TECHNICAL REPORT 4

ORCHARD PLAZA

AE SENIOR THESIS

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20 November 2013

Letter of Transmittal

Department of Architectural Engineering

The Pennsylvania State University

Dr. Boothby,

This letter is to prove submittal of Technical Report 4 for the Orchard Plaza Senior Thesis project. All necessary documents are included with this submittal. Calculations supporting my claims are included in respective appendices.

Thank you for assistance with this assignment,

Christopher Duarte

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EXECUTIVE SUMMARY

Orchard Plaza is a six story office building with street level retail on the ground and first level. The building is located in southwestern Pennsylvania on the corner of two streets in an urban environment. Completed in 2006, Orchard Plaza is also a LEED Certified building.

The structural system elements include a foundation of caissons, grade beams, and slabs on grade. The site of Orchard building slopes upward from the ground floor on the eastern side to the first level on the western side. Because of this difference in grade, a concrete retaining wall is found along the western half of the building. The gravity system comprises of a system of W-shape beams, girders, and columns that carry all vertical loads to the caissons. The lateral resisting system is composed of six eccentrically braced steel frames that are evenly distributed to resist both North-South and East-West forces.

The façade is composed of four major materials. At its base, Orchard Plaza is wrapped in a limestone veneer that extends up to the second or third level. Next, red-orange brick veneer is found between levels two and five. The sixth level is wrapped in sleek metal paneling, proving a modern crown to the building. All glazing is green in color and gives the building a very contemporary appearance.

SITE PLAN

Orchard Plaza is situated in an urban environment with close proximity to neighboring streets. The building is located in southwestern Pennsylvania. Orchard Plaza was constructed next to an above ground parking garage which accommodates parking requirements for the building. The building is primarily open office space with some retail on the ground and first levels.

CODES

The following codes were used for the design of Orchard Plaza

- 2003 International Building Code
- Minimum Design Loads for Building and Other Structures (ASCE 7-02)
- Building Code Requirements for Structural Concrete (ACI 318-02)
- AISC Manual of Steel Construction, Allowable Stress Design (ASD)

GRAVITY LOADS

A complete estimate of the building's gravity loads can be found in Appendix A

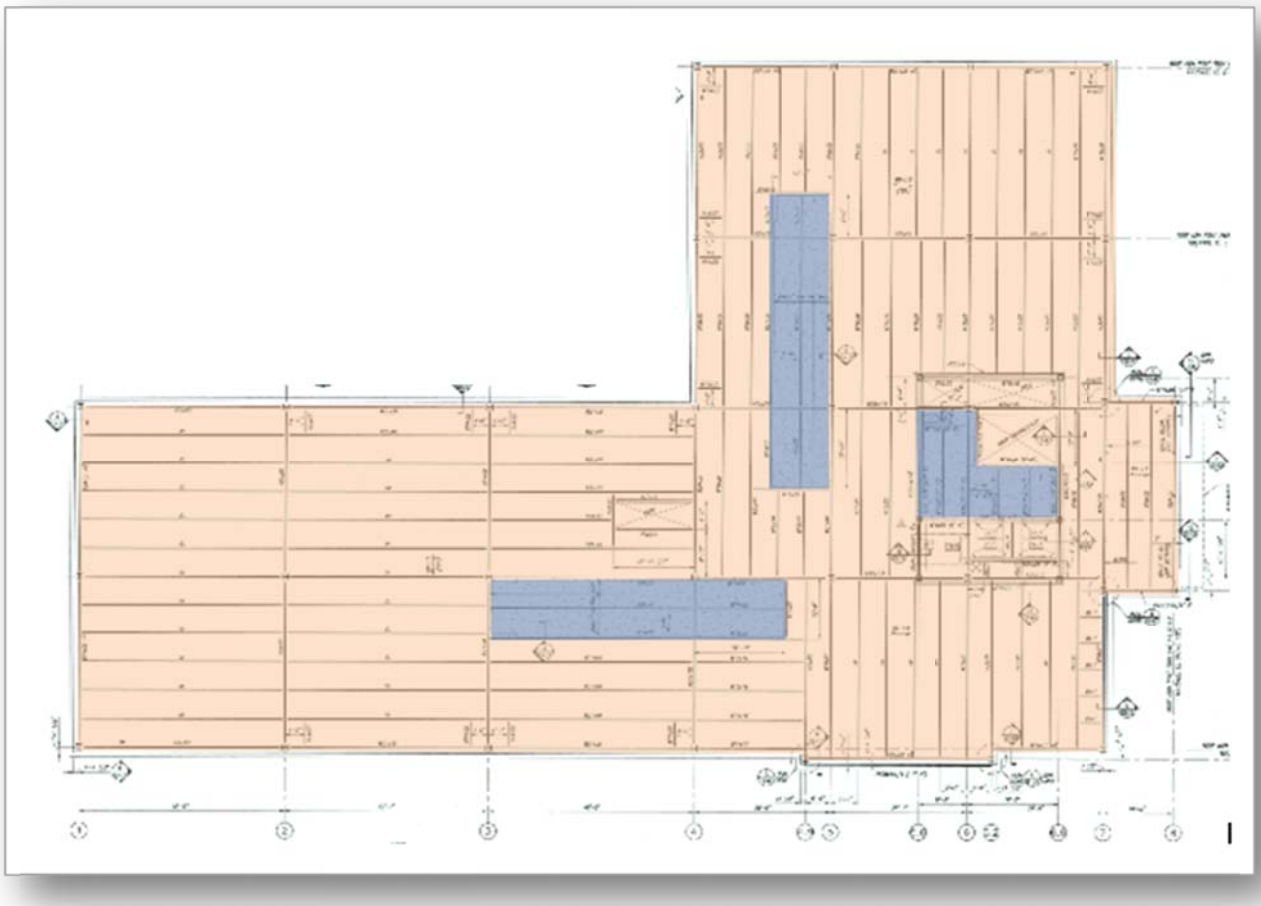
Dead Loads	
Description	**Load (psf)**
Ceiling + Misc. Mechanical	15
Roofing	11
Exterior Walls (Exterior Surface Area)	56
Floor Slab - Level 1	72
Floor Slab - Levels 2-6	66

Live Loads	
Description	**Load (psf)**
Lobbies & Corridors	100
Office Areas	80
Main Corridors Above Ground Level	80
Electrical & Mechanical Rooms	200
Stairs & Landings	100
Light Storage	125
General File Areas	175
Heavy Storage	250
Roof Live Load	30

Snow Loads	
Description	**Value**
Ground Snow Load P_g	25 psf
Flat-Roof Snow Load P_f	18 psf
Snow Exposure Factor C_e	1
Snow Importance Factor I_e	1
Thermal Factor	1
Wind Directionality Factor K_d	0.85

ROOF LOADS

The roof system of Orchard Plaza is comprised of the two components shown below.

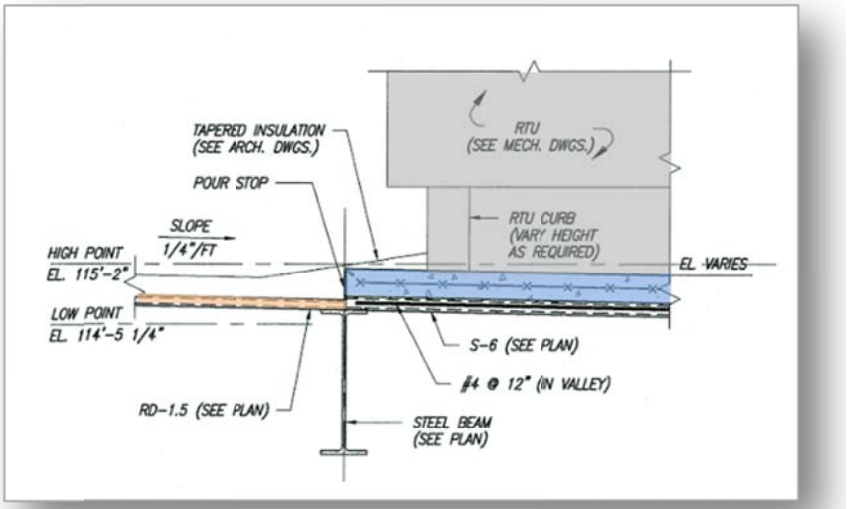


Concrete Mechanical Pad

- 4" Normal Weight Concrete
- 2"-18Gage Composite Decking
- 6x6 – W2.9 x W2.9 Welded Wire Frame

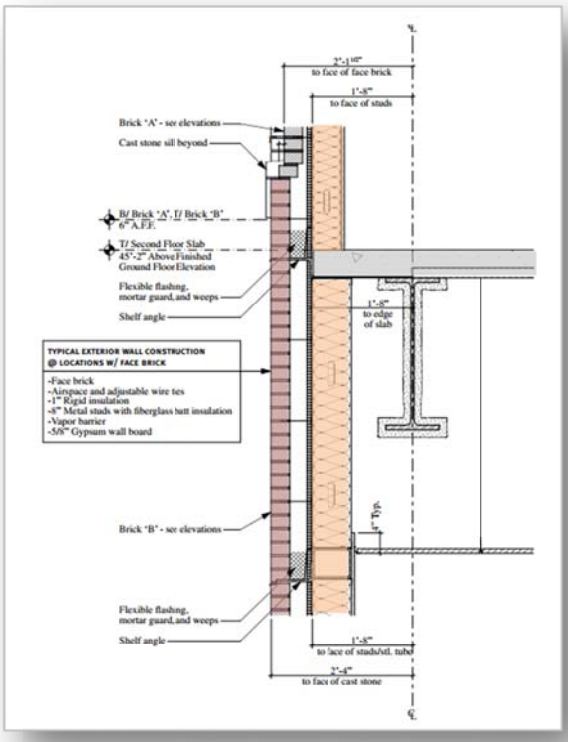
1.5B20 Roof Decking - Vulcraft

A cross section of both the roof decking and concrete mechanical pad is shown below.



EXTERIOR FAÇADE LOADS

Weight of the exterior façade was estimated using ASCE 7-02. Exterior façade loads are estimated to account for forty percent of the total building weight.



