Gateway Plaza
Wilmington, DE
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Elizabeth Hostutler
Structural Option
Advisor: Linda Hanagan

Technical Report 3:
Lateral System Analysis and Confirmation Design

EXECUTIVE SUMMARY

The aim of this technical report is to perform a detailed analysis of the existing lateral resisting system for Gateway Plaza. Lateral loads were computed in Technical Assignment 1 and refined in Technical Assignment 3. These loads were used in order to develop strength, drift, and torsion checks on the frames of the building. Due to the size of the building and the complexity of the frames, RAM Frame software was used to compute frame shears, drift and torsion values.

The report contains a detailed description of the existing lateral resisting system and a discussion of the development of wind and seismic loads. Next, the distribution of these lateral forces to the lateral resisting elements is calculated and illustrated. Finally, using all of the information from the previous sections, checks on strength, drift, torsion, overturning, and impact on foundations were analyzed.

Strength of the members in the frames was computed in RAM Frame and checked by hand calculations. An interaction equation was used to determine stability due to the combined axial and bending forces seen by members in the frames. All of the members in the frames were found to be stable, except one column between levels four and five in frame y3. This could be attributed to differences in modeling techniques, but is otherwise indicative of a successful re-model.

Drift and torsion were both determined in RAM Frame as well. Inner story drift and total building drift were tabulated and compared to the industry standard of H/400, and there were no instances where this value was exceeded. Although there are no standards for torsional rotation of a building, the greatest rotation seen, at the roof, was 0.00041 rad (0.0235°). This value is hardly one for concern.

As to be expected, the size of foundations under columns in lateral frames is much larger than the foundations under gravity columns. This is due to the tremendous overturning moments seen at the base of lateral frames.

Despite the number of different lateral frames in Gateway Plaza making construction more difficult, the lateral resisting system does a very good job at preventing drift and rotation accompanied by strong winds. These serviceability issues should not be troublesome to this building.

INTRODUCTION

Gateway Plaza is the first new office tower being built in the Central Business District of Wilmington, Delaware in over 15 years. The $52 million complex is being built on the site of a former parking lot located at 500 Delaware Ave. With 15 stories, topping out at 210'-6", the tower will provide the city with 387,000 ft2 of rentable office space with 600 parking spaces located in the rear parking garage. The ground level will be a public plaza complete with a U.S. Post Office, WSFS Branch Bank, café, and lobby space for the towers above. The remaining 14 stories will be tenant fit-out spaces.

The 52'x30' bays of Gateway Plaza introduce some unique challenges to the building's structural systems. The foundation system uses clusters of auger-cast piles drilled 70' to bedrock and grade beams to support the superstructure. The gravity system consists of composite steel framing. The W27 members span 52' to preserve the open office layout. Structural slabs in the building are 3-1/4" lightweight concrete on 3" composite Lok-floor deck, which act as a rigid diaphragm to transmit lateral loads to the lateral resisting system. The lateral system uses four types of concentrically braced steel frames located in the rear of the building. A further, detailed description of the lateral system can be found in the body of the report. See *Appendix A-Lateral Load Resisting System* for a diagram of the system.

In order to perform a detailed analysis of the lateral system, the following sections are included to provide background information and procedural methods.

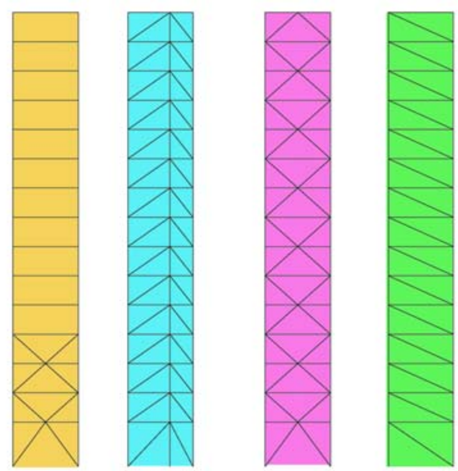
- Lateral System Description
- Controlling Lateral Loads
- Distribution of Lateral Loads
- Checks of:
  - Strength
  - Drift
  - Torsion
  - Overturning
  - Impact on Foundations

Due to the complexity of lateral system of Gateway Plaza, RAM Frame will be utilized to supplement load calculations performed by hand as well as for the checks mentioned above. These sections will help to provide a full understanding of the lateral system and the impacts that it will have on the building.

LATERAL SYSTEM DESCRIPTION

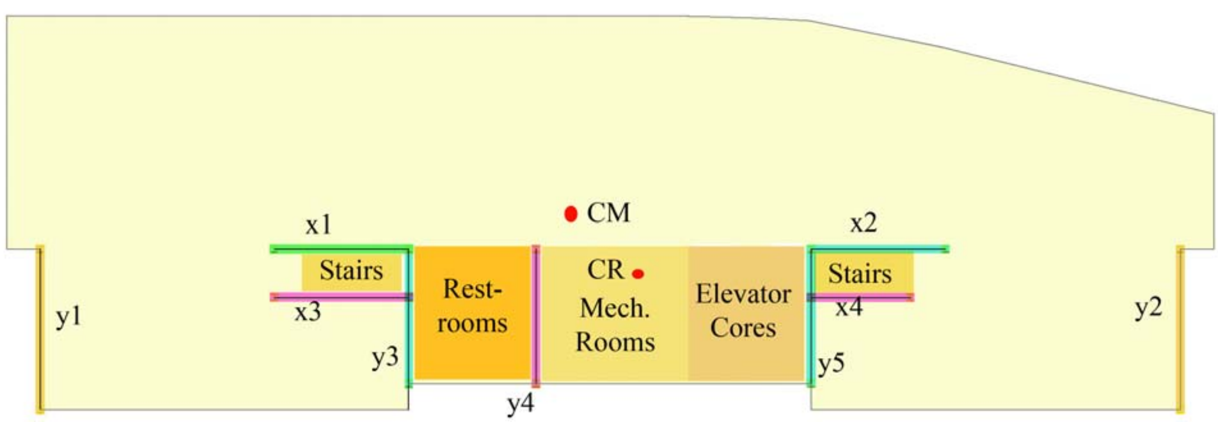
The lateral system of Gateway plaza uses concentrically braced steel frames to resist lateral loads. All of these frames are concentrated in the rear (South end) of the building in order to preserve the curtain wall façade's open view of the city from the front (North end) as well as preserve the open quality of the office space. Concentrating the lateral resisting elements to one side of the building forces the center of lateral rigidity to be located near that side of the building, further from the center of lateral force. However, since winds do not control in the short direction, the offset in this direction is not a cause for concern. There are five frames resisting the controlling wind loads in the y-direction, perpendicular to the long face of the building, and four frames in the x-direction, perpendicular to the short face of the building. The dimensions and configuration of each frame are different, making individual stiffnesses tedious to calculate.

The frames on the far ends of the building, oriented in the N-S direction and shown in orange, are moment frames with bracing on the first four floors. These open frames are free of bracing and keep the view through the curtain wall unobstructed. The other frames in the building utilize X- and chevron-bracing to provide stability. Their bracing elements are A992 steel wide flange shapes, not A36 angles, typical for a building of this height. These frames are located around the core of the building where obstructions will not create problems: around stairwells, restrooms, elevator cores, and mechanical rooms. Please see the diagrams below for the location and type of each framing element. Also, the identification system for the frames will be consistent throughout the report.



As indicated in the picture below, the center of the lateral force (CM) and center of rigidity are relatively close to each other, indicating that torsion from wind loading should not be an issue.

The floor system, 3-1/4" LW slab on 3" composite deck on composite steel framing, acts as a rigid diaphragm which transfers the lateral loads to the frames.



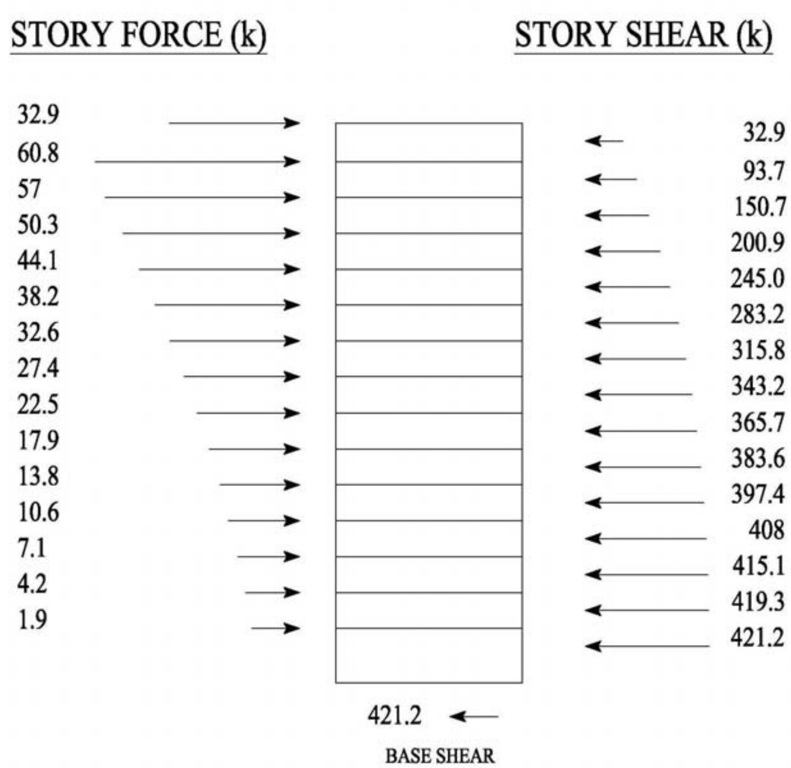
CONTROLING LATERAL LOADS

Technical Assignment 1 relied on conventional hand calculation methods to determine the controlling lateral loads. In order to determine these loads, provisions provided by ASCE 7-02 and IBC 2003. Initial assumptions are listed below and full calculations were carried out using Excel Spreadsheets and checked against RAM Frame output. These calculations are provided in detail in *Appendix B.1-Lateral Loads*.

Seismic Loading

Seismic Loads were found using the Equivalent Lateral Force Procedure as laid out in Section 9.5.5 of ASCE 7-02.

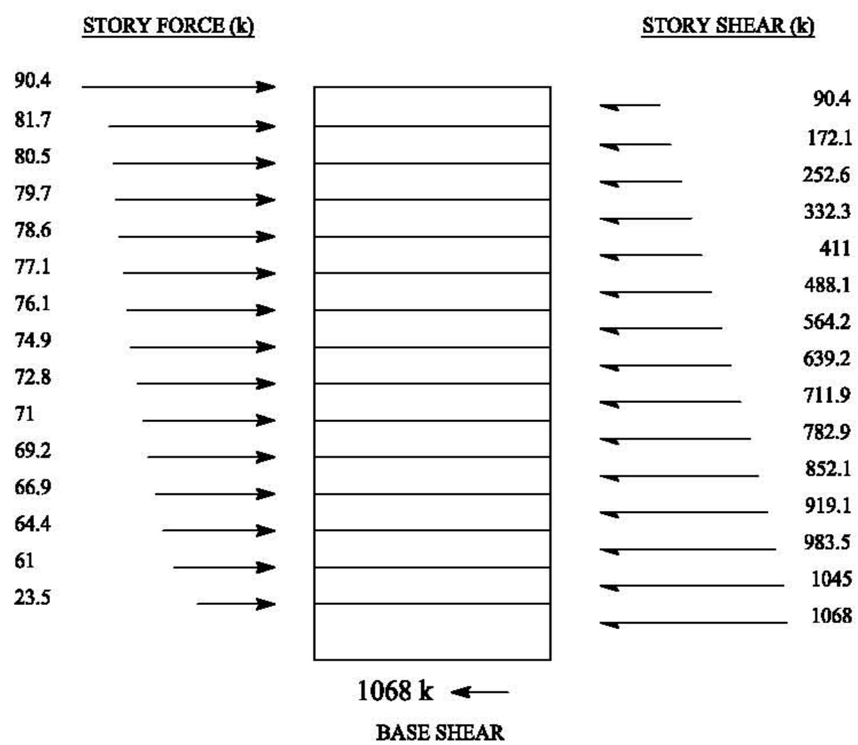
D	Site Class - Section 1615.1.1
B	Seismic Design Category - Section 1616.3
II	Seismic Use Group – Section 1616.2
.300g	S_S, Spectral Accelerations for Short Periods - Section 1615.1
.075g	S_1, Spectral Accelerations for 1 Second Period - Section 1615.1
1.56	F_a, Site Coefficient - Table 1615.1.2(1)
2.4	F_v, Site Coefficient - Table 1615.1.2(2)
0.03	C_T , Building Period Coefficient - Section 1617.4.2.1
0.75	x
5	R, Response Modification Factor - Table 1617.6



