FDA OC/ORA Office Building

Silver Spring, MD

Technical Assignment 3

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Structural Option

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Executive Summary

The lateral analysis of Wing B of the FDA OC/ORA Office Building was performed using the lateral and gravity loads that were determined in the first technical report. Different load combinations by ASCE 7-05 were studied and the load combinations that included lateral loads were used to design and check the lateral resisting members of the office building. Both Wind and Seismic Loads were analyzed for both strength and deflection, for Wind; Load Case 1 and Load Case 2 prescribed by ASCE 7-05 were analyzed. The other wind load cases were not studied in this report.

The direct shear and torisional effects from the lateral loading were calculated for each shear wall, using the Center of Mass for the seismic load application and Center of Wind Pressure for the wind load. The loads were taken about the Center of Rigidity which was calculated using the relative stiffness of the shear walls.

A spot check was done for lateral system; Shear Wall 2 was picked because of the large base shear over the other shear walls and load cases. ACI 318-08 Chapter 11 provision on shear wall design was used to design the shear wall and compare the reinforcement to the actual designed shear wall. An impact on the foundation system was also performing, checking the impact of overturning.

To calculate the drifts of the shear walls under the loads, SAP 2D models were created and compared to hand deflection calculations. The deflections for each shear wall were compared to allowable story drift and total drift as set by ASCE 7-05. The seismic drifts were modified as specified by ASCE 7-05 Chapter 11 for Seismic Provisions. The drifts were also compared to the distance that separated the Wings at the expansion joints.

Introduction

Starting the fifth phase of the consolidation efforts by the FDA, the OC/ ORA Office building plans to move the Office of Commissioner (OC), Office of Regulatory Affairs (ORA) Office building to the White Oak Campus. On the site of the former US Navy facility at the Federal Research Center- Naval Ordnance Laboratory, the OC/ ORA Office Building sits on the southern end, and forms its shape around the existing buildings.

Forming an S shaped building, the 500,000 S.F. office building was laid out and designed to mirror the existing buildings on the site and to form a unique face of the campus from the main drive off of New Hampshire Ave. Broken up into two buildings with four wings, Building 31 is comprised of Wing A, and Building 32 is comprised of wings B through D (Figure 1)

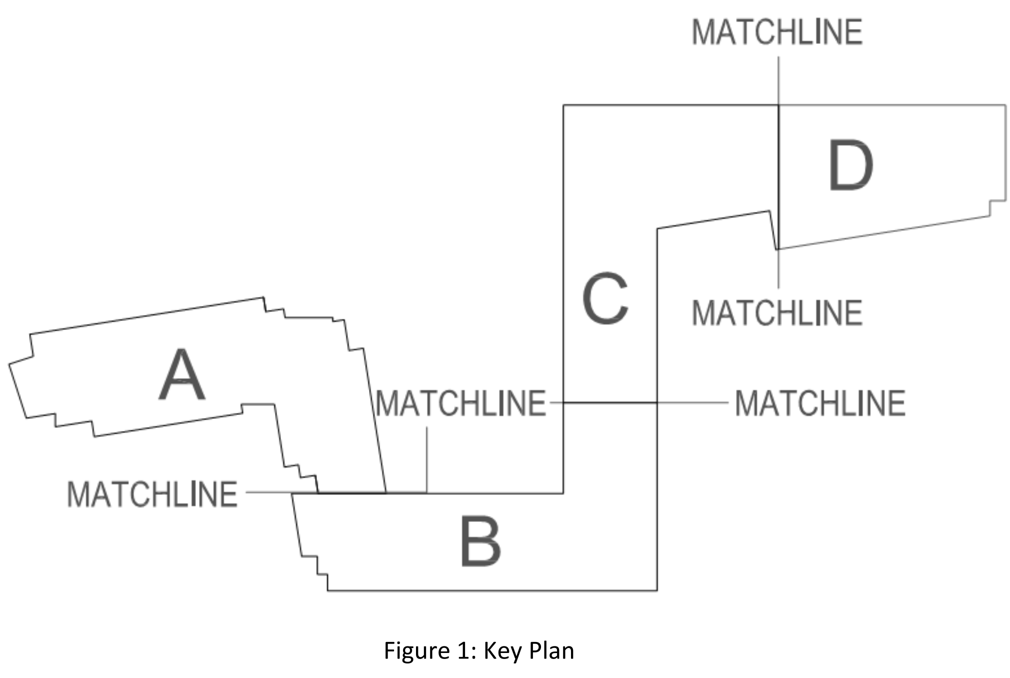


Figure 1: Key Plan

Structural System

Foundation:

The foundation of the building is separated into two categories. Spread footings that bear on undisturbed soil or spread footings that sit on a number of Geopiers. Schnabel Engineering conducted soil test to determine the bearing capacities of the soils. Where 95% compaction could not be met the use of Geopiers or vibropiers was recommended.

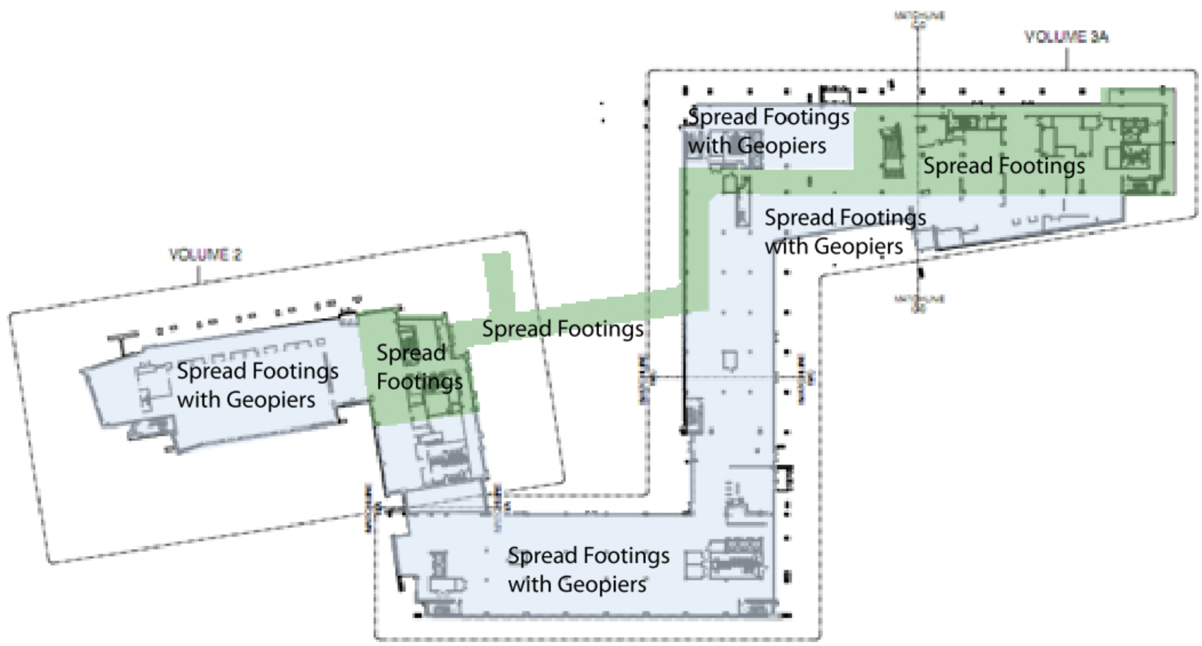


Figure 2: Foundation Key

For non-basement areas of Building 31 (Wing A), the western and central wings (Wings B and C) of Building 32, and the non-basement areas of Wing D, deep existing fill is expected within the majority of the buildings footprint. Geopiers are to be used in these areas to provide adequate bearing capacity (Figure 2). Geopiers use the concept of over consolidation to increase the soils bearing capacity. The 30 inch diameter Geopeirs should reach a depth of at least 10 feet. A detail of the typical spread footing with Geopiers is shown in Figure 3.

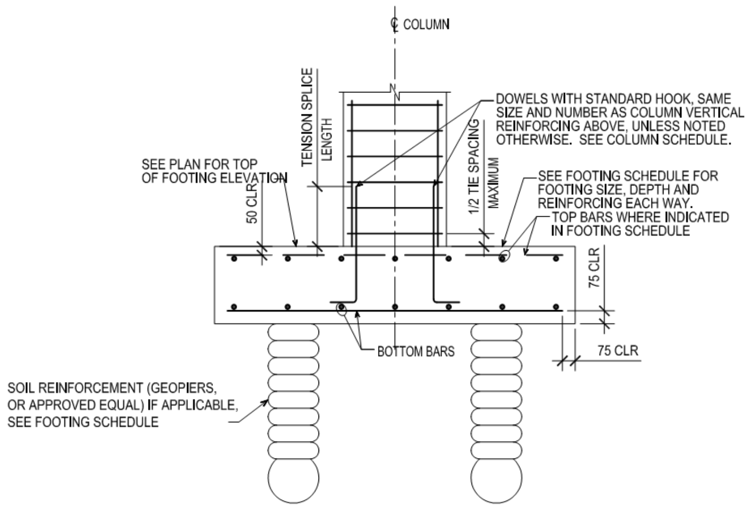


Figure 3: Typical Geopier Foundation Detail

For the basement level of Building 31 (Wing A), the basement level of Wing D of Building 32, and the underground tunnels, the foundations reach a sufficient depth where the bearing capacities on the spread footings are adequate (Figure 2).