WIND LOADS

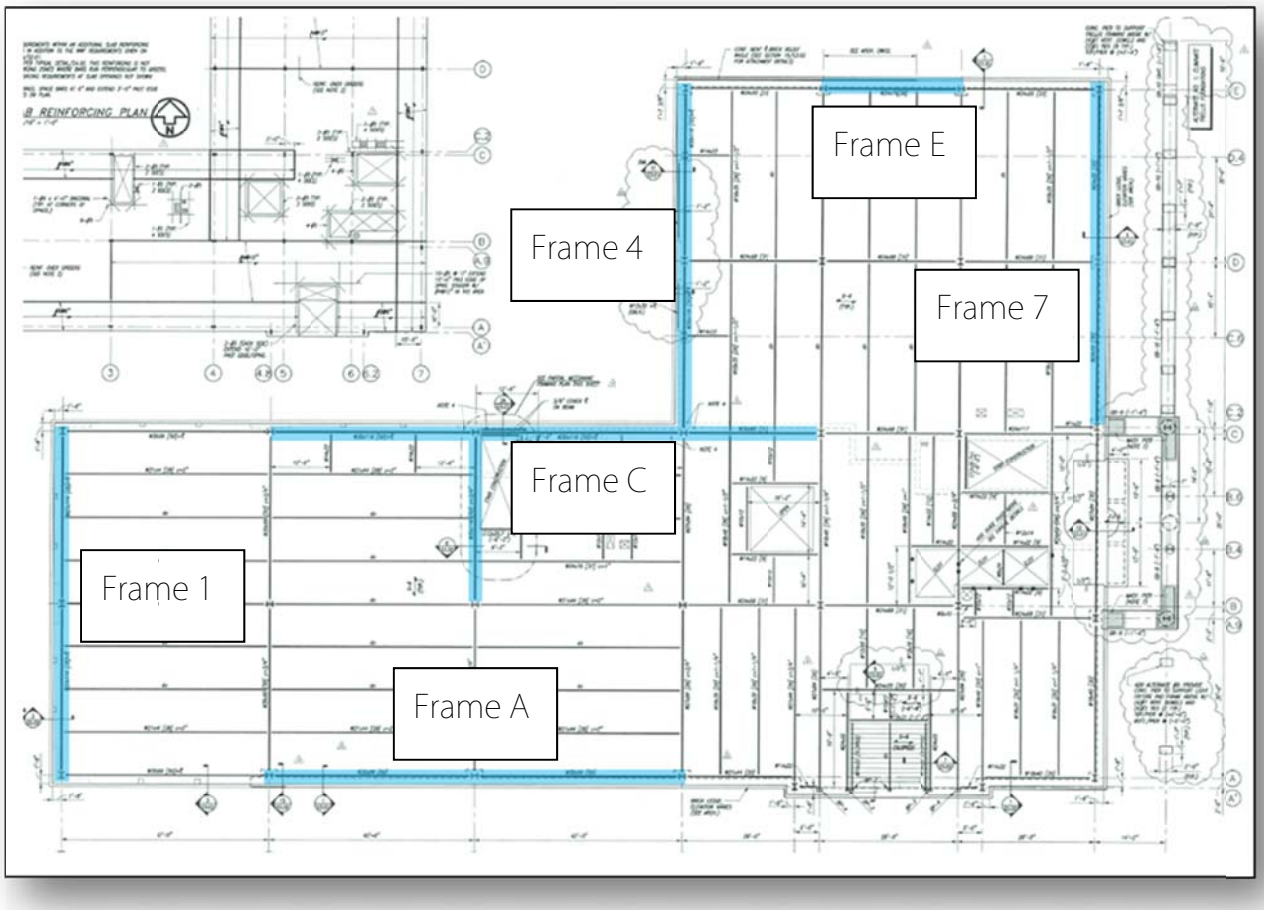
To simplify wind calculations, the building was assumed to be of a rectangular shape instead of an L-shape. This assumption proved to be effective as the largest base shear of 469k calculated is very similar to the 495k prescribed by the building documents. Calculations for wind loads can be found in Appendix B.

Wind Pressure (North-South)										
Level	z	k_z	q_h	q_z (psf)	Windward (psf)	Leeward (psf)	Trib. Area (sf)	Force (k)	Story Shear (k)	Overturning Moment (ft-k)
1	27.17	0.57	16.74	10.04	9.54	-9.81	3840	74	469	2011
2	45.17	0.61	16.74	10.75	10	-9.81	2987	59	395	2673
3	59.17	0.71	16.74	12.51	11.15	-9.81	2987	63	335	3704
4	73.17	0.79	16.74	13.92	12.06	-9.81	2987	65	273	4778
5	87.17	0.85	16.74	14.98	12.75	-9.81	2987	67	208	5878
6	101.17	0.91	16.74	16.03	13.43	-9.81	2987	69	140	7021
Roof	115.17	0.95	16.74	16.74	13.85	-9.81	2987	71	71	8139
Base Shear (k) = 469										
Total Overturning Moment (ft-k) = 34204										

Wind Pressure (East - West)										
Level	z	k_z	q_h	q_z (psf)	Windward (psf)	Leeward (psf)	Trib. Area (sf)	Force (k)	Story Shear (k)	Overturning Moment (ft-k)
1	27.17	0.57	16.74	10.04	9.64	-9.92	2592	51	320	1386
2	45.17	0.61	16.74	10.75	10.11	-9.92	2016	40	270	1825
3	59.17	0.71	16.74	12.51	11.27	-9.92	2016	43	229	2527
4	73.17	0.79	16.74	13.92	12.20	-9.92	2016	45	186	3263
5	87.17	0.85	16.74	14.98	12.90	-9.92	2016	46	142	4010
6	101.17	0.91	16.74	16.03	13.60	-9.92	2016	47	96	4795
Roof	115.17	0.95	16.74	16.74	14.07	-9.92	2016	48	48	5574
Base Shear (k) = 320										
Total Overturning Moment (ft-k) = 23380										

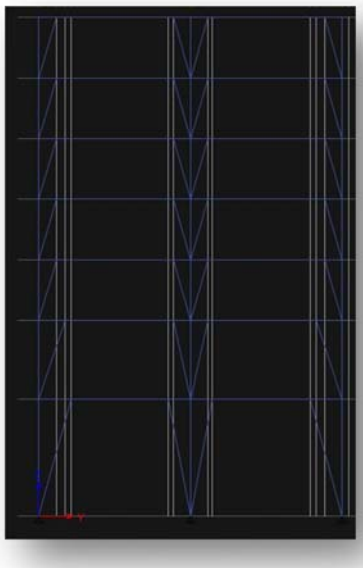
LATERAL LOAD ANALYSIS INTRODUCTION

The primary lateral load resisting elements are eccentrically braced frames formed from W-shape beams and HSS tubing. The location of all eccentrically braced framing elements is shown in blue in Figure 12 below. The orientation of these frames is distributed evenly between the north-south and east-west direction to adequately accommodate lateral loading from any direction.

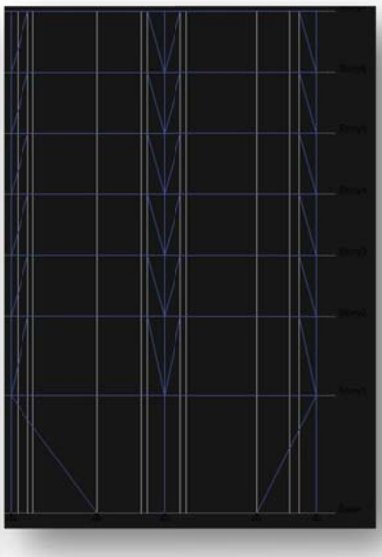


FRAMING ELEMENTS

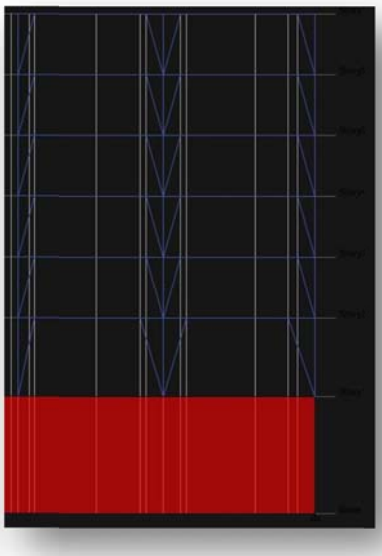
Frames 1, 4 and 7 are oriented in the North-South direction, or the Y-direction for analysis in this report. Frame 7 rests on a cast-in-place concrete foundation wall. All base connections for frames 1 ,4, and 7 are pinned.



Frame 1

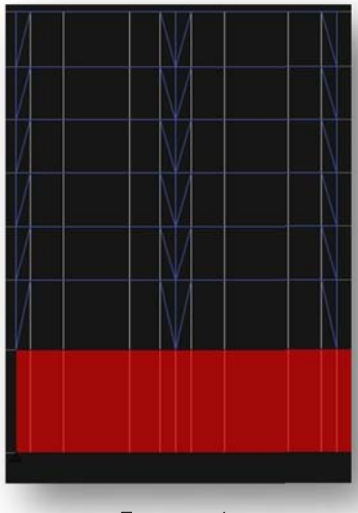


Frame 3

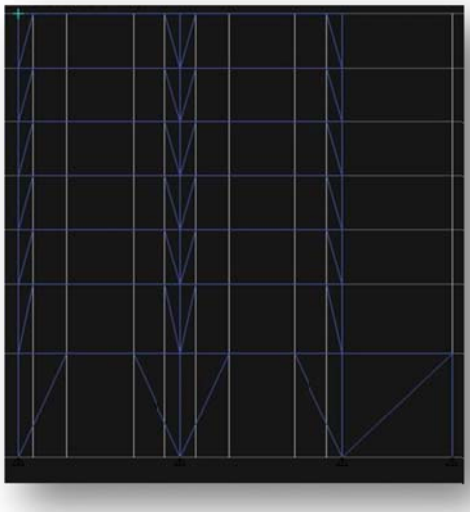


Frame 7

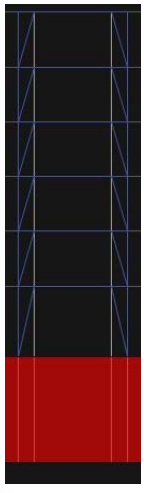
Frames A, C and E are oriented in the East-West direction, or the X-direction for analysis in this report. Frames A and E rest on a cast-in-place concrete foundation wall. All base connections for frames A, C and E are pinned.



