

# **Design Details of Building Archetypes with Dual Steel SMRF-SCBF systems**

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This document demonstrates the details and key design parameters of the building archetypes used in the study. In summary, the buildings design process is dipected in the flow chart of Fig. 1.

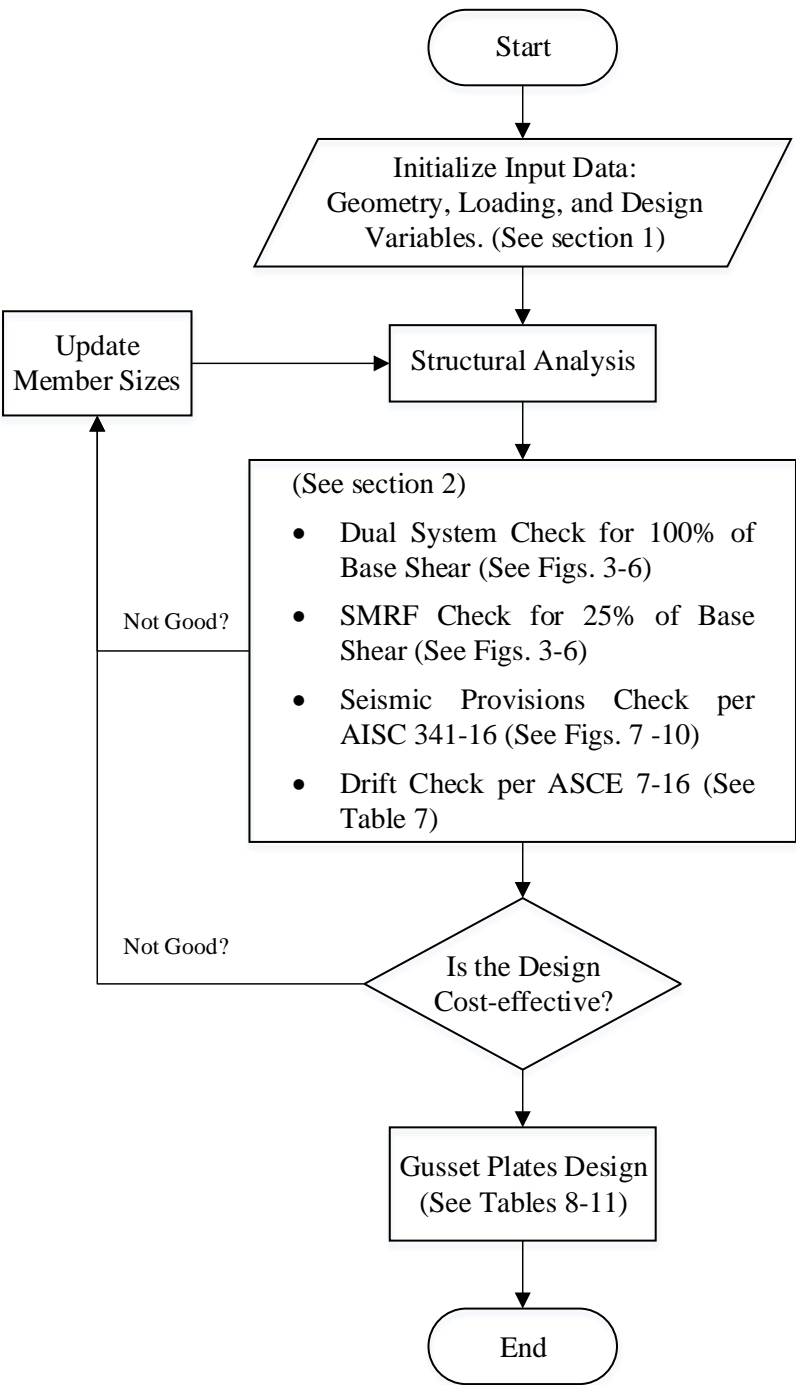


Fig. 1: Flow chart of the design process

General properties of building archetypes

The required general information to design building archetypes are as follows:

- Typical plan and elevation view of building archetypes are shown in Fig. 2. It should be noted that the plan is based on the NIST project [1] in which the bay length of all frames is 20 ft, the height of the first floor is 15 ft, and the other floors are 13 ft. Four braced frames with two-story X bracing configurations are symmetrically considered, and due to the symmetry of the plan and geometric property of using seismic force-resisting system, all building archetypes are modeled as a 2D frame.

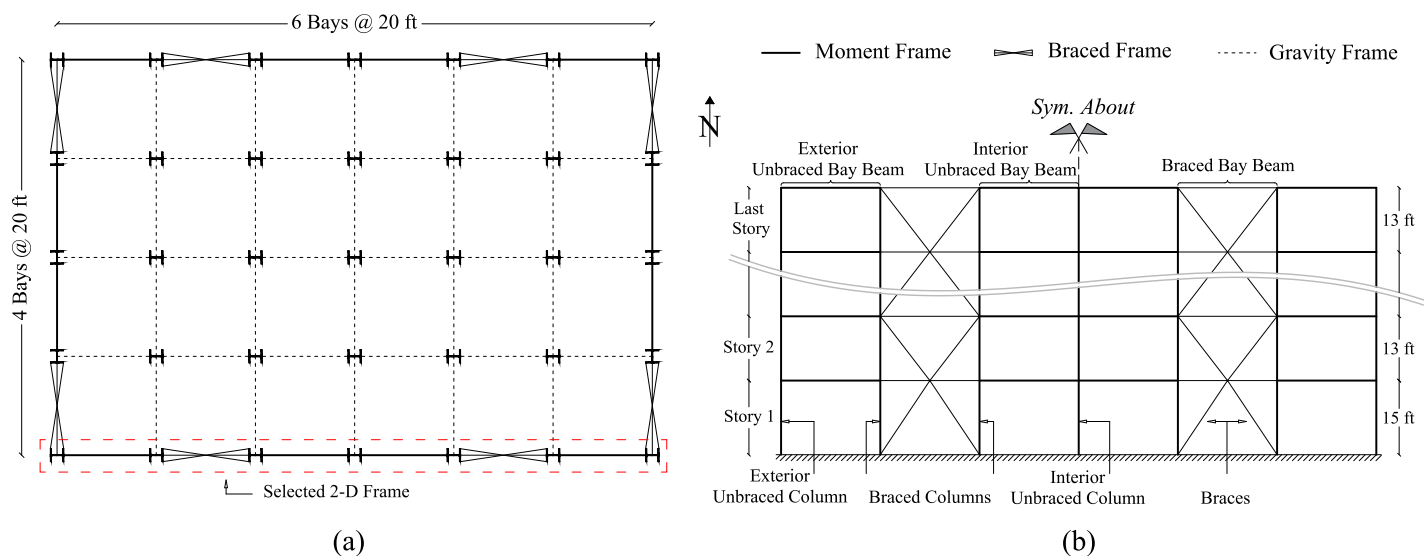


Fig. 2: Typical plan and elevation view of building archetypes; a) plan, b) elevation

- The building archetypes were analyzed and designed in ETABS, ver. 20.0 [2].
- The following codes were used to analyze and design all building archetypes:
  1. ASCE 7-16: *Minimum Design loads for Buildings and Other Structures* [3].
  2. AISC 360-16: *Specification for Structural Steel Builings* [4].
  3. AISC 341-16: *Seismic Provisions for Structural Steel Buildings* [5].
- A summary of the design gravity loads are presented in Table 1.  
Note: It is assumed in this study that there is no snow load on the building archetypes.

Table 1: Design Gravity Loads

Load	Load Type	Magnitude (psf)
Dead, $D$	Dead	90
Exterior Cladding Wall, $D$	Dead	25
Unreduced Design Floor Live, $L_o$	Floor Live	50
Unreduced Roof Live, $L_o$	Roof Live	20

- Strength and deflection load combinations for strength design and serviceability verifications are provided in Table 2.  
Note: It is assumed that the wind load does not control the design.

