

Design Details of Building Archetypes with Dual Steel

SMF-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 depicted in the flow chart of Fig. 1.

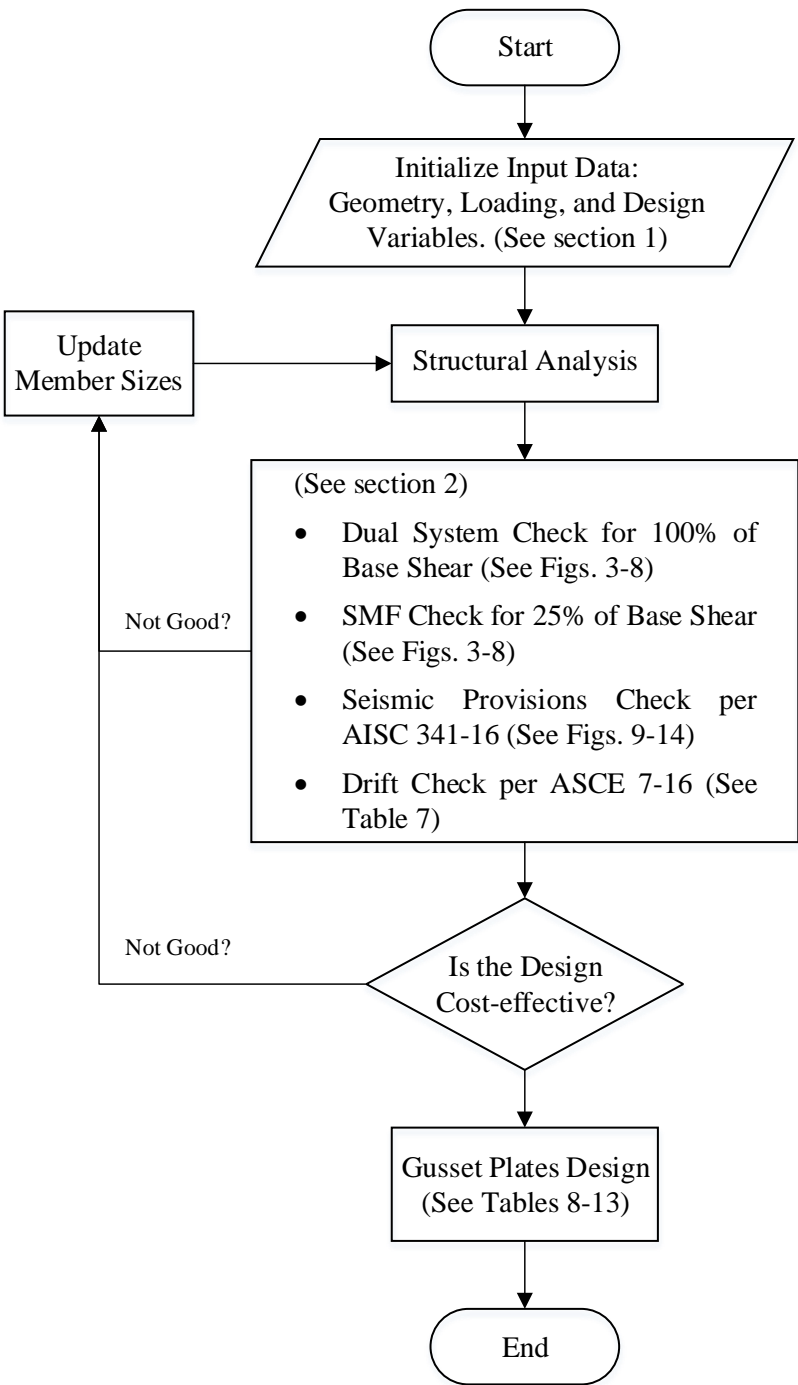


Fig. 1: Flow chart of the design process

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.

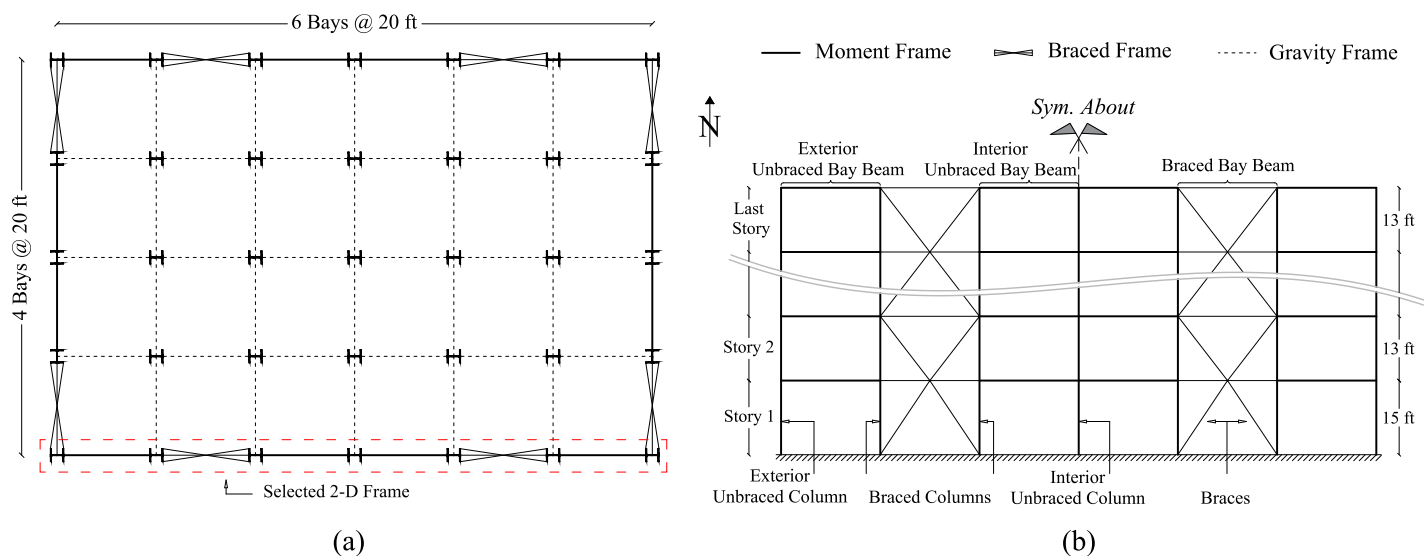


Fig. 2: Typical plan and elevation view of building archetypes; a) plan, b) elevation

- 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].
 4. AISC 358-16: *Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Application* [6].
- 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 [7], 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 _{max}	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	4-Story	8-Story	12-Story	16-Story	20-Story
Analysis Procedure	RSA	RSA	RSA	RSA	RSA	RSA
R, Ω_0, C_d	7, 2.5, 5.5	7, 2.5, 5.5	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	0.558	0.925	1.248	1.545	1.823
T_I^* (sec.)	0.371	0.614	1.199	1.969	2.672	3.140
C_s	0.143	0.143	0.105	0.078	0.063	0.053
W (kips)	984	1978	3966	5954	7942	9930
V_b ELF (kips)	140.6	282.6	416.5	463.5	499.5	529.0
V_b RSA (kips)	130.4	231.1	243.3	258.3	260.7	278.1
RSA Scaling Factor	1.078	1.223	1.712	1.794	1.916	1.902
V_b Design (kips)	140.6	282.6	416.5	463.5	499.5	529.0
V_b Drift (kips)	130.1	233.4	264.0	273.9	340.3	851.1

*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 2nd Order” method.
- The “Direct Analysis Method” (DAM) was used to check/design the steel members.
- The P- Δ 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 seismic codes 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.
- Beam to column connections of the SMFs were considered of the type Welded Unreinforced Flange-Welded Web (WUF-W) moment connections, satisfying requirements of AISC 358-16 [6] code.
- 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. 8](#).
- All beam-to-column connections of SMFs 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 SMFs for strong-column/weak-beam criteria and the P-M ratio of SCBF members for capacity-limited seismic load effects are shown in [Fig. 9](#) through [Fig. 14](#).
- The allowable drift compliance verification of all building archetypes are also illustrated in [Table 7](#).
- Gusset plates are tapered plates, which have been designed using the method presented by Astaneh-Asl et al. [8]. 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. 15](#) demonstrates the geometric details of gusset plates, and their calculated dimensions using the code mentioned above are shown in [Table 8](#) through [Table 13](#).

