Technical Report #3

Lateral System Analysis

Three PNC Plaza

Pittsburgh, PA

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EXECUTIVE SUMMARY

The third technical report for Three PNC Plaza focuses on the lateral system of the building. The report buildings on the lateral loads for both wind and seismic found in the first technical report. The lateral force resisting system for Three PNC Plaza consists of several concrete core shear walls along with a steel structure. Different load combinations according to ASCE7-10 were studied and used for the calculations. The load cases studied in this report consist of Wind Case 1, Wind Case 2, and the Seismic Load Case.

The shear walls were analyzed for both direct and torsional effects produced by the lateral loads. These calculations were done by applying the wind loads at the Center of Pressure and the Seismic Loads at the Center of Mass. The Center of Rigidity was found using relative stiffness and loads were calculated around this point. Relative stiffness was found by both hand calculations and 2D computer models. It was assumed that the computer model values were the more accurate of the two and use for calculations.

Spot checks were performed on critical members of the shear wall system. This resulted in Shear Wall 23 having the largest load and being analyzed in accordance to ACI 318. Hand calculations were performed to find typical reinforcement need and compared to actual reinforcing found in the wall. Along with shear reinforcement, the overturning effect of the wall was calculated to find its effects on the foundation of the building.

The critical Shear Wall was checked for drift utilizing a 2D SAP model. The model was meshed at a maximum size of divided objects to 24” and edge constraints were added to improve the accuracy of the model. These values were compared to allowable story drift in accordance to ASCE7.

INTRODUCTION

Three PNC Plaza is a 23 story, 780,000 square foot, mixed use high-rise building located in the heart of downtown Pittsburgh, Pennsylvania as seen in figure 2 highlighted in red. The erection of this building was a significant part to revitalizing the downtown area and marked the first new high-rise built in the city in the last 20 years.

Figure 1- Three PNC Occupancy Layout

The building is mixed-use and allows for several different tenants occupy the building as seen in figure 1. Fairmont Hotels and Resorts move into the building in March, 2010 with 185 rooms that are located on floors 14 through 23. Along with the Fairmont Hotels, 28 Residences condominium units will occupy floors 14 through 23 in the fall of 2010. The building has 10 floors of office space located from the 3rd through 13th floor. These office spaces are home to PNC Bank and the REED Smith Law Firm. The lower floors of the building house several different retail stores, restaurant, and wine bar.

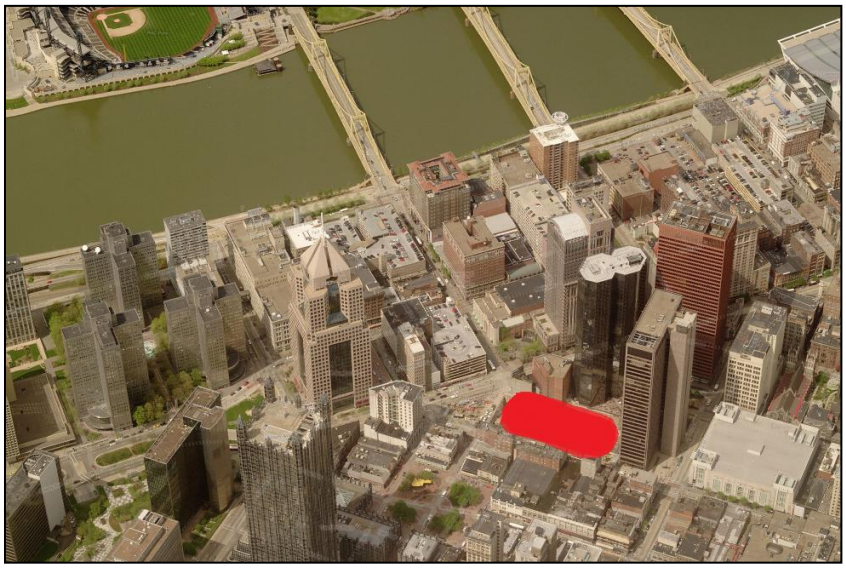


Figure 2- Three PNC Site Location

STRUCUTURE OVERVIEW

Foundation System

Pittsburgh is known for alluvial deposits which mean shallow foundations were not possible and deep foundations were required for Three PNC Plaza. Also, the Pittsburgh area soil overburden is 60' to bedrock. This means that after the 30' of excavation for the buildings parking garage structure, 30' of soil would still remain until the bedrock would be reached. Several different options for the foundation of the building were considered such as; auger cast pile, piles, H-piles, and caissons. Ultimately, the foundation system chosen for Three PNC Plaza were caissons bearing on bedrock to achieve maximum axial capacity. Four different size caissons were chosen for the foundation as seen in the Caisson Schedule in figure 3. The caissons were designed for a typical column reaction of 3500 kips. Brayman Construction Corporation was in charge of the installation of the 121 caissons for the building. A typical caisson detail has been provided in figure 2. The caissons bearing value is 15 tons per square foot and were drilled to auger refusal or socketed into the bedrock. The layout for the caissons can be seen in figures 5 and 6 located on the next page.

CAISSONS $F_{BR.}$ = 30K/SQ. FT.

MARK	SIZE Ø	VERT.REINF. length=3 X DIA.	TIES	DOWELS
A.	48"	7–#10	#4@18" O.C.	4–#8 X 8'–0" DEVELOP INTO PEDESTAL
B.	54"	9–#10	#4@18" O.C.	
C.	42"	7–#9	#3@18" O.C.	
D.	60"	9–#11	#3@18" O.C.	

Figure 3- Caisson Schedule

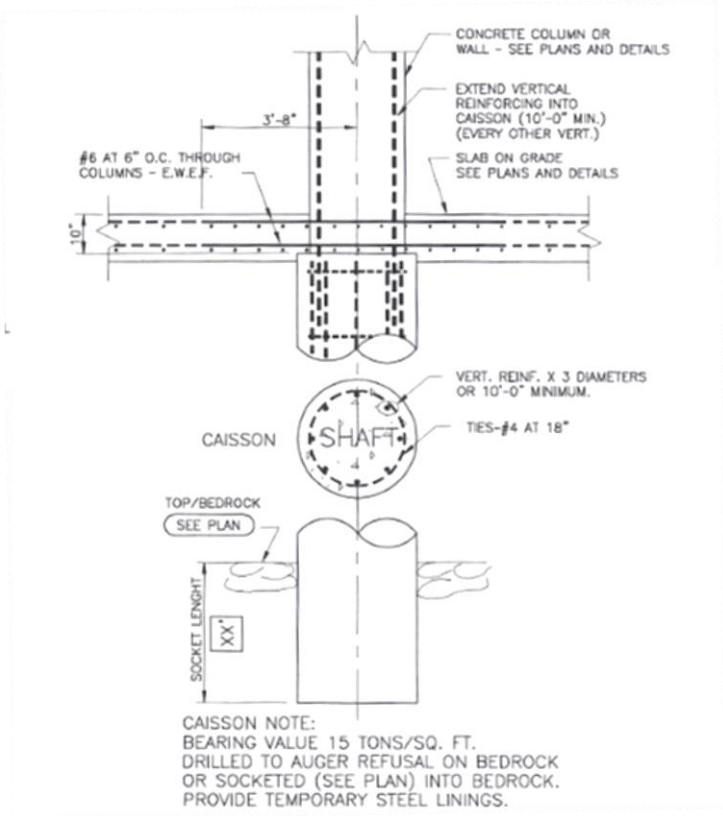
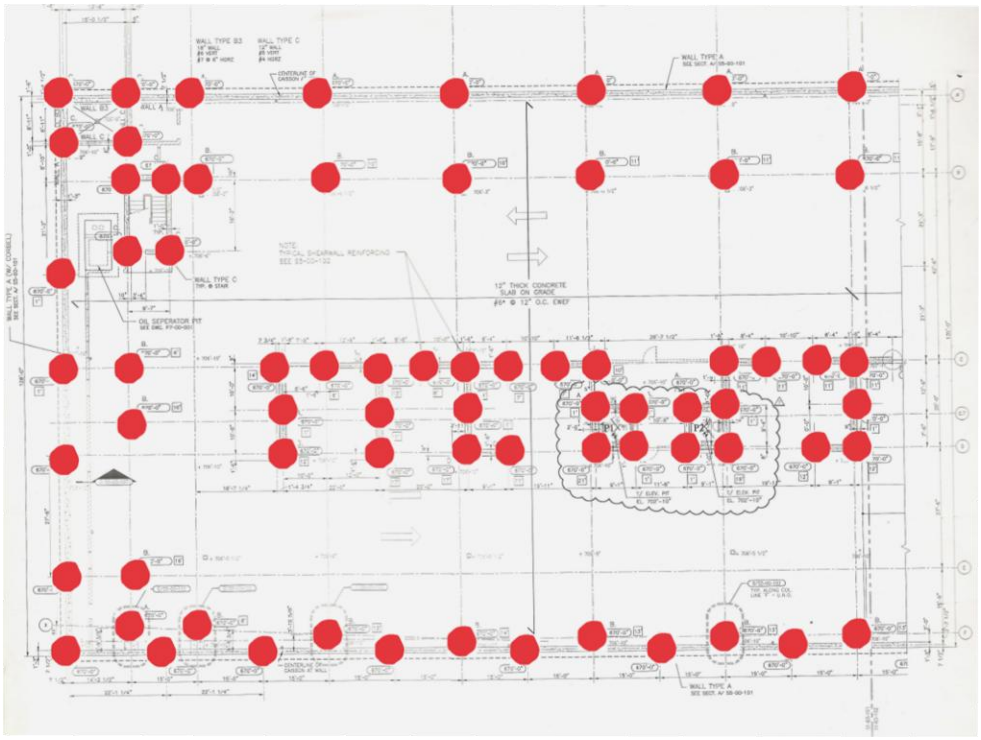
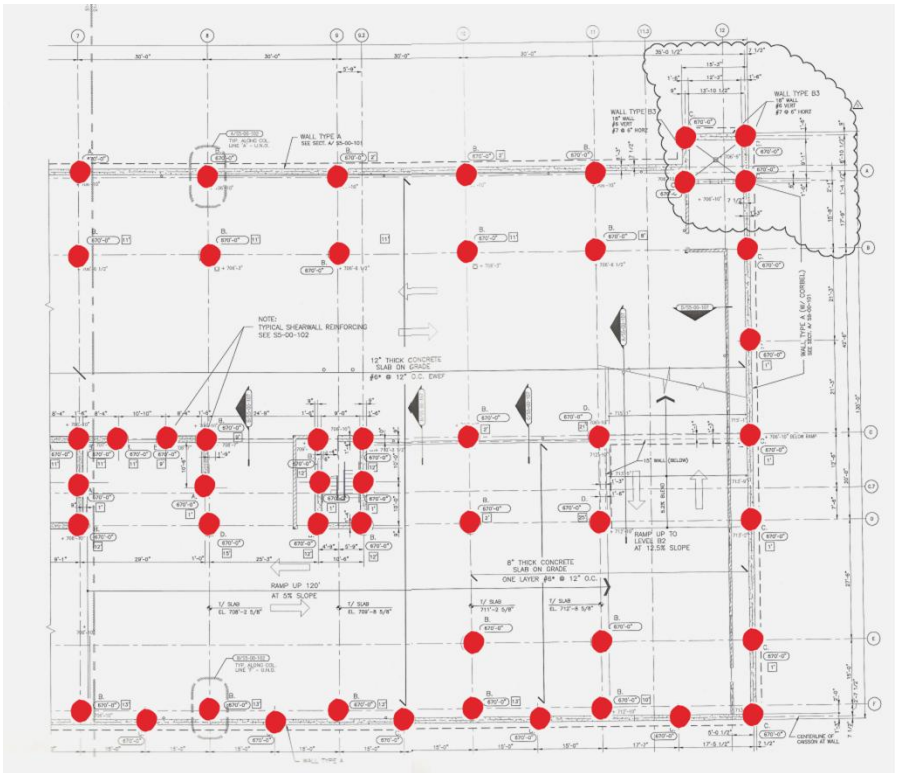


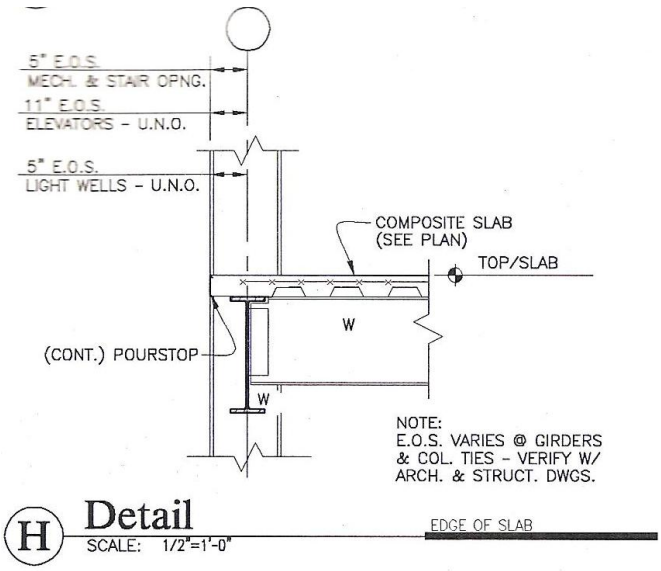
Figure 4- Caisson Detail





Floor System

Three PNC Plaza uses a composite steel and concrete floor system with a typical bay size of 30'-0" x 42'-6". The composite slab is composed of 2" 18-gauge metal floor deck with 3-½" light weight concrete, netting a total thickness of 5-½". The concrete is reinforced with one layer of 6x6-W2.1xW2.1 wielded wire fabric. The composite deck transfers its load to fill beams that are placed at 10'-0" on center and primarily W21X44 beams with W24X62 girders. This floor design is used throughout the structure and different sized fill beams are used to deal with higher load areas.



Columns

Three PNC Plaza uses a variety of steel columns and concrete shear walls to support the gravity load of the building. The size of these columns can range in sizes from W14x68 all the way to a W14x740 in some cases. The core of the building is supported by concrete shear walls up until the 14th floor which they then switch over to steel columns. The remainder of the building is supported by steel columns from the ground floor that attach to concrete columns located in the parking garage. The steel columns attach to the concrete shear wall via reinforced corbels. The steel columns in the building are spliced together at a typical distance of 24'-0" as see in figure 8.

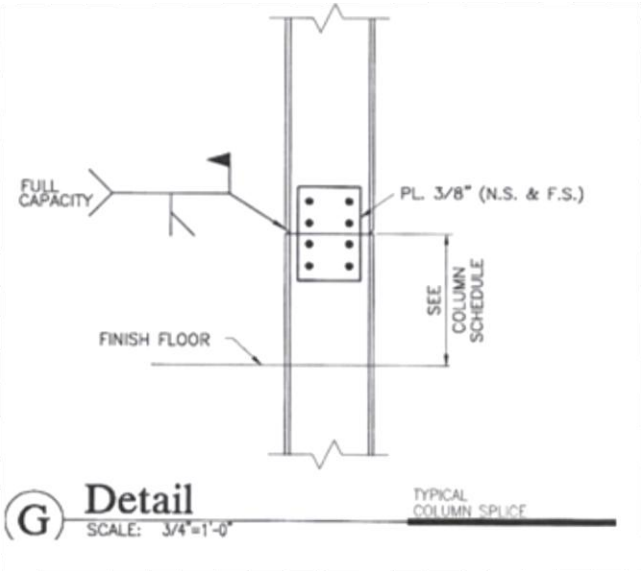


Figure 8- Splice Detail

Lateral System

The main lateral resistant system used in Three PNC Plaza is a combination of several concrete shear walls. These shear walls are located throughout the core of the building and encase the stairwells and elevators as seen in figure 9 highlighted in red. The shear walls start at the lowest level of the parking garage structure and extend up until the 14th floor where they are met with steel columns. All of the shear walls used a concrete with a compressive strength of 5000 ksi. The reinforcement for the shear walls changed depending on the location and can be seen in the shear wall Reinforcement schedule located in Appendix D. A more detailed view of the shear walls at key locations of the wall can be in figures 10-13. Once the building rises above the 14th floor the steel structure assumes the responsibilities for the lateral loads. The main lateral resisting system located above the shear walls could not be determined from provided plans. Information has been requested to investigate this further.

Figure 9- Shear Wall Layout

Roof System

The roof structural system is very similar to the floor structural system used throughout the building. It utilizes the same composite deck and slab configuration along with same typical bay dimensions. However, the fill beams are spaced closer together, at a typical spacing of 7.5 feet. These fill beams can differ in size from a W21x44 to a W27x129.

CODES AND REFERENCES

Design Codes Used:

1. International Building Code 2003
2. AISC Manual of Steel Construction Ninth Edition (ASD)
3. AISC Manual of Steel Construction Load and Resistance Factor Design Second Edition
4. ACI 318 American Concrete Institute Building Code Requirements for Structural Concrete
5. ASCE 7-98 Minimum Design Loads for Buildings and Other Structures

Thesis Codes Used:

1. International Building Code, IBC 2010
2. American Society of Civil Engineers, ASCE 7-10
3. AISC Manual of Steel Construction Thirteenth Edition (LRFD)
4. Building Code Requirements for Structural Concrete (ACI 318-08) and Commentary

MATERIAL STRENGTHS

Concrete

Location	Strength f'c
Columns	10000 psi
Interior Slab on Grade	5000 psi
Caissons and Grade Beams	5000 psi
Retaining Walls	5000 psi
Post Tension Slabs	5000 psi
Beams with PT Slab	5000 psi
Core Walls	5000 psi
Exterior Slab on Grade	4000 psi
Exterior topping Slabs	4000 psi
Composite Slab Fill	3000 psi
Footings and Misc.	3000 psi

Structural Steel

Type	Standard	Grade
W Shapes	ASTM A992	50 ksi
S,M, and HP Shapes	ASTM A36	
Tubes	ASTM A500	Class B
Channels	ASTM A36	
Angles	ASTM A36	

Plates	ASTM A36

LOADINGS

Location	Design (IBC 2003)	Thesis (ASCE 7-10)
Retail	100 psf	100 psf
Office	50 psf	50 psf
Library	150 psf	150 psf
Hotel	40 psf	40 psf
Condominium	40 psf	40 psf
Ballroom	100 psf	100 psf
Garage	40 psf	40 psf
Mechanical Rooms	200 psf	-
Assembly Areas	100 psf	Depends on Area
Balconies	100 psf	1.5*Live Load
Restaurants	100 psf	-
Roof	30 psf	20 psf
Stairs and Lobby	100 psf	100 psf
Corridors	80 psf	80 psf

Floor Dead Loads	
Composite Decking	44 psf
Superimposed Dead Load	30 psf
Total	**74 psf**

Curtain Wall Dead Load:

Assumed curtain wall was 8" thick and that the material weighted 40psf. This resulted in a load of 60plf.

Wind Load Analysis

Wind load analysis for the Main Wind-Force Resisting System in Three PNC Plaza was determined using ASCE 7-10. The analysis was calculated for both North-South, and East-West directions using the enclosed and partially enclosed section in Chapter 27 of ASCE 7-10.