Table 2: Design Load Combinations

Type of Load Combination	List of Load Combinations*
Strength	$1.4D$
	$1.2D + 1.6L + 0.5L_r$
	$1.2D + 1.6L_r + 0.5L$
	$(1.2 + 0.2S_{DS})D + 0.5L \pm 1.0E$
	$(0.9 - 0.2S_{DS})D \pm 1.0E$
Deflection	$1.0D$
	$1.0D + 1.0L$

\*Load Cases:  $D$ : Dead Load,  $L$ : Floor Live Load,  $L_r$ : Roof Live Load,  $E$ : Earthquake

- Risk category, importance factor and soil class of the building archetypes were assumed II (office), 1.0 and D respectively.
- Spectral response acceleration parameters are shown in Table 3. It should be noted that the values of  $S_s$  and  $S_I$  were taken from FEMA P695 [6], and the requirements of ASCE 7-16 § 11.4.8 were not considered for the sake of FEMA P695.

**Table 3: Spectral Response Acceleration Parameters**

SDC	$S_s$ (g)	$S_I$ (g)	$F_a$	$F_v$	$S_{MS}$ (g)	$S_{MI}$ (g)	$S_{DS}$ (g)	$S_{DI}$ (g)	$T_s$ (s)
D <sub>max</sub>	1.5	0.599	1.0	1.7	1.5	1.02	1.0	0.68	0.68

- The seismic analysis and design parameters for each building archetype are indicated in Table 4 for the E-W direction.

**Table 4: Seismic Analysis and Design Parameters**

Building Archetypes	2-Story	8-Story	12-Story	16-Story
Analysis Procedure	RSA	RSA	RSA	RSA
$R, \Omega_0, C_d$	7, 2.5, 5.5	7, 2.5, 5.5	7, 2.5, 5.5	7, 2.5, 5.5
$C_u T_a$ (sec.)	0.341	0.925	1.248	1.545
$T_I^*$ (sec.)	0.371	1.199	1.969	2.672
$C_s$	0.143	0.105	0.078	0.063
$W$ (kips)	984	3966	5954	7942
$V_b$ ELF (kips)	140.6	416.5	463.5	499.5
$V_b$ RSA (kips)	130.4	243.3	258.3	260.7
RSA Scaling Factor	1.078	1.712	1.794	1.916
$V_b$ Design (kips)	140.6	416.5	463.5	499.5
$V_b$ Drift (kips)	130.1	264.0	273.9	340.3

\*Computed from first-order eigenvalue analysis

- The following material types and corresponding nominal properties were assumed in design:
  - Wide-flange sections: A992 Grade 50,  $F_y = 50$  ksi,  $R_y = 1.1$
  - HSS sections: A500 Grade B,  $F_y = 46$  ksi,  $R_y = 1.4$
  - Connections: A572 Grade 50,  $F_y = 50$  ksi,  $R_y = 1.1$
  - $E = 29000$  ksi,  $G = 11154$  ksi,  $\nu = 0.3$
- The second order effects were considered through “General 2<sup>nd</sup> Order” method.
- The “Direct Analysis Method” (DAM) was used to check/design the steel members.
- The P- $\Delta$  effects of interior gravity frames were considered through a leaning column with large flexural and axial stiffness, but a pin was introduced at the bottom of the column in each story.
- All nodes in each floor were constrained as a rigid diaphragm.
- The complete quadratic combination (CQC) method was used for combining the value of each parameter of interest for the various modes in modal-response spectrum analysis.

## Design outputs and seismic controls

The design outputs and controlled seismic requirements provided by AISC 341-16 are as follows:

- All columns, braces, and beams satisfied the requirements of AISC 341-16 § D1.1 for highly ductile members. Table 5 shows the compactness control of the braces of all building archetypes for the highly ductile requirement of AISC 341-16.

- All brace members had a slenderness ratio less than 200.
- The panel zones were assumed to be elastic, and were designed such that their shear strength was higher than the required shear force calculated in AISC 360-16. They also satisfied the seismic requirements per AISC 341-16 § E3.6e.
- The designed cross-sections of all building archetypes are shown in Table 6, and their P-M ratio are depicted in Fig. 3 through Fig. 6.

**Table 5:** Controlling the compactness of braces for the highly ductile requirement of AISC 341-16

Archetype ID	Story Number	Braces	Dimensions*			Width to Thickness Ratio	Limit
			W (in)	b (in)	t (in)	b / t	$0.65\sqrt{(E / (R_y \cdot F_y))}$
2-Story	1	HSS 5×5×3/8	5	3.953	0.349	11.33	13.79
	2	HSS 3.5×3.5×3/8	3.5	2.453	0.349	7.03	
8-Story	1	HSS 6×6×5/8	6	4.257	0.581	7.33	13.79
	2	HSS 6×6×1/2	6	4.605	0.465	9.90	
	3	HSS 6×6×1/2	6	4.605	0.465	9.90	
	4	HSS 5×5×1/2	5	3.605	0.465	7.75	
	5	HSS 5×5×1/2	5	3.605	0.465	7.75	
	6	HSS 4.5×4.5×1/2	4.5	3.105	0.465	6.68	
	7	HSS 4.5×4.5×1/2	4.5	3.105	0.465	6.68	
	8	HSS 4×4×3/8	4	2.953	0.349	8.46	
12-Story	1	HSS 6×6×5/8	6	4.257	0.581	7.33	13.79
	2	HSS 6×6×1/2	6	4.605	0.465	9.90	
	3	HSS 6×6×1/2	6	4.605	0.465	9.90	
	4	HSS 5.5×5.5×3/8	5.5	4.453	0.349	12.76	
	5	HSS 5.5×5.5×3/8	5.5	4.453	0.349	12.76	
	6	HSS 5.5×5.5×3/8	5.5	4.453	0.349	12.76	
	7	HSS 5.5×5.5×3/8	5.5	4.453	0.349	12.76	
	8	HSS 5×5×3/8	5	3.953	0.349	11.33	
	9	HSS 5×5×3/8	5	3.953	0.349	11.33	
	10	HSS 5×5×3/8	5	3.953	0.349	11.33	
	11	HSS 4.5×4.5×3/8	4.5	3.453	0.349	9.89	
	12	HSS 4×4×5/16	4	3.127	0.291	10.75	
16-Story	1	HSS 6×6×5/8	6	4.257	0.581	7.33	13.79
	2	HSS 6×6×1/2	6	4.605	0.465	9.90	
	3	HSS 6×6×1/2	6	4.605	0.465	9.90	
	4	HSS 6×6×1/2	6	4.605	0.465	9.90	
	5	HSS 6×6×1/2	6	4.605	0.465	9.90	
	6	HSS 5.5×5.5×3/8	5.5	4.453	0.349	12.76	
	7	HSS 5.5×5.5×3/8	5.5	4.453	0.349	12.76	
	8	HSS 5.5×5.5×3/8	5.5	4.453	0.349	12.76	
	9	HSS 5.5×5.5×3/8	5.5	4.453	0.349	12.76	
	10	HSS 5×5×3/8	5	3.953	0.349	11.33	
	11	HSS 5×5×3/8	5	3.953	0.349	11.33	
	12	HSS 5×5×3/8	5	3.953	0.349	11.33	
	13	HSS 5×5×3/8	5	3.953	0.349	11.33	
	14	HSS 4.5×4.5×5/16	4.5	3.627	0.291	12.46	
	15	HSS 4.5×4.5×5/16	4.5	3.627	0.291	12.46	
	16	HSS 3.5×3.5×5/16	3.5	2.627	0.291	9.03	

\*W: nominal width; t: design wall thickness; b: nominal width minus 3 times the design wall thickness

