Paint surfaces that are to be insulated before applying the insulation.

4. Paint installed insulation to match adjacent uninsulated surfaces.
5. Color of finish coat to be **[manufacturer's standard]** **[custom color selected by Architect]** <**Insert color description**>.

B. Provide Owner with quart container of paint used in application of topcoat to use in touchup applications after Project Closeout.

2.14 ACCESSORIES

A. Flow Switches:

1. Chiller manufacturer shall furnish a switch for each **[condenser]** **[evaporator and condenser]** and verify field-mounting location before installation.
2. Paddle Flow Switches:

   a. Vane operated to actuate a double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
   b. Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of 10 A at 120-V ac.
   c. Pressure rating equal to pressure rating of heat exchanger.
   d. Construct body and wetted parts of Type 316 stainless steel.
   e. House switch in a NEMA 250, **[Type 4]** <**Insert type**> enclosure constructed of die-cast aluminum.
   f. Vane length to suit installation.

3. Pressure Differential Switches:

   a. Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
   b. Performance: Switch shall withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set-point shift due to variation in working pressure.
   c. Set Point: Screw type, field adjustable.
   d. Electrical Connections: Internally mounted screw-type terminal blocks.
   e. Switch Enclosure: NEMA 250, **[Type 4]** <**Insert type**>.
   f. Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.

B. Vibration Isolation – as specified in Division 23 "Vibration Isolation".

C. Sound Barrier:

1. Furnish removable and reusable sound-barrier covers over the compressor housing, hermetic motor, compressor suction and discharge piping, and condenser shell.
2. Provide for repeated installation and removal without use of tape or calk.
3. Inner and outer cover shall consist of a PTFE-impregnated fiberglass cloth enclosing heavy-density, needled fiberglass insulation material with a mass-loaded vinyl acoustic barrier.
4. Covers shall be double sewn and lock stitched with edges folded and sewn so no raw cut edges are exposed.
5. Form covers around control devices, gages, conduit, piping, and supports without degrading sound-barrier performance.
6. Continuously lap all exposed seams at least 2 inches for better sound containment.
7. Permanently label each section of cover to indicate its location, description, size, and number sequence.
8. Randomly place stainless-steel quilting pins to prevent covers from shifting and sagging.

D. Tool Kit: Chiller manufacturer shall assemble a tool kit specially designed for use in serving the chiller(s) furnished. Include special tools required to service chiller components not readily available to Owner service personnel in performing routine maintenance. Place tools in a lockable case with hinged cover. Provide a list of each tool furnished and attach the list to underside of case cover.

2.15 CAPACITIES AND CHARACTERISTICS – AS NOTED ON PLANS

2.16 PUMPOUT SYSTEM (REFRIGERANT RECOVERY VESSEL):

A. For units operating with refrigerant under positive pressure at 75 deg F (HCFC-22, HFC-134a), furnish each unit with pumpout system.

B. Pumpout system shall be free standing design and furnished complete with refrigerant storage receiver, tank-mounted pumpout compressor, switchover valves, piping, and unit-mounted control panel factory wired. Include tank level gauge glass.

C. Storage receiver construction to meet ASME Code and ANSI/ASHRAE 15 Safety Code. Storage capacity shall be sufficient to hold refrigerant charge when 90% full at 90 deg F or largest chiller.

D. Pumpout system may be integral part of each refrigeration machine.

E. Refrigeration machines with integral pumpout system shall have evaporator and condenser shells sized to store entire refrigerant charge of machine in either shell, shell refrigerant side isolation valves, unit-mounted pumpout compressor, switchover valves factory piped and unit-mounted control panel.

F. Pumpout system(s) shall be suitable for operation on **<Insert voltage>** volt, 3 phase, 60-Hz power.

2.17 HEAT-EXCHANGER, BRUSH-CLEANING SYSTEM

A. Furnish for field installation a brush-cleaning system on each chiller [**condenser**] <**Insert heat exchanger**> for tube cleaning and improved heat transfer.

B. System shall maintain tube fouling at or below design conditions without interrupting normal equipment operation.

C. System shall consist of a brush inserted in each tube and a catch basket attached to each end of the tube. A four-way valve shall operate to reverse the direction of water flow to push the brush through the tube while removing tube deposits. Four-way reversing valve's actuator shall be controlled by a preset time cycle that provides regular tube brushing during equipment operation. Frequency of the brushing cycle shall be set up to match Project requirements.

