901 NEW YORK Avenue

Structural Technical Report 3

Lateral System Analysis and Confirmation Design

901 New York Avenue
Washington, D.C.

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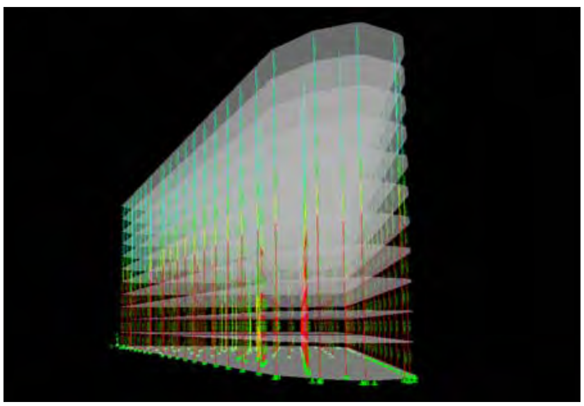
Executive Summary

The 3rd Technical Assignment addresses primarily the lateral system of 901 New York Avenue confirmation of its design. The current design of the building is a two-way flat slab rested on columns that are monolithically poured to create a moment-framed system. This system relies on the capability of the column and beam combination to withstand all loads, gravity and lateral. In order to ensure the strength of the columns, the designer over-designed the columns significantly to prevent any possible failures.

The main factors in lateral forces are wind and seismic. Previous calculations done in Technical Report 1 shall be used as a starting point to address the issue of analyzing and confirming the building's structural system.

Sub-level floors were not taken into account, since they are all below grade. All lateral effects take into account only grade levels and above. Below grade structural elements were considered to be completely stiff as a result.



ETabs was used as a modeling tool in order to analyze the building. The program features a very easy-to-use interface with a step-by-step menu bar in order to ensure a quick and fast design of any building type. Although 901 New York Avenue has an irregular shape, three separate grid systems were used to create an accurate replica of the actual building. Column sizes, reinforcement, and location were also exactly placed in order for most accurate analysis. The only setback (and a great one) is that the codes associated with ETabs is outdated by a few years. For example, the most recent code by ASCE is dated at 2005, while the one available in this version of ETabs is 1998. Even still, the coefficients, values, and factors found through hand calculations using ASCE/SEI 7-05 were manually inputted into the model specifications in order to obtain the best final result.

Using values from the hand calculations of wind and seismic, the ETabs model was used to first find centers of mass of rigidity for each floor. Then shear and torsion were taken into account for each load combination (as specified in ASCE). Finally, each story drift was found and added altogether to find the total building deflection.

901 New York Avenue's deflection came out to 0.42", which was only a fraction of the necessary 3.9". This concludes that 901 New York Avenue was built to satisfaction in terms of lateral resistance.

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<u>Introduction</u>

901 New York Avenue is a 580,000 square-foot 11-story multi-use building in the heart of Washington, D.C. The building stands at a full 130'-0" above grade and also houses a four sub-level parking garage. The greatest feature of the building is that it is not a usual square or rectangular building. Rather it's triangular in shape, and the architect used some ingenious concepts (that are typical in corner buildings as 901 NYA) to maximize the use of the space in the corners. While 4 levels below grade are designated for parking, the first floor is used for general commercial space, and the rest of the building is leased out to tenants for office use. One of the greatest interior features is a 6-story spiral staircase, which has won numerous awards locally.

Picture 1 & 2 *– Photos of the spiral staircase*

Its prime location makes it valuable land to build on, and as such, the owner desired to allot as many floors as possible within the 130'-0" height limitation, as is the height limitation for most D.C. buildings. To make the space even more attractive, it was decided to have large bay openings in order for flexibility with interior designing. Columns spaced at 20'-0 by 40'-0" in its greatest dimension opened up the floor space, and a post-tensioned two-way concrete flat slab at an 11" thickness kept floor thicknesses at a minimum (11'-8" floor-to-floor heights). The desire for maximizing the amount floor space also limited the possible idea of shear walls to resist lateral forces. The following report will review the current lateral system and the distribution of lateral loads to confirm its present design.

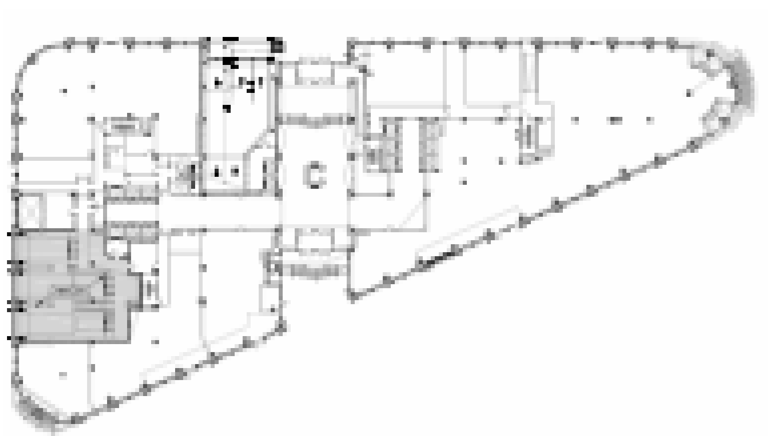


Figure 1 *– 1st Typical floor plan of 901 New York Avenue*

Gravity Loads

Gravity loads are taken from the previous Technical Report 1, as load combinations from ASCE/SEI 7-05 will still be used. Although ETabs uses an outdated code reference, custom load combinations were inputted into the model. Below is a general comparison of the two series of load combinations:

- From ASCE/SEI 7-05
  - $U = 1.4D$
  - $U = 1.2D + 1.6L + 0.5L_r$
  - $U = 1.2D + 1.6L_r + (1.0L \text{ or } 0.8W)$
  - $U = 1.2D + 1.6W + 1.0L + 0.5L_r$
  - $U = 1.2D + 1.0E + 1.0L$
  - $U = 0.9D + 1.6W$
  - $U = 0.9D + 1.0E$

- From ETabs
  - $U = 1.4D$
  - $U = 1.2D + 1.6L + 0.5(Lr \text{ or } S)$
  - $U = 1.2D + 1.6(Lr \text{ or } S) + (L \text{ or } 0.8W)$
  - $U = 1.2D + 1.6W + L + 0.5(Lr \text{ or } S)$
  - $U = 1.2D + E + L + 0.2S$
  - $U = 0.9D + 1.6W$
  - $U = 0.9D + E$

Dead load was limited to just the mechanical and electrical loads, since ETabs has the ability to add the self-weight of the slab and column into the calculations. Final loads were found to be 20 psf.

Live loads were assumed to be 100 psf throughout the floors, since most of the space is used for office, lobby, and public purposes. An increased 220 psf load was used in specific areas near the center of the building as specified in the construction set. This could be due to heavy live load traffic (as there are elevators in the area). Additional weight was also considered on the roof, as it housed the majority of the mechanical units.

Current Lateral System

901 NYA is built as a concrete-framed building. Due to the large bay spans, post-tensioning was utilized to minimize deflection in the slab. Although 11" is considered to be a thick slab, it was more crucial to the architect to have larger spans from column to column than lose a few inches in floor thickness. In the absence of shear walls, all lateral forces were intended to be resisted through what is classified as "moment-framing."

The typical square columns were 26" thick, with 8-#9 reinforcement. The first and second floor used 8,000 psi concrete, while the third and fourth used 6,000 psi, and the fifth and sixth floors used 5,000 psi. The rest of the floors used 4,000 psi concrete. Also, on the lower floors, there is the presence of larger columns with more reinforcement. This is due to the heavier axial loads that the lower columns need to take, along with the lateral forces. Located on grid line 6 and 8, these columns had a tendency to be designed at a larger dimension than the rest of the columns. This is due to the fact that these columns are located in the heavier load in the center of the building. Dimensions range from 32" square columns to 24"x36" columns. The rectangular columns were directed and faced towards the long direction of the slab. Reinforcement ranged from as little as 8-#9's to as many as 20-#11's. Higher strength concrete on the first through sixth floors is a big indication that the building was designed so that these columns would be able to sustain all the lateral forces.

Post-tensioned tendons were mandated to have at least 2 go through the column. This guaranteed a rigid frame between the slab and the column. A rigid diaphragm was assumed for the slab in order to assure that the lateral loads distributed from the slab to the columns. Although post-tensioning is a long and arduous process to install and construct, it was necessary in order to maintain a satisfactory deflection in the slab. There was no other alternative with such a long span of the slab (up to 40'-0" unsupported).

Columns were further stiffened with the use of drop panel at each column. Drop panels were typically offset 8" beyond the column perimeter for a dimension of a 42" square dropped at 8" below the bottom of the slab. Larger columns at the center of the building (in the location of the heavier loads as well) had column drop panels as large as 2'-0" offset from the perimeter of the 32" square columns. These panels further improve the rigidity of the column but also the integrity of the shear strengths of the slab (as described in Technical Report 1).

Sub-levels will not be a part of this analysis report, as these levels are assumed to be completely stiff. Lateral effects only pertain from the ground level up. The only concern sub-level structures have, for this analysis, is the capability of taking on gravity loads from the stories above. This has been addressed in Technical Report 1.

Lateral Loads

Wind Loads
Wind loads were done without considering quartering winds. When the wind is analyzed on the building, the hypotenuse of the building (the side running alongside New York Avenue) is considered the leeward side of the building. As such, the short side is considered the side wall when the wind is parallel to the short side, and the long side is the side wall when the wind is parallel to the long side.

