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November 21, 2005

Structural Technical Report #3: Lateral System Analysis and Confirmation Design

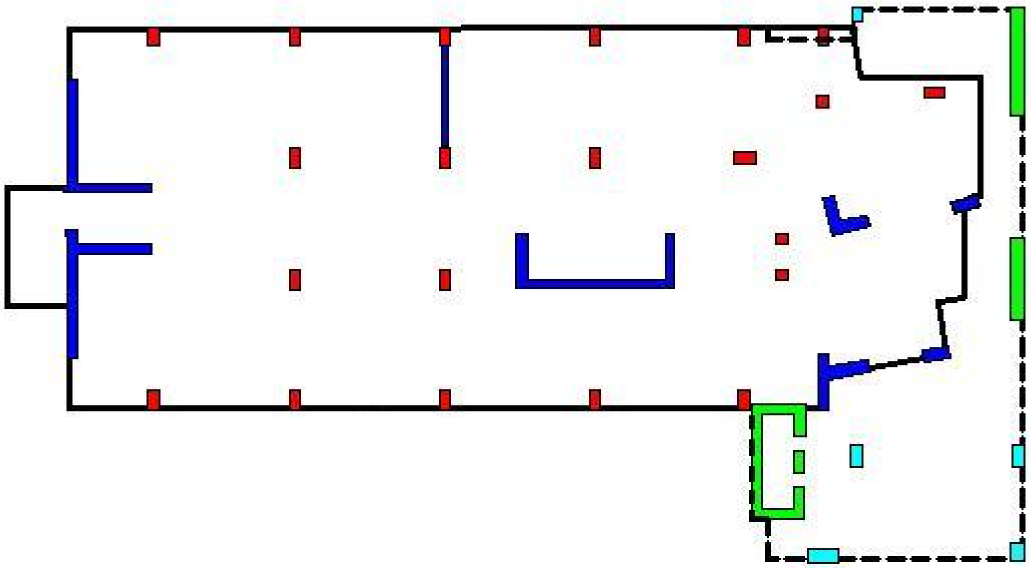
Executive Summary

This report provides a more in-depth analysis of the lateral system of the River Tower at Christina Landing than produced in previous technical reports. The River Tower is part of the latest phase of redevelopment along the banks of the Christina River in Wilmington, DE. The redevelopment site consists of luxury townhouses, a 22-story apartment building, and will now add the River Tower, a 25-story condominium tower. The River Tower's structural system consists of a slab-on-grade structural slab and 8" post-tensioned floor slabs with reinforced concrete columns for gravity load support.

This report again uses the loading information obtained from reference to the BOCA 1996 Building Code from previous technical assignments. In this report, the lateral system of the River Tower is specifically highlighted. The River Tower's main lateral resistance is provided by reinforced concrete shear walls located mainly around the perimeter of the central elevator shaft and also at the western walls of the tower. For a site in Wilmington, DE, wind provides the primary lateral loading, and this fact is confirmed in the following calculations. For the purpose of simplification, lateral loading was considered for six sections of this 25 story building, the top five floors and every four floors beneath. The report that follows contains an introduction to the overall structural system for the River Tower, followed by the results of lateral loading (both wind and seismic) calculations. Critical shear wall strength checks, drift calculations, and overturning considerations also are provided in this analysis.

The drift and overturning calculations yielded favorable and acceptable results, while the strength check calculations were not successful. Reasons for this failure of the shear walls in flexure negate the generalized assumptions of this report. Factors not considered in the scope of this analysis are the lateral resistance of the columns, which may provide additional stiffness based on their orientation in the floor plans. The post-tensioned concrete flat plate system at each floor also provides lateral stiffness for the River Tower. The self weight and other gravity loading of the structure provide enough axial force on the shear walls to stiffen each shear wall through compression.

Introduction to the Lateral System



<u>Simplified Building Schematic for Typical Floor (Levels 9 through 22):</u>

Key:
- *- Tower Columns* (red)
- *- Tower Shear Walls* (blue)
- *- Parking Garage Columns* (cyan)
- *- Parking Garage Shear Walls* (green)

Solid Lines: Tower Perimeter (whole building)
Dashed Line: Parking Garage Levels
(Foundation Level to Eighth Floor)

The River Tower at Christina Landing uses reinforced concrete shear walls as its lateral resistance. Naturally, the most amount of lateral resistance is provided on the lower levels, where the lateral forces are the greatest. There additional shear walls are located on the lower parking garage levels (the lower eight levels of the building), mostly near elevator and stairwell openings and the eastern walls, as shown in the diagram above. The shear walls located in the condominium tower, which stands the full 25 stories of the building, are relatively consistent in location and size, with occasional openings left for stairwells, elevators, and other architectural features. The thickness of these common stairwells is relatively consistent, although the concrete strength for the shared parking garage/condominium levels (foundation to eighth floors) of this tower is 6000 psi. From the ninth to 25^{th} floors, the concrete strength for the tower shear walls decreases to 5000 psi. Included below is the Concrete Shear Wall schedule from drawing sheet S200, provided by O'Donnell & Naccarato, Inc., the structural engineer on the project.

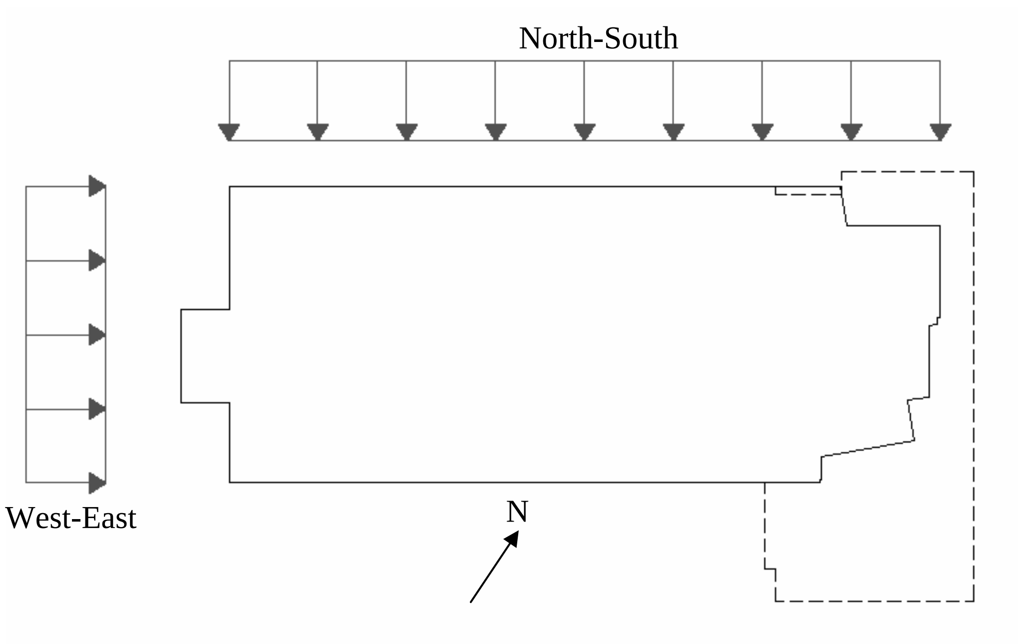
CONCRETE SHEAR WALL SCHEDULE													
LEVEL \ MARK		SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8	SW9	SW10	SW11	SW12
15TH - ROOF	VERT. STL.	#4 @ 12	#8 @ 8	#6 @ 12	(22) #9	#7 @ 12	#9 @ 12	#9 @ 12	(18) #9	#7 @ 12	-	#9 @ 12	-
	HORIZ. STL.	#4 @ 12	#4 @ 12	#4 @ 14	#4 @ 12	#4 @ 12	#4 @ 12	#4 @ 12	#4 @ 12	#4 @ 12	-	#4 @ 12	-
	f'c	5000	5000	5000	5000	5000	5000	5000	5000	5000	-	5000	-
	THICKNESS	16	12	9	12	12	12	12	12	12	-	12	-
8TH - 15TH	VERT. STL.	#5 @ 12	#10 @ 8	#11 @ 10	(22) #11	#9 @ 12	#11 @ 8	#11 @ 8	(18) #11	#9 @ 12	-	#11 @ 8	-
	HORIZ. STL.	#4 @ 12	#4 @ 12	#4 @ 14	#4 @ 12	#4 @ 12	#4 @ 12	#4 @ 12	#4 @ 12	#4 @ 12	-	#4 @ 12	-
	f'c	5000	5000	5000	5000	5000	5000	5000	5000	5000	-	5000	-
	THICKNESS	16	12	9	12	12	12	12	12	12	-	12	-
FND. - 8TH	VERT. STL.	SEE DETAIL SW1/S200	#10 @ 8	#11 @ 11	(22) #11	#9 @ 12	#11 @ 8	#11 @ 8	(18) #11	#9 @ 12	#14 @ 13	#11 @ 8	#14 @ 13
	HORIZ. STL.		#4 @ 12	#4 @ 14	#4 @ 12	#4 @ 12	#4 @ 10	#4 @ 10	#4 @ 12	#4 @ 12	#5 @ 10	#4 @ 12	#5 @ 10
	f'c	6000	6000	6000	6000	6000	6000	6000	6000	6000	5000	6000	5000
	THICKNESS	16	12	9	12	12	12	12	12	12	24	12	24

Concrete Shear Wall Schedule from Sheet S200, Courtesy of O'Donnell & Naccarato

The parking garage areas are similar to the condominium tower in that reinforced concrete shear walls provide the lateral resistance. The main structural system for the parking garage is a light precast concrete wall system with precast columns. The floor system consists of a pre-topped tee beam system. The roof level uses steel framing as its structural system, with moment connections. For the purposes of simplification, only the condominium tower and parking garage was analyzed in the following lateral analysis, considering each concrete shear wall individually.

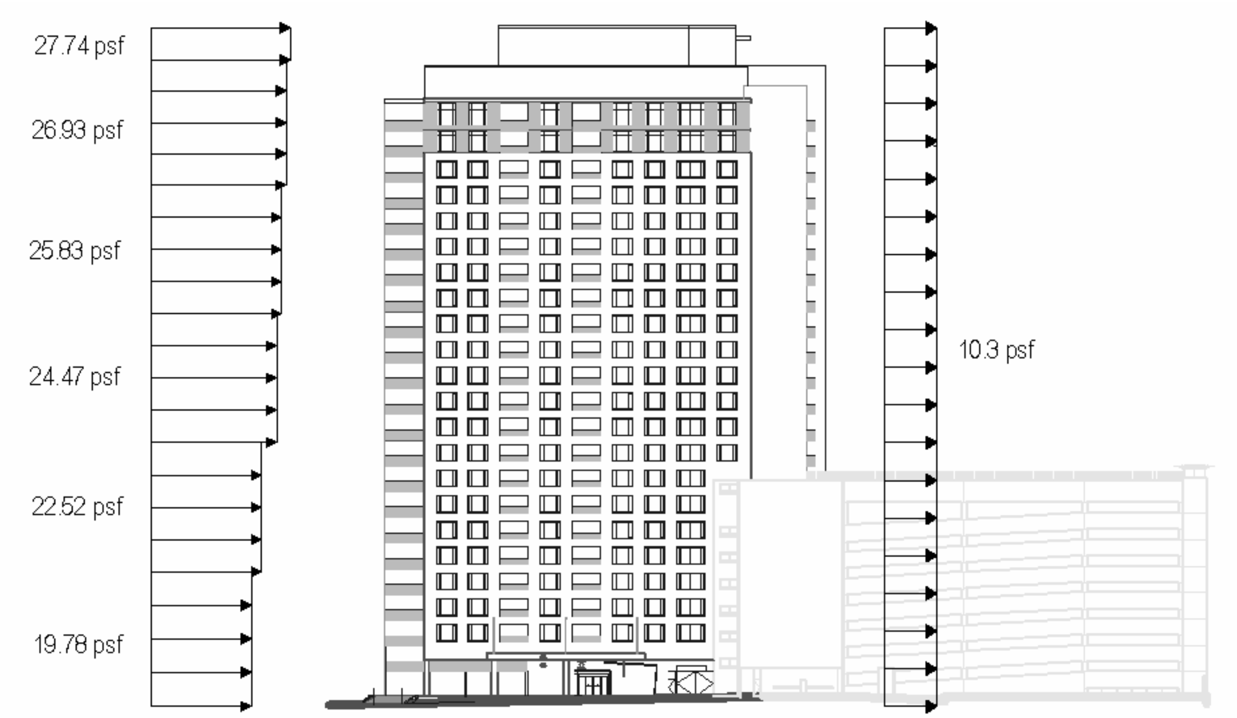
Wind Loading Criteria

- <u>Wind Importance Factor:</u> 1.04
- <u>Wind Exposure:</u> C
- <u>Components and Cladding Loads:</u> vary per code requirements
- Load Diagrams with results provided on next page
- Please consult Appendix B for detailed Wind Load Calculations

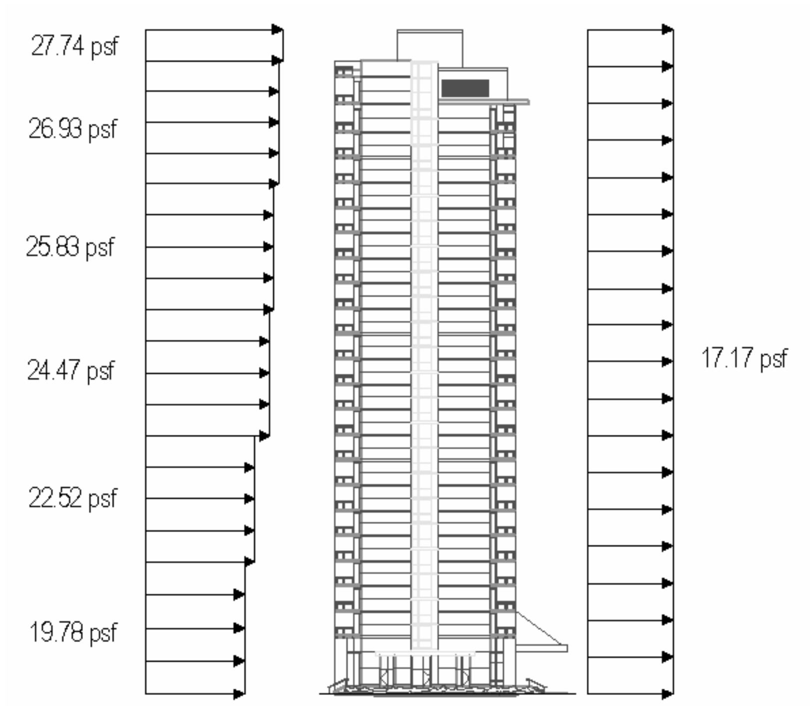


<u>Wind Direction Schematic</u>:
Condominium Tower shown in solid line;
Parking garage floors in dashed line

When compared to the seismic loading results, the wind loading controlled as the primary source of lateral loading. This is to be expected, as the site of the building is in Wilmington, DE and along the riverfront. This riverfront location provides the reasoning behind the choosing of Wind Exposure category “C,” which differs from the information on the project’s Structural Narrative. This, however, provides larger loads and therefore, a more conservative analysis of the lateral system. Diagrams of the wind pressures in both major directions of the building are provided on the next page.