Normal weight concrete was designed to be used with all the spread footings of the foundations. With a unit weight of 2350 kg/m^3 (147 pcf), the concrete has a 28 day strength of 28 MPa (4061 psi) concrete. A water to cement ratio of .48 is specified along with only 1% maximum chloride content.

Schnabel Engineering recommended the use minimum safe bearing capacities at the different locations of the foundation system. Where spread footings bear on undisturbed soil a bearing capacity of 192 kPa (4010 psf) was estimated. Beneath the spread footings of Wing A, where Geopiers were used, the estimated bearing capacity is 192 kPa (4010 psf). In the sections of Building 32 where Geopiers were used, a bearing capacity of 287 kPa (5994 psf) was estimated.

Floor System:

Building 31:

Building 31 utilizes a one way slab floor system for the majority of the buildings layout. The typical one way slab construction is an 8.07 inch thick slab with 5.91 inch drop panels, unless noted differently on the drawings. On the first three floors of Wing A there is a large open assembly space, and prevents any typical bay spacing. However, on the fourth floor the typical bay spacing is 21.85' x 26.74' to 19.685' x 19.685'.

Resistance to progressive collapse was designed into the exterior reinforced beams of building 31. Typical progressive collapse beam sizes range from 23.62" x 42.32" to 18.11" x 35.43". The interior beams on Building 31 are reinforced concrete beams with typical sizes of 18.11" x 35.43" to 18.11" x 23.62".

A large assembly pace on the first floor of Wing A is open up through the third floor. On the fourth floor framing level, post tension transfer girders were designed to support the column loads above the fourth floor and transfer the load to the foundation (Figure 4). The post tension transfer girders are 35.43" x 70.89" and have a post tension strand force of 4540 kN.

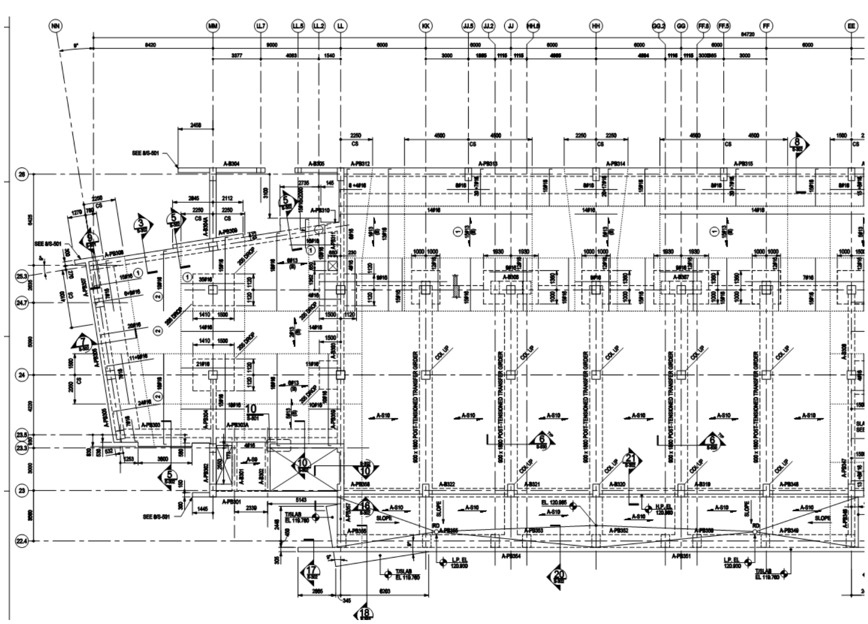


Figure 4: Framing Flan for Post Tension Transfer Girders

An atrium is provided between Wing A and Wing B that is primarily a steel superstructure with lightweight concrete on metal deck (Figure 5). The walkways over the atrium connecting the two wings are cast in place lightweight concrete on steel metal deck. The rib height on the metal deck is 50 mm with an additional 83 mm of concrete above. Supporting the walkway is W360 x 32.9 steel beams that frame into W360 x 32.9 girders with a shear connection. On the Wing A side of the atrium the girders site on an L152x152x9.5 that is attached to the concrete beam in Wing A. On the Wing B side on the atrium, an expansion joint is place, so the girders rest on a sliding connection that is connected to a beam in Wing B (Figure 6 and 7).

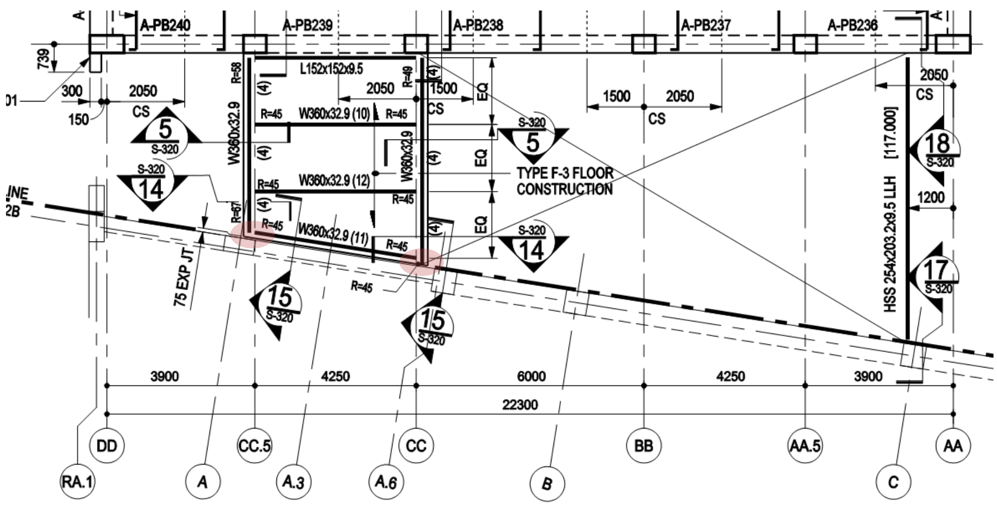


Figure 5: Wing A Atrium

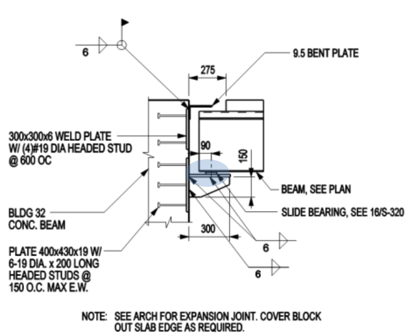


Figure 6: Expansion Joint Detail (Red)

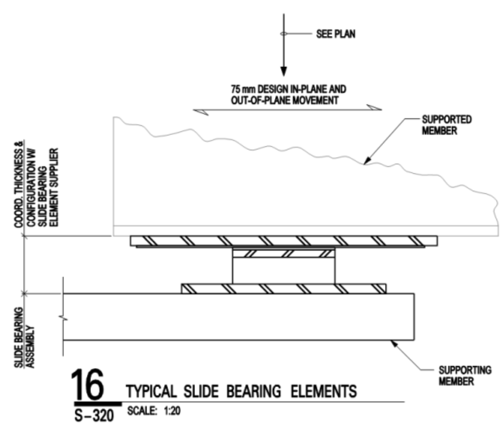


Figure 7: Expansion Joint Detail (Red)

Building 32:

Building 32 utilizes a two way flat slab system for the majority of the building's floor system. A 5.91 inch thick slab on grade is provided for the ground level and the basement levels of the building. The two-way flat slab is typically 9.449" thick with a 7.09" thick drop panel, unless noted differently on the structural drawings. The typical interior bay spacing for Building 32 is 29.528' x 19.685', and the typical exterior bay spacing of 27.559' x 29.528', figure 8 shows the typical layout of the bays.

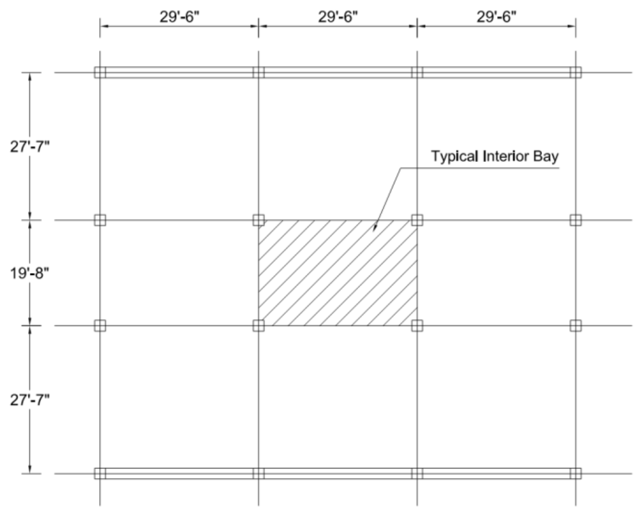


Figure 8: Building 32 Wing B Typical Bay Layout

Resistance to progressive collapse was designed into the exterior reinforced concrete beams of building 32. Typical progressive collapse beam sizes ranging from 23.62" x 40.95" to 15.75" x 40.95".