Wind Loading

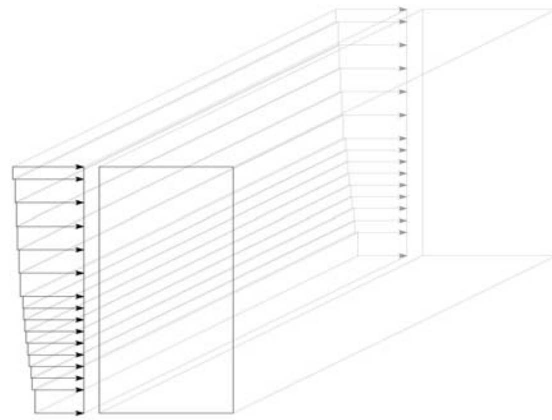
Wind Loads on the Main Wind Force Resisting System were found according to the Analytical Procedure, outlined in Section 6.5 of ASCE 7-02.

h	**210.50 ft**	*Mean Roof Height of Building*
H	**210.50 ft**	*Total Height of Roof*
Ct	**0.030**	*Fundamental Period Coefficient, ASCE 7-02 Table 9.5.5.3.2*
x	**0.750**	*Fundamental Period Factor, ASCE 7-02 Table 9.5.5.3.2*
Ta	**0.60 Hz**	*Structure is flexible so G will be calculated per ASCE Section 6.5.8.2*
Θ	**0.0 deg**	*Angle of Roof Slope*
V		*Basic Wind Speed, ASCE 7-02 Figure 6-1, IBC 2003 Figure 1609*
I	**1.00**	*Importance Factor for Wind, ASCE 7-02 Table 6-1, IBC 2003 Table 1604.5*
Exposure	**B**	*Exposure Category, ASCE 7-02 Section 6.5.6, IBC 2003 Section 1609.4*
Roof Diaphragm	**Flexible**	*Is roof diaphragm considered rigid or flexible??*
Calculated Information		
Height	HIGH	*"High" for Buildings >60', "Low" for Buildings < 60'*
Cp-w	0.8	*Windward Wall Pressure Coefficient, ASCE 7-02 Figure 6-6*
Cp-S	-0.7	*Side Wall Pressure Coefficient, ASCE 7-02 Figure 6-6*
K_d	0.85	*Wind Directionality Factor, ASCE 7-02 Table 6-4*
G_{cpi}	0.18	*Internal Pressure Coefficients for Enclosed Buildings, ASCE 7-02 Figure 6-5*



A more sophisticated approach for determining lateral loads has been taken for *Technical Assignment 3*. RAM Frame software has been utilized to confirm the controlling load case and determine the controlling load combination. A few assumptions were made in order to validate the results found using RAM Frame:

- Moment frame joints are fixed.
- Braced frame joints are pinned.
- Base of all lateral frames are pinned.
- P-delta effects are considered.
- Lateral loads, used in the RAM model, were developed based on the procedures outlined in ASCE 7-98 and IBC 2000. Hand calculations were based on the most recent editions of these codes, ASCE 7-02 and IBC 2003.



Y-direction winds acting on Gateway Plaza.

According to both hand calculations and RAM Frame, the strength-controlling load case is the y-direction wind (perpendicular to the building's long direction). A comparison of story forces for wind and seismic loads for both hand calculations and RAM Ouput is illustrated in the table below. The results validate both hand calculations and the RAM results since their forces are similar, as are their base shears and overturning moments. The table contains values for story forces at each level due to the controlling loads.

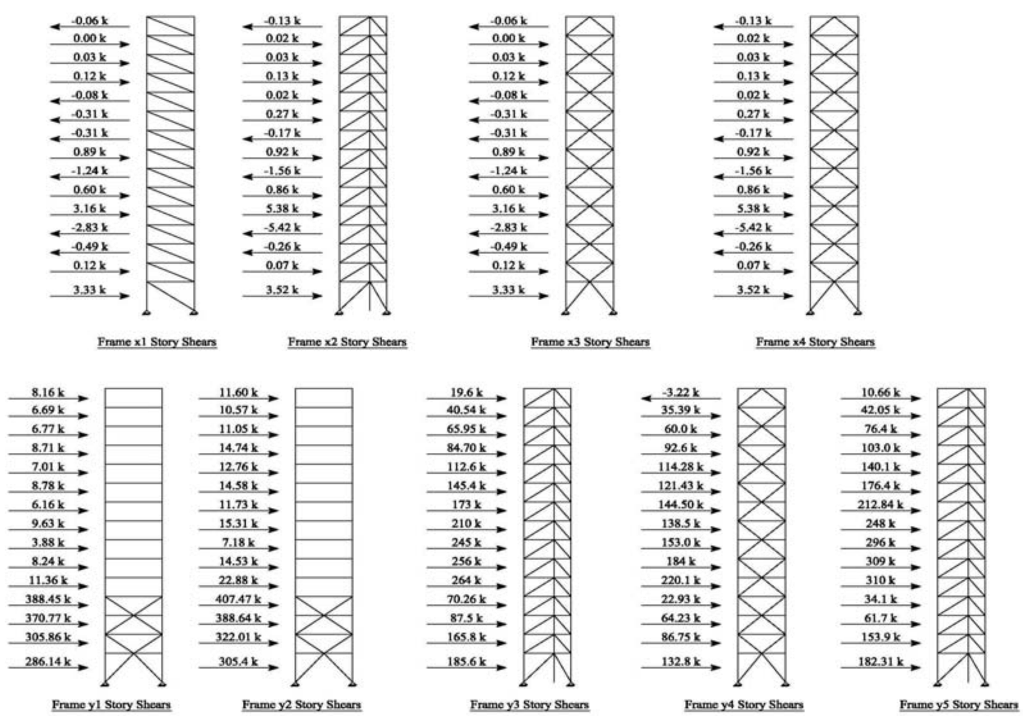
Total Story Forces at Each Level (k)								
		HAND CALCS			**RAM Output**			
		Seismic	**Wind**		**Seismic**		**Wind**	
Floor	**Height**	**x-y direction**	**y-direction**	**x-direction**	**y-direction**	**x-direction**	**y-direction**	**x-direction**
R	210.5 ft	32.86 k	***42.69 k***	12.62 k	40.70 k	40.70 k	***45.08 k***	12.65 k
15	196 ft	60.84 k	***81.74 k***	22.14 k	61.89 k	61.89 k	***86.35 k***	24.17 k
14	182.5 ft	56.95 k	***80.52 k***	21.73 k	54.27 k	54.27 k	***82.21 k***	22.95 k
13	169 ft	50.28 k	***79.71 k***	21.46 k	47.11 k	47.11 k	***81.13 k***	22.57 k
12	155.5 ft	44.08 k	***78.63 k***	21.09 k	40.42 k	40.42 k	***79.98 k***	22.17 k
11	142 ft	38.19 k	***77.13 k***	20.59 k	34.20 k	34.20 k	***78.76 k***	21.75 k
10	128.5 ft	32.62 k	***76.14 k***	20.26 k	28.45 k	28.45 k	***77.45 k***	21.29 k
9	115 ft	27.38 k	***74.91 k***	19.84 k	23.20 k	23.20 k	***76.04 k***	20.80 k
8	101.5 ft	22.48 k	***72.77 k***	19.12 k	18.43 k	18.43 k	***74.51 k***	20.27 k
7	88 ft	17.94 k	***70.96 k***	18.51 k	14.17 k	14.17 k	***72.82 k***	19.68 k
6	74.5 ft	13.79 k	***69.25 k***	17.92 k	10.43 k	10.43 k	***70.93 k***	19.06 k
5	61 ft	10.59 k	***66.94 k***	17.14 k	7.69 k	7.69 k	***68.77 k***	19.33 k
4	47.5 ft	7.13 k	***64.42 k***	16.30 k	4.80 k	4.80 k	***66.22 k***	19.29 k
3	34 ft	4.21 k	***60.99 k***	15.15 k	2.59 k	2.59 k	***63.05 k***	18.09 k
2	20.5 ft	1.89 k	***71.20 k***	19.12 k	1.04 k	1.04 k	***74.51 k***	20.93 k
Gnd	**base shear**	421.24 k	***1068 k***	282.97 k	389.39 k	389.39 k	***1097 k***	305.00 k
	overturning moment	63,405 ft-k	***124,744 ft-k***	33,306 ft-k	60,730 ft-k	60,730 ft-k	***127,713 ft-k***	35,415 ft-k

DISTRIBUTION OF LATERAL LOADS

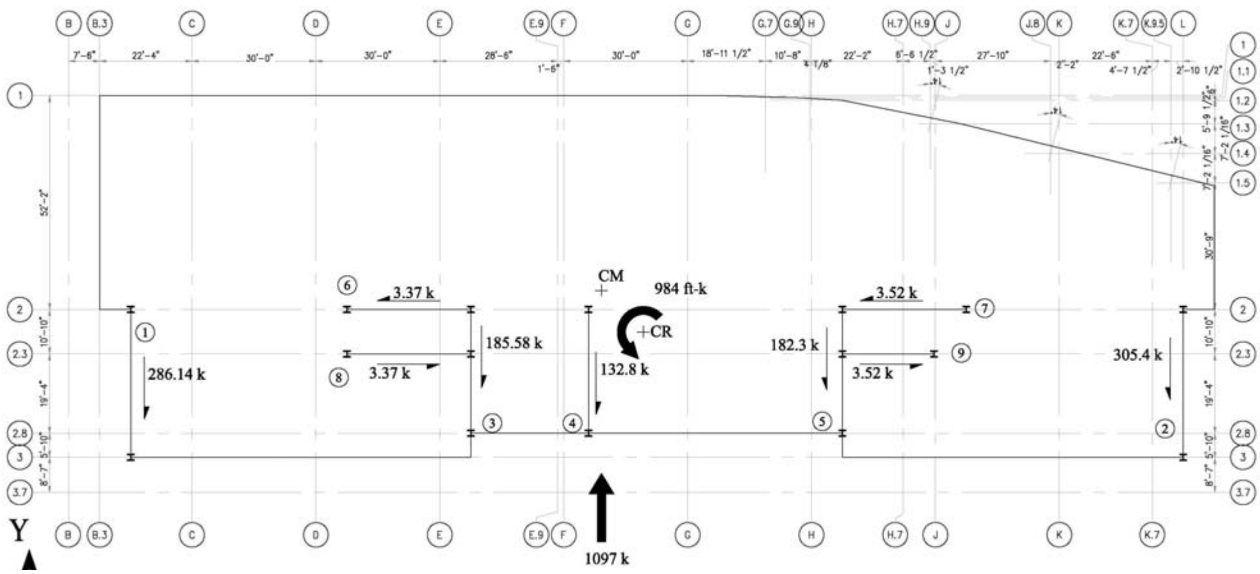
Lateral loads are computed into story shears and distributed to the frames according to the frame's relative stiffness. Shear on each frame at every level, from RAM Output, are tabulated below. The output has been verified by hand calculations in *Appendix B.2-Lateral Load Distribution to Frames: Base Shear*. The hand calculation makes the assumption that the stiffness of each lateral frame is equal. Although this assumption is difficult to verify, the procedure does a good job of estimating the story shears on each frame at each level.

Floor	Height	Frame Story Shears for Controlling Load Case in Y-Direction (k)								
		y1	y2	y3	y4	y5	x1	x2	x3	x4
R	210.5 ft	8.16	11.60	19.60	-3.22	10.66	-0.06	-0.13	-0.06	-0.13
15	196 ft	6.69	10.57	40.54	35.39	42.05	0.00	0.02	0.00	0.02
14	182.5 ft	6.77	11.05	65.95	59.97	76.40	0.03	0.03	0.03	0.03
13	169 ft	8.71	14.74	84.70	92.60	102.91	0.12	0.13	0.12	0.13
12	155.5 ft	7.01	12.76	112.55	114.28	140.12	-0.08	0.02	-0.08	0.02
11	142 ft	8.78	14.58	145.35	121.43	176.38	0.31	0.27	0.31	0.27
10	128.5 ft	6.16	11.73	172.57	144.50	212.84	-0.31	-0.17	-0.31	-0.17
9	115 ft	9.63	15.31	209.55	138.53	247.90	0.89	0.92	0.89	0.92
8	101.5 ft	3.88	7.18	244.60	153.04	296.27	-1.24	-1.56	-1.24	-1.54
7	88 ft	8.24	14.53	255.95	183.88	309.00	0.60	0.86	0.60	0.85
6	74.5 ft	11.36	22.88	264.27	220.08	309.77	3.16	5.38	3.16	5.26
5	61 ft	388.45	407.47	70.26	22.93	34.06	-2.83	-5.42	-2.83	-5.28
4	47.5 ft	370.77	388.64	87.51	64.23	61.59	-0.49	-0.26	-0.49	-0.27
3	34 ft	305.86	322.01	165.82	86.75	153.87	0.12	0.07	0.12	0.08
2	20.5 ft	286.14	305.40	185.58	132.80	182.31	3.33	3.52	3.33	3.51

The story shears on each of the frames are illustrated below.