D. Components:

1. Brush: Each brush shall have nylon bristles, titanium wires, and polypropylene tips. Brush interference fit with the ID of the tube shall not exceed 0.025 inch.
2. Basket: Single-piece polypropylene basket with neck OD to press fit inner diameter of tube. Design shall provide for insertion of eddy current probe or removal of brushes without removing baskets from the valve.
3. Four-Way Valve:

    a. Construct valve body of carbon steel with internal sealing parts of hard rubber and Type 304 stainless steel.

b. Configure valve with parallel flow connections to minimize field installation piping.
c. Construct to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, at a system working pressure equal to condenser.
d. Pipe connections shall be flanged.
e. Valve manufacturer to test and certify a maximum leakage rate of less than 0.05 percent of the design flow rate at operation conditions of maximum differential pressure.
f. Hydrostatically test to 1.5 times the design working pressure.
g. Design the valve to cause no more than 0.5-psig pressure drop at design flow conditions.
h. Provide valve with valve-mounted indicating/warning light, which shall light before the valve begins rotation.
i. Valve Actuator: Mount electric actuator to operate valve.
j. Valve Actuator: Mount pneumatic piston-type actuator to operate valve. Actuator shall be suitable for operation using field-supplied air pressure.
k. Position Switches: Factory mount microswitches on the valve to indicate the complete turn of valve in both normal and reverse flow.

4. Control Panel: Factory or field mount a control panel on chiller. Control panel shall include the following features:

a. NEMA 250, [**Type 1**] [**Type 4**] [**Type 4x**] [**Type 12**] enclosure.
b. Timer to automatically initiate the cleaning cycle over a 24-hour period.
c. Manual override of preset cleaning cycle.
d. Visual indication of "Power On," "Diverter Position," "Normal Flow," "Reverse Flow," and "Valve Malfunction" indicating a slow turn or incomplete valve turn.
e. For pneumatic actuators, mount four-way solenoid valve for actuator operation in the control panel.
f. Flow switch bypass.
g. Unloading signal to chiller.

2.18 SOURCE QUALITY CONTROL

A. Perform functional [**run**]tests of chillers before shipping.

B. Factory performance test chillers, before shipping, according to ARI 550/590.

1. Test the following conditions:

a. Design conditions indicated.
b. Reduction in capacity from design to minimum load in steps of [**10**] [**25**] [**33**] <**Insert number**> with condenser fluid at design conditions.
c. Reduction in capacity from design to minimum load in steps of [**10**] [**25**] [**33**] <**Insert number**> with varying entering condenser-fluid temperature from design to minimum conditions in [**5 deg F**] <**Insert temperature**> increments.
d. At [**one**] [**two**] [**three**] [**four**] [**five**] [**10**] <**Insert number**> point(s) of varying part-load performance to be selected by Owner at time of test.

2. Allow [**Owner**] <**Insert entity**> access to place where chillers are being tested. Notify Architect [**14**] <**Insert number**> days in advance of testing.
3. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

C. Factory sound test chillers, before shipping, according to ARI 575.

1. Test the following conditions:

a. Design conditions indicated.
b. Chiller operating at calculated worst-case sound condition.
c. At **[one]** **[two]** **[three]** **[four]** **[five]** <**Insert number**> point(s) of varying part-load performance to be selected by Owner at time of test.

2. Allow **[Owner]** <**Insert entity**> access to place where chillers are being tested. Notify Architect **[14]** <**Insert number**> days in advance of testing.
3. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

D. For chillers using R-134a refrigerant, factory test and inspect evaporator **[and condenser]** **[, condenser, and heat-reclaim condenser]** according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

E. For chillers using R-123 refrigerant, factory test and inspect evaporator **[and condenser]** **[, condenser and heat-reclaim condenser]** according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Pressure test fluid side of heat exchangers, including water boxes, to 1.5 times the rated pressure. Pressure proof test refrigerant side of heat exchangers to a minimum of 45 psig. Vacuum and pressure test for leaks.

F. For chillers located indoors, rate sound power level according to ARI 575.

PART 3 - EXECUTION

3.1 GENERAL

A. The chillers will be delivered to the designated rigger's yard. Contractor shall coordinate shipment, receive, inspect and accept responsibility for equipment. Any damage or deficiency shall be resolved by Contractor directly with manufacturer and/or hauler, with no recourse to the Owner.

B. Delivery and rigging of chillers will be staged based on the construction schedule. Contractor shall protect equipment, transport to the site, rig into place, install, pipe, wire and test equipment in accordance with drawings, specifications and manufacturer's recommendations. Contractor shall coordinate any requirements directly with the manufacturer.