Frame A



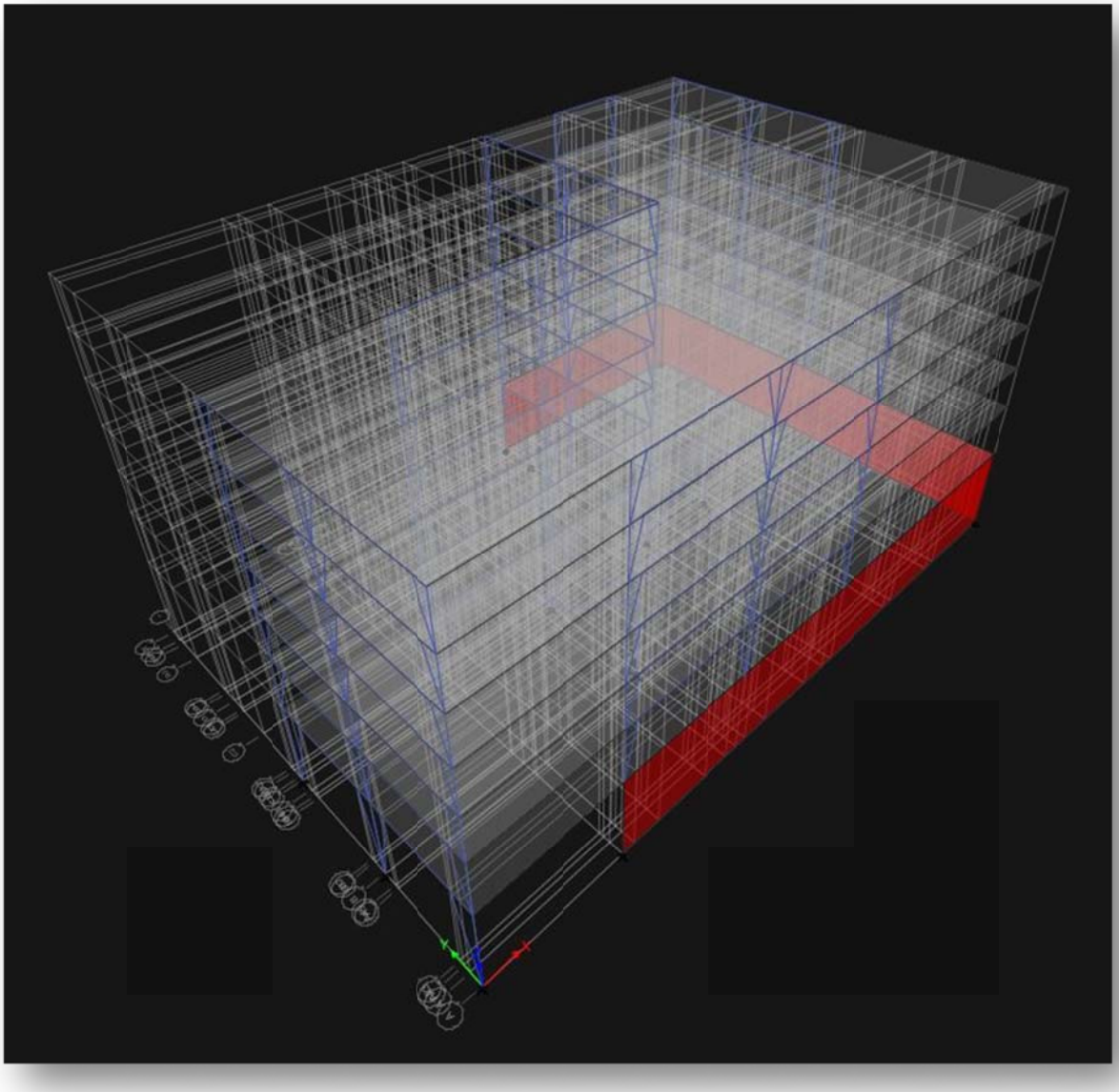
Frame C



Frame E

FRAMING OVERVIEW

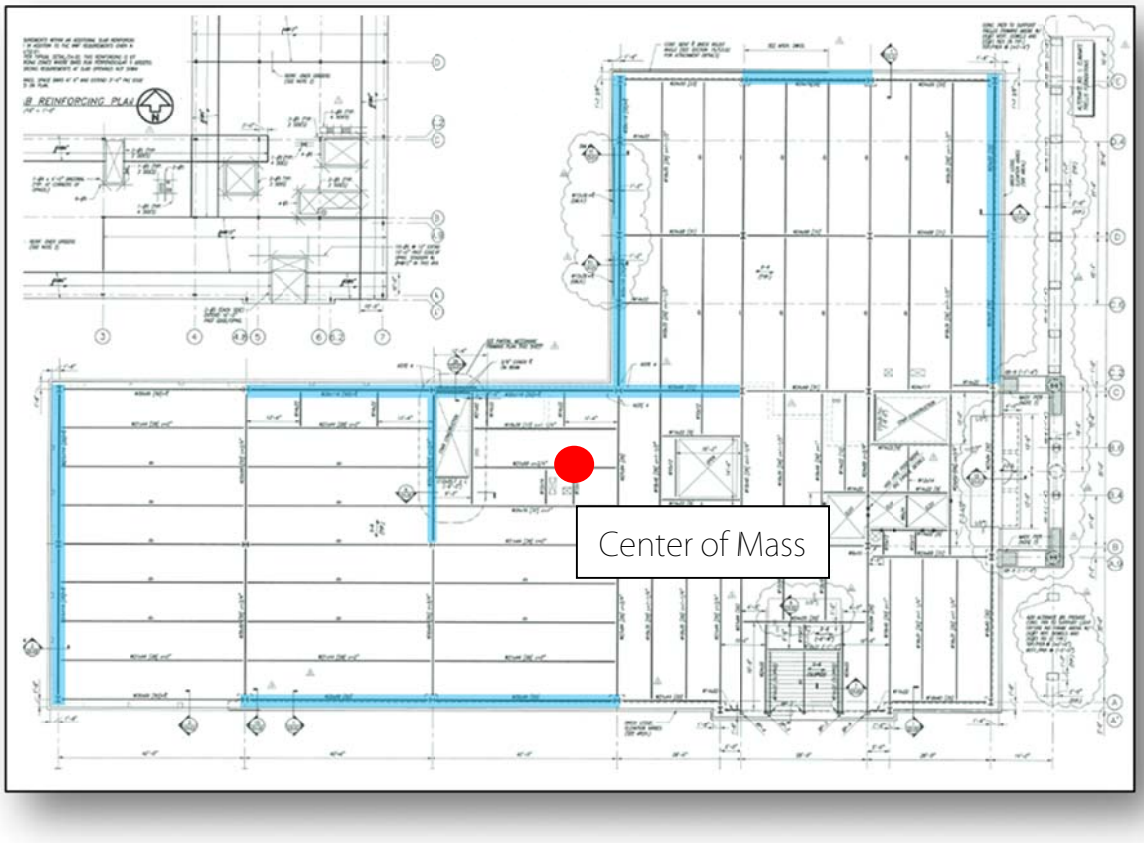
Frames were analyzed as individual elements and assumed to be attached to a rigid diaphragm. Below is an overall view of all six eccentrically braced frames within the Orchard Plaza structure.



CENTER OF MASS

Center of Mass								
Element	Wall Length (ft)	Wall Height (ft)	Unit Weight (k/sf)	Weight (k)	Distance From Zero Reference (ft)		Wx (ft-k)	Wy (ft-k)
Façade					X	Y		
1	70	14	0.056	54.88	0	35	0	1920.8
2	126	14	0.056	98.784	63	70	6223.392	6914.88
3	70	14	0.056	54.88	126	105	6914.88	5762.4
4	84	14	0.056	65.856	168	140	11063.81	9219.84
5	140	14	0.056	109.76	210	70	23049.6	7683.2
6	210	14	0.056	164.64	105	0	17287.2	0
Floor Area	Length (x)	Width (y)						
A	126	70	0.072	635.04	63	35	40007.52	22226.4
B	84	140	0.072	846.72	168	70	142249	59270.4
			Total	2030.56			246795.4	112997.9
		COM (x)	**COM (y)**					
		121.54	55.65					

The location of the center of mass is shown below in red.

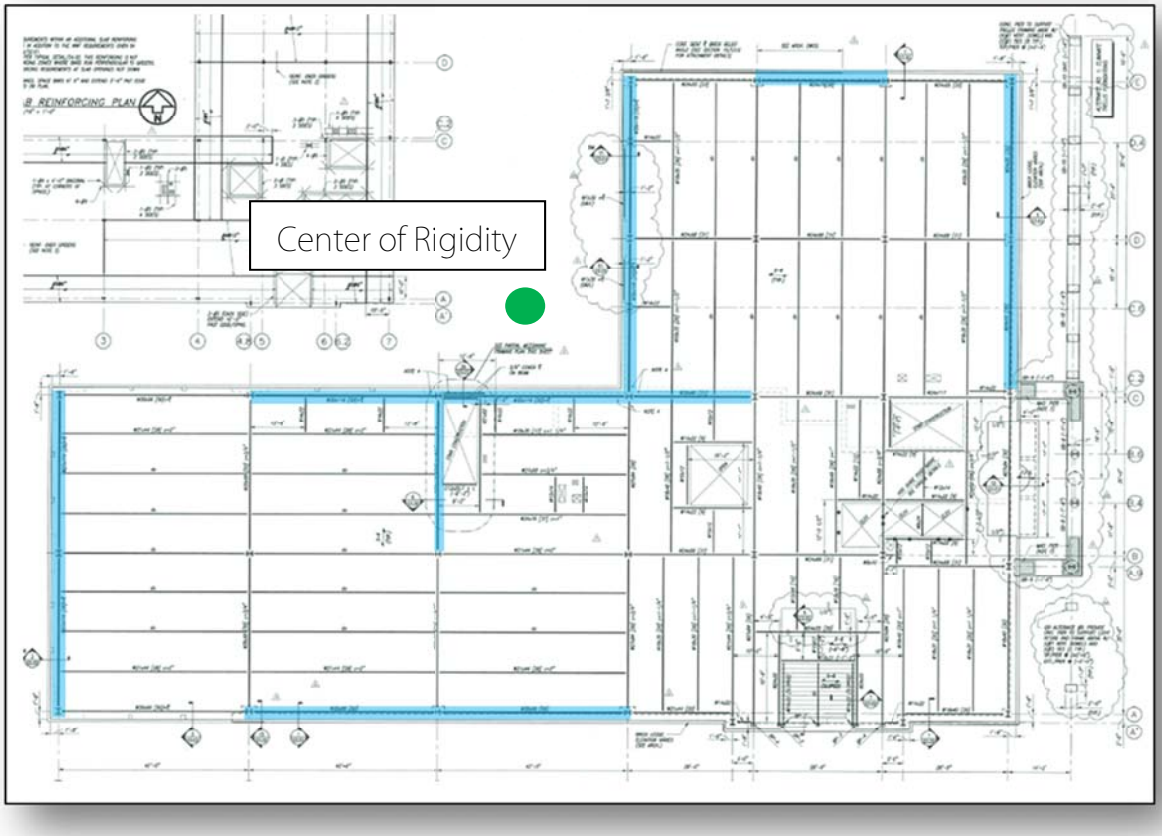


CENTER OF RIGIDITY

In order to determine the relative rigidity of each frame, a 100k load was placed at the top of each frame, and the displacements were compared. The center of rigidity was then determined from the relative rigidity values. Sample calculations can be found in Appendix C.

Center of Rigidity								
Frame	Load at Roof (k)	Displacement (in)	Relative Rigidity X (k/in)	Relative Rigidity Y (k/in)	Distance from Zero (X)	Distance from Zero (Y)	RxY	RyX
1	100	5.51	0	18.15	0	35	0	635
4	100	5.095	0	19.63	126	105	0	2061
7	100	4.485	0	22.30	210	105	0	2341
A	100	4.27	23.42	0	84	0	1967	0
C	100	4.42	22.62	0	84	70	1900	0
E	100	9.04	11.06	0	168	140	1858	0
		Total	57.11	60.07		**Total**	5726	5037
		COR (x)	**COR (y)**					
		100.27	83.85					

The location of the center of rigidity is shown below in green.

