

## ATC 154 Project – Steel SMF Conceptual Design: Ultra High Seismic

The following is a report summarizing the conceptual design of steel special moment frames for the *Ultra High Seismic* designated archetype for the ATC 154 Project, prepared by the AISC Steel Solutions Center (SSC). This is one of three total conceptual designs for steel special moment frame designs in an archetype steel structure subjected to three different levels of seismicity ranging from high to ‘ultra’ high. The designed moment frames will form the basis of advanced analytical modeling to be carried out at the University of Washington to investigate if there is a higher probability of collapse for code-designed seismic force systems when going from high seismicity to very high seismicity.

### Archetype Design Criteria

The conceptual steel moment frame design prepared by the SSC for the *Ultra High* archetype is based on archetype layouts and design criteria provided by John Hooper of MKA and Jim Harris of J.R. Harris & Company – who developed the preliminary archetype layouts and seismic design parameters.

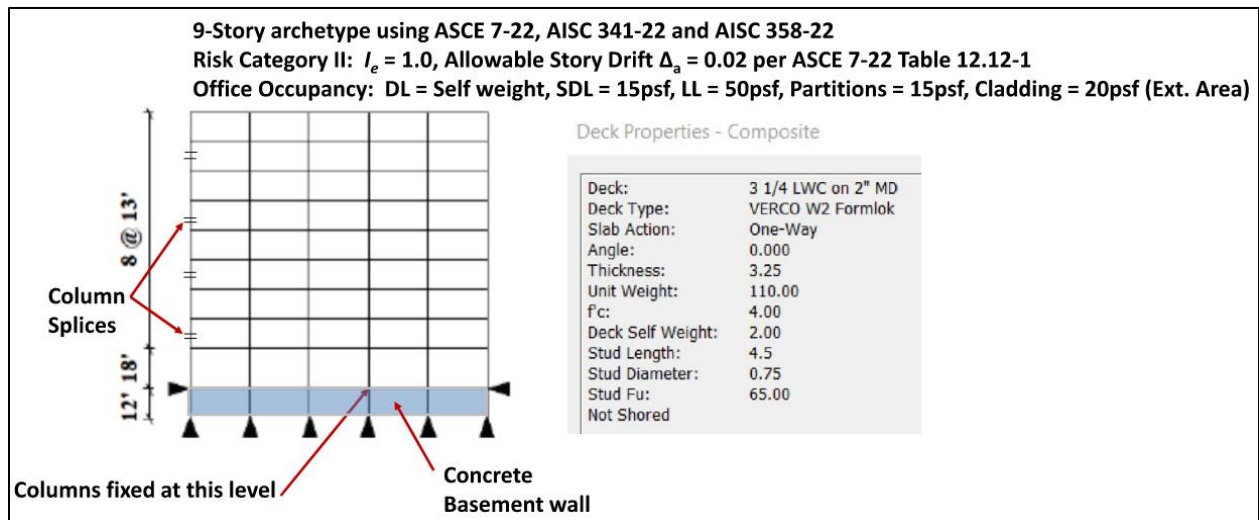


Figure 1: Elevation with Defined Loading and Base Boundary Conditions

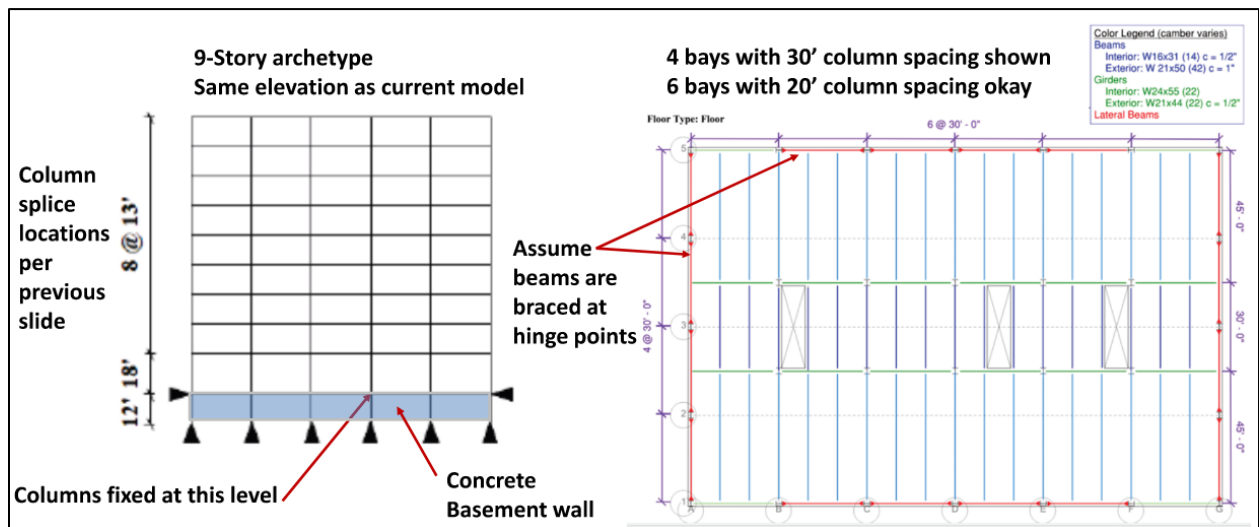


Figure 2: Elevation and Typical Floor Plan with Sized Gravity Framing (Sized by MKA)

The following criteria was also given:

- Member sizes (need to meet AISC 358 prequalification criteria)
  - Columns: W14
  - Beams: up to W36
- Connections (need to meet AISC 358 prequalification criteria)
  - Either WUF-W or RBS (the ATC-154 team recommended RBS connections as WUF-W connections are not pre-qualified to the likely seismic demands from the very high and ultra-high design cases). Therefore, the SSC chose to use RBS.
- Follow AISC 341 for final sizing and detailing of beam-column joint

### Seismic Design Criteria

The seismic design criteria given for each archetype is shown in the table below. The blue shading denotes the archetype design included in this report.

Table 1: Seismic Design Parameters for Steel Frame Archetypes

Recommendations for Archetype Designs					
	$S_{MS}$	$S_{DS}$	$S_{M1}$	$S_{D1}$	$S_1$
High D	1.5	1.0	0.9	0.6	0.47
Very High Seismic	2.25	1.5	1.8	1.2	0.72
Ultra High Seismic	3.0	2.0	2.7	1.8	1.07

Note: blue shading denotes archetype design included in this report

Where,

$S_{MS}$  = The spectral response acceleration parameter at short periods adjusted for site class effects as determined in accordance with Section 11.4.3 of ASCE 7-22 for the risk-targeted maximum considered earthquake ( $MCE_R$ ), 5% damped

$S_{DS}$  = Design earthquake spectral response acceleration parameters at short periods as determined in accordance with Section 11.4.4 of ASCE 7-22

$S_{M1}$  =  $MCE_R$ , 5% damped, spectral response acceleration parameter at a period of 1 second adjusted for site class effects as determined in accordance with Section 11.4.3 of ASCE 7-22

$S_{D1}$  = Design, 5% damped, spectral response acceleration parameter at a period of 1 s as defined in Section 11.4.4 of ASCE 7-22

$S_1$  =  $MCE_R$ , 5% damped, spectral response acceleration parameter at a period of 1 s for Site Class BC site conditions as determined in accordance with Section 11.4.3 of ASCE 7-22

### Conceptual Steel Special Moment Frame Design: Ultra High Seismic Archetype

The SSC utilized Bentley Systems RAM Structural System and RAM Frame to perform the lateral analysis and design the steel moment frames. The study structural model is based on the structural layout provided to us in the archetype design drawings. Gravity framing included in the model was as shown in the gravity design provided by MKA, which was the same as the *High D* and *Very High* archetype (gravity design information was provided in the *High D* archetype report). A typical floor framing plan and frame elevations are shown in Appendix 1.