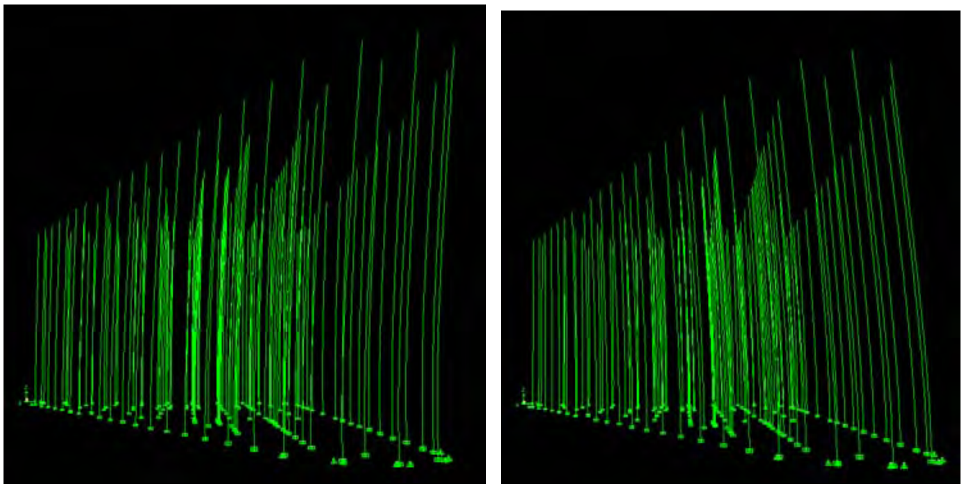


Figure 2 *– Deflection due to wind loads*

All values and calculations were based upon ASCE/SEI 7-05. Basic wind speed was found to be 90 mph, from both the drawing set and figure 6-1 in the code book. Wind forces were found using the following equations:

$$q_z = 0.00256K_zK_{zt}K_dV^2I$$

C_p values were found to find the windward, leeward, and sidewall pressures. The values varied depending on whether the windward wall was the long side or the short side. Two trials were done to find the controlling pressures, and when the windward wall is the long side of the building controlled. The following is a summary of the second trial (windward wall is long side):

	MWFRS		C & C	
Height (ft)	Kz	qz (psf)	Kz	qz (psf)
0-15	0.57	10.0491	0.70	12.3410
20	0.62	10.9306	0.70	12.3410
25	0.66	11.6358	0.70	12.3410
30	0.70	12.3410	0.70	12.3410
40	0.76	13.3988	0.76	13.3988
50	0.81	14.2803	0.81	14.2803
60	0.85	14.9855	0.85	14.9855
70	0.89	15.6907	0.89	15.6907
80	0.93	16.3959	0.93	16.3959
90	0.96	16.9248	0.96	16.9248
100	0.99	17.4537	0.99	17.4537
120	1.04	18.3352	1.04	18.3352

140	1.09	19.2167	1.09	19.2167
Eave Height = 130'	1.07	18.7760	1.07	18.7760

Surface Type	Surface Designation	Surface	Distance from Windward Edge	L / B or h / L	*Cp*	External Pressure @ q = 130' (psf)
Walls	W2	WW	-	All	0.80	15.021
	W3	LW	-	0.56	-0.50	-9.388
	W1	Side	-	All	-0.70	-13.143
Roof			0 to h	0.34	-0.90	-16.898
			h to 2h	0.34	-0.50	-9.388
			> 2h	0.34	-0.30	-5.633

Windward Pressures

qz (psf)	Cp	External Pressure	Design Pressure (psf) (+GCpi)	(-GCpi)
10.0491	0.80	6.83	3.45	10.21
10.9306	0.80	7.43	4.05	10.81
11.6358	0.80	7.91	4.53	11.29
12.3410	0.80	8.39	5.01	11.77
13.3988	0.80	9.11	5.73	12.49
14.2803	0.80	9.71	6.33	13.09
14.9855	0.80	10.19	6.81	13.57
15.6907	0.80	10.67	7.29	14.05
16.3959	0.80	11.15	7.77	14.53
16.9248	0.80	11.51	8.13	14.89
17.4537	0.80	11.87	8.49	15.25
18.3352	0.80	12.47	9.09	15.85
19.2167	0.80	13.07	9.69	16.45

Leeward Pressures

qz (psf)	Cp	External Pressure (psf)	Design Pressure (psf) (+GCpi)	(-GCpi)
10.0491	-0.5	-4.27	-7.65	-0.89
10.9306	-0.5	-4.65	-8.03	-1.27
11.6358	-0.5	-4.95	-8.32	-1.57
12.3410	-0.5	-5.24	-8.62	-1.87
13.3988	-0.5	-5.69	-9.07	-2.31
14.2803	-0.5	-6.07	-9.45	-2.69
14.9855	-0.5	-6.37	-9.75	-2.99
15.6907	-0.5	-6.67	-10.05	-3.29
16.3959	-0.5	-6.97	-10.35	-3.59
16.9248	-0.5	-7.19	-10.57	-3.81
17.4537	-0.5	-7.42	-10.80	-4.04
18.3352	-0.5	-7.79	-11.17	-4.41
19.2167	-0.5	-8.17	-11.55	-4.79

Sidewall Pressures

qz (psf)	Cp	External Pressure	Design Pressure (psf) (+GCpi)	(-GCpi)
10.0491	-0.70	-5.98	-9.36	-2.60
10.9306	-0.70	-6.50	-9.88	-3.12
11.6358	-0.70	-6.92	-10.30	-3.54
12.3410	-0.70	-7.34	-10.72	-3.96
13.3988	-0.70	-7.97	-11.35	-4.59
14.2803	-0.70	-8.50	-11.88	-5.12
14.9855	-0.70	-8.92	-12.30	-5.54
15.6907	-0.70	-9.34	-12.72	-5.96
16.3959	-0.70	-9.76	-13.14	-6.38
16.9248	-0.70	-10.07	-13.45	-6.69
17.4537	-0.70	-10.38	-13.76	-7.01
18.3352	-0.70	-10.91	-14.29	-7.53
19.2167	-0.70	-11.43	-14.81	-8.05

Roof

qz (psf)	Cp	External Pressure	Design Pressure (psf) (+GCpi)	(-GCpi)
10.0491	-0.5	-4.27	-7.65	-0.89
10.9306	-0.5	-4.65	-8.03	-1.27
11.6358	-0.5	-4.95	-8.32	-1.57
12.3410	-0.5	-5.24	-8.62	-1.87
13.3988	-0.5	-5.69	-9.07	-2.31
14.2803	-0.5	-6.07	-9.45	-2.69
14.9855	-0.5	-6.37	-9.75	-2.99
15.6907	-0.5	-6.67	-10.05	-3.29
16.3959	-0.5	-6.97	-10.35	-3.59
16.9248	-0.5	-7.19	-10.57	-3.81
17.4537	-0.5	-7.42	-10.80	-4.04
18.3352	-0.5	-7.79	-11.17	-4.41
19.2167	-0.5	-8.17	-11.55	-4.79

***Table Set 4** – Wind Summary (3)*

Seismic Loads
901 is a simple-use building, and does not represent a substantial hazard to human life, so **Occupancy Category II** was chosen. **Seismic Use Group I** was also chosen. Site Classification was designated in the GeoTechnical Report provided by the owner at **Class C** (very dense soil and hard rock). This classification is benefited to the fact that there is a 4-story parking garage below grade, which requires digging very deep into the earth. This also helps in building a solid foundation without the need for any caissons, pilings, etc. Since lateral forces were found to be resisted through concrete moment framing, R is valued at 5, and I is valued at 1.

Seismic base shear was founded with the following equation:

$$V = C_S W \quad \text{where} \quad Cs = S_{DS}/(R/I)$$
$$C_{Smax} = S_{D1}/[T(R/I)]$$

and was found to be 0.00917*(3079+8426(9)+8548) = 802^K

The following is a summary of the story shear and overturning moments and their derivations:

Level	Height Above Shear Base, *h* (ft)	Weight *W* at Height *h* (kips)	Total Weight = **Σ** *W*	(Wxhx)^k	[(Wxhx)^k] ------------ [(Wihi)^k]	Lateral Seismic Force, *Fx* (kips)	Lateral Seismic Story Shear (kips)	Overturning Moment (kip-ft)
Roof	130	3,079	3,079	12,246,577	0.10900	87.42	87.42	-
11	118.86	8,426	11,505	269,486,085	0.24000	192.48	279.90	973.86
10	107.19	8,426	19,931	215,061,633	0.19100	153.18	433.08	3,266.43
9	95.52	8,426	28,357	167,191,752	0.14900	119.50	552.58	5,054.04
8	83.85	8,426	36,783	125,754,304	0.11200	89.92	642.50	6,448.61
7	72.18	8,426	45,209	90,629,510	0.08100	65.96	708.46	7,497.98
6	60.51	8,426	53,635	64,594,810	0.05500	44.11	752.57	8,267.73
5	48.84	8,426	62,061	38,496,793	0.03430	27.51	780.08	8,782.49
4	37.17	8,426	70,487	21,128,519	0.01900	15.24	795.32	9,103.53
3	25.5	8,426	78,913	9,190,626	0.00818	6.56	801.88	9,281.38
2	13.83	8,548	87,461	2,377,499	0.00212	1.70	802.00	9,357.94
1	-	-	-	-	-	-	-	11,091.66
Σ		87,461	497,421		1.00	802.00		11,091.66

Total Weight:	**87,461**
Base Shear:	**802 kips**
Total Overturning Moment:	**11091.66 ft-kips**

***Table Set 5** – Seismic Summary*

Figure 4 *– Diagram of seismic loads*

<u>Analysis and Results</u>

ETabs v. 8.57 was used for analysis of the current lateral system. Although ETabs does not have an option for post-tensioning, there was no need to add post-tensioning to the model since the purpose of the model is to observe lateral activity, not gravity. As a result, a uniform slab at 5,000 psi was used throughout the entire model. Also, earthquake conditions used an outdated IBC 2000, and the wind conditions used ASCE 7-98. Both sets of code are outdated, but serve their purpose and use for the current analysis. Values from the hand calculations were added to the model for the seismic and wind. ETabs is also a great tool, since the user face allows for quick and easy development of the model. 3 separate grid patterns were used to create the model, since the irregular shape of a triangle creates a very difficult grid to work with. All columns needed to be placed exactly to its nearest inch in order to keep the model in correct shape. All three corners had to be radially calculated to find the disance to the columns and slab edges.