The picture below illustrates the base shear and overall torsional moment on the lateral system, as well as the story shear on each frame.



CHECKS

Strength

The strength of each lateral framing element was checked in RAM Frame's Code Check provision. The codes used as a basis for the standard provision check is AISC's LRFD and ASCE 7-98. These were used to generate combinations of dead, live, wind, and seismic loads that would result in the worst case scenario. The following load combinations were checked:

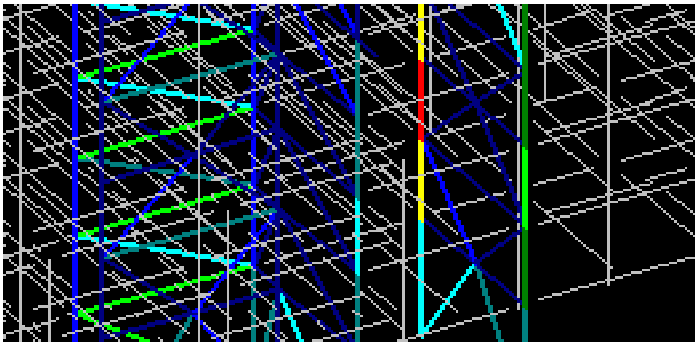
- 1.4D
- 1.2D + 1.6L
- 1.2D + 0.5L + 1.6W ✔ controls
- 1.2D + 0.5L + 1.6E
- 1.2D + 1.0E

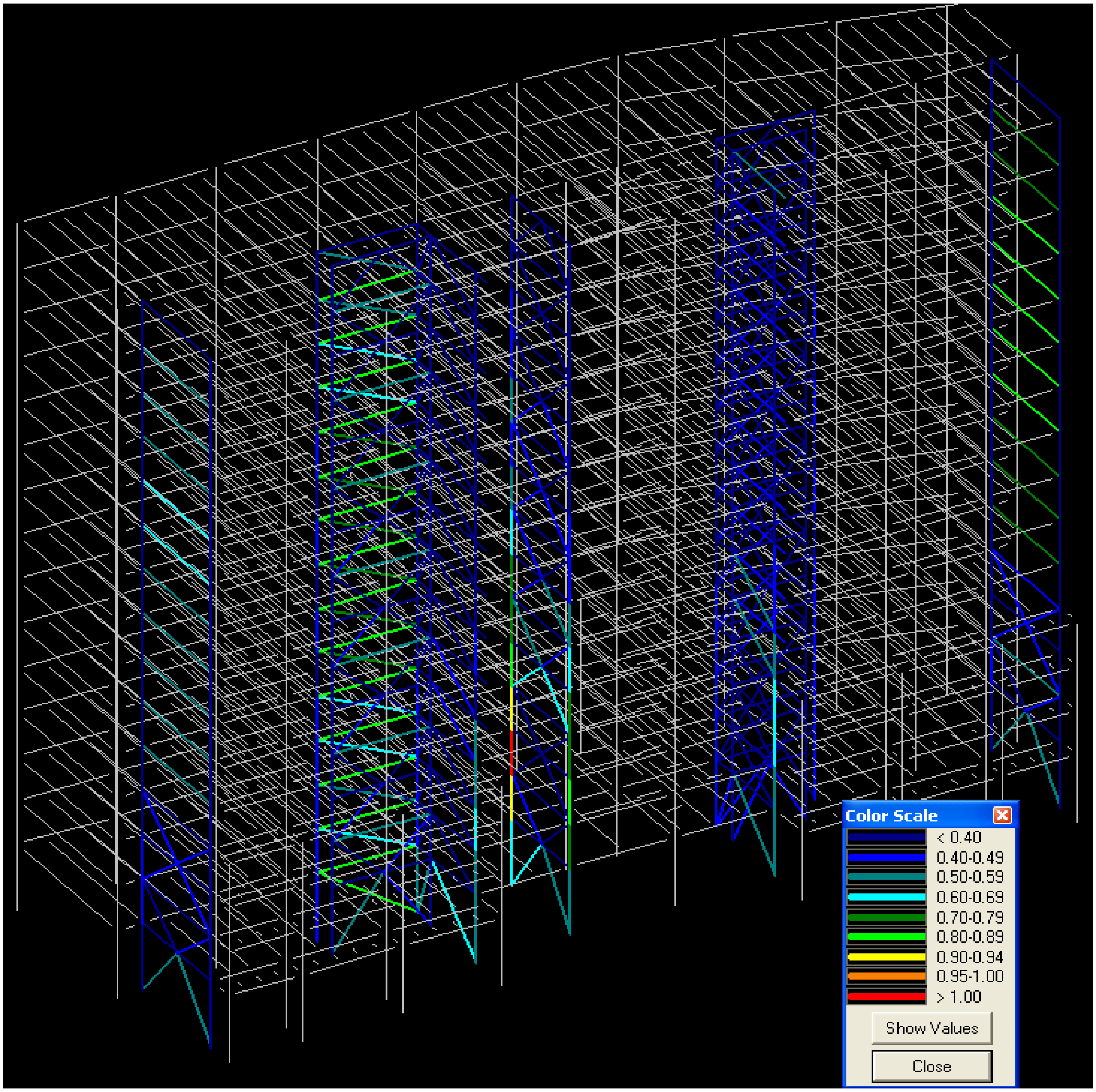
The controlling load combination, 1.2D+0.5L+1.6W, was used to generate the axial force and moment on each member. Each member in the frames was checked using an interaction equation which relates the amount of axial and flexural forces each member is subjected to. The interaction equations are as follows:

- For $\frac{P_u}{\phi P_n} \geq 0.2$; $\quad \frac{P_u}{\phi P_n} + \frac{8}{9}\left(\frac{M_{ux}}{\phi M_{nx}} + \frac{M_{uy}}{\phi M_{ny}}\right) \leq 1.0$
- For $\frac{P_u}{\phi P_n} < 0.2$; $\quad \frac{P_u}{2\phi P_n} + \left(\frac{M_{ux}}{\phi M_{nx}} + \frac{M_{uy}}{\phi M_{ny}}\right) \leq 1.0$

The results of the member check using the controlling load combination are illustrated on the next page. A color coated scale indicates a member's value from the interaction equation for combined flexural and axial forces. The "bluer" the member, the closer the value to 0.0; the "redder" the member, the higher the value which results in a member that has a value closer to 1.0.

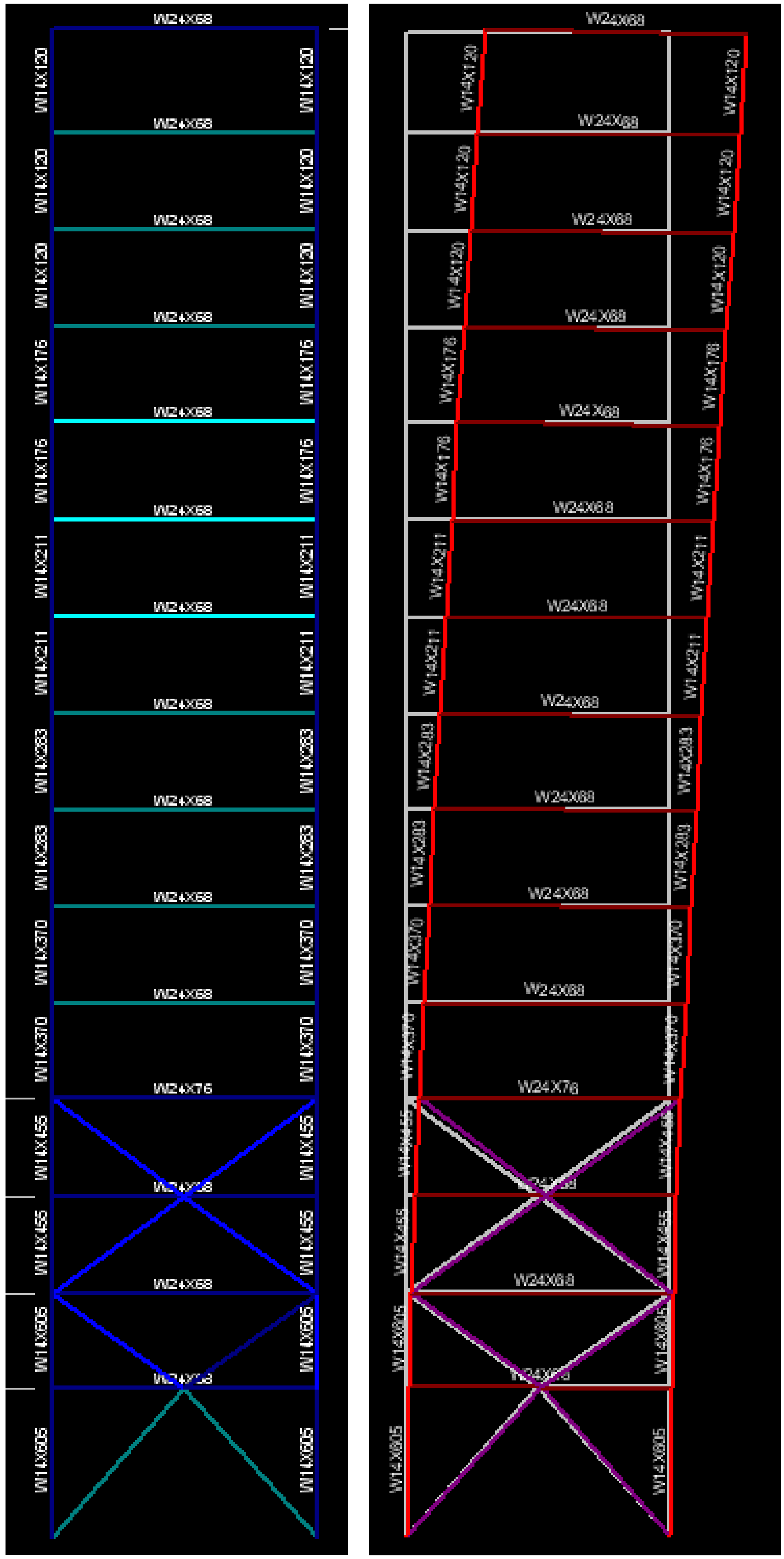
According to the RAM Frame analysis on the next page, the only member that appears to be instable is the column between the fourth and fifth floors in frame y3. Due to differences in modeling techniques and software, this single insufficient member is indicative of a successful re-model.





Strength check for lateral frame members.

Unbraced Frame: y2



To ensure the accuracy of both hand and RAM calculations, a portal method analysis was performed on moment frame, y2. The moments on the beams were compared to those found in the structural drawings to determine if the analysis was similar to that of the designer and the software.

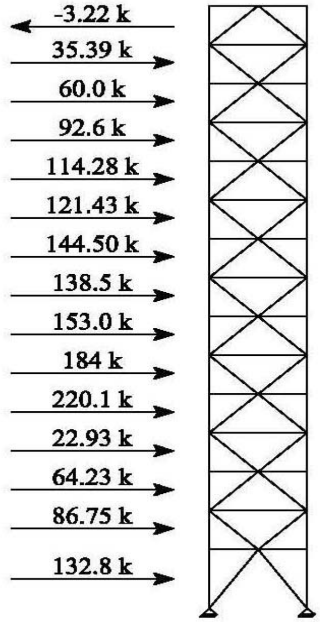
At the joints on the frame, moments obtained by the portal analysis were similar to the designer's on most of the floors. However, on the top five floors moments from the portal analysis were smaller than the designer's values. This can be attributed to a number of reasons:

- The efficiency of portal analysis decreases as the height of the building increases.
- The governing moments in the beams near the roof are more likely to come from gravity, rather than lateral, loads

For further more extensive calculations for y2's portal analysis, please refer to *Appendix C-Portal Analysis of Frame Y2.*

Braced Frame: y4

BRACING CHECK: FRAME Y4			
Floor	**Bracing Member**	**Axial Load**	**Axial Capacity**
R	W12x65	36	464
15	W12x65	110	464
14	W12x65	145	464
13	W12x65	159	464
12	W12x65	206	464
11	W12x65	197	464
10	W12x65	227	464
9	W12x65	223	464
8	W12x72	256	517
7	W12x72	256	517
6	W12x72	256	517
5	W12x72	256	517
4	W12x72	256	517
3	W12x72	302	517
2	W12x87	299	634



Frame y4 Story Shears

To ensure the accuracy of both hand and RAM calculations, the axial loads computed in the bracing elements for frame y4 were compared to the axial capacity for that member. The capacity of every bracing member is more than sufficient to carry the axial loads it is subjected to.