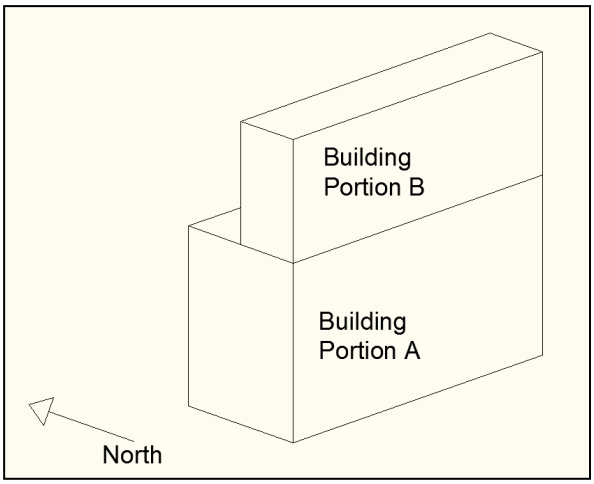


Figure 10- Building Portions

The first step in the wind calculations was determining if Three PNC Plaza should be calculated under the assumption of a rigid structure or a flexible structure. This was determined by finding the natural frequency of the building according to ASCE 7-10 Chapter 12 section 8. It was found that the natural frequency from the calculations was less than 1 resulting in the building being defined as a flexible structure.

When running the calculations for the wind load the building was simplified into two distinct portions to account for the buildings shape as seen in figure 15. It was also assumed that the small cutout of the building along the front portion 14th floor would be modeled as if it was filled. From the calculations that were performed in an excel spread sheet you can see that the North-South direction produces the strongest wind forces due to the larger surface area.

The last part of the analysis was the base shear and overturning moment calculations. Tables for these calculations have been provided along with a typical hand worked solution in appendix A to see the math involved. These values can be compared to the results from the seismic calculations to determine the governing lateral force to use during design.

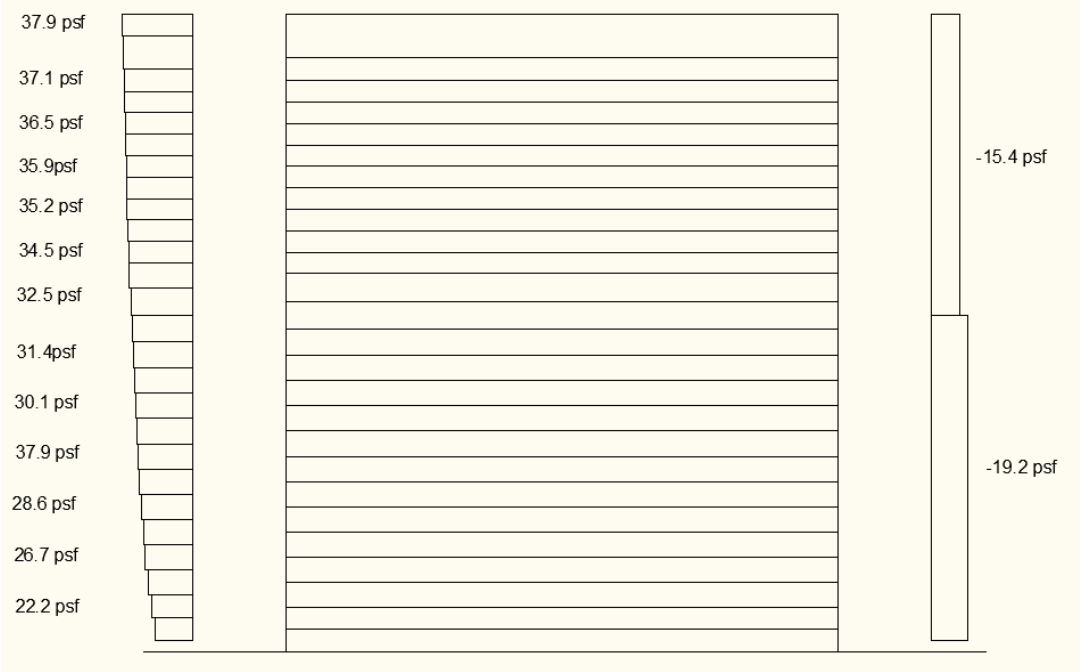


Figure 11- East/West Wind Distribution

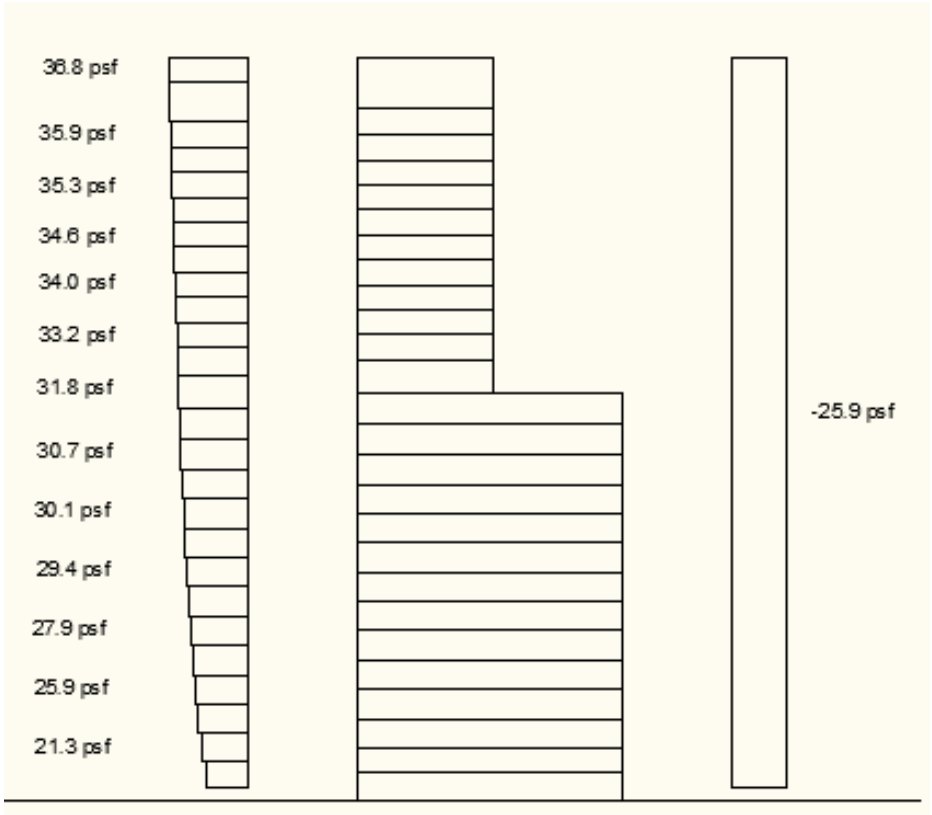


Figure 12- North/South Wind Distribution 1

*Some values not shown to allow for easy reading.

North/South

Story	Height (ft)	kz or kh	qz	Windward (psf)	Windward (plf)	Windward (kips)	Leeward (psf)	Leeward (plf)	Leeward (kips)	Story Force (kips)	Moment (k-ft)
Building Portion A											
1mezz	12.5	0.5700	17.8606	19.5169	5796.5228	36.3386	-25.9635	-7711.1691	-46.2670	82.6056	1032.5698
2	24.0	0.6520	20.4300	21.3432	6338.9335	38.0589	-25.9635	-7711.1691	-48.1948	86.2537	2070.0891
2mezz	37.5	0.7450	23.3441	23.3311	6929.3223	44.7804	-25.9635	-7711.1691	-52.0504	96.8308	3631.1533
3	51.0	0.8140	25.5062	24.7911	7362.9656	48.2365	-25.9635	-7711.1691	-52.0504	100.2869	5114.6300
4	64.5	0.8680	27.1983	25.9259	7699.9949	50.8375	-25.9635	-7711.1691	-52.0504	102.8879	6636.2685
5	78.0	0.9220	28.8903	27.0530	8034.7497	53.1048	-25.9635	-7711.1691	-52.0504	105.1552	8202.1021
6	91.5	0.9645	30.2220	27.9364	8297.1251	55.1201	-25.9635	-7711.1691	-52.0504	107.1705	9806.0979
7	105.0	1.0025	31.4127	28.7231	8530.7504	56.7941	-25.9635	-7711.1691	-52.0504	108.8445	11428.6695
8	118.5	1.0363	32.4703	29.4190	8737.4353	58.2801	-25.9635	-7711.1691	-52.0504	110.3305	13074.1664
9	132.0	1.0700	33.5278	30.1130	8943.5628	59.6734	-25.9635	-7711.1691	-52.0504	111.7238	14747.5363
10	145.5	1.1010	34.4992	30.7484	9132.2840	61.0060	-25.9635	-7711.1691	-52.0504	113.0564	16449.7024
11	159.0	1.1280	35.3452	31.2996	9295.9857	64.5194	-25.9635	-7711.1691	-53.9782	118.4976	18841.1168
12	173.5	1.1570	36.2539	31.8905	9471.4772	68.0321	-25.9635	-7711.1691	-55.9060	123.9380	21503.2480
13	188.0	1.1820	37.0373	32.3975	9622.0429	70.4168	-25.9635	-7711.1691	-56.8699	127.2866	23929.8879
Building Portion B											
14	203.0	1.2048	37.7517	32.8887	9767.9585	64.1655	-25.9635	-7711.1691	-51.0865	115.2520	23396.1635
15	214.5	1.2232	38.3282	33.2600	9878.2203	56.4828	-25.9635	-7711.1691	-44.3392	100.8220	21626.3161
16	226.0	1.2416	38.9048	33.6309	9988.3703	57.1164	-25.9635	-7711.1691	-44.3392	101.4557	22928.9815
17	237.5	1.2600	39.4813	34.0014	10098.4172	57.7495	-25.9635	-7711.1691	-44.3392	102.0887	24246.0749
18	249.0	1.2784	40.0579	34.3716	10208.3683	58.3820	-25.9635	-7711.1691	-44.3392	102.7212	25577.5864
19	260.5	1.2947	40.5686	34.6980	10305.3196	58.9769	-25.9635	-7711.1691	-44.3392	103.3161	26913.8376
20	272.0	1.3108	41.0731	35.0201	10400.9685	59.5306	-25.9635	-7711.1691	-44.3392	103.8698	28252.5858
21	283.5	1.3269	41.5776	35.3419	10496.5495	60.0804	-25.9635	-7711.1691	-44.3392	104.4196	29602.9528
22	295.0	1.3430	42.0821	35.6635	10592.0666	60.6298	-25.9635	-7711.1691	-44.3392	104.9690	30965.8531
23	306.5	1.3578	42.5458	35.9581	10679.5446	63.8258	-25.9635	-7711.1691	-46.2670	110.0928	33743.4380
Roof Main	319.0	1.3728	43.0159	36.2556	10767.9035	95.2890	-25.9635	-7711.1691	-68.4366	163.7256	52228.4816
Roof High	342.0	1.4004	43.8807	36.8025	10930.3534	61.9154	-25.9635	-7711.1691	-44.3392	106.2547	36339.0962
									Sum=	2813.86	512288.61

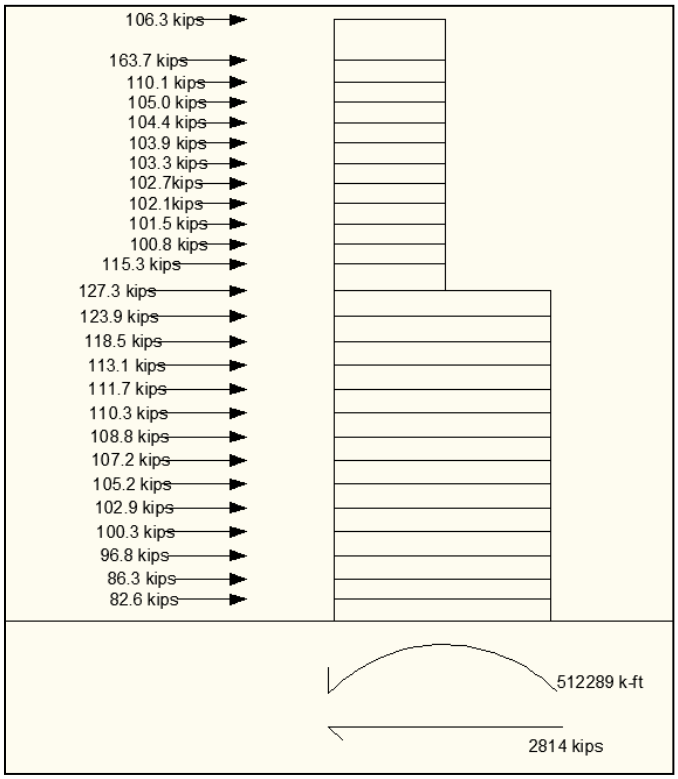


Figure 13- North/South Wind Story Forces 1

East/West

Story	Height (ft)	kz or kh	qz	Windward (psf)	Windward (plf)	Windward (kips)	Leeward (psf)	Leeward (plf)	Leeward (kips)	Story Force (kips)	Moment (k-ft)
Building Portion A											
1mezz	12.5	0.5700	17.8606	20.4289	2507.6452	15.6829	-19.1592	-2351.7925	-14.1108	29.7937	372.4207
2	24.0	0.6520	20.4300	22.2340	2729.2197	16.4206	-19.1592	-2351.7925	-14.6987	31.1193	746.8632
2mezz	37.5	0.7450	23.3441	24.2069	2971.3970	19.2396	-19.1592	-2351.7925	-15.8746	35.1142	1316.7818
3	51.0	0.8140	25.5062	25.6370	3146.9396	20.6494	-19.1592	-2351.7925	-15.8746	36.5240	1862.7233
4	64.5	0.8680	27.1983	26.7385	3282.1476	21.6982	-19.1592	-2351.7925	-15.8746	37.5728	2423.4436
5	78.0	0.9220	28.8903	27.8417	3417.5639	22.6115	-19.1592	-2351.7925	-15.8746	38.4861	3001.9178
6	91.5	0.9645	30.2220	28.6985	3522.7371	23.4235	-19.1592	-2351.7925	-15.8746	39.2981	3595.7775
7	105.0	1.0025	31.4127	29.4610	3616.3335	24.0944	-19.1592	-2351.7925	-15.8746	39.9690	4196.7410
8	118.5	1.0363	32.4703	30.1345	3699.0127	24.6893	-19.1592	-2351.7925	-15.8746	40.5639	4806.8212
9	132.0	1.0700	33.5278	30.8101	3781.9423	25.2482	-19.1592	-2351.7925	-15.8746	41.1228	5428.2125
10	145.5	1.1010	34.4992	31.4285	3857.8446	25.7843	-19.1592	-2351.7925	-15.8746	41.6589	6061.3670
11	159.0	1.1280	35.3452	31.9628	3923.4360	27.2427	-19.1592	-2351.7925	-16.4625	43.7052	6949.1313
12	173.5	1.1570	36.2539	32.5382	3994.0612	28.7009	-19.1592	-2351.7925	-17.0505	45.7514	7937.8718
13	188.0	1.1820	37.0373	33.0296	4054.3872	29.6824	-19.1592	-2351.7925	-17.3445	47.0269	8841.0560
Building Portion B											
14	203.0	1.2048	37.7517	34.2302	2139.3860	21.3547	-15.4056	-962.8528	-11.5874	32.9421	6687.2484
15	214.5	1.2232	38.3282	34.5769	2161.0537	12.3638	-15.4056	-962.8528	-5.5364	17.9002	3839.5860
16	226.0	1.2416	38.9048	34.9253	2182.8327	12.4887	-15.4056	-962.8528	-5.5364	18.0251	4073.6674
17	237.5	1.2600	39.4813	35.2753	2204.7086	12.6142	-15.4056	-962.8528	-5.5364	18.1506	4310.7639
18	249.0	1.2784	40.0579	35.6267	2226.6690	12.7402	-15.4056	-962.8528	-5.5364	18.2766	4550.8770
19	260.5	1.2947	40.5686	35.9338	2245.8615	12.8585	-15.4056	-962.8528	-5.5364	18.3949	4791.8790
20	272.0	1.3108	41.0731	36.2377	2264.8579	12.9683	-15.4056	-962.8528	-5.5364	18.5047	5033.2844
21	283.5	1.3269	41.5776	36.5427	2283.9211	13.0777	-15.4056	-962.8528	-5.5364	18.6141	5277.1096
22	295.0	1.3430	42.0821	36.8487	2303.0437	13.1875	-15.4056	-962.8528	-5.5364	18.7239	5523.5586
23	306.5	1.3578	42.5458	37.1275	2320.4706	13.8727	-15.4056	-962.8528	-5.7771	19.6498	6022.6754
Roof Main	319.0	1.3728	43.0159	37.4082	2338.0117	20.6950	-15.4056	-962.8528	-8.5453	29.2404	9327.6737
Roof High	342.0	1.4004	43.8807	37.9270	2370.4379	13.4436	-15.4056	-962.8528	-5.5364	18.9800	6491.1500
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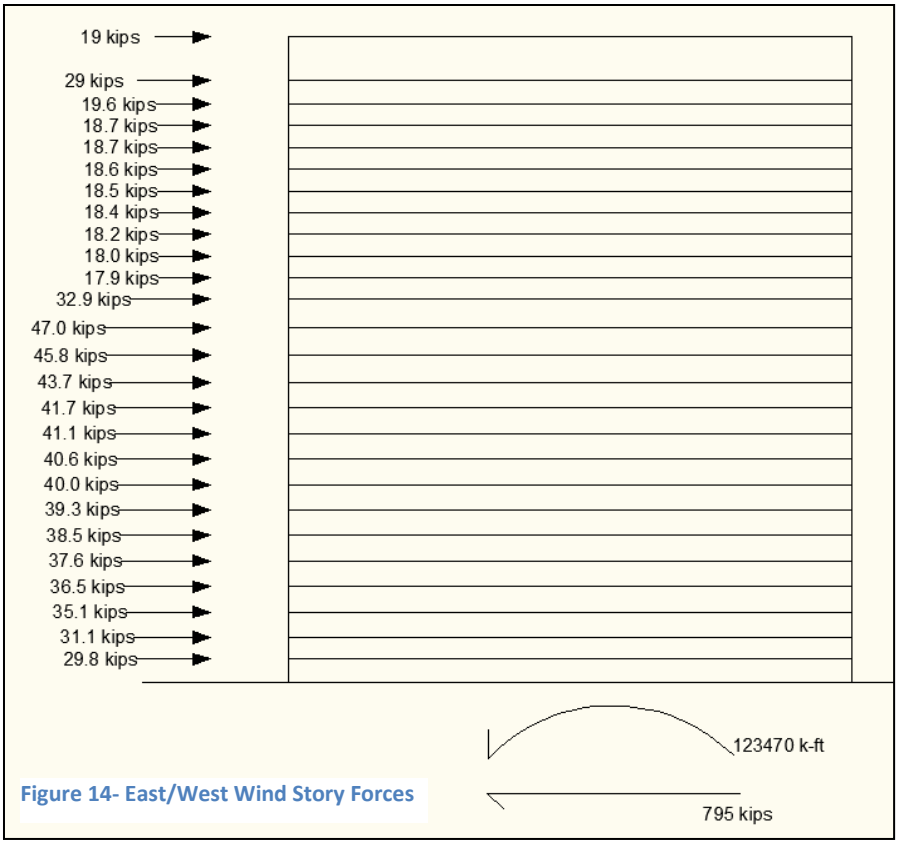


Figure 14- East/West Wind Story Forces

Seismic Load

The seismic loads were determined using the Equivalent Lateral Force Procedure according to ASCE 7-10. To aid in these calculations some of the seismic design parameters for Pittsburgh, PA were found from the USGS website using the Ground Motion Parameter Application. The configuration of Three PNC Plaza led me to use Special Reinforced Concrete Shear Walls as my seismic force-resisting system. The walls classify as special due to their cast-in-place construction.