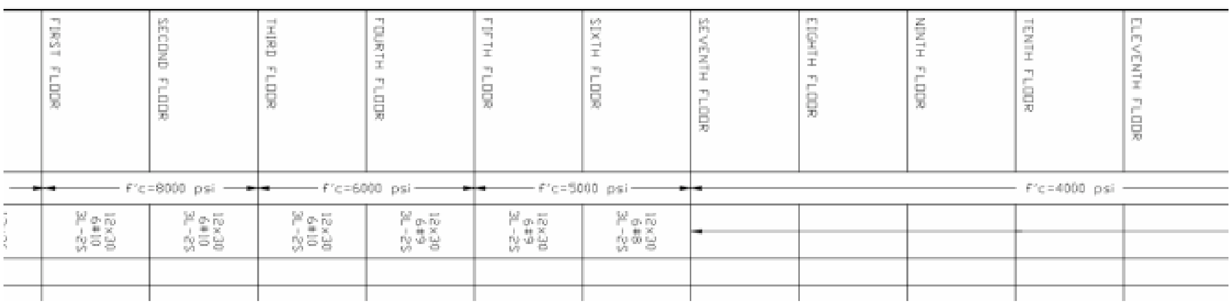


Figure 5 *– Designation of compressive strength of columns*

All columns and reinforcement as specified in the construction set were added to the model. Each column set (per floor) was also designated according to its compressive strength. This was done for a few reasons. If the model was built with just a typical 26" square column all throughout with 8-#9's for reinforcement, the building would be severely under-designed from the actual building. Columns located at the center of the building most definitely would fail with the combination of gravity and lateral loads applied. Also, 6,000 and 8,000 psi concrete columns are considerably stronger than 5,000 psi, which is still considered to be a high-strength concrete. It was necessary to build a model with as accurate a column schedule as the actual building. Column design and dimensions were found in the drawing set. Column sizes lessened going to higher stories as axial loads lessened going to higher stories.

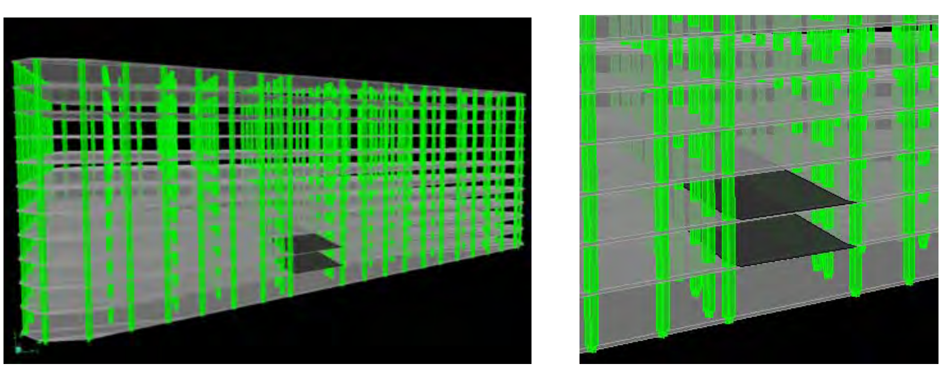


Figure 6 *– Designation of slab opening due to atrium space*

Slab openings were only considered in the major portions of the building, such as the 3-story atrium space in the center of the building. Small openings in the diaphragm (such as an opening for staircase, elevator shaft, etc.) do not have a significant effect on the model, whereas the opening for the atrium space cuts completely through the building to almost make two separate entities of the building.

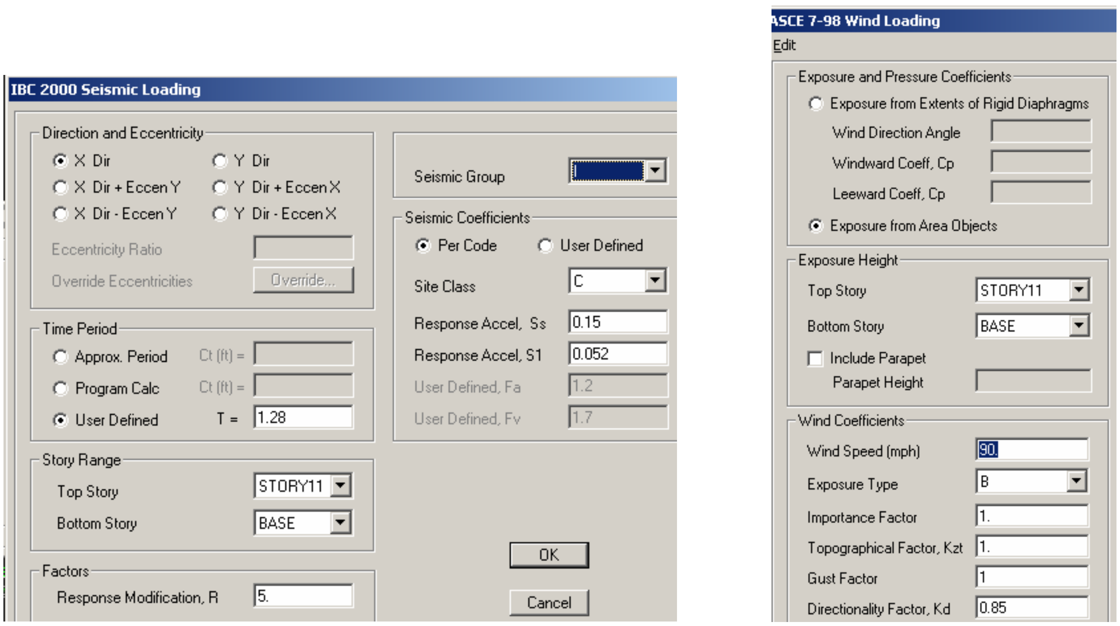


Figure 7 *– Seismic and wind custom input data (according to hand calculations)*

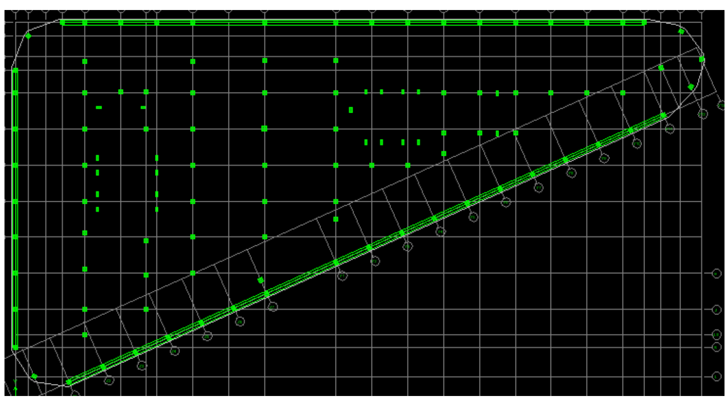


Figure 8 *– Designation of wind walls in ETabs*

As stated before, the loads were applied to the model according to the codes accepted by ETabs. A total of 10 load combinations were tried and checked to see which would control. Wind was considered to control over seismic.

Analysis of the model gave results for story drift and shear, support reactions, column interactive diagrams and forces, and center of rigidity (for mass).

Story Drift

The integrity of the building's lateral system will be assessed through its satisfaction in meeting the building's deflection requirements. Total drift of the building shall be assessed through the summation of each story's drift to get the entire building's drift. The allowable drift, or deflection, of the building is set at L/400, where L is the height of the building. Although there is no equation to derive the limiting value, L/400 was chosen as a general "rule of thumb" by the code. Using a value of L = (130')(12"/foot) = 1,560", L/400 was found to be 3.9". Below is a summary of the story drift.

Story	Item	Load	Point	X	Y	Z	DriftX *(in)*
2nd Floor	Max Drift X	09D10E	452	29.337	10.637	12.83	0.005791
3rd Floor	Max Drift X	09D10E	452	29.337	10.637	24.5	0.015941
4th Floor	Max Drift X	09D10E	452	29.337	10.637	36.17	0.024499
5th Floor	Max Drift X	09D10E	452	29.337	10.637	47.84	0.031857
6th Floor	Max Drift X	09D10E	452	29.337	10.637	59.51	0.037847
7th Floor	Max Drift X	09D10E	452	29.337	10.637	71.18	0.042518
8th Floor	Max Drift X	09D10E	452	29.337	10.637	82.85	0.046012
9th Floor	Max Drift X	09D10E	452	29.337	10.637	94.52	0.048439
10th Floor	Max Drift X	09D10E	452	29.337	10.637	106.19	0.049941
11th Floor	Max Drift X	09D10E	452	29.337	10.637	117.86	0.050718
Roof	Max Drift X	09D10E	452	29.337	10.637	130	0.051007
						Total:	**0.40457**

0.41" is significantly smaller than the required building deflection limit of 3.9". Even if the limit had been L/600 (2.6") it still would have passed. This is an important aspect of the building, since the structural engineer designing 901 NYA had assumed that there was no need for shear walls. It is also important to note from the data from ETabs that earthquake loads controlled over wind loads. This is different than expected, as information was given that the building was designed assuming that wind loads were the worst-case scenarios. However, it must be kept in mind that the codes used in 2000 and the codes used now for 2007 have gone through significant changes, from different coefficients to new equations and new diagrams. Even still, it is evident that the building was built to withstand any load combinations.

Center of Rigidity

The center of rigidity was found per floor for many reasons. It was important to state that each floor diaphragm was rigid, as it would be detrimental in a flat slab design if it weren't so. Also, in consideration of per floor drift, using the center of rigidity allowed a more accurate result of shear and torsion of the building. As viewed in the animation creatd by ETabs, the northeast side of the building sways more than the western portion. All of these factors were considered in the model, and the center of rigidity per floor was found for use of analysis.