Table 6: Designed cross-sections of building archetypes

Archetype ID	Story Number	Braced Column	Unbraced Column		Braced Beam	Unbraced Beam		Braces
			Interior	Exterior		Interior	Exterior	
2-Story	1	W8×58	W8×67	W8×58	W16×57	W10×26	W12×22	HSS 5×5×3/8
	2	W8×58	W8×67	W8×58	W10×45	W12×19	W12×19	HSS 3.5×3.5×3/8
8-Story	1	W14×211	W12×120	W10×88	W16×89	W18×40	W18×40	HSS 6×6×5/8
	2	W14×211	W12×120	W10×88	W16×89	W18×46	W18×46	HSS 6×6×1/2
	3	W12×136	W12×106	W10×77	W12×50	W18×46	W18×40	HSS 6×6×1/2
	4	W12×136	W12×106	W10×77	W16×89	W18×40	W18×35	HSS 5×5×1/2
	5	W10×88	W10×100	W10×77	W10×45	W18×35	W18×35	HSS 5×5×1/2
	6	W10×88	W10×100	W10×77	W16×89	W16×31	W16×31	HSS 4.5×4.5×1/2
	7	W8×67	W10×77	W8×67	W16×57	W14×26	W14×26	HSS 4.5×4.5×1/2
	8	W8×67	W10×77	W8×67	W10×45	W12×19	W8×21	HSS 4×4×3/8
12-Story	1	W14×311	W12×152	W12×96	W16×89	W18×40	W18×40	HSS 6×6×5/8
	2	W14×311	W12×152	W12×96	W16×89	W18×50	W18×46	HSS 6×6×1/2
	3	W14×211	W12×152	W10×100	W16×89	W18×60	W18×50	HSS 6×6×1/2
	4	W14×211	W12×152	W10×100	W16×89	W18×60	W18×46	HSS 5.5×5.5×3/8
	5	W12×170	W12×136	W10×88	W10×30	W18×55	W18×46	HSS 5.5×5.5×3/8
	6	W12×170	W12×136	W10×88	W16×89	W18×50	W18×40	HSS 5.5×5.5×3/8
	7	W12×120	W12×106	W10×77	W10×45	W18×46	W18×40	HSS 5.5×5.5×3/8
	8	W12×120	W12×106	W10×77	W12×50	W18×40	W18×35	HSS 5×5×3/8
	9	W10×77	W10×100	W10×77	W10×30	W18×35	W16×31	HSS 5×5×3/8
	10	W10×77	W10×100	W10×77	W10×45	W16×31	W14×26	HSS 5×5×3/8
	11	W8×67	W10×77	W8×67	W12×50	W14×26	W14×26	HSS 4.5×4.5×3/8
	12	W8×67	W10×77	W8×67	W10×45	W12×19	W12×19	HSS 4×4×5/16
16-Story	1	W14×426	W12×170	W12×120	W16×89	W18×40	W18×40	HSS 6×6×5/8
	2	W14×426	W12×170	W12×120	W16×89	W18×60	W18×60	HSS 6×6×1/2
	3	W14×342	W12×170	W12×106	W10×30	W18×65	W18×65	HSS 6×6×1/2
	4	W14×342	W12×170	W12×106	W16×89	W18×65	W18×65	HSS 6×6×1/2
	5	W14×257	W12×170	W12×96	W16×89	W18×65	W18×55	HSS 6×6×1/2
	6	W14×257	W12×170	W12×96	W16×89	W18×65	W18×55	HSS 5.5×5.5×3/8
	7	W14×193	W12×170	W10×100	W10×30	W18×65	W18×50	HSS 5.5×5.5×3/8
	8	W14×193	W12×170	W10×100	W16×89	W18×65	W18×50	HSS 5.5×5.5×3/8
	9	W12×152	W12×170	W10×88	W10×45	W18×65	W18×46	HSS 5.5×5.5×3/8
	10	W12×152	W12×170	W10×88	W12×50	W18×55	W18×40	HSS 5×5×3/8
	11	W12×106	W12×120	W10×77	W10×30	W18×46	W18×40	HSS 5×5×3/8
	12	W12×106	W12×120	W10×77	W12×50	W18×40	W18×35	HSS 5×5×3/8
	13	W10×77	W10×100	W10×77	W12×50	W18×35	W16×31	HSS 5×5×3/8
	14	W10×77	W10×100	W10×77	W10×45	W16×31	W14×26	HSS 4.5×4.5×5/16
	15	W10×77	W10×77	W8×67	W12×50	W14×26	W12×22	HSS 4.5×4.5×5/16
	16	W10×77	W10×77	W8×67	W10×45	W12×19	W12×19	HSS 3.5×3.5×5/16