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

Archetype ID	Story Number	Braces	Dimentions*			Width to Thickness Ratio b / t	Limit $0.65\sqrt{(E / (R_y \cdot F_y))}$
			W (in)	b (in)	t (in)		
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	
4-Story	1	HSS 6×6×1/2	6	4.605	0.465	9.90	13.79
	2	HSS 5×5×3/8	5	3.953	0.349	11.33	
	3	HSS 5×5×3/8	5	3.953	0.349	11.33	
	4	HSS 4×4×5/16	4	3.127	0.291	10.75	
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	
20-Story	1	HSS 7×7×1/2	7	5.605	0.465	12.05	13.79
	2	HSS 7×7×1/2	7	5.605	0.465	12.05	
	3	HSS 7×7×1/2	7	5.605	0.465	12.05	
	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 6×6×1/2	6	4.605	0.465	9.90	
	7	HSS 6×6×1/2	6	4.605	0.465	9.90	
	8	HSS 6×6×1/2	6	4.605	0.465	9.90	
	9	HSS 6×6×1/2	6	4.605	0.465	9.90	
	10	HSS 5×5×1/2	5	3.605	0.465	7.75	
	11	HSS 5×5×1/2	5	3.605	0.465	7.75	
	12	HSS 5.5×5.5×3/8	5.5	4.453	0.349	12.76	
	13	HSS 5.5×5.5×3/8	5.5	4.453	0.349	12.76	
	14	HSS 5×5×3/8	5	3.953	0.349	11.33	
	15	HSS 5×5×3/8	5	3.953	0.349	11.33	
	16	HSS 5×5×3/8	5	3.953	0.349	11.33	
	17	HSS 5×5×3/8	5	3.953	0.349	11.33	
	18	HSS 4.5×4.5×5/16	4.5	3.627	0.291	12.46	
	19	HSS 4.5×4.5×5/16	4.5	3.627	0.291	12.46	
	20	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
4-Story	1	W12×96	W10×100	W10×77	W16×89	W16×31	W16×31	HSS 6×6×1/2
	2	W12×96	W10×100	W10×77	W12×50	W16×31	W16×31	HSS 5×5×3/8
	3	W10×68	W10×77	W10×68	W14×53	W14×26	W14×26	HSS 5×5×3/8
	4	W10×68	W10×77	W10×68	W10×45	W12×22	W12×19	HSS 4×4×5/16
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
20-Story	1	W14×605	W14×233	W12×190	W12×50	W18×50	W18×40	HSS 7×7×1/2
	2	W14×605	W14×233	W12×190	W16×89	W18×71	W18×60	HSS 7×7×1/2
	3	W14×445	W14×193	W12×170	W12×50	W21×68	W18×65	HSS 7×7×1/2
	4	W14×445	W14×193	W12×170	W16×89	W21×68	W18×65	HSS 6×6×1/2
	5	W14×398	W14×176	W12×152	W10×30	W21×68	W18×65	HSS 6×6×1/2
	6	W14×398	W14×176	W12×152	W16×89	W21×68	W18×65	HSS 6×6×1/2
	7	W14×311	W12×190	W12×106	W10×30	W21×68	W18×60	HSS 6×6×1/2
	8	W14×311	W12×190	W12×106	W16×89	W21×68	W18×60	HSS 6×6×1/2
	9	W14×257	W12×190	W12×96	W12×50	W18×71	W18×60	HSS 6×6×1/2
	10	W14×257	W12×190	W12×96	W16×89	W18×71	W18×55	HSS 5×5×1/2
	11	W12×210	W12×170	W10×88	W14×53	W18×71	W18×55	HSS 5×5×1/2
	12	W12×210	W12×170	W10×88	W16×89	W18×65	W18×46	HSS 5.5×5.5×3/8
	13	W12×152	W12×152	W10×88	W10×45	W18×60	W18×46	HSS 5.5×5.5×3/8
	14	W12×152	W12×152	W10×88	W12×50	W18×55	W18×40	HSS 5×5×3/8
	15	W12×106	W12×136	W10×77	W10×30	W18×55	W18×35	HSS 5×5×3/8
	16	W12×106	W12×136	W10×77	W12×50	W18×40	W18×35	HSS 5×5×3/8
	17	W10×77	W12×96	W10×77	W12×50	W18×35	W18×35	HSS 5×5×3/8
	18	W10×77	W12×96	W10×77	W10×45	W18×35	W16×31	HSS 4.5×4.5×5/16
	19	W8×67	W10×77	W8×67	W12×50	W16×31	W14×26	HSS 4.5×4.5×5/16
	20	W8×67	W10×77	W8×67	W10×45	W14×26	W10×26	HSS 3.5×3.5×5/16