Drift

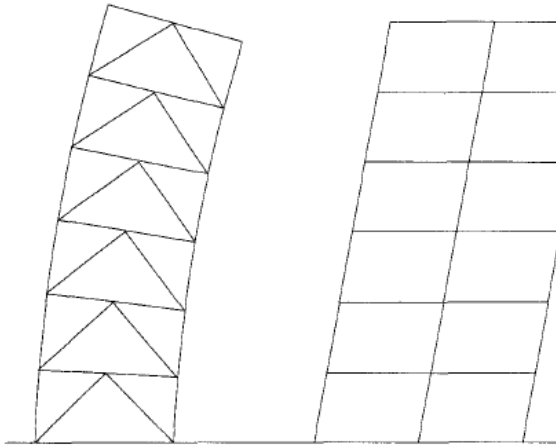
The industry and code accepted drift limitation is H/400 for both total drift and inner story drift. For this building, 210.5' tall, a total drift of 6.32" and an inner story drift of 0.4" will be acceptable. From the chart below, drift is not an issue.

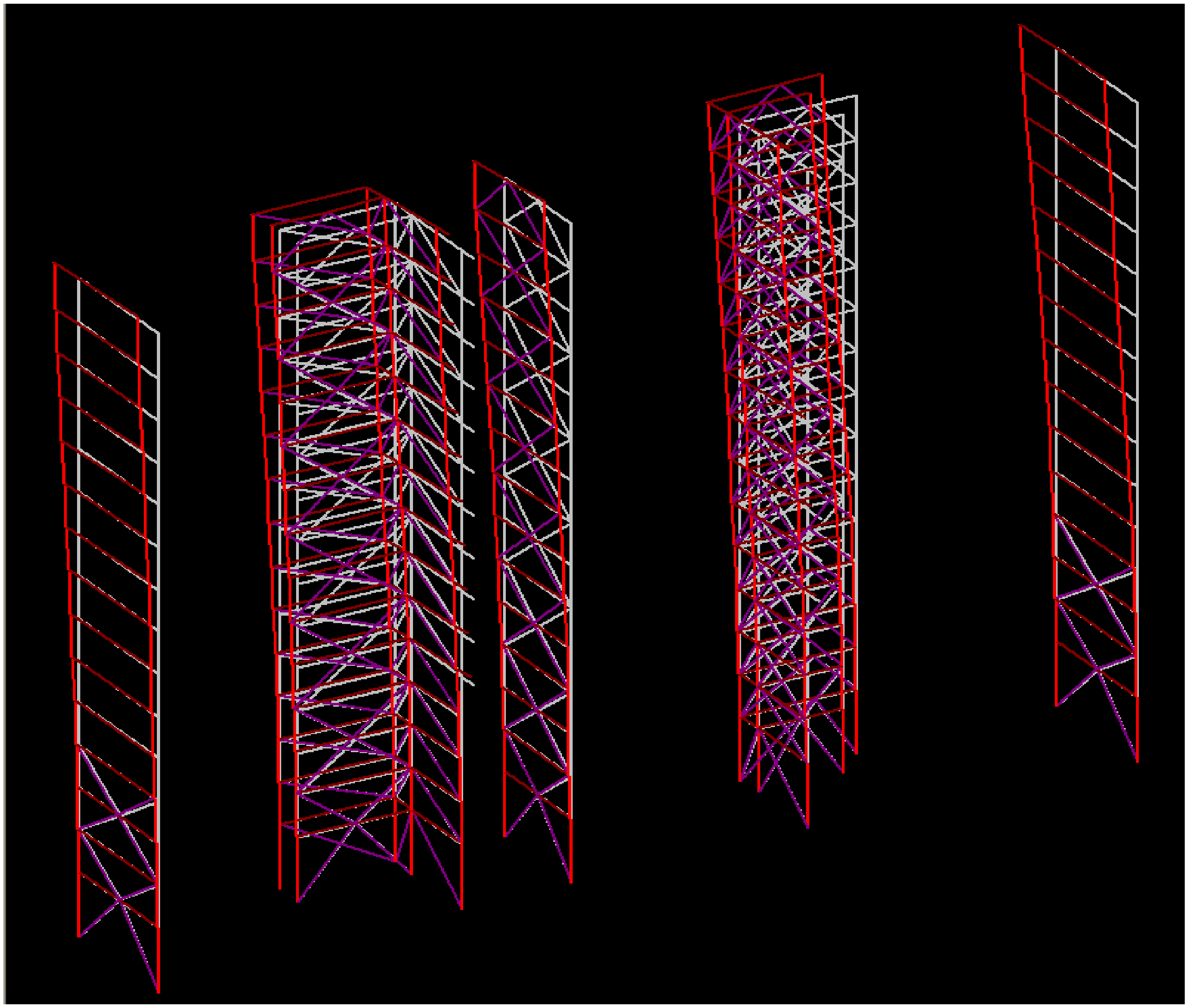
Floor	Height	Flr-Flr Height	Displacement		Inner-Story Drift	H/400	Ok?
			x	y			
R	210.5 ft	14.5	-0.1636	3.14504	0.00154	0.435	ok
15	196 ft	13.5	-0.15622	2.87778	0.00160	0.405	ok
14	182.5 ft	13.5	-0.14149	2.61857	0.00168	0.405	ok
13	169 ft	13.5	-0.12559	2.34696	0.00171	0.405	ok
12	155.5 ft	13.5	-0.10928	2.06951	0.00169	0.405	ok
11	142 ft	13.5	-0.09264	1.79564	0.00166	0.405	ok
10	128.5 ft	13.5	-0.07665	1.52684	0.00158	0.405	ok
9	115 ft	13.5	-0.0615	1.27134	0.00151	0.405	ok
8	101.5 ft	13.5	-0.04745	1.02659	0.00136	0.405	ok
7	88 ft	13.5	-0.03489	0.80626	0.00138	0.405	ok
6	74.5 ft	13.5	-0.02277	0.58343	0.00124	0.405	ok
5	61 ft	13.5	-0.01289	0.38298	0.00072	0.405	ok
4	47.5 ft	13.5	-0.0079	0.26674	0.00056	0.405	ok
3	34 ft	13.5	-0.00476	0.17533	0.00054	0.405	ok
2	20.5 ft	20.5	-0.00204	0.08763	0.00036	0.615	ok

To see how the total lateral system will react to the controlling load case, wind in the y-direction, please refer to the picture on the next page. This picture illustrates the drift of the lateral force resisting frames.

The deflected shape of the lateral frames is similar to what would be expected for each type of frame:

- Less deflection near the base and more deflection near the top for moment frames, and
- More deflection at the top of the frame and less near the base for braced frames.





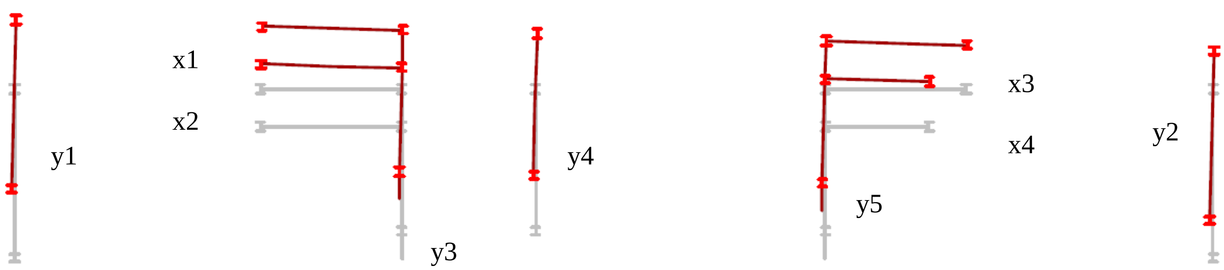
RAM Frame's drift analysis on Gateway Plaza for controlling y-direction winds.

Torsion

Since the building's center of mass is located at (131', 30.5') and the center of rigidity is approximately (13.63',4.97') eccentric, torsion will be introduced in to the rigid diaphragm of each floor. Also, a 5% accidental eccentricity was introduced to account for any accidental torsion of the building under wind loading. The torsion results in a rotation of each floor around the center of rigidity. The amount of torsion results in a 0.00041 rad (0.0235°) rotation at the roof of the building. This is hardly a concern.

Floor	Height	Theta
R	210.5 ft	0.00041
15	196 ft	0.00038
14	182.5 ft	0.00035
13	169 ft	0.00031
12	155.5 ft	0.00027
11	142 ft	0.00022
10	128.5 ft	0.00018
9	115 ft	0.00014
8	101.5 ft	0.0001
7	88 ft	0.00007
6	74.5 ft	0.00004
5	61 ft	0.00001
4	47.5 ft	0
3	34 ft	0
2	20.5 ft	0

The picture below represents the rotation of the roof, which undergoes the greatest amount of torsion, due to the controlling load case. The degree of torsion has been amplified 50 times.



Overturning

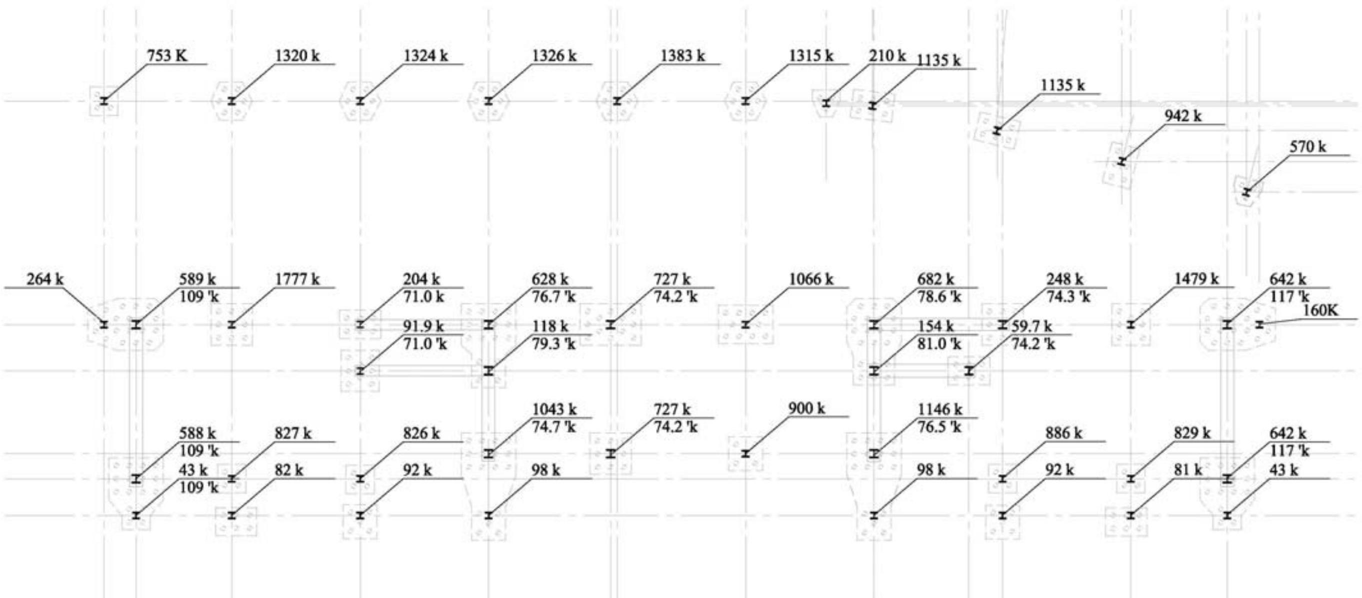
Since all of the frames in the lateral resisting system are narrow, compared to their height, the overturning at the base of each column is expected to be high. The total overturning moment of the building when subjected to the controlling loads is 127,713 ft-k. Refer to the chart below for the overturning moments of each frame.

y1	*y2*	*y3*	*y4*	*y5*	*x1*	*x2*	*x3*	*x4*
69,509 'k	***80,580 'k***	***207,760 'k***	***160,597'k***	***238,826 'k***	***146'k***	***179'k***	***146'k***	***179'k***

Impact on Foundations

The lateral resisting frames used for Gateway Plaza exert great axial load and overturning moment on the foundation system. The clusters of drilled piers extend approximately 70’ to bedrock, indicating that uplift, sliding, and overturning should not be an issue. As would be expected, the number of piers in the clusters under the columns used in the lateral frames are greater (approximately 18) than those found under gravity columns (approximately 12).

Foundation loads were compiled from RAM data and are illustrated in the drawing below, which indicates the increased loading under framing columns. The drawing indicates loads seen on the foundations. For columns in lateral frames, the top number indicates the axial load at the base and the bottom number indicates the overturning moment seen at the base. For gravity columns, the number indicates the total axial load, dead plus live, seen at the foundation.



CONCLUSIONS

In a building like Gateway Plaza with a glass curtain wall façade, movement in the structure due to wind forces needs to be predicted accurately in order to prevent such failures as window cracking or panes falling out. The different type and size of frames used make developing strength, drift, and rotational checks difficult. RAM Frame software was utilized to aide in the analysis of Gateway Plaza’s complex lateral system. RAM Frame is a finite element analysis software that generates its own load cases and combinations to determine the worst case scenario. Through the analysis contained in this report, it has been determined that the lateral resisting system of Gateway Plaza does a more than adequate job of preventing drift, rotation, and over-stressing of members.