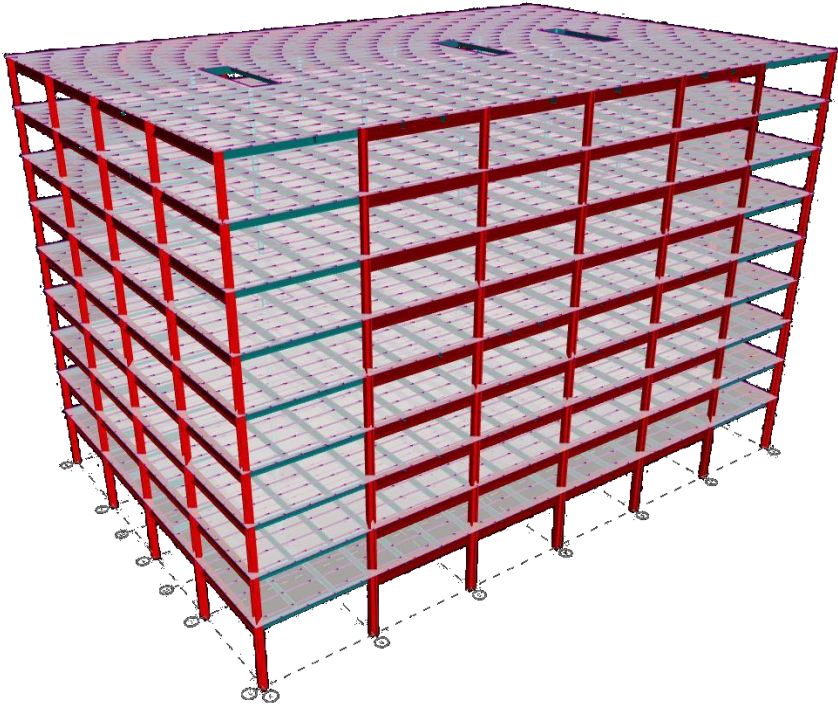


Figure 3: 3D rendering of archetype structure



Figure 4: 3D rendering of archetype lateral frames only

### Modeling Assumptions and Notes

The archetype was designed with loading and criteria per ASCE 7-22 *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (ASCE 7). Modal Response Spectrum Analysis was used per Section 12.9.1 of ASCE 7, with parameters for each mode combined using the complete quadratic combination (CQC) method. As agreed to at a coordination meeting in December of 2022, design checks were made based on LRFD requirements using AISC 360-16 *Specification for Structural Steel Buildings* (AISC 360), AISC 341-16 *Seismic Provisions for Structural Steel Buildings* (AISC 341), and AISC 358 *Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications* (AISC 358). This was done due to the current capabilities of the analysis software used by AISC staff and minimizing the time needed to complete this analysis. AISC staff did not investigate the impacts that the use of the 2022 AISC Standards would have on the overall design with the exception that sections used in the design satisfy the seismic width-to-thickness requirements for highly ductile shapes per AISC 341-22, and the beam prequalification limits for reduced beam section (RBS) moment connections from AISC 358-22 were used to take advantage of larger beam sizes. However, it is believed that the design would be generally consistent with AISC 360-22, AISC 341-22, and AISC 358-22.

The following is a list of assumptions and notes regarding the archetype lateral structural model:

1. A separate model for drift and strength were utilized. Both models were identical with a few key differences. This allowed the SSC to take advantage of provisions in Section 12.8.6 of ASCE 7 for the determination of displacements and drifts. For strength checks, the Direct Analysis Method was used per AISC 360 using reduced stiffnesses with  $\tau_b = 1.0$ . Unreduced stiffnesses were used in the determination of building periods and story drifts. See Appendix 2 for the analysis criteria used in RAM Frame for drift and strength.
2. Beams were assumed to be continuously braced. Based on discussions with MKA, it is our understanding that discrete beam bracing would be provided to satisfy the lateral bracing requirements of AISC 341 and AISC 358. For simplicity, this bracing was not included in the model.
3. Columns were assumed fixed at the base (i.e. at the top of the concrete basement wall). The concrete basement wall was not included in the model.
4. Reduced Beam Section (RBS) moment connections were utilized for all beam-column connections. The reduced section properties were used in the analysis.
5. Rigid end zone effects were not included, which is typical in the design of steel moment frames.
6. P-delta effects were included in the design of the frames for both drift and strength. The SSC used procedures recommended by Bentley that can be found on their help page [here](#).
7. Rigid diaphragms were used at each level.
8. Materials:
  - a. Beams and columns:  $F_y = 50$  ksi
  - b. Web plates and stiffener plates:  $F_y = 50$  ksi
9. By inspection the structure is classified as regular and does not have any horizontal or vertical irregularities. (Note – the structure was checked for a torsional irregularity and the structure was found to not have a torsional irregularity). Therefore, accidental torsion was not included in the strength model per Section 12.8.4.2 of ASCE 7. Accidental torsion was included in the drift model to check for a torsional irregularity. Since the structure does meet any of the conditions

listed in Section 12.5.4, the Independent Directional Procedure method per Section 12.5.1.1 of ASCE 7 was used.

### Base Shear Calculation

The following is a summary of the base shear calculations for drift and strength. More detailed information can be found in Appendix 3. Base shear results are shown below for the Equivalent Lateral Force (ELF) method and Modal Response Spectrum Analysis (RSA). RSA base shear results were within 1% of ELF base shears for strength (after scaling). Unless otherwise noted, values pertain to both X and Y directions.

$$\begin{aligned} R &= 8 \\ \Omega_o &= 3 \\ C_d &= 5.5 \end{aligned}$$

$$\begin{aligned} \text{Seismic Weight, } W &= 18,865 \text{ kips} \\ \text{Period, } T &= 1.520 \text{ sec (E-W or X-dir. period per RAM)} \\ \text{Period, } T &= 1.516 \text{ sec (N-S or Y-dir. period per RAM)} \\ T_a &= 1.307 \text{ sec} \\ C_u &= 1.4 \text{ sec} \end{aligned}$$

$$\begin{aligned} T\text{-used (drift)} &= 1.520 \text{ sec (X-dir.)} \\ T\text{-used (drift)} &= 1.516 \text{ sec (Y-dir.)} \\ C_s \text{ (drift)} &= 0.148 \\ \text{Base shear, } V \text{ (drift, ELF)} &= 2792.7 \text{ kips (X-dir., shown for reference only)} \\ \text{Base shear, } V \text{ (drift, ELF)} &= 2799.2 \text{ kips (Y-dir., shown for reference only)} \\ \text{Base shear, } V \text{ (drift, RSA)} &= 2372.5 \text{ kips (X-dir. per RAM)} \\ \text{Base shear, } V \text{ (drift, RSA)} &= 2361.2 \text{ kips (Y-dir. per RAM)} \end{aligned}$$

$$\begin{aligned} T\text{-used (strength)} &= 1.520 \text{ sec (X-dir.)} \\ T\text{-used (strength)} &= 1.516 \text{ sec (Y-dir.)} \\ C_s \text{ (strength)} &= 0.148 \\ \text{Base shear, } V \text{ (strength)} &= 2792.6 \text{ kips (X-dir.)} \\ \text{Base shear, } V \text{ (strength)} &= 2799.9 \text{ kips (Y-dir.)} \end{aligned}$$

The combined response for the modal base shear using RSA,  $V_t$  in the strength model was found to be less than 100% of the calculated base shear using the ELF procedure,  $V$  for both orthogonal directions. Therefore, the RSA base shear for strength was multiplied by  $V/V_t$  in accordance with Section 12.9.1.4 of ASCE 7. Displacements did not require scaling.

### Story Drift Ratio Check

Resulting displacements and story drifts for the structure at the center of mass are shown in Appendix 4. Story drifts are all within the allowable story drift ratio,  $\Delta_a =$  of 0.02. For practicality, the story drift ratio was converted to a maximum allowable elastic drift ratio of 0.0036 (maximum allowable elastic drift ratio = allowable drift ratio \*  $I_e / C_d = 0.02 * 1.0 / 5.5 = 0.0036$ ). This ratio was then directly compared to the drift ratios reported by RAM Frame.

Stability Coefficient Check

The resulting stability coefficients for each level are shown in Appendix 5. The stability coefficients are all less than the maximum stability coefficient,  $\theta_{max} = 0.182$  per Section 12.8.7 of ASCE 7. The  $\beta$  value used in the calculation of  $\theta_{max}$  was determined at the controlling floor (Level 3) according to the procedure recommended in NIST GCR 16-917-41 *NEHRP Seismic Design Technical Brief No. 2: Seismic Design of Steel Special Moment Frames, 2nd ed.* A  $\beta$  value of 0.35 was calculated, which is less than the minimum value per Section 12.8.7 of ASCE 7 which states that  $\beta$  shall not be less than  $1.25/\Omega_o = 0.42$ . Therefore, a conservative  $\beta$  value of 0.5 was used in the calculation of  $\theta_{max}$  to check stability.

Design Capacity Ratios (DCRs)

The resulting demand-capacity ratios (DCRs) for each frame member are shown in Appendix 6. Design checks were made based on LRFD requirements using AISC 360, AISC 341, and AISC 358. The Direct Analysis Method was used per AISC 360 using reduced stiffnesses with  $\tau_b = 1.0$ . A P-delta analysis was used and B1 factors were applied. Strong column-weak beam requirements per AISC 341 were met for all frame members.

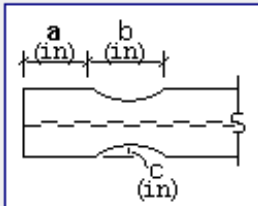
Reduced Beam Section (RBS) Properties

Reduced Beam Section (RBS) moment connections were used for all beam-column connections. The reduced section properties were used in the analysis. Reduced beam stiffness due to the RBS connection was therefore included in the analysis by direct modeling of the reduced section. The beam prequalification limits for RBS moment connections from AISC 358-22 were used to take advantage of larger beam sizes. The beam flange cut dimensions used in the analysis are shown in the figure below.