The building weight was calculated to find the base shear force from the equation V=Cs (W). The weight was tabulated by finding the weight of each floor from all structural components such as beams, slabs, and columns as show in appendix B. These weights were then summed to get the total weight of the building. After the base shear force was calculated the vertical distribution of the seismic forces could be calculated as according to ASCE 7-10 section 12.8.3. These calculations resulted in a base shear of 2301 kips and an overturning moment of 492067 k-ft. The calculations relied heavily on Microsoft excel and can be seen below in the tables provided.

Seism Calculation Table

Floor Level	Floor Height (ft)	Total Height (ft)	Weight (kips)	$w*h^k$	C_{VX}	f_i (kips)	V_i (kips)	M_z (k-ft)
Main Roof	23	319.0	1500	1919975	0.068	157	157	50172
23	12.5	306.5	1542	1878212	0.067	154	311	47157
22	11.5	295.0	1541	1789995	0.064	147	458	43256
21	11.5	283.5	1541	1703809	0.061	140	597	39568
20	11.5	272.0	1547	1624764	0.058	133	730	36202
19	11.5	260.5	1547	1539954	0.055	126	857	32862
18	11.5	249.0	1549	1457924	0.052	119	976	29738
17	11.5	237.5	1549	1374833	0.049	113	1089	26748
16	11.5	226.0	1557	1299383	0.046	106	1195	24056
15	11.5	214.5	1557	1217839	0.043	100	1295	21399
14	11.5	203.0	1842	1345526	0.048	110	1405	22375
13	15	188.0	2207	1465657	0.052	120	1525	22572
12	14.5	173.5	2529	1520266	0.054	125	1650	21607
11	14.5	159.0	2483	1339401	0.048	110	1759	17445
10	13.5	145.5	2500	1207961	0.043	99	1858	14398
9	13.5	132.0	2500	1070464	0.038	88	1946	11575
8	13.5	118.5	2510	940066	0.033	77	2023	9125
7	13.5	105.0	2723	877695	0.031	72	2095	7549
6	13.5	91.5	2729	741527	0.026	61	2156	5558
5	13.5	78.0	2729	608265	0.022	50	2205	3887
4	13.5	64.5	2739	482232	0.017	40	2245	2548
3	13.5	51.0	2726	358608	0.013	29	2274	1498
2mezz	13.5	37.5	1665	149550	0.005	12	2287	459
2	13.5	24.0	2754	142169	0.005	12	2298	280
1mezz	11.5	12.5	1452	33360	0.001	3	2301	34
Ground	12.5	0.0	1452	0	0.000	0	2301	0
		Σ	51518	28089435	1	2301		492067

T=	1.510	s
k=	1.241	
V_b=	2301	kips

LOAD COMBINATIONS

Load Combinations provided by ASCE 7-10 for strength design are:

1. 1.4(D)
2. 1.2(D) + 1.6(L) + .5(Lr or S or R)
3. 1.2D + 1.6(Lr or S or R) + (L or .5W)
4. 1.2D + 1.0W + L + .5(Lr or S or R)
5. 1.2D + 1.0E + L +.2S
6. .9D + 1.0W
7. .9D + 1.0E

For the analysis of the lateral system only load combinations that included lateral forces were explored. This would result in load combinations 4 and 5 being used for the general loading and combinations 6 and 7 for uplift.

ETABS MODEL

While a 3D model was not specified for this report great effort was made to try and accomplish a model of the building as seen in figure 15. However, the values resulting from several models that were made were known to be incorrect. This resulted in more hand and excels based calculations for the majority of the report. Also, from the plans that were provided a definitive lateral system could not be seen for the Steel Structure located above the Shear Wall portion of the building. This resulted in the calculations being made for the shear wall portion of the building only. More information has been requested to figure out how the Steel Structure deals with the lateral loads.

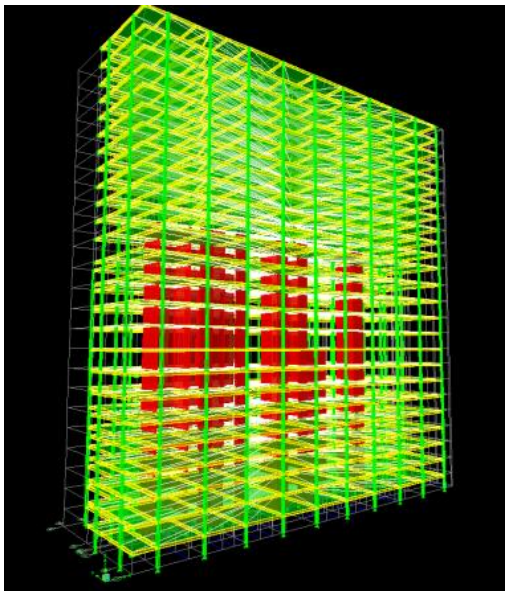


Figure 15 - Attempted ETABS model

DISTRIBUTION OF LATERAL FORCES

The lateral forces of the building were assumed to be distributed through the floor diaphragm into the concrete shear was located throughout the core of the building. These forces were distributed to individual shear walls by the concept of relative stiffness. A key assumption for this method was that the floor system of the building would act as a rigid diaphragm. The lateral loads on the building effect the shear wall is two different

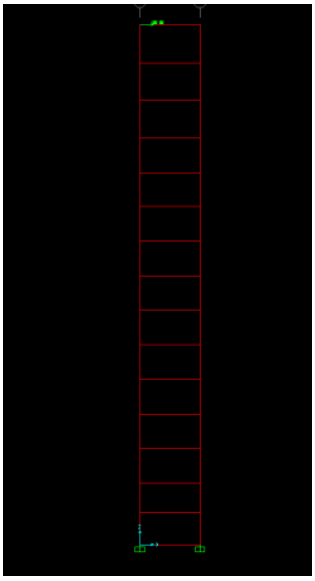


Figure 16- Loaded Shear Wall

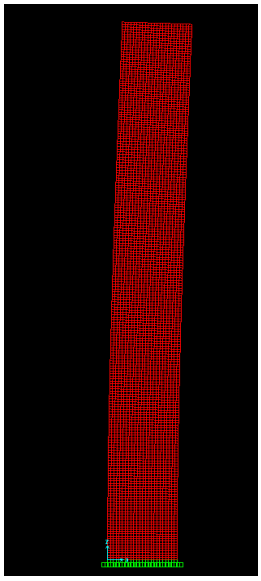


Figure 17 - Deflected Shear Wall

methods via Direct shear and Torsional Shear. The Shear Walls were broken up into 24 individual wall sections for analysis. This could lead to values not being accurate since the walls form 7 unique cores and many are joined and act together as one complete system as seen in the lateral load section figure 9.

DIRECT SHEAR

Direct Shear that acts on the individual walls was calculated using relative stiffness. The rigidity of each wall was determined from hand calculations that can be seen in Appendix C. These hand calculations revolved around the equation $k=P/\delta_p$ to find the stiffness of walls. These hand values were then compared to the results of a 2D SAP model of each wall. An example of how the SAP model was modeled can be seen in figure 16 and 17. The shear was modeled according to the material properties and dimensions given. It was then meshed use a max spacing of 24" by 24" with edge constraints to provide an accurate deflection value. The hand calculations for k were slightly different then the values found from the SAP model. It was assumed that the SAP model was more accurate and the resulting k values from the model were used for the rest of the calculations. The final distribution of the direct shear was found using the equation $V_{di} = (V*K_i)/\Sigma K$.

TORSIONAL SHEAR

The next aspect of the lateral loads that needed to be analyzed was the torsional shear. To calculate the effects caused by torsion the Center of Rigidity needed to be found. This value was calculated using an excel spread sheet and can been seen in Figures D. The load cases that were analyzed from ASCE7-10 were Wind Case 1, Wind Case 2, and the Seismic Load Case. It was found that Wind Case 2 values were extremely high in some shear walls due to the large distance from the Center of Rigidity to the Center of Pressure. It can be assumed that these calculations are not accurate most likely due to the steel frame surround the shear wall cores plays a role in resisting the lateral loads. The results from Wind Case 1 and the Seismic Load Case seemed to be within reasonable values. These calculations relied heavily on excel and can also be seen in Appendix D alongside the Direct Shear values.

DISTRIBUTION OF LATERAL FORCES

Once the Direct Shear and Tensional Shear were found the total shear could be determined for each wall. This resulted in Case 1 Wind Controlling in the North/South direction and the Seismic Load Case controlling in the East/West direction. Case 2 was ignored due to the extremely large shear values found at some walls. A typical calculation for SW1 Wind Case 1 and SW1 Seismic can be seen in the tables on the next page. The remaining calculations can be found in Appendix D.

Center of Rigidity Y direction				
	Load Direction	Yi	Ki	Yi*Ki
SW1	x	750	27.9	20925
SW4	x	750	16.84	12630
SW6	x	510	16.84	8588.4
SW7	x	750	3.33	2497.5
SW9	x	510	2.07	1055.7
SW10	x	750	2.07	1552.5
SW12	x	510	2.07	1055.7
SW13	x	750	1.63	1222.5
SW15	x	510	13.7	6987
SW16	x	750	5.93	4447.5
SW17	x	510	5.93	3024.3
SW18	x	750	7.47	5602.5
SW20	x	630	7.47	4706.1
SW21	x	750	3.32	2490
SW24	x	510	3.32	1693.2
	Sum		119.89	78477.9
			Ybar (in)=	654.583

Center of Rigidity X direction				
SW2	y	411	17.27	7097.97
SW3	y	693	17.27	11968.1
SW5	y	912	13.7	12494.4
SW8	y	1260	2.06	2595.6
SW11	y	1620	13.7	22194
SW14	y	1980	1.63	3227.4
SW19	y	2340	10.3	24102
SW22	y	2628	13.7	36003.6
SW23	y	2772	13.7	37976.4
			103.33	157659
			Xbar (in)=	1525.79
			Xbar (ft)=	127.15

			Ybar (ft)=	54.55

SW1 Wind Case 1				
k (floors 1-8)=	27.9		k (floors 9-13)	27.9
Sum k (floors 1-8)=	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear (kips)	Torsional Shear (kips)	Total Shear (kips)
1mezz	29.79	6.93	-1.61	5.32
2	31.12	7.24	-1.68	5.56
2mezz	35.11	8.17	-1.90	6.27
3	36.52	8.50	-1.98	6.52
4	37.57	8.74	-2.03	6.71
5	38.49	8.96	-2.08	6.87
6	39.30	9.15	-2.13	7.02
7	39.97	9.30	-2.16	7.14
8	40.56	9.44	-2.20	7.24
9	41.12	12.32	-2.43	9.90
10	41.66	12.49	-2.46	10.03
11	43.71	13.10	-2.58	10.52
12	45.75	13.71	-2.70	11.01
13	47.03	14.09	-2.77	11.32

SW1 Seismic Load Case				
k (floors 1-8)=	27.9		k (floors 9-13)	16.61
Sum k (floors 1-8)=	119.89		Sum k (floors 9-13)	93.09
Level	**Load E-W**	**Direct Shear (kips)**	**Torsional Shear (kips)**	**Total Shear(kips)**
1mezz	3	0.70	-0.35	0.35
2	12	2.79	-1.39	1.40

2mezz	12	2.79	-1.39	1.40
3	29	6.75	-3.36	3.39
4	40	9.31	-4.63	4.67
5	50	11.64	-5.79	5.84
6	61	14.20	-7.07	7.13
7	72	16.76	-8.34	8.41
8	77	17.92	-8.92	9.00
9	88	26.37	-0.63	25.74
10	99	29.67	-0.71	28.96
11	110	32.97	-0.79	32.18
12	125	37.46	-0.90	36.57
13	120	35.97	-0.86	35.10

SHEAR WALL CHECK

A spot check was performed in Shear Wall 23 for the Wind Case 1 loading conditions. Shear Wall 23 was analyzed because it resulted in the largest base shear value. The wall was check for vertical, horizontal, and flexural reinforcement. These calculations were done by hand according to ACI 318-08 and can be seen in Appendix E.

The vertical and horizontal reinforcements were designed for the first story of the shear wall. It was found that the horizontal shear would require (2) #8 rebar at 14" on center and then vertical shear would require (2) #4 rebar at 12". These values were slightly different then what was used in the actual design; #10 rebar at 12" vertical and #6 rebar at 12" horizontal.

The last calculation was performed to determine the flexural reinforcement required for the shear wall. The hand calculations found that it would require (37) #18 rebar which was an extremely high value. When compared to the rebar used in the actual design, (20) #11 rebar, it can be seen that this calculation was flawed. This error could be attributed to the lateral loads that were found and used in this report. For a detailed view of these calculations refer to Appendix E.

FOUNDATION ANALYSIS

The foundation was analyzed for overturning resulting from the shear walls, specifically shear wall number 23, using the load combination of .9(D) + 1.0(W). The Dead Load was calculated from the self-weight of the shear wall and the dead load from the tributary area of the floor it supports. The

next step was to find the overturning moment resulting from the wind load on the building. It was found that the uplift force created by the wind was much greater than the total dead load for the wall. This would mean that the foundation system would have to take into account the uplift forces when designing. A more detailed analysis would be required of the foundation systems if required for other reports.

DEFLECTION ANALYSIS

The deflection analysis was performed on Shear Wall 23 since it has to resist the largest forces resulting in the greatest deflection. This shear wall was modeled in SAP similar to the previous model as seen in figures 16 and 17. It was also meshed to a maximum value of 24" by 24" to increase the accuracy of the results. The deflections from the model were compared to values excepted in practice as seen in the next table. Evident in these calculations there is a serious error when looking at these shear walls from deflection only. Shear Wall 23 provided the largest displacement values because it was located the furthest away from the Center of Rigidity. This calculations show that the shear walls themselves cannot be the only lateral system located through these floors. More details have been request from the Engineers of the project to get a better understand of the lateral system. Another source of error for these calculations is that the loads placed on this shear wall are substantially larger than what was used during design or the wall could have been modeled incorrectly.

Allowable Drift Analysis						
			Allowable Wind Deflection (in)		Allowable Seismic Deflections	
Level	Level Height	Story Height	Total Drift (H/400)	Story Drift (H/400)	Total Drift (.02H)	Story Drift (.02H)
0	0	150	0	0.375	0	3
1m	150	138	0.375	0.345	3	2.76
2	288	162	0.72	0.405	5.76	3.24
2m	450	162	1.125	0.405	9	3.24
3	612	162	1.53	0.405	12.24	3.24
4	774	162	1.935	0.405	15.48	3.24
5	936	162	2.34	0.405	18.72	3.24
6	1098	162	2.745	0.405	21.96	3.24
7	1260	162	3.15	0.405	25.2	3.24
8	1422	162	3.555	0.405	28.44	3.24
9	1584	162	3.96	0.405	31.68	3.24
10	1746	162	4.365	0.405	34.92	3.24
11	1908	174	4.77	0.435	38.16	3.48
12	2082	174	5.205	0.435	41.64	3.48
13	2256	180	5.64	0.45	45.12	3.6

SW 23 Displacement Due to Wind Case 1

Level	Displacement (in)
0	**0**
1m	0.37
2	1.28
2m	2.94
3	5.15
4	7.84
5	10.9
6	14.29
7	17.91
8	21.73
9	25.68
10	29.72
11	33.82
12	38.25
13	42.69

CONCLUSION

The lateral force resisting system for Three PNC Plaza consists of several concrete core shear walls along with a steel structure. Different load combinations according to ASCE7-10 were studied and used for the calculations. The load cases studied in this report consist of Wind Case 1, Wind Case 2, and the Seismic Load Case. It was found that Wind Case 2 from these calculations was extremely large and may need to be reinvestigated. As mentioned earlier it is unknown how the steel structure surrounding the shear walls resists lateral load if any. It was assumed it did not, more information has been requested regarding this matter.

The shear walls were analyzed for both direct and torsional effects produced by the lateral loads. These calculations were done by applying the wind loads at the Center of Pressure and the seismic loads at the Center of Mass. The Center of Rigidity was found using relative stiffness and loads were calculated around this point. Relative stiffness was found by both hand calculations and 2D computer models. It was assumed that the computer model values were the more accurate of the two and use for calculations.

Spot checks were performed on critical members of the shear wall system. This resulted in Shear Wall 23 having the largest load and being analyzed in accordance to ACI 318. Hand calculations were performed to find typical reinforcement need and compared to actual reinforcing

found in the wall. Along with shear reinforcement, the overturning effect of the wall was calculated to find its effects on the foundation of the building. It was found that the horizontal and vertical reinforcement were relatively close to the actual reinforcement used within the building. However, when looking at the flexural reinforcement hand calculations it was greatly over designed. This could be attributed to overestimating the lateral forces placed along the wall or the design method used.

The critical Shear Wall was checked for drift utilizing a 2D SAP model. The model was meshed at a maximum size of divided objects to 24" and edge constraints were added to improve the accuracy of the model. These values were compared to allowable story drift in accordance to ASCE7. The critical shear wall (Shear Wall 23) was found to be substantially over the allowable limits defined by the code. This could be attributed to the calculations of the wall by itself when it the actual building it is part of the system of walls. Error could also be due to larger lateral forces placed on the shear wall then it will actually experience.

A 3D model was attempted but not accomplished for this report. It is evident that the complexity of the structure requires an in-depth analysis from a 3D model to understand how the building resists the lateral forces. Once a better understand of how the Steel Structure works within the building a 3D model will be developed to fully understand the lateral system of the building.