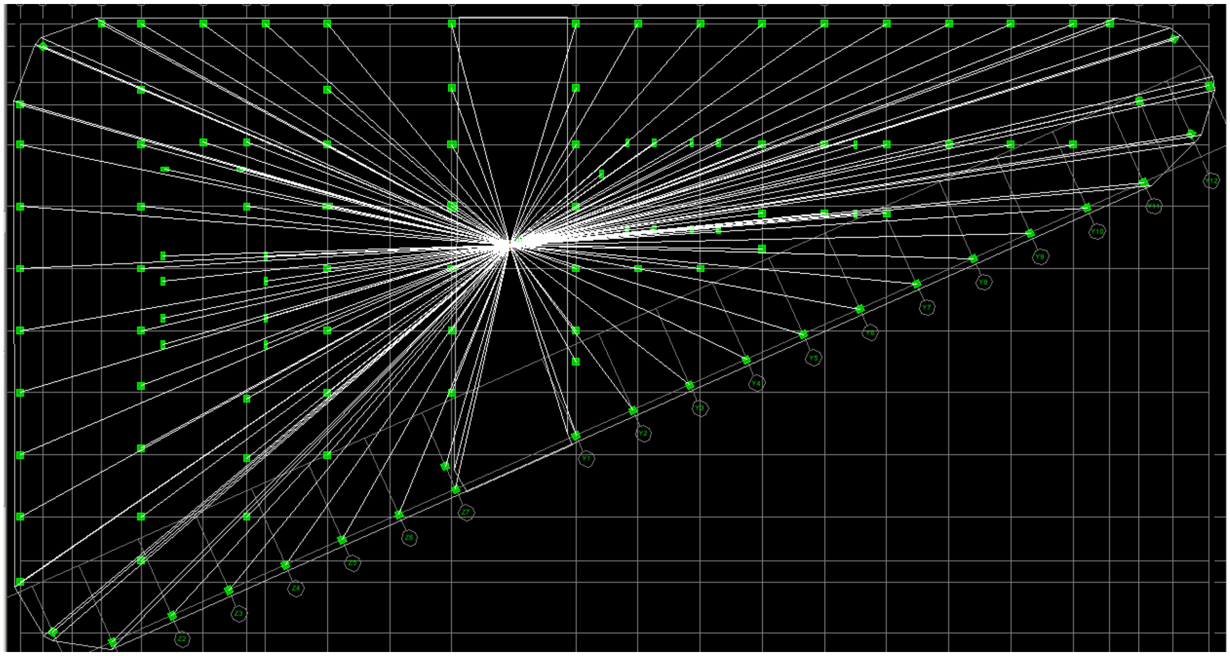


Figure 9 – Location of center of rigidity of typical floor

Story	Diaphragm	MassX	MassY	XCM	YCM	CumMassX	CumMassY	XCCM	YCCM	XCR	YCR
STORY11	D1	226.9135	226.9135	149.382	139.499	226.9135	226.9135	149.382	139.499	154.498	140.052
STORY10	D1	240.7095	240.7095	149.636	139.541	467.623	467.623	149.513	139.521	154.489	140.063
STORY9	D1	240.1539	240.1539	149.627	139.539	707.7768	707.7768	149.551	139.527	154.479	140.076
STORY8	D1	240.0882	240.0882	149.63	139.535	947.865	947.865	149.571	139.529	154.469	140.092
STORY7	D1	240.0225	240.0225	149.632	139.531	1187.8875	1187.8875	149.584	139.529	154.46	140.109
STORY6	D1	240.0882	240.0882	149.63	139.535	1427.9757	1427.9757	149.591	139.53	154.456	140.129
STORY5	D1	240.1539	240.1539	149.627	139.539	1668.1296	1668.1296	149.596	139.532	154.459	140.153
STORY4	D1	240.172	240.172	149.646	139.54	1908.3016	1908.3016	149.603	139.533	154.474	140.179
STORY3	D1	240.1418	240.1418	149.641	139.538	2148.4434	2148.4434	149.607	139.533	154.491	140.197
STORY2	D1	240.2377	240.2377	149.611	139.544	2388.681	2388.681	149.607	139.534	154.481	140.173
STORY1	D1	241.7213	241.7213	149.629	139.551	2630.4024	2630.4024	149.609	139.536	154.456	140.136

The location of center of mass rigidity further explains the thicker slab and heavier reinforcing at the location of the center of the building. The application of heavier loads in the center also contributes to a more stable building.

Conclusion

In conclusion, 901 New York Avenue has been designed to complete satisfaction. All loads have been taken into account, from gravity dead and live loads, to lateral wind and seismic, and all load combinations.

Columns have been analyzed and proven to be extremely stiff and strong enough to withstand the worst lateral effects. 26" square columns with 8 #9's are more than sufficient.

This report does raise possible questions of what effects would shear walls have on the design of the building and whether or not shear walls would have been a more cost-effective solution.

Appendix

Seismic Supplemental Calculations

TA #3 | 901 NYA | Timothy H Park | 1

SEISMIC REDESIGN

OCCUPANCY GROUP	II	
SEISMIC USE GROUP	I	
SEISMIC DESIGN CATEGORY	TBD	
SITE CLASS	C	[TABLE 20.3-1]

$S_S = 15\%$ [FIG 22-1] $F_A = 1.2$ [TABLE 11.4-1]
$S_1 = 5.2\%$ [FIG 22-2] $F_V = 1.7$ [TABLE 11.4-2]

$S_{MS} = F_A S_S = 0.18$ $S_{DS} = \frac{2}{3} S_{MS} = 0.12$
$S_{M1} = F_V S_1 = 0.088$ $S_{D1} = \frac{2}{3} S_{M1} = 0.0587$

$S_{DS} < 0.167$, $S_{D1} < 0.067$] SDC: A [TABLE 11.6-1, 11.6-2]

$V = C_s W$

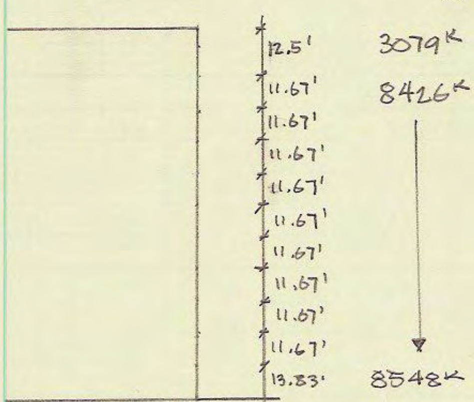
$C_s = \frac{S_{DS}}{R/I} = \frac{0.12}{5} = 0.024$ $R = 5$ [TABLE 12.2-1 : INT MOM. RES. FRAME]

$C_{s_{max}} = \frac{S_{D1}}{T(R/I)} = \frac{0.0587}{1.28(5)} = 0.00917$ ← CONTROLS

$T_a = C_t h_n^x = 1.28$ $C_t = 0.016$, $x = 0.9$, $h_n = 130'$ [TABLE 12.8-2]

$V = 0.00917(108693^k) =$ ~~496.7^k~~

$F_x = C_{vx} V$ WHERE $C_{vx} = \frac{w_x h_x^k}{\sum_{i=1}^{n} w_i h_i^k}$ k: < 0.5 → 1; > 2.5 → 2] 2.173; $= 1.84$



$V = 0.00917(3079 + 8426(9) + 8548) = 802^k$

TA #3 | 901 NYA | Timothy H Park | 2

$$C_{vx} = \frac{w_x h_x^k}{\sum w_i h_i^k}$$

		$C_{vx} V$
2	$\frac{(8548)(13.33)^{2.173}}{1123383308} \times 802^k =$	1.7^k
3	$\frac{(8426)(25)^{2.173}}{1123383308} \times 802^k =$	6.56^k
4	$\frac{(8426)(36.67)^{2.173}}{1123383308} \times 802 =$	15.24^k
5	$\frac{(8426)(48.33)^{2.173}}{1123383308} \times 802 =$	27.51^k
6	$\frac{(8426)(60)^{2.173}}{1123383308} \times 802 =$	44.11^k
7	71.67' : 0.081 (802) =	65.96^k
8	83.33' : 0.112 (802) =	89.82^k
9	95' : 0.149 (802) =	119.50^k
10	106.67' : 0.191 (802) =	153.18^k
11	118.34' : 0.24 (802) =	192.48^k
R	130.83' : 0.109 (802) =	87.42^k

Force	ΣF_x
87.42	87.42
192.48	278.32
153.18	431.5
119.5	551
89.92	640.9
65.96	706.9
44.11	751
27.51	778.5
15.24	793.7
6.56	800.3
1.7	802

(SEE EXCEL SPREADSHEET FOR REST)

Seismic Design for 901 New York Avenue

Level	Height Above Shear Base, *h*	Weight *W* at Height *h* (kips)	Total Weight = Σ*W*	(Wxhx)^k	[(Wxhx)^k] / [(Wihi)^k]	Lateral Seismic Force, *Fx* (kips)	Lateral Seismic Story Shear (kips)	Overturning Moment (kip-ft)
Roof	130	3,079	3,079	12,246,577	0.10900	87.42	87.42	-
11	118.86	8,426	11,505	269,486,085	0.24000	192.48	279.90	973.86
10	107.19	8,426	19,931	215,061,633	0.19100	153.18	433.08	3,266.43
9	95.52	8,426	28,357	167,191,752	0.14900	119.50	552.58	5,054.04
8	83.85	8,426	36,783	125,754,304	0.11200	89.92	642.50	6,448.61
7	72.18	8,426	45,209	90,629,510	0.08100	65.96	708.46	7,497.98
6	60.51	8,426	53,635	64,594,810	0.05500	44.11	752.57	8,267.73
5	48.84	8,426	62,061	38,496,793	0.03430	27.51	780.08	8,782.49
4	37.17	8,426	70,487	21,128,519	0.01900	15.24	795.32	9,103.53
3	25.5	8,426	78,913	9,190,626	0.00818	6.56	801.88	9,281.38
2	13.83	8,548	87,461	2,377,499	0.00212	1.70	802.00	9,357.94
1	-	-	-	-	-	-	-	11,091.66
Σ		87,461	497,421		1.00	802.00		11,091.66

Total Weight: 87,461
Base Shear: 802 kips
Total Overturning Moment: 11091.66 ft-kips