Atriums are provided between Wings B and C, and between wings C and D. The floor system for the atriums is a cast in place lightweight concrete on metal deck. The rib height on the metal deck is 1.97" with an additional 2.52" of concrete above. Supporting the walkways are W150 x 30 steel beams that frame into W610 x 217 girders with a shear connections. Expansion joints at the Intersections of the wings are provided and sliding connections are required at the atrium walkways.

Columns

Typical reinforced concrete columns were designed for the FDA OC/ ORA Office Building. Designed as the primary gravity system, the typical sizes of the columns are 600mm x 600mm, 900mm x 600mm, and 600 mm diameter. Various types of columns are provided ranging from square columns, rectangular columns and circular columns (Figure 9). The concrete for the columns is a normal weight concrete with 28 day strength of 28 MPa (4061 psi). The slab and the beams are monolithic with the columns forming a continuous system.

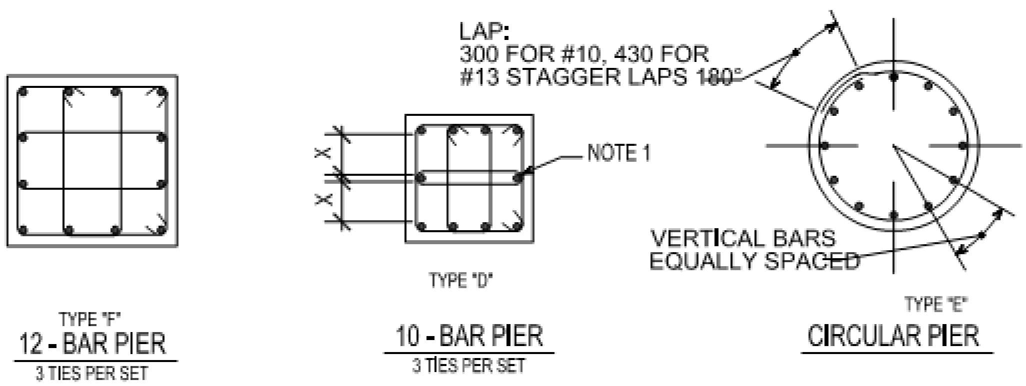


Figure 9: Typical Column Details

Lateral System

Ordinary reinforced concrete shear walls were design for the primary lateral resisting system. The typical shear wall has #16 at 300mm (#5 at 11.82 inches) for both vertical and horizontal reinforcement with 13 #16 (13 #5) for the end zone reinforcement and #13 ties at 300mm (#5 ties at 11.81 inches) for the vertical reinforcement (Figure 10 and 11).

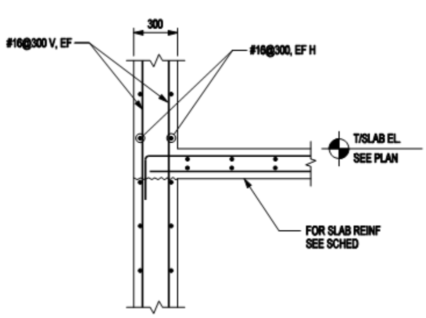


Figure 10: Shear Wall Detail

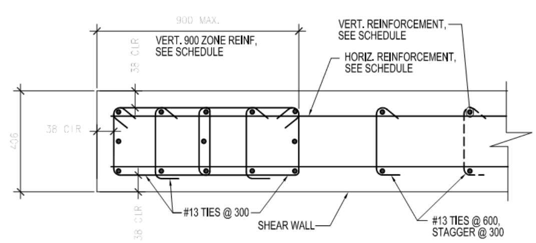


Figure 11: Shear Wall End Zone

Shear walls are provided around each elevator core and the stair shaft of Wing A. Wings B through D provide shear walls around each elevator core; Figures 16 through 19 shows the location of the shears walls in each wing, shown in red. At the intersection of each wing, in the atriums, slide bearing connections are provided at the expansion joints, shown in blue. These connections allow each wing's lateral systems to act independently of the other wing.