APPENDIX

APPENDIX A: WIND

Typical Wind Hand Calculation

Risk Category: III
Basic Wind Speed: V = 120 mph
Directionality Factor: $K_d = 0.85$
Exposure Category: B, urban
Topographic Factor: $K_{zt} = 1.0$

Gust Factor:

Cannot assume rigid, cannot use Approximate Natural Frequency due to 319 > 300

Section 26.9.5:

$g_Q = 3.4$ $g_v = 3.4$

$$g_R = \sqrt{2\ln(3600 n_1)} + \frac{0.577}{\sqrt{2\ln(3600 n_1)}}$$, where: $n_1 = \frac{1}{T_a}$ T_a = natural period

Sec 12.8.2.1: $T_a = C_t h_n^x$ $C_t = 0.02$ $x = 0.75$

$T_a = 0.02(319)^{0.75} = 1.5096$ $h_n = 319$ main roof height

$n_1 = \frac{1}{1.5096} = 0.6624$, less than 1.0, Flexible assumption was correct

Sec 27:

$$g_R = \sqrt{2\ln(3600 \cdot 0.6624)} + \frac{0.577}{\sqrt{2\ln(3600 \cdot 0.6624)}} = \underline{4.09}$$

$I_z = c\left(\frac{33}{z}\right)^{1/6}$ where $z = 0.6(\text{height})$ $0.6(319) = 191.4$
$c = 0.30$

$= 0.30\left(\frac{33}{191.4}\right)^{1/6} = \underline{0.2238}$

$L_z = l\left(\frac{z}{33}\right)^{\epsilon}$ where $l = 320$
$\epsilon = 1/3.0$

$= 320\left(\frac{191.4}{33}\right)^{1/3} = \underline{574.945}$

$$Q = \frac{1}{\sqrt{1+0.63\left(\frac{B+h}{L_z}\right)^{0.63}}} = \frac{1}{\sqrt{1+0.63\left(\frac{297+319}{574.945}\right)^{0.63}}} = \underline{0.7766}$$

$$R = \sqrt{\frac{1}{\beta} R_n R_h R_B (0.53 + 0.47 R_L)}$$

$$R_n = \frac{7.47 N_1}{(1 + 10.3 N_1)^{5/3}} \quad , \quad N_1 = \frac{n_1 L_{\bar{z}}}{\bar{V}_{\bar{z}}} \quad , \quad \bar{V}_{\bar{z}} = \bar{b} \left(\frac{\bar{z}}{33}\right)^{\bar{\alpha}} \left(\frac{88}{66}\right) V$$

Solve $\bar{V}_{\bar{z}}$: $\bar{\alpha} = 1/4.0$ $\bar{b} = 0.45$

$$\bar{V}_{\bar{z}} = 0.45 \left(\frac{191.4}{33}\right)^{1/4} \left(\frac{88}{66}\right) \cdot 120 = 111.735$$

Solve N_1: $\frac{0.6624 (574.945)}{111.735} = 3.408$

Solve R_n: $\frac{7.47 (3.408)}{(1 + 10.3 (3.408))^{5/3}} = 0.06455$

R_L: $\eta = 15.4 n_1 L / \bar{V}_z = 15.4 (0.6624)(122.75) / 111.735 = 11.2066$

$$R_L = \frac{1}{11.2066} - \frac{1}{2(11.2066)^2} \left(1 - e^{-2(11.2066)}\right) = \underline{0.08525}$$

R_B: $\eta = 4.6 n_1 B / \bar{V}_{\bar{z}} = 4.6 (0.6624)(297) / 111.735 = 8.0993$

$$R_B = \frac{1}{8.0993} - \frac{1}{2(8.0993)^2} \left(1 - e^{-2(8.0993)}\right) = \underline{0.1158}$$

R_h: $\eta = 4.6 n_1 h / \bar{V}_{\bar{z}} = 4.6 (0.6624)(319) / 111.735 = 8.6992$

$$R_h = \frac{1}{8.6992} - \frac{1}{2(8.6992)^2} \left(1 - e^{-2(8.6992)}\right) = \underline{0.1083}$$

* $\beta = 1.5\%$ for steel and concrete buildings

$$R = \sqrt{\frac{1}{0.015} (0.06455)(0.1083)(0.1158)(0.53 + 0.47 (0.08525))}$$

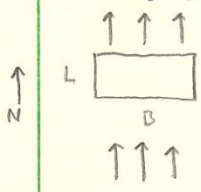
$$= \underline{0.1754}$$

$$G_f = 0.925 \left(\frac{1 + 1.7 I_{\bar{z}} \sqrt{g_Q^2 Q^2 + g_R^2 R^2}}{1 + 1.7 g_v I_{\bar{z}}}\right) = 0.8231$$

Enclosure Classification: Enclosed, $GC_{pi} = \pm 0.18$

$L/B = \frac{122.75}{297} = 0.41$

Windward Wall 0.8
Leeward Wall -0.5



$p = q G_f C_p - q_i (GC_{pi})$ $K_z = 1.3728$

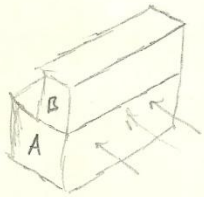
$q = 0.00256(1.3728)(1.0)(.85)(120)^2$

$= 43.0159$

windward $p = 28.325 - 28.325(-.18) = 33.424$ psf

leeward $p = -14.1625 - 5.0985 = -19.261$ psf

* These values are off from spread sheet values due to taking into accent shape of building.



Spread sheet seperates building into two parts to get a more accurate analysis.

Wind Load Design Criteria	
Design Wind Speed, V	120
Directionality Factor, K_d	0.85
Exposure	B
Topographic Factor, k_{zt}	1
Mean Roof Height	319
K_h	1.373
q_h	43.02

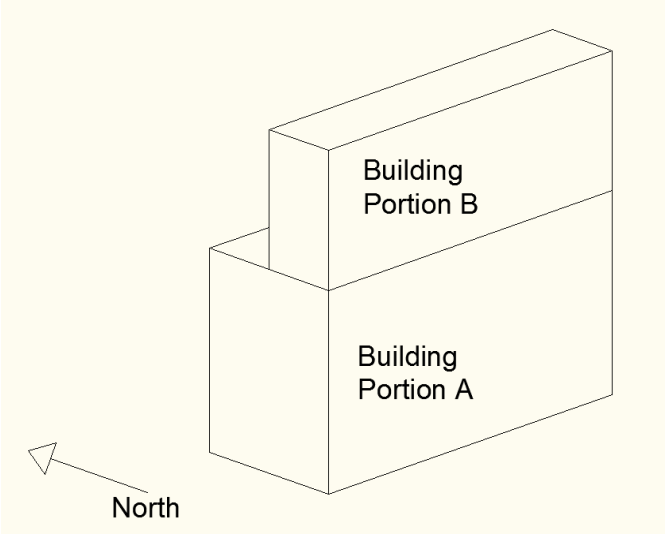
	Building Dimensions			
	Portion A		Portion B	
	N-S Direction	E-W Direction	N-S Direction	E-W Direction
B	297.00	122.75	297.00	62.50
L	122.75	297.00	62.50	297.00
h	188.00	188.00	342.00	342.00

B=Normal to wind direction

L= Parallel to wind direction

h= Height

Velocity Pressure Coefficients			
Story	**Height (ft)**	**k_z**	**q_z**
Ground	0	0.5700	17.8606
1mezz	12.5	0.5700	17.8606
2	24.0	0.6520	20.4300
2mezz	37.5	0.7450	23.3441
3	51.0	0.8140	25.5062
4	64.5	0.8680	27.1983
5	78.0	0.9220	28.8903
6	91.5	0.9645	30.2220
7	105.0	1.0025	31.4127
8	118.5	1.0363	32.4703
9	132.0	1.0700	33.5278
10	145.5	1.1010	34.4992
11	159.0	1.1280	35.3452
12	173.5	1.1570	36.2539
13	188.0	1.1820	37.0373
14	203.0	1.2048	37.7517
15	214.5	1.2232	38.3282
16	226.0	1.2416	38.9048
17	237.5	1.2600	39.4813
18	249.0	1.2784	40.0579
19	260.5	1.2947	40.5686
20	272.0	1.3108	41.0731
21	283.5	1.3269	41.5776
22	295.0	1.3430	42.0821
23	306.5	1.3578	42.5458
Roof Main	319.0	1.3728	43.0159
Roof High	342.0	1.4004	43.8807



North/South Forces

Story	Height (ft)	kz or kh	qz	Windward (psf)	Windward (plf)	Windward (kips)	Leeward (psf)	Leeward (plf)	Leeward (kips)	Story Force (kips)	Moment (k-ft)
Building Portion A											
1mezz	12.5	0.5700	17.8606	19.5169	2395.7009	15.0187	-25.9635	-3187.0236	-19.1221	34.1409	426.7607
2	24.0	0.6520	20.4300	21.3432	2619.8791	15.7297	-25.9635	-3187.0236	-19.9189	35.6486	855.5671
2mezz	37.5	0.7450	23.3441	23.3311	2863.8866	18.5077	-25.9635	-3187.0236	-21.5124	40.0201	1500.7544
3	51.0	0.8140	25.5062	24.7911	3043.1112	19.9361	-25.9635	-3187.0236	-21.5124	41.4485	2113.8749
4	64.5	0.8680	27.1983	25.9259	3182.4053	21.0111	-25.9635	-3187.0236	-21.5124	42.5235	2742.7675
5	78.0	0.9220	28.8903	27.0530	3320.7594	21.9482	-25.9635	-3187.0236	-21.5124	43.4606	3389.9260
6	91.5	0.9645	30.2220	27.9364	3429.1990	22.7811	-25.9635	-3187.0236	-21.5124	44.2935	4052.8570
7	105.0	1.0025	31.4127	28.7231	3525.7563	23.4730	-25.9635	-3187.0236	-21.5124	44.9854	4723.4653
8	118.5	1.0363	32.4703	29.4190	3611.1791	24.0872	-25.9635	-3187.0236	-21.5124	45.5996	5403.5486
9	132.0	1.0700	33.5278	30.1130	3696.3715	24.6630	-25.9635	-3187.0236	-21.5124	46.1754	6095.1518
10	145.5	1.1010	34.4992	30.7484	3774.3699	25.2138	-25.9635	-3187.0236	-21.5124	46.7262	6798.6565
11	159.0	1.1280	35.3452	31.2996	3842.0277	26.6658	-25.9635	-3187.0236	-22.3092	48.9750	7787.0272
12	173.5	1.1570	36.2539	31.8905	3914.5583	28.1176	-25.9635	-3187.0236	-23.1059	51.2235	8887.2852
13	188.0	1.1820	37.0373	32.3975	3976.7871	29.1032	-25.9635	-3187.0236	-23.5043	52.6075	9890.2146
Building Portion B											
14	203.0	1.2048	37.7517	32.8887	2055.5468	20.8226	-25.9635	-1622.7208	-16.6167	37.4393	7600.1798
15	214.5	1.2232	38.3282	33.2600	2078.7501	11.8861	-25.9635	-1622.7208	-9.3306	21.2167	4550.9924
16	226.0	1.2416	38.9048	33.6309	2101.9298	12.0195	-25.9635	-1622.7208	-9.3306	21.3501	4825.1224
17	237.5	1.2600	39.4813	34.0014	2125.0878	12.1527	-25.9635	-1622.7208	-9.3306	21.4833	5102.2885
18	249.0	1.2784	40.0579	34.3716	2148.2256	12.2858	-25.9635	-1622.7208	-9.3306	21.6164	5382.4887
19	260.5	1.2947	40.5686	34.6980	2168.6279	12.4110	-25.9635	-1622.7208	-9.3306	21.7416	5663.6864
20	272.0	1.3108	41.0731	35.0201	2188.7560	12.5275	-25.9635	-1622.7208	-9.3306	21.8581	5945.4095
21	283.5	1.3269	41.5776	35.3419	2208.8698	12.6432	-25.9635	-1622.7208	-9.3306	21.9738	6229.5776
22	295.0	1.3430	42.0821	35.6635	2228.9703	12.7588	-25.9635	-1622.7208	-9.3306	22.0894	6516.3832
23	306.5	1.3578	42.5458	35.9581	2247.3789	13.4313	-25.9635	-1622.7208	-9.7363	23.1677	7100.8918
Roof Main	319.0	1.3728	43.0159	36.2556	2265.9729	20.0524	-25.9635	-1622.7208	-14.4016	34.4541	10990.8421
Roof High	342.0	1.4004	43.8807	36.8025	2300.1586	13.0293	-25.9635	-1622.7208	-9.3306	22.3600	7647.1162
									Sum=	908.58	142222.84

East/West Forces

Story	Height (ft)	kz or kh	qz	Windward (psf)	Windward (plf)	Windward (kips)	Leeward (psf)	Leeward (plf)	Leeward (kips)	Story Force (kips)	Moment (k-ft)
Building Portion A											
1mezz	12.5	0.5700	17.8606	20.4289	6067.3778	37.9456	-19.1592	-5690.2840	-34.1417	72.0873	901.0911
2	24.0	0.6520	20.4300	22.2340	6603.4889	39.7305	-19.1592	-5690.2840	-35.5643	75.2948	1807.0743
2mezz	37.5	0.7450	23.3441	24.2069	7189.4494	46.5512	-19.1592	-5690.2840	-38.4094	84.9606	3186.0219
3	51.0	0.8140	25.5062	25.6370	7614.1839	49.9623	-19.1592	-5690.2840	-38.4094	88.3717	4506.9556
4	64.5	0.8680	27.1983	26.7385	7941.3267	52.4998	-19.1592	-5690.2840	-38.4094	90.9093	5863.6476
5	78.0	0.9220	28.8903	27.8417	8268.9734	54.7098	-19.1592	-5690.2840	-38.4094	93.1192	7263.2960
6	91.5	0.9645	30.2220	28.6985	8523.4453	56.6744	-19.1592	-5690.2840	-38.4094	95.0838	8700.1705
7	105.0	1.0025	31.4127	29.4610	8749.9066	58.2976	-19.1592	-5690.2840	-38.4094	96.7070	10154.2329
8	118.5	1.0363	32.4703	30.1345	8949.9533	59.7370	-19.1592	-5690.2840	-38.4094	98.1464	11630.3537
9	132.0	1.0700	33.5278	30.8101	9150.6058	61.0894	-19.1592	-5690.2840	-38.4094	99.4988	13133.8421
10	145.5	1.1010	34.4992	31.4285	9334.2553	62.3864	-19.1592	-5690.2840	-38.4094	100.7958	14665.7923
11	159.0	1.1280	35.3452	31.9628	9492.9571	65.9151	-19.1592	-5690.2840	-39.8320	105.7471	16813.7840
12	173.5	1.1570	36.2539	32.5382	9663.8386	69.4434	-19.1592	-5690.2840	-41.2546	110.6979	19206.0932
13	188.0	1.1820	37.0373	33.0296	9809.8005	71.8182	-19.1592	-5690.2840	-41.9658	113.7840	21391.3941
Building Portion B											
14	203.0	1.2048	37.7517	34.2302	10166.3621	66.0150	-15.4056	-4575.4766	-34.4931	100.5081	20403.1450
15	214.5	1.2232	38.3282	34.5769	10269.3271	58.7526	-15.4056	-4575.4766	-26.3090	85.0616	18245.7126
16	226.0	1.2416	38.9048	34.9253	10372.8211	59.3462	-15.4056	-4575.4766	-26.3090	85.6552	19358.0677
17	237.5	1.2600	39.4813	35.2753	10476.7752	59.9426	-15.4056	-4575.4766	-26.3090	86.2516	20484.7503
18	249.0	1.2784	40.0579	35.6267	10581.1311	60.5415	-15.4056	-4575.4766	-26.3090	86.8505	21625.7673
19	260.5	1.2947	40.5686	35.9338	10672.3338	61.1037	-15.4056	-4575.4766	-26.3090	87.4127	22771.0089
20	272.0	1.3108	41.0731	36.2377	10762.6048	61.6254	-15.4056	-4575.4766	-26.3090	87.9344	23918.1674
21	283.5	1.3269	41.5776	36.5427	10853.1930	62.1454	-15.4056	-4575.4766	-26.3090	88.4544	25076.8250
22	295.0	1.3430	42.0821	36.8487	10944.0638	62.6671	-15.4056	-4575.4766	-26.3090	88.9761	26247.9507
23	306.5	1.3578	42.5458	37.1275	11026.8762	65.9232	-15.4056	-4575.4766	-27.4529	93.3760	28619.7536
Roof Main	319.0	1.3728	43.0159	37.4082	11110.2314	98.3428	-15.4056	-4575.4766	-40.6074	138.9502	44325.1053
Roof High	342.0	1.4004	43.8807	37.9270	11264.3208	63.8838	-15.4056	-4575.4766	-26.3090	90.1928	30845.9448
									Sum=	2444.83	441145.95

APPENDIX B: Seismic

Hand Calculations

11.4 Seismic Ground Motion Values

Site Class: D (provided)

$S_{MS} = F_a S_S$ $\quad S_{M1} = F_v S_1$

$S_S = 0.201$
$S_1 = 0.118$
} From USGS Web site: earthquake.usgs.gov/designmaps

Table 11.4-1: $F_a = 1.6$
Table 11.4-2: $F_v = 2.328$ (interpolation used)

$S_{MS} = 1.6(0.201) = 0.3216$

$S_{M1} = 2.328(0.118) = 0.2747$

$S_{DS} = \frac{2}{3} S_{MS} = \frac{2}{3}(0.3216) = 0.2144$

$S_{D1} = \frac{2}{3} S_{M1} = \frac{2}{3}(0.2747) = 0.1831$

$I_e = 1.25$ due to Risk Category III

Seismic Design Category: B

Equivalent Lateral Force Procedure:

$V = C_s W$

$W = 53477$ (calculated using excel)

$C_s = \frac{S_{DS}}{\left(\frac{R}{I_e}\right)} = \frac{0.2144}{\left(\frac{6}{1.25}\right)}$ $\quad R = 6$, Special reinforced concrete shear walls
↳ Special due to cast in place construction

$= 0.04467$

$V = 0.04467(55481) = 2301$ K

$T_a = 1.5096$ see wind calcs

12.8.3: Vertical Distribution of Seismic Forces: See Spread Sheets

$F_x = C_{vx} V$ $\quad C_{vx} = \frac{w_x h_x^k}{\sum_{n=1} w_i h_i^k}$ $\quad k = 1.2410$

Floor Weight Calculations (MEP, Decking, and Curtain Wall)

Floor	Area (sf)	Perimeter (ft)	Composite Deck Weight (psf)	M.E.P Weight (psf)	Curtain Wall Weight (plf)	Total Weight from Decking, MEP, and Curtain Wall (lbs)
1st Floor Mezz.	15165	831.35	44	30	60	1172091
2nd Floor	31420.5	831.35	44	30	60	2374998
2nd Floor Mezz.	17225.5	831.35	44	30	60	1324568
3rd Floor	31338	831.35	44	30	60	2368893
4th Floor	28987.5	780	44	30	60	2191875
5th Floor	28987.5	780	44	30	60	2191875
6th Floor	28987.5	780	44	30	60	2191875
7th Floor	28987.5	780	44	30	60	2191875
8th Floor	28987.5	780	44	30	60	2191875
9th Floor	28987.5	780	44	30	60	2191875
10th Floor	28987.5	780	44	30	60	2191875
11th Floor	28987.5	780	44	30	60	2191875
12th Floor	28987.5	780	44	30	60	2191875
13th Floor	24525	750	44	30	60	1859850
14th Floor	16875	685	44	30	60	1289850
15th Floor	16875	685	44	30	60	1289850
16th Floor	16875	685	44	30	60	1289850
17th Floor	16875	685	44	30	60	1289850
18th Floor	16875	685	44	30	60	1289850
19th Floor	16875	685	44	30	60	1289850
20th Floor	16875	685	44	30	60	1289850
21st floor	16875	685	44	30	60	1289850
22nd Floor	16875	685	44	30	60	1289850
23rd Floor	16875	685	44	30	60	1289850
Main Roof	16875	685	44	30	60	1289850
High Roof	2112.5	613.9	44	30	60	193159
					sum=	43208784.0

Typical Floor Weight Calculation for Floor Beam Weights

4th, 5th, 6th, and 7th Floor Beams				
Beam	# of Beams	Length (ft)	Unit Weight (lbs/ft)	Weight (lbs)
W21x44	50	42.5	44	93500
W21x166	35	42.5	166	246925
W24x55	1	42.5	55	2337.5
W21x73	2	42.5	73	6205
W24x68	1	35	68	2380
W13x35	2	35	35	2450
W21x57	1	20	57	1140
W21x57	1	15	57	855
W21x22	7	10	22	1540
W12x16	15	20	16	4800
W12x22	4	20	22	1760
W18x46	1	20	46	920
W21x73	2	30	73	4380
W21x50	16	30	50	24000
W21x62	1	15	62	930
W21x62	2	30	62	3720
W16x26	1	15	26	390
W16x26	2	30	26	1560
W21x44	2	10	44	880
W21x166	2	20	166	6640
W21x44	5	2.5	44	550
W21x73	1	20	73	1460
W21x73	4	25	73	7300
W8x15	3	5	15	225
			Sum=	416847.5

Typical Floor Weight Calculation for Column Weight

2nd Floor Column Weight				
Column	Number of Columns	Height	Unit Weight	Weight (lbs)
W10x49	4	13.5	49	2646
W12x65	4	13.5	65	3510
W14x455	1	13.5	455	6142.5
W14x550	5	13.5	550	37125
W14x233	7	13.5	233	22018.5
W14x426	2	13.5	426	11502
W14x730	5	13.5	730	49275
W14x455	1	13.5	455	6142.5
W14x605	4	13.5	605	32670
W14x370	2	13.5	370	9990
			sum=	181021.5