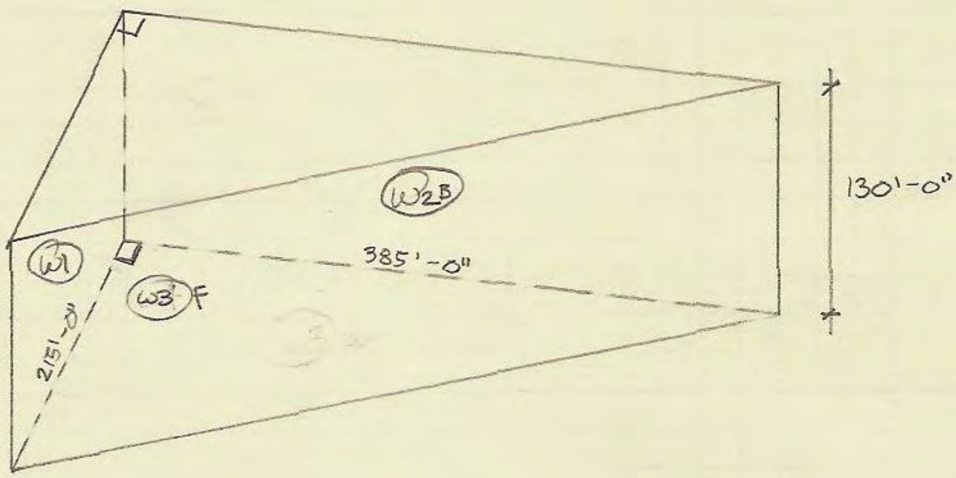
Wind Supplemental Calculations

WIND REDESIGN

NONSYMMETRICAL, CAN'T USE SIMPLIFIED METHOD

EXPOSURE CAT B [SECTION 6.5.6.3]

ASSUME TRIANGULAR BUILDING



$V = 90$ MPH [FIGURE 6-1]

$q_z = 0.00256 K_z K_{zt} K_D V^2 I$

$K_{zt} = 1.0$
$K_D = 0.85$
$V = 90$ MPH
$I = 1.0$

$q_z = 17.63 K_z$ K_z CASE 2 FOR MWFRS
CASE 1 FOR C+C

C_p: WW 0.8
SIDE −0.7
LW −0.5 FOR 11 TO 215'
−0.34 FOR 11 TO 385'

h/L = 130/215 = 0.
130/385 = 0.

Roof C_p: −0.9, −0.5, −0.3

(SEE EXCEL SHEET FOR MORE INFORMATION)

Wind Loads on 901 New York Avenue

	MWFRS		C & C	
Height (ft)	Kz	qz (psf)	Kz	qz (psf)
0-15	0.57	10.0491	0.70	12.3410
20	0.62	10.9306	0.70	12.3410
25	0.66	11.6358	0.70	12.3410
30	0.70	12.3410	0.70	12.3410
40	0.76	13.3988	0.76	13.3988
50	0.81	14.2803	0.81	14.2803
60	0.85	14.9855	0.85	14.9855
70	0.89	15.6907	0.89	15.6907
80	0.93	16.3959	0.93	16.3959
90	0.96	16.9248	0.96	16.9248
100	0.99	17.4537	0.99	17.4537
120	1.04	18.3352	1.04	18.3352
140	1.09	19.2167	1.09	19.2167
Eave Height = 130'	1.07	18.7760	1.07	18.7760

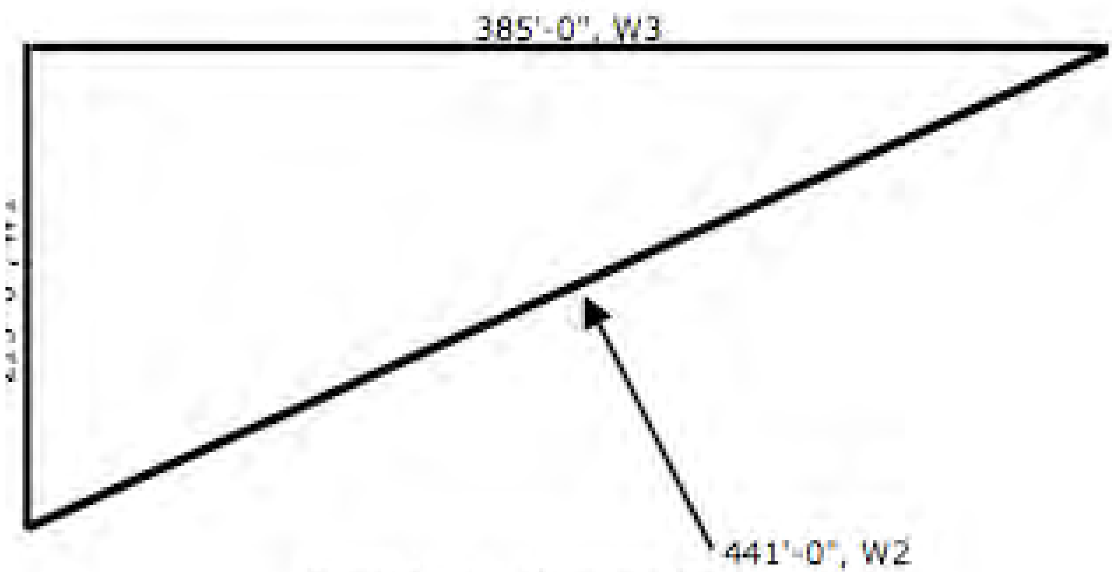


Figure 1: Walls Description for 901 NYA

Trial 1

Surface Type	Surface Designation	Surface	Distance from Windward Edge	L/B or h/L	Cp	External Pressure @ q = 130' (psf)
Walls	W1	WW	-	All	0.80	15.021
	W3	LW	-	1.80	-0.34	-6.384
	W2	Side	-	All	-0.70	-13.143
Roof			0 to h	0.34	-0.90	-16.898
			h to 2h	0.34	-0.50	-9.388
			> 2h	0.34	-0.30	-5.633

Windward Pressures

qz (psf)	Cp	External Pressure	Design Pressure (psf) (+GCpi)	(-GCpi)
10.0491	0.80	6.83	3.45	10.21
10.9306	0.80	7.43	4.05	10.81
11.6358	0.80	7.91	4.53	11.29
12.3410	0.80	8.39	5.01	11.77
13.3988	0.80	9.11	5.73	12.49
14.2803	0.80	9.71	6.33	13.09
14.9855	0.80	10.19	6.81	13.57
15.6907	0.80	10.67	7.29	14.05
16.3959	0.80	11.15	7.77	14.53
16.9248	0.80	11.51	8.13	14.89
17.4537	0.80	11.87	8.49	15.25
18.3352	0.80	12.47	9.09	15.85
19.2167	0.80	13.07	9.69	16.45

Leeward Pressures

qz (psf)	Cp	External Pressure	Design Pressure (psf) (+GCpi)	(-GCpi)
10.0491	-0.34	-2.90	-6.28	0.48
10.9306	-0.34	-3.16	-6.54	0.22
11.6358	-0.34	-3.36	-6.74	0.02
12.3410	-0.34	-3.57	-6.95	-0.19
13.3988	-0.34	-3.87	-7.25	-0.49
14.2803	-0.34	-4.13	-7.51	-0.75
14.9855	-0.34	-4.33	-7.71	-0.95
15.6907	-0.34	-4.53	-7.91	-1.15
16.3959	-0.34	-4.74	-8.12	-1.36
16.9248	-0.34	-4.89	-8.27	-1.51
17.4537	-0.34	-5.04	-8.42	-1.66
18.3352	-0.34	-5.30	-8.68	-1.92
19.2167	-0.34	-5.55	-8.93	-2.17

Sidewall Pressures

qz (psf)	Cp	External Pressure	Design Pressure (psf) (+GCpi)	(-GCpi)
10.0491	-0.70	-5.98	-9.36	-2.60
10.9306	-0.70	-6.50	-9.88	-3.12
11.6358	-0.70	-6.92	-10.30	-3.54
12.3410	-0.70	-7.34	-10.72	-3.96
13.3988	-0.70	-7.97	-11.35	-4.59
14.2803	-0.70	-8.50	-11.88	-5.12
14.9855	-0.70	-8.92	-12.30	-5.54
15.6907	-0.70	-9.34	-12.72	-5.96
16.3959	-0.70	-9.76	-13.14	-6.38
16.9248	-0.70	-10.07	-13.45	-6.69
17.4537	-0.70	-10.38	-13.76	-7.01
18.3352	-0.70	-10.91	-14.29	-7.53
19.2167	-0.70	-11.43	-14.81	-8.05

Roof

qz (psf)	Cp	External Pressure	Design Pressure (psf) (+GCpi)	(-GCpi)
10.0491	-0.5	-4.27	-7.65	-0.89
10.9306	-0.5	-4.65	-8.03	-1.27
11.6358	-0.5	-4.95	-8.32	-1.57
12.3410	-0.5	-5.24	-8.62	-1.87
13.3988	-0.5	-5.69	-9.07	-2.31
14.2803	-0.5	-6.07	-9.45	-2.69
14.9855	-0.5	-6.37	-9.75	-2.99
15.6907	-0.5	-6.67	-10.05	-3.29
16.3959	-0.5	-6.97	-10.35	-3.59
16.9248	-0.5	-7.19	-10.57	-3.81
17.4537	-0.5	-7.42	-10.80	-4.04
18.3352	-0.5	-7.79	-11.17	-4.41
19.2167	-0.5	-8.17	-11.55	-4.79

Trial 2

Surface Type	Surface Designation	Surface	Distance from Windward Edge	L/B or h/L	Cp	External Pressure @ q = 130' (psf)
Walls	W2	WW	-	All	0.80	15.021
	W3	LW	-	0.56	-0.50	-9.388
	W1	Side	-	All	-0.70	-13.143
Roof			0 to h	0.34	-0.90	-16.898
			h to 2h	0.34	-0.50	-9.388
			> 2h	0.34	-0.30	-5.633