APPENDICES

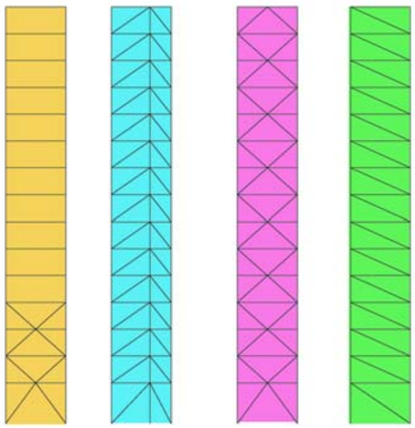
Appendix A-Lateral Load Resisting System

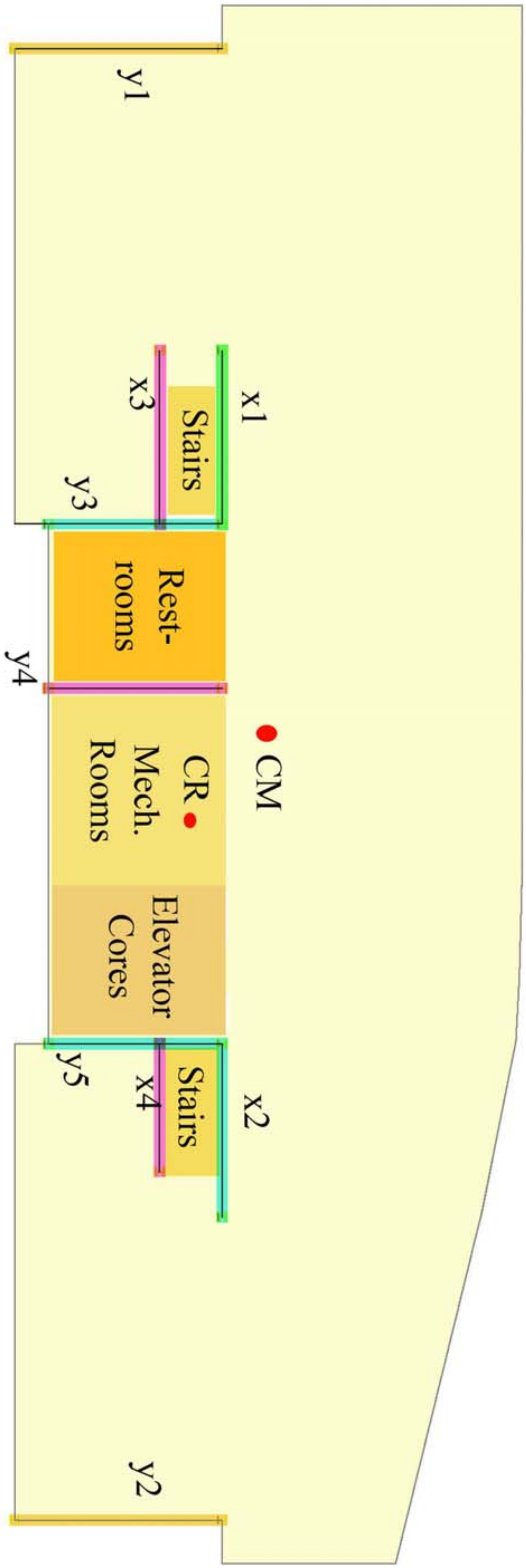
Appendix B-Load Calculations

- **B.1 Lateral Loads**
  - **B.1.1 Wind Load Calculations**
  - **B.1.2 Seismic Load Calculations**
- **B.2 Lateral Load Distribution to Frames: Base Shear**

Appendix C-Portal Analysis of Frame Y2

Appendix A – Lateral Load Resisting System





Appendix B – Load Calculations

B.1 Lateral Loads

B.1.1 Wind Load Calculations

Design Wind Pressures
Title

Gateway Plaza, Wilmington, DE
Project Name

Per IBC 2003 and ASCE 7-02
Reference

Input Information

	L: Length of Building in X- Direction	B: Length of Building in Y - Direction	L/B	B/L	Story Heights (ft)	Building Story Height (ft)
						210.50 ft
R	270.00 ft	88.00 ft	3.07	0.33	14.50 ft	210.50 ft
15	270.00 ft	88.00 ft	3.07	0.33	13.50 ft	196.00 ft
14	270.00 ft	88.00 ft	3.07	0.33	13.50 ft	182.50 ft
13	270.00 ft	88.00 ft	3.07	0.33	13.50 ft	169.00 ft
12	270.00 ft	88.00 ft	3.07	0.33	13.50 ft	155.50 ft
11	270.00 ft	88.00 ft	3.07	0.33	13.50 ft	142.00 ft
10	270.00 ft	88.00 ft	3.07	0.33	13.50 ft	128.50 ft
9	270.00 ft	88.00 ft	3.07	0.33	13.50 ft	115.00 ft
8	270.00 ft	88.00 ft	3.07	0.33	13.50 ft	101.50 ft
7	270.00 ft	88.00 ft	3.07	0.33	13.50 ft	88.00 ft
6	270.00 ft	88.00 ft	3.07	0.33	13.50 ft	74.50 ft
5	270.00 ft	88.00 ft	3.07	0.33	13.50 ft	61.00 ft
4	270.00 ft	88.00 ft	3.07	0.33	13.50 ft	47.50 ft
3	270.00 ft	88.00 ft	3.07	0.33	13.50 ft	34.00 ft
2	270.00 ft	88.00 ft	3.07	0.33	10.25 ft	20.50 ft
Int.	270.00 ft	88.00 ft	3.07	0.33	10.25 ft	10.25 ft
					210.50 ft	

h	210.50 ft	*Mean Roof Height of Building*
H	210.50 ft	*Total Height of Roof*
Ct	0.030	*Fundamental Period Coefficient, ASCE 7-02 Table 9.5.5.3.2*
x	0.750	*Fundamental Period Factor, ASCE 7-02 Table 9.5.5.3.2*
Ta	0.60 Hz	*Structure is flexible so G will be calculated per ASCE Section 6.5.8.2*
Θ	0.0 deg	*Angle of Roof Slope*
V	90 mph	*Basic Wind Speed, ASCE 7-02 Figure 6-1, IBC 2003 Figure 1609*
I	1.00	*Importance Factor for Wind, ASCE 7-02 Table 6-1, IBC 2003 Table 1604.5*
Exposure	B	*Exposure Category, ASCE 7-02 Section 6.5.6, IBC 2003 Section 1609.4*
Roof Diapragm	2	*Is roof diaphragm considered rigid or flexible??*

Calculated Information

Height	HIGH	*"High" for Buildings >60', "Low" for Buildings < 60'*
Cp-w	0.8	*Windward Wall Pressure Coefficient, ASCE 7-02 Figure 6-6*
Cp-S	-0.7	*Side Wall Pressure Coefficient, ASCE 7-02 Figure 6-6*
Kd	0.85	*Wind Directionality Factor, ASCE 7-02 Table 6-4*
Gcpi	0.18	*Internal Pressure Coefficients for Enclosed Buildings, ASCE 7-02 Figure 6-5*

Gust Effect Calculations
Title

Gateway Plaza, Wilmington, DE
Project Name

Per IBC 2003 and ASCE 7-02
Reference

Criteria			Reference/Description
h	210.5		height of building
zmin	30		RIGID: From Table 6-2 of ASCE 7-02
zbar	126.3		RIGID: 0.6*h > zmin: ASCE 7-02 Section 6.5.8
c	0.3		RIGID: From Table 6-2 of ASCE
g_q	3.4		per section 6.5.8.1 and 6.5.8.2 of ASCE 7-02
g_v	3.4		per section 6.5.8.1 and 6.5.8.2 of ASCE 7-02
l	320		RIGID: Table 6-2 of ASCE 7-02
e	0.33		RIGID: Table 6-2 of ASCE 7-02
n_1, Y-dir	0.561		Natural Period
n_1, X-dir	0.81		Natural Period
β	0.05		Damping Factor
V	90		Basic Wind Speed
βbar	0.45		FLEXIBLE: Table 6-2 ASCE 7-02
αbar	0.25		FLEXIBLE: Table 6-2 ASCE 7-02
I_z	0.239868		Equation 6-5 ASCE 7-02
L_z	500.5264		Equation 6-7 ASCE 7-02
	Y - Direction	X - Direction	
g_r	4.049343	4.138937	FLEXIBLE: Equation 6-9
V_z	75.52941	75.52941	FLEXIBLE: Equation 6-14
h_h	10.38434	10.38434	FLEXIBLE: Section 6.5.8.2
R_h	0.091662	0.091662	FLEXIBLE: Section 6.5.8.2
N_1	5.367795	5.367795	FLEXIBLE: Equation 6-12
R_n	0.048501	0.048501	FLEXIBLE: Equation 6-11

Gust Effect Calculations
Title

Gateway Plaza, Wilmington, DE
Project Name

Per IBC 2003 and ASCE 7-02
Reference

Stiff Building Calculations / Flexible Building Calculations

Level	Height	B	L	Q	G stiff X-dir	nl	nb	Rl	Rb	R	G flex X-dir
Int.	10.25	88	270	0.829	0.833	44.592	4.341	0.0222	0.204	0.099	0.838
3	13.5	88	270	0.829	0.833	44.592	4.341	0.0222	0.204	0.099	0.838
4	13.5	88	270	0.829	0.833	44.592	4.341	0.0222	0.204	0.099	0.838
5	13.5	88	270	0.829	0.833	44.592	4.341	0.0222	0.204	0.099	0.838
6	13.5	88	270	0.829	0.833	44.592	4.341	0.0222	0.204	0.099	0.838
7	13.5	88	270	0.829	0.833	44.592	4.341	0.0222	0.204	0.099	0.838
8	13.5	88	270	0.829	0.833	44.592	4.341	0.0222	0.204	0.099	0.838
9	13.5	88	270	0.829	0.833	44.592	4.341	0.0222	0.204	0.099	0.838
10	13.5	88	270	0.829	0.833	44.592	4.341	0.0222	0.204	0.099	0.838
11	13.5	88	270	0.829	0.833	44.592	4.341	0.0222	0.204	0.099	0.838
12	13.5	88	270	0.829	0.833	44.592	4.341	0.0222	0.204	0.099	0.838
13	13.5	88	270	0.829	0.833	44.592	4.341	0.0222	0.204	0.099	0.838
14	13.5	88	270	0.829	0.833	44.592	4.341	0.0222	0.204	0.099	0.838
15	13.5	88	270	0.829	0.833	44.592	4.341	0.0222	0.204	0.099	0.838
R	14.5	88	270	0.829	0.833	44.592	4.341	0.0222	0.204	0.099	0.838
0	0	0	0	0.856	0.848	0.000	0.000	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Stiff Building Calculations / Flexible Building Calculations

Level	Height	B	L		G stiff Y-dir	nl	nb	Rl	Rb	R	G flex Y-dir
Int.	10.25	270	88	0.787	0.811	10.066	9.225	0.0944	0.103	0.072	0.813
3	13.5	270	88	0.787	0.811	10.066	9.225	0.0944	0.103	0.072	0.813
4	13.5	270	88	0.787	0.811	10.066	9.225	0.0944	0.103	0.072	0.813
5	13.5	270	88	0.787	0.811	10.066	9.225	0.0944	0.103	0.072	0.813
6	13.5	270	88	0.787	0.811	10.066	9.225	0.0944	0.103	0.072	0.813
7	13.5	270	88	0.787	0.811	10.066	9.225	0.0944	0.103	0.072	0.813
8	13.5	270	88	0.787	0.811	14.534	13.320	0.0664	0.072	0.060	0.812
9	13.5	270	88	0.787	0.811	14.534	13.320	0.0664	0.072	0.060	0.812
10	13.5	270	88	0.787	0.811	14.534	13.320	0.0664	0.072	0.060	0.812
11	13.5	270	88	0.787	0.811	14.534	13.320	0.0664	0.072	0.060	0.812
12	13.5	270	88	0.787	0.811	14.534	13.320	0.0664	0.072	0.060	0.812
13	13.5	270	88	0.787	0.811	14.534	13.320	0.0664	0.072	0.060	0.812
14	13.5	270	88	0.787	0.811	14.534	13.320	0.0664	0.072	0.060	0.812
15	13.5	270	88	0.787	0.811	14.534	13.320	0.0664	0.072	0.060	0.812
R	14.5	270	88	0.787	0.811	14.534	13.320	0.0664	0.072	0.060	0.812
0	0	0	0	0.856	0.848	0.000	0.000	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Summary

h			G flex Y-dir	G flex X-dir		height	par to shor	par to long
10	0	1	0.813	0.838	1	0	0.813	0.838
24	20	3	0.813	0.838	2	15	0.813	0.838
37.3	30	5	0.813	0.838	3	20	0.813	0.838
50.8	50	7	0.813	0.838	4	25	0.813	0.838
64	60	8	0.813	0.838	5	30	0.813	0.838
78	70	9	0.813	0.838	6	40	0.813	0.838
91	90	11	0.812	0.838	7	50	0.813	0.838
105	100	12	0.812	0.838	8	60	0.813	0.838
118	110	13	0.812	0.838	9	70	0.813	0.838
132	130	15	0.812	0.838	10	80	0.813	0.838
145	140	16	0.812	0.838	11	90	0.812	0.838
159	150	17	0.812	0.838	12	100	0.812	0.838
172	170	19	0.812	0.838	13	110	0.812	0.838
172	170	19	#DIV/0!	#DIV/0!	14	120	0.812	0.838
					15	130	0.812	0.838