Reduced Beam Section Properties ×

**Default Dimensions**

		Incr. (in)	
a =	<input type="text" value="0.50"/>	x bf	<input type="text" value="0.2500"/>
b =	<input type="text" value="0.65"/>	x d	<input type="text" value="0.2500"/>
c =	<input type="text" value="0.20"/>	x bf	<input type="text" value="0.1250"/>



a: 0.50bf - 0.75bf  
 b: 0.65d - 0.85d  
 c: 0.10bf - 0.25bf

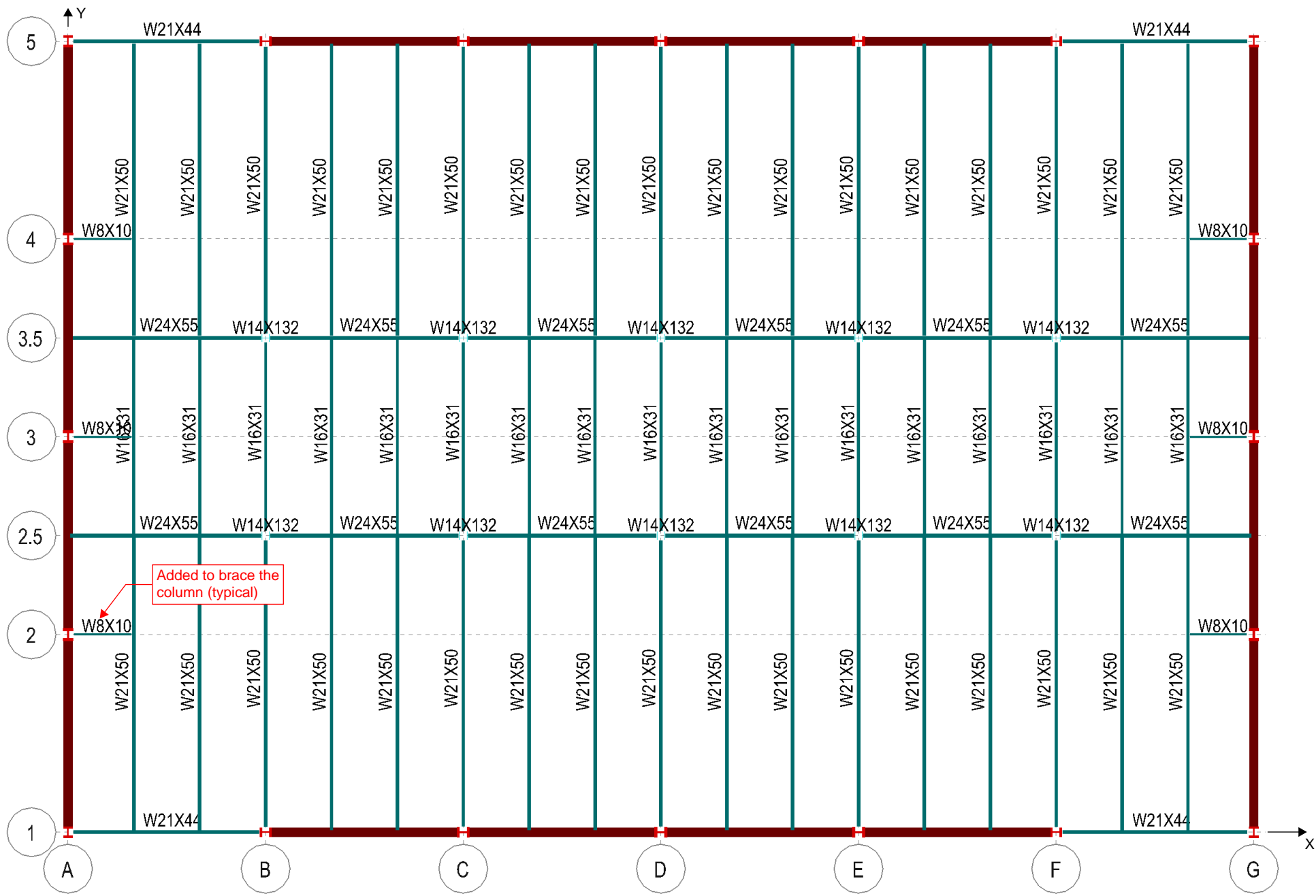
Size	a	b	c
W33X130	5.75	21.75	2.25
W36X282	8.5	24.25	3.375
W36X232	6.25	24.25	2.375
W36X361	8.5	24.75	3.375

Figure 5: Reduced beam section properties

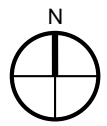
### AISC Disclaimer

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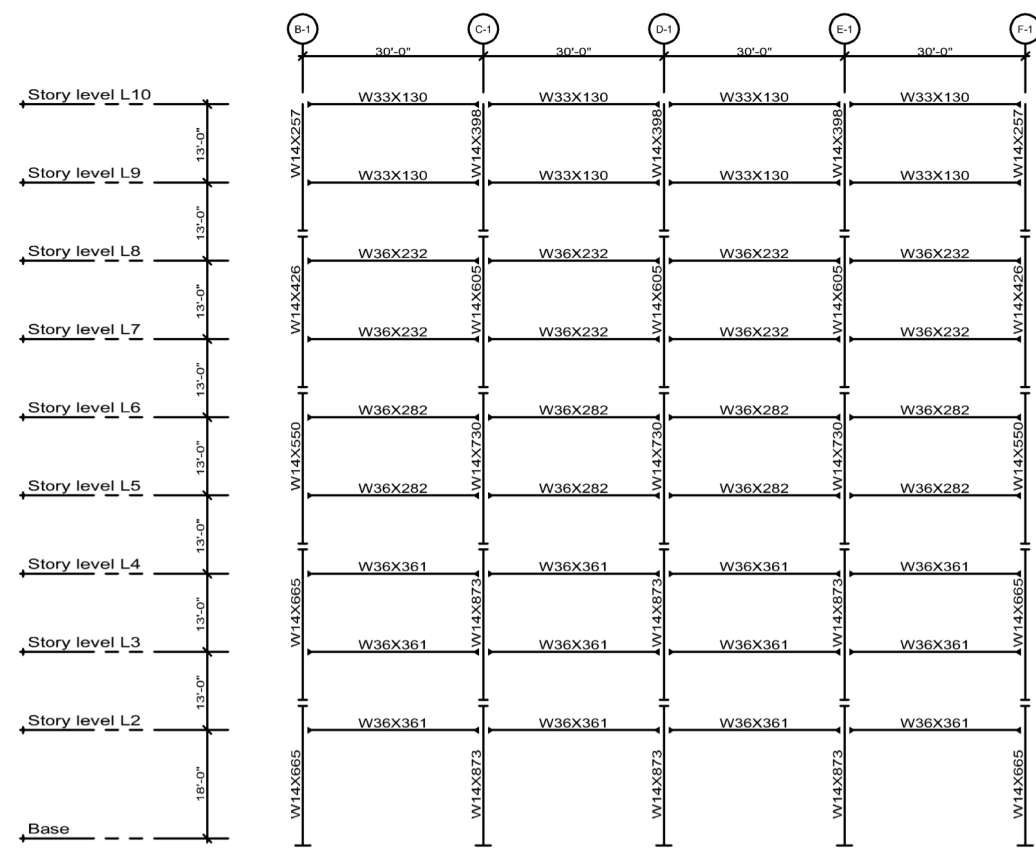
## APPENDIX 1: TYPICAL FLOOR PLAN AND FRAME ELEVATIONS