Windward Pressures *(same as Trial 1)*

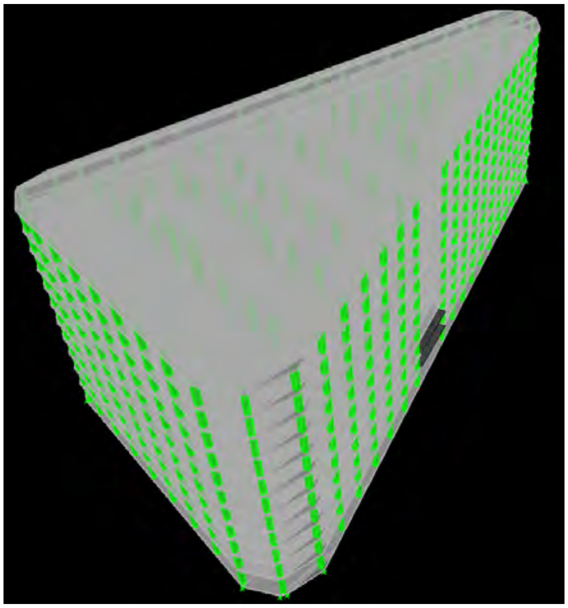
Leeward Pressures

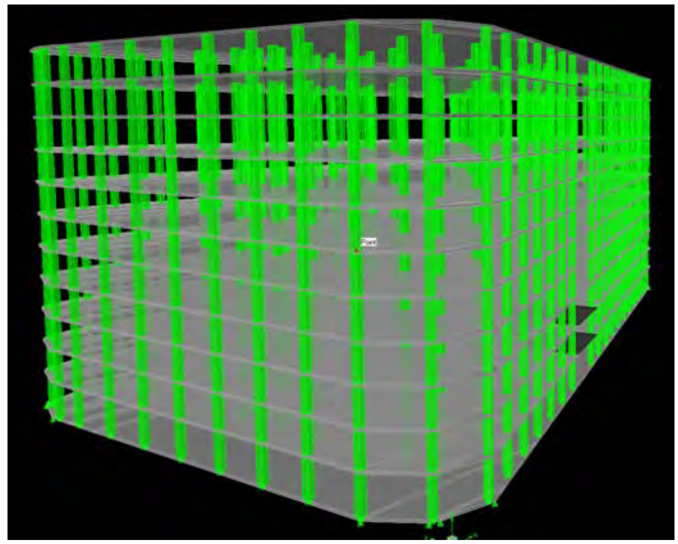
qz (psf)	Cp	External Pressure (psf)	Design Pressure (psf) (+GCpi)	(-GCpi)
10.0491	-0.5	-4.27	-7.65	-0.89
10.9306	-0.5	-4.65	-8.03	-1.27
11.6358	-0.5	-4.95	-8.32	-1.57
12.3410	-0.5	-5.24	-8.62	-1.87
13.3988	-0.5	-5.69	-9.07	-2.31
14.2803	-0.5	-6.07	-9.45	-2.69
14.9855	-0.5	-6.37	-9.75	-2.99
15.6907	-0.5	-6.67	-10.05	-3.29
16.3959	-0.5	-6.97	-10.35	-3.59
16.9248	-0.5	-7.19	-10.57	-3.81
17.4537	-0.5	-7.42	-10.80	-4.04
18.3352	-0.5	-7.79	-11.17	-4.41
19.2167	-0.5	-8.17	-11.55	-4.79