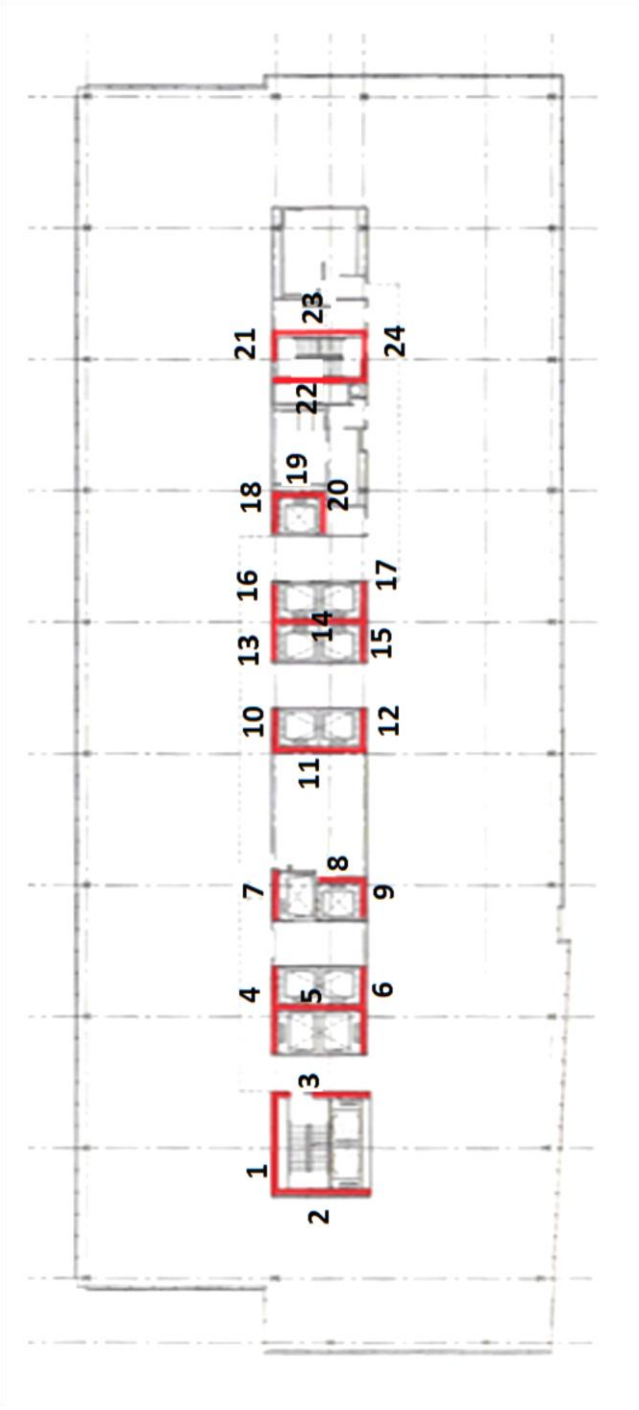
Seismic Calculation Table

Floor Level	Floor Height (ft)	Total Height (ft)	Weight (kips)	$w*h^k$	C_{vx}	f_i (kips)	V_i (kips)	M_z (k-ft)
Main Roof	23	319.0	1500	1919975	0.068	157	157	50172
23	12.5	306.5	1542	1878212	0.067	154	311	47157
22	11.5	295.0	1541	1789995	0.064	147	458	43256
21	11.5	283.5	1541	1703809	0.061	140	597	39568
20	11.5	272.0	1547	1624764	0.058	133	730	36202
19	11.5	260.5	1547	1539954	0.055	126	857	32862
18	11.5	249.0	1549	1457924	0.052	119	976	29738
17	11.5	237.5	1549	1374833	0.049	113	1089	26748
16	11.5	226.0	1557	1299383	0.046	106	1195	24056
15	11.5	214.5	1557	1217839	0.043	100	1295	21399
14	11.5	203.0	1842	1345526	0.048	110	1405	22375
13	15	188.0	2207	1465657	0.052	120	1525	22572
12	14.5	173.5	2529	1520266	0.054	125	1650	21607
11	14.5	159.0	2483	1339401	0.048	110	1759	17445
10	13.5	145.5	2500	1207961	0.043	99	1858	14398
9	13.5	132.0	2500	1070464	0.038	88	1946	11575
8	13.5	118.5	2510	940066	0.033	77	2023	9125
7	13.5	105.0	2723	877695	0.031	72	2095	7549
6	13.5	91.5	2729	741527	0.026	61	2156	5558
5	13.5	78.0	2729	608265	0.022	50	2205	3887
4	13.5	64.5	2739	482232	0.017	40	2245	2548
3	13.5	51.0	2726	358608	0.013	29	2274	1498
2mezz	13.5	37.5	1665	149550	0.005	12	2287	459
2	13.5	24.0	2754	142169	0.005	12	2298	280
1mezz	11.5	12.5	1452	33360	0.001	3	2301	34
Ground	11.5	0.0	-	0	0.000	0	2301	0
		Σ	51518	28089435	1	2301		492067

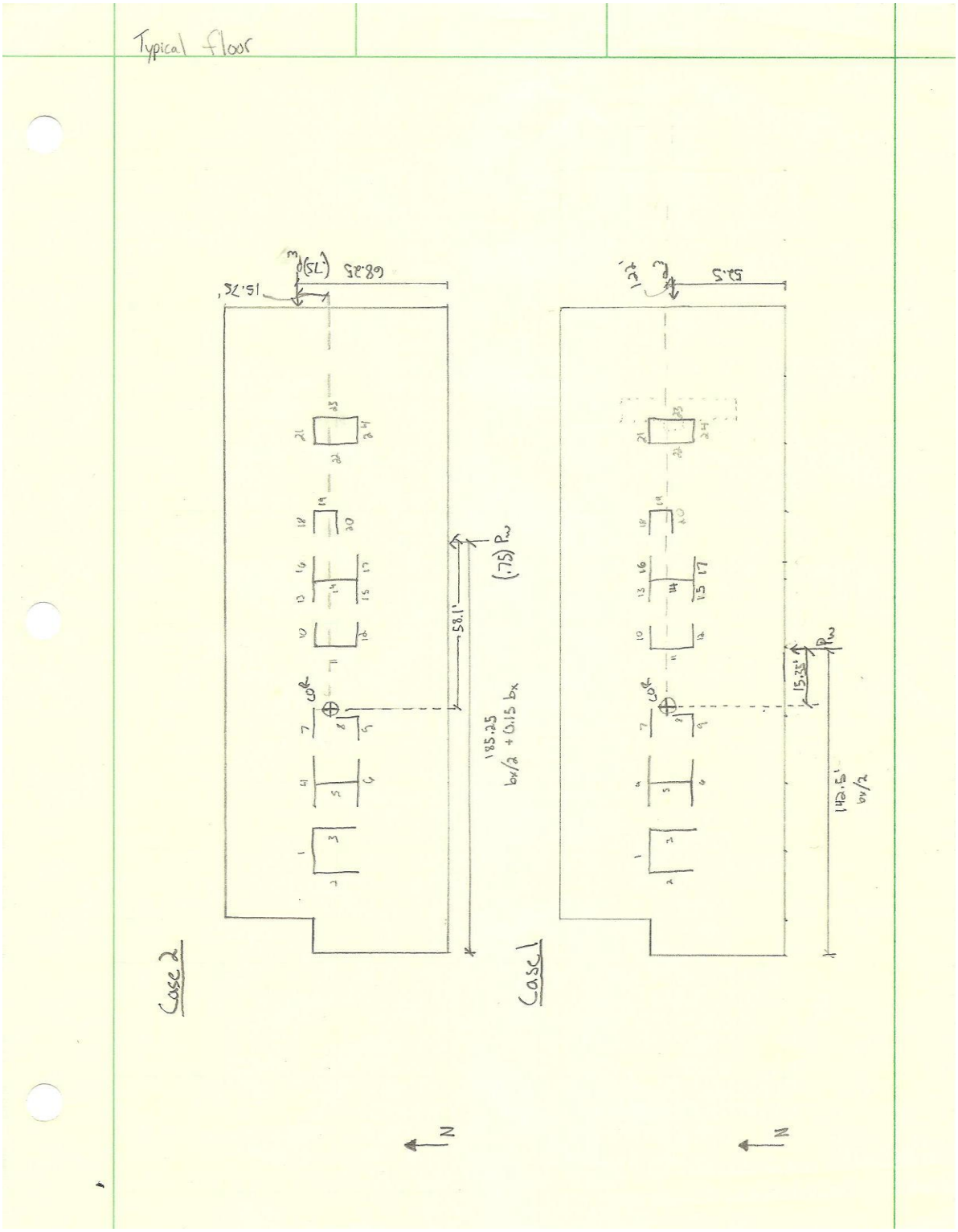
T=	1.510	s
k=	1.241	
V_b=	2301	kips

APPENDIX C: Shear Wall Information

Shear Wall Key and Numbering



Wind Case 1 and 2 Shear Wall Diagrams



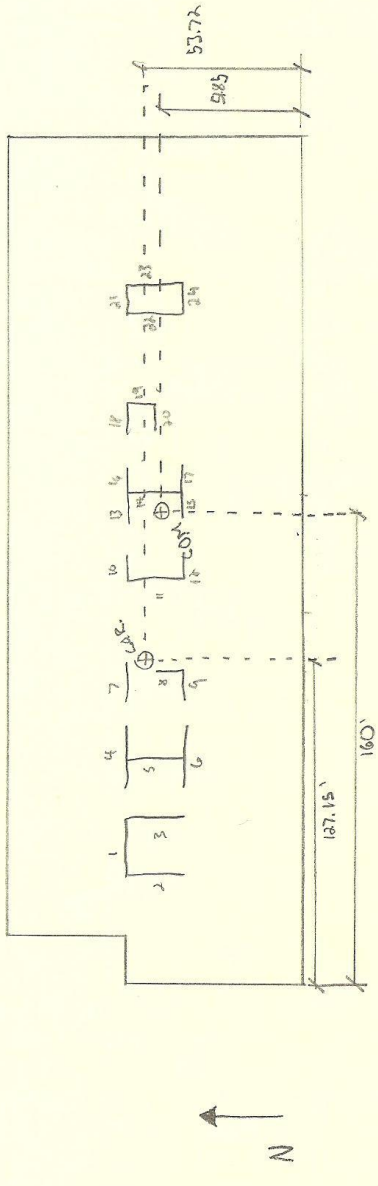
Seismic Load Case Shear Wall Diagrams

XCM = 160' } floors 9-13
YCM = 51.85' }

XCM = 160.2' } floors 1-8
YCM = 51.86' }

} ETABS MODEL

Assume XCM = 160' } for all floors
YCM = 51.85' }



Relative Stiffness Calculations											
	Height (ft)	Length (ft)	Thickness (ft)	I (in^4)	f'c (psi)	Ec (ksi)	Imaginary Load (k)	Dp	k (k/in) hand calcs	Displacement SAP (in)	k (k/in) SAP
SW1	214.5	23.5	1.5	3.4E+07	5000	4000	100	4.26004	23.47	3.58	27.9
SW2	214.5	20	1.5	2.1E+07	5000	4000	100	6.89502	14.50	5.79	17.27
SW3	214.5	20	1.5	2.1E+07	5000	4000	100	6.89502	14.50	5.79	17.27
SW4	214.5	19.83	1.5	2E+07	5000	4000	100	7.07316	14.14	5.94	16.84
SW5	214.5	18.5	1.5	1.6E+07	5000	4000	100	8.7043	11.49	7.3	13.7
SW6	214.5	19.83	1.5	2E+07	5000	4000	100	7.07316	14.14	5.94	16.84
SW7	214.5	11.54	1.5	3983386	5000	4000	100	35.7491	2.80	30.05	3.33
SW8	214.5	8.92	1.5	1839626	5000	4000	100	77.3458	1.29	48.6	2.06
SW9	214.5	9.83	1.5	2462043	5000	4000	100	57.8072	1.73	48.3	2.07
SW10	214.5	9.83	1.5	2462043	5000	4000	100	57.8072	1.73	48.3	2.07
SW11	214.5	18.5	1.5	1.6E+07	5000	4000	100	8.7043	11.49	7.3	13.7
SW12	214.5	9.83	1.5	2462043	5000	4000	100	57.8072	1.73	48.3	2.07
SW13	214.5	9.1	1.5	1953256	5000	4000	100	72.8498	1.37	61.22	1.63
SW14	214.5	18.5	1.5	1.6E+07	5000	4000	100	8.7043	11.49	7.3	13.7
SW15	214.5	9.1	1.5	1953256	5000	4000	100	72.8498	1.37	61.22	1.63
SW16	132	9.1	1.5	1953256	5000	4000	100	17.0121	5.88	16.87	5.93
SW17	132	9.1	1.5	1953256	5000	4000	100	17.0121	5.88	16.87	5.93
SW18	132	9.83	1.5	2462043	5000	4000	100	13.5039	7.41	13.39	7.47
SW19	132	12.1	1.5	4591886	5000	4000	100	7.25474	13.78	9.7	10.3
SW20	132	9.83	1.5	2462043	5000	4000	100	13.5039	7.41	13.39	7.47
SW21	214.5	12	1.5	4478976	5000	4000	100	31.7987	3.14	30.12	3.32
SW22	214.5	18.5	1.5	1.6E+07	5000	4000	100	8.7043	11.49	7.3	13.7
SW23	214.5	18.5	1.5	1.6E+07	5000	4000	100	8.7043	11.49	7.3	13.7
SW24	214.5	12	1.5	4478976	5000	4000	100	31.7987	3.14	30.12	3.32

Center of Rigidity Y direction				
	Load Direction	Yi	Ki	Yi*Ki
SW1	x	750	27.9	20925
SW4	x	750	16.84	12630
SW6	x	510	16.84	8588.4
SW7	x	750	3.33	2497.5
SW9	x	510	2.07	1055.7
SW10	x	750	2.07	1552.5
SW12	x	510	2.07	1055.7
SW13	x	750	1.63	1222.5
SW15	x	510	13.7	6987
SW16	x	750	5.93	4447.5
SW17	x	510	5.93	3024.3
SW18	x	750	7.47	5602.5
SW20	x	630	7.47	4706.1
SW21	x	750	3.32	2490
SW24	x	510	3.32	1693.2
	Sum		119.89	78477.9
			Ybar (in)=	654.583
			Ybar (ft)=	54.55

Center of Rigidity X direction				
SW2	y	411	17.27	7097.97
SW3	y	693	17.27	11968.1
SW5	y	912	13.7	12494.4
SW8	y	1260	2.06	2595.6
SW11	y	1620	13.7	22194
SW14	y	1980	1.63	3227.4
SW19	y	2340	10.3	24102
SW22	y	2628	13.7	36003.6
SW23	y	2772	13.7	37976.4
			103.33	157659
			Xbar (in)=	1525.79
			Xbar (ft)=	127.15

Torsional Rigidity			
	di (in)	k	Torsional Rigidity (k/in)ft^2
SW1	105.34	27.9	2149.949898
SW2	1114.78	17.27	149041.8328
SW3	832.78	17.27	83174.54212
SW4	105.34	16.84	1297.675852
SW5	613.78	13.7	35841.28244
SW6	134.66	16.84	2120.590519
SW7	105.34	3.33	256.6069233
SW8	265.78	2.06	1010.530259
SW9	134.66	2.07	260.6664118
SW10	105.34	2.07	159.5124118
SW11	94.22	13.7	844.5867714
SW12	134.66	2.07	260.6664118
SW13	105.34	1.63	125.6063919
SW14	454.22	13.7	19628.65677
SW15	134.66	1.63	205.2590585
SW16	105.34	5.93	456.9606771
SW17	134.66	5.93	746.7400105
SW18	105.34	7.47	575.6317468
SW19	814.22	10.3	47419.6413
SW20	14.66	7.47	11.14874675
SW21	105.34	3.32	255.8363319
SW22	1102.22	13.7	115583.1828
SW23	1246.22	13.7	147756.8108
SW24	134.66	3.32	418.0736652
		Total	609601.9911

APPENDIX D: Distribution of Forces

Wind Case 1:

Design Wind Loads North/South				
Level	Windward Load	Leeward Load	Story Shear (1.0W)	Q = P*e/S(K*d2) =
1mezz	36.3386	46.267	82.6056	0.00027779
2	38.0589	48.1948	86.2537	0.000290058
2mezz	44.7804	52.0504	96.8308	0.000325627
3	48.2365	52.0504	100.2869	0.00033725
4	50.8375	52.0504	102.8879	0.000345997
5	53.1048	52.0504	105.1552	0.000353621
6	55.1201	52.0504	107.1705	0.000360398
7	56.7941	52.0504	108.8445	0.000366028
8	58.2801	52.0504	110.3305	0.000371025
9	59.6734	52.0504	111.7238	0.000409338
10	61.006	52.0504	113.0564	0.000414221
11	64.5194	53.9782	118.4976	0.000434157
12	68.0321	55.906	123.9381	0.00045409
13	70.4168	56.8699	127.2867	0.000466358
14	64.1655	51.0865	115.252	0.000387575
15	56.4828	44.3392	100.822	0.000339049
16	57.1164	44.3392	101.4556	0.00034118
17	57.7495	44.3392	102.0887	0.000343309
18	58.382	44.3392	102.7212	0.000345436
19	58.9769	44.3392	103.3161	0.000347437
20	59.5306	44.3392	103.8698	0.000349299
21	60.0804	44.3392	104.4196	0.000351147
22	60.6298	44.3392	104.969	0.000352995
23	63.8258	46.267	110.0928	0.000370226
Roof Main	95.289	68.4366	163.7256	0.000550585
Roof High	61.9154	44.3392	106.2546	0.000357318
		Base Shear	2813.8552	

Design Wind Loads East/West				
Level	Windward Load	Leeward Load	Story Shear (1.0W)	Q = P*e/S(K*d2) =
1mezz	15.6829	14.1108	29.7937	0.000750216
2	16.4206	14.6987	31.1193	0.000783595
2mezz	19.2396	15.8746	35.1142	0.000884188
3	20.6494	15.8746	36.524	0.000919688
4	21.6982	15.8746	37.5728	0.000946097
5	22.6115	15.8746	38.4861	0.000969094
6	23.4235	15.8746	39.2981	0.00098954
7	24.0944	15.8746	39.969	0.001006434
8	24.6893	15.8746	40.5639	0.001021414
9	25.2482	15.8746	41.1228	0.001128169
10	25.7843	15.8746	41.6589	0.001142876
11	27.2427	16.4625	43.7052	0.001199014
12	28.7009	17.0505	45.7514	0.00125515
13	29.6824	17.3445	47.0269	0.001290142
14	21.3547	11.5874	32.9421	0.000829494
15	12.3638	5.5364	17.9002	0.000450734
16	12.4887	5.5364	18.0251	0.000453879
17	12.6142	5.5364	18.1506	0.000457039
18	12.7402	5.5364	18.2766	0.000460211
19	12.8585	5.5364	18.3949	0.00046319
20	12.9683	5.5364	18.5047	0.000465955
21	13.0777	5.5364	18.6141	0.00046871
22	13.1875	5.5364	18.7239	0.000471475
23	13.8727	5.7771	19.6498	0.000494789
Roof Main	20.695	8.5453	29.2403	0.000736281
Roof High	13.4436	5.5364	18.98	0.000477923
		Base Shear	795.1086	