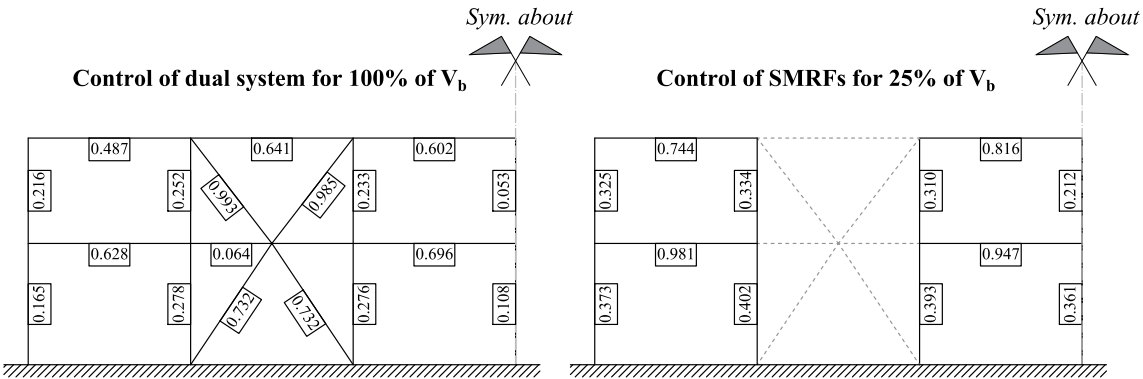


Fig. 3: The P-M ratio of designed cross-sections of 2-Story building archetype

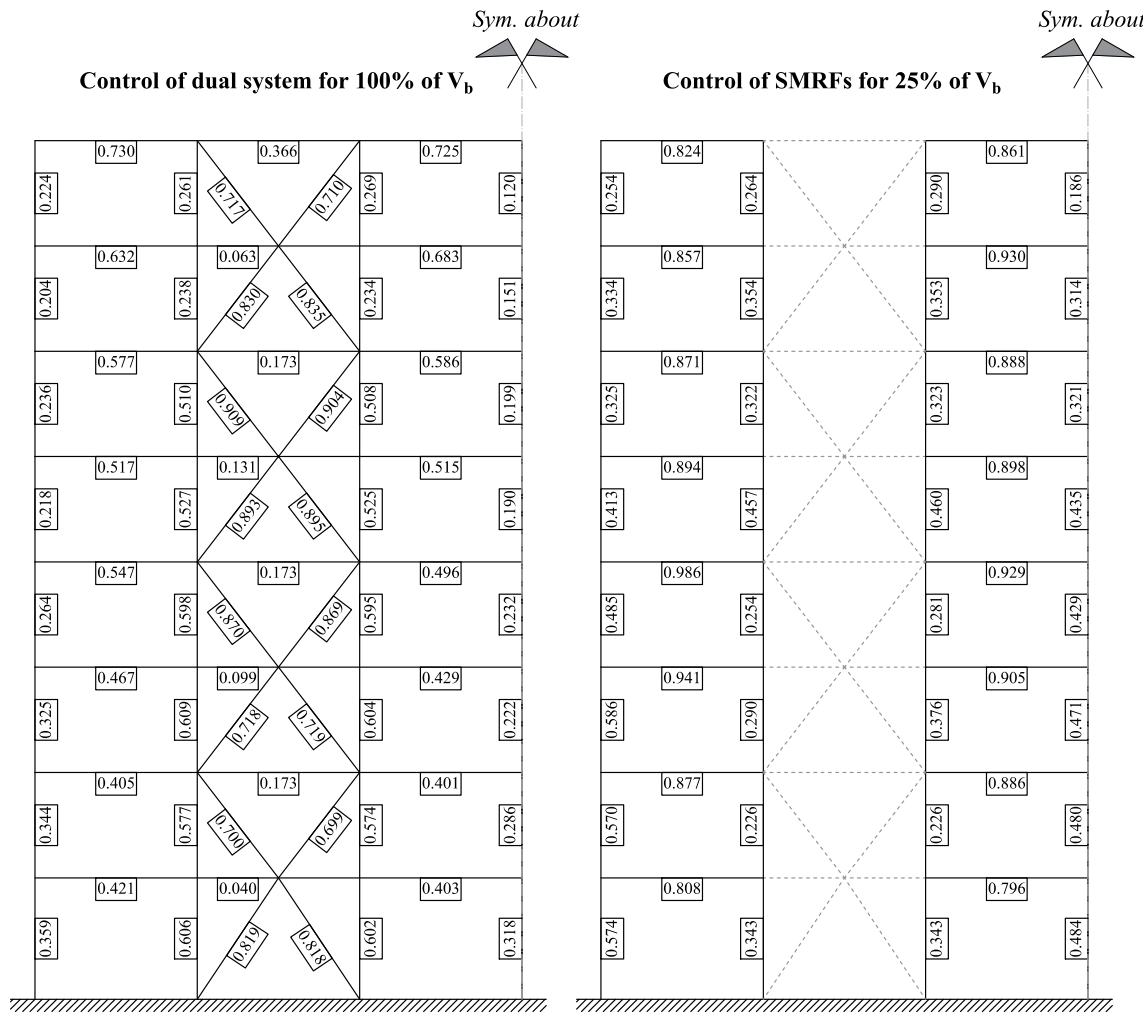
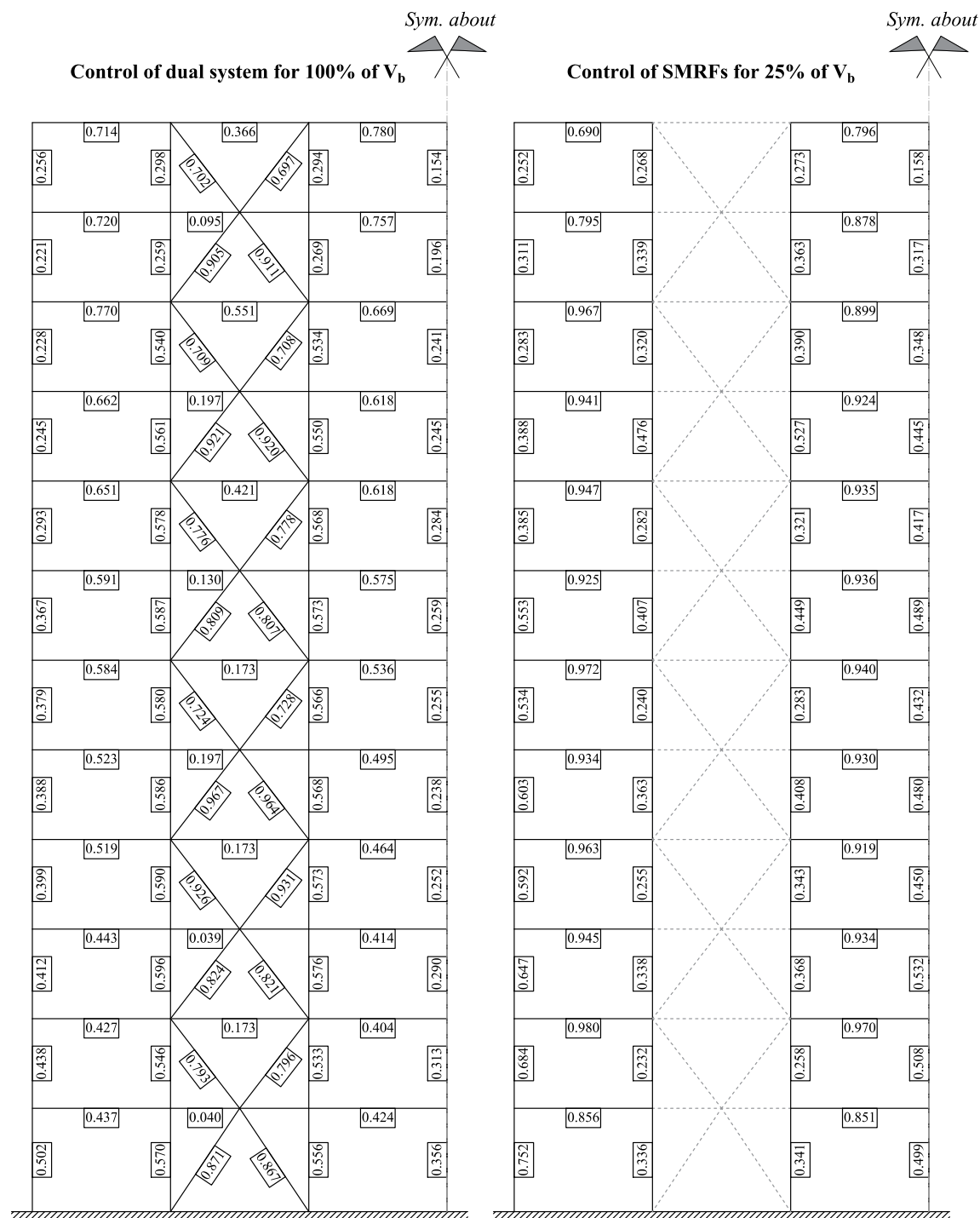
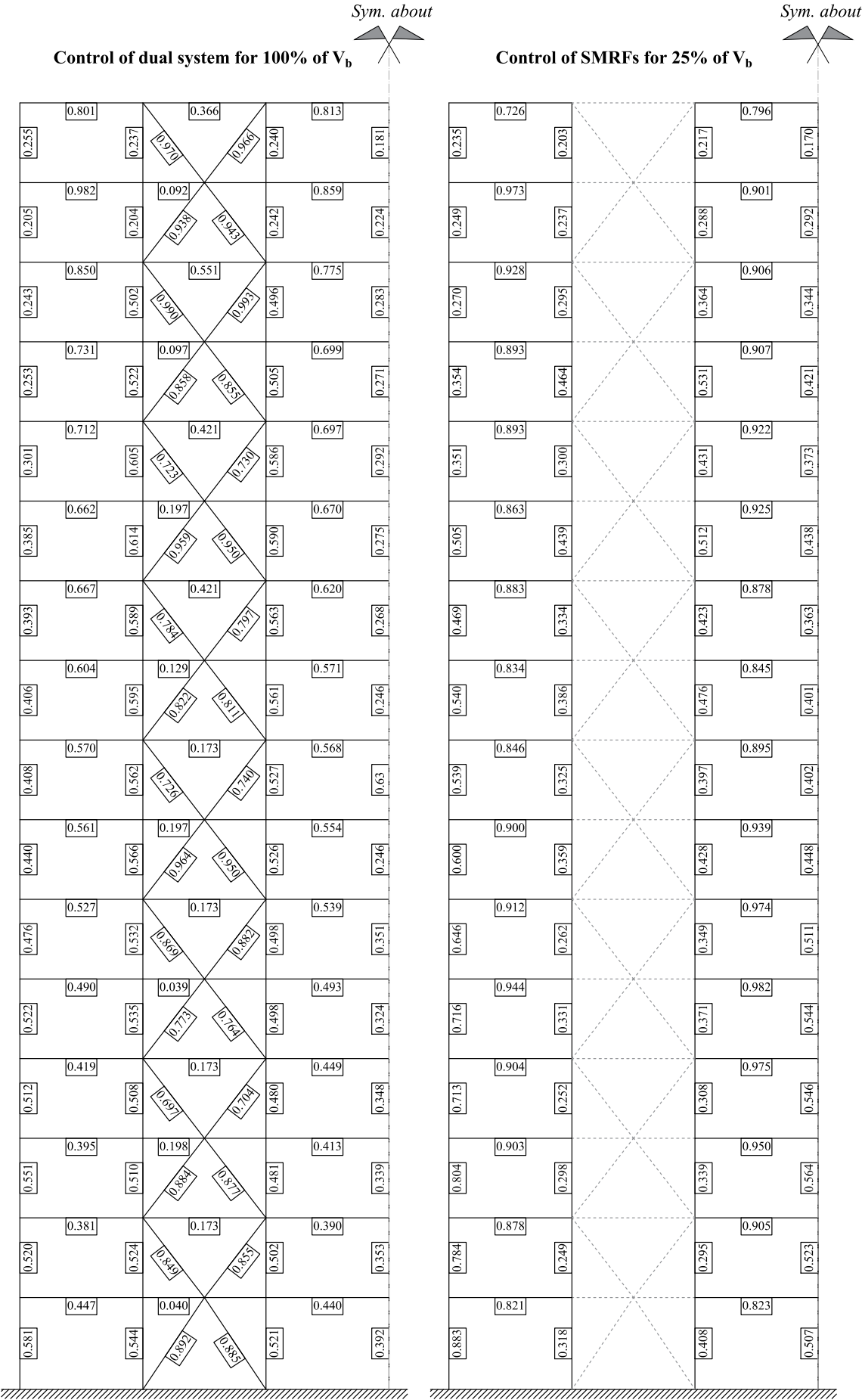