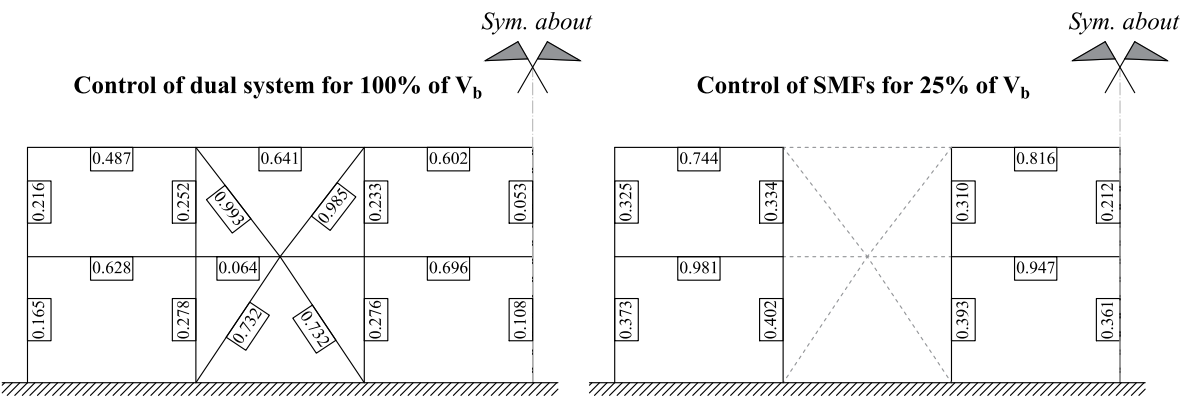


Fig. 3: The P-M ratio of designed cross-sections of 2-Story building archetype

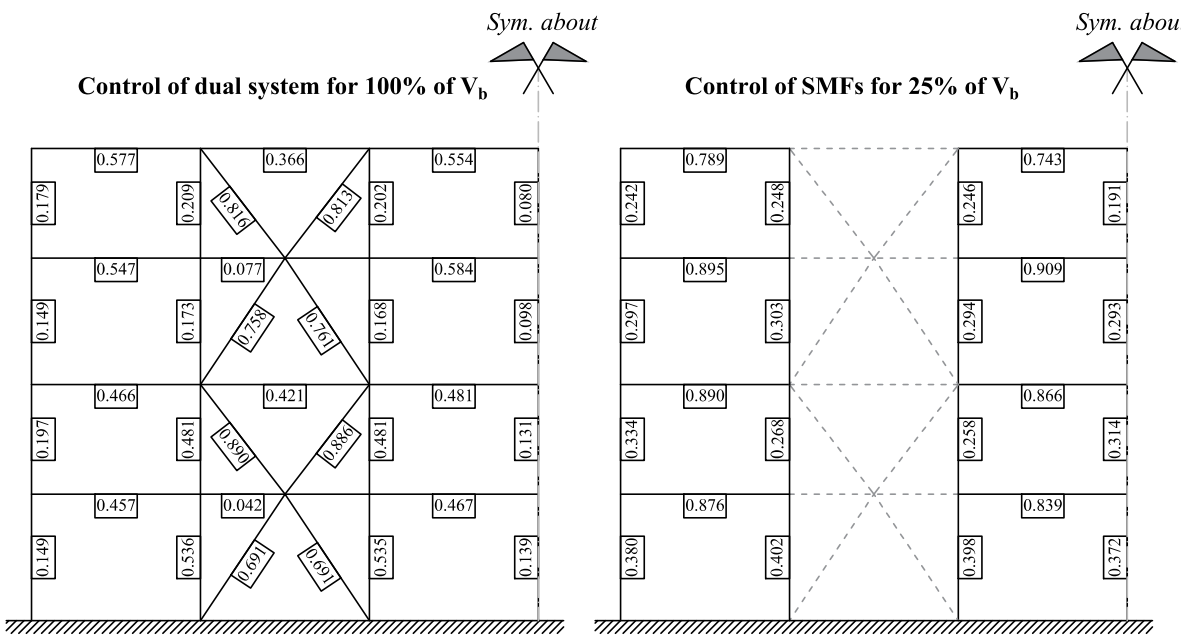


Fig. 4: The P-M ratio of designed cross-sections of 4-Story building archetype

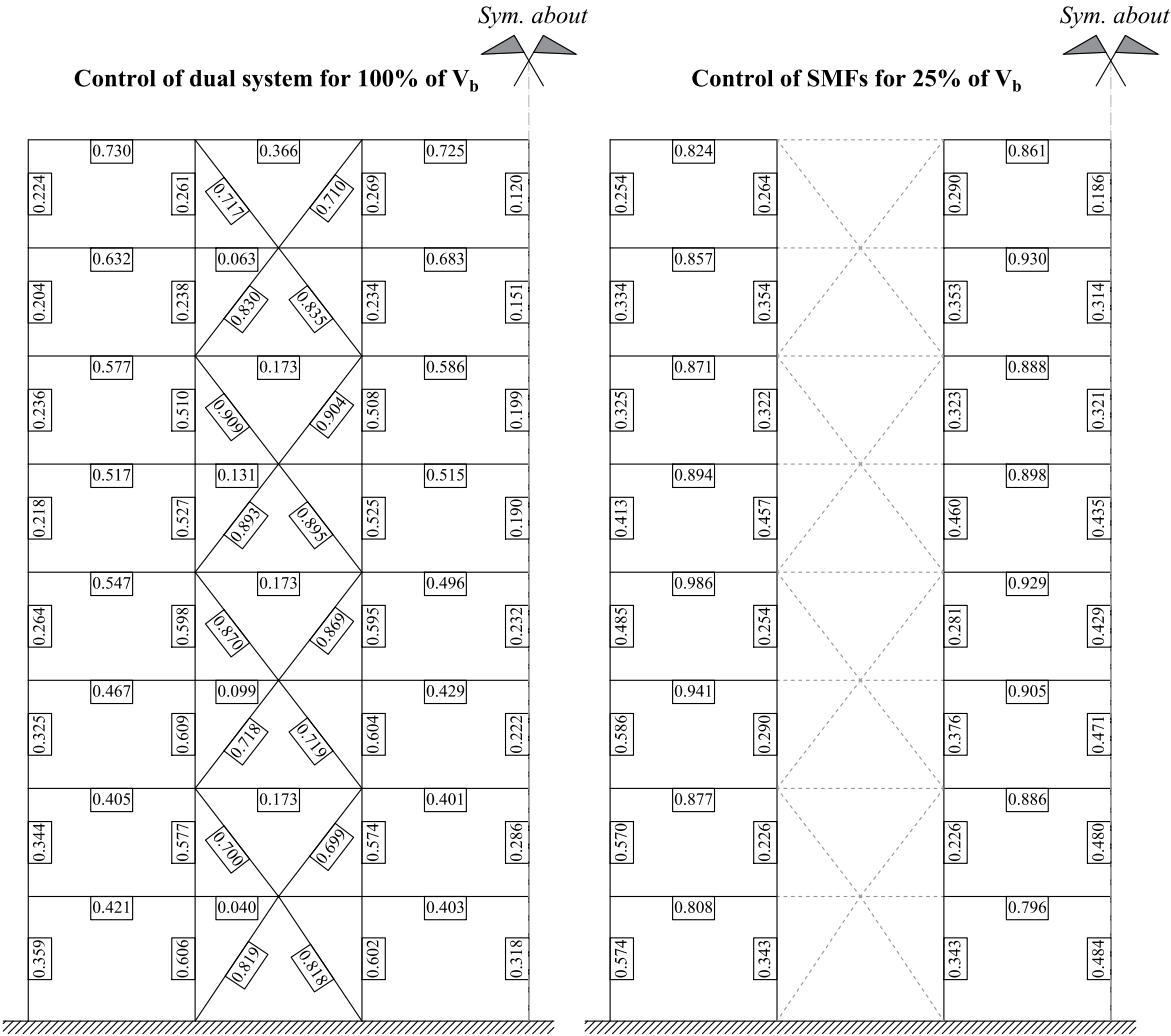


Fig. 5: The P-M ratio of designed cross-sections of 8-Story building archetype

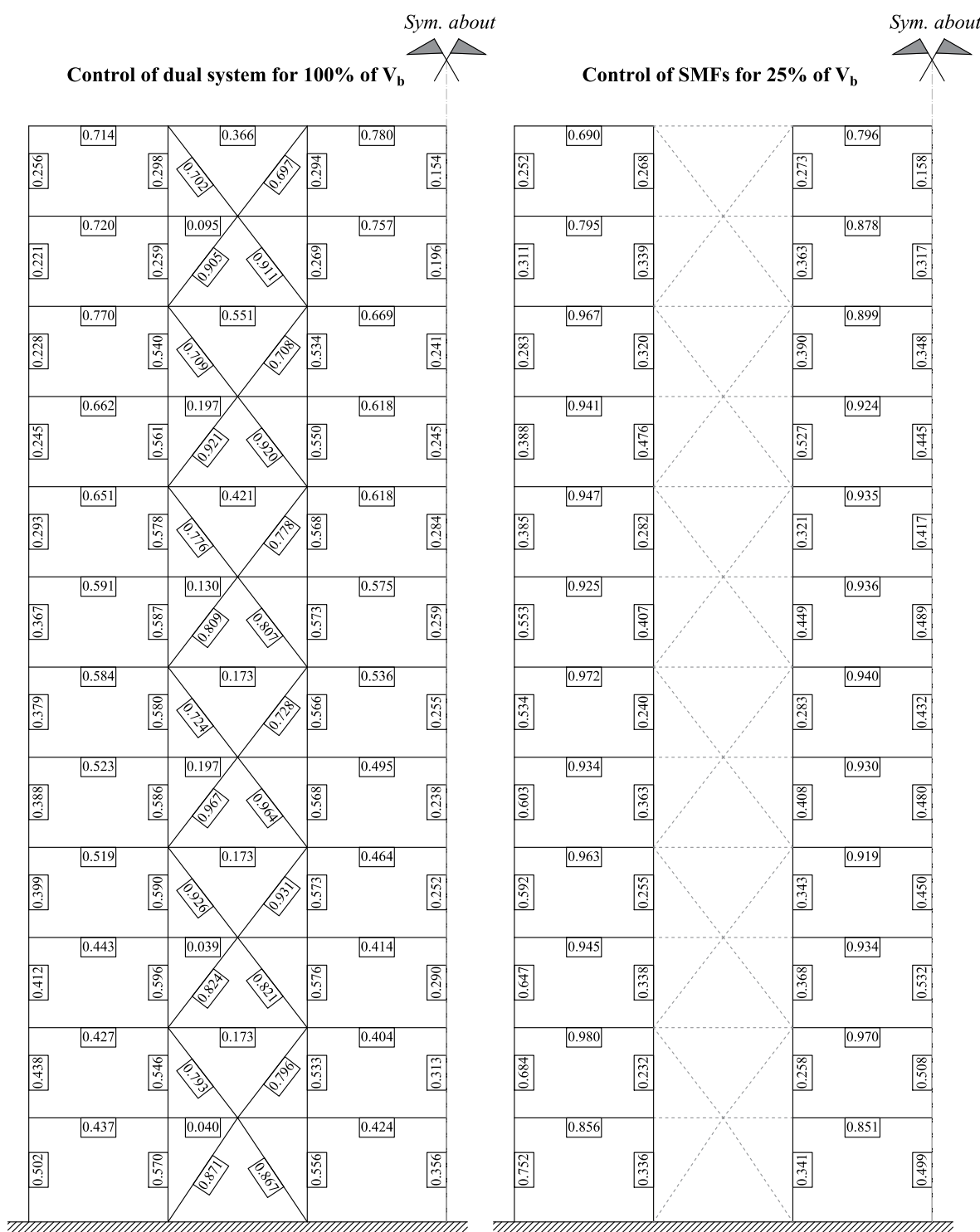