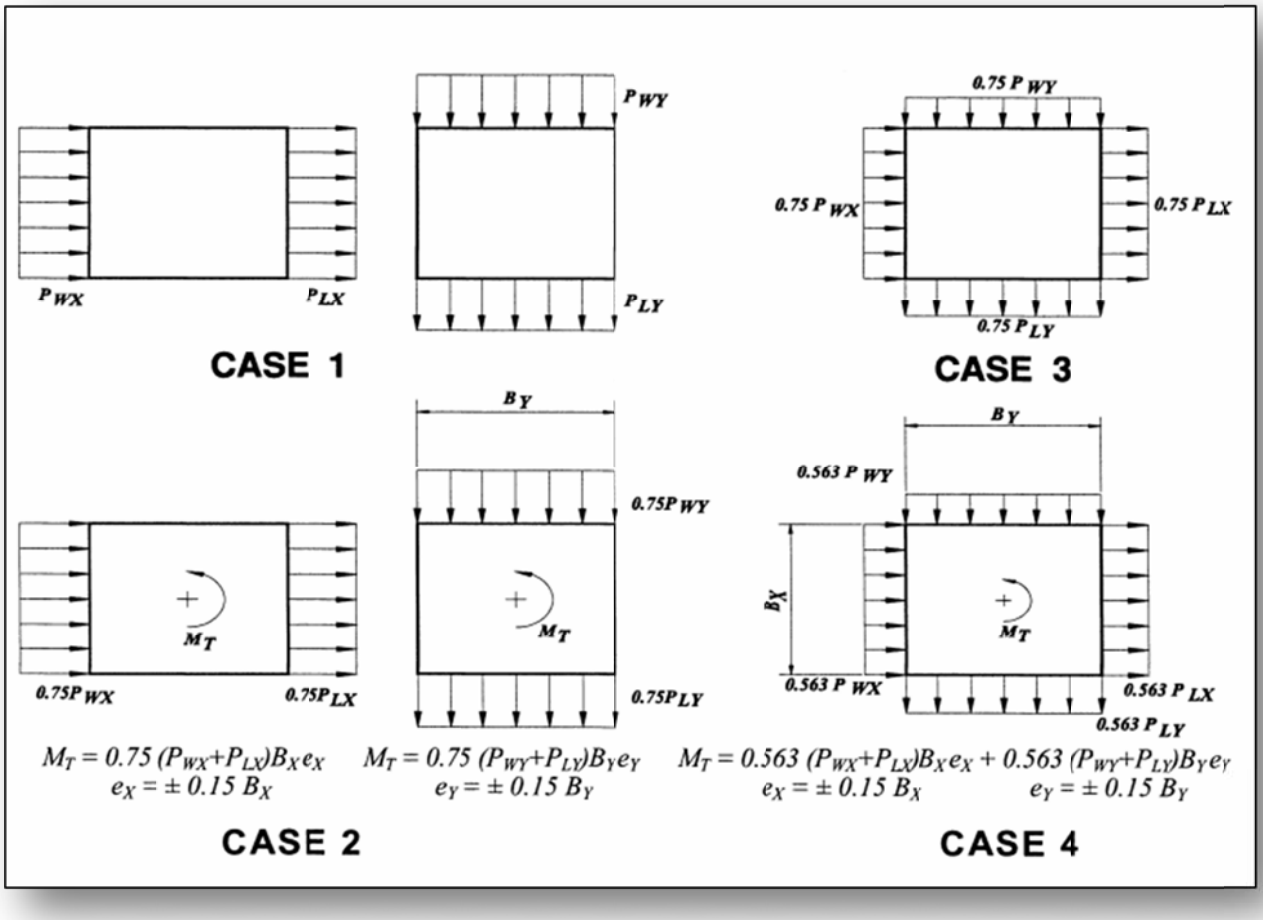


DISTRIBUTION OF LATERAL FORCES

Lateral forces applied to the exterior of Orchard Plaza are absorbed first by the floor slabs and then transferred into one of the six eccentrically braced frames. The forces each frame experiences is proportional to the relative stiffness of the

The four wind cases delineated in ASCE-02 Figure 6-9 (see below) were used to determine the worst-case wind loading scenario for Orchard Plaza. The building was assumed to react to wind loading as if it were rectangular in shape.

Based on the relative rigidities, the critical lateral frames are Frame 7 for the North/South direction and Frame A for the East/West direction. Case 2 was found to be the controlling wind load case



CASE 1 – NORTH/SOUTH

Frame	Floor	Rx	Ry	V (k)	e (ft)	T	x (ft)	y (ft)	Fx (k)	Fy (k)	dx (ft)	dy (ft)	kd^2	Fx-M	Fy-M	F
1	1	0	18.15	74	4.73	350.02	0	35	0	22.4	-100.27	0	182481	0	-0.954	21.4
1	2	0	18.15	59	4.73	279.07	0	35	0	17.8	-100.27	0	182481	0	-0.760	17.1
1	3	0	18.15	63	4.73	297.99	0	35	0	19.0	-100.27	0	182481	0	-0.812	18.2
1	4	0	18.15	65	4.73	307.45	0	35	0	19.6	-100.27	0	182481	0	-0.838	18.8
1	5	0	18.15	67	4.73	316.91	0	35	0	20.2	-100.27	0	182481	0	-0.864	19.4
1	6	0	18.15	69	4.73	326.37	0	35	0	20.8	-100.27	0	182481	0	-0.889	20.0
1	7	0	18.15	71	4.73	335.83	0	35	0	21.5	-100.27	0	182481	0	-0.915	20.5
4	1	0	19.63	74	4.73	350.02	126	105	0	24.2	25.73	0	12996	0	0.265	24.4
4	2	0	19.63	59	4.73	279.07	126	105	0	19.3	25.73	0	12996	0	0.211	19.5
4	3	0	19.63	63	4.73	297.99	126	105	0	20.6	25.73	0	12996	0	0.225	20.8
4	4	0	19.63	65	4.73	307.45	126	105	0	21.2	25.73	0	12996	0	0.233	21.5
4	5	0	19.63	67	4.73	316.91	126	105	0	21.9	25.73	0	12996	0	0.240	22.1
4	6	0	19.63	69	4.73	326.37	126	105	0	22.5	25.73	0	12996	0	0.247	22.8
4	7	0	19.63	71	4.73	335.83	126	105	0	23.2	25.73	0	12996	0	0.254	23.5
7	2	0	22.3	59	4.73	279.07	210	105	0	21.9	109.73	0	268507	0	1.022	22.9
7	3	0	22.3	63	4.73	297.99	210	105	0	23.4	109.73	0	268507	0	1.092	24.5
7	4	0	22.3	65	4.73	307.45	210	105	0	24.1	109.73	0	268507	0	1.126	25.3
7	5	0	22.3	67	4.73	316.91	210	105	0	24.9	109.73	0	268507	0	1.161	26.0
7	6	0	22.3	69	4.73	326.37	210	105	0	25.6	109.73	0	268507	0	1.196	26.8
7	7	0	22.3	71	4.73	335.83	210	105	0	26.4	109.73	0	268507	0	1.230	27.6

CASE 1 – EAST/WEST

A	2	23.42	0	40	13.85	554	84	0	16.4	0	0	-83.85	164662	-1.629	0	14.8
A	3	23.42	0	43	13.85	595.55	84	0	17.6	0	0	-83.85	164662	-1.751	0	15.9
A	4	23.42	0	45	13.85	623.25	84	0	18.4	0	0	-83.85	164662	-1.833	0	16.6
A	5	23.42	0	46	13.85	637.1	84	0	18.9	0	0	-83.85	164662	-1.873	0	17.0
A	6	23.42	0	47	13.85	650.95	84	0	19.3	0	0	-83.85	164662	-1.914	0	17.3
A	7	23.42	0	48	13.85	664.8	84	0	19.7	0	0	-83.85	164662	-1.955	0	17.7
C	1	22.62	0	51	13.85	706.35	84	70	20.2	0	0	-13.85	4339	-0.331	0	19.9
C	2	22.62	0	40	13.85	554	84	70	15.8	0	0	-13.85	4339	-0.260	0	15.6
C	3	22.62	0	43	13.85	595.55	84	70	17.0	0	0	-13.85	4339	-0.279	0	16.7
C	4	22.62	0	45	13.85	623.25	84	70	17.8	0	0	-13.85	4339	-0.292	0	17.5
C	5	22.62	0	46	13.85	637.1	84	70	18.2	0	0	-13.85	4339	-0.299	0	17.9
C	6	22.62	0	47	13.85	650.95	84	70	18.6	0	0	-13.85	4339	-0.305	0	18.3
C	7	22.62	0	48	13.85	664.8	84	70	19.0	0	0	-13.85	4339	-0.312	0	18.7
E	2	11.06	0	40	13.85	554	168	140	7.7	0	0	56.15	34870	0.515	0	8.3
E	3	11.06	0	43	13.85	595.55	168	140	8.3	0	0	56.15	34870	0.554	0	8.9
E	4	11.06	0	45	13.85	623.25	168	140	8.7	0	0	56.15	34870	0.580	0	9.3
E	5	11.06	0	46	13.85	637.1	168	140	8.9	0	0	56.15	34870	0.592	0	9.5
E	6	11.06	0	47	13.85	650.95	168	140	9.1	0	0	56.15	34870	0.605	0	9.7
E	7	11.06	0	48	13.85	664.8	168	140	9.3	0	0	56.15	34870	0.618	0	9.9

CASE 2 – EAST/WEST (EX+)

A	2	23.42	0	30	13.85	415.5	84	0	12.3	0	0	-83.85	164662	-1.222	0	630	-1.85	0	9.22
A	3	23.42	0	32.25	13.85	446.6625	84	0	13.2	0	0	-83.85	164662	-1.313	0	677	-1.99	0	9.91
A	4	23.42	0	33.75	13.85	467.4375	84	0	13.8	0	0	-83.85	164662	-1.374	0	709	-2.08	0	10.37
A	5	23.42	0	34.5	13.85	477.825	84	0	14.1	0	0	-83.85	164662	-1.405	0	725	-2.13	0	10.60
A	6	23.42	0	35.25	13.85	488.2125	84	0	14.4	0	0	-83.85	164662	-1.436	0	740	-2.18	0	10.84
A	7	23.42	0	36	13.85	498.6	84	0	14.8	0	0	-83.85	164662	-1.466	0	756	-2.22	0	11.07
C	1	22.62	0	38.25	13.85	529.7625	84	70	15.1	0	0	-13.85	4339	-0.249	0	803	-0.38	0	14.52
C	2	22.62	0	30	13.85	415.5	84	70	11.9	0	0	-13.85	4339	-0.195	0	630	-0.30	0	11.39
C	3	22.62	0	32.25	13.85	446.6625	84	70	12.8	0	0	-13.85	4339	-0.210	0	677	-0.32	0	12.24
C	4	22.62	0	33.75	13.85	467.4375	84	70	13.4	0	0	-13.85	4339	-0.219	0	709	-0.33	0	12.81
C	5	22.62	0	34.5	13.85	477.825	84	70	13.7	0	0	-13.85	4339	-0.224	0	725	-0.34	0	13.09
C	6	22.62	0	35.25	13.85	488.2125	84	70	14.0	0	0	-13.85	4339	-0.229	0	740	-0.35	0	13.38
C	7	22.62	0	36	13.85	498.6	84	70	14.3	0	0	-13.85	4339	-0.234	0	756	-0.35	0	13.66
E	2	11.06	0	30	13.85	415.5	168	140	5.8	0	0	56.15	34870	0.386	0	630	0.59	0	6.78
E	3	11.06	0	32.25	13.85	446.6625	168	140	6.2	0	0	56.15	34870	0.415	0	677	0.63	0	7.29
E	4	11.06	0	33.75	13.85	467.4375	168	140	6.5	0	0	56.15	34870	0.435	0	709	0.66	0	7.63
E	5	11.06	0	34.5	13.85	477.825	168	140	6.7	0	0	56.15	34870	0.444	0	725	0.67	0	7.80
E	6	11.06	0	35.25	13.85	488.2125	168	140	6.8	0	0	56.15	34870	0.454	0	740	0.69	0	7.97
E	7	11.06	0	36	13.85	498.6	168	140	7.0	0	0	56.15	34870	0.464	0	756	0.70	0	8.13