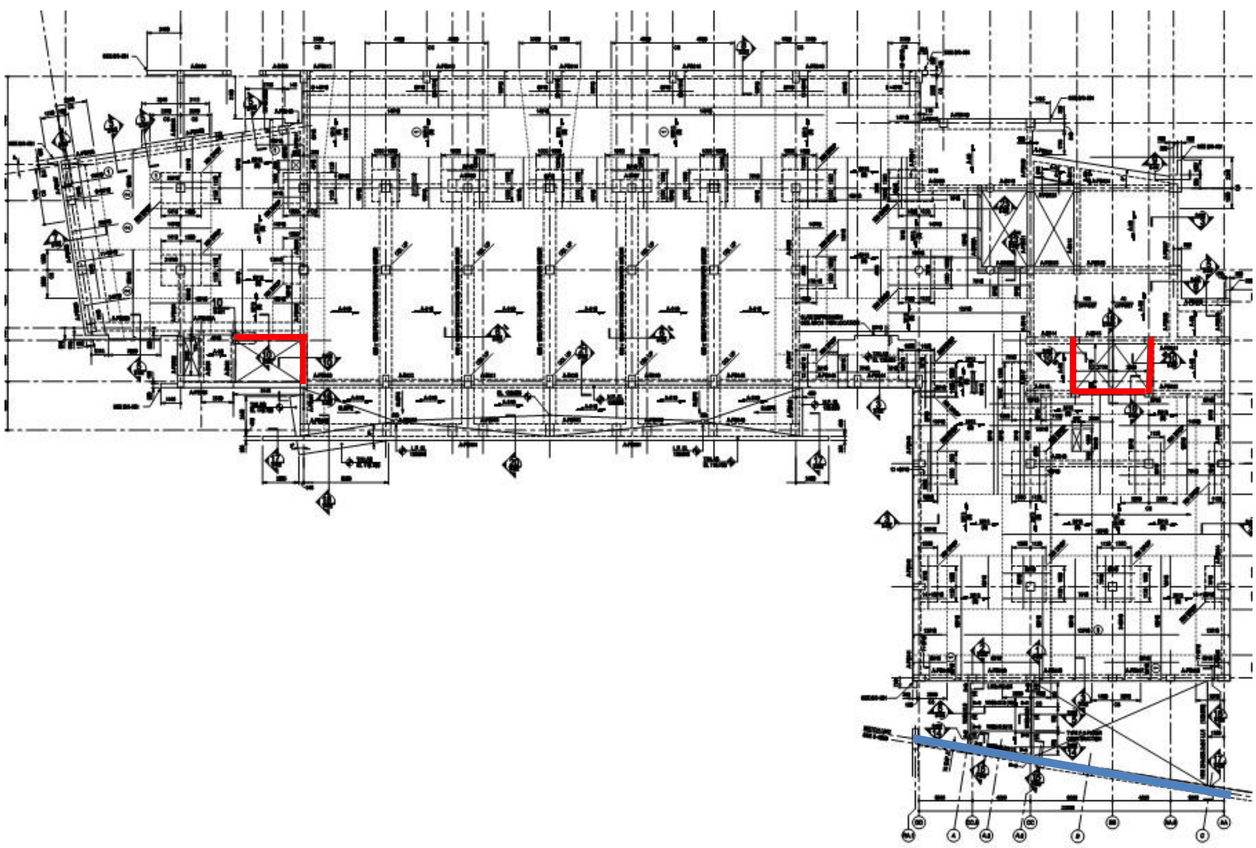


Figure 12: Shears Walls of Wing A

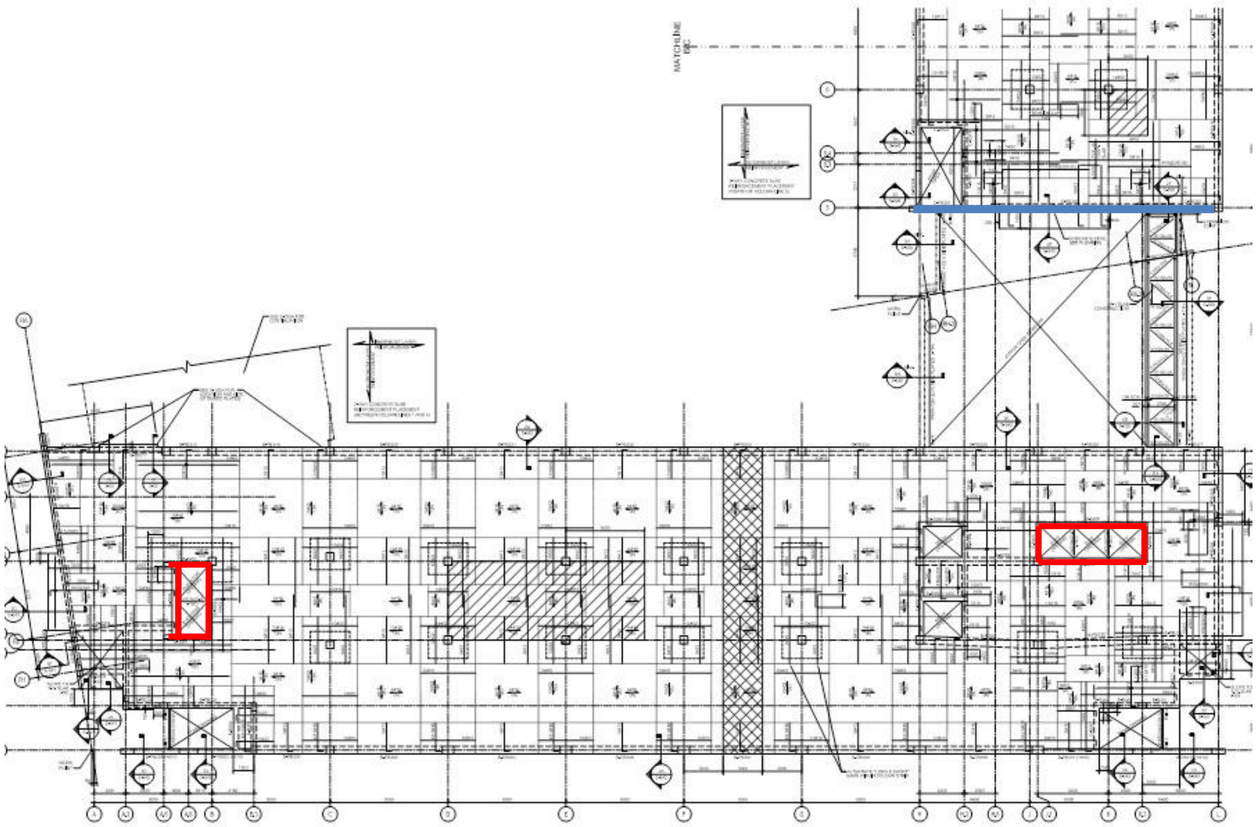


Figure 13: Shear Walls of Wing B

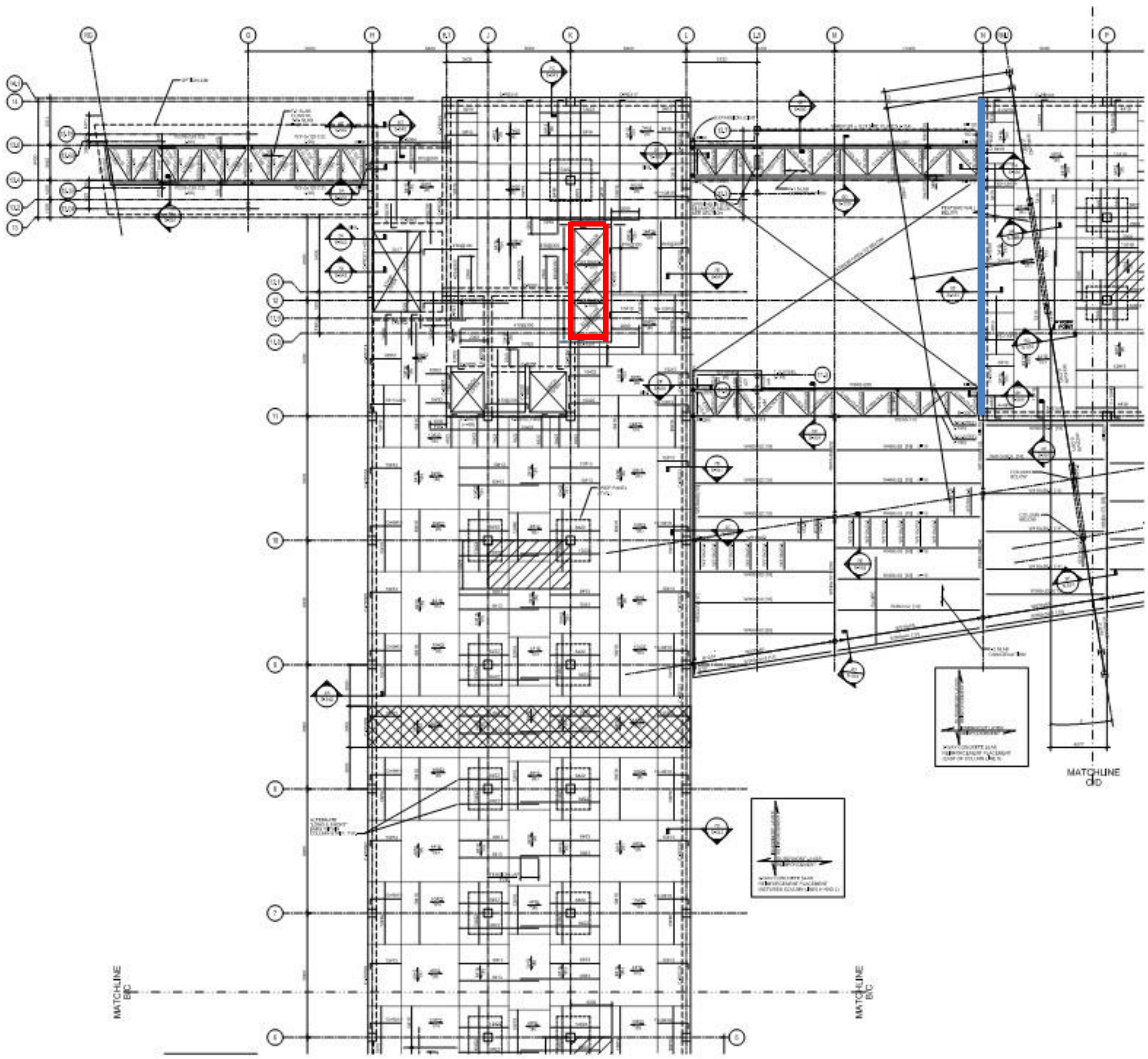


Figure 14: Shear Walls of Wing C

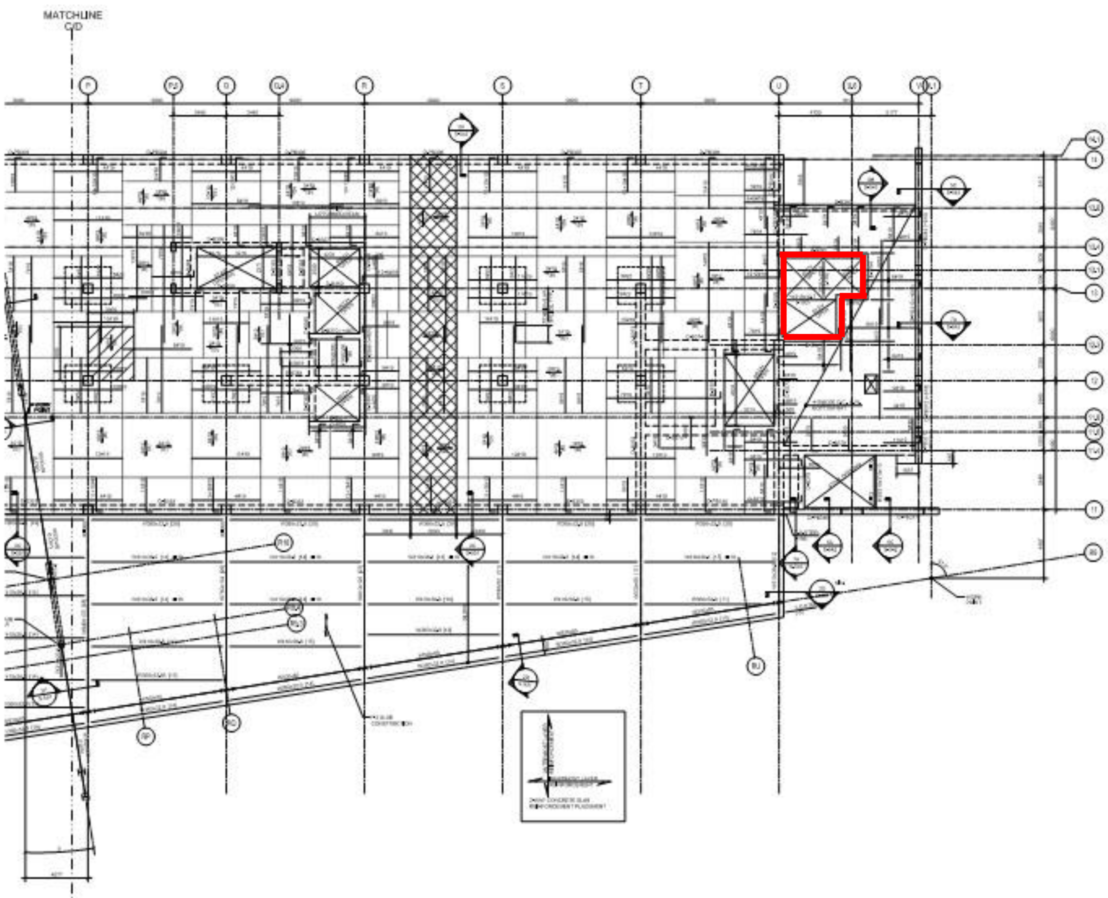


Figure 15: Shear Walls of Wing D

Load Paths

Gravity Load Resisting System:

Reinforced Concrete columns make up the primary gravity load resisting system. The live load, self weight and superimposed dead load that sits on the floor system is transferred to the reinforced concrete beams. Reinforced concrete columns pick up the loads from the beams and the load is transferred to the buildings foundations. In Wing A reinforced concrete columns bear on a post tension transfer girder. Figure 16, shows a diagram of the post tension transfer girder that transfers the gravity load to the exterior columns. Surrounding columns that the transfer girders bear on transfer the load from the girders into the columns. Columns then transfer the load into the foundation of the building.