Design Wind Pressures

Title

Gateway Plaza, Wilmington, DE

Project Name

Per IBC 2003 and ASCE 7-02

Reference

Design Wind Pressures on Main-Wind-Force-Resisting-Systems

ASCE Section 6.5

Height above ground level, z	Kz	G X-Dir	G Y-Dir	L/B	B/L	Cp Leeward X-Dir	Cp Leeward Y-Dir	Velocity Pressure, qz	Velocity Pressure, qh	Design Windward Wall Pressure in X- Dir	Design Windward Wall Pressure in Y-Dir	Design Leeward Wall Pressure in X-Dir	Design Leeward Wall Pressure in Y-Dir	Total Pressure for MWFRS in X-Dir	Total Pressure for MWFRS in Y-Dir	Building Floor Elevation
0 ft	0.575	0.8378	0.8131	3.07	0.33	-0.248	-0.500	10.1 psf	21.2 psf	6.8 psf	6.6 psf	-4.4 psf	-8.6 psf	**11.2 psf**	**15.2 psf**	10.25 ft
15 ft	0.575	0.8378	0.8131	3.07	0.33	-0.248	-0.500	10.1 psf	21.2 psf	6.8 psf	6.6 psf	-4.4 psf	-8.6 psf	**11.2 psf**	**15.2 psf**	20.50 ft
20 ft	0.624	0.8378	0.8131	3.07	0.33	-0.248	-0.500	11.0 psf	21.2 psf	7.4 psf	7.2 psf	-4.4 psf	-8.6 psf	**11.8 psf**	**15.8 psf**	34.00 ft
25 ft	0.665	0.8378	0.8131	3.07	0.33	-0.248	-0.500	11.7 psf	21.2 psf	7.9 psf	7.6 psf	-4.4 psf	-8.6 psf	**12.3 psf**	**16.3 psf**	47.50 ft
30 ft	0.701	0.8378	0.8131	3.07	0.33	-0.248	-0.500	12.3 psf	21.2 psf	8.3 psf	8.0 psf	-4.4 psf	-8.6 psf	**12.7 psf**	**16.7 psf**	61.00 ft
40 ft	0.761	0.8378	0.8131	3.07	0.33	-0.248	-0.500	13.4 psf	21.2 psf	9.0 psf	8.7 psf	-4.4 psf	-8.6 psf	**13.4 psf**	**17.4 psf**	74.50 ft
50 ft	0.811	0.8378	0.8131	3.07	0.33	-0.248	-0.500	14.3 psf	21.2 psf	9.6 psf	9.3 psf	-4.4 psf	-8.6 psf	**14.0 psf**	**17.9 psf**	88.00 ft
60 ft	0.854	0.8378	0.8131	3.07	0.33	-0.248	-0.500	15.1 psf	21.2 psf	10.1 psf	9.8 psf	-4.4 psf	-8.6 psf	**14.5 psf**	**18.4 psf**	101.50 ft
70 ft	0.892	0.8378	0.8131	3.07	0.33	-0.248	-0.500	15.7 psf	21.2 psf	10.5 psf	10.2 psf	-4.4 psf	-8.6 psf	**14.9 psf**	**18.9 psf**	115.00 ft
80 ft	0.927	0.8378	0.8131	3.07	0.33	-0.248	-0.500	16.3 psf	21.2 psf	11.0 psf	10.6 psf	-4.4 psf	-8.6 psf	**15.4 psf**	**19.3 psf**	128.50 ft
90 ft	0.959	0.8378	0.8124	3.07	0.33	-0.248	-0.500	16.9 psf	21.2 psf	11.3 psf	11.0 psf	-4.4 psf	-8.6 psf	**15.7 psf**	**19.6 psf**	142.00 ft
100 ft	0.988	0.8378	0.8124	3.07	0.33	-0.248	-0.500	17.4 psf	21.2 psf	11.7 psf	11.3 psf	-4.4 psf	-8.6 psf	**16.1 psf**	**19.9 psf**	155.50 ft
120 ft	1.041	0.8378	0.8124	3.07	0.33	-0.248	-0.500	18.3 psf	21.2 psf	12.3 psf	11.9 psf	-4.4 psf	-8.6 psf	**16.7 psf**	**20.6 psf**	169.00 ft
140 ft	1.088	0.8378	0.8124	3.07	0.33	-0.248	-0.500	19.2 psf	21.2 psf	12.9 psf	12.5 psf	-4.4 psf	-8.6 psf	**17.3 psf**	**21.1 psf**	182.50 ft
160 ft	1.130	0.8378	0.8124	3.07	0.33	-0.248	-0.500	19.9 psf	21.2 psf	13.4 psf	12.9 psf	-4.4 psf	-8.6 psf	**17.8 psf**	**21.6 psf**	196.00 ft
180 ft	1.169	0.8378	0.8124	3.07	0.33	-0.248	-0.500	20.6 psf	21.2 psf	13.8 psf	13.4 psf	-4.4 psf	-8.6 psf	**18.2 psf**	**22.0 psf**	210.50 ft
200 ft	1.205	0.8378	0.8124	3.07	0.33	-0.248	-0.500	21.2 psf	21.2 psf	14.2 psf	13.8 psf	-4.4 psf	-8.6 psf	**18.6 psf**	**22.4 psf**	210.50 ft
250 ft	1.284	0.8378	0.8124	3.07	0.33	-0.248	-0.500	22.6 psf	21.2 psf	15.2 psf	14.7 psf	-4.4 psf	-8.6 psf	**19.6 psf**	**23.3 psf**	
300 ft	1.353	0.8378	0.8124													
350 ft	1.414	0.8378	0.8124													
400 ft	1.469	0.8378	0.8124													
450 ft	1.519	0.8378	0.8124													
500 ft	1.565	0.8378	0.8124													

Design Wind Pressures
Title

Gateway Plaza, Wilmington, DE
Project Name

Per IBC 2003 and ASCE 7-02
Reference

Total Pressure for Frames Resisting Wind Forces Parellel to Y Direction

Total, Windward, Leeward? **Total**

Height above ground level, z	Total Design Pressure	0.5	2	3	4	5	6	7	8	9	10	11	12	13	14	15	R
Floor To Floor Heights		**10.25 ft**	**10.25 ft**	**13.50 ft**	**13.50 ft**	**13.50 ft**	**13.50 ft**	**13.50 ft**	**13.50 ft**	**13.50 ft**	**13.50 ft**	**13.50 ft**	**13.50 ft**	**13.50 ft**	**13.50 ft**	**13.50 ft**	**14.50 ft**
Story Elevations		10.25 ft	20.50 ft	34.00 ft	47.50 ft	61.00 ft	74.50 ft	88.00 ft	101.50 ft	115.00 ft	128.50 ft	142.00 ft	155.50 ft	169.00 ft	182.50 ft	196.00 ft	210.50 ft
Mid - Story Elevations		15.38 ft	27.25 ft	40.75 ft	54.25 ft	67.75 ft	81.25 ft	94.75 ft	108.25 ft	121.75 ft	135.25 ft	148.75 ft	162.25 ft	175.75 ft	189.25 ft	203.25 ft	210.50 ft
0 ft	15.2 psf																
20 ft	15.8 psf		78.9 plf	78.9 plf	78.9 plf	78.9 plf	78.9 plf	78.9 plf	78.9 plf	78.9 plf	78.9 plf	78.9 plf	78.9 plf	78.9 plf	78.9 plf	78.9 plf	78.9 plf
25 ft	16.3 psf		8.1 plf	81.3 plf	81.3 plf	81.3 plf	81.3 plf	81.3 plf	81.3 plf	81.3 plf	81.3 plf	81.3 plf	81.3 plf	81.3 plf	81.3 plf	81.3 plf	81.3 plf
30 ft	16.7 psf			83.3 plf	83.3 plf	83.3 plf	83.3 plf	83.3 plf	83.3 plf	83.3 plf	83.3 plf	83.3 plf	83.3 plf	83.3 plf	83.3 plf	83.3 plf	83.3 plf
40 ft	17.4 psf			69.4 plf	173.5 plf	173.5 plf	173.5 plf	173.5 plf	173.5 plf	173.5 plf	173.5 plf	173.5 plf	173.5 plf	173.5 plf	173.5 plf	173.5 plf	173.5 plf
50 ft	17.9 psf				134.5 plf	179.3 plf	179.3 plf	179.3 plf	179.3 plf	179.3 plf	179.3 plf	179.3 plf	179.3 plf	179.3 plf	179.3 plf	179.3 plf	179.3 plf
60 ft	18.4 psf					184.2 plf	184.2 plf	184.2 plf	184.2 plf	184.2 plf	184.2 plf	184.2 plf	184.2 plf	184.2 plf	184.2 plf	184.2 plf	184.2 plf
70 ft	18.9 psf					18.9 plf	188.7 plf	188.7 plf	188.7 plf	188.7 plf	188.7 plf	188.7 plf	188.7 plf	188.7 plf	188.7 plf	188.7 plf	188.7 plf
80 ft	19.3 psf						86.7 plf	192.6 plf	192.6 plf	192.6 plf	192.6 plf	192.6 plf	192.6 plf	192.6 plf	192.6 plf	192.6 plf	192.6 plf
90 ft	19.6 psf							156.9 plf	196.1 plf	196.1 plf	196.1 plf	196.1 plf	196.1 plf	196.1 plf	196.1 plf	196.1 plf	196.1 plf
100 ft	19.9 psf								199.5 plf	199.5 plf	199.5 plf	199.5 plf	199.5 plf	199.5 plf	199.5 plf	199.5 plf	199.5 plf
120 ft	20.6 psf								30.8 plf	308.3 plf	411.0 plf	411.0 plf	411.0 plf	411.0 plf	411.0 plf	411.0 plf	411.0 plf
140 ft	21.1 psf										179.3 plf	421.8 plf	421.8 plf	421.8 plf	421.8 plf	421.8 plf	421.8 plf
160 ft	21.6 psf											43.1 plf	334.4 plf	431.5 plf	431.5 plf	431.5 plf	431.5 plf
180 ft	22.0 psf													198.1 plf	440.3 plf	440.3 plf	440.3 plf
200 ft	22.4 psf														56.1 plf	358.8 plf	448.5 plf
250 ft	23.3 psf																245.0 plf
300 ft																	
350 ft																	
400 ft																	
450 ft																	
500 ft																	
Total Story Shear @ Floor		0 plf	87 plf	313 plf	552 plf	799 plf	1056 plf	1319 plf	1588 plf	1866 plf	2148 plf	2433 plf	2725 plf	3020 plf	3318 plf	3621 plf	3956 plf
Story Force per Floor		**0.000 klf**	**0.087 klf**	**0.226 klf**	**0.239 klf**	**0.248 klf**	**0.256 klf**	**0.263 klf**	**0.270 klf**	**0.277 klf**	**0.282 klf**	**0.286 klf**	**0.291 klf**	**0.295 klf**	**0.298 klf**	**0.303 klf**	**0.335 klf**

Total Wind Force on MWFRS in Y Direction

Floor Level	0.5	2	3	4	5	6	7	8	9	10	11	12	13	14	15	R
Length of Building	**270.0 ft**	**270.0 ft**	**270.0 ft**	**270.0 ft**	**270.0 ft**	**270.0 ft**	**270.0 ft**	**270.0 ft**	**270.0 ft**	**270.0 ft**	**270.0 ft**	**270.0 ft**	**270.0 ft**	**270.0 ft**	**270.0 ft**	**270.0 ft**
Frame Story Force per Floor	0.0 k	23.5 k	61.0 k	64.4 k	66.9 k	69.2 k	71.0 k	72.8 k	74.9 k	76.1 k	77.1 k	78.6 k	79.7 k	80.5 k	81.7 k	90.4 k
Frame Story Shear per Floor	1068.0 k	1068.0 k	1044.5 k	983.5 k	919.1 k	852.1 k	782.9 k	711.9 k	639.2 k	564.2 k	488.1 k	411.0 k	332.3 k	252.6 k	172.1 k	90.4 k