Fig. 6: The P-M ratio of designed cross-sections of 12-Story building archetype

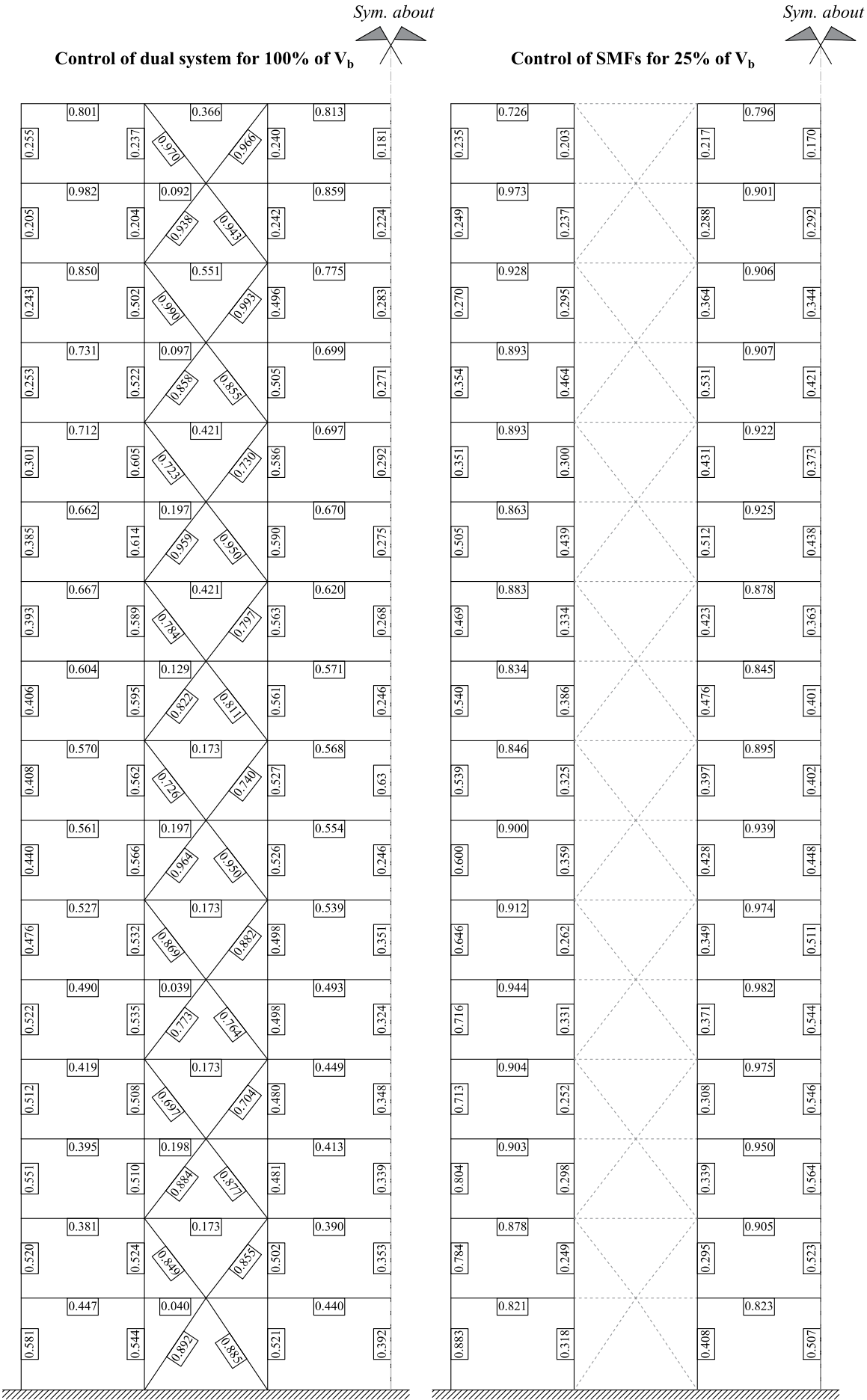


Fig. 7: The P-M ratio of designed cross-sections of 16-Story building archetype

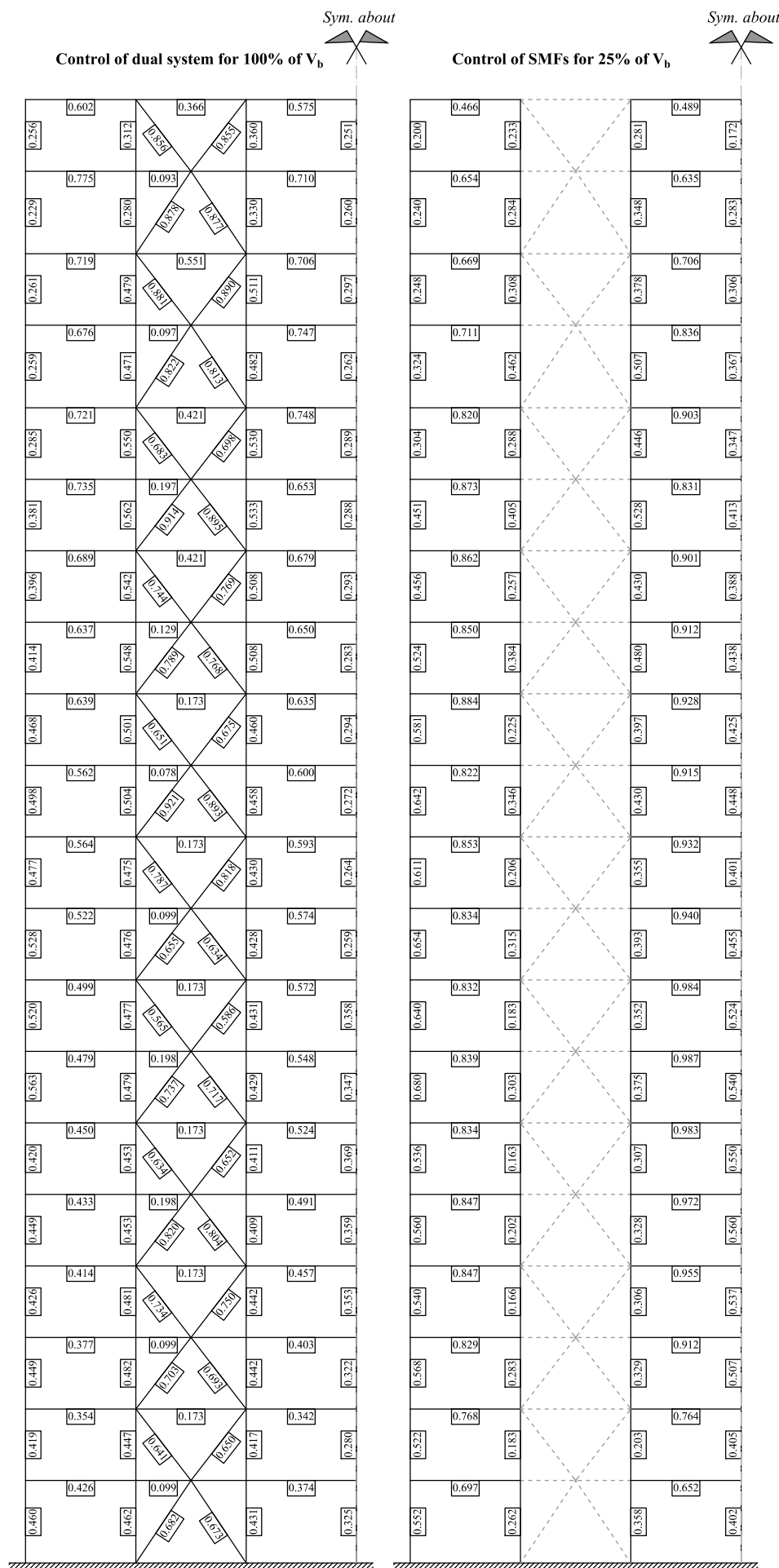


Fig. 8: The P-M ratio of designed cross-sections of 20-Story building archetype

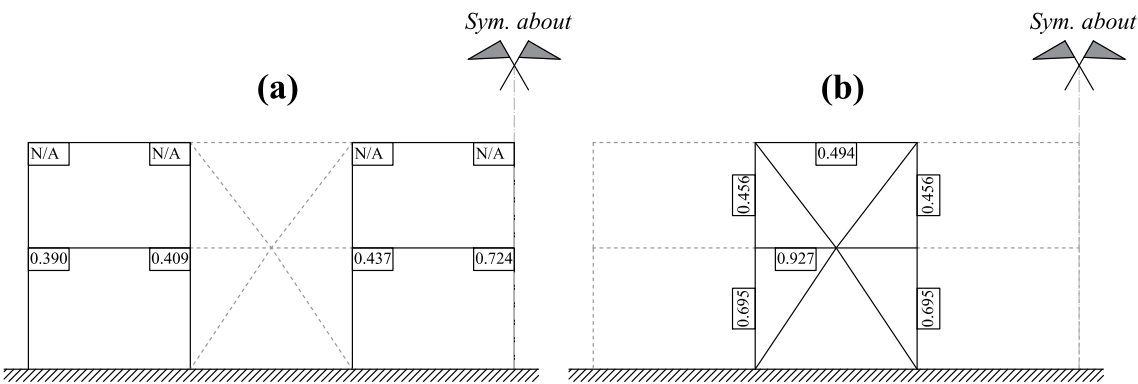


Fig. 9: Seismic provisions check per AISC 341-16 for 2-Story building archetype; a) strong-column/weak-beam criteria, b) capacity-limited seismic load effects