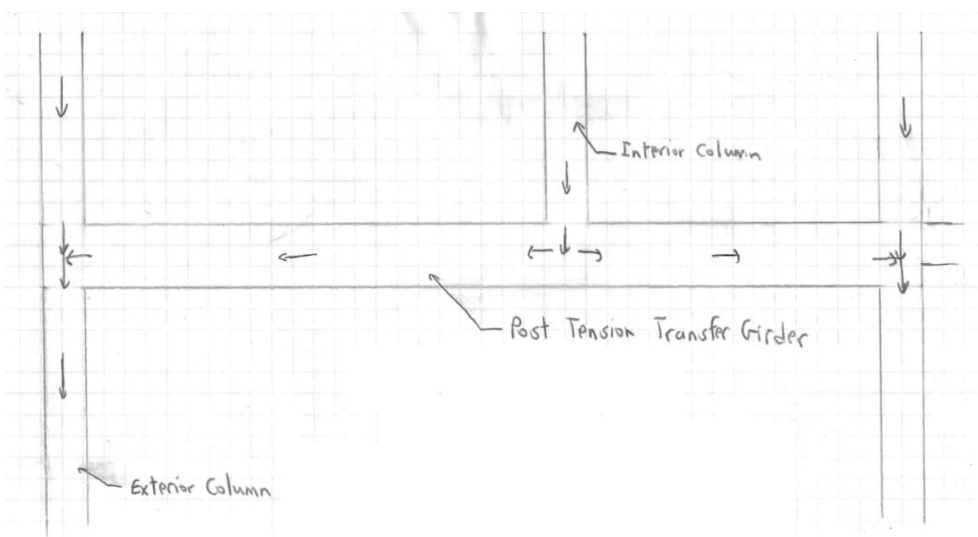


Figure 16: Transfer of Gravity Load

Resistance to progressive collapse has been designed for the office building. Design considerations that are involved with this design are removing an exterior column, and the floor system above and the adjacent columns are designed to carry the additional load.

Lateral Load Resisting System:

Reinforced concrete shear walls are the primary lateral load resisting system. Lateral force due to wind is transmitted against the curtain wall of the building. Rigid floor system picks up each story shear at each level and transmits the lateral force to the shear walls located around each elevator core. Shear walls are design to resist the moment from the lateral load. The resisting moment forces are transmitted through the shear walls onto large spread footings.

Each wing acts independently with respect to the others wings. This is primarily due to the large expansion joints provided between each wing, along with the slide bearing connections design at the atriums connections.

This report specifically looks at the lateral system in Wing B. There are eight shear walls that are provided around the two elevator cores that are provided in Wing B. In shear walls 4 and 8 coupling beams are provided between the elevator doors and shear wall piers. Figure 17 provides the layout and location of the shear walls in Wing B. Appendix C provided dimension and details of the shear walls that are provided in Wing B.

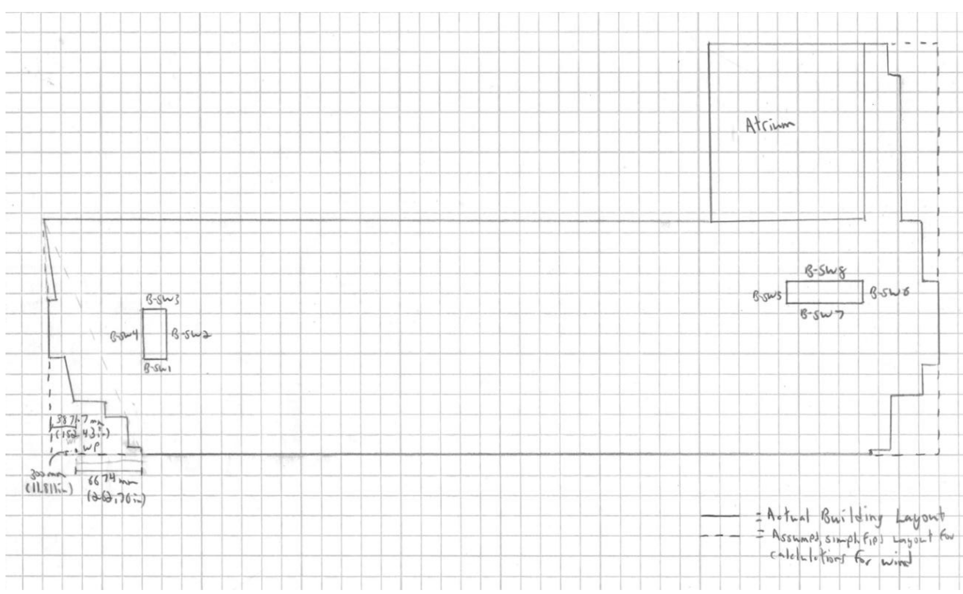


Figure 17: Wing B Shear Wall Layout

Codes and References

Design Codes:

National Model Code:

GSA Facilities Standards for the Public Building Service
International Building Code 2003

Structural Standards:

GSA Facilities Standards for the Public Building Service
ASCE 7-02, Minimum Design Loads for Buildings and other Structures

Design Codes:

AISC-ASD, Specifications for Structural Steel Buildings – Allowable Stress Design
ACE 318-02, Building code Requirements for Structural Concrete

Design Codes (Used for this Thesis)

National Model Code:

GSA Facilities Standards for the Public Building Service – 2005
2006 International Building Code

Structural Standards

GSA Facilities Standards for the Public Building Service – 2005
ASCE 7-05, Minimum Design Loads for Buildings and other Structures

Design Standards:

Steel Construction Manual 13th edition, American Institute of Steel Construction

ACI 318-05, Building Code Requirements for Structural Concrete, American Concrete Institute

Design of Buildings to Resist Progressive Collapse 2005, Unified Facilities Criteria

Gravity Loads

The primary design guide lines for the FDA OC/ORA Office Building are the GSA Facilities Standards for the Public Service-2005, and the ASCE 7-02. The GSA outlines general requirements for the required live load for office interiors and the telecom room. The GSA Facilities Standards for the Public Building Service requires the designer to implement progressive collapse design into the structural design.

The latest version of design codes is being used for the analysis of the buildings gravity and lateral systems. When comparing to the designed loads and the ASCE 7-05 required loads, only one major difference appeared. ASCE 7-05 requires a load of 100 psf for special purpose roofs, specifically green roofs. Comparing to the designed load of 31.33 psf, one possible reason for the significant difference is the dead load; the structural engineer added a green roof dead load.

Live Loads					
	Design		GSA 05	ASCE 7-05	
Location	kPa	psf	psf	psf	
Office	3.8	79.36	80	50	(Partitions)
Typical Roof	1.5	31.33		20	
Public Lobbies	4.8	100.25		100	
Mech Room	7.3	152.46		150	(Assumed)
Telecom Room	12	250.63	250	150	
Pedestrian Bridge	4.8	100.25		60	
Balconies	4.8	100.25		100	
High Density Filing	12	250.63		250	(Assumed)
Green Roof	1.5	31.33		100	

Figure 18: Live Loads

Dead Loads		
	psf	
Superimposed Dead Load (MEP, Ceiling)	15	(Assumed)
Roofing System	40	(Assumed)
Mechanical Unit	150	(Assumed)
Exteior Curtain Wall	30	(Assumed)
Atrium Cutrain Wall	20	(Assumed)
Mechanical Pentouse Walls	20	(Assumed)

Figure 19: Dead Loads

SNOW LOADS (S)					ASCE 7-05 Ref.
Ground Snow Load	p_g =	25	psf		Figure 7-1
Exposure Factor	C_e =	1		Terrain Category B	Table 7-2
Thermal Factor	C_t =	1			Table 7-3
Importance Factor	I =	1		Occupance Category II	Table 7-3
	p_f =	17.5	psf	p_f = .7*Ce*Ct*I*pg	Eq. 7-1
	p_{fmin} =	20	psf	$p_{fmin} = p_g$*I	Section 7.3
	p_f =	**20**	**psf**		
Snow Drift					
Snow Density	γ =	30	pcf		Eq. 7-3
	h =	14.66	ft		
	h_d =	0.67	ft		
	h_c =	13.99	ft		
Snow Surcharge	**S_d =**	**52.5**	**psf**		Section 7.7.1

Figure 20: Snow Loads

Lateral Loads

To simplify the lateral analysis of the office building, lateral loads were determined for only Wing B. This was allowed because the wings have different lateral systems that do not interact with the other wings. The structural engineer also provided large expansion joints in the atriums that connect each wing, along with slide bearing connections. The slide bearing connections allow the wings to move and react independently from the lateral forces.