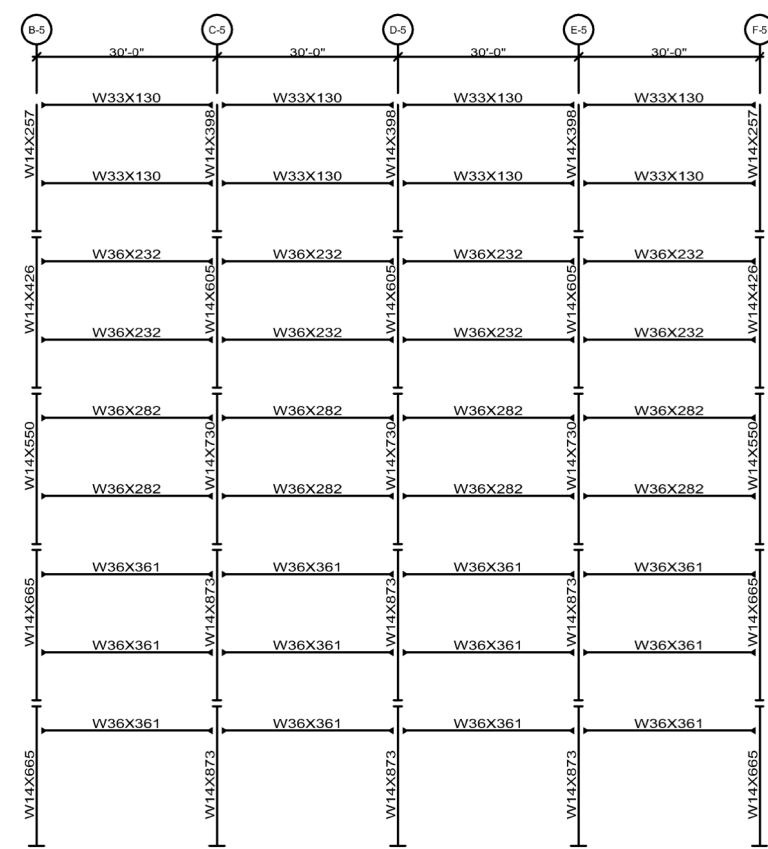
TYPICAL FLOOR PLAN



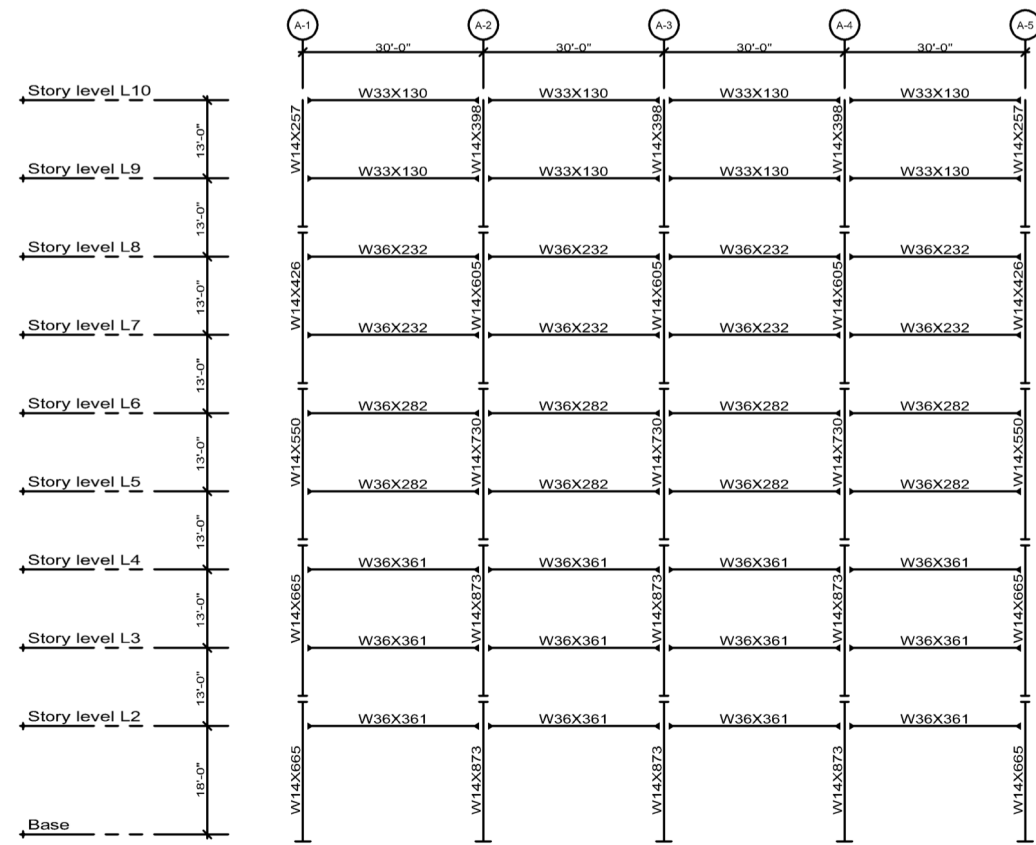
# FRAME ELEVATIONS



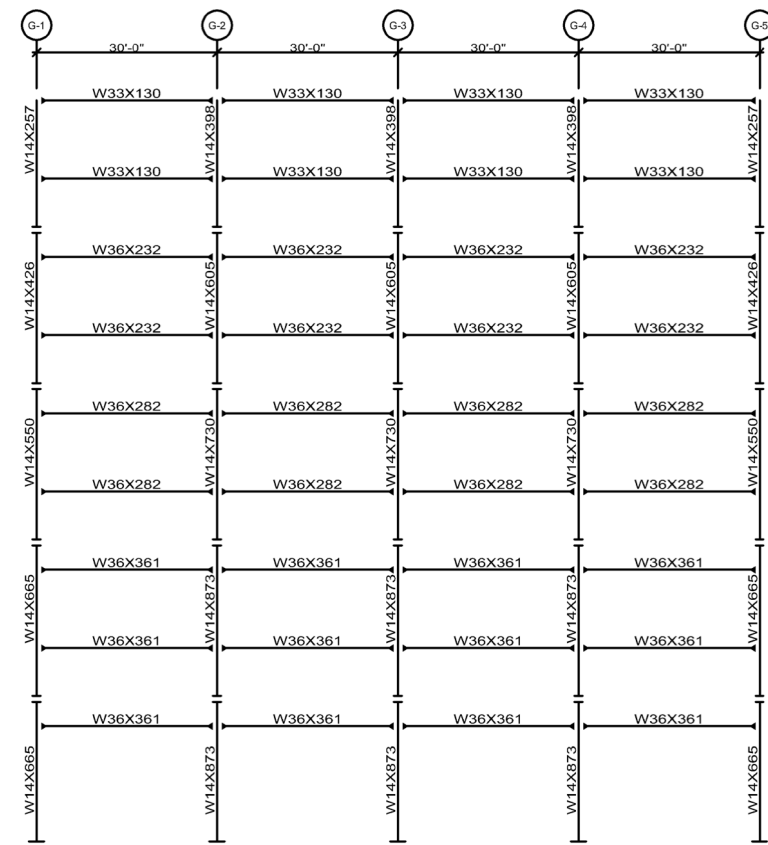
Frame along gridline 1



Frame along gridline 5



Frame along gridline A



Frame along gridline G

# ANALYSIS CRITERIA FOR DRIFT:

# APPENDIX 2: ANALYSIS CRITERIA

**General Criteria**

**Rigid End Zones**

- Ignore Effects
- Include Effects
- Reduction %:

**Member Force Output**

- At Face of Joint
- At Centerline of Joint

**Response Spectra Analysis**

- Consider Sign for Analysis Results
- Include nodal mass in Z-direction (applicable for semirigid diaphragms only)

**Eigenvalue Analysis**

- Eigen Vectors (Subspace Iteration)
- Eigen Vectors (Lanczos)
- Load Dependent Ritz Vectors

**Diaphragm**

- Store forces for diaphragm cross-section force calculations
- Store stresses and internal forces

**P-Delta**

- No
- Yes
- Use Mass Loads
- Scale Factor:
- Use Gravity Loads
- Load Scale Factors:
  - Dead:  Roof:
  - Live:  Snow:

**Solver Type**

**Direct Solver**

- In-Core
- Out-of-Core

**Direct Sparse Solver**

- In-Core
- Out-of-Core

**Options**

- Use Single CPU Core
- Use All Available CPU Cores

**AISC 360 Direct Analysis Method**

- Use Reduced Stiffness for Steel Members
- $T_b = 1.0$
- Use  $T_b$

**Wall**

- Include out-of-plane stiffness (bending)
- Release rotational fixity at wall foundation nodes
- Store stresses and internal forces
- Include Rigid Link at Fixed Beam-to-Wall Locations

**Buckling Restrained Braces**

- Exclude Buckling Restrained Braces from the Gravity Load Case Analysis

**Analytical Model**

Merge Node Tolerance (in):

**Mesh Controls**

Max. Distance Between Nodes on Mesh Line (ft):

Geometry Tolerance (in):

OK Cancel Help

# ANALYSIS CRITERIA FOR STRENGTH:

**General Criteria**

**Rigid End Zones**

- Ignore Effects
- Include Effects
- Reduction %:

**Member Force Output**

- At Face of Joint
- At Centerline of Joint

**Response Spectra Analysis**

- Consider Sign for Analysis Results
- Include nodal mass in Z-direction (applicable for semirigid diaphragms only)

**Eigenvalue Analysis**

- Eigen Vectors (Subspace Iteration)
- Eigen Vectors (Lanczos)
- Load Dependent Ritz Vectors

**Diaphragm**

- Store forces for diaphragm cross-section force calculations
- Store stresses and internal forces

**P-Delta**

- No
- Yes
- Use Mass Loads
- Scale Factor:
- Use Gravity Loads
- Load Scale Factors:
  - Dead:  Roof:
  - Live:  Snow:

**Solver Type**

**Direct Solver**

- In-Core
- Out-of-Core

**Direct Sparse Solver**

- In-Core
- Out-of-Core

**Options**

- Use Single CPU Core
- Use All Available CPU Cores

**AISC 360 Direct Analysis Method**

- Use Reduced Stiffness for Steel Members
- $T_b = 1.0$
- Use  $T_b$

**Wall**

- Include out-of-plane stiffness (bending)
- Release rotational fixity at wall foundation nodes
- Store stresses and internal forces
- Include Rigid Link at Fixed Beam-to-Wall Locations

**Buckling Restrained Braces**

- Exclude Buckling Restrained Braces from the Gravity Load Case Analysis

**Analytical Model**

Merge Node Tolerance (in):

**Mesh Controls**

Max. Distance Between Nodes on Mesh Line (ft):

Geometry Tolerance (in):