Fig. 4: The P-M ratio of designed cross-sections of 8-Story building archetype



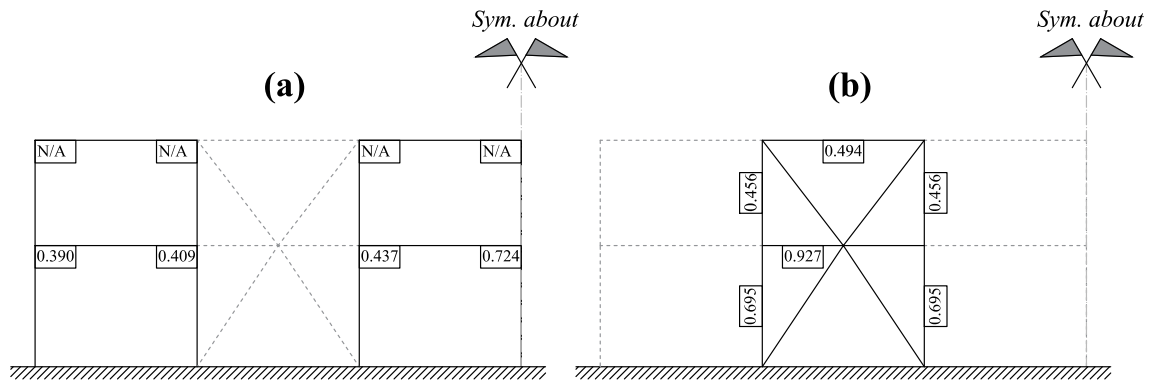
**Fig. 5:** The P-M ratio of designed cross-sections of 12-Story building archetype