Wind Loads

The wind loads were determined using Method 2 of the ASCE 7-05 Chapter 6. The first assumption under the wind analysis was that the 5 story reinforced concrete structure would act rigidly under lateral loads. After further calculation under the Chapter 6 commentary, the 5 story structure did not act rigidly. This is partially due to the size of the shear walls that were provided in Wing B. However, in the East to West direction the structure did meet the requirements to be rigid. Appendix A contains a summary of the results from the Wind Calculations. Detailed information on the calculation of the wind design variables can be provided upon request.

In the North to South direction the Base Shear was larger than the East to West direction; this is due to the large façade area in this direction. The wind forces are shown in Figures 21 and 22.

Design Wind Loads in N-S Direction				
	External Windward Load (kips)	External Leeward Loads (kips)	Base Shear (kips)	
			1.0W	1.6W
Level 1	0	0		
Level 2	30.374	16.163	**46.538**	**74.460**
Level 3	32.008	14.721	**46.729**	**74.767**
Level 4	35.086	14.721	**49.807**	**79.692**
level 5	37.598	14.721	**52.319**	**83.710**
Roof	24.162	9.157	**33.319**	**53.311**
Parapet	4.790	1.796	**6.586**	**10.537**
Base Shear			**235.298**	**376.477**

Figure 21: N-S Wind Loads

Design Wind Loads in E-W Direction				
	External Windward Load (kips)	External Leeward Loads (kips)	Base Shear (kips)	
			1.0W	1.6W
Level 1	0	0		
Level 2	14.675	7.809	**22.484**	**35.974**
Level 3	15.464	7.112	**22.576**	**36.122**
Level 4	16.951	7.112	**24.064**	**38.502**
level 5	18.165	7.112	**25.277**	**40.443**
Roof	11.674	4.424	**16.098**	**25.756**
Parapet	2.314	0.868	**3.182**	**5.091**
Base Shear			**113.680**	**181.888**

Figure 22: E-W Wind Loads

Seismic Loads

Seismic Loads for the FDA OC/ ORA Office Building were calculated using ASCE 7-05 Chapter 11 and 12. Initially the self weight of each floor needed to be estimated for the seismic calculations. This was done by assuming the framing systems for each floor were close enough to be approximated as the equal. The slab, beams and columns were all measured and their self weights were added up is Microsoft Excel. The exterior wall weight was assumed to be 30 psf because of the cmu backup behind the brick veneer curtain wall.

The Seismic Design Category was calculated using Table 11.6-1 and 11.6-2 in the ASCE 7-05. A SDC of A was determined for the Wing B of the office building; Appendix B contains the summary of the results from the seismic calculations, more detailed calculations can be provided upon request. The SDC calculated is different than the SDC of B that was designed by the structural engineer. A possible reason for this difference is the use of the USGS Ground Motion Parameter gave a much lower mapped acceleration. The story lateral forces and story shear forces were calculated with the equivalent lateral force procedure, using excel in Figure 35. Figure 23 shows a table of the story forces along with the calculated base shear of 270.3 k.

Design Seismic Load		
	Story Shear (kips)	Base Shear (kips)
		1.0E
Level 1	0	
Level 2	15.211	
Level 3	31.240	
Level 4	49.935	
level 5	70.175	
Roof	103.740	
Base Shear		**270.300**

Figure 23: Seismic Loads

Load Combinations

Load Combinations provided by ASCE 7-05 for strength design are listed below.

- 1.4(D + F)
- 1.2(D + F + T) + 1.6(L + H) + .5(L_r or S or R)
- 1.2D + 1.6(L_r or S or R) + (L or .8W)
- 1.2D + 1.6W + L + .5(L_r or S or R)
- 1.2D + 1.0E + L +.2S
- .9D + 1.6W + 1.6H
- .9D + 1.0E +1.6H

Lateral load analysis was performed for this report and the load combinations that did not include lateral load forces were disregarded. It was also noted that the load combination including a factor of .9D are used to calculate the uplift forces for the lateral loads. For strength design the load combinations including 1.6W and 1.0E were the controlling load combinations. The combinations that were considered for this report are;

- 1.2D + 1.6W + L + .5(L_r or S or R)
- 1.2D + 1.0E + L +.2S
- .9D + 1.6W + 1.6H
- .9D + 1.0E +1.6H

Distribution of Lateral Forces

The lateral forces that the building resists are assumed to be distributed throughout the structure by the concept of relative stiffness. The shear walls that have a higher stiffness take a larger part of the lateral load. The loads are transmitted through the floor that is assumed to act as a rigid diagram, and are transferred to the shear walls. There are two methods that the lateral loads act on the shear walls; Direct Shear and Torisional Shear.

Direct Shear

The Direct Shear acting on each shear wall was calculated using the relative stiffness of each shear wall. The rigidity of each shear was determined by hand calculations found in Appendix C and compared to SAP 2D Models results. The rigidity of each shear was determined using the equation $k = P/\delta_p$, Appendix C provides calculations on the determination of the relative stiffness of each shear wall. The results from the SAP modeled shear walls were very comparable to the hand calculations, and it was determined that the relative stiffness's from SAP could be used for the distribution of lateral forces. The distribution of the direction shear was determined using the equation $v_{di} = V*K_i/\sum K$.

Torisional Shear

In order to calculate the torisional effects acting on the shear walls the Center of Rigidity and Torisional Rigidity needed to be determined. The excel tables that were used to calculate the Center of Rigidity and Torisional rigidity can be found in Appendix D. The load cases that were studied for the analysis were ASCE7-05 Wind Case 1 and 2, and the Seismic Load Case.

Each load case provides a different eccentricity that will change the torisional effects of the lateral loading. Appendix E provided diagrams that outline the loading conditions and eccentric effects for each case.

Center of Rigidity (Measured from the Work Point)				
Y Center of Rigidity (in.)				
	Yi	Ki		
B-SW1	340.394	39.393		
B-SW3	557.24	39.393		
B-SW7	570.91	454.980		
B-SW8	677.72	243.836		
YR			**592.03**	**in.**
YR			**15037.6**	**mm**
X Center of Rigidity (in.)				
	Xi	Ki		
B-SW2	354.213	153.615		
B-SW4	247.402	36.360		
B-SW5	2843.43	22.110		
B-SW6	3165.236	30.296		
XR			**916.6**	**in.**
XR			**23282.11**	**mm**

Figure 24: Center of Rigidity

Distribution of Lateral Forces

After determining the direct and torisional shear distributions to the shear walls it was determined that for strength checks that the Wind Case 1 loading in the N-S direction provided a larger base shear as compared to the other load cases. For the loading in the E-W direction the seismic load case provide a larger base shear then the other load cases. Appendix E contains the distribution breakdown for each load case action on each shear wall. The distribution for B-SW2 under Load Case 1 is shown in Figure 25.

B-SW2				
K =	153.615		e =	59.690
∑K =	242.381		d2 =	46.87
	Loads N-S (kips)	Direct Shear (kips)	Torisional Shear (kips)	Total Shear (kips)
Level 2	74.460	47.191	-15.12	**32.068**
Level 3	74.767	47.385	-15.19	**32.200**
Level 4	79.692	50.507	-16.19	**34.321**
Level 5	83.710	53.054	-17.00	**36.051**
Roof	63.848	40.465	-12.97	**27.497**

Figure 25: Distribution of Lateral Forces under Load Case 2

Shear Wall Check

As spot check of Shear Wall 2 in Wing B was performed using Wind Case 1 Loading. This was done because the Wind Case 1 Loading provided a larger base shear in that shear wall then the other load cases for the other shear walls. Appendix F provided the supporting calculations for the shear wall spot. It was determined that ACI 318-08 Chapter 11 provision on shear walls was the appropriate method to design the shear wall under the wind loading.

The vertical and horizontal reinforcement was designed using the resultant shear at the first story. It was determined that the vertical reinforcement required is #4 rebar at 12 inches on center. Compared to the design of #5 rebar at 12 inches on center, the engineer's design is relatively close to the reinforced that was designed for this report.