OK Cancel Help

**Loads and Applied Forces**

RAM Frame 17.04.01.07



DataBase: ATC 154\_SSC\_SMF Study - Ultra High\_Final -Drift

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**LOAD CASE: RSA\_Drift**

Dynamic Response Spectra for ASCE 7-16 ←

Damping Ratio: 0.050

Scale Factors (X-Dir): +Ecc Case: 0.1250 -Ecc Case: 0.1250

Scale Factors (Y-Dir): +Ecc Case: 0.1250 -Ecc Case: 0.1250

Design Spectral Acceleration Parameters : Use

SMS : 3.000 g SM1 = 2.700 g

SDS : 2.000 SD1: 1.800

To : 0.180 sec Ts : 0.900 sec TL : 6.000 sec

Modal Combination Technique: CQC

Ground Level: Base

Note - results were checked and verified to be consistent with ASCE 7-22

Dir Eccent

X + And -

Y + And -

**DIRECTION**

Type: Dyn\_ASCE716\_CQC\_X\_+E

Type: Dyn\_ASCE716\_CQC\_X\_-E

Type: Dyn\_ASCE716\_CQC\_Y\_+E

Type: Dyn\_ASCE716\_CQC\_Y\_-E

**GENERATED RESPONSE SPECTRA CURVE**

Period	Spectral Acceleration (S(T))
0.0000(T <sub>0</sub> )	0.8000 g
0.1800(T <sub>0</sub> )	2.0000 g
0.9000(T <sub>s</sub> )	2.0000 g
0.9000 < T < 6.0000 (T <sub>L</sub> )	1.8000 g/T
T > 6.0000	10.8000 g/(T*T)



# Loads and Applied Forces

RAM Frame 17.04.01.07

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DataBase: ATC 154\_SSC\_SMF Study - Ultra High\_Final -Drift

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## LOAD CASE: ELF\_Drift

Seismic ASCE 7-16 Equivalent Lateral Force

Importance Factor: 1.00 TL: 6.00 s

Site values are from a Ground Motion Hazard Analysis

Site Class D: Stiff Soil, Default

Ss: 0.001 g S1: 1.070 g

Use Specified: SDs: 2.000 g SD1: 1.800 g

Use Specified Seismic Design Category: E

Provisions for: Drift

Ground Level: Base

Note - results were checked and verified to be consistent with ASCE 7-22

Dir	Eccent	R	Ta Equation			Building Period-T			
X	+ And -	8.00	Std,Ct=0.028,x=0.80			Calculated			
Y	+ And -	8.00	Std,Ct=0.028,x=0.80			Calculated			
Dir	Ta	Cu	T	T-used	Cs	Cs(max)	Cs(min)	Cs-used	k
					Eq12.8-2	Eq12.8-3	Eq12.8-6		
X	1.307	1.400	1.520	1.520	0.250	0.148	0.067	0.148	1.510
Y	1.307	1.400	1.516	1.516	0.250	0.148	0.067	0.148	1.508

Total Building Weight (kips) = 18865.44

## APPLIED DIAPHRAGM FORCES

Applied forces are shown for ELF method for reference only.

Type: EQ\_ASCE716\_X\_+E\_Drft

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Story level L10	1	122.00	621.71	0.00	89.88	66.10
Story level L9	1	109.00	537.72	0.00	89.88	66.10
Story level L8	1	96.00	460.82	0.00	89.88	66.10
Story level L7	1	83.00	374.70	0.00	89.88	66.10
Story level L6	1	70.00	295.61	0.00	89.89	66.10
Story level L5	1	57.00	218.57	0.00	89.89	66.10
Story level L4	1	44.00	151.76	0.00	89.89	66.10
Story level L3	1	31.00	90.23	0.00	89.89	66.10
Story level L2	1	18.00	41.60	0.00	89.90	66.10

## APPLIED STORY FORCES

Type: EQ\_ASCE716\_X\_+E\_Drft

Level	Ht	Fx	Fy
	ft	kips	kips
Story level L10	122.00	621.71	0.00
Story level L9	109.00	537.72	0.00



# Loads and Applied Forces

RAM Frame 17.04.01.07

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DataBase: ATC 154\_SSC\_SMF Study - Ultra High\_Final - Drift

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Story level L8	96.00	460.82	0.00
Story level L7	83.00	374.70	0.00
Story level L6	70.00	295.61	0.00
Story level L5	57.00	218.57	0.00
Story level L4	44.00	151.76	0.00
Story level L3	31.00	90.23	0.00
Story level L2	18.00	41.60	0.00
		<u>2792.70</u>	0.00

## APPLIED DIAPHRAGM FORCES

Type: EQ\_ASCE716\_X\_-E\_Drft

Level	Diaph.#	Ht ft	Fx kips	Fy kips	X ft	Y ft
Story level L10	1	122.00	621.71	0.00	89.88	53.90
Story level L9	1	109.00	537.72	0.00	89.88	53.90
Story level L8	1	96.00	460.82	0.00	89.88	53.90
Story level L7	1	83.00	374.70	0.00	89.88	53.90
Story level L6	1	70.00	295.61	0.00	89.89	53.90
Story level L5	1	57.00	218.57	0.00	89.89	53.90
Story level L4	1	44.00	151.76	0.00	89.89	53.90
Story level L3	1	31.00	90.23	0.00	89.89	53.90
Story level L2	1	18.00	41.60	0.00	89.90	53.90

## APPLIED STORY FORCES

Type: EQ\_ASCE716\_X\_-E\_Drft

Level	Ht ft	Fx kips	Fy kips
Story level L10	122.00	621.71	0.00
Story level L9	109.00	537.72	0.00
Story level L8	96.00	460.82	0.00
Story level L7	83.00	374.70	0.00
Story level L6	70.00	295.61	0.00
Story level L5	57.00	218.57	0.00
Story level L4	44.00	151.76	0.00
Story level L3	31.00	90.23	0.00
Story level L2	18.00	41.60	0.00
		<u>2792.70</u>	0.00

## APPLIED DIAPHRAGM FORCES

Type: EQ\_ASCE716\_Y\_+E\_Drft

Level	Diaph.#	Ht	Fx	Fy	X	Y
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# Loads and Applied Forces

RAM Frame 17.04.01.07

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DataBase: ATC 154\_SSC\_SMF Study - Ultra High\_Final - Drift

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		ft	kips	kips	ft	ft
Story level L10	1	122.00	0.00	622.75	98.98	60.00
Story level L9	1	109.00	0.00	538.73	98.98	60.00
Story level L8	1	96.00	0.00	461.79	98.98	60.00
Story level L7	1	83.00	0.00	375.59	98.98	60.00
Story level L6	1	70.00	0.00	296.39	98.99	60.00
Story level L5	1	57.00	0.00	219.23	98.99	60.00
Story level L4	1	44.00	0.00	152.29	98.99	60.00
Story level L3	1	31.00	0.00	90.60	98.99	60.00
Story level L2	1	18.00	0.00	41.82	99.00	60.00

## APPLIED STORY FORCES

Type: EQ\_ASCE716\_Y\_+E\_Drft

Level	Ht ft	Fx kips	Fy kips
Story level L10	122.00	0.00	622.75
Story level L9	109.00	0.00	538.73
Story level L8	96.00	0.00	461.79
Story level L7	83.00	0.00	375.59
Story level L6	70.00	0.00	296.39
Story level L5	57.00	0.00	219.23
Story level L4	44.00	0.00	152.29
Story level L3	31.00	0.00	90.60
Story level L2	18.00	0.00	41.82
		0.00	2799.19

## APPLIED DIAPHRAGM FORCES

Type: EQ\_ASCE716\_Y\_-E\_Drft

Level	Diaph.#	Ht ft	Fx kips	Fy kips	X ft	Y ft
Story level L10	1	122.00	0.00	622.75	80.78	60.00
Story level L9	1	109.00	0.00	538.73	80.78	60.00
Story level L8	1	96.00	0.00	461.79	80.78	60.00
Story level L7	1	83.00	0.00	375.59	80.78	60.00
Story level L6	1	70.00	0.00	296.39	80.79	60.00
Story level L5	1	57.00	0.00	219.23	80.79	60.00
Story level L4	1	44.00	0.00	152.29	80.79	60.00
Story level L3	1	31.00	0.00	90.60	80.79	60.00
Story level L2	1	18.00	0.00	41.82	80.80	60.00

## APPLIED STORY FORCES

Type: EQ\_ASCE716\_Y\_-E\_Drft

Level	Ht	Fx	Fy
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# Loads and Applied Forces

RAM Frame 17.04.01.07

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DataBase: ATC 154\_SSC\_SMF Study - Ultra High\_Final - Drift

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	ft	kips	kips
Story level L10	122.00	0.00	622.75
Story level L9	109.00	0.00	538.73
Story level L8	96.00	0.00	461.79
Story level L7	83.00	0.00	375.59
Story level L6	70.00	0.00	296.39
Story level L5	57.00	0.00	219.23
Story level L4	44.00	0.00	152.29
Story level L3	31.00	0.00	90.60
Story level L2	18.00	0.00	41.82

0.00

2799.19

## BASE SHEAR (Dynamic Load Cases)

LdC	Shear-X	Shear-Y
<b>Dyn1</b>	<b>-2372.52</b>	<b>1.81</b>
<b>Dyn2</b>	<b>-2372.52</b>	<b>-1.81</b>
<b>Dyn3</b>	<b>0.00</b>	<b>-2361.20</b>
<b>Dyn4</b>	<b>-0.00</b>	<b>-2359.73</b>