Wind Pressures (psf) in West-East Direction



Wind Pressures (psf) in North-South Direction

Seismic Loading Criteria

- Seismic Importance Factor: 1.0
- A_v (Velocity related acceleration coefficient) = 0.075
- A_a (Peak acceleration coefficient) = 0.05
- Seismic Design Category: B
- Basic Seismic Force Resisting System: Dual system with shear wall and intermediate concrete frame
- Response Modification Factor, R = 6
- Site Coefficient, S_4 = 2.0
- Analysis Procedure Used: Equivalent Force Method
- Base Shear = V = 849.73 kips
- *Please see Appendix C for detailed Seismic Load Calculations and results*

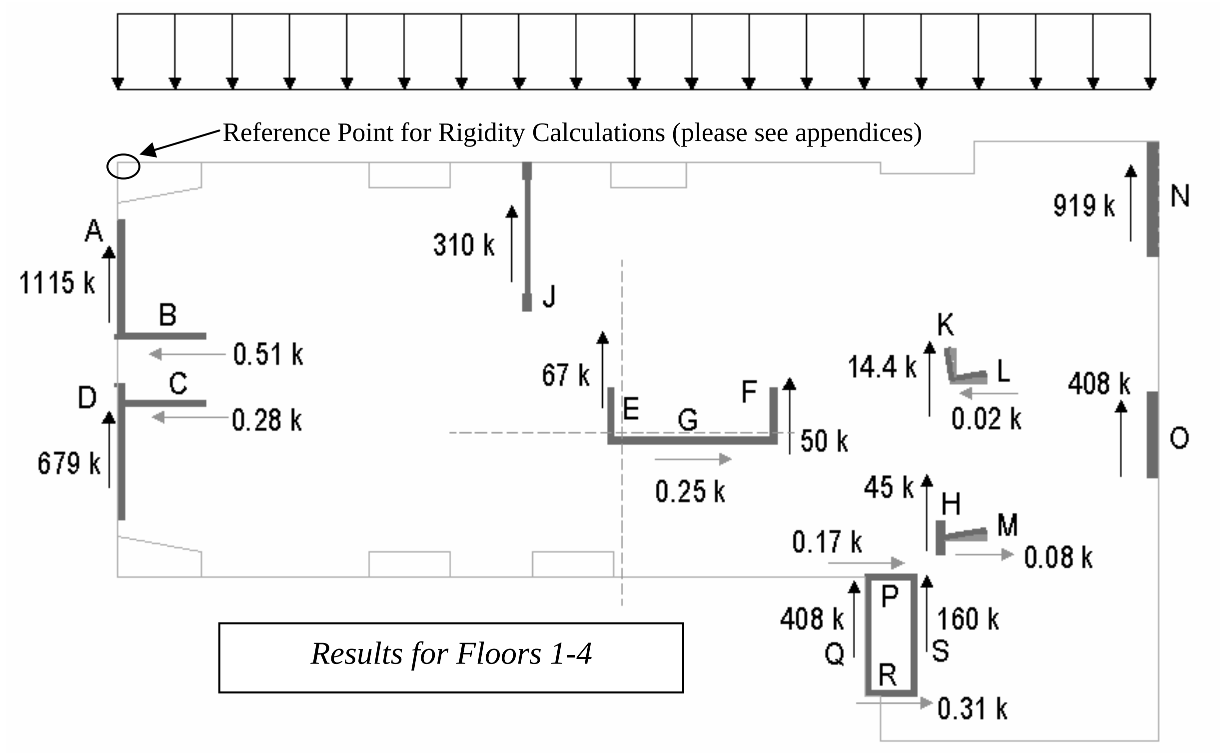
Due to the magnitude of the wind loading, seismic loading was not considered in the lateral resistance calculations. The results of the seismic loading criteria are given in Appendix C for comparative purposes, and also relate to the story drift calculations.

Lateral Resistance Calculations

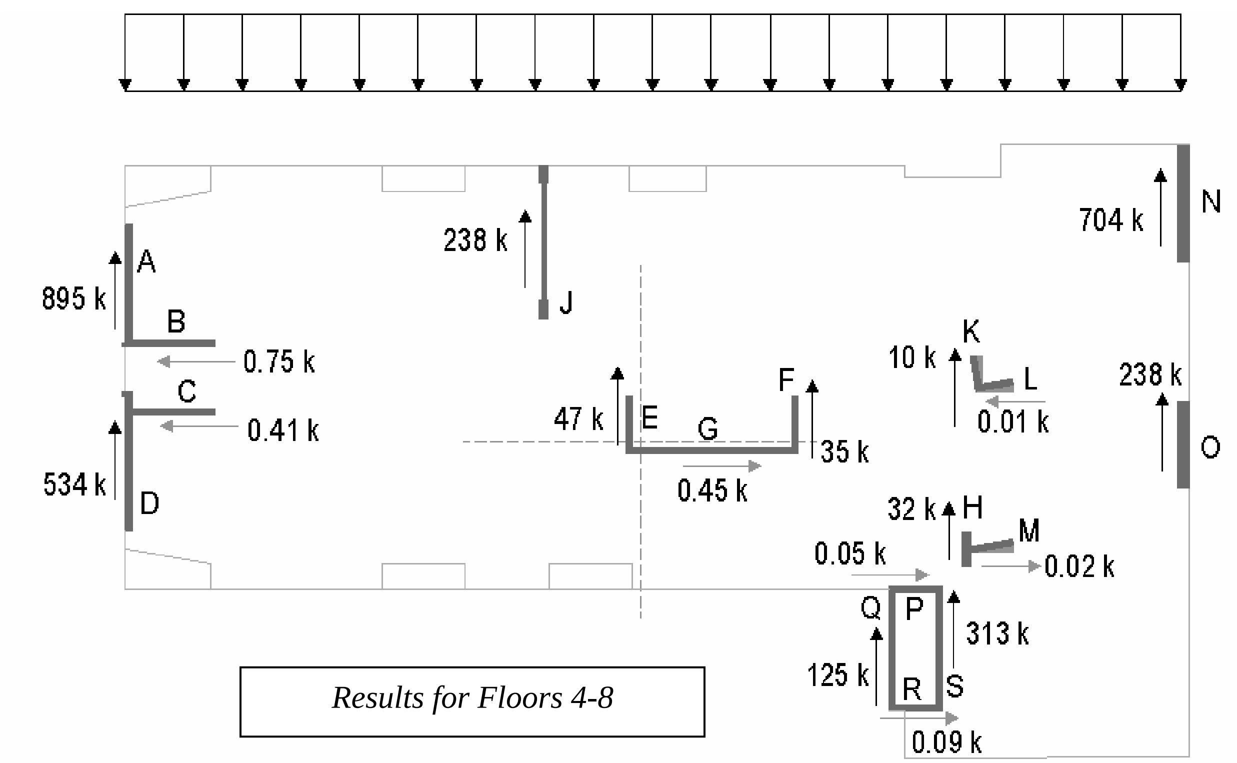
Analyzing the shear wall system for such a tall building can be a complicated task. Therefore, rather than consider each of the 25 floors individually, the building was simplified due to the relatively consistent layout of the shear wall system. The floors were divided into six approximate sections, consisting of 4 floors each. The lone exception concerns the top five floors, and the roof was not considered in this analysis since it does not contain shear walls and relies on steel framing for lateral resistance. The parking garage of the River Tower makes up the lower eight floors of the structure, and the remaining floors consist of the condominium tower, which accounts for the change in building footprint in these diagrams. The wind pressures were averaged for each floor of these generalized six sections of the building. Each shearwall was also considered a separate entity from each other, even though there are mostly combined shapes on the actual floor plan layout. Small openings in the shear walls, shorter sections of shear walls, and other inconsistencies between levels were not included in this analysis as these would not sufficiently affect the distribution of the lateral forces.

On the next page, net results of the distribution by rigidity method of the shear walls, shown for each of the six groups of floors. These values are the total shear forces on the wall, both concentric and eccentric forces combined with respect to their directions. For more detailed calculations and explanations, please consult Appendices D and E for each respective wind direction. The center of rigidity for each system is shown. In the instance of walls K and L, which were rotated 10 degrees from the normal plane; this rotation was neglected for this report since the shear walls in question were very short in length. Both the actual placement and the generalized arrangement used for analysis are both shown in the following diagrams.

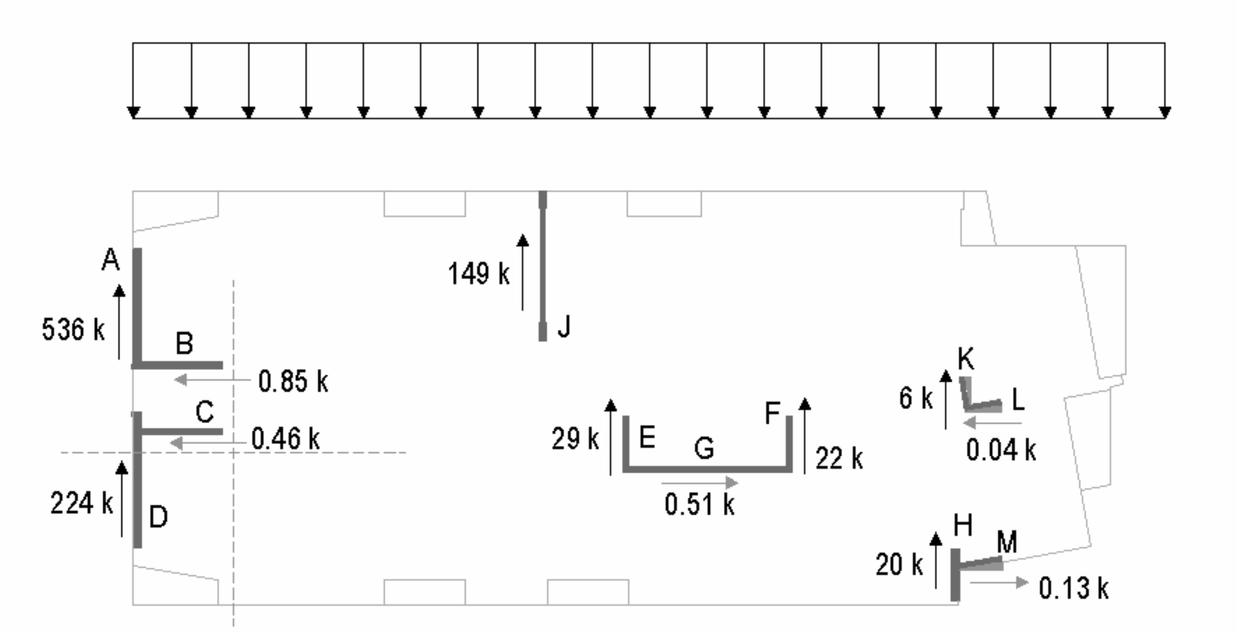
Results for the North-South Wind Direction