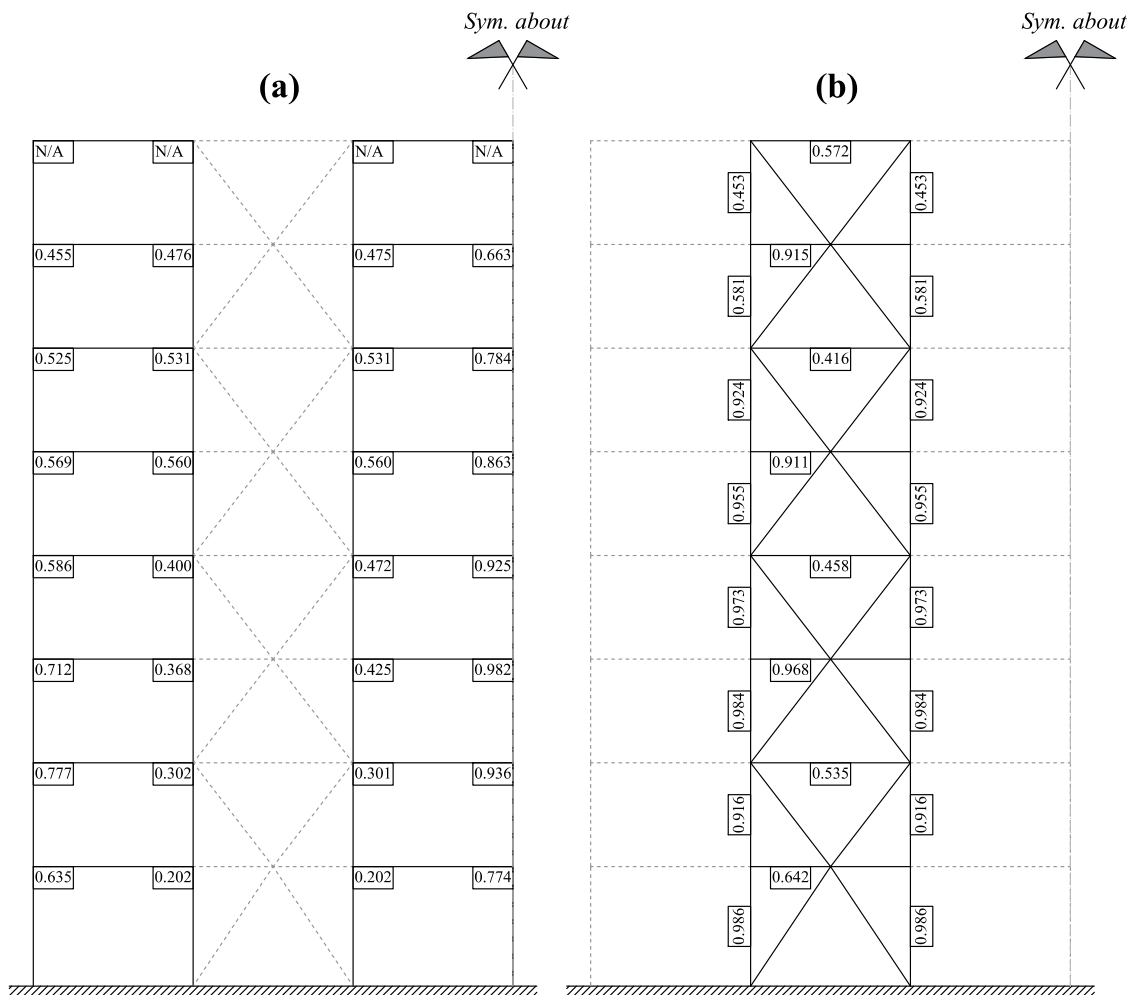


**Fig. 6:** The P-M ratio of designed cross-sections of 16-Story building archetype

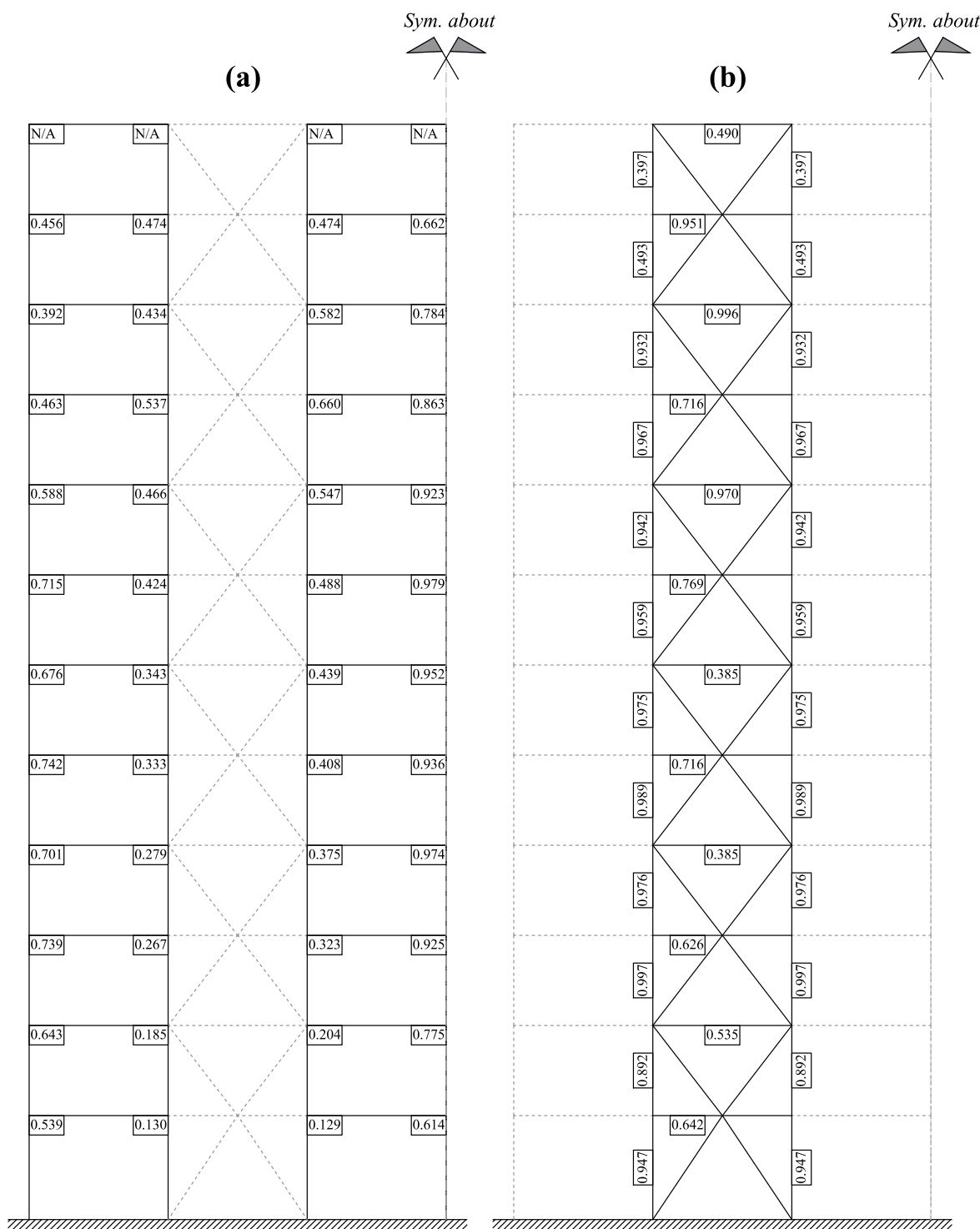
- All beam-to-column connections of SMRFs satisfied the requirements of AISC 341-16 § E3.4 for strong-column/weak-beam criteria.
- The required strength of columns and beams in SCBFs was determined using the capacity-limited seismic load effects. For this purpose, a code in Tcl/Tk language programming was developed according to provisions per AISC 341-16 § F2.3.
- Control of SMRFs for strong-column/weak-beam criteria, and the P-M ratio of SCBF members for capacity-limited seismic load effects are shown in Fig. 7 through Fig. 10.



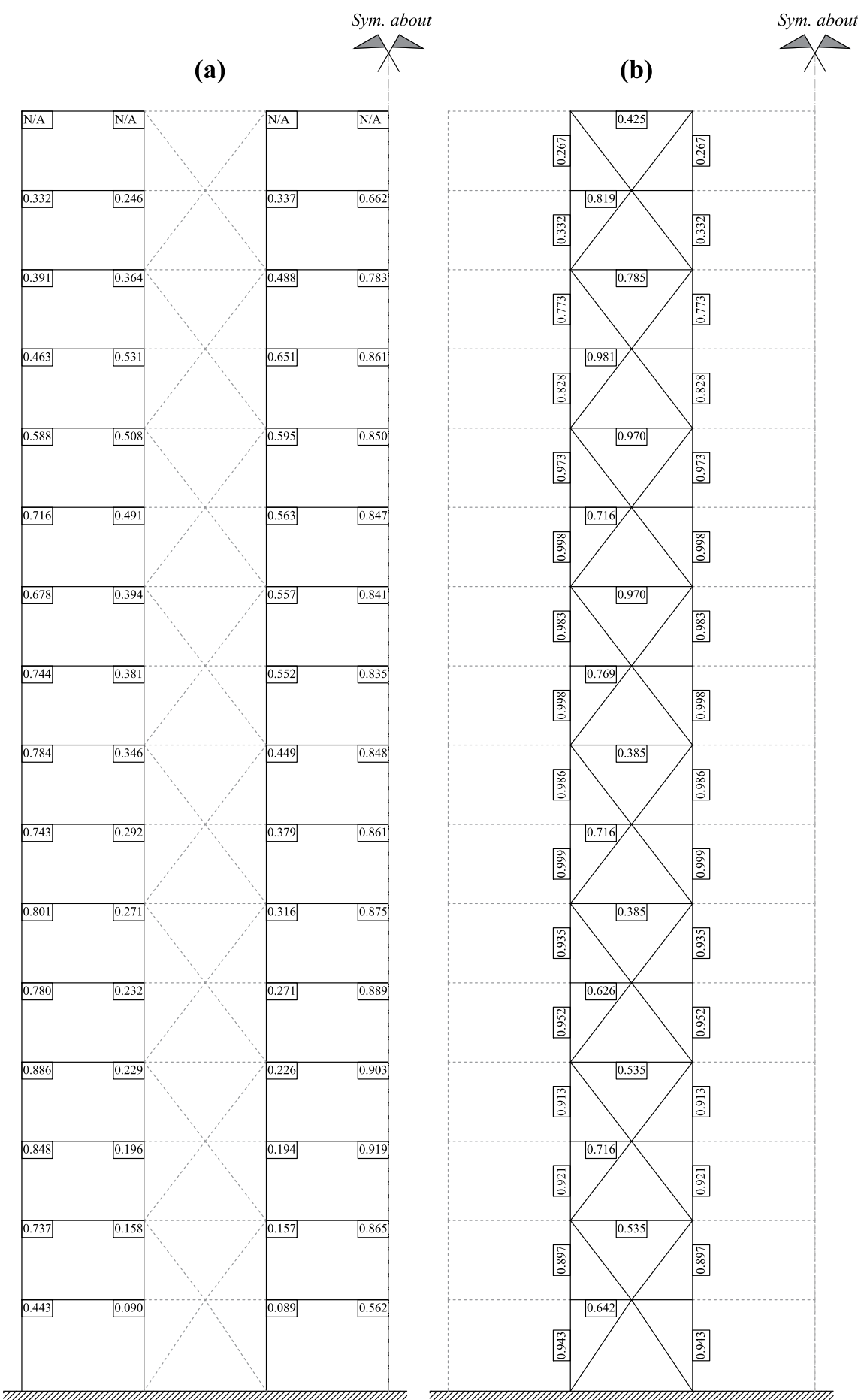
**Fig. 7:** Seismic provisions check per AISC 341-16 for 2-Story building archetype; a) strong-column/weak-beam criteria, b) capacity-limited seismic load effects



**Fig. 8:** Seismic provisions check per AISC 341-16 for 8-Story building archetype; a) strong-column/weak-beam criteria, b) capacity-limited seismic load effects



**Fig. 9:** Seismic provisions check per AISC 341-16 for 12-Story building archetype; a) strong-column/weak-beam criteria, b) capacity-limited seismic load effects



**Fig. 10:** Seismic provisions check per AISC 341-16 for 16-Story building archetype; a) strong-column/weak-beam criteria, b) capacity-limited seismic load effects

- The allowable drift compliance verification of all building archetypes are also illustrated in [Table 7](#).