RSA BASE SHEAR - DRIFT



# Loads and Applied Forces

RAM Frame 17.04.01.07



DataBase: ATC 154\_SSC\_SMF Study - Ultra High\_Final - Strength

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## LOAD CASE: ELF\_Strength

Seismic ASCE 7-16 Equivalent Lateral Force

Importance Factor: 1.00 TL: 6.00 s

Site values are from a Ground Motion Hazard Analysis

Site Class D: Stiff Soil, Default

Ss: 0.001 g S1: 1.070 g

Use Specified: SDs: 2.000 g SD1: 1.800 g

Use Specified Seismic Design Category: D

Provisions for: Force

Ground Level: Base

Note - results were checked and verified to be consistent with ASCE 7-22

Dir	Eccent	R	Ta Equation			Building Period-T			
X	None	8.00	Std,Ct=0.028,x=0.80			User Defined			
Y	None	8.00	Std,Ct=0.028,x=0.80			User Defined			
Dir	Ta	Cu	T	T-used	Cs Eq12.8-2	Cs(max) Eq12.8-3	Cs(min) Eq12.8-5	Cs-used	k
X	1.307	1.400	1.520	1.520	0.250	0.148	0.088	0.148	1.510
Dir	Ta	Cu	T	T-used	Cs Eq12.8-2	Cs(max) Eq12.8-3	Cs(min) Eq12.8-5	Cs-used	k
Y	1.307	1.400	1.516	1.516	0.250	0.148	0.088	0.148	1.508

Total Building Weight (kips) = 18865.44

## APPLIED DIAPHRAGM FORCES

Type: EQ\_ASCE716\_X\_NoE\_F

Level	Diaph.#	Ht ft	Fx kips	Fy kips	X ft	Y ft
Story level L10	1	122.00	621.69	0.00	89.88	60.00
Story level L9	1	109.00	537.70	0.00	89.88	60.00
Story level L8	1	96.00	460.80	0.00	89.88	60.00
Story level L7	1	83.00	374.68	0.00	89.88	60.00
Story level L6	1	70.00	295.59	0.00	89.89	60.00
Story level L5	1	57.00	218.56	0.00	89.89	60.00
Story level L4	1	44.00	151.75	0.00	89.89	60.00
Story level L3	1	31.00	90.22	0.00	89.89	60.00
Story level L2	1	18.00	41.60	0.00	89.90	60.00

## APPLIED STORY FORCES

Type: EQ\_ASCE716\_X\_NoE\_F

Level	Ht ft	Fx kips	Fy kips
Story level L10	122.00	621.69	0.00
Story level L9	109.00	537.70	0.00



# Loads and Applied Forces

RAM Frame 17.04.01.07

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DataBase: ATC 154\_SSC\_SMF Study - Ultra High\_Final - Strength

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Story level L8	96.00	460.80	0.00
Story level L7	83.00	374.68	0.00
Story level L6	70.00	295.59	0.00
Story level L5	57.00	218.56	0.00
Story level L4	44.00	151.75	0.00
Story level L3	31.00	90.22	0.00
Story level L2	18.00	41.60	0.00

2792.58

0.00

## APPLIED DIAPHRAGM FORCES

Type: EQ\_ASCE716\_Y\_NoE\_F

Level	Diaph.#	Ht ft	Fx kips	Fy kips	X ft	Y ft
Story level L10	1	122.00	0.00	622.88	89.88	60.00
Story level L9	1	109.00	0.00	538.85	89.88	60.00
Story level L8	1	96.00	0.00	461.90	89.88	60.00
Story level L7	1	83.00	0.00	375.69	89.88	60.00
Story level L6	1	70.00	0.00	296.49	89.89	60.00
Story level L5	1	57.00	0.00	219.31	89.89	60.00
Story level L4	1	44.00	0.00	152.35	89.89	60.00
Story level L3	1	31.00	0.00	90.64	89.89	60.00
Story level L2	1	18.00	0.00	41.84	89.90	60.00

## APPLIED STORY FORCES

Type: EQ\_ASCE716\_Y\_NoE\_F

Level	Ht ft	Fx kips	Fy kips
Story level L10	122.00	0.00	622.88
Story level L9	109.00	0.00	538.85
Story level L8	96.00	0.00	461.90
Story level L7	83.00	0.00	375.69
Story level L6	70.00	0.00	296.49
Story level L5	57.00	0.00	219.31
Story level L4	44.00	0.00	152.35
Story level L3	31.00	0.00	90.64
Story level L2	18.00	0.00	41.84

0.00

2799.95

### BASE SHEAR (Dynamic Load Cases)

LdC	Shear-X	Shear-Y
Dyn5	-2792.81	-0.00
Dyn6	0.00	-2799.07

RSA BASE SHEAR - STRENGTH



# Periods and Modes

RAM Frame 17.04.01.07



DataBase: ATC 154\_SSC\_SMF Study - Ultra High\_Final - Drift

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## CRITERIA:

Rigid End Zones: Ignore Effects  
P-Delta: Yes Scale Factor (DL): 1.00 Scale Factor (LL): 0.50  
Scale Factor (Roof): 1.00 Scale Factor (Snow): 0.15

Ground Level: Base

### Mesh Criteria :

Max. Distance Between Nodes on Mesh Line (ft) : 4.00

Merge Node Tolerance (in) : 0.0100

Geometry Tolerance (in) : 0.0050

Walls Out-of-plane Stiffness Not Included in Analysis.

Sign considered for Dynamic Load Case Results.

Rigid Links Not Included at Fixed Beam-to-Wall Locations

Eigenvalue Analysis : Eigen Vectors (Subspace Iteration)

## Load Case: Eigen Eigen Solution

### FREQUENCIES AND PERIODS:

Mode	Period ( T ) sec	Cyclic Frequency ( f ) Hz	Circular Frequency ( $\omega$ ) rad/sec	Eigenvalue (rad/sec)**2
1	1.5199	0.6579	4.1339	17.0888
2	1.5164	0.6595	4.1435	17.1682
3	0.9585	1.0433	6.5551	42.9695
4	0.5777	1.7309	10.8757	118.2803
5	0.5771	1.7328	10.8877	118.5419
6	0.3694	2.7071	17.0090	289.3044
7	0.3382	2.9569	18.5790	345.1787
8	0.3380	2.9586	18.5896	345.5717
9	0.2224	4.4962	28.2504	798.0857
10	0.2222	4.5002	28.2756	799.5073

### MODAL PARTICIPATION FACTORS:

Mode	X-Dir	Y-Dir	Rotation
1	75.0358	-0.0000	0.0007
2	0.0000	74.9983	-0.5112
3	-0.0001	0.0910	431.4576
4	29.2462	-0.0000	0.0004
5	0.0000	29.3389	-0.2310
6	-0.0001	0.0367	167.5959
7	17.1750	-0.0000	0.0006
8	0.0000	17.1974	-0.1314
9	-11.2623	0.0000	0.0007
10	-0.0000	-11.2469	0.0556



# Periods and Modes

RAM Frame 17.04.01.07



DataBase: ATC 154\_SSC\_SMF Study - Ultra High\_Final - Drift

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## MODAL DIRECTION FACTORS:

Mode	X-Dir	Y-Dir	Rotation
1	100.00	0.00	0.00
2	0.00	100.00	0.00
3	0.00	0.00	100.00
4	100.00	0.00	0.00
5	0.00	100.00	0.00
6	0.00	0.00	100.00
7	100.00	0.00	0.00
8	0.00	100.00	0.00
9	100.00	0.00	0.00
10	0.00	100.00	0.00

## MODAL EFFECTIVE MASS FACTORS:

Mode	X-Dir		Y-Dir		Rotation	
	%Mass	%SumM	%Mass	%SumM	%Mass	%SumM
1	80.08	80.08	0.00	0.00	0.00	0.00
2	0.00	80.08	80.00	80.00	0.00	0.00
3	0.00	80.08	0.00	80.00	80.68	80.68
4	12.17	92.25	0.00	80.00	0.00	80.68
5	0.00	92.25	12.24	92.25	0.00	80.68
6	0.00	92.25	0.00	92.25	12.17	92.86
7	4.20	96.45	0.00	92.25	0.00	92.86
8	0.00	96.45	4.21	96.45	0.00	92.86
9	1.80	98.25	0.00	96.45	0.00	92.86
10	0.00	98.25	1.80	98.25	0.00	92.86



Drift

RAM Structural System 17.04.01.07

DataBase: ATC 154\_SSC\_SMF Study - Ultra High\_Final - Drift

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Building Code: IBC

Steel Code: IBC

**CRITERIA:**

Rigid End Zones: Ignore Effects

Member Force Output: At Face of Joint

P-Delta: Yes Scale Factor (DL): 1.00 Scale Factor (LL): 0.50  
 Scale Factor (Roof): 1.00 Scale Factor (Snow): 0.15

Ground Level: Base

**LOAD CASE DEFINITIONS:**

Dyn1 RSA\_Drift Dyn\_ASCE716\_CQC\_X\_+E  
 Dyn2 RSA\_Drift Dyn\_ASCE716\_CQC\_X\_-E  
 Dyn3 RSA\_Drift Dyn\_ASCE716\_CQC\_Y\_+E  
 Dyn4 RSA\_Drift Dyn\_ASCE716\_CQC\_Y\_-E

**RESULTS:**

Location (ft): (89.870, 60.000)