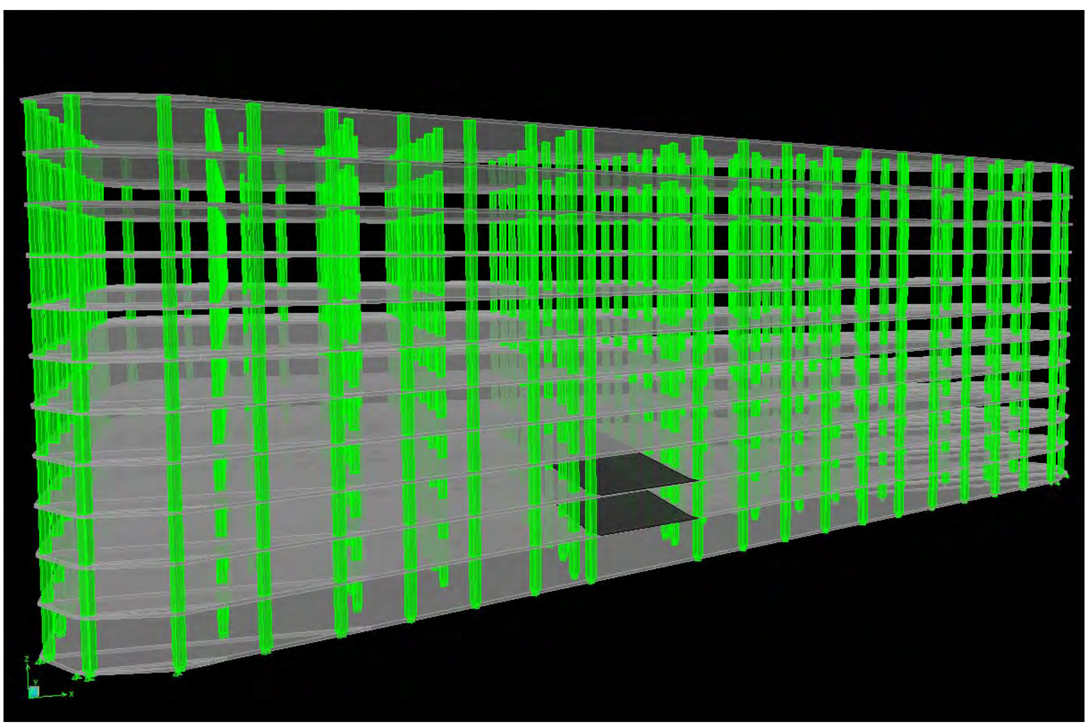
Sidewall Pressures *(same as Trial 1)*

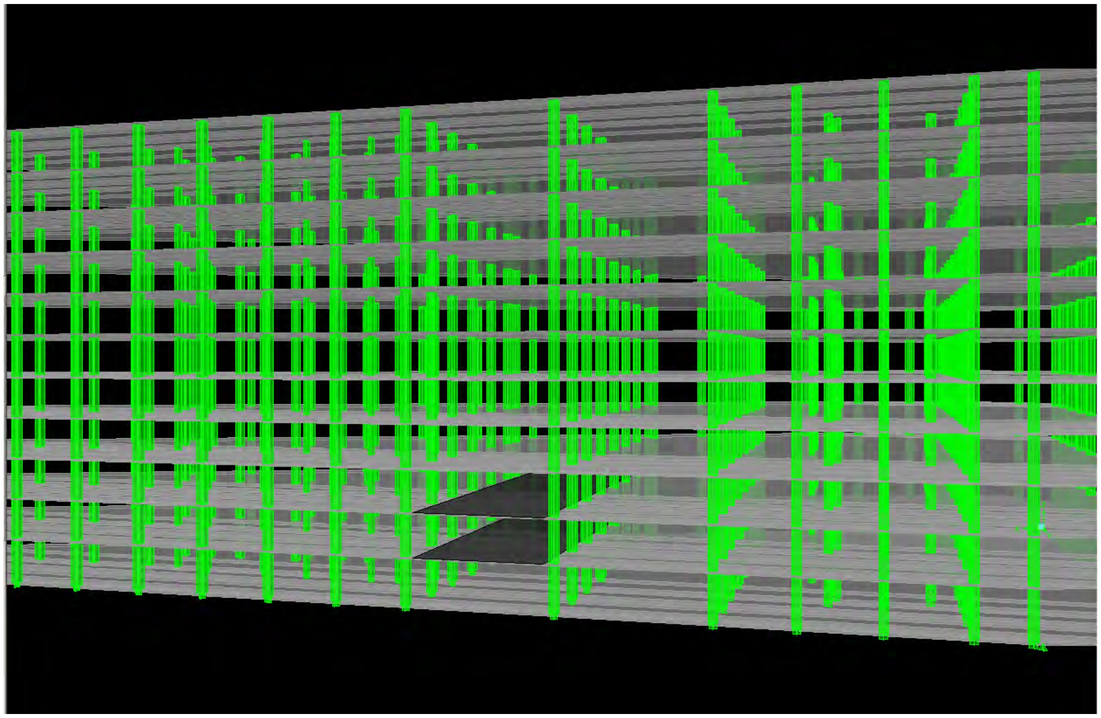
Roof *(same as Trial 1)*

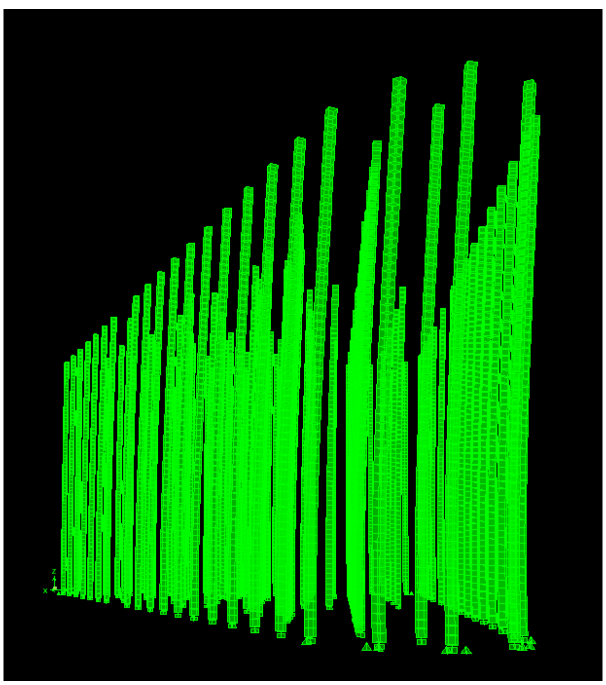
ETabs Renderings

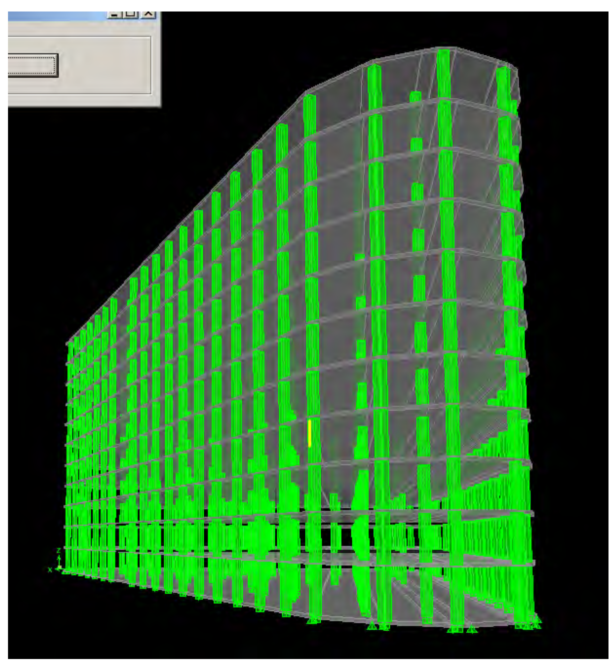


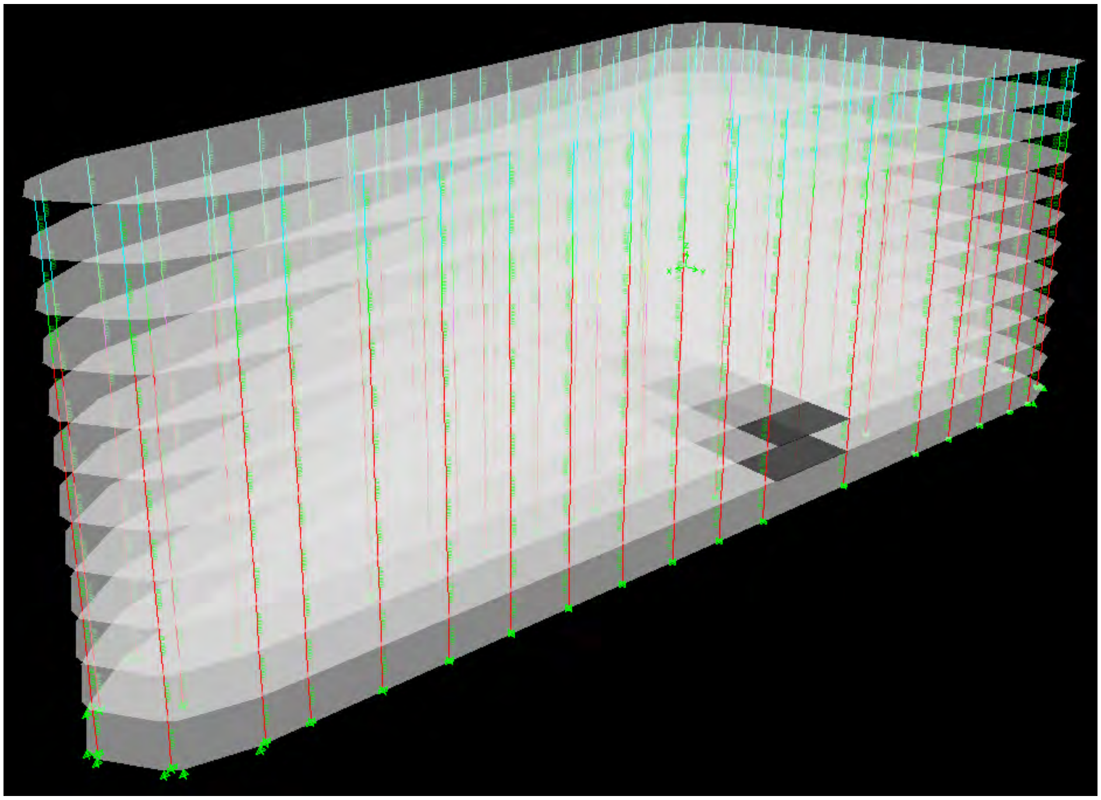


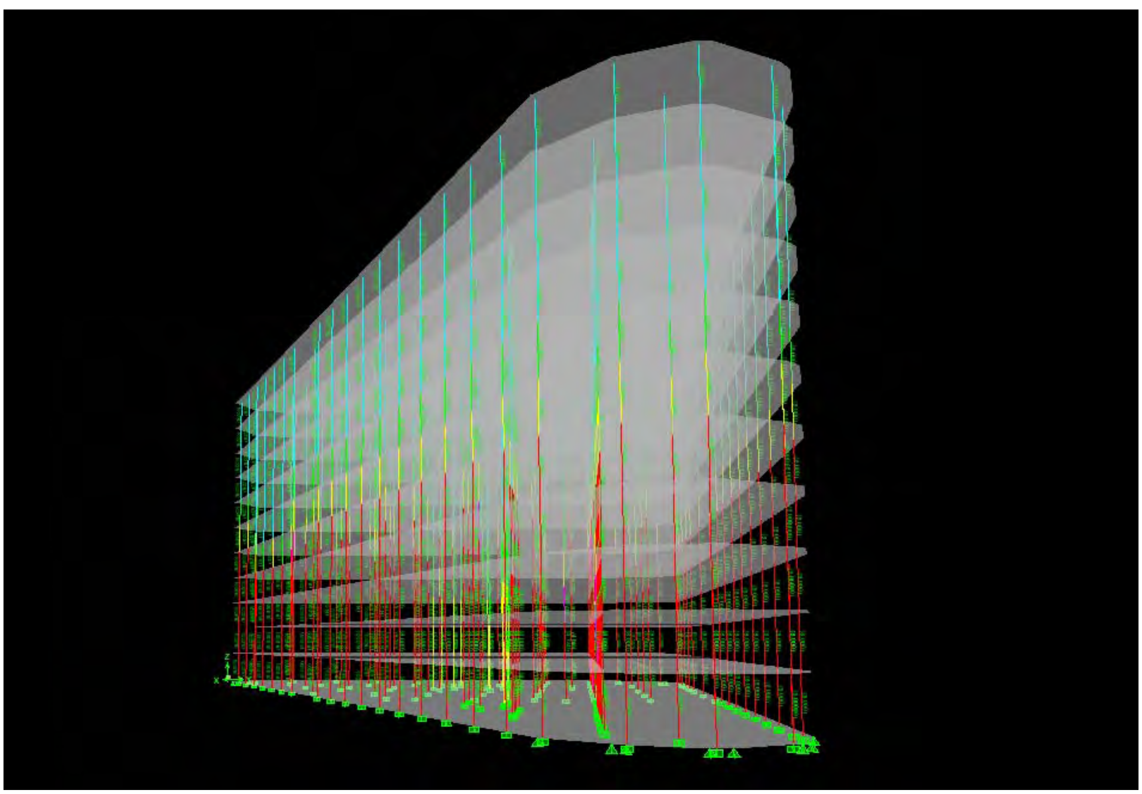












Story Drift Calculation Summary

Story	Item	Load	Point	X	Y	Z	DriftX	DriftY
STORY1	Max Drift X	14D	459	370.019	210.904	12.83	0	
STORY1	Max Drift Y	14D	459	370.019	210.904	12.83		0
STORY1	Max Drift X	12D16L	459	370.019	210.904	12.83	0	
STORY1	Max Drift Y	12D16L	459	370.019	210.904	12.83		0
STORY1	Max Drift X	12D08W	452	29.337	10.637	12.83	0.001004	
STORY1	Max Drift Y	12D08W	456	384.696	191.023	12.83		0.001088
STORY1	Max Drift X	12D16WL05E	452	29.337	10.637	12.83	0.004903	
STORY1	Max Drift Y	12D16WL05E	456	384.696	191.023	12.83		0.002196
STORY1	Max Drift X	12D10E10L	452	29.337	10.637	12.83	0.005791	
STORY1	Max Drift Y	12D10E10L	456	384.696	191.023	12.83		0.00004
STORY1	Max Drift X	09D10E	452	29.337	10.637	12.83	0.005791	
STORY1	Max Drift Y	09D10E	456	384.696	191.023	12.83		0.00004
STORY1	Max Drift X	09D16W	452	29.337	10.637	12.83	0.002008	
STORY1	Max Drift Y	09D16W	456	384.696	191.023	12.83		0.002176
STORY2	Max Drift X	14D	484	176.178	214.626	24.5	0	
STORY2	Max Drift Y	14D	484	176.178	214.626	24.5		0
STORY2	Max Drift X	12D16L	484	176.178	214.626	24.5	0	
STORY2	Max Drift Y	12D16L	484	176.178	214.626	24.5		0
STORY2	Max Drift X	12D08W	452	29.337	10.637	24.5	0.002703	
STORY2	Max Drift Y	12D08W	456	384.696	191.023	24.5		0.002964
STORY2	Max Drift X	12D16WL05E	452	29.337	10.637	24.5	0.013377	
STORY2	Max Drift Y	12D16WL05E	456	384.696	191.023	24.5		0.00599
STORY2	Max Drift X	12D10E10L	452	29.337	10.637	24.5	0.015941	
STORY2	Max Drift Y	12D10E10L	456	384.696	191.023	24.5		0.000126
STORY2	Max Drift X	09D10E	452	29.337	10.637	24.5	0.015941	
STORY2	Max Drift Y	09D10E	456	384.696	191.023	24.5		0.000126
STORY2	Max Drift X	09D16W	452	29.337	10.637	24.5	0.005407	
STORY2	Max Drift Y	09D16W	456	384.696	191.023	24.5		0.005927
STORY3	Max Drift X	14D	459	370.019	210.904	36.17	0	
STORY3	Max Drift Y	14D	459	370.019	210.904	36.17		0
STORY3	Max Drift X	12D16L	459	370.019	210.904	36.17	0	
STORY3	Max Drift Y	12D16L	459	370.019	210.904	36.17		0
STORY3	Max Drift X	12D08W	452	29.337	10.637	36.17	0.004054	
STORY3	Max Drift Y	12D08W	456	384.696	191.023	36.17		0.004465
STORY3	Max Drift X	12D16WL05E	452	29.337	10.637	36.17	0.020357	
STORY3	Max Drift Y	12D16WL05E	456	384.696	191.023	36.17		0.00902
STORY3	Max Drift X	12D10E10L	452	29.337	10.637	36.17	0.024499	
STORY3	Max Drift Y	12D10E10L	456	384.696	191.023	36.17		0.00018
STORY3	Max Drift X	09D10E	452	29.337	10.637	36.17	0.024499	
STORY3	Max Drift Y	09D10E	456	384.696	191.023	36.17		0.00018
STORY3	Max Drift X	09D16W	452	29.337	10.637	36.17	0.008107	
STORY3	Max Drift Y	09D16W	456	384.696	191.023	36.17		0.00893
STORY4	Max Drift X	14D	459	370.019	210.904	47.84	0	
STORY4	Max Drift Y	14D	459	370.019	210.904	47.84		0
STORY4	Max Drift X	12D16L	459	370.019	210.904	47.84	0	
STORY4	Max Drift Y	12D16L	459	370.019	210.904	47.84		0
STORY4	Max Drift X	12D08W	452	29.337	10.637	47.84	0.005149	
STORY4	Max Drift Y	12D08W	456	384.696	191.023	47.84		0.005686
STORY4	Max Drift X	12D16WL05E	452	29.337	10.637	47.84	0.026228	
STORY4	Max Drift Y	12D16WL05E	456	384.696	191.023	47.84		0.011472
STORY4	Max Drift X	12D10E10L	452	29.337	10.637	47.84	0.031857	
STORY4	Max Drift Y	12D10E10L	456	384.696	191.023	47.84		0.000198
STORY4	Max Drift X	09D10E	452	29.337	10.637	47.84	0.031857	
STORY4	Max Drift Y	09D10E	456	384.696	191.023	47.84		0.000198