CASE 2 – EAST/WEST (EX-)

A	2	23.42	0	30	-13.85	-415.5	84	0	12.3	0	0	-83.85	164662	1.222	0	-630	1.85	0	15.37
A	3	23.42	0	32.25	-13.85	-446.663	84	0	13.2	0	0	-83.85	164662	1.313	0	-677	1.99	0	16.52
A	4	23.42	0	33.75	-13.85	-467.438	84	0	13.8	0	0	-83.85	164662	1.374	0	-709	2.08	0	17.29
A	5	23.42	0	34.5	-13.85	-477.825	84	0	14.1	0	0	-83.85	164662	1.405	0	-725	2.13	0	17.68
A	6	23.42	0	35.25	-13.85	-488.213	84	0	14.4	0	0	-83.85	164662	1.436	0	-740	2.18	0	18.06
A	7	23.42	0	36	-13.85	-498.6	84	0	14.8	0	0	-83.85	164662	1.466	0	-756	2.22	0	18.44
C	1	22.62	0	38.25	-13.85	-529.763	84	70	15.1	0	0	-13.85	4339	0.249	0	-803	0.38	0	15.77
C	2	22.62	0	30	-13.85	-415.5	84	70	11.9	0	0	-13.85	4339	0.195	0	-630	0.30	0	12.37
C	3	22.62	0	32.25	-13.85	-446.663	84	70	12.8	0	0	-13.85	4339	0.210	0	-677	0.32	0	13.29
C	4	22.62	0	33.75	-13.85	-467.438	84	70	13.4	0	0	-13.85	4339	0.219	0	-709	0.33	0	13.91
C	5	22.62	0	34.5	-13.85	-477.825	84	70	13.7	0	0	-13.85	4339	0.224	0	-725	0.34	0	14.22
C	6	22.62	0	35.25	-13.85	-488.213	84	70	14.0	0	0	-13.85	4339	0.229	0	-740	0.35	0	14.53
C	7	22.62	0	36	-13.85	-498.6	84	70	14.3	0	0	-13.85	4339	0.234	0	-756	0.35	0	14.84
E	2	11.06	0	30	-13.85	-415.5	168	140	5.8	0	0	56.15	34870	-0.386	0	-630	-0.59	0	4.83
E	3	11.06	0	32.25	-13.85	-446.663	168	140	6.2	0	0	56.15	34870	-0.415	0	-677	-0.63	0	5.20
E	4	11.06	0	33.75	-13.85	-467.438	168	140	6.5	0	0	56.15	34870	-0.435	0	-709	-0.66	0	5.44
E	5	11.06	0	34.5	-13.85	-477.825	168	140	6.7	0	0	56.15	34870	-0.444	0	-725	-0.67	0	5.56
E	6	11.06	0	35.25	-13.85	-488.213	168	140	6.8	0	0	56.15	34870	-0.454	0	-740	-0.69	0	5.68
E	7	11.06	0	36	-13.85	-498.6	168	140	7.0	0	0	56.15	34870	-0.464	0	-756	-0.70	0	5.80

CASE 2 – NORTH/SOUTH (EX+)

Frame	Floor	Rx	Ry	V (k)	e (ft)	T	x (ft)	y (ft)	Fx (k)	Fy (k)	dx (ft)	dy (ft)	kd^2	Fx-M	Fy-M	MT	Fx-MT	Fy-MT	F
1	1	0	18.15	55.5	4.73	262.515	0	35	0	16.8	-100.27	0	182481	0	-0.715	1748	0	-4.76	11.29
1	2	0	18.15	44.25	4.73	209.3025	0	35	0	13.4	-100.27	0	182481	0	-0.570	1394	0	-3.80	9.00
1	3	0	18.15	47.25	4.73	223.4925	0	35	0	14.3	-100.27	0	182481	0	-0.609	1488	0	-4.06	9.61
1	4	0	18.15	48.75	4.73	230.5875	0	35	0	14.7	-100.27	0	182481	0	-0.628	1536	0	-4.18	9.92
1	5	0	18.15	50.25	4.73	237.6825	0	35	0	15.2	-100.27	0	182481	0	-0.648	1583	0	-4.31	10.22
1	6	0	18.15	51.75	4.73	244.7775	0	35	0	15.6	-100.27	0	182481	0	-0.667	1630	0	-4.44	10.53
1	7	0	18.15	53.25	4.73	251.8725	0	35	0	16.1	-100.27	0	182481	0	-0.686	1677	0	-4.57	10.83
4	1	0	19.63	55.5	4.73	262.515	126	105	0	18.1	25.73	0	12996	0	0.199	1748	0	1.32	19.66
4	2	0	19.63	44.25	4.73	209.3025	126	105	0	14.5	25.73	0	12996	0	0.158	1394	0	1.05	15.67
4	3	0	19.63	47.25	4.73	223.4925	126	105	0	15.4	25.73	0	12996	0	0.169	1488	0	1.13	16.74
4	4	0	19.63	48.75	4.73	230.5875	126	105	0	15.9	25.73	0	12996	0	0.174	1536	0	1.16	17.27
4	5	0	19.63	50.25	4.73	237.6825	126	105	0	16.4	25.73	0	12996	0	0.180	1583	0	1.20	17.80
4	6	0	19.63	51.75	4.73	244.7775	126	105	0	16.9	25.73	0	12996	0	0.185	1630	0	1.23	18.33
4	7	0	19.63	53.25	4.73	251.8725	126	105	0	17.4	25.73	0	12996	0	0.190	1677	0	1.27	18.86
7	2	0	22.3	44.25	4.73	209.3025	210	105	0	16.4	109.73	0	268507	0	0.767	1394	0	5.11	22.30
7	3	0	22.3	47.25	4.73	223.4925	210	105	0	17.5	109.73	0	268507	0	0.819	1488	0	5.45	23.81
7	4	0	22.3	48.75	4.73	230.5875	210	105	0	18.1	109.73	0	268507	0	0.845	1536	0	5.63	24.57
7	5	0	22.3	50.25	4.73	237.6825	210	105	0	18.7	109.73	0	268507	0	0.871	1583	0	5.80	25.32
7	6	0	22.3	51.75	4.73	244.7775	210	105	0	19.2	109.73	0	268507	0	0.897	1630	0	5.97	26.08
7	7	0	22.3	53.25	4.73	251.8725	210	105	0	19.8	109.73	0	268507	0	0.923	1677	0	6.15	26.84

CASE 2 – NORTH/SOUTH (EX-)

Frame	Floor	Rx	Ry	V (k)	e (ft)	T	x (ft)	y (ft)	Fx (k)	Fy (k)	dx (ft)	dy (ft)	kd^2	Fx-M	Fy-M	MT	Fx-MT	Fy-MT	F
1	1	0	18.15	55.5	-4.73	-262.515	0	35	0	16.8	-100.27	0	182481	0	0.715	-1748	0	4.76	22.25
1	2	0	18.15	44.25	-4.73	-209.303	0	35	0	13.4	-100.27	0	182481	0	0.570	-1394	0	3.80	17.74
1	3	0	18.15	47.25	-4.73	-223.493	0	35	0	14.3	-100.27	0	182481	0	0.609	-1488	0	4.06	18.94
1	4	0	18.15	48.75	-4.73	-230.588	0	35	0	14.7	-100.27	0	182481	0	0.628	-1536	0	4.18	19.54
1	5	0	18.15	50.25	-4.73	-237.683	0	35	0	15.2	-100.27	0	182481	0	0.648	-1583	0	4.31	20.14
1	6	0	18.15	51.75	-4.73	-244.778	0	35	0	15.6	-100.27	0	182481	0	0.667	-1630	0	4.44	20.75
1	7	0	18.15	53.25	-4.73	-251.873	0	35	0	16.1	-100.27	0	182481	0	0.686	-1677	0	4.57	21.35
4	1	0	19.63	55.5	-4.73	-262.515	126	105	0	18.1	25.73	0	12996	0	-0.199	-1748	0	-1.32	16.62
4	2	0	19.63	44.25	-4.73	-209.303	126	105	0	14.5	25.73	0	12996	0	-0.158	-1394	0	-1.05	13.25
4	3	0	19.63	47.25	-4.73	-223.493	126	105	0	15.4	25.73	0	12996	0	-0.169	-1488	0	-1.13	14.15
4	4	0	19.63	48.75	-4.73	-230.588	126	105	0	15.9	25.73	0	12996	0	-0.174	-1536	0	-1.16	14.60
4	5	0	19.63	50.25	-4.73	-237.683	126	105	0	16.4	25.73	0	12996	0	-0.180	-1583	0	-1.20	15.04
4	6	0	19.63	51.75	-4.73	-244.778	126	105	0	16.9	25.73	0	12996	0	-0.185	-1630	0	-1.23	15.49
4	7	0	19.63	53.25	-4.73	-251.873	126	105	0	17.4	25.73	0	12996	0	-0.190	-1677	0	-1.27	15.94
																0			
7	2	0	22.3	44.25	-4.73	-209.303	210	105	0	16.4	109.73	0	268507	0	-0.767		0	0.00	15.66
7	3	0	22.3	47.25	-4.73	-223.493	210	105	0	17.5	109.73	0	268507	0	-0.819	-1488	0	-5.45	11.27
7	4	0	22.3	48.75	-4.73	-230.588	210	105	0	18.1	109.73	0	268507	0	-0.845	-1536	0	-5.63	11.63
7	5	0	22.3	50.25	-4.73	-237.683	210	105	0	18.7	109.73	0	268507	0	-0.871	-1583	0	-5.80	11.98
7	6	0	22.3	51.75	-4.73	-244.778	210	105	0	19.2	109.73	0	268507	0	-0.897	-1630	0	-5.97	12.34
7	7	0	22.3	53.25	-4.73	-251.873	210	105	0	19.8	109.73	0	268507	0	-0.923	-1677	0	-6.15	12.70