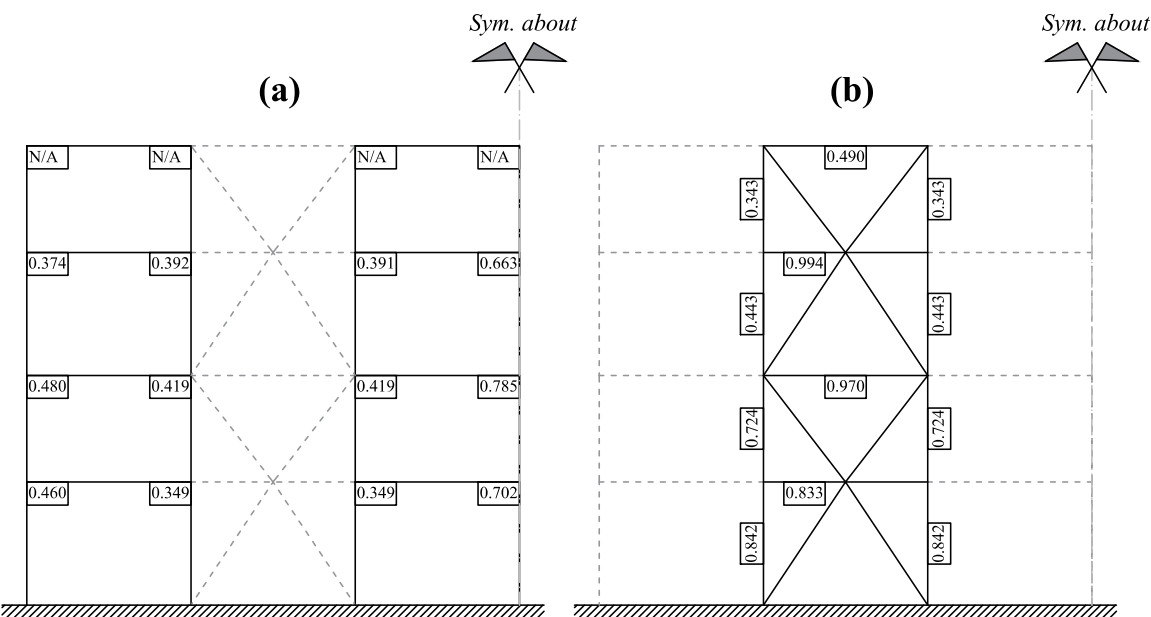


Fig. 10: Seismic provisions check per AISC 341-16 for 4-Story building archetype; a) strong-column/weak-beam criteria, b) capacity-limited seismic load effects

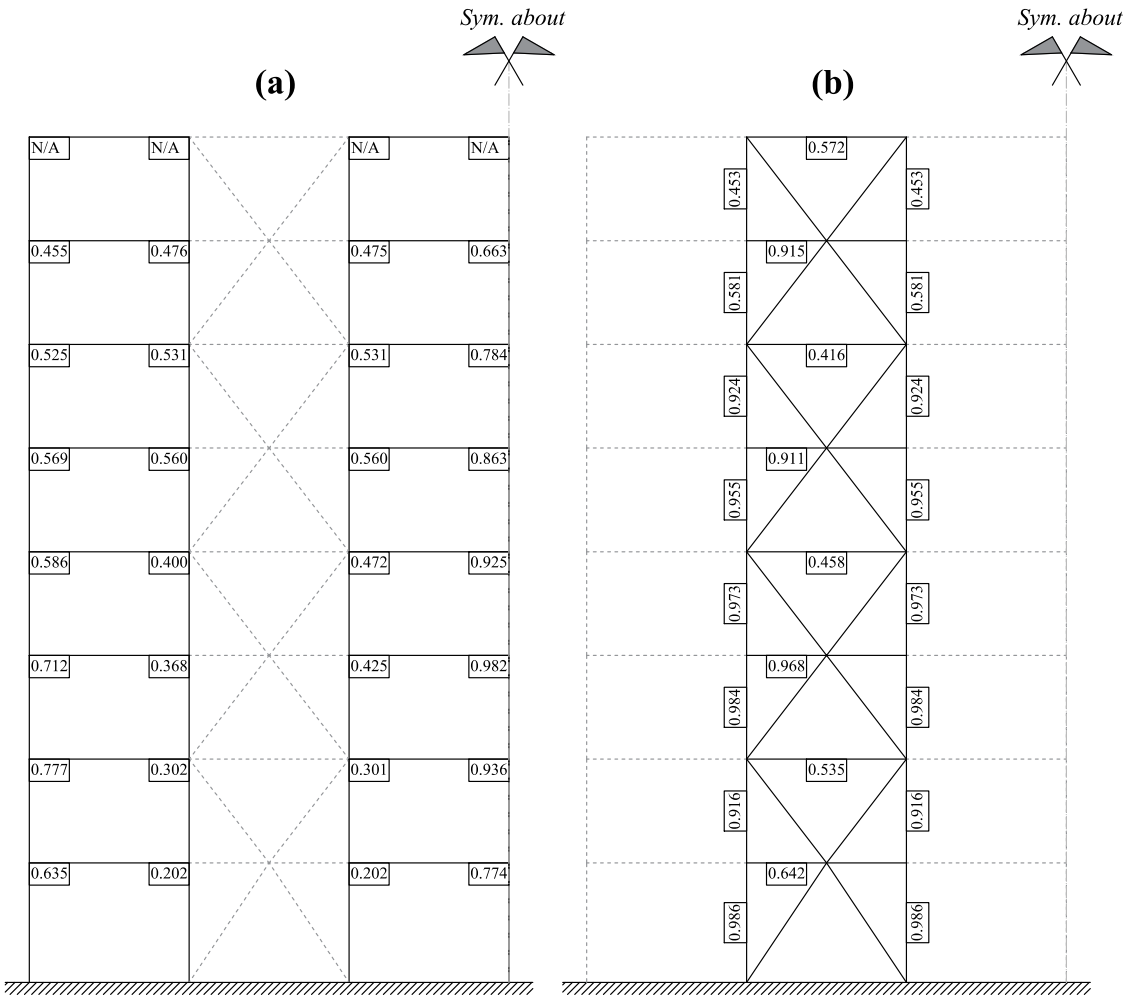


Fig. 11: Seismic provisions check per AISC 341-16 for 8-Story building archetype; a) strong-column/weak-beam criteria, b) capacity-limited seismic load effects