Flexural reinforcement was also design to resist the compressive force of the moment created by the shear loading. It was determined that 22 #8 rebar was required for each end of the shear wall to support the flexural loads created by the shear forces at each level. The actual design the shear wall 2 is 13 #6 rebar, which was significantly lower than the flexural reinforcement determined for this report. A probable source for this error can either be found in the lateral loads that were used to design the shear wall, or the use of ACE 318-08 Chapter 11 to design the shear wall.

Foundation Analysis

An overturning analysis of the foundation supporting Shear Wall 2 was done using the load combination .9D + 1.6W + 1.6H. The dead load acting through the shear was calculated using an approximated tributary area of the shear wall, including the self weight of the shear wall. The overturning moment was calculated from the shear forces acting from Wind Load Case 1, and the uplift force due to the moment was calculated. It was observed that the uplift due to the wind was not counteracted by the dead load acting through the shear wall. Therefore the foundation should be designed to resist uplift. The Geopiers that were designed with the foundation may take some uplift resistance, but at this time it is unknown. A more in depth analysis of the Geopiers would be required and if needed would be preformed for later thesis reports. Appendix G provided the supporting calculations of the overturning analysis.

Deflection Analysis

For the deflection analysis the shear walls were modeled separately in SAP. Each load case was applied to the shear walls. First the deflections of the shear walls were calculated using excel to verify the validity of the SAP output. The results of the excel calculations can be found in Appendix H. The SAP output can be found in Appendix I, the deflection were taken from the middle of the shear wall at each level the load was applied. The deflection calculated from SAP was slighter higher than the deflections calculated by hand, so it was determined the results from SAP could be used in the drift analysis.

Appendix I includes a separation of each load case to Total Drift and Story Drift. It should be noted the wind deflection were compared to H/400 by standard practice, and the seismic deflections were compared to $.02H_{sx}$, where the deflection due to seismic was C_d*δ/I. The allowable Total drifts and Story Drifts for Wind and Seismic are provided in Table 26.

Allowable Drift Anaylsis						
			Allowable Wind defl. (in)		Allowable Seismic defl. (in)	
Level	Level Height	Story Height (in.)	Total Drift	Story Drift	Total Drift	Story Drift
			H/400	H/400	$.02H_{sx}$	$.02H_{sx}$
Roof	871.925	154.724	2.180	0.387	17.4385	3.09448
Level 5	717.201	154.724	1.793	0.387	14.34402	3.09448
Level 4	562.477	154.724	1.406	0.387	11.24954	3.09448
Level 3	407.753	154.724	1.019	0.387	8.15506	3.09448
Level 2	253.029	185.039	0.633	0.463	5.06058	3.70078

Figure 26: Allowable Deflections

In Shear Wall 5 the deflections were calculated and it was determined that the story drift at the roof level and the 5th floor exceeded the allowable story drift for the Wind Case 2 Loading, these values are shown in red. Also values shown in orange are total drifts that were considered high for the building, Figure 27. A 6 inch expansion joint is provided between each wing, so there is no concern on the wings interfering during loading.

B-SW5 Deflection Anaylsis										
	Story Height (in.)	Level Height (in.)	Wind Case 1 Defl. (in.)		Wind Case 2 Defl. (in.)		Seismic Case Defl. (in.)			
			Total Drift	Story Drift	Total Drift	Story Drift	Total Drift	=4.5*δ/1	Story Drift	=4.5*δ/1
Roof	154.724	871.925	1.6110	0.3866	1.6777	0.4024	2.7643	12.4392	0.6904	3.1069
Level 5	154.724	717.201	1.2244	0.3767	1.2753	0.3921	2.0738	9.3322	0.6632	2.9843
Level 4	154.724	562.477	0.8477	0.3463	0.8832	0.3605	1.4106	6.3479	0.5940	2.6732
Level 3	154.724	407.753	0.5014	0.2842	0.5227	0.2961	0.8166	3.6747	0.4714	2.1212
Level 2	185.039	253.029	0.2172	0.2172	0.2266	0.2266	0.3452	1.5535	0.3452	1.5535

Figure 27: Shear Wall 5 Deflection Results

The deflections of the shear walls were calculated individually using separate 2D SAP models. The diaphragm of the building allows the shear walls to act together and the actual deflection of the building can be determined best by using a full 3D model. A 3D model was not in the scope of the report. To obtain a better understanding on how the shear walls react with the diaphragm and the other structural components a full 3D model will be made for further thesis analysis.

Conclusion

Different load combinations by ASCE 7-05 were studied and the load combinations that included lateral loads were used to design and check the lateral resisting members of the office building. Both Wind and Seismic Loads were analyzed for both strength and deflection, for Wind; Load Case 1 and Load Case 2 prescribed by ASCE 7-05 were analyzed. The other wind load cases were not studied in this report.

The direct shear and torisional effects from the lateral loading were calculated for each shear wall, using the Center of Mass for the seismic load application and Center of Wind Pressure for the wind load. The loads were taken about the Center of Rigidity which was calculated using the relative stiffness of the shear walls.

A spot check was done for lateral system; Shear Wall 2 was picked because of the large base shear over the other shear walls and load cases. ACI 318-08 Chapter 11 provision on shear wall design was used to design the shear wall and compare the reinforcement to the actual designed shear wall. The shear vertical shear reinforcement was determined to be #4 at 12 inches on center, which was relatively close to the actual design of the shear wall. However the flexural steel designed was much higher than the actual design. This difference is most likely due to the method of design, or the difference in the shear loads from the designer's loads. From the foundation check of Shear Wall 2 it was determined that the foundation will likely have uplift and further analysis of the Geopiers will be required to get the actual impact on the foundations

The deflections for each shear wall were compared to allowable story drift and total drift as set by ASCE 7-05. The seismic drifts were modified as specified by ASCE 7-05 Chapter 11 for Seismic Provisions. It was concluded that the Shear Wall 5 and 6 the story drifts limits were exceeded, but for the rest of the of the shear walls the deflections were within limits.

A 3D model was not done for this report, and the interaction between the diaphragm and the shear walls could not be made with the 2D models that were used. For further analysis and 3D model is going to be developed.

Appendix A: Wind Loads

Method 2: Approximate Fundamental Frequency					
H	70.14	ft.			
Ab	21435.00	s.f.			
N-S			W-E		
B =	297.55	ft.	B =	137.44	ft.
L =	137.44	ft.	L =	297.55	ft.
n =	4		n =	4	
A1 =	19.375	s.f.	A5	11.948	s.f.
A2 =	19.375	s.f.	A6	11.948	s.f.
A3 =	9.6875	s.f.	A7	26.647	s.f.
A4 =	9.6875	s.f.	A8	26.647	s.f.
D1 =	19.685	ft.	D5	12.139	ft.
D2 =	19.685	ft.	D6	12.139	ft.
D3 =	9.843	ft.	D7	27.07	ft.
D4	9.843	ft.	D8	27.07	ft.
Cw =	0.018		Cw =	0.042	
n_1 =	0.732		n_2 =	1.121	
n < 1, Therefore flexible sturcture			n > 1, Therefore rigid sturcture		
ASCE 7-05 C6-16					

Method 2: N-S Gust Effect Factor: flexible Structures			
gq = gv =	3.400		ASCE 7-05 6.5.8.2
gr =	4.114		ASCE 7-05 Eq. 6-9
z =	42.085		
zmin =	30.000		ASCE 7-05 Table 6-2
c =	0.300		ASCE 7-05 Table 6-2
Iz =	0.288		ASCE 7-05 Eq. 6-5
∈ =	0.333		ASCE 7-05 Table 6-2
ℓ =	320.000		ASCE 7-05 Table 6-2
Lz =	347.019		ASCE 7-05 Eq. 6-7
Q =	0.778		ASCE 7-05 Eq. 6-6
V =	90.000	mph	
b =	0.450		ASCE 7-05 Table 6-2
α =	0.250		ASCE 7-05 Table 6-2
Vz =	63.123		ASCE 7-05 Eq. 6-14
N1 =	4.022		ASCE 7-05 Eq. 6-12
Rn =	0.058		ASCE 7-05 Eq. 6-11
Rh =	0.232		
	η =	3.739	
RB =	0.061		
	η =	15.863	
RL =	0.040		
	η =	24.529	
R =	0.174		ASCE 7-05 Eq. 6-10
Gf =	0.813		ASCE 7-05 Eq. 6-8

Method 2: E-W Gust Effect Factors, G and G_f			
n_1 =	1.43		ASCE 7-05 C6-17
	n_1 > 1 therefore structure is rigid		
H/L =	0.51		
	If H/L ≤ 4 then G = .85		ASCE 7-05 6.5.8.1
G =	0.85		