All drift ratios less than 0.0036

Story	LdC	Displacement		Story Drift		Drift Ratio	
		X in	Y in	X in	Y in	X	Y
Story level L10	Dyn1	4.6717	-0.0035	0.4203	-0.0003	0.0027	0.0000
	Dyn2	4.6717	0.0035	0.4203	0.0003	0.0027	0.0000
	Dyn3	-0.0000	4.6326	-0.0000	0.4187	0.0000	0.0027
	Dyn4	0.0000	4.6311	0.0000	0.4186	0.0000	0.0027
Story level L9	Dyn1	4.3057	-0.0032	0.5506	-0.0004	0.0035	0.0000
	Dyn2	4.3057	0.0032	0.5506	0.0004	0.0035	0.0000
	Dyn3	-0.0000	4.2681	-0.0000	0.5484	0.0000	0.0035
	Dyn4	0.0000	4.2667	0.0000	0.5483	0.0000	0.0035
Story level L8	Dyn1	3.8149	-0.0029	0.5106	-0.0004	0.0033	0.0000
	Dyn2	3.8149	0.0029	0.5106	0.0004	0.0033	0.0000
	Dyn3	-0.0000	3.7794	-0.0000	0.5084	0.0000	0.0033
	Dyn4	0.0000	3.7781	0.0000	0.5083	0.0000	0.0033
Story level L7	Dyn1	3.3415	-0.0025	0.5594	-0.0004	0.0036	0.0000
	Dyn2	3.3415	0.0025	0.5594	0.0004	0.0036	0.0000
	Dyn3	-0.0000	3.3081	-0.0000	0.5568	0.0000	0.0036
	Dyn4	0.0000	3.3070	0.0000	0.5566	0.0000	0.0036
Story level L6	Dyn1	2.8091	-0.0021	0.5490	-0.0004	0.0035	0.0000
	Dyn2	2.8091	0.0021	0.5490	0.0004	0.0035	0.0000
	Dyn3	-0.0000	2.7784	-0.0000	0.5458	0.0000	0.0035
	Dyn4	0.0000	2.7775	0.0000	0.5456	0.0000	0.0035



Bentley

# Drift

All drift ratios less than 0.0036  
(typical all load cases)

RAM Structural System 17.04.01.07

DataBase: ATC 154\_SSC\_SMF Study - Ultra High\_Final - Drift

Building Code: IBC

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Steel Code: IBC

Story	LdC	Displacement		Story Drift		Drift Ratio	
Story level L5	Dyn1	2.2757	-0.0017	0.5597	-0.0004	0.0036	0.0000
	Dyn2	2.2757	0.0017	0.5597	0.0004	0.0036	0.0000
	Dyn3	-0.0000	2.2483	-0.0000	0.5541	0.0000	0.0036
	Dyn4	0.0000	2.2476	0.0000	0.5539	0.0000	0.0036
Story level L4	Dyn1	1.7246	-0.0013	0.5242	-0.0004	0.0034	0.0000
	Dyn2	1.7246	0.0013	0.5242	0.0004	0.0034	0.0000
	Dyn3	-0.0000	1.7028	-0.0000	0.5166	0.0000	0.0033
	Dyn4	0.0000	1.7023	0.0000	0.5165	0.0000	0.0033
Story level L3	Dyn1	1.2033	0.0009	0.5531	-0.0004	0.0035	0.0000
	Dyn2	1.2033	-0.0009	0.5531	0.0004	0.0035	0.0000
	Dyn3	-0.0000	1.1891	-0.0000	0.5454	0.0000	0.0035
	Dyn4	0.0000	1.1888	0.0000	0.5452	0.0000	0.0035
Story level L2	Dyn1	0.6507	0.0005	0.6507	0.0005	0.0030	0.0000
	Dyn2	0.6507	-0.0005	0.6507	-0.0005	0.0030	0.0000
	Dyn3	-0.0000	0.6443	-0.0000	0.6443	0.0000	0.0030
	Dyn4	0.0000	0.6441	0.0000	0.6441	0.0000	0.0030



Bentley

# Drift

RAM Structural System 17.04.01.07  
DataBase: ATC 154\_SSC\_SMF Study - Ultra High\_Final - Drift  
Building Code: IBC

All less than 1.2 --> no torsional irregularity

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Steel Code: IBC

## TORSIONAL IRREGULARITY DATA:

### X-Axis:

Story	LdC	Drift in	Coord ft	Drift in	Coord ft	Max/Min	Max/Ave
Story level L10	Dyn2	0.4419	(0.00 0.00)	0.3991	(0.00 120.00)	1.107	1.051
Story level L9	Dyn2	0.5797	(0.00 0.00)	0.5220	(0.00 120.00)	1.111	1.052
Story level L8	Dyn2	0.5363	(0.00 0.00)	0.4855	(0.00 120.00)	1.105	1.050
Story level L7	Dyn2	0.5877	(0.00 0.00)	0.5316	(0.00 120.00)	1.106	1.050
Story level L6	Dyn2	0.5765	(0.00 0.00)	0.5221	(0.00 120.00)	1.104	1.049
Story level L5	Dyn2	0.5878	(0.00 0.00)	0.5321	(0.00 120.00)	1.105	1.050
Story level L4	Dyn2	0.5501	(0.00 0.00)	0.4988	(0.00 120.00)	1.103	1.049
Story level L3	Dyn2	0.5807	(0.00 0.00)	0.5261	(0.00 120.00)	1.104	1.049
Story level L2	Dyn2	0.6865	(0.00 0.00)	0.6158	(0.00 120.00)	1.115	1.054

### Y-Axis:

Story	LdC	Drift in	Coord ft	Drift in	Coord ft	Max/Min	Max/Ave
Story level L10	Dyn4	0.4675	(0.00 0.00)	0.3712	(180.00 0.00)	1.259	1.115
Story level L9	Dyn4	0.6143	(0.00 0.00)	0.4846	(180.00 0.00)	1.267	1.118
Story level L8	Dyn4	0.5663	(0.00 0.00)	0.4524	(180.00 0.00)	1.252	1.112
Story level L7	Dyn4	0.6207	(0.00 0.00)	0.4951	(180.00 0.00)	1.254	1.113
Story level L6	Dyn4	0.6078	(0.00 0.00)	0.4861	(180.00 0.00)	1.250	1.111
Story level L5	Dyn4	0.6176	(0.00 0.00)	0.4930	(180.00 0.00)	1.253	1.112
Story level L4	Dyn4	0.5751	(0.00 0.00)	0.4603	(180.00 0.00)	1.249	1.111
Story level L3	Dyn4	0.6076	(0.00 0.00)	0.4855	(180.00 0.00)	1.252	1.112
Story level L2	Dyn4	0.7250	(0.00 0.00)	0.5671	(180.00 0.00)	1.278	1.122



# ASCE 7 Stability Coefficients

RAM Frame 17.04.01.07



DataBase: ATC 154\_SSC\_SMF Study - Ultra High\_Final - Drift

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**CRITERIA:**

Rigid End Zones: Ignore Effects  
 Member Force Output: At Face of Joint  
 P-Delta: Yes Scale Factor (DL): 1.00 Scale Factor (LL): 0.50  
 Scale Factor (Roof): 1.00 Scale Factor (Snow): 0.15  
 Ground Level: Base  
 Mesh Criteria :  
 Max. Distance Between Nodes on Mesh Line (ft) : 4.00  
 Merge Node Tolerance (in) : 0.0100  
 Geometry Tolerance (in) : 0.0050  
 Walls Out-of-plane Stiffness Not Included in Analysis.  
 Sign considered for Dynamic Load Case Results.  
 Rigid Links Not Included at Fixed Beam-to-Wall Locations  
 Eigenvalue Analysis : Eigen Vectors (Subspace Iteration)

**STABILITY COEFFICIENTS:ASCE 7-10/16 Eq. (12.8-16)**

$\beta = 0.50$

Cd : X-Dir = 5.50 Y-Dir = 5.50

Note that the reported drifts are unfactored elastic story drift values.

Calculated vertical load includes dead, live and roof loads. Live loads are reduced with live load reduction factors.

Calculated vertical load is the sum of the total vertical load at and above story.

**Vertical Load Factors:**

Dead Load : 1.00 Live Load : 0.20 Roof Load : 1.00 Snow Load : 0.20

Per Section 12.8.6.1, ASCE 7-22 - reducible live loads can be used (0.5L where L=0.4Lo --> 0.5\*0.4=0.2)

**LOAD CASE: ELF\_Drift**

All values for  $\theta_x/(1+\theta_x)$  less than  $\theta_{xmax}$ .  
 $\theta_x/(1+\theta_x)$  used for comparison since P-delta analysis was used.