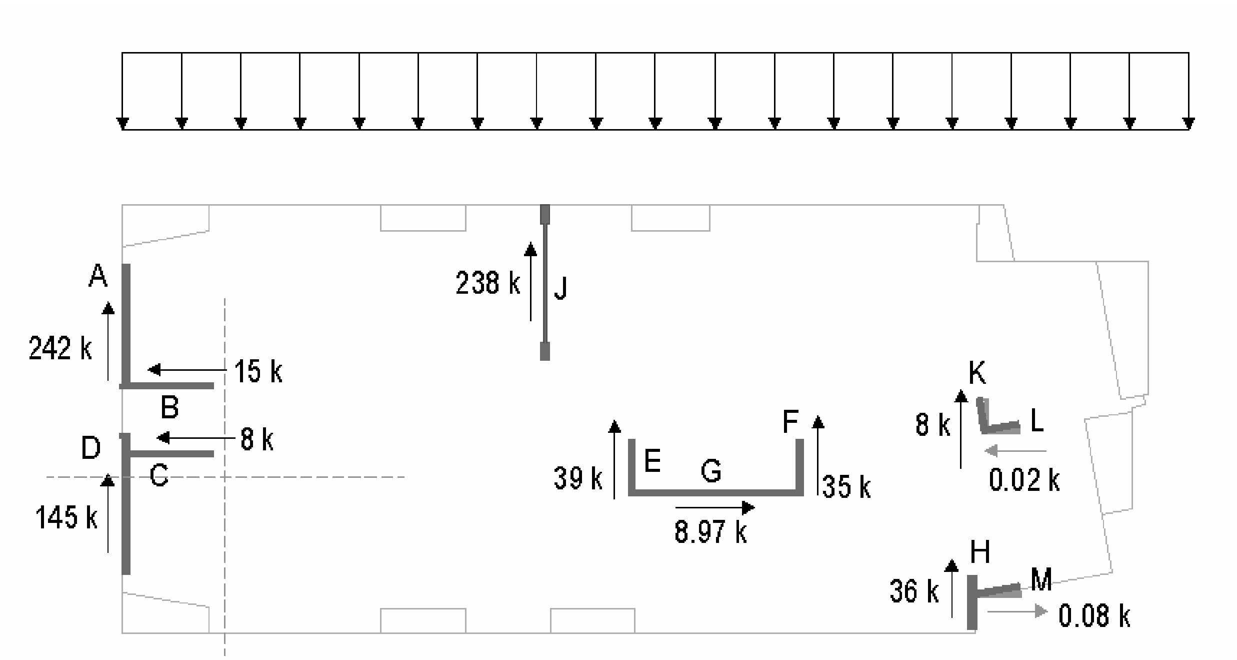
Results for Floors 1-4



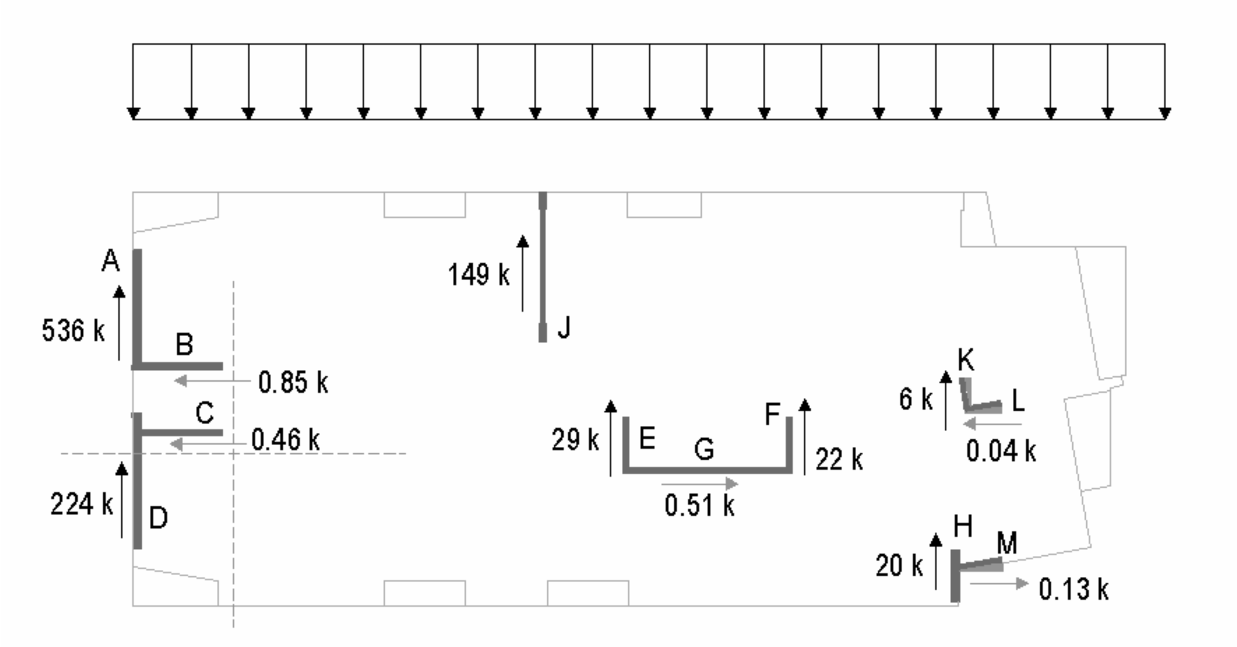
Results for Floors 4-8



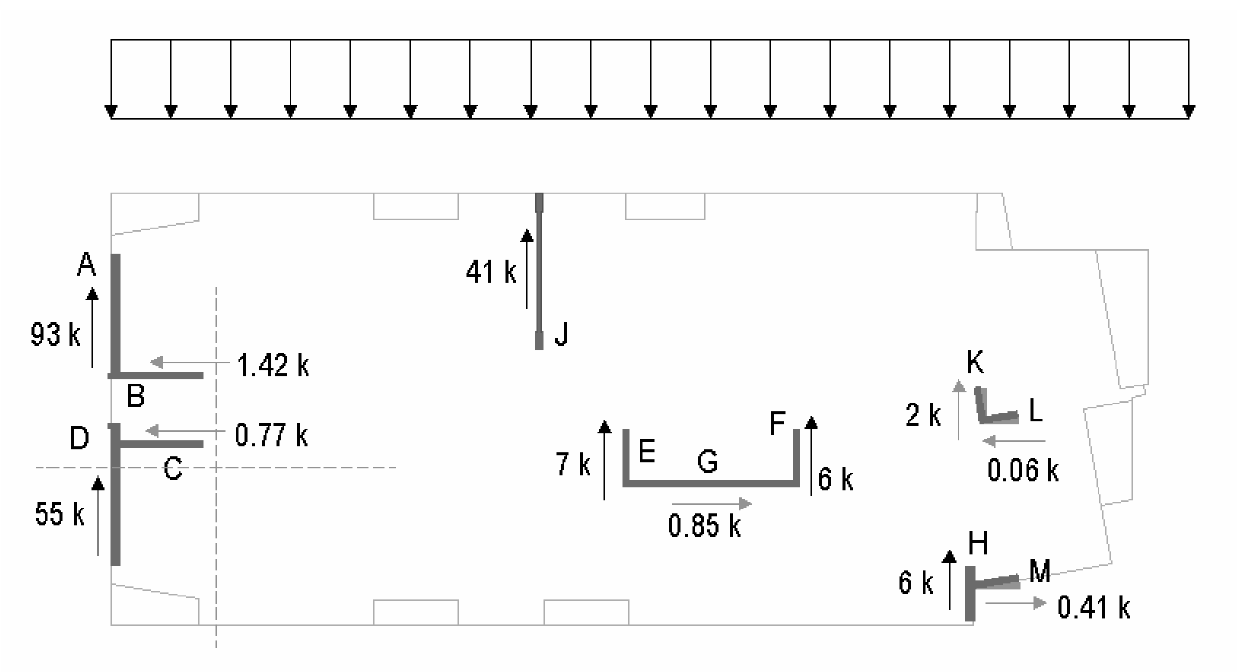
Results for Floors 9-12



Results for Floors 13-16

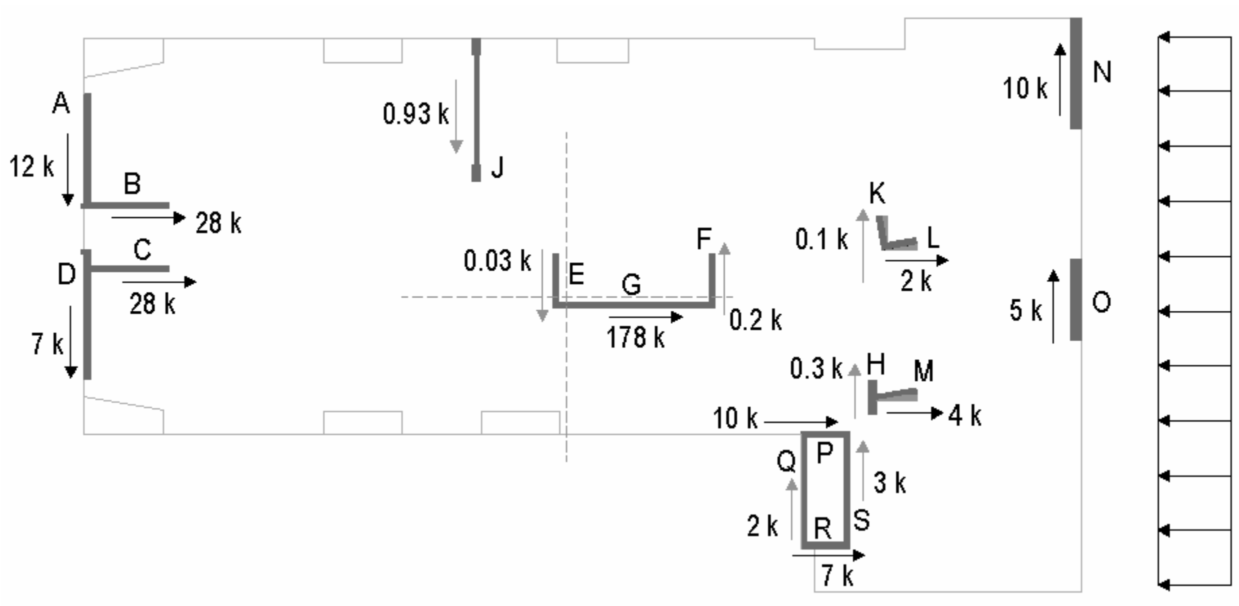


Results for Floors 17-20

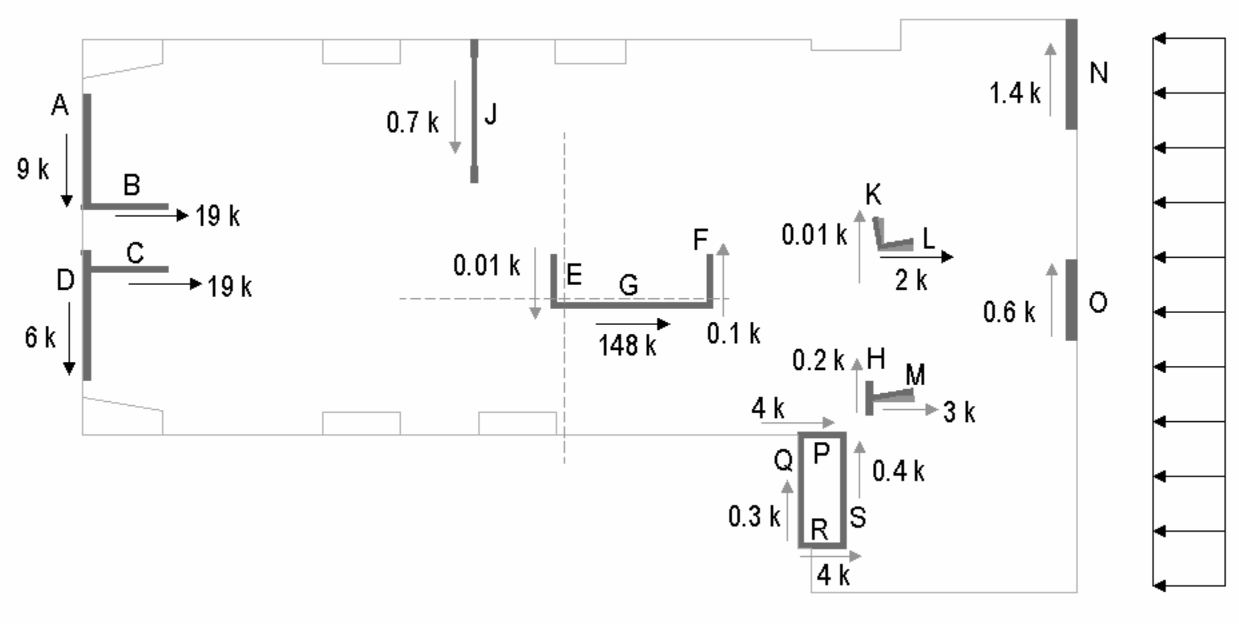


Results for Floors 21-25

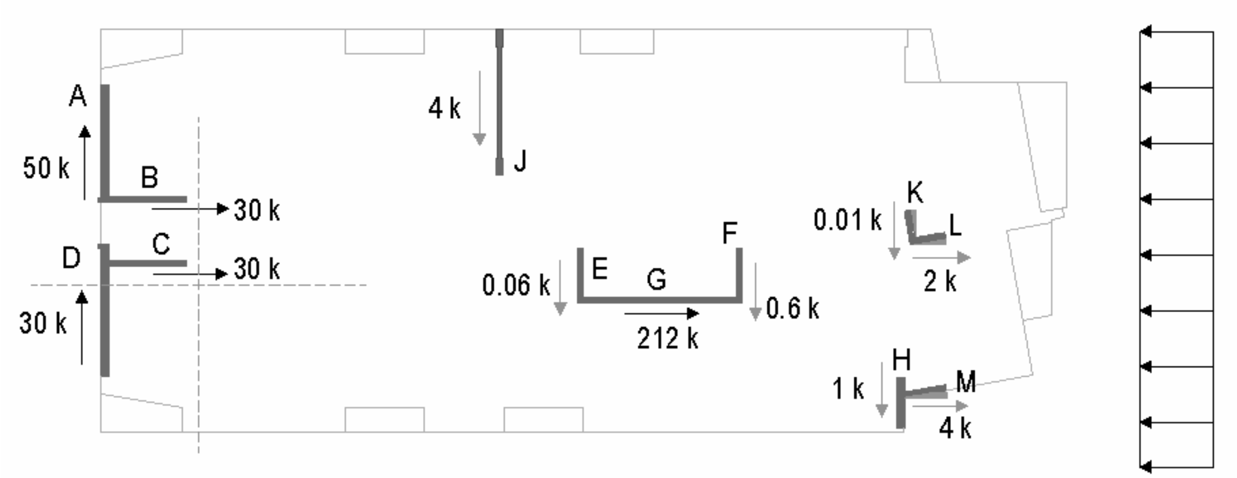
Results for West-East Wind Direction



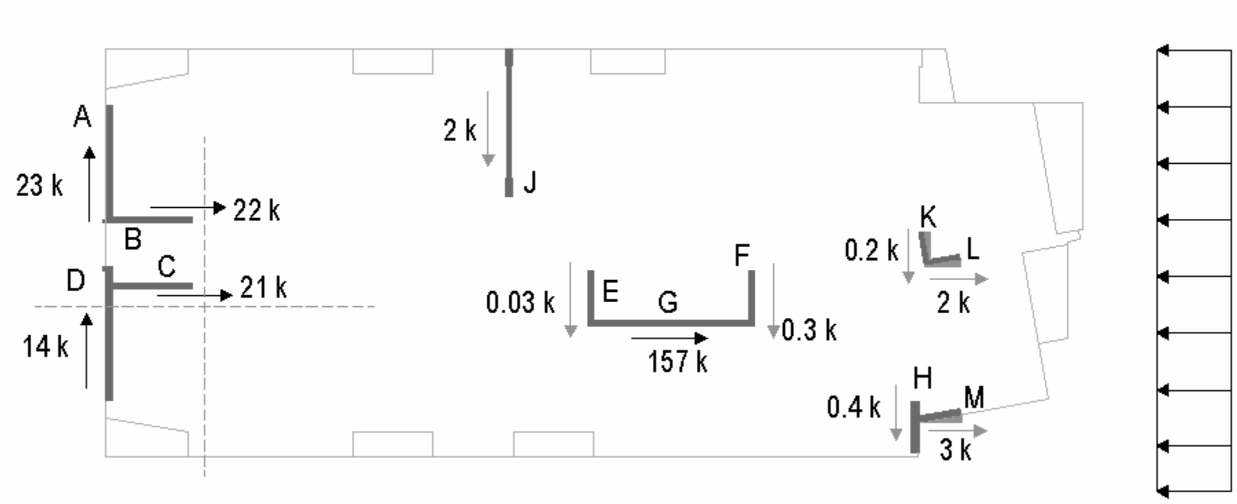
Results for Floors 1-4



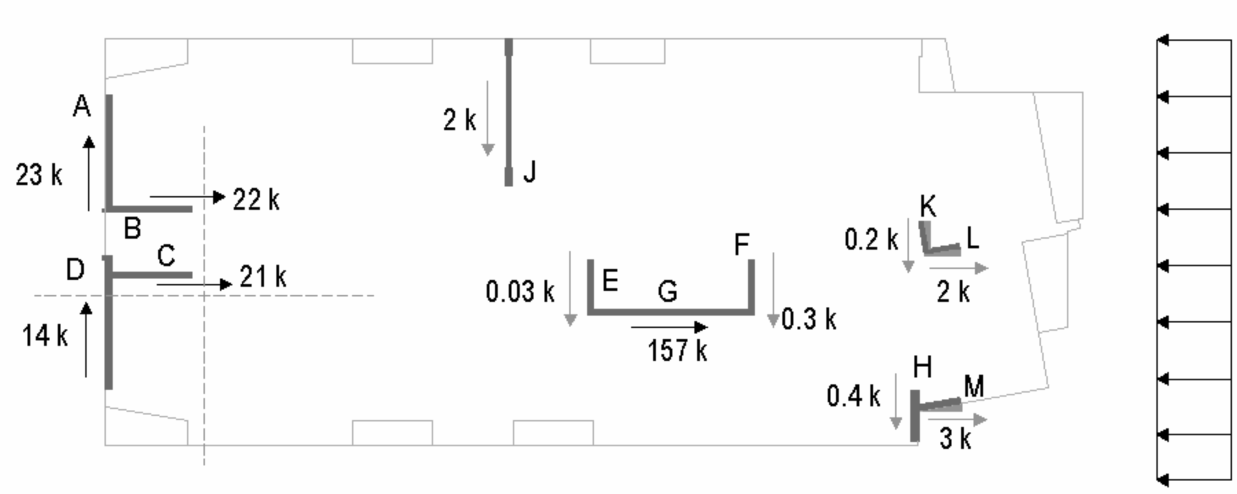
Results for Floors 5-8



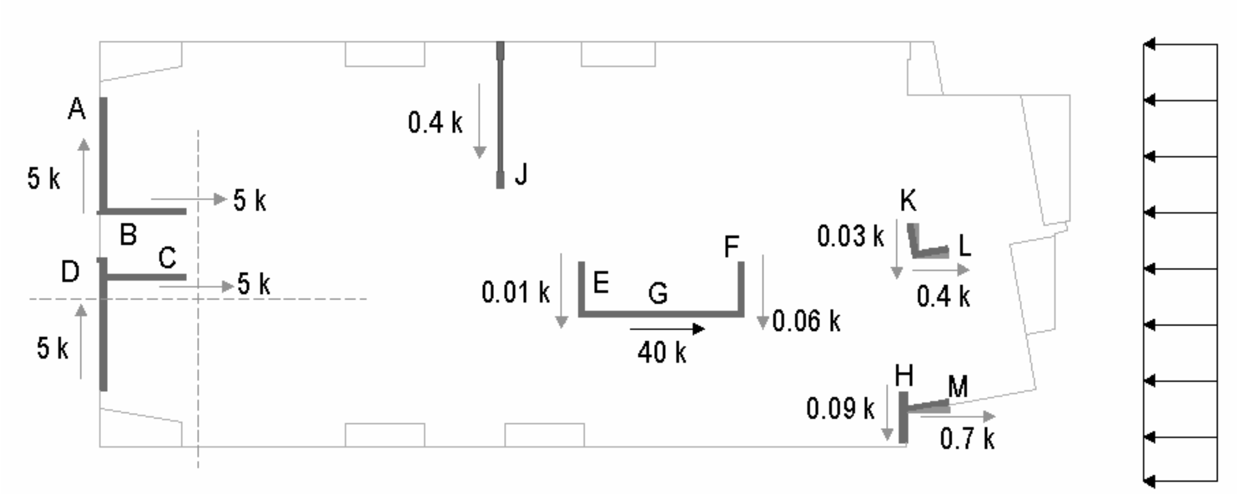
Results for Floors 9-12



Results for Floors 13-16



Results for Floors 17-20



Results for Floors 20-25

Strength Check

The reinforced concrete columns were judged to be only gravity load-carrying, and likewise, gravity loads were not considered in this shear wall analysis. To approximate the legitimacy of the reinforcement chosen for these reinforced concrete shear walls, these walls were likened to a very thin, deep beam cantilevered from the base of the building, spanning the full height of the building. This approximate analysis provides a credible solution for hand calculations. In future reports, this system will be more accurately modeled using computer software, most likely *ETABS*.

Based on this initial strength check of the most critical shear walls for each wind direction, it appears that the axial loading needs to be considered when analyzing these shear walls as cantilevered deep beams. In the most extreme shear cases, such as Wall A and D in the N-S wind case, shear strength checks did not pass. This area of study will be covered in more detail in future reports. Please consult Appendix F for more detailed calculations and information.

Drift and Story Drift Check

The River Tower meets BOCA 1996 restrictions on story drift in all of its floors, even in this generalized analysis. The shear wall drift values, based on the height of the walls, yielded small values (less than one inch) in most cases, except for the extreme shear cases. Because of the basic concrete nature of the entire building, essentially a very tall and wide shear wall, the actual story drift was approximated using the deflection criteria for shear walls. This approximation yielded values much smaller than that of the allowable drift, ensuring its legitimacy. Please consult Appendix G for more detailed calculations and information.

Overturning Effects

Because the River Tower contains mostly 25 floors of concrete slabs, shear walls, and columns, its significant weight counteracts any possible overturning effect of the wind. Appendix H provides calculations to support this claim. The maximum overturning moment caused by lateral loads, caused by the controlling case, the N-S wind loading, is 295172.2 kip-ft. This moment distributed over the span in the North-South direction still does not compare to an overall building weight of 54470 kips, so overturning effects are sufficiently accounted for in this design and its foundation. Please consult Appendix H for more detailed calculations and information.

Conclusion

As expected, the North-South directed wind loading was the controlling lateral loading case. Wilmington, Delaware, does not lie near any major seismic fault lines, so its earthquake loads will not control over wind. Distribution by rigidity yielded predictable results as well, since most of the lateral loads were distributed to the longest shear walls in each respective direction. Strength checks of these critical members were not able to fully account for these distributed shears, which indicates that more than just the shear walls might be needed for lateral resistance, especially for flexural strength of the wall. The generalization of the building into basically a six floor structure rather than its actual 25 stories has resulted in larger shears distributed to the lower floors than in reality as well.

Some factors not considered in the scope of this analysis are the lateral resistance of the columns, which due to their orientation may in fact provide additional stiffness. The post-tensioned concrete flat plate system at each floor also provides lateral stiffness for the River Tower. Finally, the self weight and other gravity loading of the structure provide enough axial force on the shear walls to stiffen each shear wall through compression. These combined effects, from floor-to-floor rather than specific groups of floors, will be more accurately accounted for in future reports, with the aid of computer software analysis.

APPENDICES

A. Design Self-Weight Calculations

B. Wind Load Calculations

C. Seismic Load Calculations

D. Distribution by Rigidity: East-West Wind Direction

E. Distribution by Rigidity: North-South Direction

F. Strength Check on Critical Shear Walls

G. Story Drift Calculations

H. Overturning Moment Calculations

APPENDIX A

Design Dead Load (Self-Weight) Calculations

Assumptions based on criteria listed on construction drawings and documents, and verified using the BOCA 1996 Building Code.

Column Self-Weight Calculations

Ground Level

Width (in)	Depth (in)	Area (ft^2)	Height (ft)	Weight (pcf)	Self Wt. (kips)
16.00	36.00	4.00	10.25	147.00	6.03
16.00	52.00	5.78	10.25	147.00	8.71
14.00	24.00	2.33	10.25	147.00	3.52
24.00	28.00	4.67	10.25	147.00	7.03
16.00	36.00	4.00	10.25	147.00	6.03
16.00	36.00	4.00	10.25	147.00	6.03
16.00	20.00	2.22	10.25	147.00	3.35
16.00	36.00	4.00	10.25	147.00	6.03
16.00	36.00	4.00	10.25	147.00	6.03
16.00	36.00	4.00	10.25	147.00	6.03
				Σ (k) =	58.76

Level 2

Width (in)	Depth (in)	Area (ft^2)	Height (ft)	Weight (pcf)	Self Wt. (kips)
16.00	36.00	4.00	10.25	147.00	6.03
16.00	52.00	5.78	10.25	147.00	8.71
14.00	24.00	2.33	10.25	147.00	3.52
24.00	28.00	4.67	10.25	147.00	7.03