SW1				
k (floors 1-8)=	27.9		k (floors 9-13)	27.9
Sum k (floors 1-8)=	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear (kips)	Torsional Shear (kips)	Total Shear (kips)
1mezz	29.79	6.93	-1.61	5.32
2	31.12	7.24	-1.68	5.56
2mezz	35.11	8.17	-1.90	6.27
3	36.52	8.50	-1.98	6.52
4	37.57	8.74	-2.03	6.71
5	38.49	8.96	-2.08	6.87
6	39.30	9.15	-2.13	7.02
7	39.97	9.30	-2.16	7.14
8	40.56	9.44	-2.20	7.24
9	41.12	12.32	-2.43	9.90
10	41.66	12.49	-2.46	10.03
11	43.71	13.10	-2.58	10.52
12	45.75	13.71	-2.70	11.01
13	47.03	14.09	-2.77	11.32

SW2				
k	17.27		k (floors 9-13)	17.27
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	82.61	13.81	-41.40	-27.60
2	86.25	14.42	-43.23	-28.81
2mezz	96.83	16.18	-48.53	-32.35
3	100.29	16.76	-50.26	-33.50
4	102.89	17.20	-51.57	-34.37
5	105.16	17.58	-52.70	-35.13
6	107.17	17.91	-53.71	-35.80
7	108.84	18.19	-54.55	-36.36
8	110.33	18.44	-55.30	-36.86
9	111.72	20.74	-61.01	-40.27
10	113.06	20.99	-61.74	-40.75
11	118.50	22.00	-64.71	-42.71
12	123.94	23.01	-67.68	-44.67
13	127.29	23.63	-69.51	-45.88

SW3				
k	5.93		k (floors 9-13)	5.93
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	82.61	4.74	-23.11	-18.36
2	86.25	4.95	-24.13	-19.18
2mezz	96.83	5.56	-27.08	-21.53
3	100.29	5.76	-28.05	-22.30
4	102.89	5.90	-28.78	-22.87
5	105.16	6.03	-29.41	-23.38
6	107.17	6.15	-29.98	-23.83
7	108.84	6.25	-30.44	-24.20
8	110.33	6.33	-30.86	-24.53
9	111.72	7.12	-34.05	-26.92
10	113.06	7.21	-34.45	-27.25
11	118.50	7.55	-36.11	-28.56
12	123.94	7.90	-37.77	-29.87
13	127.29	8.11	-38.79	-30.68

SW7				
k	3.33		k (floors 9-13)	3.33
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	29.79	0.83	-0.19	0.64
2	31.12	0.86	-0.20	0.66
2mezz	35.11	0.98	-0.23	0.75
3	36.52	1.01	-0.24	0.78
4	37.57	1.04	-0.24	0.80
5	38.49	1.07	-0.25	0.82
6	39.30	1.09	-0.25	0.84
7	39.97	1.11	-0.26	0.85
8	40.56	1.13	-0.26	0.86
9	41.12	1.47	-0.29	1.18
10	41.66	1.49	-0.29	1.20
11	43.71	1.56	-0.31	1.26
12	45.75	1.64	-0.32	1.31
13	47.03	1.68	-0.33	1.35

SW8				
k	2.06		k (floors 9-13)	2.06
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	82.61	1.65	-0.28	1.37
2	86.25	1.72	-0.29	1.43
2mezz	96.83	1.93	-0.33	1.60
3	100.29	2.00	-0.34	1.66
4	102.89	2.05	-0.35	1.70
5	105.16	2.10	-0.36	1.74
6	107.17	2.14	-0.36	1.77
7	108.84	2.17	-0.37	1.80
8	110.33	2.20	-0.37	1.82
9	111.72	2.47	-0.41	2.06
10	113.06	2.50	-0.42	2.08
11	118.50	2.62	-0.44	2.19
12	123.94	2.74	-0.46	2.29
13	127.29	2.82	-0.47	2.35

SW9				
k	2.07		k (floors 9-13)	2.07
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	29.79	0.51	0.20	0.71
2	31.12	0.54	0.20	0.74
2mezz	35.11	0.61	0.23	0.84
3	36.52	0.63	0.24	0.87
4	37.57	0.65	0.25	0.90
5	38.49	0.66	0.25	0.92
6	39.30	0.68	0.26	0.94
7	39.97	0.69	0.26	0.95
8	40.56	0.70	0.27	0.97
9	41.12	0.91	0.29	1.21
10	41.66	0.93	0.30	1.22
11	43.71	0.97	0.31	1.28
12	45.75	1.02	0.33	1.34
13	47.03	1.05	0.34	1.38

SW4				
k	16.84		k (floors 9-13)	16.84
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	29.79	4.18	-0.97	3.21
2	31.12	4.37	-1.02	3.35
2mezz	35.11	4.93	-1.15	3.78
3	36.52	5.13	-1.19	3.94
4	37.57	5.28	-1.23	4.05
5	38.49	5.41	-1.26	4.15
6	39.30	5.52	-1.28	4.24
7	39.97	5.61	-1.31	4.31
8	40.56	5.70	-1.33	4.37
9	41.12	7.44	-1.46	5.98
10	41.66	7.54	-1.48	6.05
11	43.71	7.91	-1.56	6.35
12	45.75	8.28	-1.63	6.65
13	47.03	8.51	-1.67	6.83

SW10				
k	2.07		k (floors 9-13)	2.07
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	29.79	0.51	-0.12	0.39
2	31.12	0.54	-0.12	0.41
2mezz	35.11	0.61	-0.14	0.47
3	36.52	0.63	-0.15	0.48
4	37.57	0.65	-0.15	0.50
5	38.49	0.66	-0.15	0.51
6	39.30	0.68	-0.16	0.52
7	39.97	0.69	-0.16	0.53
8	40.56	0.70	-0.16	0.54
9	41.12	0.91	-0.18	0.73
10	41.66	0.93	-0.18	0.74
11	43.71	0.97	-0.19	0.78
12	45.75	1.02	-0.20	0.82
13	47.03	1.05	-0.21	0.84

SW5				
k	13.7		k (floors 9-13)	13.7
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	82.61	10.95	-9.96	1.00
2	86.25	11.44	-10.40	1.04
2mezz	96.83	12.84	-11.67	1.17
3	100.29	13.30	-12.09	1.21
4	102.89	13.64	-12.40	1.24
5	105.16	13.94	-12.67	1.27
6	107.17	14.21	-12.92	1.29
7	108.84	14.43	-13.12	1.31
8	110.33	14.63	-13.30	1.33
9	111.72	16.45	-14.67	1.78
10	113.06	16.65	-14.85	1.80
11	118.50	17.45	-15.56	1.89
12	123.94	18.25	-16.28	1.98
13	127.29	18.74	-16.71	2.03

SW11				
k	13.7		k (floors 9-13)	13.7
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	82.61	10.95	0.23	11.19
2	86.25	11.44	0.24	11.68
2mezz	96.83	12.84	0.28	13.11
3	100.29	13.30	0.28	13.58
4	102.89	13.64	0.29	13.93
5	105.16	13.94	0.30	14.24
6	107.17	14.21	0.30	14.51
7	108.84	14.43	0.31	14.74
8	110.33	14.63	0.31	14.94
9	111.72	16.45	0.35	16.80
10	113.06	16.65	0.35	17.00
11	118.50	17.45	0.37	17.82
12	123.94	18.25	0.38	18.64
13	127.29	18.74	0.39	19.14

SW6				
k	16.84		k (floors 9-13)	16.84
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	29.79	4.18	1.59	5.78
2	31.12	4.37	1.66	6.03
2mezz	35.11	4.93	1.88	6.81
3	36.52	5.13	1.95	7.08
4	37.57	5.28	2.01	7.28
5	38.49	5.41	2.06	7.46
6	39.30	5.52	2.10	7.62
7	39.97	5.61	2.13	7.75
8	40.56	5.70	2.17	7.86
9	41.12	7.44	2.39	9.83
10	41.66	7.54	2.42	9.96
11	43.71	7.91	2.54	10.45
12	45.75	8.28	2.66	10.94
13	47.03	8.51	2.74	11.24

SW12				
k	2.07		k (floors 9-13)	2.07
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	29.79	0.51	0.20	0.71
2	31.12	0.54	0.20	0.74
2mezz	35.11	0.61	0.23	0.84
3	36.52	0.63	0.24	0.87
4	37.57	0.65	0.25	0.90
5	38.49	0.66	0.25	0.92
6	39.30	0.68	0.26	0.94
7	39.97	0.69	0.26	0.95
8	40.56	0.70	0.27	0.97
9	41.12	0.91	0.29	1.21
10	41.66	0.93	0.30	1.22
11	43.71	0.97	0.31	1.28
12	45.75	1.02	0.33	1.34
13	47.03	1.05	0.34	1.38

SW13				
k	1.63		k (floors 9-13)	1.63
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	29.79	0.41	-0.09	0.31
2	31.12	0.42	-0.10	0.32
2mezz	35.11	0.48	-0.11	0.37
3	36.52	0.50	-0.12	0.38
4	37.57	0.51	-0.12	0.39
5	38.49	0.52	-0.12	0.40
6	39.30	0.53	-0.12	0.41
7	39.97	0.54	-0.13	0.42
8	40.56	0.55	-0.13	0.42
9	41.12	0.72	-0.14	0.58
10	41.66	0.73	-0.14	0.59
11	43.71	0.77	-0.15	0.61
12	45.75	0.80	-0.16	0.64
13	47.03	0.82	-0.16	0.66

SW14				
k	13.7		k (floors 9-13)	13.7
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	82.61	10.95	5.45	16.40
2	86.25	11.44	5.69	17.13
2mezz	96.83	12.84	6.39	19.23
3	100.29	13.30	6.62	19.92
4	102.89	13.64	6.79	20.43
5	105.16	13.94	6.94	20.88
6	107.17	14.21	7.07	21.28
7	108.84	14.43	7.18	21.62
8	110.33	14.63	7.28	21.91
9	111.72	16.45	8.03	24.49
10	113.06	16.65	8.13	24.78
11	118.50	17.45	8.52	25.97
12	123.94	18.25	8.91	27.16
13	127.29	18.74	9.15	27.90

SW15				
k	1.63		k (floors 9-13)	1.63
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	29.79	0.41	0.15	0.56
2	31.12	0.42	0.16	0.58
2mezz	35.11	0.48	0.18	0.66
3	36.52	0.50	0.19	0.69
4	37.57	0.51	0.19	0.71
5	38.49	0.52	0.20	0.72
6	39.30	0.53	0.20	0.74
7	39.97	0.54	0.21	0.75
8	40.56	0.55	0.21	0.76
9	41.12	0.72	0.23	0.95
10	41.66	0.73	0.23	0.96
11	43.71	0.77	0.25	1.01
12	45.75	0.80	0.26	1.06
13	47.03	0.82	0.26	1.09

SW19				
k	10.3		k (floors 9-13)	17.27
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	82.61	8.23	13.17	21.41
2	86.25	8.60	13.75	22.35
2mezz	96.83	9.65	15.44	25.09
3	100.29	10.00	15.99	25.99
4	102.89	10.26	16.41	26.66
5	105.16	10.48	16.77	27.25
6	107.17	10.68	17.09	27.77
7	108.84	10.85	17.36	28.21
8	110.33	11.00	17.59	28.59

SW20				
k	7.47		k (floors 9-13)	3.33
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	29.79	1.86	0.01	1.86
2	31.12	1.94	0.01	1.95
2mezz	35.11	2.19	0.01	2.20
3	36.52	2.28	0.01	2.29
4	37.57	2.34	0.01	2.35
5	38.49	2.40	0.01	2.41
6	39.30	2.45	0.01	2.46
7	39.97	2.49	0.01	2.50
8	40.56	2.53	0.01	2.54

SW21				
k	3.32		k (floors 9-13)	3.32
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	29.79	0.83	-0.19	0.63
2	31.12	0.86	-0.20	0.66
2mezz	35.11	0.97	-0.23	0.75
3	36.52	1.01	-0.24	0.78
4	37.57	1.04	-0.24	0.80
5	38.49	1.07	-0.25	0.82
6	39.30	1.09	-0.25	0.84
7	39.97	1.11	-0.26	0.85
8	40.56	1.12	-0.26	0.86
9	41.12	1.47	-0.29	1.18
10	41.66	1.49	-0.29	1.19
11	43.71	1.56	-0.31	1.25
12	45.75	1.63	-0.32	1.31
13	47.03	1.68	-0.33	1.35

SW16				
k	5.93			
Sum k	119.89			
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	29.79	1.47	-0.34	1.13
2	31.12	1.54	-0.36	1.18
2mezz	35.11	1.74	-0.40	1.33
3	36.52	1.81	-0.42	1.39
4	37.57	1.86	-0.43	1.43
5	38.49	1.90	-0.44	1.46
6	39.30	1.94	-0.45	1.49
7	39.97	1.98	-0.46	1.52
8	40.56	2.01	-0.47	1.54

SW17				
k	5.93			
Sum k	119.89			
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	29.79	1.47	0.56	2.03
2	31.12	1.54	0.59	2.12
2mezz	35.11	1.74	0.66	2.40
3	36.52	1.81	0.69	2.49
4	37.57	1.86	0.71	2.56
5	38.49	1.90	0.72	2.63
6	39.30	1.94	0.74	2.68
7	39.97	1.98	0.75	2.73
8	40.56	2.01	0.76	2.77

SW18				
k	7.47			
Sum k	119.89			
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	29.79	1.86	-0.43	1.42
2	31.12	1.94	-0.45	1.49
2mezz	35.11	2.19	-0.51	1.68
3	36.52	2.28	-0.53	1.75
4	37.57	2.34	-0.54	1.80
5	38.49	2.40	-0.56	1.84
6	39.30	2.45	-0.57	1.88
7	39.97	2.49	-0.58	1.91
8	40.56	2.53	-0.59	1.94

SW22				
k	13.7		k (floors 9-13)	13.7
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	82.61	10.95	32.11	43.06
2	86.25	11.44	33.53	44.96
2mezz	96.83	12.84	37.64	50.48
3	100.29	13.30	38.98	52.28
4	102.89	13.64	39.99	53.63
5	105.16	13.94	40.87	54.81
6	107.17	14.21	41.66	55.87
7	108.84	14.43	42.31	56.74
8	110.33	14.63	42.88	57.51
9	111.72	16.45	47.31	63.77
10	113.06	16.65	47.88	64.53
11	118.50	17.45	50.18	67.63
12	123.94	18.25	52.49	70.74
13	127.29	18.74	53.90	72.65

SW23				
k	13.7		k (floors 9-13)	13.7
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	82.61	10.95	41.05	52.00
2	86.25	11.44	42.86	54.29
2mezz	96.83	12.84	48.11	60.95
3	100.29	13.30	49.83	63.13
4	102.89	13.64	51.12	64.76
5	105.16	13.94	52.25	66.19
6	107.17	14.21	53.25	67.46
7	108.84	14.43	54.08	68.51
8	110.33	14.63	54.82	69.45
9	111.72	16.45	60.48	76.94
10	113.06	16.65	61.20	77.85
11	118.50	17.45	64.15	81.60
12	123.94	18.25	67.09	85.35
13	127.29	18.74	68.91	87.65

SW24				
k	3.32		k (floors 9-13)	3.32
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	29.79	0.83	0.31	1.14
2	31.12	0.86	0.33	1.19
2mezz	35.11	0.97	0.37	1.34
3	36.52	1.01	0.38	1.40
4	37.57	1.04	0.40	1.44
5	38.49	1.07	0.41	1.47
6	39.30	1.09	0.41	1.50
7	39.97	1.11	0.42	1.53
8	40.56	1.12	0.43	1.55
9	41.12	1.47	0.47	1.94
10	41.66	1.49	0.48	1.96
11	43.71	1.56	0.50	2.06
12	45.75	1.63	0.52	2.16
13	47.03	1.68	0.54	2.22

Wind Case 2:

Design Wind Loads North/South				
Level	Windward Load	Leeward Load	Story Shear (1.0W)*.75	Q = P*e/S(K*d2) =
1mezz	36.3386	46.267	61.9542	0.001600682
2	38.0589	48.1948	64.690275	0.001671372
2mezz	44.7804	52.0504	72.6231	0.001876329
3	48.2365	52.0504	75.215175	0.001943299
4	50.8375	52.0504	77.165925	0.0019937
5	53.1048	52.0504	78.8664	0.002037634
6	55.1201	52.0504	80.377875	0.002076685
7	56.7941	52.0504	81.633375	0.002109123
8	58.2801	52.0504	82.747875	0.002137918
9	59.6734	52.0504	83.79285	0.002358688
10	61.006	52.0504	84.7923	0.002386821
11	64.5194	53.9782	88.8732	0.002501695
12	68.0321	55.906	92.953575	0.002616553
13	70.4168	56.8699	95.465025	0.002687248
14	64.1655	51.0865	86.439	0.002233284
15	56.4828	44.3392	75.6165	0.001953668
16	57.1164	44.3392	76.0917	0.001965945
17	57.7495	44.3392	76.566525	0.001978213
18	58.382	44.3392	77.0409	0.00199047
19	58.9769	44.3392	77.487075	0.002001997
20	59.5306	44.3392	77.90235	0.002012726
21	60.0804	44.3392	78.3147	0.00202338
22	60.6298	44.3392	78.72675	0.002034026
23	63.8258	46.267	82.5696	0.002133312
Roof Main	95.289	68.4366	122.7942	0.003172576
Roof High	61.9154	44.3392	79.69095	0.002058938
		Base Shear	2110.3914	

Design Wind Loads East/West				
Level	Windward Load	Leeward Load	Story Shear (1.0W)*.75	Q = P*e/S(K*d2) =
1mezz	15.6829	14.1108	22.345275	0.002129685
2	16.4206	14.6987	23.339475	0.002224441
2mezz	19.2396	15.8746	26.33565	0.00251
3	20.6494	15.8746	27.393	0.002610774
4	21.6982	15.8746	28.1796	0.002685744
5	22.6115	15.8746	28.864575	0.002751027
6	23.4235	15.8746	29.473575	0.00280907
7	24.0944	15.8746	29.97675	0.002857027
8	24.6893	15.8746	30.422925	0.002899551
9	25.2482	15.8746	30.8421	0.003202602
10	25.7843	15.8746	31.244175	0.003244353
11	27.2427	16.4625	32.7789	0.003403717
12	28.7009	17.0505	34.31355	0.003563073
13	29.6824	17.3445	35.270175	0.003662408
14	21.3547	11.5874	24.706575	0.002354736
15	12.3638	5.5364	13.42515	0.001279525
16	12.4887	5.5364	13.518825	0.001288453
17	12.6142	5.5364	13.61295	0.001297424
18	12.7402	5.5364	13.70745	0.001306431
19	12.8585	5.5364	13.796175	0.001314887
20	12.9683	5.5364	13.878525	0.001322736
21	13.0777	5.5364	13.960575	0.001330556
22	13.1875	5.5364	14.042925	0.001338404
23	13.8727	5.7771	14.73735	0.001404589
Roof Main	20.695	8.5453	21.930225	0.002090128
Roof High	13.4436	5.5364	14.235	0.001356711
		Base Shear	596.33145	

SW1				
k (floors 1-8)=	27.9		k (floors 9-13)	16.61
Sum k (floors 1-8)=	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	22.35	5.20	-4.58	0.62
2	23.34	5.43	-4.78	0.65
2mezz	26.34	6.13	-5.40	0.73
3	27.39	6.37	-5.61	0.76
4	28.18	6.56	-5.77	0.78
5	28.86	6.72	-5.91	0.80
6	29.47	6.86	-6.04	0.82
7	29.98	6.98	-6.14	0.83
8	30.42	7.08	-6.23	0.85
9	30.84	9.24	-6.89	2.36
10	31.24	9.36	-6.98	2.39
11	32.78	9.82	-7.32	2.51
12	34.31	10.28	-7.66	2.62
13	35.27	10.57	-7.87	2.70