Design Wind Pressures
Title

Gateway Plaza, Wilmington, DE
Project Name

Per IBC 2003 and ASCE 7-02
Reference

Total Pressure for Frames Resisting Wind Forces Parellel to X Direction

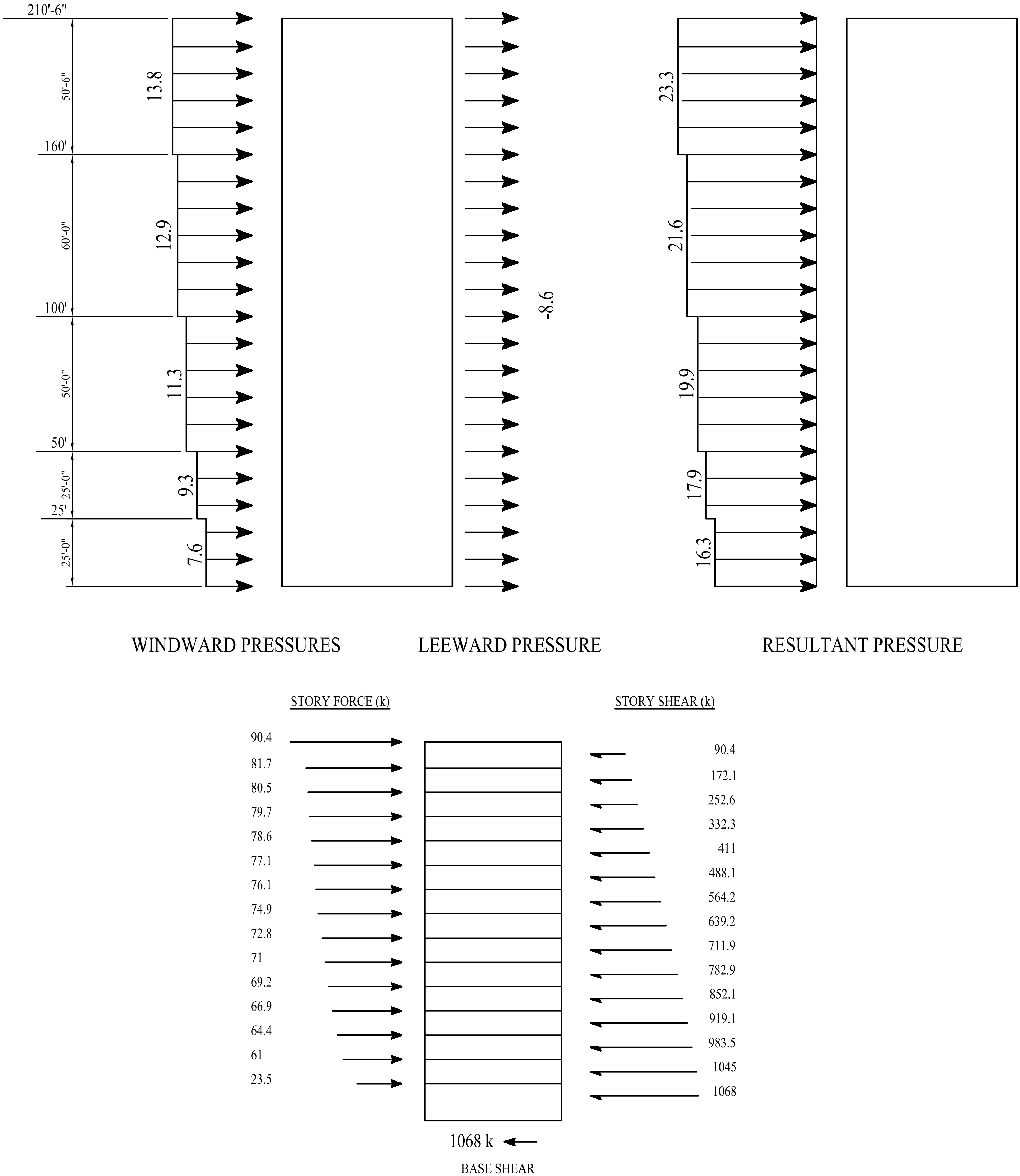
Total, Windward, Leeward? Total

Height above ground level, z	Total Design Pressure	Int.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	R
Floor To Floor Heights		**10.25 ft**	**10.25 ft**	**13.50 ft**	**13.50 ft**	**13.50 ft**	**13.50 ft**	**13.50 ft**	**13.50 ft**	**13.50 ft**	**13.50 ft**	**13.50 ft**	**13.50 ft**	**13.50 ft**	**13.50 ft**	**13.50 ft**	**14.50 ft**
Story Elevations		10.25 ft	20.50 ft	34.00 ft	47.50 ft	61.00 ft	74.50 ft	88.00 ft	101.50 ft	115.00 ft	128.50 ft	142.00 ft	155.50 ft	169.00 ft	182.50 ft	196.00 ft	210.50 ft
Mid - Story Elevations		15.38 ft	27.25 ft	40.75 ft	54.25 ft	67.75 ft	81.25 ft	94.75 ft	108.25 ft	121.75 ft	135.25 ft	148.75 ft	162.25 ft	175.75 ft	189.25 ft	203.25 ft	210.50 ft
0 ft	11.2 psf																
20 ft	11.8 psf		58.9 plf	58.9 plf	58.9 plf	58.9 plf	58.9 plf	58.9 plf	58.9 plf	58.9 plf	58.9 plf	58.9 plf	58.9 plf	58.9 plf	58.9 plf	58.9 plf	58.9 plf
25 ft	12.3 psf		6.1 plf	61.3 plf	61.3 plf	61.3 plf	61.3 plf	61.3 plf	61.3 plf	61.3 plf	61.3 plf	61.3 plf	61.3 plf	61.3 plf	61.3 plf	61.3 plf	61.3 plf
30 ft	12.7 psf			63.4 plf	63.4 plf	63.4 plf	63.4 plf	63.4 plf	63.4 plf	63.4 plf	63.4 plf	63.4 plf	63.4 plf	63.4 plf	63.4 plf	63.4 plf	63.4 plf
40 ft	13.4 psf			53.6 plf	133.9 plf	133.9 plf	133.9 plf	133.9 plf	133.9 plf	133.9 plf	133.9 plf	133.9 plf	133.9 plf	133.9 plf	133.9 plf	133.9 plf	133.9 plf
50 ft	14.0 psf				104.8 plf	139.8 plf	139.8 plf	139.8 plf	139.8 plf	139.8 plf	139.8 plf	139.8 plf	139.8 plf	139.8 plf	139.8 plf	139.8 plf	139.8 plf
60 ft	14.5 psf					144.9 plf	144.9 plf	144.9 plf	144.9 plf	144.9 plf	144.9 plf	144.9 plf	144.9 plf	144.9 plf	144.9 plf	144.9 plf	144.9 plf
70 ft	14.9 psf					14.9 plf	149.5 plf	149.5 plf	149.5 plf	149.5 plf	149.5 plf	149.5 plf	149.5 plf	149.5 plf	149.5 plf	149.5 plf	149.5 plf
80 ft	15.4 psf						69.1 plf	153.6 plf	153.6 plf	153.6 plf	153.6 plf	153.6 plf	153.6 plf	153.6 plf	153.6 plf	153.6 plf	153.6 plf
90 ft	15.7 psf							125.8 plf	157.3 plf	157.3 plf	157.3 plf	157.3 plf	157.3 plf	157.3 plf	157.3 plf	157.3 plf	157.3 plf
100 ft	16.1 psf								160.8 plf	160.8 plf	160.8 plf	160.8 plf	160.8 plf	160.8 plf	160.8 plf	160.8 plf	160.8 plf
120 ft	16.7 psf								25.1 plf	250.5 plf	334.0 plf	334.0 plf	334.0 plf	334.0 plf	334.0 plf	334.0 plf	334.0 plf
140 ft	17.3 psf										146.7 plf	345.1 plf	345.1 plf	345.1 plf	345.1 plf	345.1 plf	345.1 plf
160 ft	17.8 psf											35.5 plf	275.2 plf	355.1 plf	355.1 plf	355.1 plf	355.1 plf
180 ft	18.2 psf													163.9 plf	364.2 plf	364.2 plf	364.2 plf
200 ft	18.6 psf														46.6 plf	298.1 plf	372.7 plf
250 ft	19.6 psf																205.5 plf
300 ft																	
350 ft																	
400 ft																	
450 ft																	
500 ft																	
Total Story Shear @ Floor		0.0 plf	65.0 plf	237.1 plf	422.3 plf	617.1 plf	820.7 plf	1031.0 plf	1248.3 plf	1473.8 plf	1704.0 plf	1937.9 plf	2177.6 plf	2421.4 plf	2668.4 plf	2919.9 plf	3200.0 plf
Story Force per Floor		**0.000 klf**	**0.065 klf**	**0.172 klf**	**0.185 klf**	**0.195 klf**	**0.204 klf**	**0.210 klf**	**0.217 klf**	**0.225 klf**	**0.230 klf**	**0.234 klf**	**0.240 klf**	**0.244 klf**	**0.247 klf**	**0.252 klf**	**0.280 klf**

Total Wind Force on MWFRS in X Direction

Floor Level	Int.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	R
Length of Building	**88.0 ft**	**88.0 ft**	**88.0 ft**	**88.0 ft**	**88.0 ft**	**88.0 ft**	**88.0 ft**	**88.0 ft**	**88.0 ft**	**88.0 ft**	**88.0 ft**	**88.0 ft**	**88.0 ft**	**88.0 ft**	**88.0 ft**	**88.0 ft**
Frame Story Force per Floor	0.0 k	5.7 k	15.1 k	16.3 k	17.1 k	17.9 k	18.5 k	19.1 k	19.8 k	20.3 k	20.6 k	21.1 k	21.5 k	21.7 k	22.1 k	24.6 k
Frame Story Shear per Floor	281.6 k	281.6 k	275.9 k	260.7 k	244.4 k	227.3 k	209.4 k	190.9 k	171.7 k	151.9 k	131.6 k	111.1 k	90.0 k	68.5 k	46.8 k	24.6 k

DESIGN PRESSURE (psf) FOR WINDS IN THE NORTH-SOUTH DIRECTION



GATEWAY PLAZA

500 DELAWARE AVE.
WILMINGTON, DE

WIND LOADING DIAGRAM

APPENDIX B-CALCULATIONS

SCALE: NTS

PAGE: -

Equivalent Lateral Force Procedure

Design Seismic Forces

Title

Per IBC 2003 and ASCE 7-02

Reference

Gateway Plaza

Project Name

Input Information

D	Site Class - Section 1615.1.1
II	Seismic Use Group - Section 1616.2
B	Seismic Design Category - Section 1616.3
.300g	S_S, Spectral Accelerations for Short Periods - Section 1615.1
.075g	S_1, Spectral Accelerations for 1 Second Period - Section 1615.1
1.56	F_a, Site Coefficient - Table 1615.1.2(1)
2.4	F_v, Site Coefficient - Table 1615.1.2(2)
0.468	S_{MS}, Maximum Spectral Accelerations for Short Periods - Section 1615.1.2
0.18	S_{M1}, Maximum Spectral Accelerations for 1 Second Period - Section 1615.1.2
0.312	S_{DS}, Design Spectral Accelerations for Short Periods - Section 1615.1.3
0.12	S_{D1}, Design Spectral Accelerations for 1 Second Period - Section 1615.1.3
0.03	C_T , Building Period Coefficient - Section 1617.4.2.1
0.75	x
210.5 ft	h_n , Building Height - Section 1617.4.2.1
1.66	$T_a = C_T*h_n^{3/4}$ - Approximate Fundamental Period - Section 1617.4.2.1
0.077	$T_O = 0.2 * (S_{D1}/S_{DS})$- Section 1615.1.4
0.385	$T_S = S_{D1}/S_{DS}$ - Section 1615.1.4
0.072	S_a, Spectral Response Acceleration - Section 1615.1.4
1.25	I_e, Seismic Occupancy Importance Factor - Table 1604.5
5	R, Response Modification Factor - Table 1617.6
0.0780	C_S, Seismic Response Coefficient - Section 1617.4.1.1
0.0172	C_S (min) - Section 1617.4.1.1
0.0181	C_S (Max) - Section 1617.4.1.1
0.0181	C_S (Actual) - Section 1617.4.1.1
23,279 k	W, Effective Seismic Weight of Structure - Section 1617.4.1
421.2	$V = C_S*W$ - Seismic Base Shear - Section 1617.4.1
1.579	k, Distribution Exponent - Section 1617.4.3