C. Consult equipment supplier regarding rigging requirements. If disassembly is required, both disassembly and reassembly shall be done by the Contractor in strict compliance with the manufacturer's instructions, under supervision of chiller manufacturer's representative, and shall not void any warranties.

3.2 EXAMINATION

A. Examine chillers before installation. Reject chillers that are damaged.

B. Examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting chiller performance, maintenance, and operations before equipment installation.

1. Final chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 CHILLER INSTALLATION

A. Install chillers on support structure indicated. Level machine to within manufacturer's tolerances.

B. Equipment Mounting: Install chiller on concrete bases using **[elastomeric pads]** **[restrained spring isolators]** <**Insert device**>. Comply with requirements for concrete bases specified in Division 03 Section "[**Cast-in-Place Concrete**] [**Miscellaneous Cast-in-Place Concrete**]." Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Equipment Mounting: Install chiller using **[elastomeric pads]** **[restrained spring isolators]** <**Insert device**>. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Maintain manufacturer's recommended clearances for service and maintenance.

E. Charge chiller with refrigerant and fill with oil if not factory installed.

F. Install separate devices furnished by manufacturer and not factory installed.

G. Nameplates: In addition to the manufacturer's standard nameplate, as specified in ASHRAE Standard 15, provide engraved brass nameplate with minimum 0.5-inch letters on each chiller to indicate the name and address of installer, horsepower or equivalent kW of prime mover, type and number of pounds of refrigerant and pressure applied for refrigerant leakage test.

3.4 HEAT-EXCHANGER, BRUSH-CLEANING SYSTEM INSTALLATION

A. Install brush-cleaning system control panel adjacent to chiller control panel.

B. Arrange piping to provide service access to four-way valve assembly without affecting access to chiller. Secure valve to prevent lateral movement and vibration during operation.

C. Provide field electric power, as required, to each system control panel and electric actuated valve.

D. Provide pneumatic piping with pressure regulator and isolation valve to each pneumatic supply connection. Coordinate field source of air with manufacturer to ensure that requirements are satisfied for proper valve operation.

E. Interconnect brush-cleaning system controls with chiller controls. Coordinate requirements to ensure safe, trouble-free operation.

F. Functionally test the entire brush-cleaning system, including the valve, actuator, position indicator, and control panel, with chiller in operation.

3.5 CONNECTIONS

A. Comply with requirements for piping specified in Division 23 Section "Hydronic Piping" and Division 23 Section "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to chiller to allow service and maintenance.

C. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, [**strainer,**] [**flexible connector,**] thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve,[**flexible connector,**] flow switch, thermometer, plugged tee with shutoff valve and pressure gage,[**flow meter,**] and drain connection with valve. Make connections to chiller with a [**flange**] [**mechanical coupling**] [**flange or mechanical coupling**].

D. Condenser-Fluid Connections: Connect to condenser inlet with shutoff valve, [**strainer,**] [**flexible connector,**] thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve,[**flexible connector,**] flow switch, thermometer, plugged tee with shutoff valve and pressure gage,[**flow meter,**] and drain connection with valve. Make connections to chiller with a [**flange**] [**mechanical coupling**] [**flange or mechanical coupling**].

E. Heat-Reclaim Condenser-Fluid Connections: Connect to condenser inlet with shutoff valve, [**strainer,**] [**flexible connector,**] thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve,[**flexible connector,**] flow switch, thermometer, plugged tee with shutoff valve and pressure gage,[**flow meter,**] and drain connection with valve. Make connections to chiller with a [**flange**] [**mechanical coupling**] [**flange or mechanical coupling**].

F. Refrigerant Pressure Relief Device Connections: For chillers installed indoors, extend [**vent piping**] [**separate vent piping for each chiller**] to the outdoors without valves or restrictions. Comply with ASHRAE 15. Connect to chiller pressure relief device with flexible connector and dirt leg with drain valve.

G. For chillers equipped with a purge system, extend [**purge vent piping**] [**separate purge vent piping for each chiller**] to the outdoors. Comply with ASHRAE 15 and ASHRAE 147.

H. Miscellaneous Unit Water Piping: Provide a water supply manifold piped to the compressor oil cooler and the unit-mounted refrigerant recovery unit condenser. The supply manifold shall be complete and include valves, sight glasses, thermometers and other devices to verify sufficient water flow.

I. Miscellaneous Unit Refrigerant Piping: Provide all interconnecting refrigerant piping between the chiller, refrigerant recovery unit, compressor and condenser, and remote refrigerant storage vessel, if required.

J. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that refrigerant charge is sufficient and chiller has been leak tested.
3. Verify that pumps are installed and functional.
4. Verify that thermometers and gages are installed.
5. Operate chiller for run-in period.
6. Check bearing lubrication and oil levels.
7. Verify that refrigerant pressure relief device is vented outside.

8. Verify proper motor rotation.
9. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
10. Verify and record performance of fluid flow and low-temperature interlocks for evaporator[**and condenser**] [**, condenser, and heat-reclaim condenser**].
11. Verify and record performance of chiller protection devices.
12. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.

C. Prepare test and inspection startup reports.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain chillers.[**Video record the training sessions.**]

3.8 FACTORY PERFORMANCE TESTS

A. Manufacturer shall conduct factory performance test for each chiller in accordance with ARI 550/590-98, to verify design capacity and part load capacity points indicated on Bid form. Owner and/or Owner's representative may elect to witness tests. Notify Owner and/or Owners representative of test date at least 2 weeks in advanced.

B. Before shipment of chillers, all records and certifications approving testing requirements shall be submitted to and approved by Owner.

C. Defective work or material shall be replaced or repaired, as necessary, and inspection and test repeated. Repairs shall be made with new materials. Run new performance test in accordance with ARI standard.

D. If chiller assembly fails to meet design capacity, Owner may elect not to accept delivery until chiller is modified at manufacturer's expense to meet design capacity or to assess penalty charge of $5,000 per ton (prorated per fraction of a ton) that chiller capacity falls short of design capacity. Compressor KW input in no case shall exceed that indicated in these specifications for design conditions.

E. If chiller assembly fails to meet any of part load performance data supplied by manufacturer with his bid, Owner may elect not to accept delivery until chiller is modified at manufacturer's expense to meet all of design and part load performance data or to assess penalty charge equal to 10 years operating cost differential. This differential is to be determined by using part load data included in bid form and data obtained from performance test, subtracting bid data annual operating cost from test data annual operating cost, and multiplying difference by ten. Penalty charge shall apply to all chillers.

F. All design conditions and part load performance data shall be evaluated with 480 volt, 3-phase, 60 hertz power supplied to chiller.

G. Conduct test at approved ARI certified test facility of the manufacturer.

H. Instrumentation used for testing must be calibrated within 6 months of test date and traceable to National Bureau of Standards. Documentation verifying NBS traceability shall be submitted to Engineer.

I. Performance test shall be two-point test [**per chiller**] [**for one chiller**]. Points **[shall] [will]** be selected at time of test. Points will be selected from submitted performance from 25 to 100% of capacity.

3.9 COMMISSIONING

A. The manufacturer shall be present during all commissioning events. The anticipated schedule is for commissioning to occur during the least six to eight weeks of construction just prior to the anticipated end of construction date of [**Insert Date**]. Include 40 hours of field time to perform the commissioning requirements.

B. Verify that installation complies with the Contract Documents.

C. A factory-authorized representative shall perform the startup service.
   1. Fill out startup checklists and attach copy with Contractor Startup Report.

D. Complete installation and startup checks according to manufacturer's written instructions and check for the following items:
   1. No physical damage to unit.
   2. Unit is level.
   3. Chiller vibration isolation and flexible pipe connections are installed.
   4. Clearances have been maintained and piping is installed for easy removal for service and tube cleaning.
   5. Chilled and condenser water pipes have been connected to correct ports.
   6. Labels and safety instructions are clearly visible.
   7. Oil levels are as recommended by manufacturer.
   8. Refrigerant charge is sufficient and chiller has been leak tested.
   9. Shipping skids, blocks and straps are removed.
   10. Refrigerant pressure relief is vented to outside.
   11. Thermometers and pressure gauges are installed.
   12. Controls and safety interlocks are installed and connected.
   13. Pumps are installed, connected and operational.

E. Check and record performance of chiller protection devices.

F. Check and record performance of chilled and condenser water flow and low temperature interlocks.

G. Operate chiller for run-in period as recommended by manufacturer.

H. Check static deflection of vibration isolators, including deflection during chiller startup and shutdown.

I. Check refrigerant charge. Check oil level.

END OF SECTION 23 6416

SECTION 23 6500

COOLING TOWERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Requirements Division 01, Division 23 Specification Sections, and Common Work Requirements for HVAC apply to the work specified in this Section.

1.2 SUMMARY

A. Section Includes:
   1. Open-circuit, forced-draft, counterflow cooling towers.

1.3 DEFINITIONS

A. BMS: Building management system.

B. FRP: Fiber-reinforced polyester.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design cooling tower support structure and seismic restraints, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Cooling tower support structure shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to SEI/ASCE 7.