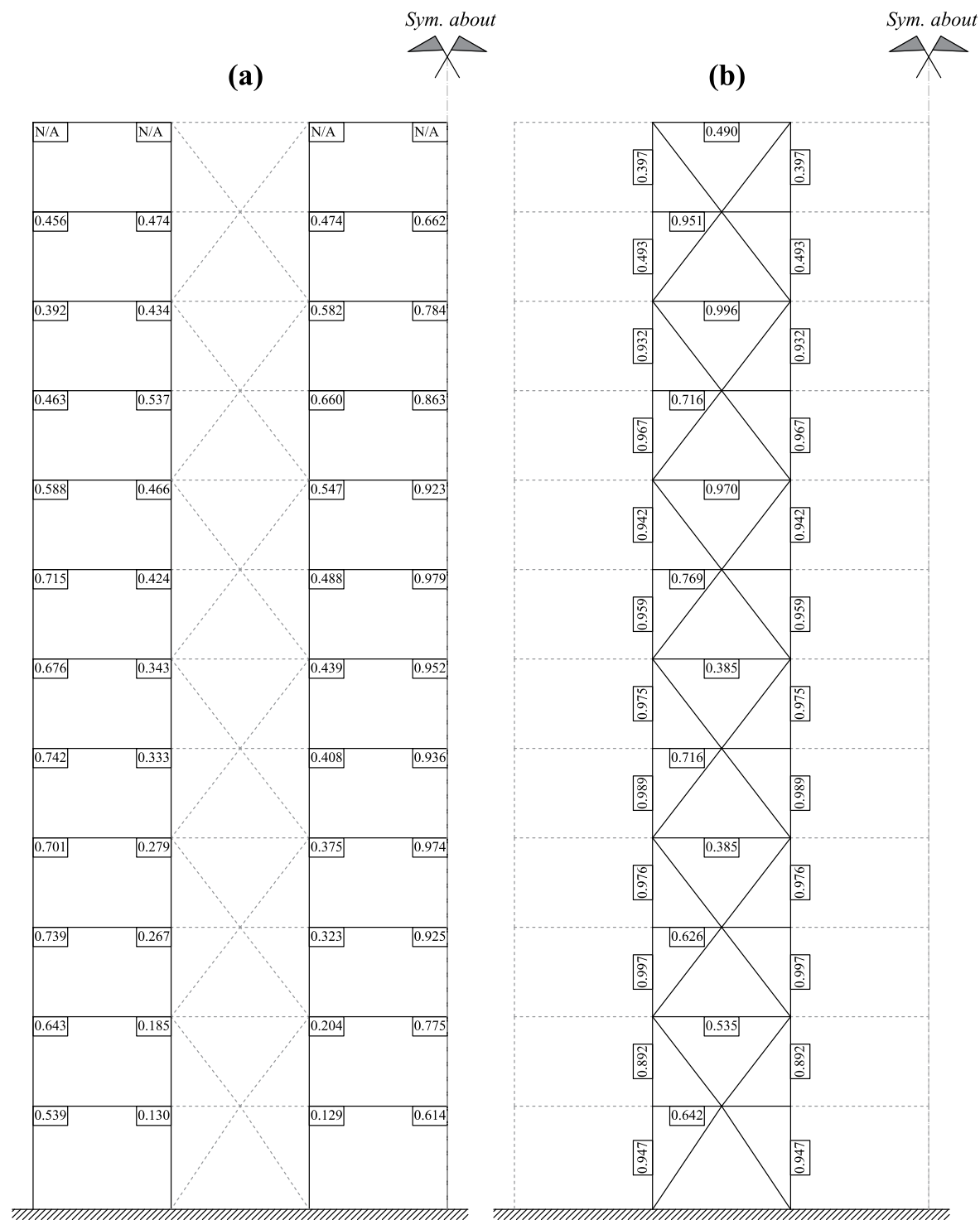


Fig. 12: Seismic provisions check per AISC 341-16 for 12-Story building archetype; a) strong-column/weak-beam criteria, b) capacity-limited seismic load effects

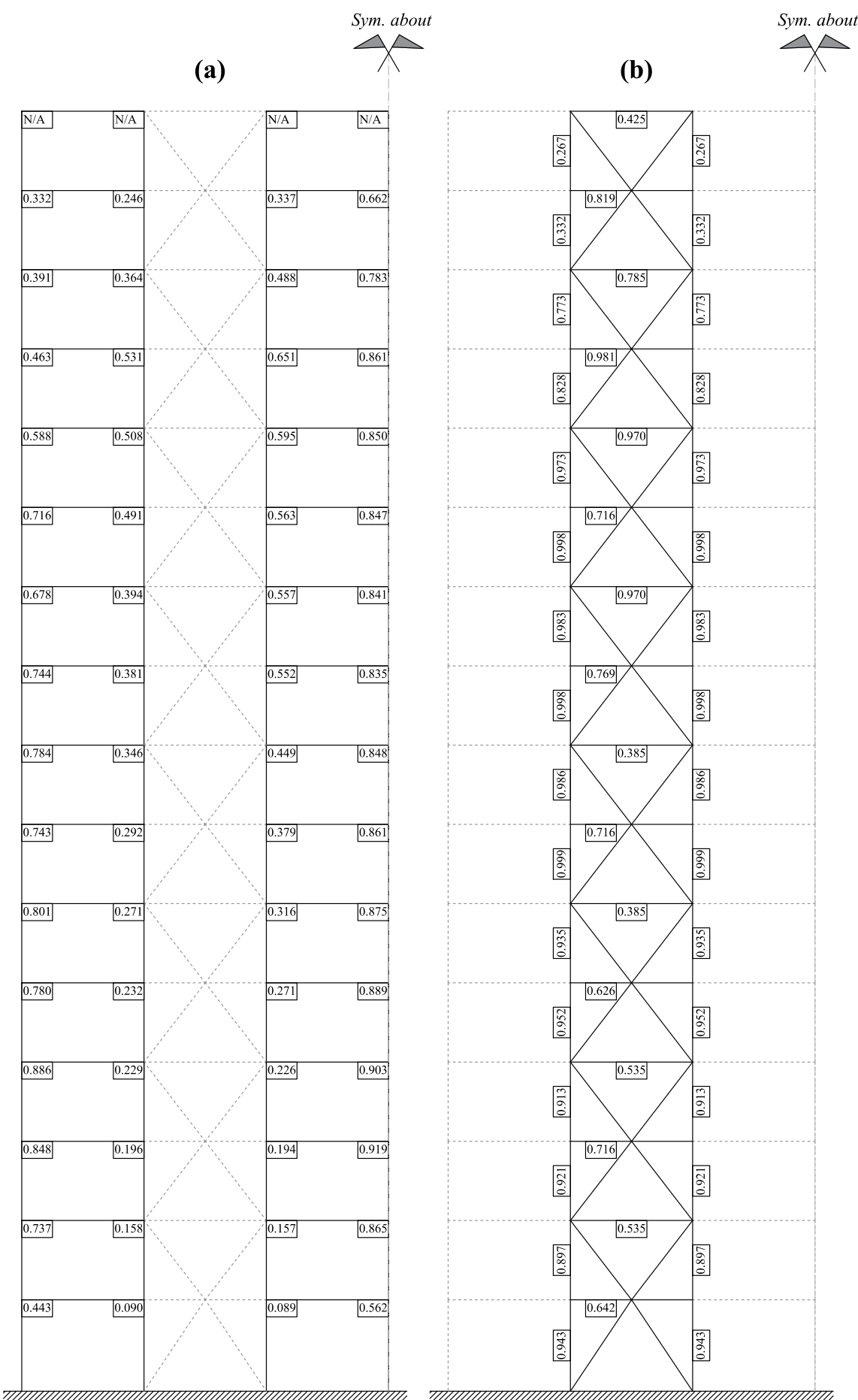


Fig. 13: Seismic provisions check per AISC 341-16 for 16-Story building archetype; a) strong-column/weak-beam criteria, b) capacity-limited seismic load effects