STORY4	Max Drift X	09D16W	452	29.337	10.637	47.84	0.010299	
STORY4	Max Drift Y	09D16W	456	384.696	191.023	47.84		0.011373
STORY5	Max Drift X	14D	459	370.019	210.904	59.51	0	
STORY5	Max Drift Y	14D	459	370.019	210.904	59.51		0
STORY5	Max Drift X	12D16L	459	370.019	210.904	59.51	0	
STORY5	Max Drift Y	12D16L	459	370.019	210.904	59.51		0
STORY5	Max Drift X	12D08W	452	29.337	10.637	59.51	0.005992	
STORY5	Max Drift Y	12D08W	456	384.696	191.023	59.51		0.00664
STORY5	Max Drift X	12D16WL05E	452	29.337	10.637	59.51	0.030908	
STORY5	Max Drift Y	12D16WL05E	456	384.696	191.023	59.51		0.013389
STORY5	Max Drift X	12D10E10L	452	29.337	10.637	59.51	0.037847	
STORY5	Max Drift Y	12D10E10L	456	384.696	191.023	59.51		0.000218
STORY5	Max Drift X	09D10E	452	29.337	10.637	59.51	0.037847	
STORY5	Max Drift Y	09D10E	456	384.696	191.023	59.51		0.000218
STORY5	Max Drift X	09D16W	452	29.337	10.637	59.51	0.011984	
STORY5	Max Drift Y	09D16W	456	384.696	191.023	59.51		0.01328
STORY6	Max Drift X	14D	459	370.019	210.904	71.18	0	
STORY6	Max Drift Y	14D	459	370.019	210.904	71.18		0
STORY6	Max Drift X	12D16L	459	370.019	210.904	71.18	0	
STORY6	Max Drift Y	12D16L	459	370.019	210.904	71.18		0
STORY6	Max Drift X	12D08W	452	29.337	10.637	71.18	0.00661	
STORY6	Max Drift Y	12D08W	456	384.696	191.023	71.18		0.007349
STORY6	Max Drift X	12D16WL05E	452	29.337	10.637	71.18	0.034479	
STORY6	Max Drift Y	12D16WL05E	456	384.696	191.023	71.18		0.014816
STORY6	Max Drift X	12D10E10L	452	29.337	10.637	71.18	0.042518	
STORY6	Max Drift Y	12D10E10L	456	384.696	191.023	71.18		0.000237
STORY6	Max Drift X	09D10E	452	29.337	10.637	71.18	0.042518	
STORY6	Max Drift Y	09D10E	456	384.696	191.023	71.18		0.000237
STORY6	Max Drift X	09D16W	452	29.337	10.637	71.18	0.013219	
STORY6	Max Drift Y	09D16W	456	384.696	191.023	71.18		0.014697
STORY7	Max Drift X	14D	459	370.019	210.904	82.85	0	
STORY7	Max Drift Y	14D	459	370.019	210.904	82.85		0
STORY7	Max Drift X	12D16L	459	370.019	210.904	82.85	0	
STORY7	Max Drift Y	12D16L	459	370.019	210.904	82.85		0
STORY7	Max Drift X	12D08W	452	29.337	10.637	82.85	0.007038	
STORY7	Max Drift Y	12D08W	456	384.696	191.023	82.85		0.007842
STORY7	Max Drift X	12D16WL05E	452	29.337	10.637	82.85	0.037082	
STORY7	Max Drift Y	12D16WL05E	456	384.696	191.023	82.85		0.015806
STORY7	Max Drift X	12D10E10L	452	29.337	10.637	82.85	0.046012	
STORY7	Max Drift Y	12D10E10L	456	384.696	191.023	82.85		0.000247
STORY7	Max Drift X	09D10E	452	29.337	10.637	82.85	0.046012	
STORY7	Max Drift Y	09D10E	456	384.696	191.023	82.85		0.000247
STORY7	Max Drift X	09D16W	452	29.337	10.637	82.85	0.014076	
STORY7	Max Drift Y	09D16W	456	384.696	191.023	82.85		0.015683
STORY8	Max Drift X	14D	459	370.019	210.904	94.52	0	
STORY8	Max Drift Y	14D	459	370.019	210.904	94.52		0
STORY8	Max Drift X	12D16L	459	370.019	210.904	94.52	0	
STORY8	Max Drift Y	12D16L	459	370.019	210.904	94.52		0
STORY8	Max Drift X	12D08W	452	29.337	10.637	94.52	0.007309	
STORY8	Max Drift Y	12D08W	456	384.696	191.023	94.52		0.008152
STORY8	Max Drift X	12D16WL05E	452	29.337	10.637	94.52	0.038837	
STORY8	Max Drift Y	12D16WL05E	456	384.696	191.023	94.52		0.016429
STORY8	Max Drift X	12D10E10L	452	29.337	10.637	94.52	0.048439	
STORY8	Max Drift Y	12D10E10L	456	384.696	191.023	94.52		0.00025
STORY8	Max Drift X	09D10E	452	29.337	10.637	94.52	0.048439	
STORY8	Max Drift Y	09D10E	456	384.696	191.023	94.52		0.00025
STORY8	Max Drift X	09D16W	452	29.337	10.637	94.52	0.014618	

STORY8	Max Drift Y	09D16W	456	384.696	191.023	94.52		0.016304
STORY9	Max Drift X	14D	459	370.019	210.904	106.19	0	
STORY9	Max Drift Y	14D	459	370.019	210.904	106.19		0
STORY9	Max Drift X	12D16L	459	370.019	210.904	106.19	0	
STORY9	Max Drift Y	12D16L	459	370.019	210.904	106.19		0
STORY9	Max Drift X	12D08W	452	29.337	10.637	106.19	0.007456	
STORY9	Max Drift Y	12D08W	456	384.696	191.023	106.19		0.008319
STORY9	Max Drift X	12D16WL05E	452	29.337	10.637	106.19	0.039883	
STORY9	Max Drift Y	12D16WL05E	456	384.696	191.023	106.19		0.016764
STORY9	Max Drift X	12D10E10L	452	29.337	10.637	106.19	0.049941	
STORY9	Max Drift Y	12D10E10L	456	384.696	191.023	106.19		0.000252
STORY9	Max Drift X	09D10E	452	29.337	10.637	106.19	0.049941	
STORY9	Max Drift Y	09D10E	456	384.696	191.023	106.19		0.000252
STORY9	Max Drift X	09D16W	452	29.337	10.637	106.19	0.014912	
STORY9	Max Drift Y	09D16W	456	384.696	191.023	106.19		0.016638
STORY10	Max Drift X	14D	459	370.019	210.904	117.86	0	
STORY10	Max Drift Y	14D	459	370.019	210.904	117.86		0
STORY10	Max Drift X	12D16L	459	370.019	210.904	117.86	0	
STORY10	Max Drift Y	12D16L	459	370.019	210.904	117.86		0
STORY10	Max Drift X	12D08W	452	29.337	10.637	117.86	0.007518	
STORY10	Max Drift Y	12D08W	456	384.696	191.023	117.86		0.008385
STORY10	Max Drift X	12D16WL05E	452	29.337	10.637	117.86	0.040394	
STORY10	Max Drift Y	12D16WL05E	456	384.696	191.023	117.86		0.016897
STORY10	Max Drift X	12D10E10L	452	29.337	10.637	117.86	0.050718	
STORY10	Max Drift Y	12D10E10L	456	384.696	191.023	117.86		0.000254
STORY10	Max Drift X	09D10E	452	29.337	10.637	117.86	0.050718	
STORY10	Max Drift Y	09D10E	456	384.696	191.023	117.86		0.000254
STORY10	Max Drift X	09D16W	452	29.337	10.637	117.86	0.015035	
STORY10	Max Drift Y	09D16W	456	384.696	191.023	117.86		0.01677
STORY11	Max Drift X	14D	459	370.019	210.904	130	0	
STORY11	Max Drift Y	14D	459	370.019	210.904	130		0
STORY11	Max Drift X	12D16L	459	370.019	210.904	130	0	
STORY11	Max Drift Y	12D16L	459	370.019	210.904	130		0
STORY11	Max Drift X	12D08W	452	29.337	10.637	130	0.007532	
STORY11	Max Drift Y	12D08W	456	384.696	191.023	130		0.008398
STORY11	Max Drift X	12D16WL05E	452	29.337	10.637	130	0.040568	
STORY11	Max Drift Y	12D16WL05E	456	384.696	191.023	130		0.016923
STORY11	Max Drift X	12D10E10L	452	29.337	10.637	130	0.051007	
STORY11	Max Drift Y	12D10E10L	456	384.696	191.023	130		0.000254
STORY11	Max Drift X	09D10E	452	29.337	10.637	130	0.051007	
STORY11	Max Drift Y	09D10E	456	384.696	191.023	130		0.000254
STORY11	Max Drift X	09D16W	452	29.337	10.637	130	0.015064	
STORY11	Max Drift Y	09D16W	456	384.696	191.023	130		0.016796