CASE 2 – SUMMATION OF FORCES

Frame	Floor	F (ex+)	F (ex-)	Sum
A	2	9.22	15.37	24.59
A	3	9.91	16.52	26.44
A	4	10.37	17.29	27.67
A	5	10.60	17.68	28.28
A	6	10.84	18.06	28.90
A	7	11.07	18.44	29.51
C	1	14.52	15.77	30.28
C	2	11.39	12.37	23.75
C	3	12.24	13.29	25.53
C	4	12.81	13.91	26.72
C	5	13.09	14.22	27.31
C	6	13.38	14.53	27.91
C	7	13.66	14.84	28.50
E	2	6.78	4.83	11.61
E	3	7.29	5.20	12.48
E	4	7.63	5.44	13.07
E	5	7.80	5.56	13.36
E	6	7.97	5.68	13.65
E	7	8.13	5.80	13.94

Frame	Floor	F (ex+)	F (ex-)	Sum
1	1	11.29	22.25	33.54
1	2	9.00	17.74	26.74
1	3	9.61	18.94	28.55
1	4	9.92	19.54	29.46
1	5	10.22	20.14	30.37
1	6	10.53	20.75	31.27
1	7	10.83	21.35	32.18
4	1	19.66	16.62	36.27
4	2	15.67	13.25	28.92
4	3	16.74	14.15	30.88
4	4	17.27	14.60	31.86
4	5	17.80	15.04	32.84
4	6	18.33	15.49	33.82
4	7	18.86	15.94	34.80
7	2	22.30	15.66	37.96
7	3	23.81	11.27	35.08
7	4	24.57	11.63	36.20
7	5	25.32	11.98	37.31
7	6	26.08	12.34	38.42
7	7	26.84	12.70	39.54

CASE 3 – NORTH/SOUTH

Frame	Floor	Rx	Ry	V (k)	e (ft)	T	x (ft)	y (ft)	Fx (k)	Fy (k)	dx (ft)	dy (ft)	kd^2	Fx-M	Fy-M	Fx
1	1	0	18.15	38.25	13.85	529.7625	0	35	0	11.6	-100.27	0	182481	0	-1.444	10.1
1	2	0	18.15	30	13.85	415.5	0	35	0	9.1	-100.27	0	182481	0	-1.132	7.9
1	3	0	18.15	32.25	13.85	446.6625	0	35	0	9.7	-100.27	0	182481	0	-1.217	8.5
1	4	0	18.15	33.75	13.85	467.4375	0	35	0	10.2	-100.27	0	182481	0	-1.274	8.9
1	5	0	18.15	34.5	13.85	477.825	0	35	0	10.4	-100.27	0	182481	0	-1.302	9.1
1	6	0	18.15	35.25	13.85	488.2125	0	35	0	10.7	-100.27	0	182481	0	-1.330	9.3
1	7	0	18.15	36	13.85	498.6	0	35	0	10.9	-100.27	0	182481	0	-1.359	9.5
4	1	0	19.63	38.25	13.85	529.7625	126	105	0	12.5	25.73	0	12996	0	0.401	12.9
4	2	0	19.63	30	13.85	415.5	126	105	0	9.8	25.73	0	12996	0	0.314	10.1
4	3	0	19.63	32.25	13.85	446.6625	126	105	0	10.5	25.73	0	12996	0	0.338	10.9
4	4	0	19.63	33.75	13.85	467.4375	126	105	0	11.0	25.73	0	12996	0	0.354	11.4
4	5	0	19.63	34.5	13.85	477.825	126	105	0	11.3	25.73	0	12996	0	0.361	11.6
4	6	0	19.63	35.25	13.85	488.2125	126	105	0	11.5	25.73	0	12996	0	0.369	11.9
4	7	0	19.63	36	13.85	498.6	126	105	0	11.8	25.73	0	12996	0	0.377	12.1
7	2	0	22.3	30	13.85	415.5	210	105	0	11.1	109.73	0	268507	0	1.522	12.7
7	3	0	22.3	32.25	13.85	446.6625	210	105	0	12.0	109.73	0	268507	0	1.637	13.6
7	4	0	22.3	33.75	13.85	467.4375	210	105	0	12.5	109.73	0	268507	0	1.713	14.2
7	5	0	22.3	34.5	13.85	477.825	210	105	0	12.8	109.73	0	268507	0	1.751	14.6
7	6	0	22.3	35.25	13.85	488.2125	210	105	0	13.1	109.73	0	268507	0	1.789	14.9
7	7	0	22.3	36	13.85	498.6	210	105	0	13.4	109.73	0	268507	0	1.827	15.2

CASE 3 – EAST/WEST

A	2	23.42	0	30	4.73	141.9	84	0	12.3	0	0	-83.85	164662	-1.038	0	11.3
A	3	23.42	0	32.25	4.73	152.5425	84	0	13.2	0	0	-83.85	164662	-1.116	0	12.1
A	4	23.42	0	33.75	4.73	159.6375	84	0	13.8	0	0	-83.85	164662	-1.168	0	12.7
A	5	23.42	0	34.5	4.73	163.185	84	0	14.1	0	0	-83.85	164662	-1.193	0	12.9
A	6	23.42	0	35.25	4.73	166.7325	84	0	14.4	0	0	-83.85	164662	-1.219	0	13.2
A	7	23.42	0	36	4.73	170.28	84	0	14.8	0	0	-83.85	164662	-1.245	0	13.5
C	1	22.62	0	38.25	4.73	180.9225	84	70	15.1	0	0	-13.85	4339	-0.211	0	14.9
C	2	22.62	0	30	4.73	141.9	84	70	11.9	0	0	-13.85	4339	-0.166	0	11.7
C	3	22.62	0	32.25	4.73	152.5425	84	70	12.8	0	0	-13.85	4339	-0.178	0	12.6
C	4	22.62	0	33.75	4.73	159.6375	84	70	13.4	0	0	-13.85	4339	-0.186	0	13.2
C	5	22.62	0	34.5	4.73	163.185	84	70	13.7	0	0	-13.85	4339	-0.190	0	13.5
C	6	22.62	0	35.25	4.73	166.7325	84	70	14.0	0	0	-13.85	4339	-0.195	0	13.8
C	7	22.62	0	36	4.73	170.28	84	70	14.3	0	0	-13.85	4339	-0.199	0	14.1
E	2	11.06	0	30	4.73	141.9	168	140	5.8	0	0	56.15	34870	0.328	0	6.1
E	3	11.06	0	32.25	4.73	152.5425	168	140	6.2	0	0	56.15	34870	0.353	0	6.6
E	4	11.06	0	33.75	4.73	159.6375	168	140	6.5	0	0	56.15	34870	0.369	0	6.9
E	5	11.06	0	34.5	4.73	163.185	168	140	6.7	0	0	56.15	34870	0.377	0	7.1
E	6	11.06	0	35.25	4.73	166.7325	168	140	6.8	0	0	56.15	34870	0.386	0	7.2
E	7	11.06	0	36	4.73	170.28	168	140	7.0	0	0	56.15	34870	0.394	0	7.4

CASE 4 – EAST/WEST (EX+)

A	2	23.42	0	22.52	13.85	311.902	84	0	9.2	0	0	-83.85	164662	-0.917	0	473	-1.39	0	6.92
A	3	23.42	0	24.209	13.85	335.2947	84	0	9.9	0	0	-83.85	164662	-0.986	0	508	-1.49	0	7.44
A	4	23.42	0	25.335	13.85	350.8898	84	0	10.4	0	0	-83.85	164662	-1.032	0	532	-1.56	0	7.79
A	5	23.42	0	25.898	13.85	358.6873	84	0	10.6	0	0	-83.85	164662	-1.055	0	544	-1.60	0	7.96
A	6	23.42	0	26.461	13.85	366.4849	84	0	10.8	0	0	-83.85	164662	-1.078	0	556	-1.63	0	8.13
A	7	23.42	0	27.024	13.85	374.2824	84	0	11.1	0	0	-83.85	164662	-1.101	0	568	-1.67	0	8.31
C	1	22.62	0	28.713	13.85	397.6751	84	70	11.4	0	0	-13.85	4339	-0.187	0	603	-0.28	0	10.90
C	2	22.62	0	22.52	13.85	311.902	84	70	8.9	0	0	-13.85	4339	-0.146	0	473	-0.22	0	8.55
C	3	22.62	0	24.209	13.85	335.2947	84	70	9.6	0	0	-13.85	4339	-0.157	0	508	-0.24	0	9.19
C	4	22.62	0	25.335	13.85	350.8898	84	70	10.0	0	0	-13.85	4339	-0.165	0	532	-0.25	0	9.62
C	5	22.62	0	25.898	13.85	358.6873	84	70	10.3	0	0	-13.85	4339	-0.168	0	544	-0.26	0	9.83
C	6	22.62	0	26.461	13.85	366.4849	84	70	10.5	0	0	-13.85	4339	-0.172	0	556	-0.26	0	10.04
C	7	22.62	0	27.024	13.85	374.2824	84	70	10.7	0	0	-13.85	4339	-0.176	0	568	-0.27	0	10.26
E	2	11.06	0	22.52	13.85	311.902	168	140	4.4	0	0	56.15	34870	0.290	0	473	0.44	0	5.09
E	3	11.06	0	24.209	13.85	335.2947	168	140	4.7	0	0	56.15	34870	0.312	0	508	0.47	0	5.47
E	4	11.06	0	25.335	13.85	350.8898	168	140	4.9	0	0	56.15	34870	0.326	0	532	0.49	0	5.72
E	5	11.06	0	25.898	13.85	358.6873	168	140	5.0	0	0	56.15	34870	0.334	0	544	0.51	0	5.85
E	6	11.06	0	26.461	13.85	366.4849	168	140	5.1	0	0	56.15	34870	0.341	0	556	0.52	0	5.98
E	7	11.06	0	27.024	13.85	374.2824	168	140	5.2	0	0	56.15	34870	0.348	0	568	0.53	0	6.11

CASE 4 – EAST/WEST (EX-)