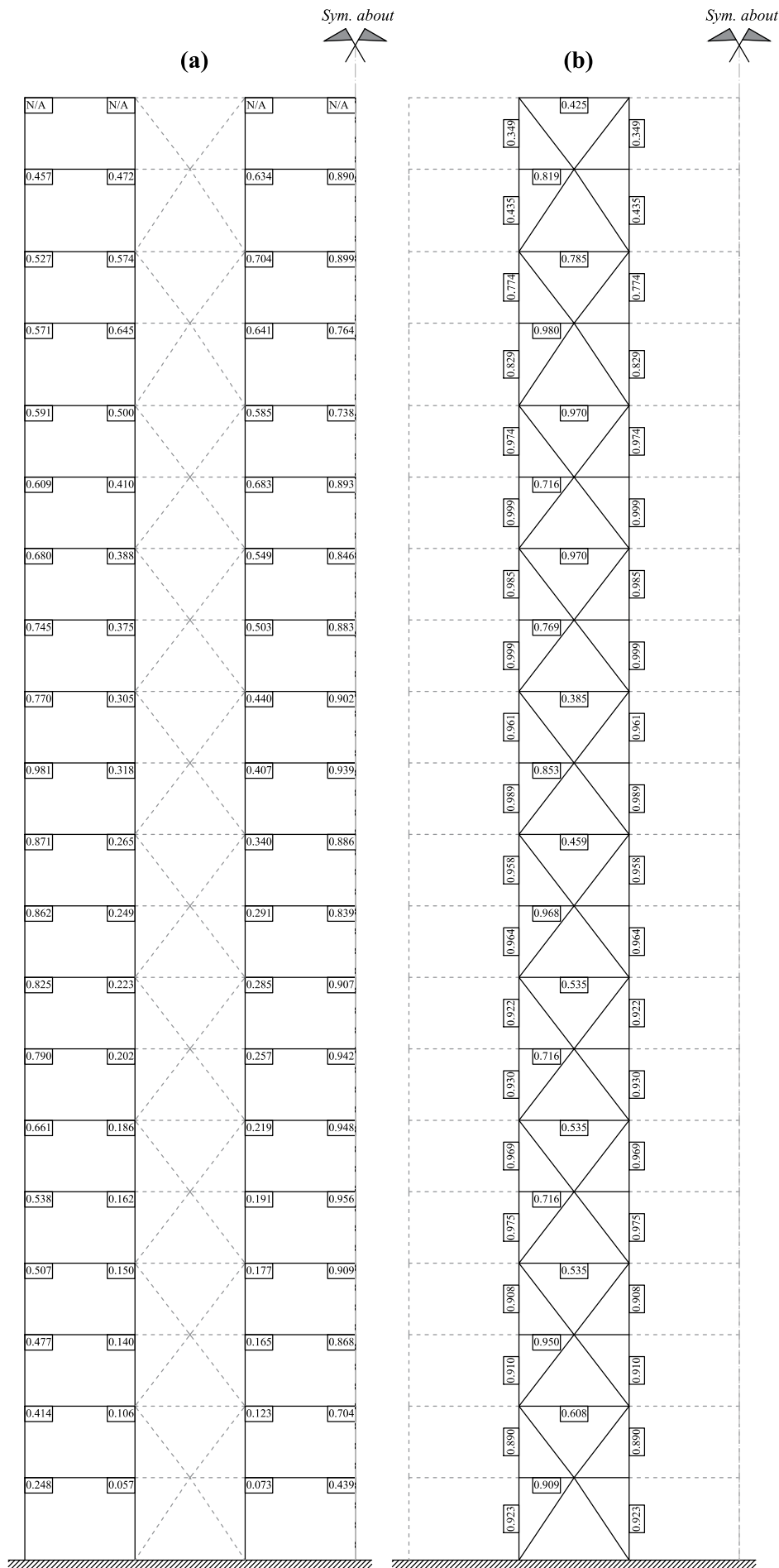


Fig. 14: Seismic provisions check per AISC 341-16 for 20-Story building archetype; a) strong-column/weak-beam criteria, b) capacity-limited seismic load effects

Table 7: Verification of design story drifts for building archetypes

Archetype ID	Story Number	δ_{xe} (in)	$\delta_x = \delta_{xe} \cdot C_d / I_e$ (in)	Δ_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
4-Story	1	0.14	0.75	0.75	0.42
	2	0.35	1.90	1.15	0.74
	3	0.53	2.91	1.01	0.65
	4	0.71	3.90	0.99	0.63
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
20-Story	1	0.16	0.86	0.86	0.48
	2	0.36	1.97	1.11	0.71
	3	0.56	3.10	1.13	0.72
	4	0.81	4.48	1.38	0.88
	5	1.07	5.90	1.42	0.91
	6	1.35	7.43	1.54	0.98
	7	1.63	8.99	1.56	1.00
	8	1.94	10.67	1.68	1.07
	9	2.25	12.37	1.71	1.09
	10	2.59	14.27	1.90	1.22
	11	2.95	16.21	1.94	1.25
	12	3.33	18.29	2.08	1.33
	13	3.71	20.41	2.12	1.36
	14	4.12	22.64	2.23	1.43
	15	4.53	24.91	2.27	1.46
	16	4.95	27.24	2.33	1.49
	17	5.39	29.62	2.38	1.52
	18	5.83	32.04	2.42	1.55
	19	6.27	34.47	2.42	1.55
	20	6.68	36.76	2.29	1.47

δ_{xe} : elastic absolute displacement; δ_x : inelastic absolute displacement; Δ_i : inelastic drift; Δ_i / h_{sx} : inelastic drift ratio