16.00	36.00	4.00	10.25	147.00	6.03
16.00	36.00	4.00	10.25	147.00	6.03
16.00	20.00	2.22	10.25	147.00	3.35
16.00	36.00	4.00	10.25	147.00	6.03
16.00	36.00	4.00	10.25	147.00	6.03
16.00	36.00	4.00	10.25	147.00	6.03
14.00	22.00	2.14	10.25	147.00	3.22
				Σ (k) =	61.99

Levels 3 to 7

Width (in)	Depth (in)	Area (ft^2)	Height (ft)	Weight (pcf)	Self Wt. (kips)
16.00	36.00	4.00	10.25	147.00	6.03
16.00	52.00	5.78	10.25	147.00	8.71
14.00	24.00	2.33	10.25	147.00	3.52
24.00	28.00	4.67	10.25	147.00	7.03
16.00	36.00	4.00	10.25	147.00	6.03
16.00	36.00	4.00	10.25	147.00	6.03
16.00	20.00	2.22	10.25	147.00	3.35
16.00	36.00	4.00	10.25	147.00	6.03
16.00	36.00	4.00	10.25	147.00	6.03
14.00	22.00	2.14	10.25	147.00	3.22
				Σ (k) =	55.96

Level 8

Width (in)	Depth (in)	Area (ft^2)	Height (ft)	Weight (pcf)	Self Wt. (kips)
16.00	36.00	4.00	10.25	147.00	6.03
16.00	36.00	4.00	10.25	147.00	6.03
24.00	28.00	4.67	10.25	147.00	7.03
16.00	36.00	4.00	10.25	147.00	6.03
16.00	20.00	2.22	10.25	147.00	3.35
16.00	36.00	4.00	10.25	147.00	6.03
16.00	36.00	4.00	10.25	147.00	6.03
12.00	48.00	4.00	10.25	147.00	6.03
12.00	48.00	4.00	10.25	147.00	6.03
14.00	22.00	2.14	10.25	147.00	3.22
14.00	22.00	2.14	10.25	147.00	3.22
				Σ (k) =	59.01

Column Self-Weight Calculations (continued)

Level 9 to 23					
Width (in)	Depth (in)	Area (ft^2)	Height (ft)	Weight (pcf)	Self Wt. (kips)
16.00	36.00	4.00	10.25	147.00	6.03
16.00	36.00	4.00	10.25	147.00	6.03
16.00	36.00	4.00	10.25	147.00	6.03
16.00	20.00	2.22	10.25	147.00	3.35
16.00	36.00	4.00	10.25	147.00	6.03
12.00	48.00	4.00	10.25	147.00	6.03
12.00	48.00	4.00	10.25	147.00	6.03
14.00	22.00	2.14	10.25	147.00	3.22
				Σ (k) =	42.73

Levels 24 and 25					
Width (in)	Depth (in)	Area (ft^2)	Height (ft)	Weight (pcf)	Self Wt. (kips)
16.00	20.00	2.22	10.0	147.00	3.27
12.00	16.00	1.33	10.0	147.00	1.96
12.00	48.00	4.00	10.0	147.00	5.88
12.00	48.00	4.00	10.0	147.00	5.88
14.00	22.00	2.14	10.0	147.00	3.14
				Σ (k) =	20.13

Shear Wall Self-Weight Calculations

Foundation to Eighth Floor					
Thick (in)	Length (ft)	Area (ft^2)	Height (ft)	Weight (pcf)	Self Wt. (kips)
16.00	44.00	58.67	10.25	147.00	88.40
12.00	28.00	28.00	10.25	147.00	42.19
9.00	19.00	14.25	10.25	147.00	21.47
12.00	18.00	18.00	10.25	147.00	27.12
12.00	30.00	30.00	10.25	147.00	45.20
12.00	12.00	12.00	10.25	147.00	18.08
12.00	9.00	9.00	10.25	147.00	13.56
12.00	18.00	18.00	10.25	147.00	27.12
12.00	42.00	42.00	10.25	147.00	63.28
24.00	15.00	30.00	10.25	147.00	45.20
12.00	25.00	25.00	10.25	147.00	37.67
24	18	36.00	10.25	147.00	54.24
				Σ (k) =	483.54

9th to 22nd Floors					
Thick (in)	Length (ft)	Area (ft^2)	Height (ft)	Weight (pcf)	Self Wt. (kips)
16.00	44.00	58.67	10.25	147.00	88.40
12.00	28.00	28.00	10.25	147.00	42.19
9.00	19.00	14.25	10.25	147.00	21.47
12.00	18.00	18.00	10.25	147.00	27.12
12.00	30.00	30.00	10.25	147.00	45.20
12.00	12.00	12.00	10.25	147.00	18.08
12.00	9.00	9.00	10.25	147.00	13.56
12.00	18.00	18.00	10.25	147.00	27.12
12.00	42.00	42.00	10.25	147.00	63.28
12.00	25.00	25.00	10.25	147.00	37.67
				Σ (k) =	384.10

Shear Wall Self-Weight Calculations (continued)

23rd Level to Roof					
Thick (in)	Length (ft)	Area (ft^2)	Height (ft)	Weight (pcf)	Column Wt. (kips)
16.00	44.00	58.67	10.00	147.00	86.24
12.00	28.00	28.00	10.00	147.00	41.16
9.00	19.00	14.25	10.00	147.00	20.95
12.00	18.00	18.00	10.00	147.00	26.46
12.00	30.00	30.00	10.00	147.00	44.10
12.00	12.00	12.00	10.00	147.00	17.64
12.00	9.00	9.00	10.00	147.00	13.23
12.00	18.00	18.00	10.00	147.00	26.46
12.00	42.00	42.00	10.00	147.00	61.74
12.00	25.00	25.00	10.00	147.00	36.75
				Σ (k) =	374.73

Self-Weight Calculations per Floor

First Floor:
W_{slab} = (8" slab)*(147 pcf)*(1ft/12")*(29449 sf)*(1 kip/1000 lb) = 2886.0 kips
$W_{columns}$ = 58.76 kips
$W_{shear\ wall}$ = 483.54 kips
W_{first} = 3428.30 kips = 0.116 ksf

Second Floor:
W_{slab} = (8" slab)*(147 pcf)*(1ft/12")*(29663 sf)*(1 kip/1000 lb) = 2906.97 kips
$W_{columns}$ = 61.99 kips
$W_{shear\ wall}$ = 483.54 kips
W_{second} = 3452.50 kips = 0.1164 ksf

Third through Sixth Floors (values per floor):
W_{slab} = (8" slab)*(147 pcf)*(1ft/12")*(30486 sf)*(1 kip/1000 lb) = 2987.63 kips
$W_{columns}$ = 55.96 kips
$W_{shear\ wall}$ = 483.54 kips
$W_{3\text{-}6th}$ = 3527.13 kips per floor = 0.1157 ksf per floor

Seventh Floor:
W_{slab} = (8" slab)*(147 pcf)*(1ft/12")*(39560 sf)*(1 kip/1000 lb) = 3876.88 kips
$W_{columns}$ = 55.96 kips
$W_{shear\ wall}$ = 483.54 kips
$W_{seventh}$ = 4416.38 kips = 0.112 ksf

Self-Weight Calculations per Floor (continued)

Eighth Floor:
W_{slab} = (8" slab)*(147 pcf)*(1ft/12")*(31610 sf)*(1 kip/1000 lb) = 3097.78 kips
$W_{columns}$ = 59.01 kips
$W_{shear\ wall}$ = 483.54 kips
W_{eighth} = 3640.33 kips = 0.115 ksf

Ninth through 22nd Floors (values per floor):
W_{slab} = (8" slab)*(147 pcf)*(1ft/12")*(12186 sf)*(1 kip/1000 lb) = 1194.23 kips
$W_{columns}$ = 42.73 kips
$W_{shear\ wall}$ = 384.10 kips
$W_{9\text{-}22nd}$ = 1621.06 kips per floor = 0.133 ksf per floor

23rd Floor:
W_{slab} = (8" slab)*(147 pcf)*(1ft/12")*(9307 sf)*(1 kip/1000 lb) = 912.09 kips
$W_{columns}$ = 42.73 kips
$W_{shear\ wall}$ = 374.73 kips
W_{23rd} = 1329.55 kips = 0.143 ksf

24th to 25th Floor:
W_{slab} = (8" slab)*(147 pcf)*(1ft/12")*(1070 sf)*(1 kip/1000 lb) = 104.86 kips
$W_{columns}$ = 20.13 kips
$W_{shear\ wall}$ = 374.73 kips
$W_{24\text{-}25th}$ = 499.72 kips = 0.467 ksf

Roof:
Because the roof consists of a small amount of mostly steel framing, which is relatively light compared to the mostly concrete construction of the other floors, this floor self-weight was estimated.
W_{roof} = (374.73 kips)$_{shear\ walls}$ + (25 kips)$_{steel,\ etc.}$ ≈ 400 kips = 0.373 ksf

Total Building Weight:
$W_{building}$ = **54469.86 kips**

APPENDIX B

Wind Load Calculations

Assumptions based on criteria listed on construction drawings and documents, and verified using the BOCA 1996 Building Code.