A	2	23.42	0	22.52	-13.85	-311.902	84	0	9.2	0	0	-83.85	164662	0.917	0	-473	1.39	0	11.54
A	3	23.42	0	24.209	-13.85	-335.295	84	0	9.9	0	0	-83.85	164662	0.986	0	-508	1.49	0	12.40
A	4	23.42	0	25.335	-13.85	-350.89	84	0	10.4	0	0	-83.85	164662	1.032	0	-532	1.56	0	12.98
A	5	23.42	0	25.898	-13.85	-358.687	84	0	10.6	0	0	-83.85	164662	1.055	0	-544	1.60	0	13.27
A	6	23.42	0	26.461	-13.85	-366.485	84	0	10.8	0	0	-83.85	164662	1.078	0	-556	1.63	0	13.56
A	7	23.42	0	27.024	-13.85	-374.282	84	0	11.1	0	0	-83.85	164662	1.101	0	-568	1.67	0	13.85
C	1	22.62	0	28.713	-13.85	-397.675	84	70	11.4	0	0	-13.85	4339	0.187	0	-603	0.28	0	11.84
C	2	22.62	0	22.52	-13.85	-311.902	84	70	8.9	0	0	-13.85	4339	0.146	0	-473	0.22	0	9.28
C	3	22.62	0	24.209	-13.85	-335.295	84	70	9.6	0	0	-13.85	4339	0.157	0	-508	0.24	0	9.98
C	4	22.62	0	25.335	-13.85	-350.89	84	70	10.0	0	0	-13.85	4339	0.165	0	-532	0.25	0	10.44
C	5	22.62	0	25.898	-13.85	-358.687	84	70	10.3	0	0	-13.85	4339	0.168	0	-544	0.26	0	10.68
C	6	22.62	0	26.461	-13.85	-366.485	84	70	10.5	0	0	-13.85	4339	0.172	0	-556	0.26	0	10.91
C	7	22.62	0	27.024	-13.85	-374.282	84	70	10.7	0	0	-13.85	4339	0.176	0	-568	0.27	0	11.14
E	2	11.06	0	22.52	-13.85	-311.902	168	140	4.4	0	0	56.15	34870	-0.290	0	-473	-0.44	0	3.63
E	3	11.06	0	24.209	-13.85	-335.295	168	140	4.7	0	0	56.15	34870	-0.312	0	-508	-0.47	0	3.90
E	4	11.06	0	25.335	-13.85	-350.89	168	140	4.9	0	0	56.15	34870	-0.326	0	-532	-0.49	0	4.08
E	5	11.06	0	25.898	-13.85	-358.687	168	140	5.0	0	0	56.15	34870	-0.334	0	-544	-0.51	0	4.17
E	6	11.06	0	26.461	-13.85	-366.485	168	140	5.1	0	0	56.15	34870	-0.341	0	-556	-0.52	0	4.26
E	7	11.06	0	27.024	-13.85	-374.282	168	140	5.2	0	0	56.15	34870	-0.348	0	-568	-0.53	0	4.35

CASE 4 – NORTH/SOUTH (EX+)

Frame	Floor	Rx	Ry	V (k)	e (ft)	T	x (ft)	y (ft)	Fx (k)	Fy (k)	dx (ft)	dy (ft)	kd^2	Fx-M	Fy-M	MT	Fx-MT	Fy-MT	F
1	1	0	18.15	41.662	4.73	197.0613	0	35	0	12.6	-100.27	0	182481	0	-10.285	1312	0	-3.58	-1.27
1	2	0	18.15	33.217	4.73	157.1164	0	35	0	10.0	-100.27	0	182481	0	-8.200	1046	0	-2.85	-1.01
1	3	0	18.15	35.469	4.73	167.7684	0	35	0	10.7	-100.27	0	182481	0	-8.756	1117	0	-3.04	-1.08
1	4	0	18.15	36.595	4.73	173.0944	0	35	0	11.1	-100.27	0	182481	0	-9.034	1153	0	-3.14	-1.12
1	5	0	18.15	37.721	4.73	178.4203	0	35	0	11.4	-100.27	0	182481	0	-9.312	1188	0	-3.24	-1.15
1	6	0	18.15	38.847	4.73	183.7463	0	35	0	11.7	-100.27	0	182481	0	-9.590	1224	0	-3.33	-1.19
1	7	0	18.15	36.973	4.73	174.8823	0	35	0	11.2	-100.27	0	182481	0	-9.127	1165	0	-3.17	-1.13
										0.0								0.00	
4	1	0	19.63	41.662	4.73	197.0613	126	105	0	13.6	25.73	0	12996	0	2.854	1312	0	0.99	17.46
4	2	0	19.63	33.217	4.73	157.1164	126	105	0	10.9	25.73	0	12996	0	2.276	1046	0	0.79	13.92
4	3	0	19.63	35.469	4.73	167.7684	126	105	0	11.6	25.73	0	12996	0	2.430	1117	0	0.84	14.87
4	4	0	19.63	36.595	4.73	173.0944	126	105	0	12.0	25.73	0	12996	0	2.507	1153	0	0.87	15.34
4	5	0	19.63	37.721	4.73	178.4203	126	105	0	12.3	25.73	0	12996	0	2.584	1188	0	0.90	15.81
4	6	0	19.63	38.847	4.73	183.7463	126	105	0	12.7	25.73	0	12996	0	2.661	1224	0	0.93	16.28
4	7	0	19.63	36.973	4.73	174.8823	126	105	0	12.1	25.73	0	12996	0	2.533	1165	0	0.88	15.50
										0.0								0.00	
7	2	0	22.3	33.217	4.73	157.1164	210	105	0	12.3	109.73	0	268507	0	11.025	1046	0	3.83	27.19
7	3	0	22.3	35.469	4.73	167.7684	210	105	0	13.2	109.73	0	268507	0	11.773	1117	0	4.09	29.03
7	4	0	22.3	36.595	4.73	173.0944	210	105	0	13.6	109.73	0	268507	0	12.147	1153	0	4.22	29.96
7	5	0	22.3	37.721	4.73	178.4203	210	105	0	14.0	109.73	0	268507	0	12.520	1188	0	4.35	30.88
7	6	0	22.3	38.847	4.73	183.7463	210	105	0	14.4	109.73	0	268507	0	12.894	1224	0	4.48	31.80
7	7	0	22.3	36.973	4.73	174.8823	210	105	0	13.7	109.73	0	268507	0	12.272	1165	0	4.27	30.26

CASE 4 – NORTH/SOUTH (EX-)

Frame	Floor	Rx	Ry	V (k)	e (ft)	T	x (ft)	y (ft)	Fx (k)	Fy (k)	dx (ft)	dy (ft)	kd^2	Fx-M	Fy-M	MT	Fx-MT	Fy-MT	F
1	1	0	18.15	41.662	-4.73	-197.061	0	35	0	12.6	-100.27	0	182481	0	10.285	-1312	0	3.58	26.45
1	2	0	18.15	33.217	-4.73	-157.116	0	35	0	10.0	-100.27	0	182481	0	8.200	-1046	0	2.85	21.09
1	3	0	18.15	35.469	-4.73	-167.768	0	35	0	10.7	-100.27	0	182481	0	8.756	-1117	0	3.04	22.52
1	4	0	18.15	36.595	-4.73	-173.094	0	35	0	11.1	-100.27	0	182481	0	9.034	-1153	0	3.14	23.23
1	5	0	18.15	37.721	-4.73	-178.42	0	35	0	11.4	-100.27	0	182481	0	9.312	-1188	0	3.24	23.95
1	6	0	18.15	38.847	-4.73	-183.746	0	35	0	11.7	-100.27	0	182481	0	9.590	-1224	0	3.33	24.66
1	7	0	18.15	36.973	-4.73	-174.882	0	35	0	11.2	-100.27	0	182481	0	9.127	-1165	0	3.17	23.47
																		0.00	
4	1	0	19.63	41.662	-4.73	-197.061	126	105	0	13.6	25.73	0	12996	0	-2.854	-1312	0	-0.99	9.77
4	2	0	19.63	33.217	-4.73	-157.116	126	105	0	10.9	25.73	0	12996	0	-2.276	-1046	0	-0.79	7.79
4	3	0	19.63	35.469	-4.73	-167.768	126	105	0	11.6	25.73	0	12996	0	-2.430	-1117	0	-0.84	8.32
4	4	0	19.63	36.595	-4.73	-173.094	126	105	0	12.0	25.73	0	12996	0	-2.507	-1153	0	-0.87	8.58
4	5	0	19.63	37.721	-4.73	-178.42	126	105	0	12.3	25.73	0	12996	0	-2.584	-1188	0	-0.90	8.84
4	6	0	19.63	38.847	-4.73	-183.746	126	105	0	12.7	25.73	0	12996	0	-2.661	-1224	0	-0.93	9.11
4	7	0	19.63	36.973	-4.73	-174.882	126	105	0	12.1	25.73	0	12996	0	-2.533	-1165	0	-0.88	8.67
																		0.00	
7	2	0	22.3	33.217	-4.73	-157.116	210	105	0	12.3	109.73	0	268507	0	-11.025	-1046	0	-3.83	-2.53
7	3	0	22.3	35.469	-4.73	-167.768	210	105	0	13.2	109.73	0	268507	0	-11.773	-1117	0	-4.09	-2.70
7	4	0	22.3	36.595	-4.73	-173.094	210	105	0	13.6	109.73	0	268507	0	-12.147	-1153	0	-4.22	-2.78
7	5	0	22.3	37.721	-4.73	-178.42	210	105	0	14.0	109.73	0	268507	0	-12.520	-1188	0	-4.35	-2.87
7	6	0	22.3	38.847	-4.73	-183.746	210	105	0	14.4	109.73	0	268507	0	-12.894	-1224	0	-4.48	-2.96
7	7	0	22.3	36.973	-4.73	-174.882	210	105	0	13.7	109.73	0	268507	0	-12.272	-1165	0	-4.27	-2.81

CASE 4 – SUMMATION OF FORCES

Frame	Floor	F (ex+)	F (ex-)	Sum
A	2	6.92	11.54	18.46
A	3	7.44	12.40	19.84
A	4	7.79	12.98	20.77
A	5	7.96	13.27	21.23
A	6	8.13	13.56	21.69
A	7	8.31	13.85	22.15
C	1	10.90	11.84	22.73
C	2	8.55	9.28	17.83
C	3	9.19	9.98	19.17
C	4	9.62	10.44	20.06
C	5	9.83	10.68	20.50
C	6	10.04	10.91	20.95
C	7	10.26	11.14	21.40
E	2	5.09	3.63	8.72
E	3	5.47	3.90	9.37
E	4	5.72	4.08	9.81
E	5	5.85	4.17	10.03
E	6	5.98	4.26	10.24
E	7	6.11	4.35	10.46

Frame	Floor	F (ex+)	F (ex-)	Sum
1	1	-1.27	25.26	23.98
1	2	-1.01	20.14	19.12
1	3	-1.08	21.50	20.42
1	4	-1.12	22.19	21.07
1	5	-1.15	22.87	21.72
1	6	-1.19	23.55	22.36
1	7	-1.13	22.41	21.28
4	1	17.46	10.10	27.56
4	2	13.92	8.05	21.97
4	3	14.87	8.60	23.46
4	4	15.34	8.87	24.21
4	5	15.81	9.14	24.95
4	6	16.28	9.42	25.70
4	7	15.50	8.96	24.46
7	2	27.19	-1.25	25.94
7	3	29.03	-1.33	27.70
7	4	29.96	-1.38	28.58
7	5	30.88	-1.42	29.46
7	6	31.80	-1.46	30.34
7	7	30.26	-1.39	28.87

SEISMIC CONSIDERATIONS

Seismic Loads					
Level	**h_x (ft)**	**w_x (k)**	**c_{vx}**	**F_v (k)**	**Overturning Moment (ft-k)**
1	0	2016	0	0	0
2	18	1892	0.0691	28	509
3	32	1892	0.1283	53	1683
4	46	1892	0.1894	78	3570
5	60	1892	0.252	103	6192
6	74	1892	0.3156	130	9598
Roof	88	227	0.0456	19	1646
$\Sigma(w_i)(h_i)^k$ = 610000					
Base Shear (k) = 410					
Total Overturning Moment (ft-k) = 23198					

After considering seismic loading, it is determined that they do not the controlling case for the lateral system. Both the North-South and East-West directions for wind loading result in a higher overturning moment than the seismic load cases.