**Table 7:** Verification of design story drifts for building archetypes

Archetype ID	Story Number	$\delta_{xe}$ (in)	$\delta_x = \delta_{xe} \cdot C_d / I_e$ (in)	$\Delta_i$	$\Delta_i / h_{sx} < 2\%$
2-Story	1	0.12	0.67	0.67	0.37
	2	0.23	1.27	0.61	0.39
8-Story	1	0.12	0.67	0.67	0.37
	2	0.29	1.62	0.95	0.61
	3	0.47	2.56	0.94	0.60
	4	0.69	3.82	1.26	0.80
	5	0.92	5.05	1.23	0.79
	6	1.17	6.43	1.38	0.89
	7	1.41	7.74	1.31	0.84
	8	1.64	9.01	1.27	0.82
12-Story	1	0.12	0.66	0.66	0.37
	2	0.28	1.57	0.91	0.58
	3	0.45	2.47	0.91	0.58
	4	0.67	3.71	1.24	0.79
	5	0.90	4.95	1.24	0.80
	6	1.15	6.30	1.35	0.86
	7	1.39	7.65	1.35	0.86
	8	1.66	9.12	1.48	0.95
	9	1.93	10.62	1.50	0.96
	10	2.22	12.19	1.56	1.00
	11	2.50	13.75	1.56	1.00
	12	2.77	15.24	1.49	0.96
16-Story	1	0.14	0.78	0.78	0.43
	2	0.34	1.85	1.07	0.68
	3	0.53	2.91	1.06	0.68
	4	0.75	4.11	1.20	0.77
	5	0.97	5.34	1.23	0.79
	6	1.25	6.86	1.52	0.97
	7	1.53	8.40	1.54	0.99
	8	1.82	10.03	1.63	1.04
	9	2.12	11.66	1.64	1.05
	10	2.44	13.43	1.77	1.13
	11	2.77	15.25	1.82	1.16
	12	3.12	17.16	1.90	1.22
	13	3.47	19.11	1.95	1.25
	14	3.85	21.19	2.08	1.34
	15	4.23	23.25	2.06	1.32
	16	4.58	25.22	1.97	1.26

$\delta_{xe}$ : elastic absolute displacement;  $\delta_x$ : inelastic absolute displacement;  $\Delta_i$ : inelastic drift;  $\Delta_i / h_{sx}$ : inelastic drift ratio

- Gusset plates are tapered plates, which have been designed using the method presented by Astaneh-Asl et al. [7]. The required strength of gusset plates has been determined using the capacity-limited seismic load effects, and the design process has been done using the developed MATLAB code. Fig. 11 demonstrates the geometric details of gusset plates, and their calculated dimensions using the code mentioned above are shown in Table 8 through Table 11.

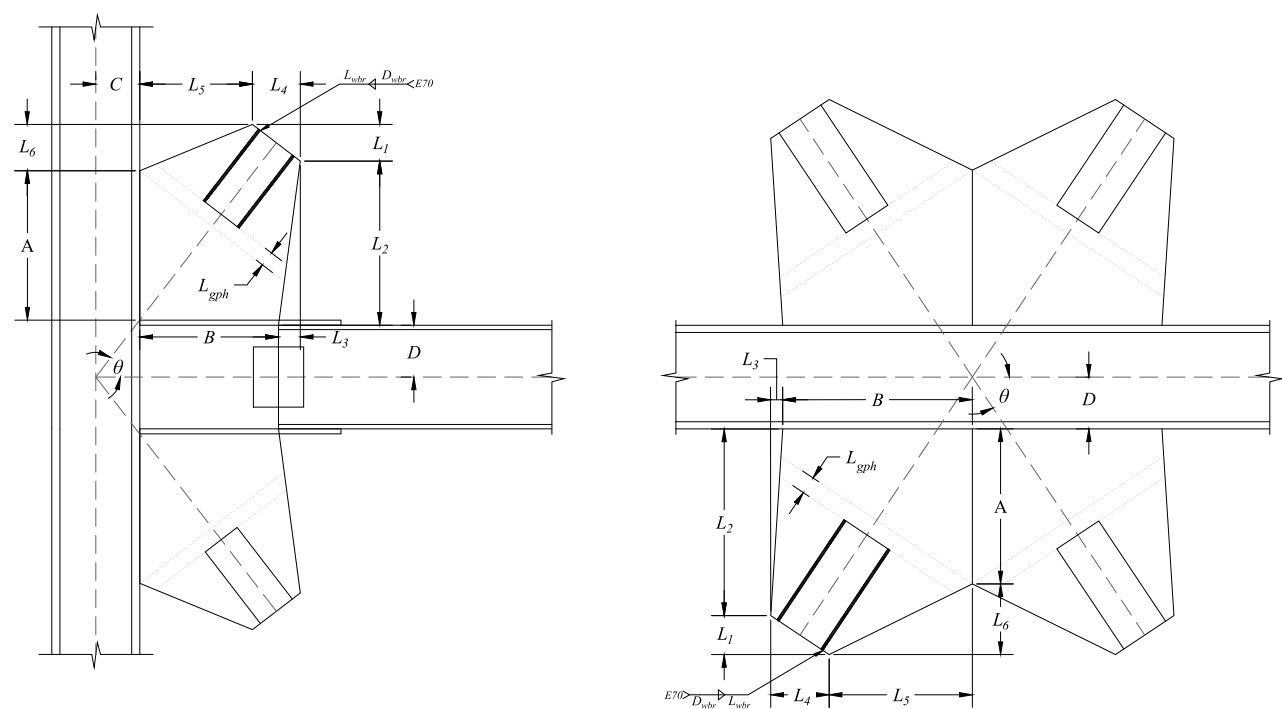


Fig. 11: Geometric parameters of gusset plates

Table 8: Gusset plates details of 2-Story building archetype

Level		Dimintions A, B, and L <sub>1</sub> to L <sub>6</sub> for gusset plates (all dimensions are in inches)										Weld properties	
		L <sub>1</sub>	L <sub>2</sub>	L <sub>3</sub>	L <sub>4</sub>	L <sub>5</sub>	L <sub>6</sub>	A	B	t <sub>g</sub>	L <sub>gph</sub>	L <sub>wbr</sub>	D <sub>wbr</sub>
3	Lower	3.35	19.14	2.54	4.36	13.34	5.51	16.98	15.16	0.5	1.5	10	0.31
2	Upper	3.35	14.31	1.9	4.36	16.44	6.78	10.88	18.89	0.5	1.5	10	0.31
2	Lower	3.88	17.5	1.13	5.82	15.53	7.68	13.71	20.22	0.75	2.0	12	0.38
1	Upper	3.88	32.28	2.08	5.82	15.53	7.68	28.48	19.27	0.75	2.0	12	0.38

t<sub>g</sub>: gusset plate thickness

**Table 9:** Gusset plates details of 8-Story building archetype

Level		Dimintions $A$ , $B$ , and $L_1$ to $L_6$ for gusset plates (all dimensions are in inches)										Weld properties	
		$L_1$	$L_2$	$L_3$	$L_4$	$L_5$	$L_6$	$A$	$B$	$t_g$	$L_{gph}$	$L_{wbr}$	$D_{wbr}$
9	Lower	3.66	19.41	2.58	4.76	13.34	5.51	17.56	15.52	0.5	1.5	10	0.38
8	Upper	3.66	14.31	1.9	4.76	16.35	6.75	11.21	19.21	0.5	1.5	10	0.38
8	Lower	3.96	17.17	2.28	5.15	18.47	7.63	13.51	21.35	0.75	2	12	0.44
7	Upper	3.96	20.85	2.77	5.15	16.01	6.61	18.21	18.39	0.75	2	12	0.44
7	Lower	3.96	20.85	2.77	5.15	16.01	6.61	18.21	18.39	0.75	2	12	0.44
6	Upper	3.96	17.17	2.28	5.15	16.04	6.62	14.51	18.91	0.75	2	12	0.44
6	Lower	4.27	17.24	2.29	5.55	16.01	6.61	14.89	19.27	0.75	2	12	0.5
5	Upper	4.27	22.63	3.01	5.55	16.01	6.61	20.29	18.55	0.75	2	12	0.5
5	Lower	4.27	22.63	3.01	5.55	16.01	6.61	20.29	18.55	0.75	2	12	0.5
4	Upper	4.27	17.17	2.28	5.55	16.76	6.92	14.52	20.03	0.75	2	12	0.5
4	Lower	4.88	18.31	2.43	6.34	17.48	7.22	15.98	21.39	0.75	2	13	0.56
3	Upper	4.88	25.73	3.42	6.34	17.08	7.05	23.55	20	0.75	2	13	0.56
3	Lower	4.88	25.73	3.42	6.34	17.08	7.05	23.55	20	0.75	2	13	0.56
2	Upper	4.88	18.31	2.43	6.34	19.24	7.94	15.25	23.14	0.75	2	13	0.56
2	Lower	4.44	21.57	1.39	6.66	18.11	8.96	17.05	23.38	1	2.5	14	0.63
1	Upper	4.44	41.73	2.69	6.66	18.11	8.96	37.22	22.08	1	2.5	14	0.63