Assumptions:
- In the case of each direction, it was assumed that the wind forces were applied to the longest side of each wall. The shape of the River Tower was adjusted to be as rectangular as possible for simplicity.

Coefficients and Categories

Exposure Category: C (BOCA 1996 1609.4)
Worst Case L/B Ratio: (73.5 ft)/(164 ft) = 0.448
Basic Wind Speed (V): 80 mph (Figure 1609.3 – Wilmington, DE)
Basic Velocity Pressure (P_v): 16.4 psf (Table 1609.7(3) based on V = 80 mph)
Wall Pressure Coefficients (C_p): For N-S Direction (Table 1609.7)
- Windward Walls: $C_p = 0.8$
- Leeward Walls: $C_p = -0.5$

Wall Pressure Coefficients (C_p): For W-E Direction (Table 1609.7)
- Windward Walls: $C_p = 0.8$
- Leeward Walls: $C_p = -0.3$

Importance Factor (I): 1.04 (Table 1609.5 and interpolation)
Internal Pressure Coefficients (GC_{pi}): +/- 0.25 (Table 1609.7(6))
Velocity Pressure Exposure (K_z and K_h): see below (Table 1609.7(4))
Gust Response Factors (G_h and G_z): see below (Table 1609.7(5))

Building Main Windforce-Resisting System:
- Windward wall design pressure, P

$P = (P_v)(I)[(K_z)(G_h)(C_p) – (K_h)(GC_{pi})]$
- Leeward wall design pressure, P

$P = (P_v)(I)[(K_z)(G_h)(C_p) – (K_h)(GC_{pi})]$

North-South Direction Wind Pressure Totals						
Level	**Elev. (ft)**	**K coeff.**	**G coeff.**	**P (windward)**	**P (leeward)**	**Total P (psf)**
Roof	279.22	1.84	1.09	27.47	-17.17	44.63
25	269.22	1.82	1.10	27.22	-17.17	44.38
24	259.39	1.81	1.10	27.12	-17.17	44.28
23	247.36	1.78	1.10	26.74	-17.17	43.91
22	236.00	1.76	1.10	26.49	-17.17	43.65
21	225.75	1.74	1.11	26.23	-17.17	43.40
20	215.50	1.71	1.11	25.83	-17.17	43.00
19	205.25	1.69	1.11	25.62	-17.17	42.79
18	195.00	1.67	1.11	25.36	-17.17	42.53
17	184.75	1.64	1.12	25.02	-17.17	42.18
16	174.50	1.62	1.12	24.82	-17.17	41.99
15	164.25	1.59	1.13	24.47	-17.17	41.64
14	154.00	1.56	1.13	24.15	-17.17	41.31
13	143.75	1.53	1.14	23.80	-17.17	40.97
12	133.50	1.50	1.15	23.43	-17.17	40.60
11	123.25	1.46	1.15	22.91	-17.17	40.08
10	113.00	1.43	1.16	22.54	-17.17	39.70
9	102.75	1.39	1.16	22.00	-17.17	39.17
8	92.50	1.35	1.17	21.55	-17.17	38.72
7	82.25	1.30	1.18	20.93	-17.17	38.10
6	72.00	1.25	1.19	20.30	-17.17	37.46
5	61.75	1.20	1.20	19.65	-17.17	36.82
4	51.50	1.14	1.21	18.82	-17.17	35.99
3	41.25	1.07	1.23	17.96	-17.17	35.12
2	31.00	0.99	1.26	17.02	-17.17	34.19
1	10.50	0.80	1.32	14.41	-17.17	31.58

North-South Wind Pressure and Forces				
Level	Trib. Width (ft)	Trib Height (ft)	P (plf)	F (kips)
Roof	172.5	10.00	7699.19	76.99
25	172.5	9.83	7656.25	75.26
24	172.5	12.03	7638.98	91.90
23	172.5	11.36	7574.01	86.04
22	172.5	10.25	7530.47	77.19
21	172.5	10.25	7486.74	76.74
20	172.5	10.25	7416.76	76.02
19	172.5	10.25	7380.56	75.65
18	172.5	10.25	7336.12	75.20
17	172.5	10.25	7276.83	74.59
16	172.5	10.25	7243.27	74.24
15	172.5	10.25	7182.68	73.62
14	172.5	10.25	7126.73	73.05
13	172.5	10.25	7066.60	72.43
12	172.5	10.25	7003.75	71.79
11	172.5	10.25	6913.13	70.86
10	172.5	10.25	6848.76	70.20
9	172.5	10.25	6756.38	69.25
8	180.75	10.25	6998.37	71.73
7	180.75	10.25	6886.15	70.58
6	180.75	10.25	6771.47	69.41
5	180.75	10.25	6654.32	68.21
4	180.75	10.25	6504.86	66.67
3	180.75	10.25	6348.74	65.07
2	180.75	20.50	6179.31	126.68
1	180.75	10.50	5707.26	59.93
			Sum of F:	1959.30

West-East Direction Wind Pressure Totals						
Level	Elev. (ft)	K coeff.	G coeff.	P (windward)	P (leeward)	Total P (psf)
Roof	279.22	1.84	1.09	27.47	-10.30	37.77
25	269.22	1.82	1.10	27.22	-10.30	37.52
24	259.39	1.81	1.10	27.12	-10.30	37.42
23	247.36	1.78	1.10	26.74	-10.30	37.04
22	236.00	1.76	1.10	26.49	-10.30	36.79
21	225.75	1.74	1.11	26.23	-10.30	36.53
20	215.50	1.71	1.11	25.83	-10.30	36.13
19	205.25	1.69	1.11	25.62	-10.30	35.92
18	195.00	1.67	1.11	25.36	-10.30	35.66
17	184.75	1.64	1.12	25.02	-10.30	35.32
16	174.50	1.62	1.12	24.82	-10.30	35.12
15	164.25	1.59	1.13	24.47	-10.30	34.77
14	154.00	1.56	1.13	24.15	-10.30	34.45
13	143.75	1.53	1.14	23.80	-10.30	34.10
12	133.50	1.50	1.15	23.43	-10.30	33.73
11	123.25	1.46	1.15	22.91	-10.30	33.21
10	113.00	1.43	1.16	22.54	-10.30	32.84
9	102.75	1.39	1.16	22.00	-10.30	32.30
8	92.50	1.35	1.17	21.55	-10.30	31.85
7	82.25	1.30	1.18	20.93	-10.30	31.23
6	72.00	1.25	1.19	20.30	-10.30	30.60
5	61.75	1.20	1.20	19.65	-10.30	29.95
4	51.50	1.14	1.21	18.82	-10.30	29.12
3	41.25	1.07	1.23	17.96	-10.30	28.26
2	31.00	0.99	1.26	17.02	-10.30	27.32
1	10.50	0.80	1.32	14.41	-10.30	24.71

West-East Wind Pressure and Forces				
Level	**Trib. Width (ft)**	**Trib Height (ft)**	**P (plf)**	**F (kips)**
Roof	72.1667	10.00	2725.47	27.25
25	72.1667	9.83	2707.51	26.61
24	72.1667	12.03	2700.28	32.48
23	72.1667	11.36	2673.11	30.37
22	72.1667	10.25	2654.89	27.21
21	72.1667	10.25	2636.59	27.03
20	72.1667	10.25	2607.32	26.73
19	72.1667	10.25	2592.17	26.57
18	72.1667	10.25	2573.58	26.38
17	72.1667	10.25	2548.78	26.12
16	72.1667	10.25	2534.74	25.98
15	72.1667	10.25	2509.39	25.72
14	72.1667	10.25	2485.98	25.48
13	72.1667	10.25	2460.82	25.22
12	72.1667	10.25	2434.53	24.95
11	72.1667	10.25	2396.62	24.57
10	72.1667	10.25	2369.69	24.29
9	72.1667	10.25	2331.04	23.89
8	104.417	10.25	3325.87	34.09
7	104.417	10.25	3261.04	33.43
6	104.417	10.25	3194.79	32.75
5	104.417	10.25	3127.11	32.05
4	104.417	10.25	3040.78	31.17
3	104.417	10.25	2950.59	30.24
2	104.417	20.50	2852.71	58.48
1	104.417	10.50	2580.01	27.09
			Sum of F:	756.16

APPENDIX C

Seismic Load Calculations

Assumptions based on criteria listed on construction drawings and documents, and verified using the BOCA 1996 Building Code.

Seismic Hazard Exposure Group: II (Table 1610.1.5 – Substantial occupancy building)
Effective Peak Velocity-related Acceleration: $A_v = 0.075$
(Wilmington, DE – Figure 1610.1.3(1): halfway between 0.05 and 0.10 regions)
Effective Peak Acceleration Coefficient: $A_a = 0.05$ (Wilmington, DE – Figure 1610.1.3(2))
Seismic Performance Category: B (Table 1610.1.7 since $0.05 < A_v < 0.10$)
Seismic Resisting System: Dual-system with intermediate moment frame of reinforced concrete with reinforced concrete shear walls (Table 1610.3.3 – No height limitations)
- Response Modification Factor (R): 8.0
- Deflection Amplification Factor (Cd): 6.5

Site Coefficient: S_4, 2.0 (Table 1610.3.1)

Use Equivalent Lateral Force Procedure (Section 1610.3.5.2)

$V = (C_s)(W)$

Seismic Design Coefficient (C_s): (Section 1610.4.1.1)
min of $C_s = (1.2A_vS) / (RT)^{(2/3)}$ = See below
…and $(2.5A_a)/(R) = (2.5)(0.05)/(8.0) = 0.0156$

Approximate Fundamental Period (T_a):
$T_a = (C_T)(h_n)^{(3/4)}$
$C_T = 0.02$ (Section 1610.4.1.2.1: Seismic-Resisting System with shear walls)
$h_n = 279.22$ ft (Section 1610.4.1.2.1: Height from base to highest level of building)
$T_a = (0.02)(279.22)^{(3/4)} = 1.366$ seconds

Coefficient for Upper Limit on Calculated Period (C_a): 1.7 (Table 1610.4.1.2)
Fundamental Period (T): $T = (C_a)(T_a)$
$T = (1.7)(1.366) = 2.322$ seconds

$C_s = [(1.2)(0.075)(2.0)]/[(8.0)(2.322)]^{(2/3)} = 0.0257 > 0.0156 \rightarrow$ Use $C_s = 0.0156$

V = (0.0156)*(54469.86 kips) = **849.73 kips**

Vertical Distribution of Seismic Forces: $F_x = (C_{vx})(V)$ (Section 1610.4.2)
$C_{vx} = (w_x h^k_x) / (\Sigma\, w_i h^k_i)$

(k determined through linear interpolation: 1.911)

Level	w_x (k)	h_x (ft)	$w_x h_x^k$	C_{vx}	F_x (k)
Roof	375	279.22	17611207	0.028729	24.41
25	499.72	269.22	21889292	0.035707	30.34
24	499.72	259.39	20388130	0.033259	28.26
23	1329.55	247.36	49540908	0.080815	68.67
22	1621.06	236.00	55215501	0.090072	76.54
21	1621.06	225.75	50725707	0.082747	70.31
20	1621.06	215.50	46417675	0.07572	64.34
19	1621.06	205.25	42292167	0.06899	58.62
18	1621.06	195.00	38349985	0.062559	53.16
17	1621.06	184.75	34591977	0.056429	47.95
16	1621.06	174.50	31019041	0.050601	43.00
15	1621.06	164.25	27632130	0.045076	38.30
14	1621.06	154.00	24432261	0.039856	33.87
13	1621.06	143.75	21420524	0.034943	29.69
12	1621.06	133.50	18598088	0.030339	25.78
11	1621.06	123.25	15966220	0.026045	22.13
10	1621.06	113.00	13526297	0.022065	18.75
9	1621.06	102.75	11279826	0.0184	15.64
8	3097.78	92.50	17635236	0.028768	24.44
7	4416.38	82.25	20089819	0.032772	27.85
6	3427.13	72.00	12090260	0.019723	16.76
5	3427.13	61.75	9016690.8	0.014709	12.50
4	3427.13	51.50	6375032.3	0.010399	8.84
3	3427.13	41.25	4172442.2	0.006806	5.78
2	3452.5	31.00	2435760.2	0.003973	3.38
1	3428.3	10.50	305879.51	0.000499	0.42
		$\Sigma\, w_i h^k_i$ =	613018057	$\Sigma\, F_x$ (k) =	849.73

APPENDIX D

Distribution by Rigidity: West-East Direction

Shear Wall Dimensions (for both Wind Directions)					
Wall	**t (in)**	**L (ft)**	**I (in^4)**	**X_i (ft)**	**Y_i (ft)**
A	16	25	36000000	0.666667	0
B	12	14.5	5268024	0	30.25
C	12	14.5	5268024	0	37.93
D	12	23.1667	21485045	0.666667	0
E	16	9.25	1823508	85.91667	0
F	12	9.25	1367631	114.333	0
G	12	28.42	39665776	0	48.458
H	12	8.93	1230547	143.4167	0
J	9	19.3333	9365328	71.41667	0
K	12	6.08333	389016.4	145.594	0
L	12	6.307	433523.1	0	37.932
M	12	7.47	720286.9	0	65.4322
O	24	19.927	27346358	180.5	0
P	24	14.708	10995997	180.5	0
Q	12	8.8333	1191003	0	72.172
R	12	19.1667	12167063	130.9	0
S	12	8.8333	1191003	0	92.333

	R/E for Each Wall: West - East Direction								
Level	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**J**
6	0.0032	0.00047	0.00047	0.00191	0.00016	0.00012	0.00353	0.00011	0.00083
5	0.00625	0.00091	0.00091	0.00373	0.00032	0.00024	0.00688	0.00021	0.00625
4	0.01176	0.00172	0.00172	0.00702	0.0006	0.00045	0.01296	0.0004	0.01176
3	0.026269	0.003844	0.003844	0.015677	0.001331	0.000998	0.028943	0.000898	0.026269
2	0.078969	0.011556	0.011556	0.047129	0.004	0.003	0.08701	0.002699	0.020544
1	0.066958	0.239411	0.023177	0.017383	0.416097	0.015641	0.066958	0.239411	0.108417