Equivalent Lateral Force Procedure

Design Seismic Forces

Title

Per IBC 2003 and ASCE 7-02

Reference

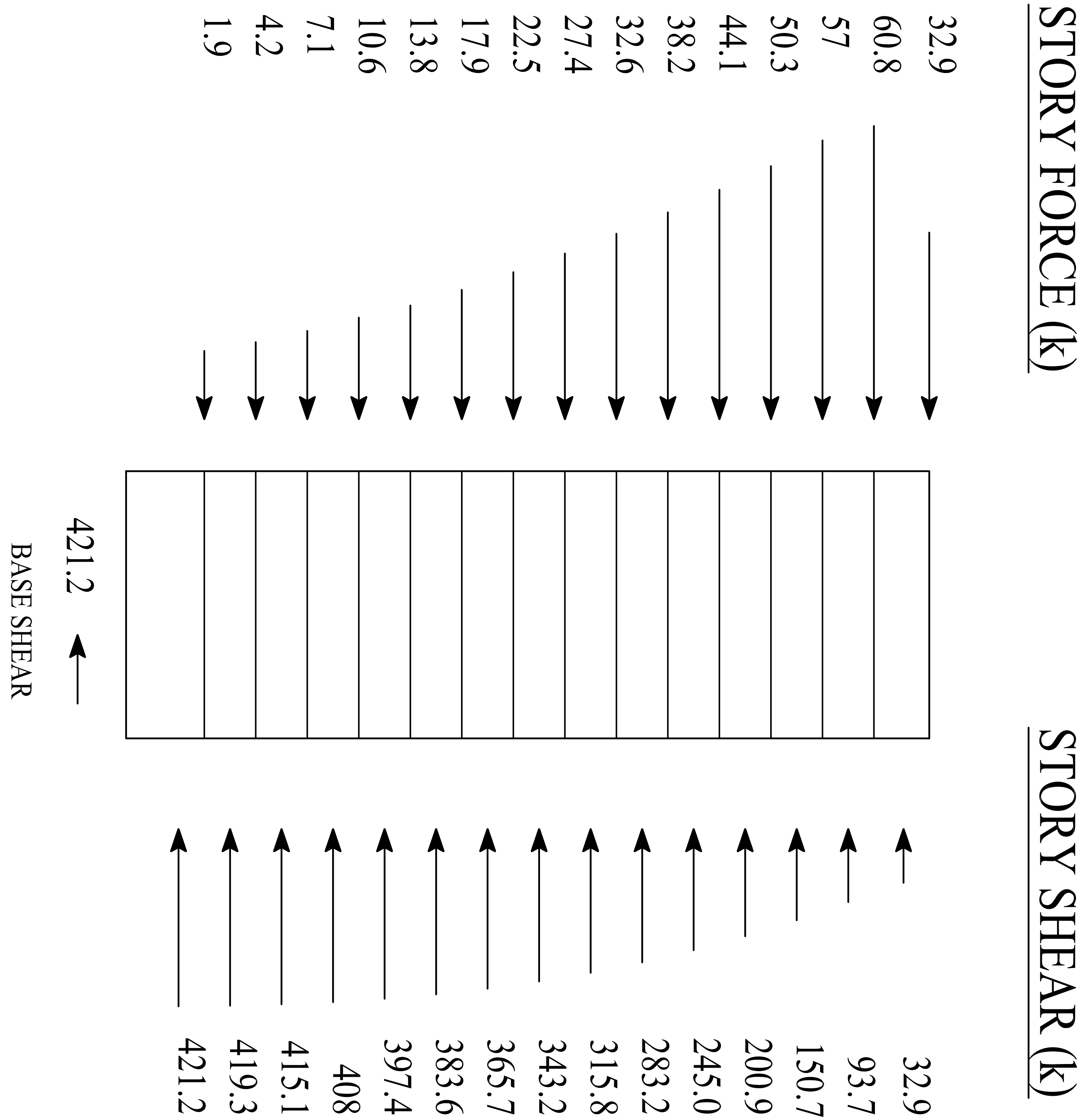
0

Project Name

	Mass Calculations						Force Calculations				
Floor	**Floor-Floor Height (ft)**	**Area (ft^2)**	**Floor Load (psf)**	**Perimeter**	**Wall Loading (psf)**	**Weight**	**Height from Ground**	**$w_x h_x^k$**	**Cvx, (Eq. 9.5.4-2)**	**Story Force (k)**	**Story Shear (k)**
						0 k	210.5 ft	0	0	0.0 k	0.0 k
R		21,000	35.0 psf	718 ft	15.0 psf	735 k	210.5 ft	3424484	0.0780	32.9 k	32.9 k
15	14.5 ft	21,900	66.0 psf	718 ft	15.0 psf	1523 k	196 ft	6,341,674	0.144	60.8 k	93.7 k
14	13.5 ft	21,900	66.0 psf	718 ft	15.0 psf	1596 k	182.5 ft	5,936,241	0.135	57.0 k	150.7 k
13	13.5 ft	21,900	66.0 psf	718 ft	15.0 psf	1591 k	169 ft	5,240,159	0.119	50.3 k	200.9 k
12	13.5 ft	21,900	66.0 psf	718 ft	15.0 psf	1591 k	155.5 ft	4,594,680	0.105	44.1 k	245.0 k
11	13.5 ft	21,900	66.0 psf	718 ft	15.0 psf	1591 k	142 ft	3,980,871	0.091	38.2 k	283.2 k
10	13.5 ft	21,900	66.0 psf	718 ft	15.0 psf	1591 k	128.5 ft	3,399,968	0.077	32.6 k	315.8 k
9	13.5 ft	21,900	66.0 psf	718 ft	15.0 psf	1591 k	115 ft	2,853,389	0.065	27.4 k	343.2 k
8	13.5 ft	21,900	66.0 psf	718 ft	15.0 psf	1591 k	101.5 ft	2,342,780	0.053	22.5 k	365.7 k
7	13.5 ft	21,900	66.0 psf	718 ft	15.0 psf	1591 k	88 ft	1,870,090	0.043	17.9 k	383.6 k
6	13.5 ft	21,900	66.0 psf	718 ft	15.0 psf	1591 k	74.5 ft	1,437,681	0.033	13.8 k	397.4 k
5	13.5 ft	23,000	66.0 psf	773 ft	15.0 psf	1675 k	61 ft	1,103,690	0.025	10.6 k	408.0 k
4	13.5 ft	23,000	66.0 psf	773 ft	15.0 psf	1675 k	47.5 ft	743,559	0.017	7.1 k	415.1 k
3	13.5 ft	23,000	66.0 psf	773 ft	15.0 psf	1675 k	34 ft	438,559	0.010	4.2 k	419.3 k
2	13.5 ft	23,000	66.0 psf	773 ft	15.0 psf	1675 k	20.5 ft	197,284	0.004	1.9 k	421.2 k
Gnd	20.5 ft	21,000					**TOTAL**	**43,905,108**	**1.000**	**421.24**	
TOTAL	**210.5 ft**	**353,000**				**23,279 k**					

2-5 Floor Plan
Area = 23,011 ft^2
Perimeter = 773'

Typical Floor Plan
Area = 21,900 ft^2
Perimeter = 718'



GATEWAY PLAZA

500 DELAWARE AVE.
WILMINGTON, DE

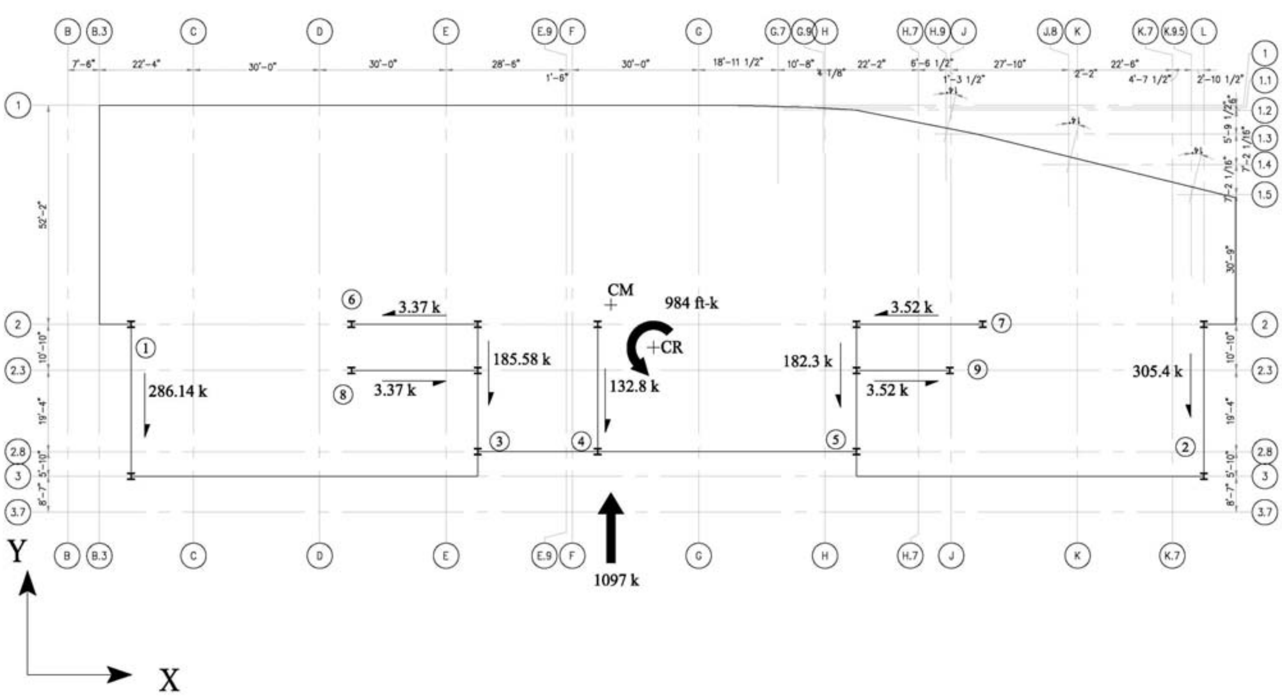
SEISMIC LOADING DIAGRAM	
APPENDIX B-CALCULATIONS	
SCALE: NTS	PAGE: -

B.2: Lateral Load Distribution to Frames: Base Shear

$F_{i,direct}$	1097.8
M	14963 ft-k
x_{cr}	131.60 ft
y_{cr}	30.50 ft

Frame No.	x_i	y_i	d_i	d_i^2	$F_{i,moment}$	$F_{i,direct}$	$F_{i,total}$
Y1	7.50 ft		124.10 ft	15,400.81	50.36 k	219.56	269.92
Y2	89.83 ft		41.77 ft	1,744.73	16.95 k	219.56	236.51
Y3	118.33 ft		13.27 ft	176.01	5.38 k	219.56	224.94
Y4	179.83 ft		-48.23 ft	2,326.45	-19.57 k	219.56	219.56
Y5	262.40 ft		-130.80 ft	17,108.64	-53.08 k	219.56	219.56
X1		25.17 ft	5.33 ft	28.44	2.16 k	0	2.16
X2		36.00 ft	-5.50 ft	30.25	-2.23 k	0	-2.23
X3		25.17 ft	5.33 ft	28.44	2.16 k	0	2.16
X4		36.00 ft	-5.50 ft	30.25	-2.23 k	0	-2.23
				36,874.03			

The picture below illustrates base shears from RAM Output. The results above are very similar to the RAM Output, and validates calculations.



Appendix C-Portal Analysis of Frame Y2

PORTAL ANALYSIS OF FRAME: Y2							
Floor	**Height from Ground**	**Story Force**	**Shear Below Floor**	**Moment Below Floor**	**Moment in Beam**	**Design Moment**	**Conservative ?**
R	210.5 ft	11.60 k	11.60 k	2441.8 'k	39.2 'k	183	unconservative
15	196 ft	10.57 k	22.17 k	4513.5 'k	114.0 'k	313	unconservative
14	182.5 ft	11.05 k	33.22 k	6530.1 'k	186.9 'k	334	unconservative
13	169 ft	14.74 k	47.96 k	9021.2 'k	274.0 'k	375	unconservative
12	155.5 ft	12.76 k	60.72 k	11005.4 'k	366.8 'k	396	unconservative
11	142 ft	14.58 k	75.30 k	13075.7 'k	459.1 'k	402	conservative
10	128.5 ft	11.73 k	87.03 k	14583.1 'k	547.9 'k	398	conservative
9	115 ft	15.31 k	102.34 k	16343.7 'k	639.1 'k	383	conservative
8	101.5 ft	7.18 k	109.52 k	17072.5 'k	715.0 'k	354	conservative
7	88 ft	14.53 k	124.05 k	18351.1 'k	788.3 'k	325	conservative
6	74.5 ft	22.88 k	146.93 k	20055.7 'k	914.6 'k	181	conservative
5	61 ft	407.47 k	554.40 k	44911.3 'k	2367.0 'k	n/a	n/a
4	47.5 ft	388.64 k	943.04 k	63371.7 'k	5053.9 'k	n/a	n/a
3	34 ft	322.01 k	1265.05 k	74320.1 'k	7452.3 'k	n/a	n/a
2	20.5 ft	305.40 k	1570.45 k	80580.8 'k	9569.8 'k	n/a	n/a

PORTAL FRAME ANALYSIS DIAGRAM