SW2				
k	0.412307274		k (floors 9-13)	17.27
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	61.95	10.35	-238.57	-228.21
2	64.69	10.81	-249.10	-238.29
2mezz	72.62	12.14	-279.65	-267.51
3	75.22	12.57	-289.63	-277.06
4	77.17	12.90	-297.14	-284.25
5	78.87	13.18	-303.69	-290.51
6	80.38	13.43	-309.51	-296.08
7	81.63	13.64	-314.35	-300.70
8	82.75	13.83	-318.64	-304.81
9	83.79	15.56	-351.54	-335.99
10	84.79	15.74	-355.74	-340.00
11	88.87	16.50	-372.86	-356.36
12	92.95	17.26	-389.98	-372.72
13	95.47	17.72	-400.51	-382.79

SW3				
k	0		k (floors 9-13)	5.93
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	61.95	3.56	-133.14	-129.58
2	64.69	3.71	-139.02	-135.30
2mezz	72.62	4.17	-156.06	-151.90
3	75.22	4.32	-161.63	-157.32
4	77.17	4.43	-165.83	-161.40
5	78.87	4.53	-169.48	-164.95
6	80.38	4.61	-172.73	-168.11
7	81.63	4.68	-175.43	-170.74
8	82.75	4.75	-177.82	-173.07
9	83.79	5.34	-196.18	-190.84
10	84.79	5.40	-198.52	-193.12
11	88.87	5.67	-208.08	-202.41
12	92.95	5.93	-217.63	-211.71
13	95.47	6.09	-223.51	-217.43

SW7				
k	3.33		k (floors 9-13)	3.33
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	22.35	0.62	-0.55	0.07
2	23.34	0.65	-0.57	0.08
2mezz	26.34	0.73	-0.64	0.09
3	27.39	0.76	-0.67	0.09
4	28.18	0.78	-0.69	0.09
5	28.86	0.80	-0.71	0.10
6	29.47	0.82	-0.72	0.10
7	29.98	0.83	-0.73	0.10
8	30.42	0.85	-0.74	0.10
9	30.84	1.10	-0.82	0.28
10	31.24	1.12	-0.83	0.29
11	32.78	1.17	-0.87	0.30
12	34.31	1.23	-0.91	0.31
13	35.27	1.26	-0.94	0.32

SW8				
k	0.52955913		k (floors 9-13)	2.06
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	61.95	1.24	-1.62	-0.38
2	64.69	1.29	-1.69	-0.40
2mezz	72.62	1.45	-1.90	-0.45
3	75.22	1.50	-1.96	-0.46
4	77.17	1.54	-2.01	-0.48
5	78.87	1.57	-2.06	-0.49
6	80.38	1.60	-2.10	-0.50
7	81.63	1.63	-2.13	-0.50
8	82.75	1.65	-2.16	-0.51
9	83.79	1.86	-2.38	-0.53
10	84.79	1.88	-2.41	-0.53
11	88.87	1.97	-2.53	-0.56
12	92.95	2.06	-2.64	-0.59
13	95.47	2.11	-2.72	-0.60

SW9				
k	2.07		k (floors 9-13)	2.07
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	22.35	0.39	0.56	0.94
2	23.34	0.40	0.58	0.98
2mezz	26.34	0.45	0.65	1.11
3	27.39	0.47	0.68	1.15
4	28.18	0.49	0.70	1.19
5	28.86	0.50	0.72	1.22
6	29.47	0.51	0.73	1.24
7	29.98	0.52	0.74	1.26
8	30.42	0.53	0.76	1.28
9	30.84	0.69	0.83	1.52
10	31.24	0.69	0.85	1.54
11	32.78	0.73	0.89	1.62
12	34.31	0.76	0.93	1.69
13	35.27	0.78	0.95	1.74

SW4				
k	16.84		k (floors 9-13)	16.84
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	22.35	3.14	-2.76	0.38
2	23.34	3.28	-2.89	0.39
2mezz	26.34	3.70	-3.26	0.44
3	27.39	3.85	-3.39	0.46
4	28.18	3.96	-3.49	0.47
5	28.86	4.05	-3.57	0.48
6	29.47	4.14	-3.65	0.49
7	29.98	4.21	-3.71	0.50
8	30.42	4.27	-3.76	0.51
9	30.84	5.58	-4.16	1.42
10	31.24	5.65	-4.21	1.44
11	32.78	5.93	-4.42	1.51
12	34.31	6.21	-4.62	1.58
13	35.27	6.38	-4.75	1.63

SW10				
k	2.07		k (floors 9-13)	2.07
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	22.35	0.39	-0.34	0.05
2	23.34	0.40	-0.35	0.05
2mezz	26.34	0.45	-0.40	0.05
3	27.39	0.47	-0.42	0.06
4	28.18	0.49	-0.43	0.06
5	28.86	0.50	-0.44	0.06
6	29.47	0.51	-0.45	0.06
7	29.98	0.52	-0.46	0.06
8	30.42	0.53	-0.46	0.06
9	30.84	0.69	-0.51	0.17
10	31.24	0.69	-0.52	0.18
11	32.78	0.73	-0.54	0.19
12	34.31	0.76	-0.57	0.19
13	35.27	0.78	-0.58	0.20

SW5				
k	0.497811286		k (floors 9-13)	13.7
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	61.95	8.21	-57.37	-49.16
2	64.69	8.58	-59.90	-51.33
2mezz	72.62	9.63	-67.25	-57.62
3	75.22	9.97	-69.65	-59.68
4	77.17	10.23	-71.46	-61.23
5	78.87	10.46	-73.03	-62.57
6	80.38	10.66	-74.43	-63.77
7	81.63	10.82	-75.59	-64.77
8	82.75	10.97	-76.63	-65.65
9	83.79	12.34	-84.54	-72.20
10	84.79	12.49	-85.55	-73.06
11	88.87	13.09	-89.66	-76.58
12	92.95	13.69	-93.78	-80.09
13	95.47	14.06	-96.31	-82.26

SW11				
k	13.7		k (floors 9-13)	13.7
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	61.95	8.21	1.35	9.57
2	64.69	8.58	1.41	9.99
2mezz	72.62	9.63	1.58	11.21
3	75.22	9.97	1.64	11.61
4	77.17	10.23	1.68	11.91
5	78.87	10.46	1.72	12.18
6	80.38	10.66	1.75	12.41
7	81.63	10.82	1.78	12.60
8	82.75	10.97	1.81	12.78
9	83.79	12.34	1.99	14.33
10	84.79	12.49	2.02	14.50
11	88.87	13.09	2.11	15.20
12	92.95	13.69	2.21	15.90
13	95.47	14.06	2.27	16.33

SW6				
k	16.84		k (floors 9-13)	16.84
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	22.35	3.14	4.52	7.65
2	23.34	3.28	4.72	8.00
2mezz	26.34	3.70	5.32	9.02
3	27.39	3.85	5.54	9.38
4	28.18	3.96	5.70	9.65
5	28.86	4.05	5.83	9.89
6	29.47	4.14	5.96	10.10
7	29.98	4.21	6.06	10.27
8	30.42	4.27	6.15	10.42
9	30.84	5.58	6.79	12.37
10	31.24	5.65	6.88	12.53
11	32.78	5.93	7.22	13.15
12	34.31	6.21	7.56	13.76
13	35.27	6.38	7.77	14.15

SW12				
k	2.07		k (floors 9-13)	2.07
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	22.35	0.39	0.56	0.94
2	23.34	0.40	0.58	0.98
2mezz	26.34	0.45	0.65	1.11
3	27.39	0.47	0.68	1.15
4	28.18	0.49	0.70	1.19
5	28.86	0.50	0.72	1.22
6	29.47	0.51	0.73	1.24
7	29.98	0.52	0.74	1.26
8	30.42	0.53	0.76	1.28
9	30.84	0.69	0.83	1.52
10	31.24	0.69	0.85	1.54
11	32.78	0.73	0.89	1.62
12	34.31	0.76	0.93	1.69
13	35.27	0.78	0.95	1.74

SW13				
k	1.63		k (floors 9-13)	1.63
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	22.35	0.30	-0.27	0.04
2	23.34	0.32	-0.28	0.04
2mezz	26.34	0.36	-0.32	0.04
3	27.39	0.37	-0.33	0.04
4	28.18	0.38	-0.34	0.05
5	28.86	0.39	-0.35	0.05
6	29.47	0.40	-0.35	0.05
7	29.98	0.41	-0.36	0.05
8	30.42	0.41	-0.36	0.05
9	30.84	0.54	-0.40	0.14
10	31.24	0.55	-0.41	0.14
11	32.78	0.57	-0.43	0.15
12	34.31	0.60	-0.45	0.15
13	35.27	0.62	-0.46	0.16

SW14				
k	13.7		k (floors 9-13)	13.7
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	61.95	8.21	31.42	39.63
2	64.69	8.58	32.81	41.38
2mezz	72.62	9.63	36.83	46.46
3	75.22	9.97	38.14	48.12
4	77.17	10.23	39.13	49.36
5	78.87	10.46	40.00	50.45
6	80.38	10.66	40.76	51.42
7	81.63	10.82	41.40	52.22
8	82.75	10.97	41.96	52.94
9	83.79	12.34	46.30	58.64
10	84.79	12.49	46.85	59.34
11	88.87	13.09	49.10	62.19
12	92.95	13.69	51.36	65.05
13	95.47	14.06	52.75	66.81

SW15				
k	1.63		k (floors 9-13)	1.63
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	22.35	0.30	0.44	0.74
2	23.34	0.32	0.46	0.77
2mezz	26.34	0.36	0.52	0.87
3	27.39	0.37	0.54	0.91
4	28.18	0.38	0.55	0.93
5	28.86	0.39	0.56	0.96
6	29.47	0.40	0.58	0.98
7	29.98	0.41	0.59	0.99
8	30.42	0.41	0.60	1.01
9	30.84	0.54	0.66	1.20
10	31.24	0.55	0.67	1.21
11	32.78	0.57	0.70	1.27
12	34.31	0.60	0.73	1.33
13	35.27	0.62	0.75	1.37

SW19				
k	10.3		k (floors 9-13)	17.27
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	61.95	6.18	75.90	82.08
2	64.69	6.45	79.26	85.70
2mezz	72.62	7.24	88.97	96.21
3	75.22	7.50	92.15	99.65
4	77.17	7.69	94.54	102.23
5	78.87	7.86	96.62	104.49
6	80.38	8.01	98.48	106.49
7	81.63	8.14	100.01	108.15
8	82.75	8.25	101.38	109.63

SW20				
k	7.47		k (floors 9-13)	3.33
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	22.35	1.39	0.02	1.42
2	23.34	1.45	0.02	1.48
2mezz	26.34	1.64	0.03	1.67
3	27.39	1.71	0.03	1.74
4	28.18	1.76	0.03	1.79
5	28.86	1.80	0.03	1.83
6	29.47	1.84	0.03	1.87
7	29.98	1.87	0.03	1.90
8	30.42	1.90	0.03	1.93

SW21				
k	3.32		k (floors 9-13)	3.32
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	22.35	0.62	-0.54	0.07
2	23.34	0.65	-0.57	0.08
2mezz	26.34	0.73	-0.64	0.09
3	27.39	0.76	-0.67	0.09
4	28.18	0.78	-0.69	0.09
5	28.86	0.80	-0.70	0.10
6	29.47	0.82	-0.72	0.10
7	29.98	0.83	-0.73	0.10
8	30.42	0.84	-0.74	0.10
9	30.84	1.10	-0.82	0.28
10	31.24	1.11	-0.83	0.28
11	32.78	1.17	-0.87	0.30
12	34.31	1.22	-0.91	0.31
13	35.27	1.26	-0.94	0.32

SW16				
k	5.93			
Sum k	119.89			
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	22.35	1.11	-0.97	0.13
2	23.34	1.15	-1.02	0.14
2mezz	26.34	1.30	-1.15	0.16
3	27.39	1.35	-1.19	0.16
4	28.18	1.39	-1.23	0.17
5	28.86	1.43	-1.26	0.17
6	29.47	1.46	-1.28	0.17
7	29.98	1.48	-1.31	0.18
8	30.42	1.50	-1.32	0.18

SW17				
k	5.93			
Sum k	119.89			
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	22.35	1.11	1.59	2.70
2	23.34	1.15	1.66	2.82
2mezz	26.34	1.30	1.87	3.18
3	27.39	1.35	1.95	3.30
4	28.18	1.39	2.01	3.40
5	28.86	1.43	2.05	3.48
6	29.47	1.46	2.10	3.56
7	29.98	1.48	2.13	3.62
8	30.42	1.50	2.17	3.67

SW18				
k	7.47			
Sum k	119.89			
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	22.35	1.39	-1.23	0.17
2	23.34	1.45	-1.28	0.17
2mezz	26.34	1.64	-1.44	0.20
3	27.39	1.71	-1.50	0.20
4	28.18	1.76	-1.55	0.21
5	28.86	1.80	-1.58	0.21
6	29.47	1.84	-1.62	0.22
7	29.98	1.87	-1.64	0.22
8	30.42	1.90	-1.67	0.23

SW22				
k	13.7		k (floors 9-13)	13.7
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	61.95	8.21	185.01	193.23
2	64.69	8.58	193.18	201.76
2mezz	72.62	9.63	216.87	226.50
3	75.22	9.97	224.61	234.59
4	77.17	10.23	230.44	240.67
5	78.87	10.46	235.52	245.97
6	80.38	10.66	240.03	250.69
7	81.63	10.82	243.78	254.60
8	82.75	10.97	247.11	258.08
9	83.79	12.34	272.62	284.96
10	84.79	12.49	275.88	288.36
11	88.87	13.09	289.15	302.24
12	92.95	13.69	302.43	316.12
13	95.47	14.06	310.60	324.66

SW23				
k	13.7		k (floors 9-13)	13.7
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	61.95	8.21	236.51	244.73
2	64.69	8.58	246.96	255.53
2mezz	72.62	9.63	277.24	286.87
3	75.22	9.97	287.14	297.11
4	77.17	10.23	294.58	304.81
5	78.87	10.46	301.07	311.53
6	80.38	10.66	306.84	317.50
7	81.63	10.82	311.64	322.46
8	82.75	10.97	315.89	326.86
9	83.79	12.34	348.51	360.85
10	84.79	12.49	352.67	365.16
11	88.87	13.09	369.64	382.73
12	92.95	13.69	386.61	400.30
13	95.47	14.06	397.06	411.12

SW24				
k	3.32		k (floors 9-13)	3.32
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	22.35	0.62	0.89	1.51
2	23.34	0.65	0.93	1.58
2mezz	26.34	0.73	1.05	1.78
3	27.39	0.76	1.09	1.85
4	28.18	0.78	1.12	1.90
5	28.86	0.80	1.15	1.95
6	29.47	0.82	1.17	1.99
7	29.98	0.83	1.19	2.02
8	30.42	0.84	1.21	2.05
9	30.84	1.10	1.34	2.44
10	31.24	1.11	1.36	2.47
11	32.78	1.17	1.42	2.59
12	34.31	1.22	1.49	2.71
13	35.27	1.26	1.53	2.79

Seismic Load Case:

North South Seismic Loading			
Level	Seismic Load		Q = P*e/S(K*d2) =
1mezz	3		9.20273E-06
2	12		3.68109E-05
2mezz	12		3.68109E-05
3	29		8.89597E-05
4	40		0.000122703
5	50		0.000153379
6	61		0.000187122
7	72		0.000220865
8	77		0.000236203
9	88		0.000294108
10	99		0.000330872
11	110		0.000367635
12	125		0.000417767
13	120		0.000401057
14	110		0.000337433
15	100		0.000306758
16	106		0.000325163
17	113		0.000346636
18	119		0.000365041
19	126		0.000386514
20	133		0.000407988
21	140		0.000429461
22	147		0.000450934
23	154		0.000472407
Roof Main	157		0.000481609
	Total	2303	

East West Seismic Loading			
Level	Seismic Load		Q = P*e/S(K*d2) =
1mezz	3		0.000161663
2	12		0.000646651
2mezz	12		0.000646651
3	29		0.001562741
4	40		0.002155505
5	50		0.002694381
6	61		0.003287145
7	72		0.003879909
8	77		0.004149347
9	88		0.000294108
10	99		0.000330872
11	110		0.000367635
12	125		0.000417767
13	120		0.000401057
14	110		0.000337433
15	100		0.000306758
16	106		0.000325163
17	113		0.000346636
18	119		0.000365041
19	126		0.000386514
20	133		0.000407988
21	140		0.000429461
22	147		0.000450934
23	154		0.000472407
Roof Main	157		0.000481609
	Total	2303	

SW1				
k (floors 1-8)=	27.9		k (floors 9-13)	16.61
Sum k (floors 1-8)=	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear (kips)	Torsional Shear (kips)	Total Shear(kips)
1mezz	3.00	0.70	-0.35	0.35
2	12.00	2.79	-1.39	1.40
2mezz	12.00	2.79	-1.39	1.40
3	29.00	6.75	-3.36	3.39
4	40.00	9.31	-4.63	4.67
5	50.00	11.64	-5.79	5.84
6	61.00	14.20	-7.07	7.13
7	72.00	16.76	-8.34	8.41
8	77.00	17.92	-8.92	9.00
9	88.00	26.37	-0.63	25.74
10	99.00	29.67	-0.71	28.96
11	110.00	32.97	-0.79	32.18
12	125.00	37.46	-0.90	36.57
13	120.00	35.97	-0.86	35.10

SW2				
k	1.738953498		k (floors 9-13)	17.27
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.50	-1.37	-0.87
2	12.00	2.01	-5.49	-3.48
2mezz	12.00	2.01	-5.49	-3.48
3	29.00	4.85	-13.26	-8.41
4	40.00	6.69	-18.29	-11.60
5	50.00	8.36	-22.86	-14.50
6	61.00	10.20	-27.89	-17.69
7	72.00	12.03	-32.92	-20.88
8	77.00	12.87	-35.20	-22.33
9	88.00	16.34	-43.83	-27.50
10	99.00	18.38	-49.31	-30.94
11	110.00	20.42	-54.79	-34.37
12	125.00	23.20	-62.26	-39.06
13	120.00	22.28	-59.77	-37.50

SW3				
k	0.060804106		k (floors 9-13)	5.93
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.17	-0.77	-0.59
2	12.00	0.69	-3.06	-2.37
2mezz	12.00	0.69	-3.06	-2.37
3	29.00	1.66	-7.40	-5.73
4	40.00	2.30	-10.21	-7.91
5	50.00	2.87	-12.76	-9.89
6	61.00	3.50	-15.56	-12.06
7	72.00	4.13	-18.37	-14.24
8	77.00	4.42	-19.65	-15.23
9	88.00	5.61	-24.46	-18.85
10	99.00	6.31	-27.52	-21.21
11	110.00	7.01	-30.58	-23.57
12	125.00	7.97	-34.75	-26.78
13	120.00	7.65	-33.36	-25.71

SW7				
k	3.33		k (floors 9-13)	3.33
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.08	-0.04	0.04
2	12.00	0.33	-0.17	0.17
2mezz	12.00	0.33	-0.17	0.17
3	29.00	0.81	-0.40	0.40
4	40.00	1.11	-0.55	0.56
5	50.00	1.39	-0.69	0.70
6	61.00	1.69	-0.84	0.85
7	72.00	2.00	-1.00	1.00
8	77.00	2.14	-1.06	1.07
9	88.00	3.15	-0.08	3.07
10	99.00	3.54	-0.08	3.46
11	110.00	3.93	-0.09	3.84
12	125.00	4.47	-0.11	4.36
13	120.00	4.29	-0.10	4.19