	R/E for Each Wall: West- East Direction (continued)								
Level	**K**	**L**	**M**	**N**	**O**	**P**	**Q**	**R**	**S**
6	3.5E-05	3.9E-05	6.4E-05						
5	0.00162	6.7E-05	7.5E-05						
4	0.00306	0.00013	0.00014						
3	0.006834	0.000284	0.000316						
2	0.000853	0.000951	0.00158	0.059986	0.024121	0.002613	0.026689	0.002613	0.026689
1	0.004945	0.00551	0.009155	0.314822	0.139762	0.015138	0.141067	0.015138	0.141067

	Center of Rigidity: West-East Wind Direction			
Level	**Σk_x =**	**Σk_y =**	**X_{bar} (ft)**	**Y_{bar} (ft)**
6	0.00637	0.00457	17.4895	45.6595
5	0.00638	0.00457	17.4895	45.6595
4	0.01243	0.00891	17.4895	45.6595
3	0.02341	0.01678	17.4895	45.6595
2	0.05229	0.03747	17.4895	45.6595
1	0.29468	0.11788	85.2682	47.2815

Story Forces		**Trib H (ft)**	**Trib W (ft)**
F_6 (k) =	71.84	53.72	72.1667
F_5 (k) =	107.73	41	72.1667
F_4 (k) =	104.11	41	72.1667
F_3 (k) =	100.05	41	72.1667
F_2 (k) =	116.41	41	104.417
F_1 (k) =	156.65	51.5	104.417
F_{ground} (k)	73.54	51.5	104.417

Story Shears	
F_6 (k) =	71.84
F_5 (k) =	179.57
F_4 (k) =	283.67
F_3 (k) =	383.73
F_2 (k) =	500.14
F_1 (k) =	656.78
F_{ground} (k)	730.32

	Concentric Forces per Wall: Wind Acting in West-East Direction					
	Wall B		**Wall C**		**Wall G**	
Level	**Proportion of R**	**Shear (k)**	**Proportion**	**Shear (k)**	**Proportion**	**Shear (k)**
6	0.073513	5.28	0.073513	5.28	0.553519	39.76
5	0.073513	13.20	0.073513	13.20	0.553519	99.39
4	0.073513	20.85	0.073513	20.85	0.553519	157.02
3	0.073513	28.21	0.073513	28.21	0.553519	212.40
2	0.039215	19.61	0.039215	19.61	0.295269	147.68
1	0.043511	28.58	0.043511	28.58	0.270391	177.59

	Wall L		**Wall M**	
Level	**Proportion of R**	**Shear (k)**	**Proportion**	**Shear (k)**
6	0.00604963	0.43	0.010051	0.72
5	0.00604963	1.09	0.010051	1.80
4	0.00604963	1.72	0.010051	2.85
3	0.00604963	2.32	0.010051	3.86
2	0.00322712	1.61	0.005362	2.68
1	0.00358068	2.35	0.005949	3.91

	Wall P		**Wall R**	
Level	**Proportion of R**	**Shear (k)**	**Proportion**	**Shear (k)**
2	0.008866	4.43	0.008865745	4.43
1	0.015061	9.89	0.009837082	6.46

First Level of Floors: Eccentric Shears – West-East Wind Direction					
Wall	**R**	**dx**	**$R*dx^2$**	**$R*dx/\Sigma Rx^2$**	**Torsional Shear (k)**
A	0.3932	87.19	2988.741	0.0036	12.05
B	0.0670	16.86	19.028	0.0001	0.40
C	0.0670	9.18	5.640	0.0001	0.22
D	0.2394	87.19	1819.885	0.0022	7.34
E	0.0232	1.94	0.087	0.0000	0.02
F	0.0174	26.48	12.189	0.0000	0.16
G	0.4161	1.35	0.759	0.0001	0.20
H	0.0156	47.11	34.708	0.0001	0.26
J	0.1084	24.31	64.068	0.0003	0.93
N	0.0049	57.74	16.485	0.0000	0.10
O	0.0055	9.18	0.464	0.0000	0.02
P	0.0092	18.32	3.074	0.0000	0.06
Q	0.3148	92.65	2702.252	0.0031	10.25
R	0.1398	92.65	1199.640	0.0014	4.55
S	0.0151	25.06	9.510	0.0000	0.13

Second Level of Floors: Eccentric Shears					
Wall	**R**	**dx**	**$R*dx^2$**	**$R*dx/\Sigma Rx^2$**	**Torsional Shear (k)**
A	0.0790	87.19	600.280	0.0038	9.25
B	0.0116	16.86	3.284	0.0001	0.26
C	0.0116	9.18	0.973	0.0001	0.14
D	0.0471	87.19	358.251	0.0022	5.52
E	0.0040	1.94	0.015	0.0000	0.01
F	0.0030	26.48	2.104	0.0000	0.11
G	0.0870	1.35	0.159	0.0001	0.16
H	0.0027	47.11	5.990	0.0001	0.17
J	0.0205	24.31	12.140	0.0003	0.67
K	0.0009	57.74	2.845	0.0000	0.01
L	0.0010	9.18	0.080	0.0000	0.00
M	0.0016	18.32	0.531	0.0000	0.01
N	0.0600	92.65	514.887	0.0006	1.44
O	0.0241	92.65	207.037	0.0002	0.58
P	0.0026	25.06	1.641	0.0000	0.02

Third Level of Floors: Eccentric Shears					
Wall	**R**	**dx**	**R*dx²**	**R*dx/ΣRx²**	**Tors. Shear (k)**
A	0.0263	87.19	199.680	0.0070	49.79
B	0.0038	16.86	1.092	0.0002	1.41
C	0.0038	9.18	0.324	0.0001	0.77
D	0.0157	87.19	119.171	0.0042	29.71
E	0.0013	1.94	0.005	0.0000	0.06
F	0.0010	26.48	0.700	0.0001	0.57
G	0.0289	1.35	0.053	0.0001	0.85
H	0.0009	47.11	1.993	0.0001	0.92
J	0.0068	24.31	4.038	0.0005	3.61
K	0.0003	57.74	0.946	1.71912E-06	0.01
L	0.0003	9.18	0.027	3.04435E-07	0.00
M	0.0005	18.32	0.176	1.01019E-06	0.01

Fourth Level of Floors: Eccentric Shears					
Wall	**R**	**dx**	**R*dx²**	**R*dx/ΣRx²**	**Tors. Shear (k)**
A	0.0118	87.19	89.411	0.0070	23.38
B	0.0017	16.86	0.489	0.0002	0.66
C	0.0017	9.18	0.145	0.0001	0.36
D	0.0070	87.19	53.361	0.0042	13.95
E	0.0006	1.94	0.002	0.0000	0.03
F	0.0004	26.48	0.313	0.0001	0.27
G	0.0130	1.35	0.024	0.0001	0.40
H	0.0004	47.11	0.892	0.0001	0.43
J	0.0031	24.31	1.808	0.0005	1.70
K	0.0001	57.74075	0.424	4.99389E-05	0.17
L	0.000142	9.175396	0.012	8.84353E-06	0.03
M	0.000235	18.3248	0.079	2.93449E-05	0.10

Fifth Level of Floors: Eccentric Shears					
Wall	**R**	**dx**	**R*dx^2**	**R*dx/ΣRx^2**	**Tors. Shear (k)**
A	0.0062	87.19	47.472	0.007	23.3
B	0.0009	16.86	0.26	0.0002	0.66
C	0.0009	9.18	0.077	0.0001	0.36
D	0.0037	87.19	28.332	0.0042	13.91
E	0.0003	1.94	0.001	0	0.03
F	0.0002	26.48	0.166	0.0001	0.27
G	0.0069	1.35	0.013	0.0001	0.4
H	0.0002	47.11	0.474	0.0001	0.43
J	0.0016	24.31	0.96	0.0005	1.69
K	0.0001	57.74	0.225	4.99E-05	0.17
L	0.0001	9.18	0.006	8.84E-06	0.03
M	0.0001	18.32	0.042	2.93E-05	0.1

Sixth Level of Floors: Eccentric Shears					
Wall	**R**	**dx**	**R*dx^2**	**R*dx/ΣRx^2**	**Tors. Shear (k)**
A	0.0032	87.19	24.348	0.0036	4.78
B	0.0005	16.86	0.133	0.0001	0.14
C	0.0005	9.18	0.039	0.0001	0.07
D	0.0019	87.19	14.531	0.0021	2.85
E	0.0002	1.94	0.001	0.0000	0.01
F	0.0001	26.48	0.085	0.0000	0.06
G	0.0035	1.35	0.006	0.0001	0.08
H	0.0001	47.11	0.243	0.0001	0.09
J	0.0008	24.31	0.492	0.0003	0.35
K	0.0000	57.74	0.115	2.56129E-05	0.03
L	0.0000	9.18	0.003	4.53571E-06	0.01
M	0.0001	18.32	0.022	2.93449E-05	0.04

Torsional Moments	
Level	**ft-kips**
6	1335.725
5	3338.859
4	5274.599
3	7134.966
2	2464.158
1	3350.32

APPENDIX E

<u>Distribution by Rigidity:</u> North-South Direction

Please see Appendix D for Shear Wall dimensions and standard values.

	R/E for Each Wall: North-South Direction								
Level	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**J**
6	0.0032	0.00047	0.00047	0.00191	0.00016	0.00012	0.00353	0.00011	0.00083
5	0.00625	0.00091	0.00091	0.00373	0.00032	0.00024	0.00688	0.00021	0.00162
4	0.01176	0.00172	0.00172	0.00702	0.0006	0.00045	0.01296	0.0004	0.00306
3	0.02627	0.00384	0.00384	0.01568	0.00133	0.001	0.02894	0.0009	0.00683
2	0.07897	0.01156	0.01156	0.04713	0.004	0.003	0.08701	0.0027	0.02054
1	0.39318	0.06696	0.06696	0.23941	0.02318	0.01738	0.4161	0.01564	0.39318

	R/E for Each Wall: North-South Direction (continued)								
Level	**K**	**L**	**M**	**N**	**O**	**P**	**Q**	**R**	**S**
6	3.5E-05	3.9E-05	6.4E-05						
5	6.7E-05	7.5E-05	0.00012						
4	0.00013	0.00014	0.00024						
3	0.00028	0.00032	0.00053						
2	0.00085	0.00095	0.00158	0.05999	0.02412	0.00261	0.02669	0.00261	0.02669
1	0.10842	0.00494	0.00551	0.00916	0.31482	0.13976	0.01514	0.14107	0.01514

	Center of Rigidity: N-S Wind Direction			
Level	**Σk_x =**	**Σk_y =**	**X_{bar} (ft)**	**Y_{bar} (ft)**
6	0.00638	0.00457	17.4895	45.6595
5	0.01243	0.00891	17.4895	45.6595
4	0.02341	0.01678	17.4895	45.6595
3	0.05229	0.03747	17.4895	45.6595
2	0.29468	0.11788	85.2682	47.2815
1	1.53887	0.59495	87.8532	47.1074

Story Forces		Trib H (ft)	Trib W (ft)
F_6 (k) =	203.54	53.72	172.5
F_5 (k) =	306.10	41	172.5
F_4 (k) =	297.43	41	172.5
F_3 (k) =	287.74	41	172.5
F_2 (k) =	281.05	41	180.75
F_1 (k) =	335.11	51.5	180.75
F_{ground} (k)	159.27	51.5	180.75

Story Shears	
F_6 (k) =	203.54
F_5 (k) =	509.64
F_4 (k) =	807.07
F_3 (k) =	1094.82
F_2 (k) =	1375.87
F_1 (k) =	1710.98
F_{ground} (k)	1870.25

	Concentric Forces per Wall: Wind Acting in N-S Direction					
	Wall A		Wall D		Wall E	
Level	Proportion of R	Shear (k)	Proportion	Shear (k)	Proportion	Shear (k)
6	0.700994	142.68	0.418358	85.15	0.035507	7.23
5	0.700994	357.26	0.418358	213.21	0.035507	18.10
4	0.700994	565.75	0.299815	241.97	0.035507	28.66
3	0.700994	767.46	0.418358	458.03	0.035507	38.87
2	0.669921	921.72	0.399814	550.09	0.033934	46.69
1	0.660853	1130.71	0.402403	688.50	0.038956	66.65

	Wall F		Wall H		Wall J	
Level	Proportion of R	Shear (k)	Proportion	Shear (k)	Proportion	Shear (k)
6	0.02663059	5.42	0.023961	4.88	0.182362	37.12
5	0.02663059	13.57	0.023961	12.21	0.182362	92.94
4	0.02663059	21.49	0.023961	19.34	0.182362	147.18
3	0.02663059	29.16	0.023961	26.23	0.182362	199.65
2	0.02545015	35.02	0.022899	31.51	0.174279	239.78
1	0.02921736	49.99	0.026289	44.98	0.182228	311.79

	Wall K		Wall N		Wall O	
Level	Proportion of R	Shear (k)	Proportion	Shear (k)	Proportion	Shear (k)
6	0.00757495	1.54				
5	0.00757495	3.86				
4	0.00757495	6.11				
3	0.00757495	8.29				
2	0.007239178	9.96	0.508886478	700.16	0.204624	281.54
1	0.008310743	14.22	0.529153438	905.37	0.234913	401.93

	Wall Q		Wall S	
Level	Proportion of R	Shear (k)	Proportion	Shear (k)
2	0.090571	124.61	0.226416039	311.52
1	0.091669	156.84	0.091669343	156.84

First Level of Floors: Eccentric Shears – N-S Wind Direction					
Wall	**R**	**dx**	**R*dx^2**	**R*dx/ΣRx^2**	**Torsional Shear (k)**
A	0.3932	87.19	2988.741	0.0036	15.51
B	0.0670	16.86	19.028	0.0001	0.51
C	0.0670	9.18	5.640	0.0001	0.28
D	0.2394	87.19	1819.885	0.0022	9.45
E	0.0232	1.94	0.087	0.0000	0.02
F	0.0174	26.48	12.189	0.0000	0.21
G	0.4161	1.35	0.759	0.0001	0.25
H	0.0156	47.11	34.708	0.0001	0.33
J	0.1084	24.31	64.068	0.0003	1.19
K	0.0049	57.74	16.485	0.0000	0.13
L	0.0055	9.18	0.464	0.0000	0.02
M	0.0092	18.32	3.074	0.0000	0.08
N	0.3148	92.65	2702.252	0.0031	13.20
O	0.1398	92.65	1199.640	0.0014	5.86
P	0.0151	25.06	9.510	0.0000	0.17