DRIFT & DISPLACEMENT

A comparison between the code allowable story drifts of L/400 and the actual drifts found from the model is seen below

Floor Height	Code Allowable	Displacement
27.17	0.815	0.184
45.17	1.355	0.256
59.17	1.775	0.327
73.17	2.195	0.389
87.17	2.615	0.447
101.17	3.035	0.502
115.17	3.455	0.562

APPENDIX A – GRAVITY LOAD CALCULATIONS

Gravity Loads Avg Floor Area = 20580 ft²

Floor Weights ASD

First Level Deck + Concrete = 63 psf – 2VLI18 Vulcraft

Level 2-6 Deck + Concrete = 57 psf – 2VLI18 Vulcraft

Steel Beams (typical)

$28'/3_{spaces} = 9.33'$

$35'/4_{spaces} = 8.75'$ ← controls

W21×44 @ 8.75′ $44\,plf/8.75' = 5.03$ psf

Steel Girders (typical)

42′ spacing

W30×99 $99\,plf/42' = 2.36$ psf

Exterior Wall

Total Surface Area (approximate)

$(213.33')(88')(2) + (144')(88') + (144')(88-18') = 60300\,ft^2$

Assume exterior = 40% bldg weight

$60300\,ft^2\,(0.4)(56\,psf) = 1350.7\,K$

$\frac{1350.7\,K}{6\,levels} = 225.1\,K/level$

Steel Columns (typical)

W14×159 as average $\frac{(\text{heaviest level 1} + \text{heaviest level 6})}{2}$

Avg 14 columns/level $\frac{(257\,plf + 61\,plf)}{2} = 159\,plf$

$159 \times 14'\,story\,(typ) \times 14 = \frac{31164\,lb}{Floor\ Area} = \frac{31164\,lb}{20580\,sf} = 1.51\,psf$

APPENDIX A – GRAVITY LOAD CALCULATIONS

Gravity Loads

Floor Self Weights ASD

First Floor Self weight = 63 + 5.03 + 2.36 + 1.51 = 72 psf

Floor 2-6 Self Weight = 57 + 5.03 + 2.36 + 1.51 = 66 psf

Roof

Concrete Pad Area

$2(60.82')(12.75')(4\text{" thick}) + (23')(29')(4\text{" thick}) = 481\ cf\ conc.$

$481\ cf\ (150\ lb/cf) = \frac{72129\ lb}{20580\ sf} = 3.5\ psf$

1.5B20 Gage – Vulcraft = 2.14 psf ⟶ 2.5 psf per ASCE

Roof Total = 2.5 psf + 3.5 psf + 1 psf + 4 psf = 11 psf

1 psf = Acoustic ceiling
4 psf = Mechanical Duct
} ASCE 7-02 Table C3-1

Floor Total Weights

Level 1 = 72 psf + 1 psf + 4 psf + 10 psf = 87 psf

10 psf = misc. loads

(87 psf)(20580 sf) + 225.1 K (exterior wall/level) = 2016 K

Levels 2-6 = 66 psf + 1 psf + 4 psf + 10 psf = 81 psf

(81 psf)(20580 sf) + 225.1 K = 1892 K

Roof = 11 psf (20580 sf) = 227 K

Total Building Weight

227 K + 2016 + 1892(5) = 11703 K

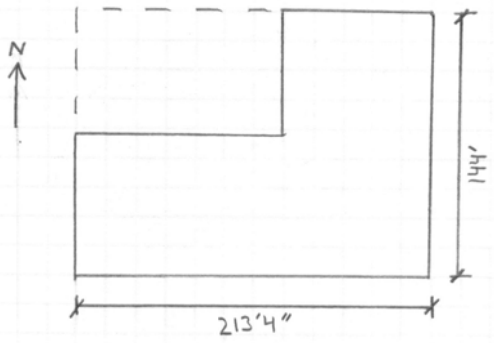
APPENDIX B – WIND LOAD CALCULATIONS

Wind Loads ASCE 7-02

Basic Wind Speed	= 90 mph	K_d	= 0.85
Importance Factor	= I_w = 1.0	K_{zt}	= 1.0
Building Category	II	h	= 88'
Exposure Category	B	B	= 213.33 ft
Internal Pressure	GC_{pi} = ±0.18	L	= 144 ft

$g_a = g_v = 3.4$ §6.5.8.1

Rigid Structure



Consider building as if it were perfectly rectangular

Values from Table 6-2

z_g = 1200	α = 7	ℓ = 320
z_{min} = 30 ft	c = 0.3	$\bar{\epsilon}$ = 0.33

$\bar{z} = 0.6(88\text{ft}) = 52.8 > 30$ ✓ok

$I_{\bar{z}} = c\left(33/\bar{z}\right)^{1/6} = 0.3\left(33/52.8\right)^{1/6} = 0.277$

$L_{\bar{z}} = \ell\left(\bar{z}/33\right)^{\bar{\epsilon}} = 320\left(52.8/33\right)^{0.33} = 374.3$

APPENDIX B – WIND LOAD CALCULATIONS

Wind Loads Cont.

North - South

$$Q = \sqrt{\frac{1}{1 + 0.63\left(\frac{B+h}{L_{\bar{z}}}\right)^{0.63}}} = \sqrt{\frac{1}{1 + 0.63\left(\frac{213.33 + 88}{374.3}\right)}} = 0.803$$

East - West

$$Q = \sqrt{\frac{1}{1 + 0.63\left(\frac{144 + 88}{374.3}\right)}} = 0.825$$

Gust Factor

North - South

$$G = 0.925\left(\frac{1 + 1.7 g_Q I_{\bar{z}} Q}{1 + 1.7 g_v I_{\bar{z}}}\right) = 0.925\left(\frac{1 + 1.7(3.4)(0.277)(0.803)}{1 + 1.7(3.4)(0.277)}\right)$$

$$G = 0.8128$$

East - West

$$G = 0.925\left(\frac{1 + 1.7(3.4)(0.277)(0.825)}{1 + 1.7(3.4)(0.277)}\right)$$

$$G = 0.8254$$

$$K_z = \begin{cases} 2.01\left(\frac{z}{z_g}\right)^{2/\alpha} & 15' < z < z_g \\ 2.01\left(\frac{15}{z_g}\right)^{2/\alpha} & z < 15' \end{cases}$$

$$q_h = 0.00256\, K_z\, K_{zt}\, K_d\, V^2 I_w$$

$$q_h = 0.00256(0.95)(1)(0.85)(90^2)(1)$$

$$q_h = 16.74 \text{ psf}$$

APPENDIX B – WIND LOAD CALCULATIONS

Wind Loads Cont.

$p = qGC_p - q_i(GC_{pi})$

WW $C_p = 0.8$ Table 6-6

LW $C_p = -0.5$ Table 6-6

North - South

Windward

$P_{WW} = q_z(0.8128)(0.8) - q_i(-0.18)$

Leeward

$P_{LW} = q_z(0.8128)(-0.5) - q_i(0.18)$

East - West

Windward

$P_{WW} = q_z(0.8254)(0.8) - q_i(-0.18)$

Leeward

$P_{LW} = q_z(0.8254)(-0.5) - q_i(0.18)$

APPENDIX C – SEISMIC LOAD CALCULATIONS

Seismic Loads ASCE 7-02

Site Class C — Response Modification Factor $R = 3$

Importance Factor $I_e = 1.0$ — Design Base Shear $V = 495K$

Building Category II — Seismic Response Coefficient $C_s = .035$

Following Values are from geohazards.usgs.gov/designmaps/us 2002 USGS Hazard Data

$S_s = 0.124_g$ $S_{MS} = 0.149_g$
$S_1 = 0.05_g$ $S_{M1} = 0.084_g$

Following Values From Documents S4.01

$S_{DS} = 0.104_g$
$S_{D1} = 0.068_g$

Fundamental Period

$$C_s = \frac{S_{D1}}{T(R/I)} \qquad T = \frac{S_{D1}}{C_s(R/I)} = \frac{.068}{.035\left(\frac{3}{1}\right)} = 0.648_{sec}$$

Vertical Distribution of Forces

	T	K
	0.5	1
Interpolate	0.648	1.074
	2.5	2

C_{vx} at Roof

$$\frac{227(88)^{1.074}}{227(88)^{1.074} + 1892(74)^{1.074} + 1892(60)^{1.074} + 1892(46)^{1.074} + 1892(32)^{1.074} + 1892(18)^{1.074}}$$

$\Sigma w_i h_i^{\,K} = 610000$

C_{vx} at roof $= 0.0456$

Check

$\Sigma C_{vx} = 1$ ✓ OK

APPENDIX C – SEISMIC LOAD CALCULATIONS

Seismic Loads

Total Building Weight = 11703 K (building weight calculation)

$V = C_s W$ $C_s = 0.035$ (given)

$V = 0.035(11703) = 409.6$ K

F_v at Roof

$F_v = C_{vx} V = 0.0456 (409.6) = 18.7$

All othe C_{vx} and F_v in spread sheet

Check

$\Sigma F_v = 409.6$ K ✓ OK

APPENDIX D – SAMPLE CALCULATIONS

Center of Mass Sample Calculation

Floor Area A

Area = 8820 sq ft
W = 0.072 ksf

$W = 8820(0.072) = 635.04\ k$

$\bar{x} = 63'$
$\bar{y} = 35'$

$W\bar{x} = 635.04(63') = 40007.52\ ft\text{-}k$
$W\bar{y} = 635.04(35') = 22226.4\ ft\text{-}k$

$$COM_x = \frac{\Sigma W_x}{\Sigma W} = \frac{246795.4}{2030.6} = 121.5\ ft$$

$$COM_y = \frac{\Sigma W_y}{\Sigma W} = \frac{112998}{2030.6} = 55.7\ ft$$

Relative Rigidity Sample Calculation

Use 100k trial load

Frame 1

L = 100 k
Δ = 5.51 in

$$\text{Relative Rigidity} = \frac{L}{\Delta} = \frac{100k}{5.51in} = 18.15$$

$$COR_x = \frac{\Sigma R_x Y}{\Sigma \text{Relative Rigidity}(x)} = \frac{5726}{57.11} = 100.27ft$$

$$COR_y = \frac{\Sigma R_y X}{\Sigma \text{Relative Rigidity}(y)} = \frac{5037}{60.07} = 83.85ft$$

APPENDIX D – SAMPLE CALCULATIONS

Wind Load Sample Calculation

Story 1 Frame 1

$$V_i^d = \frac{R_y}{\Sigma R_y}(V) = \frac{18.15}{60.07}(74) = 22.4\ K$$

$$J = \Sigma R_i(d_i)^2 = 667855$$

$$V_i^T = \frac{R_y V e\, dx}{J} = \frac{18.15(74)(4.73)(-100.27)}{667855} = -0.954\ K$$

Total = 22.4 - 0.954 = 21.4 K

Drift Sample Calculation

Story 7 Frame 1

$h = 115.17$
$P = 11.3$
$\frac{P}{h} = 0.098$

Overturning Moment Sample Calculation

Story 1 Frame 1,

$$M = h \cdot P = (27.17')(74) = 2011\ ft\ k$$

Total M = 34204 ft k