 $t_g$ : gusset plate thickness**Table 10:** Gusset plates details of 12-Story building archetype

Level		Dimintions $A$ , $B$ , and $L_1$ to $L_6$ for gusset plates (all dimensions are in inches)										Weld properties	
		$L_1$	$L_2$	$L_3$	$L_4$	$L_5$	$L_6$	$A$	$B$	$t_g$	$L_{gph}$	$L_{wbr}$	$D_{wbr}$
13	Lower	3.66	19.41	2.58	4.76	13.34	5.51	17.56	15.52	0.5	1.5	10	0.31
12	Upper	3.66	14.31	1.9	4.76	14.72	6.08	11.89	17.58	0.5	1.5	10	0.31
12	Lower	3.96	15.45	2.05	5.15	15.52	6.41	13.01	18.62	0.5	1.5	11	0.38
11	Upper	3.96	21.94	2.92	5.15	14.41	5.95	19.95	16.65	0.5	1.5	11	0.38
11	Lower	4.27	24.13	3.21	5.55	16.01	6.61	21.78	18.35	0.75	2	12	0.38
10	Upper	4.27	17.17	2.28	5.55	16.1	6.65	14.79	19.37	0.75	2	12	0.38
10	Lower	4.27	17.17	2.28	5.55	16.1	6.65	14.79	19.37	0.75	2	12	0.38
9	Upper	4.27	24.72	3.28	5.55	16.01	6.61	22.38	18.27	0.75	2	12	0.38
9	Lower	4.27	24.72	3.28	5.55	16.01	6.61	22.38	18.27	0.75	2	12	0.38
8	Upper	4.27	17.24	2.29	5.55	16.01	6.61	14.89	19.27	0.75	2	12	0.38
8	Lower	4.57	19.42	2.58	5.94	17.61	7.27	16.72	20.98	0.5	1.5	14	0.38
7	Upper	4.57	25.22	3.35	5.94	17.61	7.27	22.52	20.21	0.5	1.5	14	0.38
7	Lower	4.57	25.22	3.35	5.94	17.61	7.27	22.52	20.21	0.5	1.5	14	0.38
6	Upper	4.57	19.24	2.56	5.94	17.61	7.27	16.54	21	0.5	1.5	14	0.38
6	Lower	4.57	19.24	2.56	5.94	17.61	7.27	16.54	21	0.5	1.5	14	0.38
5	Upper	4.57	26.31	3.5	5.94	17.61	7.27	23.62	20.06	0.5	1.5	14	0.38
5	Lower	4.57	26.31	3.5	5.94	17.61	7.27	23.62	20.06	0.5	1.5	14	0.38
4	Upper	4.57	18.89	2.51	5.94	19.76	8.16	15.3	23.19	0.5	1.5	14	0.38
4	Lower	4.88	20.6	2.74	6.34	21	8.67	16.81	24.6	0.75	2	15	0.5
3	Upper	4.88	29.41	3.91	6.34	19.21	7.93	26.36	21.65	0.75	2	15	0.5
3	Lower	4.88	29.41	3.91	6.34	19.21	7.93	26.36	21.65	0.75	2	15	0.5
2	Upper	4.88	20.6	2.74	6.34	21	8.67	16.81	24.6	0.75	2	15	0.5
2	Lower	4.44	23.9	1.54	6.66	19.67	9.72	18.61	24.78	0.75	2	16	0.56
1	Upper	4.44	45.11	2.91	6.66	19.67	9.72	39.83	23.41	0.75	2	16	0.56

 $t_g$ : gusset plate thickness

Table 11: Gusset plates details of 16-Story building archetype

Level		Dimentions $A$ , $B$ , and $L_1$ to $L_6$ for gusset plates (all dimensions are in inches)										Weld properties	
		$L_1$	$L_2$	$L_3$	$L_4$	$L_5$	$L_6$	$A$	$B$	$t_g$	$L_{gph}$	$L_{wbr}$	$D_{wbr}$
17	Lower	3.35	18.95	2.52	4.36	12.27	5.07	17.24	14.12	0.5	1.5	9	0.31
16	Upper	3.35	13.16	1.75	4.36	13.92	5.75	10.77	16.53	0.5	1.5	9	0.31
16	Lower	3.96	14.31	1.9	5.15	14.64	6.04	12.23	17.89	0.5	1.5	10	0.38
15	Upper	3.96	20.55	2.73	5.15	13.34	5.51	19.01	15.76	0.5	1.5	10	0.38
15	Lower	3.96	20.55	2.73	5.15	13.34	5.51	19.01	15.76	0.5	1.5	10	0.38
14	Upper	3.96	14.31	1.9	5.15	14.64	6.04	12.23	17.89	0.5	1.5	10	0.38
14	Lower	4.27	17.17	2.28	5.55	16.76	6.92	14.52	20.03	0.75	2	12	0.38
13	Upper	4.27	24.57	3.26	5.55	16.01	6.61	22.23	18.29	0.75	2	12	0.38
13	Lower	4.27	24.57	3.26	5.55	16.01	6.61	22.23	18.29	0.75	2	12	0.38
12	Upper	4.27	17.17	2.28	5.55	16.1	6.65	14.79	19.37	0.75	2	12	0.38
12	Lower	4.27	17.17	2.28	5.55	16.1	6.65	14.79	19.37	0.75	2	12	0.38
11	Upper	4.27	25.1	3.34	5.55	16.01	6.61	22.76	18.22	0.75	2	12	0.38
11	Lower	4.27	25.1	3.34	5.55	16.01	6.61	22.76	18.22	0.75	2	12	0.38
10	Upper	4.27	17.24	2.29	5.55	16.01	6.61	14.89	19.27	0.75	2	12	0.38
10	Lower	4.57	17.34	2.3	5.94	16.01	6.61	15.3	19.65	0.75	2	12	0.44
9	Upper	4.57	24.08	3.2	5.94	16.01	6.61	22.04	18.76	0.75	2	12	0.44
9	Lower	4.57	24.08	3.2	5.94	16.01	6.61	22.04	18.76	0.75	2	12	0.44
8	Upper	4.57	17.17	2.28	5.94	16.02	6.61	15.13	19.68	0.75	2	12	0.44
8	Lower	4.57	17.17	2.28	5.94	16.02	6.61	15.13	19.68	0.75	2	12	0.44
7	Upper	4.57	24.66	3.28	5.94	16.01	6.61	22.63	18.68	0.75	2	12	0.44
7	Lower	4.57	24.66	3.28	5.94	16.01	6.61	22.63	18.68	0.75	2	12	0.44
6	Upper	4.57	17.17	2.28	5.94	18.44	7.61	14.13	22.1	0.75	2	12	0.44
6	Lower	4.88	18.31	2.43	6.34	19.24	7.94	15.25	23.14	0.75	2	13	0.56
5	Upper	4.88	26.91	3.58	6.34	17.08	7.05	24.74	19.84	0.75	2	13	0.56
5	Lower	4.88	26.91	3.58	6.34	17.08	7.05	24.74	19.84	0.75	2	13	0.56
4	Upper	4.88	18.65	2.48	6.34	17.08	7.05	16.48	20.94	0.75	2	13	0.56
4	Lower	4.88	18.65	2.48	6.34	17.08	7.05	16.48	20.94	0.75	2	13	0.56
3	Upper	4.88	27.64	3.67	6.34	17.08	7.05	25.47	19.75	0.75	2	13	0.56
3	Lower	4.88	27.64	3.67	6.34	17.08	7.05	25.47	19.75	0.75	2	13	0.56
2	Upper	4.88	18.31	2.43	6.34	19.24	7.94	15.25	23.14	0.75	2	13	0.56
2	Lower	4.44	21.57	1.39	6.66	18.11	8.96	17.05	23.38	1	2.5	14	0.63
1	Upper	4.44	43.95	2.83	6.66	18.11	8.96	39.43	21.94	1	2.5	14	0.63

$t_g$ : gusset plate thickness



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