Second Level of Floors: Eccentric Shears					
Wall	**R**	**dx**	**R*dx^2**	**R*dx/ΣRx^2**	**Torsional Shear (k)**
A	0.0790	87.19	600.280	0.0038	26.38
B	0.0116	16.86	3.284	0.0001	0.75
C	0.0116	9.18	0.973	0.0001	0.41
D	0.0471	87.19	358.251	0.0022	15.74
E	0.0040	1.94	0.015	0.0000	0.03
F	0.0030	26.48	2.104	0.0000	0.30
G	0.0870	1.35	0.159	0.0001	0.45
H	0.0027	47.11	5.990	0.0001	0.49
J	0.0205	24.31	12.140	0.0003	1.91
K	0.0009	57.74	2.845	0.0000	0.04
L	0.0010	9.18	0.080	0.0000	0.01
M	0.0016	18.32	0.531	0.0000	0.02
N	0.0600	92.65	514.887	0.0006	4.10
O	0.0241	92.65	207.037	0.0002	1.65
P	0.0026	25.06	1.641	0.0000	0.05

Third Level of Floors: Eccentric Shears					
Wall	**R**	**dx**	**$R*dx^2$**	**$R*dx/\Sigma Rx^2$**	**Tors. Shear (k)**
A	0.0263	87.19	199.680	0.0070	525.32
B	0.0038	16.86	1.092	0.0002	14.86
C	0.0038	9.18	0.324	0.0001	8.09
D	0.0157	87.19	119.171	0.0042	313.51
E	0.0013	1.94	0.005	0.0000	0.59
F	0.0010	26.48	0.700	0.0001	6.06
G	0.0289	1.35	0.053	0.0001	8.97
H	0.0009	47.11	1.993	0.0001	9.70
J	0.0068	24.31	4.038	0.0005	38.10
K	0.0003	57.74	0.946	1.71912E-06	0.13
L	0.0003	9.18	0.027	3.04435E-07	0.02
M	0.0005	18.32	0.176	1.01019E-06	0.08

Fourth Level of Floors: Eccentric Shears					
Wall	**R**	**dx**	**$R*dx^2$**	**$R*dx/\Sigma Rx^2$**	**Tors. Shear (k)**
A	0.0118	87.19	89.411	0.0070	30.11
B	0.0017	16.86	0.489	0.0002	0.85
C	0.0017	9.18	0.145	0.0001	0.46
D	0.0070	87.19	53.361	0.0042	17.97
E	0.0006	1.94	0.002	0.0000	0.03
F	0.0004	26.48	0.313	0.0001	0.35
G	0.0130	1.35	0.024	0.0001	0.51
H	0.0004	47.11	0.892	0.0001	0.56
J	0.0031	24.31	1.808	0.0005	2.18
K	0.0001	57.74075	0.424	4.99389E-05	0.22
L	0.000142	9.175396	0.012	8.84353E-06	0.04
M	0.000235	18.3248	0.079	2.93449E-05	0.13

Fifth Level of Floors: Eccentric Shears					
Wall	R	dx	$R*dx^2$	$R*dx/\Sigma Rx^2$	Tors. Shear (k)
A	0.0062	87.19	47.472	0.0070	244.54
B	0.0009	16.86	0.260	0.0002	6.92
C	0.0009	9.18	0.077	0.0001	3.77
D	0.0037	87.19	28.332	0.0042	145.94
E	0.0003	1.94	0.001	0.0000	0.28
F	0.0002	26.48	0.166	0.0001	2.82
G	0.0069	1.35	0.013	0.0001	4.17
H	0.0002	47.11	0.474	0.0001	4.52
J	0.0016	24.31	0.960	0.0005	17.74
K	0.0001	57.74	0.225	4.99E-05	1.75
L	0.0001	9.18	0.006	8.84E-06	0.31
M	0.0001	18.32	0.042	2.93E-05	1.03

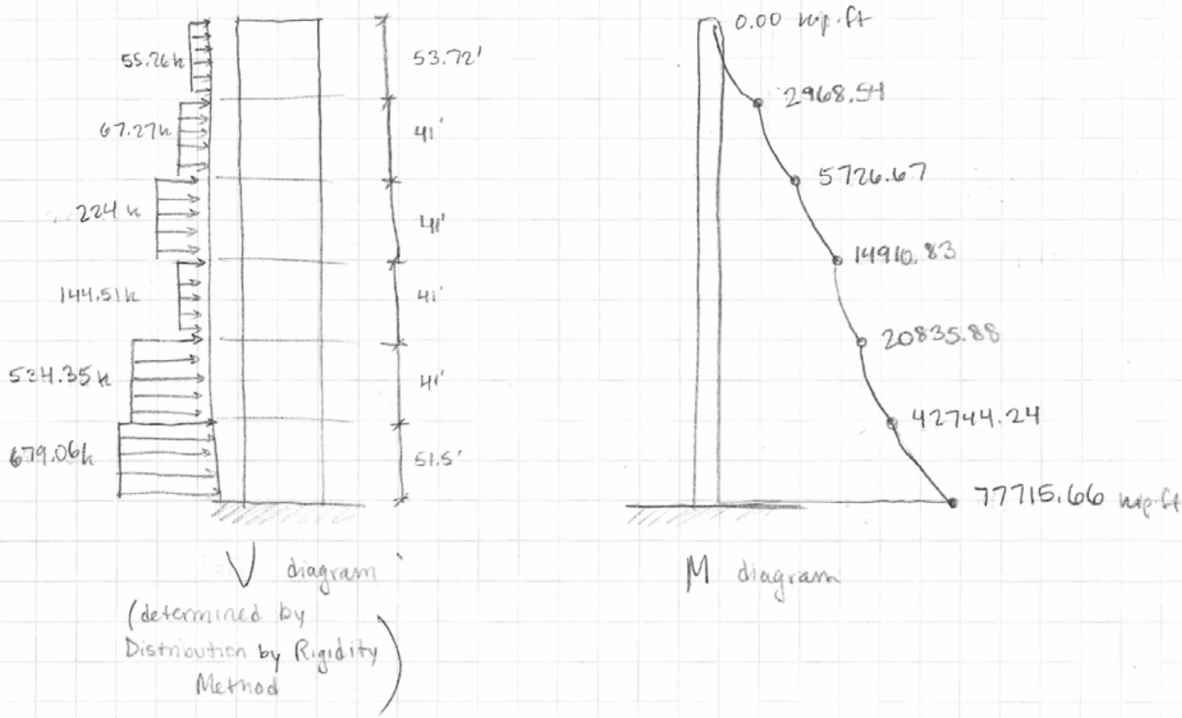
Sixth Level of Floors: Eccentric Shears					
Wall	R	dx	$R*dx^2$	$R*dx/\Sigma Rx^2$	Tors. Shear (k)
A	0.0032	87.19	24.348	0.0036	50.09
B	0.0005	16.86	0.133	0.0001	1.42
C	0.0005	9.18	0.039	0.0001	0.77
D	0.0019	87.19	14.531	0.0021	29.89
E	0.0002	1.94	0.001	0.0000	0.06
F	0.0001	26.48	0.085	0.0000	0.58
G	0.0035	1.35	0.006	0.0001	0.85
H	0.0001	47.11	0.243	0.0001	0.93
J	0.0008	24.31	0.492	0.0003	3.63
K	0.0000	57.74	0.115	2.56129E-05	0.36
L	0.0000	9.18	0.003	4.53571E-06	0.06
M	0.0001	18.32	0.022	2.93449E-05	0.41

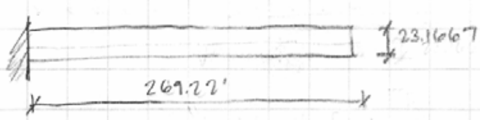
Torsional Moments	
Level	ft-kips
6	13995.72
5	35043.15
4	55494.85
3	75280.31
2	7026.321
1	4314.666

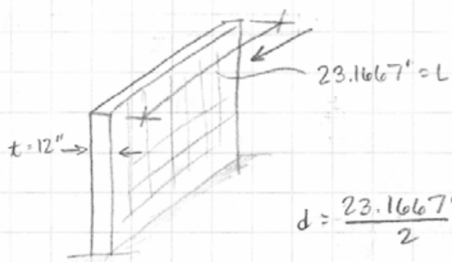
APPENDIX F

Strength Check on Selected Critical Shear Walls

Wall D - North-South Directed Wind







Base M = 77715.66 ft·kip for Wall D

$d = \frac{23.1667'}{2} = 11.58'$

M@d = 6982.18 kip·ft

$\text{Req'd } M_n = \frac{M_u}{\Phi} = \frac{77715.66 \text{ kip·ft}}{0.9} = 86530.73 \text{ kip·ft}$

Actual steel → (22) #11's on lower 15 floors, (vertical)
(22) #9's on 15th - roof

(For simplicity, consider consistent #11's and $f'_c = 6000$ psi)

$A_s = (22)(1.39 in^2) = 30.58 in^2$

$a = \frac{A_s f_y}{0.85 f'_c b} = \frac{(30.58 in^2)(60 ksi)}{0.85(5 ksi)(12")} = 35.98"$

Ductility Check

$d = 11.58' \, (12^{in}/ft) = 138.96''$

$\beta_1 = 0.75$ for $f'c = 6$ ksi

$c = a/\beta_1 = \frac{35.98''}{0.75} = 48'' < 0.375(138.96'') = 52.11''$

Use $\Phi = 0.9$

$\Phi M_n = (\Phi) A_s f_y (d - a/2)$

$= (0.9)(30.58 in^2)(60 ksi)\left(138.96'' - \frac{35.98''}{2}\right) = 199760.18$ kip·in

$= 16646.68$ kip·ft

$\Phi M_n <$ Req'd M_n (Not OK)

Check shear

$V_{max} = 679.06$ kip $= V_u$

$V_c = \frac{1}{2}(2)(\sqrt{f'c})(b_w)(d) = 129.17$ kip

Req'd $V_s = \frac{V_u}{\Phi} + V_c = \frac{679.06k}{0.75} - 129.17k = 776.3$ kip

Actual Steel → #4 @ 12" → $A_v = 0.2 in^2$

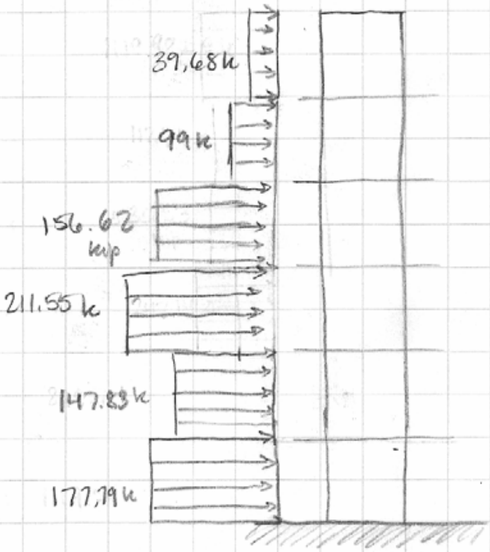
Actual $V_s = A_v f_y (d/s) = 4(0.2 in^2)(60 ksi)\left(\frac{138.96''}{12''}\right) = 555.84$ kip

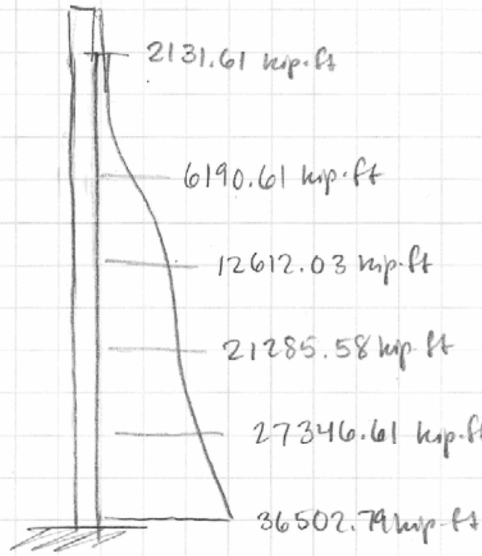
Actual $V_s <$ Req'd V_s (Not OK)

Since neither strength check worked in this case, I believe that there are two factors not accounted for that can aid lateral resistant capacity:

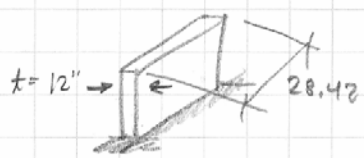
1) Concrete columns (not in scope of this report)
2) The axial load provided by the live and dead loads

Wall G → W-E Directed Wind





V (determined through Dist. by Rigidity)



Base $M = 36502.79$ ft·kip $= M_u$

Req'd $M_n = \frac{36502.79 \text{ ft·kip}}{0.9} = 40558.66$ ft·kip

Actual steel → #9 @ 12"

$\frac{23.16667'}{1'} \cong 24$ bars

$A_s = 24(1in^2) = 24 in^2$

$a = \frac{A_s f_y}{0.85 f'_c b} = \frac{(24in^2)(60ksi)}{0.85(6ksi)(12")} = 23.53"$

Ductility check

$d = 28.42'/2 = 14.21'(12in/ft) = 170.52"$

$c = \frac{23.52"}{0.75} = 31.36" < 0.375(170.52") = 63.95"$

$\Phi M_n = (0.9)(24in^2)(60ksi)(170.52" - \frac{63.95"}{2}) = 179554.32$ kip·in

$= 14962$ kip·ft

Not OK

Check shear

$V_{max} = 211.55 \text{ kip} = V_u$

$V_c = \frac{1}{2}(2)(\sqrt{f'_c})(b_w)(d) = (\sqrt{6000})(12")(170.52") = 158.5 \text{ kip}$

Req'd $V_s = V_u/\Phi + V_c = \frac{211.55 \text{ kip}}{0.75} + 158.5 \text{ k} = 440.57 \text{ kip}$

Actual Steel → #4 @ 12" per floor → $A_v = 0.2 \text{ in}^2$

Actual $V_s = (4)(0.2 \text{ in}^2)(60 \text{ ksi})\left(\frac{170.52"}{12"}\right) = 682.08 \text{ kip} > 441 \text{ kip}$

Meets shear requirements

Once again, it appears that the axial loading provided by DL + LL needs to be considered to achieve a comprehensive analysis of lateral resistance in each wall.