SW8				
k	93.09		k (floors 9-13)	2.06
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.06	-0.01	0.05
2	12.00	0.24	-0.04	0.20
2mezz	12.00	0.24	-0.04	0.20
3	29.00	0.58	-0.09	0.49
4	40.00	0.80	-0.12	0.67
5	50.00	1.00	-0.15	0.84
6	61.00	1.22	-0.19	1.03
7	72.00	1.44	-0.22	1.21
8	77.00	1.54	-0.24	1.30
9	88.00	1.95	-0.30	1.65
10	99.00	2.19	-0.33	1.86
11	110.00	2.44	-0.37	2.06
12	125.00	2.77	-0.42	2.35
13	120.00	2.66	-0.41	2.25

SW9				
k	2.07		k (floors 9-13)	2.07
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.05	0.04	0.09
2	12.00	0.21	0.17	0.38
2mezz	12.00	0.21	0.17	0.38
3	29.00	0.50	0.41	0.91
4	40.00	0.69	0.56	1.25
5	50.00	0.86	0.70	1.57
6	61.00	1.05	0.86	1.91
7	72.00	1.24	1.01	2.25
8	77.00	1.33	1.08	2.41
9	88.00	1.96	0.08	2.03
10	99.00	2.20	0.09	2.29
11	110.00	2.45	0.10	2.54
12	125.00	2.78	0.11	2.89
13	120.00	2.67	0.10	2.77

SW4				
k	16.84		k (floors 9-13)	16.84
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.42	-0.21	0.21
2	12.00	1.69	-0.84	0.85
2mezz	12.00	1.69	-0.84	0.85
3	29.00	4.07	-2.03	2.05
4	40.00	5.62	-2.80	2.82
5	50.00	7.02	-3.50	3.53
6	61.00	8.57	-4.27	4.30
7	72.00	10.11	-5.03	5.08
8	77.00	10.82	-5.38	5.43
9	88.00	15.92	-0.38	15.54
10	99.00	17.91	-0.43	17.48
11	110.00	19.90	-0.48	19.42
12	125.00	22.61	-0.54	22.07
13	120.00	21.71	-0.52	21.19

SW5				
k	0		k (floors 9-13)	13.7
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.40	-0.33	0.07
2	12.00	1.59	-1.32	0.27
2mezz	12.00	1.59	-1.32	0.27
3	29.00	3.84	-3.19	0.66
4	40.00	5.30	-4.40	0.91
5	50.00	6.63	-5.50	1.13
6	61.00	8.09	-6.71	1.38
7	72.00	9.55	-7.92	1.63
8	77.00	10.21	-8.47	1.74
9	88.00	12.96	-10.54	2.42
10	99.00	14.58	-11.86	2.72
11	110.00	16.20	-13.18	3.02
12	125.00	18.41	-14.97	3.43
13	120.00	17.67	-14.37	3.30

SW6				
k	16.84		k (floors 9-13)	16.84
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.42	0.34	0.76
2	12.00	1.69	1.37	3.06
2mezz	12.00	1.69	1.37	3.06
3	29.00	4.07	3.31	7.39
4	40.00	5.62	4.57	10.19
5	50.00	7.02	5.71	12.74
6	61.00	8.57	6.97	15.54
7	72.00	10.11	8.23	18.34
8	77.00	10.82	8.80	19.61
9	88.00	15.92	0.62	16.54
10	99.00	17.91	0.70	18.61
11	110.00	19.90	0.78	20.68
12	125.00	22.61	0.89	23.50
13	120.00	21.71	0.85	22.56

SW10				
k	2.07		k (floors 9-13)	2.07
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.05	-0.03	0.03
2	12.00	0.21	-0.10	0.10
2mezz	12.00	0.21	-0.10	0.10
3	29.00	0.50	-0.25	0.25
4	40.00	0.69	-0.34	0.35
5	50.00	0.86	-0.43	0.43
6	61.00	1.05	-0.52	0.53
7	72.00	1.24	-0.62	0.62
8	77.00	1.33	-0.66	0.67
9	88.00	1.96	-0.05	1.91
10	99.00	2.20	-0.05	2.15
11	110.00	2.45	-0.06	2.39
12	125.00	2.78	-0.07	2.71
13	120.00	2.67	-0.06	2.60

SW11				
k	13.7		k (floors 9-13)	13.7
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.40	0.01	0.41
2	12.00	1.59	0.03	1.62
2mezz	12.00	1.59	0.03	1.62
3	29.00	3.84	0.08	3.92
4	40.00	5.30	0.10	5.41
5	50.00	6.63	0.13	6.76
6	61.00	8.09	0.16	8.25
7	72.00	9.55	0.19	9.73
8	77.00	10.21	0.20	10.41
9	88.00	12.96	0.25	13.21
10	99.00	14.58	0.28	14.86
11	110.00	16.20	0.31	16.51
12	125.00	18.41	0.35	18.76
13	120.00	17.67	0.34	18.01

SW12				
k	2.07		k (floors 9-13)	2.07
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.05	0.04	0.09
2	12.00	0.21	0.17	0.38
2mezz	12.00	0.21	0.17	0.38
3	29.00	0.50	0.41	0.91
4	40.00	0.69	0.56	1.25
5	50.00	0.86	0.70	1.57
6	61.00	1.05	0.86	1.91
7	72.00	1.24	1.01	2.25
8	77.00	1.33	1.08	2.41
9	88.00	1.96	0.08	2.03
10	99.00	2.20	0.09	2.29
11	110.00	2.45	0.10	2.54
12	125.00	2.78	0.11	2.89
13	120.00	2.67	0.10	2.77

SW13				
k	1.63		k (floors 9-13)	1.63
Sum k	108.6		Sum k (floors 9-13)	81.8
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.04	-0.02	0.02
2	12.00	0.16	-0.08	0.08
2mezz	12.00	0.16	-0.08	0.08
3	29.00	0.39	-0.20	0.20
4	40.00	0.54	-0.27	0.27
5	50.00	0.68	-0.34	0.34
6	61.00	0.83	-0.41	0.42
7	72.00	0.98	-0.49	0.49
8	77.00	1.05	-0.52	0.53
9	88.00	1.54	-0.04	1.50
10	99.00	1.73	-0.04	1.69
11	110.00	1.93	-0.05	1.88
12	125.00	2.19	-0.05	2.14
13	120.00	2.10	-0.05	2.05

SW14				
k	13.7		k (floors 9-13)	13.7
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.40	0.18	0.58
2	12.00	1.59	0.72	2.31
2mezz	12.00	1.59	0.72	2.31
3	29.00	3.84	1.75	5.59
4	40.00	5.30	2.41	7.71
5	50.00	6.63	3.01	9.64
6	61.00	8.09	3.67	11.76
7	72.00	9.55	4.34	13.88
8	77.00	10.21	4.64	14.85
9	88.00	12.96	5.77	18.73
10	99.00	14.58	6.49	21.07
11	110.00	16.20	7.22	23.42
12	125.00	18.41	8.20	26.61
13	120.00	17.67	7.87	25.54

SW15				
k	1.63		k (floors 9-13)	1.63
Sum k	108.6		Sum k (floors 9-13)	81.8
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.04	0.03	0.07
2	12.00	0.16	0.13	0.30
2mezz	12.00	0.16	0.13	0.30
3	29.00	0.39	0.32	0.72
4	40.00	0.54	0.44	0.99
5	50.00	0.68	0.55	1.23
6	61.00	0.83	0.67	1.50
7	72.00	0.98	0.80	1.78
8	77.00	1.05	0.85	1.90
9	88.00	1.54	0.06	1.60
10	99.00	1.73	0.07	1.80
11	110.00	1.93	0.08	2.00
12	125.00	2.19	0.09	2.27
13	120.00	2.10	0.08	2.18

SW19				
k	10.3		k (floors 9-13)	17.27
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.30	0.44	0.74
2	12.00	1.20	1.75	2.94
2mezz	12.00	1.20	1.75	2.94
3	29.00	2.89	4.22	7.11
4	40.00	3.99	5.82	9.81
5	50.00	4.98	7.27	12.26
6	61.00	6.08	8.87	14.95
7	72.00	7.18	10.47	17.65
8	77.00	7.68	11.20	18.88

SW20				
k	7.47		k (floors 9-13)	3.33
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.19	0.00	0.19
2	12.00	0.75	0.01	0.75
2mezz	12.00	0.75	0.01	0.75
3	29.00	1.81	0.02	1.82
4	40.00	2.49	0.02	2.52
5	50.00	3.12	0.03	3.15
6	61.00	3.80	0.04	3.84
7	72.00	4.49	0.04	4.53
8	77.00	4.80	0.05	4.84

SW21				
k	3.32		k (floors 9-13)	3.32
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.08	-0.04	0.04
2	12.00	0.33	-0.17	0.17
2mezz	12.00	0.33	-0.17	0.17
3	29.00	0.80	-0.40	0.40
4	40.00	1.11	-0.55	0.56
5	50.00	1.38	-0.69	0.70
6	61.00	1.69	-0.84	0.85
7	72.00	1.99	-0.99	1.00
8	77.00	2.13	-1.06	1.07
9	88.00	3.14	-0.08	3.06
10	99.00	3.53	-0.08	3.45
11	110.00	3.92	-0.09	3.83
12	125.00	4.46	-0.11	4.35
13	120.00	4.28	-0.10	4.18

SW16				
k	5.93			
Sum k	108.6			
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.15	-0.07	0.07
2	12.00	0.59	-0.30	0.30
2mezz	12.00	0.59	-0.30	0.30
3	29.00	1.43	-0.71	0.72
4	40.00	1.98	-0.98	0.99
5	50.00	2.47	-1.23	1.24
6	61.00	3.02	-1.50	1.52
7	72.00	3.56	-1.77	1.79
8	77.00	3.81	-1.90	1.91

SW17				
k	5.93			
Sum k	108.6			
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.15	0.12	0.27
2	12.00	0.59	0.48	1.08
2mezz	12.00	0.59	0.48	1.08
3	29.00	1.43	1.17	2.60
4	40.00	1.98	1.61	3.59
5	50.00	2.47	2.01	4.49
6	61.00	3.02	2.45	5.47
7	72.00	3.56	2.90	6.46
8	77.00	3.81	3.10	6.91

SW18				
k	7.47			
Sum k	108.6			
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.19	-0.09	0.09
2	12.00	0.75	-0.37	0.38
2mezz	12.00	0.75	-0.37	0.38
3	29.00	1.81	-0.90	0.91
4	40.00	2.49	-1.24	1.25
5	50.00	3.12	-1.55	1.56
6	61.00	3.80	-1.89	1.91
7	72.00	4.49	-2.23	2.25
8	77.00	4.80	-2.39	2.41

SW22				
k	13.7		k (floors 9-13)	13.7
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.40	1.06	1.46
2	12.00	1.59	4.25	5.85
2mezz	12.00	1.59	4.25	5.85
3	29.00	3.84	10.28	14.13
4	40.00	5.30	14.18	19.49
5	50.00	6.63	17.73	24.36
6	61.00	8.09	21.63	29.72
7	72.00	9.55	25.53	35.07
8	77.00	10.21	27.30	37.51
9	88.00	12.96	33.99	46.95
10	99.00	14.58	38.24	52.82
11	110.00	16.20	42.49	58.69
12	125.00	18.41	48.29	66.69
13	120.00	17.67	46.36	64.03

SW23				
k	13.7		k (floors 9-13)	13.7
Sum k	103.33		Sum k (floors 9-13)	93.03
Level	Load N-S	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.40	1.36	1.76
2	12.00	1.59	5.44	7.03
2mezz	12.00	1.59	5.44	7.03
3	29.00	3.84	13.14	16.99
4	40.00	5.30	18.13	23.43
5	50.00	6.63	22.66	29.29
6	61.00	8.09	27.65	35.74
7	72.00	9.55	32.63	42.18
8	77.00	10.21	34.90	45.11
9	88.00	12.96	43.46	56.42
10	99.00	14.58	48.89	63.47
11	110.00	16.20	54.32	70.52
12	125.00	18.41	61.73	80.14
13	120.00	17.67	59.26	76.93

SW24				
k	3.32		k (floors 9-13)	3.32
Sum k	119.89		Sum k (floors 9-13)	93.09
Level	Load E-W	Direct Shear	Torsional Shear	Total Shear
1mezz	3.00	0.08	0.07	0.15
2	12.00	0.33	0.27	0.60
2mezz	12.00	0.33	0.27	0.60
3	29.00	0.80	0.65	1.46
4	40.00	1.11	0.90	2.01
5	50.00	1.38	1.13	2.51
6	61.00	1.69	1.37	3.06
7	72.00	1.99	1.62	3.62
8	77.00	2.13	1.73	3.87
9	88.00	3.14	0.12	3.26
10	99.00	3.53	0.14	3.67
11	110.00	3.92	0.15	4.08
12	125.00	4.46	0.17	4.63
13	120.00	4.28	0.17	4.45

APPENDIX E: Shear Wall Spot Check and Overturning

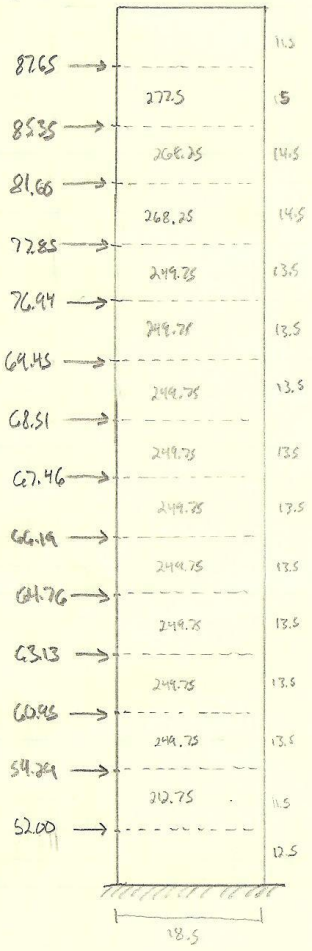
Spot Check SW23 Case 1 Wind

Load Comb. 4) 1.2D + 1.0W + L + .5(Lr, S, R) strength (Neglecting Term)

5) .9D + 1.0W Overturning

H= 214.5' L=18.5' t=1.5' f'_c = 5000psi f_y = 60,000psi

1.0(W)



DL = 44 psf
LL = 50 psf
SDL = 30 psf

A_t ≈ 900sf for gravity load

V_u = 976 K
M_u = 104139 IK

Gravity Load
1.2D + 1.0W + L

1.2(44+30)900) = 79920 ≈ 79.92 K

50(900) = 45000 ≈ 45 K

P_u = 124.92

Self weight $1.2\left[150\left(18.5\right)\left(214.5\right)\left(1.5\right)\right]$ = 1071427.5 ≈ 1071.4 K

Total P_u = 1196.3

• Check wall permitted shear str

$V_c < \phi V_n$ = $\phi(6)\sqrt{f'_c}\,hd$ d=.8ℓw

= .75(6)$\sqrt{5000}$ .8(185)(222)/1000 = 1130 K > 976 K ∴OK

• Shear str by conc

$a = \frac{\ell_w}{2}$ = 111" = 9.25'

M_u = V_u(257.4 - 111) = 24634V_u

$V_c = 2\sqrt{f'_c}\,hd$ = 2$\sqrt{5000}$(18)(.8)(222)/1000 = 301.9 K

$V_c = 3.3\sqrt{f'_c}\,hd + \frac{N_u d}{\ell_w}$

= 3.3$\sqrt{5000}$(18)(.8)(222)/1000 = 497.3 K

$= \left[\frac{.6\sqrt{5000}}{\frac{24634V_u}{V_u} - \frac{222}{2}}\right]\frac{12(.8)(222)}{1000}$ = 108.2 K

Key horiz shear

$V_u > \frac{1}{2}\phi V_c$ $\frac{1}{2}\phi V_c$ = 40.6 < V_u

665.08 = .75(108.2 + V_s) V_s = 878

$V_s = \frac{A_v f_y d}{s}$ $\frac{A_v}{s} = \frac{V_s}{f_y d} = \frac{878}{60(.8)(222)}$ = 0.082

$s = \frac{A_v}{0.082} = \frac{2(.79)}{0.082}$ = 19.27 ∴ty 2 #8 @ 14" OC check $\rho_t = \frac{A_v}{sh} = \frac{2(.79)}{14(18)}$ = 0.094 > .082 ∴OK

Use (2) #8 @ 14" O.C. For horizontal sheet

* Actual Rebar used #6 @ 12" OC on levels B3-7

Vertical Shear

$\rho_h = \frac{A_v}{sh} > .0025 + .5\left(2.5 - \frac{h_w}{l_w}\right)(\rho_v - .0025)$

$\rightarrow .0025 + .5(2.5 - \frac{25.24}{22.0})(.004 - .0025) = -0.4 < .0025$

$\rho_h = .0025$

Try 2(#4)

$s = \frac{A_v(2)}{.0025(12)} = 13.3"$ ∴ use 2 #4 @ 12" for vertical reinforce

* Actual Rebar used #8 @ 12" on levels 13-14

Design Flexural

$M_u = 104139$ IF $M_n = A_s f_y (d - a/2) = A_s f_y (jd)$ $jd = .7d = .9(.8(22)) = 159.84$

$< \rightarrow .85 f'_c ab = A_s f_y$

$M_u = \phi M_n = \phi A_s f_y (jd)$

$= 104139 (12000) = .9(A_s)(60,000)(159.84)$

$A_s = 144.7$

Use 37 #18 bars @ each pod ≈ Seems really high not positive on calculation

Overturning Check SW23

.9D + 1.0W $M_u = 709677.72$

.9D : $.9[(74 \cdot 900)] = 59940 \approx 59.9^K$

$.9[150(18.5)(.394)(1.5)] = 803570 \simeq 803.5^K$ } $= 863.4^K$

Uplift due to wind: $T = \frac{M_u}{d} = \frac{104139}{.8(22)} = 7036^K$

$4759 > 863.4$ resulting in uplift

- The foundation system should take this into effect.
- Error could be attributed to error in Center of Mass & Center of Rigidity Calcs

- Overturn will be an issue

APPENDIX F: Deflection Check

Allowable Drift Analysis						
			Allowable Wind Deflection (in)		Allowable Seismic Deflections	
Level	Level Height	Story Height	Total Drift (H/400)	Story Drift (H/400)	Total Drift (.02H)	Story Drift (.02H)
0	0	150	0	0.375	0	3
1m	150	138	0.375	0.345	3	2.76
2	288	162	0.72	0.405	5.76	3.24
2m	450	162	1.125	0.405	9	3.24
3	612	162	1.53	0.405	12.24	3.24
4	774	162	1.935	0.405	15.48	3.24
5	936	162	2.34	0.405	18.72	3.24
6	1098	162	2.745	0.405	21.96	3.24
7	1260	162	3.15	0.405	25.2	3.24
8	1422	162	3.555	0.405	28.44	3.24
9	1584	162	3.96	0.405	31.68	3.24
10	1746	162	4.365	0.405	34.92	3.24
11	1908	174	4.77	0.435	38.16	3.48
12	2082	174	5.205	0.435	41.64	3.48
13	2256	180	5.64	0.45	45.12	3.6

SW 23 Displacement Due to Wind Case 1	
Level	Displacement (in)
0	**0**
1m	0.37
2	1.28
2m	2.94
3	5.15
4	7.84
5	10.9
6	14.29
7	17.91
8	21.73
9	25.68
10	29.72
11	33.82
12	38.25
13	42.69