**Type : EQ\_ASCE716\_X\_+E\_Drft**

Level	Diaph. #	Ht ft	Shear X kips	Shear Y kips	Drift X in	Drift Y in	Vertical Load kips
Story level L10	1	122.00	628.67	0.00	0.54	0.00	1810.78
Story level L9	1	109.00	1178.24	0.00	0.73	0.00	3583.83
Story level L8	1	96.00	1647.63	0.00	0.70	0.00	5408.29
Story level L7	1	83.00	2035.53	0.00	0.77	0.00	7238.82
Story level L6	1	70.00	2340.39	0.00	0.75	0.00	9104.32
Story level L5	1	57.00	2569.25	0.00	0.74	0.00	10971.68
Story level L4	1	44.00	2725.28	0.00	0.68	0.00	12873.93
Story level L3	1	31.00	2826.86	0.00	0.69	0.00	14780.31
Story level L2	1	18.00	2864.33	0.00	0.79	0.00	16839.31

Level	Diaph. #	$\theta_x$	$\theta_y$	$\theta_x/(1+\theta_x)$	$\theta_y/(1+\theta_y)$	$\theta_{xmax}$	$\theta_{ymax}$
Story level L10	1	0.010	0.000	0.010	0.000	0.182	0.182
Story level L9	1	0.014	0.000	0.014	0.000	0.182	0.182
Story level L8	1	0.015	0.000	0.014	0.000	0.182	0.182
Story level L7	1	0.017	0.000	0.017	0.000	0.182	0.182



# ASCE 7 Stability Coefficients

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DataBase: ATC 154\_SSC\_SMF Study - Ultra High Final - Drift

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Story level L6	1	0.019	0.000	0.018	0.000	0.182	0.182
Story level L5	1	0.020	0.000	0.020	0.000	0.182	0.182
Story level L4	1	0.020	0.000	0.020	0.000	0.182	0.182
Story level L3	1	0.023	0.000	0.023	0.000	0.182	0.182
Story level L2	1	0.022	0.000	0.021	0.000	0.182	0.182

## Type : EQ\_ASCE716\_X\_-E\_Drft

Level	Diaph. #	Ht ft	Shear X kips	Shear Y kips	Drift X in	Drift Y in	Vertical Load kips
Story level L10	1	122.00	628.67	-0.00	0.54	-0.00	1810.78
Story level L9	1	109.00	1178.24	-0.00	0.73	-0.00	3583.83
Story level L8	1	96.00	1647.63	-0.00	0.70	-0.00	5408.29
Story level L7	1	83.00	2035.53	-0.00	0.77	-0.00	7238.82
Story level L6	1	70.00	2340.39	-0.00	0.75	-0.00	9104.32
Story level L5	1	57.00	2569.25	-0.00	0.74	-0.00	10971.68
Story level L4	1	44.00	2725.28	-0.00	0.68	-0.00	12873.93
Story level L3	1	31.00	2826.86	-0.00	0.69	-0.00	14780.31
Story level L2	1	18.00	2864.33	-0.00	0.79	-0.00	16839.31

Level	Diaph. #	$\theta_x$	$\theta_y$	$\theta_x/(1+\theta_x)$	$\theta_y/(1+\theta_y)$	$\theta_{xmax}$	$\theta_{ymax}$
Story level L10	1	0.010	0.000	0.010	0.000	0.182	0.182
Story level L9	1	0.014	0.000	0.014	0.000	0.182	0.182
Story level L8	1	0.015	0.000	0.014	0.000	0.182	0.182
Story level L7	1	0.017	0.000	0.017	0.000	0.182	0.182
Story level L6	1	0.019	0.000	0.018	0.000	0.182	0.182
Story level L5	1	0.020	0.000	0.020	0.000	0.182	0.182
Story level L4	1	0.020	0.000	0.020	0.000	0.182	0.182
Story level L3	1	0.023	0.000	0.023	0.000	0.182	0.182
Story level L2	1	0.022	0.000	0.021	0.000	0.182	0.182

## Type : EQ\_ASCE716\_Y\_+E\_Drft

Level	Diaph. #	Ht ft	Shear X kips	Shear Y kips	Drift X in	Drift Y in	Vertical Load kips
Story level L10	1	122.00	0.00	629.73	0.00	0.54	1810.78
Story level L9	1	109.00	0.00	1180.34	0.00	0.73	3583.83
Story level L8	1	96.00	0.00	1650.72	0.00	0.70	5408.29
Story level L7	1	83.00	0.00	2039.52	0.00	0.77	7238.82
Story level L6	1	70.00	0.00	2345.15	0.00	0.75	9104.32
Story level L5	1	57.00	0.00	2574.45	0.00	0.74	10971.68
Story level L4	1	44.00	0.00	2730.71	0.00	0.67	12873.93
Story level L3	1	31.00	0.00	2832.61	0.00	0.69	14780.31
Story level L2	1	18.00	0.00	2870.60	0.00	0.79	16839.31

Level	Diaph. #	$\theta_x$	$\theta_y$	$\theta_x/(1+\theta_x)$	$\theta_y/(1+\theta_y)$	$\theta_{xmax}$	$\theta_{ymax}$
Story level L10	1	0.000	0.010	0.000	0.010	0.182	0.182
Story level L9	1	0.000	0.014	0.000	0.014	0.182	0.182



# ASCE 7 Stability Coefficients

RAM Frame 17.04.01.07

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DataBase: ATC 154\_SSC\_SMF Study - Ultra High\_Final - Drift

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Story level L8	1	0.000	0.015	0.000	0.014	0.182	0.182
Story level L7	1	0.000	0.017	0.000	0.017	0.182	0.182
Story level L6	1	0.000	0.019	0.000	0.018	0.182	0.182
Story level L5	1	0.000	0.020	0.000	0.020	0.182	0.182
Story level L4	1	0.000	0.020	0.000	0.020	0.182	0.182
Story level L3	1	0.000	0.023	0.000	0.022	0.182	0.182
Story level L2	1	0.000	0.021	0.000	0.021	0.182	0.182

## Type : EQ\_ASCE716\_Y\_-E\_Drft

Level	Diaph. #	Ht ft	Shear X kips	Shear Y kips	Drift X in	Drift Y in	Vertical Load kips
Story level L10	1	122.00	-0.00	629.73	-0.00	0.54	1810.78
Story level L9	1	109.00	-0.00	1180.34	-0.00	0.73	3583.83
Story level L8	1	96.00	-0.00	1650.72	-0.00	0.70	5408.29
Story level L7	1	83.00	-0.00	2039.53	-0.00	0.77	7238.82
Story level L6	1	70.00	-0.00	2345.16	-0.00	0.75	9104.32
Story level L5	1	57.00	-0.00	2574.46	-0.00	0.74	10971.68
Story level L4	1	44.00	-0.00	2730.72	-0.00	0.67	12873.93
Story level L3	1	31.00	-0.00	2832.62	-0.00	0.69	14780.31
Story level L2	1	18.00	-0.00	2870.62	-0.00	0.79	16839.31

Level	Diaph. #	$\theta_x$	$\theta_y$	$\theta_x/(1+\theta_x)$	$\theta_y/(1+\theta_y)$	$\theta_{xmax}$	$\theta_{ymax}$
Story level L10	1	0.000	0.010	0.000	0.010	0.182	0.182
Story level L9	1	0.000	0.014	0.000	0.014	0.182	0.182
Story level L8	1	0.000	0.015	0.000	0.014	0.182	0.182
Story level L7	1	0.000	0.017	0.000	0.017	0.182	0.182
Story level L6	1	0.000	0.019	0.000	0.018	0.182	0.182
Story level L5	1	0.000	0.020	0.000	0.020	0.182	0.182
Story level L4	1	0.000	0.020	0.000	0.020	0.182	0.182
Story level L3	1	0.000	0.023	0.000	0.022	0.182	0.182
Story level L2	1	0.000	0.021	0.000	0.021	0.182	0.182

**APPENDIX 6: FRAME DEMAND CAPACITY RATIOS (DCRs)**

Story level L10	0.30	0.31	0.31	0.30
Story level L9	0.44	0.45	0.45	0.44
Story level L8	0.34	0.35	0.35	0.34
Story level L7	0.39	0.40	0.40	0.39
Story level L6	0.37	0.38	0.38	0.37
Story level L5	0.39	0.40	0.40	0.39
Story level L4	0.35	0.35	0.35	0.35
Story level L3	0.38	0.38	0.38	0.38
Story level L2	0.39	0.38	0.38	0.39
	0.53	0.44	0.44	0.53
	B	C	D	E
	1	1	1	1
	FRAME ALONG GRIDLINE 1			

Note: No web doubler plates required (typical all frames)



Story level L10	0.24	0.31	0.31	0.24
Story level L9	0.38	0.46	0.46	0.38
Story level L8	0.31	0.36	0.36	0.31
Story level L7	0.36	0.41	0.41	0.36
Story level L6	0.34	0.38	0.38	0.34
Story level L5	0.37	0.41	0.41	0.37
Story level L4	0.34	0.36	0.36	0.34
Story level L3	0.36	0.38	0.38	0.36
Story level L2	0.38	0.38	0.38	0.38
	0.43	0.43	0.43	0.43
	A 1	A 2	A 3	A 4
				A 5

FRAME ALONG GRIDLINE A

Story level L10	0.24	0.31	0.31	0.24
Story level L9	0.37	0.46	0.46	0.37
Story level L8	0.31	0.36	0.36	0.31
Story level L7	0.36	0.41	0.41	0.36
Story level L6	0.34	0.38	0.38	0.34
Story level L5	0.37	0.41	0.41	0.37
Story level L4	0.34	0.36	0.36	0.34
Story level L3	0.36	0.38	0.38	0.36
Story level L2	0.38	0.38	0.38	0.38
	0.43	0.43	0.43	0.43
	G 1	G 2	G 3	G 4
				G 5

FRAME ALONG GRIDLINE G