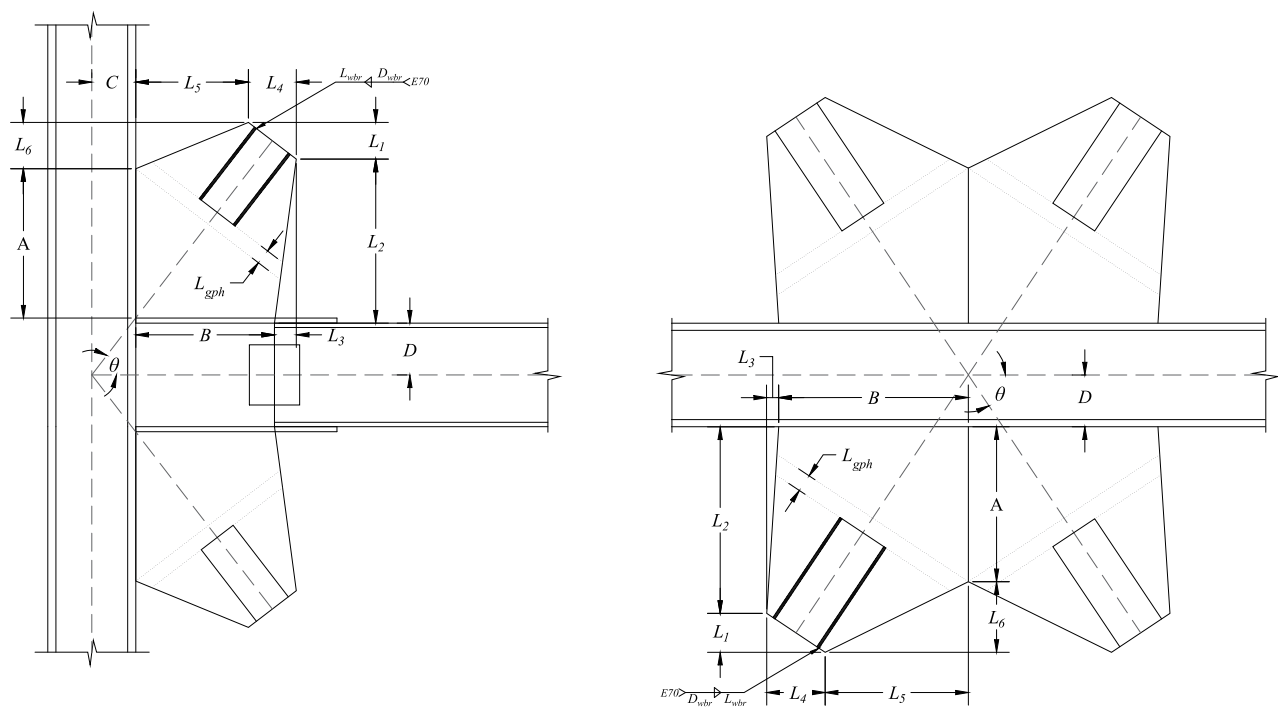


Fig. 15: Geometric parameters of gusset plates

Table 8: Gusset plates details of 2-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}
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	12	0.38
1	Upper	3.88	32.28	2.08	5.82	15.53	7.68	28.48	19.27	0.75	2	12	0.38

t_g : gusset plate thickness

Table 9: Gusset plates details of 4-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}
5	Lower	3.66	17.54	2.33	4.76	11.21	4.63	16.57	13.63	0.5	1.5	8	0.38
4	Upper	3.66	12.02	1.60	4.76	13.63	5.63	10.05	16.79	0.5	1.5	8	0.38
4	Lower	4.27	17.17	2.28	5.55	17.43	7.19	14.24	20.70	0.75	2	12	0.38
3	Upper	4.27	24.45	3.25	5.55	16.01	6.61	22.11	18.31	0.75	2	12	0.38
3	Lower	4.27	24.45	3.25	5.55	16.01	6.61	22.11	18.31	0.75	2	12	0.38
2	Upper	4.27	17.17	2.28	5.55	18.52	7.64	13.79	21.78	0.75	2	12	0.38
2	Lower	4.44	19.24	1.24	6.66	16.56	8.19	15.49	21.98	0.75	2	13	0.56
1	Upper	4.44	37.15	2.40	6.66	16.56	8.19	33.40	20.82	0.75	2	13	0.56

Table 10: 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 11:** 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 12: 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

Table 13: Gusset plates details of 20-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}
21	Lower	3.35	17.91	2.38	4.36	12.27	5.07	16.20	14.25	0.50	1.5	9	0.31
20	Upper	3.35	13.16	1.75	4.36	13.92	5.75	10.77	16.53	0.50	1.5	9	0.31
20	Lower	3.96	15.45	2.05	5.15	15.52	6.41	13.01	18.62	0.50	1.5	11	0.31
19	Upper	3.96	21.94	2.92	5.15	14.41	5.95	19.95	16.65	0.50	1.5	11	0.31
19	Lower	3.96	21.94	2.92	5.15	14.41	5.95	19.95	16.65	0.50	1.5	11	0.31
18	Upper	3.96	15.45	2.05	5.15	15.52	6.41	13.01	18.62	0.50	1.5	11	0.31
18	Lower	4.27	17.17	2.28	5.55	16.76	6.92	14.52	20.03	0.75	2	12	0.38
17	Upper	4.27	24.57	3.26	5.55	16.01	6.61	22.23	18.29	0.75	2	12	0.38
17	Lower	4.27	24.57	3.26	5.55	16.01	6.61	22.23	18.29	0.75	2	12	0.38
16	Upper	4.27	17.17	2.28	5.55	16.10	6.65	14.79	19.37	0.75	2	12	0.38
16	Lower	4.27	17.17	2.28	5.55	16.10	6.65	14.79	19.37	0.75	2	12	0.38
15	Upper	4.27	25.10	3.34	5.55	16.01	6.61	22.76	18.22	0.75	2	12	0.38
15	Lower	4.27	25.10	3.34	5.55	16.01	6.61	22.76	18.22	0.75	2	12	0.38
14	Upper	4.27	17.24	2.29	5.55	16.01	6.61	14.89	19.27	0.75	2	12	0.38
14	Lower	4.57	17.34	2.30	5.94	16.01	6.61	15.30	19.65	0.75	2	12	0.44
13	Upper	4.57	23.58	3.13	5.94	16.01	6.61	21.54	18.82	0.75	2	12	0.44
13	Lower	4.57	23.58	3.13	5.94	16.01	6.61	21.54	18.82	0.75	2	12	0.44
12	Upper	4.57	17.17	2.28	5.94	17.35	7.16	14.58	21.01	0.75	2	12	0.44
12	Lower	4.27	17.17	2.28	5.55	17.43	7.19	14.24	20.70	0.75	2	12	0.5
11	Upper	4.27	24.56	3.26	5.55	16.01	6.61	22.22	18.30	0.75	2	12	0.5
11	Lower	4.27	24.56	3.26	5.55	16.01	6.61	22.22	18.30	0.75	2	12	0.5
10	Upper	4.27	17.17	2.28	5.55	16.76	6.92	14.52	20.03	0.75	2	12	0.5
10	Lower	4.88	18.31	2.43	6.34	17.48	7.22	15.98	21.39	0.75	2	13	0.56
9	Upper	4.88	26.64	3.54	6.34	17.08	7.05	24.46	19.88	0.75	2	13	0.56
9	Lower	4.88	26.64	3.54	6.34	17.08	7.05	24.46	19.88	0.75	2	13	0.56
8	Upper	4.88	18.65	2.48	6.34	17.08	7.05	16.48	20.94	0.75	2	13	0.56
8	Lower	4.88	18.65	2.48	6.34	17.08	7.05	16.48	20.94	0.75	2	13	0.56
7	Upper	4.88	27.40	3.64	6.34	17.08	7.05	25.22	19.78	0.75	2	13	0.56
7	Lower	4.88	27.40	3.64	6.34	17.08	7.05	25.22	19.78	0.75	2	13	0.56
6	Upper	4.88	18.65	2.48	6.34	17.08	7.05	16.48	20.94	0.75	2	13	0.56
6	Lower	4.88	18.65	2.48	6.34	17.08	7.05	16.48	20.94	0.75	2	13	0.56
5	Upper	4.88	27.87	3.70	6.34	17.08	7.05	25.70	19.72	0.75	2	13	0.56
5	Lower	4.88	27.87	3.70	6.34	17.08	7.05	25.70	19.72	0.75	2	13	0.56
4	Upper	4.88	18.31	2.43	6.34	17.48	7.22	15.98	21.39	0.75	2	13	0.56
4	Lower	5.49	20.08	2.67	7.13	18.68	7.71	17.89	23.14	1.00	2.5	14	0.63
3	Upper	5.49	31.40	4.17	7.13	18.68	7.71	29.17	21.64	1.00	2.5	14	0.63
3	Lower	5.49	31.40	4.17	7.13	18.68	7.71	29.17	21.64	1.00	2.5	14	0.63
2	Upper	5.49	20.08	2.67	7.13	18.68	7.71	17.86	23.14	1.00	2.5	14	0.63
2	Lower	4.99	24.20	1.56	7.49	18.11	8.96	20.23	24.04	1.00	2.5	14	0.63
1	Upper	4.99	45.98	2.97	7.49	18.11	8.96	42.02	22.64	1.00	2.5	14	0.63

t_g : gusset plate thickness

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