   1. Dead Loads: <**Insert loads**>.
   2. Live Loads: <**Insert loads**>.
   3. Roof Loads: <**Insert loads**>.
   4. Seismic Loads: <**Insert loads**>.
   5. Wind Loads: <**Insert loads**>.
   6. Deflection Limits: Design system to withstand design loads without deflections greater than the following:

      a. <**Insert deflection limits**>.

C. Seismic Performance: Cooling towers shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, pressure drop, fan performance data, rating curves with selected points indicated, materials of construction, furnished specialties, and accessories.

1. Maximum flow rate.
2. Minimum flow rate.
3. Drift loss as percent of design flow rate.
4. Volume of water in suspension for purposes of sizing a remote storage tank.
5. Sound power levels in eight octave bands for operation with fans off, fans at minimum, and design speed.
6. Performance curves for the following:

   a. Varying entering-water temperatures from design to minimum.
   b. Varying ambient wet-bulb temperatures from design to minimum.
   c. Varying water flow rates from design to minimum.
   d. Varying fan operation (off, minimum, and design speed).

7. Fan airflow, brake horsepower, and drive losses.
8. Pump flow rate, head, brake horsepower, and efficiency.
9. Motor amperage, efficiency, and power factor at 100, 75, 50, and 25 percent of nameplate horsepower.
10. Electrical power requirements for each cooling tower component requiring power.

B. Shop Drawings: Complete set of manufacturer's prints of cooling tower assemblies, control panels, sections and elevations, and unit isolation. Include the following:

1. Assembled unit dimensions.
2. Weight and load distribution.
3. Required clearances for maintenance and operation.
4. Sizes and locations of piping and wiring connections.
5. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For cooling tower support structure indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of support structure.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
3. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

D. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Structural supports.
2. Piping roughing-in requirements.
3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.

E. Certificates: For certification required in "Quality Assurance" Article.

F. Seismic Qualification Certificates: For cooling towers, accessories, and components, from manufacturers.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

G. Source quality-control reports.

H. Field quality-control reports.

I. Startup service reports.

J. Operation and Maintenance Data: For each cooling tower to include in emergency, operation, and maintenance manuals. Include start-up instructions, maintenance data, parts lists, controls, accessories, and trouble-shooting guide.

K. Warranty: Sample of special warranty.

1.6 CODES AND STANDARDS

A. American Society of Mechanical Engineers (ASME).

1. Boiler and Pressure Vessel Code, Section VIII, Division 1, “Rules for Construction of Pressure Vessels.”
2. Performance Test Code PTC 23, “Atmospheric Water Cooling Equipment.”

B. Cooling Technology Institute (CTI).

1. Standard 201, “Standard for the Certification of Water-Cooling Tower Thermal Performance.”
2. Acceptance Test Code ATC 105, “Acceptance Test Code for Water Cooling Towers.”

C. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).

1. Standard 90.1, “Energy Standard for Building Except Low-Rise Residential Buildings.”

D. National Fire Protection Association (NFPA).

1. Standard 70, “National Electrical Code.”

E. American National Standards Institute (ANSI).

F. American Society for Testing and Materials (ASTM).

G. Institute of Electrical and Electronics Engineers (IEEE).

H. National Electrical Manufacturers Association (NEMA).

I. Factory Mutual (FM).

J. Underwriters Laboratories (UL).

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: [**Certified by CTI**] [**An NRTL**].

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. ASME Compliance: Fabricate and label heat-exchanger coils to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

E. CTI Certification: Cooling tower thermal performance according to CTI STD 201, "Certification Standard for Commercial Water-Cooling Towers Thermal Performance."

F. FMG approval and listing in the latest edition of FMG's "Approval Guide."

1.8 DELIVERY, STORAGE, AND HANDLING

A. Factory assemble entire unit. For shipping, disassemble into as large as practical sub-assemblies so that minimum amount of field work is required for reassembly.

B. Ship cooling towers equipped with gear drives with a full charge of oil.

C. Ship each cooling tower with a firmly attached stainless steel nameplate indicating name of manufacturer and model number.

D. Reject and damaged cooling tower equipment upon arrival at the site.

E. Store cooling tower equipment to prevent damage, and protect from weather, dirt, fumes, water and construction debris. Provide a clean, dry space for storage if one is not available at the site.

F. Handle cooling tower equipment according to the manufacturer's rigging and installation instructions for unloading and transporting into the final location.

1.9 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace the following components of cooling towers that fail in materials or workmanship within specified warranty period:

1. Fan assembly including fan, drive, and motor.