APPENDIX G

Story Drift and Shear Wall Drift Calculations

Allowable Story Drift: (BOCA 1996, Table 1610.3.8 – Exposure Group II, "All other buildings")

Allowable Story Drift: $\Delta_a = 0.015(h_{sx})$			
Level	**h_{sx} (ft)**	**Δ_a (ft)**	**Δ_a (in)**
Roof	279.22	4.19	50.26
25	269.22	4.04	48.46
24	259.39	3.89	46.69
23	247.36	3.71	44.52
22	236.00	3.54	42.48
21	225.75	3.39	40.64
20	215.50	3.23	38.79
19	205.25	3.08	36.95
18	195.00	2.93	35.10
17	184.75	2.77	33.26
16	174.50	2.62	31.41
15	164.25	2.46	29.57
14	154.00	2.31	27.72
13	143.75	2.16	25.88
12	133.50	2.00	24.03
11	123.25	1.85	22.19
10	113.00	1.70	20.34
9	102.75	1.54	18.50
8	92.50	1.39	16.65
7	82.25	1.23	14.81
6	72.00	1.08	12.96
5	61.75	0.93	11.12
4	51.50	0.77	9.27
3	41.25	0.62	7.43
2	31.00	0.47	5.58
1	10.50	0.16	1.89

Actual Story Drift Approximations

Using the approximation that the entire building can be treated as a very tall and wide shear wall (since most of the main structural features are reinforced or post-tensioned concrete) and using:

$$\Delta = (Ph^3/3EI) + (2.78Ph/A_{wall}E)$$

The following drift values are based on the story shears provided by the wind loading in the North-South direction:

Level	F (kips)	Elev (ft)	t (ft)	L (ft)	A (ft^2)	I (ft^4)	f'c (psi)	E (k/ft^2)	Δ (in)
Roof	76.99	279.22	172.5	72.1667	12448.76	5402794	5000	598876.7	0.000173
25	75.26	269.22	172.5	72.1667	12448.76	5402794	5000	598876.7	0.000152
24	91.90	259.39	172.5	72.1667	12448.76	5402794	5000	598876.7	0.000166
23	86.04	247.36	172.5	72.1667	12448.76	5402794	5000	598876.7	0.000135
22	77.19	236	172.5	72.1667	12448.76	5402794	5000	598876.7	0.000105
21	76.74	225.75	172.5	72.1667	12448.76	5402794	5000	598876.7	9.15E-05
20	76.02	215.5	172.5	72.1667	12448.76	5402794	5000	598876.7	7.89E-05
19	75.65	205.25	172.5	72.1667	12448.76	5402794	5000	598876.7	6.79E-05
18	75.20	195	172.5	72.1667	12448.76	5402794	5000	598876.7	5.79E-05
17	74.59	184.75	172.5	72.1667	12448.76	5402794	5000	598876.7	4.89E-05
16	74.24	174.5	172.5	72.1667	12448.76	5402794	5000	598876.7	4.1E-05
15	73.62	164.25	172.5	72.1667	12448.76	5402794	5000	598876.7	3.4E-05
14	73.05	154	172.5	72.1667	12448.76	5402794	5000	598876.7	2.78E-05
13	72.43	143.75	172.5	72.1667	12448.76	5402794	5000	598876.7	2.25E-05
12	71.79	133.5	172.5	72.1667	12448.76	5402794	5000	598876.7	1.79E-05
11	70.86	123.25	172.5	72.1667	12448.76	5402794	5000	598876.7	1.39E-05
10	70.20	113	172.5	72.1667	12448.76	5402794	5000	598876.7	1.07E-05
9	69.25	102.75	172.5	72.1667	12448.76	5402794	5000	598876.7	7.96E-06
8	71.73	92.5	180.75	104.4167	18873.31	17147728	6000	656036.6	1.81E-06
7	70.58	82.25	180.75	104.4167	18873.31	17147728	6000	656036.6	1.27E-06
6	69.41	72	180.75	104.4167	18873.31	17147728	6000	656036.6	8.61E-07
5	68.21	61.75	180.75	104.4167	18873.31	17147728	6000	656036.6	5.55E-07
4	66.67	51.5	180.75	104.4167	18873.31	17147728	6000	656036.6	3.34E-07
3	65.07	41.25	180.75	104.4167	18873.31	17147728	6000	656036.6	1.86E-07
2	126.68	31	180.75	104.4167	18873.31	17147728	6000	656036.6	1.85E-07
1	59.93	10.5	180.75	104.4167	18873.31	17147728	6000	656036.6	1.38E-08

For the wind loading in the West-East direction:

Level	F (kips)	Elev (ft)	t (ft)	L (ft)	A (ft2)	I (ft4)	f'c (psi)	E (k/SF)	Δ (in)
Roof	27.25	279.22	72.17	172.50	12448.76	5402793.80	5000.00	598876.73	6.14E-05
25	26.61	269.22	72.17	172.50	12448.76	5402793.80	5000.00	598876.73	5.37E-05
24	32.48	259.39	72.17	172.50	12448.76	5402793.80	5000.00	598876.73	5.87E-05
23	30.37	247.36	72.17	172.50	12448.76	5402793.80	5000.00	598876.73	4.76E-05
22	27.21	236.00	72.17	172.50	12448.76	5402793.80	5000.00	598876.73	3.7E-05
21	27.03	225.75	72.17	172.50	12448.76	5402793.80	5000.00	598876.73	3.22E-05
20	26.73	215.50	72.17	172.50	12448.76	5402793.80	5000.00	598876.73	2.77E-05
19	26.57	205.25	72.17	172.50	12448.76	5402793.80	5000.00	598876.73	2.38E-05
18	26.38	195.00	72.17	172.50	12448.76	5402793.80	5000.00	598876.73	2.03E-05
17	26.12	184.75	72.17	172.50	12448.76	5402793.80	5000.00	598876.73	1.71E-05
16	25.98	174.50	72.17	172.50	12448.76	5402793.80	5000.00	598876.73	1.44E-05
15	25.72	164.25	72.17	172.50	12448.76	5402793.80	5000.00	598876.73	1.19E-05
14	25.48	154.00	72.17	172.50	12448.76	5402793.80	5000.00	598876.73	9.71E-06
13	25.22	143.75	72.17	172.50	12448.76	5402793.80	5000.00	598876.73	7.83E-06
12	24.95	133.50	72.17	172.50	12448.76	5402793.80	5000.00	598876.73	6.22E-06
11	24.57	123.25	72.17	172.50	12448.76	5402793.80	5000.00	598876.73	4.83E-06
10	24.29	113.00	72.17	172.50	12448.76	5402793.80	5000.00	598876.73	3.7E-06
9	23.89	102.75	72.17	172.50	12448.76	5402793.80	5000.00	598876.73	2.75E-06
8	34.09	92.50	104.42	180.75	18873.31	17147727.62	6000.00	656036.59	8.58E-07
7	33.43	82.25	104.42	180.75	18873.31	17147727.62	6000.00	656036.59	6.03E-07
6	32.75	72.00	104.42	180.75	18873.31	17147727.62	6000.00	656036.59	4.06E-07
5.00	32.05	61.75	104.42	180.75	18873.31	17147727.62	6000.00	656036.59	2.61E-07
4.00	31.17	51.50	104.42	180.75	18873.31	17147727.62	6000.00	656036.59	1.56E-07
3.00	30.24	41.25	104.42	180.75	18873.31	17147727.62	6000.00	656036.59	8.62E-08
2.00	58.48	31.00	104.42	180.75	18873.31	17147727.62	6000.00	656036.59	8.55E-08
1.00	27.09	10.50	104.42	180.75	18873.31	17147727.62	6000.00	656036.59	6.25E-09

Shear Wall Deflection Calculations

$$\Delta = (Ph^3/3EI) + (2.78Ph/A_{wall}E)$$

Shear Wall Deflection: First Group of Floors for N-S Wind Direction						
Wall	t (in)	L (ft)	A (in^2)	I (in^4)	P (kips)	Delta (in)
A	16	25	4800	36000000	1115.19	0.623
B	12	14.5	2088	5268024	0.51	0.002
C	12	14.5	2088	5268024	0.28	0.001
D	12	23.1667	3336.005	21485044.7	679.06	0.623
E	16	9.25	1776	1823508	66.63	0.645
F	12	9.25	1332	1367631	50.20	0.648
G	12	28.42	4092.48	39665776.4	0.25	0.000
H	12	8.93	1285.92	1230546.74	45.31	0.649
J	9	19.3333	2087.996	9365327.56	310.60	0.629
K	12	6.08333	875.9995	389016.361	14.35	0.643
L	12	6.307	908.208	433523.088	0.02	0.001
M	12	7.47	1075.68	720286.945	0.08	0.002
N	24	19.927	5738.976	27346358.1	918.57	0.640
O	24	14.708	4235.904	10995996.6	407.79	0.677
P	12	8.8333	1271.995	1191002.52	0.17	0.003
Q	12	19.1667	2760.005	12167063.5	159.59	0.248
R	12	8.8333	1271.995	1191002.52	0.31	0.005
S	12	19.1667	2760.005	12167063.5	160.09	0.249
				Sum of N-S Walls:		6.274
				Sum of W-E Walls:		0.013

Shear Wall Deflection: Second Group of Floors for N-S Wind Direction						
Wall	**t (in)**	**L (ft)**	**A (in^2)**	**I (in^4)**	**P (kips)**	**Delta (in)**
A	16	25	4800	36000000	895.35	0.273
B	12	14.5	2088	5268024	0.75	0.001
C	12	14.5	2088	5268024	0.41	0.001
D	12	23.1667	3336.005	21485044.7	534.35	0.265
E	16	9.25	1776	1823508	46.66	0.231
F	12	9.25	1332	1367631	35.32	0.233
G	12	28.42	4092.48	39665776.4	0.45	0.000
H	12	8.93	1285.92	1230546.74	31.99	0.234
J	9	19.3333	2087.996	9365327.56	237.87	0.256
K	12	6.08333	875.9995	389016.361	10.00	0.227
L	12	6.307	908.208	433523.088	0.01	0.000
M	12	7.47	1075.68	720286.945	0.02	0.000
N	24	19.927	5738.976	27346358.1	704.26	0.261
O	24	14.708	4235.904	10995996.6	283.18	0.244
P	12	8.8333	1271.995	1191002.52	0.05	0.000
Q	12	19.1667	2760.005	12167063.5	125.46	0.103
R	12	8.8333	1271.995	1191002.52	0.09	0.001
S	12	19.1667	2760.005	12167063.5	312.52	0.258
				Sum of N-S Walls:		2.585
				Sum of W-E Walls:		0.004

Shear Wall Deflection: Third Group of Floors for N-S Wind Direction						
Wall	**t (in)**	**L (ft)**	**A (in^2)**	**I (in^4)**	**P (kips)**	**Delta (in)**
A	16	25	4800	36000000	242.14	0.081
B	12	14.5	2088	5268024	14.86	0.029
C	12	14.5	2088	5268024	8.09	0.016
D	12	23.1667	3336.005	21485044.7	144.51	0.078
E	16	9.25	1776	1823508	39.47	0.214
F	12	9.25	1332	1367631	35.22	0.254
G	12	28.42	4092.48	39665776.4	8.97	0.003
H	12	8.93	1285.92	1230546.74	35.94	0.288
J	9	19.3333	2087.996	9365327.56	237.76	0.280
K	12	6.08333	875.9995	389016.361	8.42	0.210
L	12	6.307	908.208	433523.088	0.02	0.001
M	12	7.47	1075.68	720286.945	0.08	0.001
				Sum of N-S Walls:		1.405
				Sum of W-E Walls:		0.050

Shear Wall Deflection: Fourth Group of Floors for N-S Wind Direction						
Wall	**t (in)**	**L (ft)**	**A (in^2)**	**I (in^4)**	**P (kips)**	**Delta (in)**
A	16	25	4800	36000000	535.65	0.179
B	12	14.5	2088	5268024	0.85	0.002
C	12	14.5	2088	5268024	0.46	0.001
D	12	23.1667	3336.005	21485044.7	224.00	0.122
E	16	9.25	1776	1823508	28.69	0.156
F	12	9.25	1332	1367631	21.84	0.158
G	12	28.42	4092.48	39665776.4	0.51	0.000
H	12	8.93	1285.92	1230546.74	19.89	0.159
J	9	19.3333	2087.996	9365327.56	149.36	0.176
K	12	6.08333	875.9995	389016.361	6.33	0.158
L	12	6.307	908.208	433523.088	0.04	0.001
M	12	7.47	1075.68	720286.945	0.13	0.002
				Sum of N-S Walls:		1.107
				Sum of W-E Walls:		0.005

Shear Wall Deflection: Fifth Group of Floors for N-S Wind Direction						
Wall	**t (in)**	**L (ft)**	**A (in^2)**	**I (in^4)**	**P (kips)**	**Delta (in)**
A	16	25	4800	36000000	112.72	0.038
B	12	14.5	2088	5268024	6.92	0.014
C	12	14.5	2088	5268024	3.77	0.007
D	12	23.1667	3336.005	21485044.7	67.27	0.037
E	16	9.25	1776	1823508	18.37	0.100
F	12	9.25	1332	1367631	16.39	0.118
G	12	28.42	4092.48	39665776.4	4.17	0.001
H	12	8.93	1285.92	1230546.74	16.73	0.134
J	9	19.3333	2087.996	9365327.56	110.68	0.130
K	12	6.08333	875.9995	389016.361	5.61	0.140
L	12	6.307	908.208	433523.088	0.31	0.007
M	12	7.47	1075.68	720286.945	1.03	0.014
				Sum of N-S Walls:		0.696
				Sum of W-E Walls:		0.043

Shear Wall Deflection: Sixth Group of Floors for N-S Wind Direction						
Wall	t (in)	L (ft)	A (in^2)	I (in^4)	P (kips)	Delta (in)
A	16	25	4800	36000000	92.59	0.064
B	12	14.5	2088	5268024	1.42	0.006
C	12	14.5	2088	5268024	0.77	0.003
D	12	23.1667	3336.005	21485044.7	55.26	0.062
E	16	9.25	1776	1823508	7.28	0.088
F	12	9.25	1332	1367631	6.00	0.096
G	12	28.42	4092.48	39665776.4	0.85	0.001
H	12	8.93	1285.92	1230546.74	5.80	0.103
J	9	19.3333	2087.996	9365327.56	40.75	0.102
K	12	6.08333	875.9995	389016.361	1.90	0.106
L	12	6.307	908.208	433523.088	0.06	0.003
M	12	7.47	1075.68	720286.945	0.41	0.012
				Sum of N-S Walls:		0.620
				Sum of W-E Walls:		0.026

APPENDIX H

Overturning Moments

Based on Controlling Case: N-S Wind			
Level	**F (kips)**	**Elev (ft)**	**M (kip-ft)**
Roof	76.99	279.22	21497.67
25	75.26	269.22	20261.76
24	91.90	259.39	23837.14
23	86.04	247.36	21283.05
22	77.19	236.00	18216.21
21	76.74	225.75	17323.84
20	76.02	215.50	16382.7
19	75.65	205.25	15527.32
18	75.20	195.00	14663.08
17	74.59	184.75	13780.05
16	74.24	174.50	12955.49
15	73.62	164.25	12092.5
14	73.05	154.00	11249.54
13	72.43	143.75	10412.19
12	71.79	133.50	9583.761
11	70.86	123.25	8733.449
10	70.20	113.00	7932.576
9	69.25	102.75	7115.731
8	71.73	92.50	6635.326
7	70.58	82.25	5805.454
6	69.41	72.00	4997.342
5	68.21	61.75	4211.767
4	66.67	51.50	3433.753
3	65.07	41.25	2684.328
2	126.68	31.00	3926.951
1	59.93	10.50	629.2253
Total Overturning M (kip-ft) =			295172.2

$T_{overturning} = C_{overturning}$ = Moment/Span = (295,172.2 kip/ft)/(182.72 ft) = 1633.041 kip
C_{weight} = (Weight/2) = (54470 kips)/2 = 27235 kips

Since $C_{weight} > C_{overturning}$, the weight of the building eliminates chance of overturning