Technical Assignment #3

Basic Wind Information				(ASCE Ref)	
Basic Wind Speed	V =	90	mph	ASCE 7-05 Figure 6-1	
Directionality Factor	k_d =	0.85		ASCE 7-05 Table 6-4	
Importance Factor	I =	1.0		ASCE 7-05 Table 6-1	
Exposure Category		B		ASCE 7-05 6.5.6	
Topgraphic Factor	k_{zt} =	1.0		ASCE 7-05 6.5.7	
	z_g =	1200	ft		
	α =	7			
Velocity Presure Expusure Coefficient evaluated at Height z	K_z =	Varies			
Velocity Presure Expusure Coefficient evaluated at Mean Roof Height	K_h =	0.8930			
Velocity Pressure at Height z	q_z =	Varies			
Velocity Pressure at Mean Roof Height	q_h =	15.7			
Equivalent height of Structure	h =	70.1			
Intensity of turbulance	I_z =	0.3			
Integral Length Scale of Turbulence	L_z =	347.0			
Background Response Factor (N/S)	Q =	0.778			
Background Reponse Factor (E/W)	Q =	0.829			
Gust Effect Factor (N/S)	G =	0.813			
Gust Effect Factor (E/W)	G =	0.850			
Internal Pressure Coefficients	G_{cpi} =	± 0.18			
External Pressure Coefficient (Windward)	C_p =	0.8			
External Pressure Coefficient (N/S Leeward)	C_p =	-0.3			
External Pressure Coefficient (E/W Leeward)	C_p =	-0.5			
External Pressure Coefficient (Sidewall)	C_p =	-0.7			
External Pressure Coefficient (Roof Section 1)	C_p =	-0.9	(From Windward Edget to 70.14 ft.)		
External Pressure Coefficient (Roof Section 2)	C_p =	-0.5	(From 70.14 to 140.28 ft.)		
External Pressure Coefficient (Roof Section 3)	C_p =	-0.3	(From 140.28 to 297.53 ft.)		
Basic Building Information					
Mean Building Height	h =	21379	mm		
		70.14	ft		
N-S	L =	137.44	ft		
	B =	297.55	ft		
E-W	L =	297.55	ft		
	B =	137.44	ft		

Design Wind Pressures p in N-S Direction							
Location	Story Height		Level Height		K_z	q_z (psf)	External Pressure qGCp (psf)
	(mm)	(ft)	(mm)	(ft)			
Windward	0	0	0	0			
	4700	15.420	4700	15.4199	0.5793	10.210	6.638
	3930	12.894	8630	28.3136	0.6891	12.146	7.896
	3930	12.894	12560	41.2073	0.7671	13.521	8.790
	3930	12.894	16490	54.1010	0.8291	14.614	9.501
	3930	12.894	20420	66.9948	0.8814	15.535	10.099
	959	3.146	21379	70.1411	0.8930	15.740	10.232
Leeward				All	0.8930	15.740	-3.837
Side				All	0.8930	15.740	-8.953
Roof	(From Windward Edget to 70.14 ft.)			70.1411	0.8930	15.740	-11.511
	(From 70.14 to 140.28 ft.)			70.1411	0.8930	15.740	-6.395

Design Wind Pressures p in E-W Direction							
Location	Story Height		Level Height		K_z	q_z (psf)	External Pressure qGCp (psf)
	(mm)	(ft)	(mm)	(ft)			
Windward	0	0	0	0			
	4700	15.420	4700	15.4199	0.5793	10.210	6.943
	3930	12.894	8630	28.3136	0.6891	12.146	8.259
	3930	12.894	12560	41.2073	0.7671	13.521	9.194
	3930	12.894	16490	54.1010	0.8291	14.614	9.938
	3930	12.894	20420	66.9948	0.8814	15.535	10.564
	959	3.146	21379	70.1411	0.8930	15.740	10.703
Leeward				All	0.8930	15.740	-4.014
Side				All	0.8930	15.740	-9.365
Roof	(From Windward Edget to 70.14 ft.)			70.1411	0.8930	15.740	-12.041
	(From 70.14 to 140.28 ft.)			70.1411	0.8930	15.740	-6.689
	(From 140.28 to 297.53 ft.)			70.1411	0.8930	15.740	-4.014

Design Wind Loads in N-S Direction				
	External Windward Load (kips)	External Leeward Loads (kips)	Base Shear (kips)	
			1.0W	1.6W
Level 1	0	0		
Level 2	30.374	16.163	**46.538**	**74.460**
Level 3	32.008	14.721	**46.729**	**74.767**
Level 4	35.086	14.721	**49.807**	**79.692**
level 5	37.598	14.721	**52.319**	**83.710**
Roof	24.162	9.157	**33.319**	**53.311**
Parapet	4.790	1.796	**6.586**	**10.537**
Base Shear			**235.298**	**376.477**

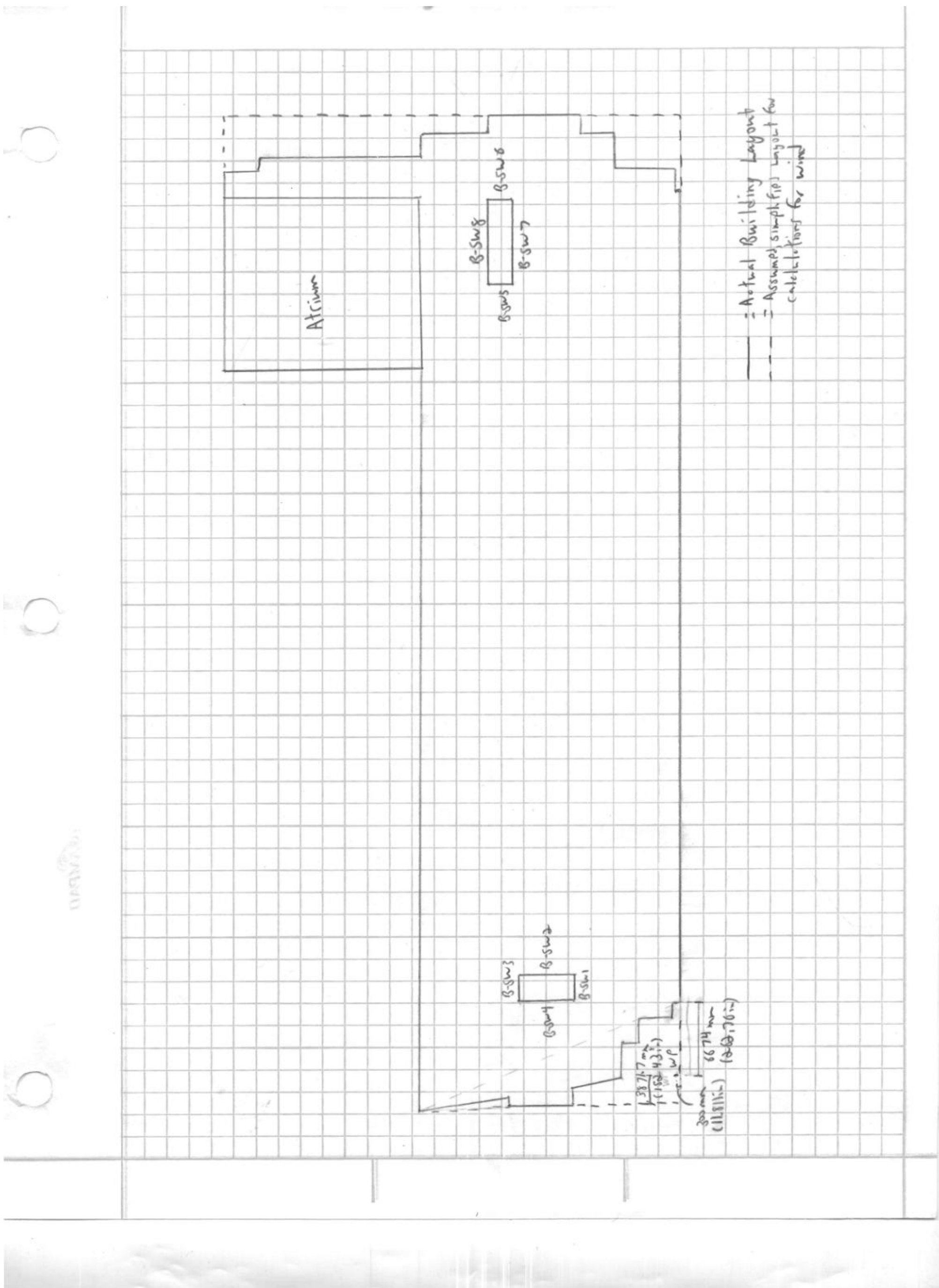
Design Wind Loads in E-W Direction				
	External Windward Load (kips)	External Leeward Loads (kips)	Base Shear (kips)	
			1.0W	1.6W
Level 1	0	0		
Level 2	14.675	7.809	**22.484**	**35.974**
Level 3	15.464	7.112	**22.576**	**36.122**
Level 4	16.951	7.112	**24.064**	**38.502**
level 5	18.165	7.112	**25.277**	**40.443**
Roof	11.674	4.424	**16.098**	**25.756**
Parapet	2.314	0.868	**3.182**	**5.091**
Base Shear			**113.680**	**181.888**

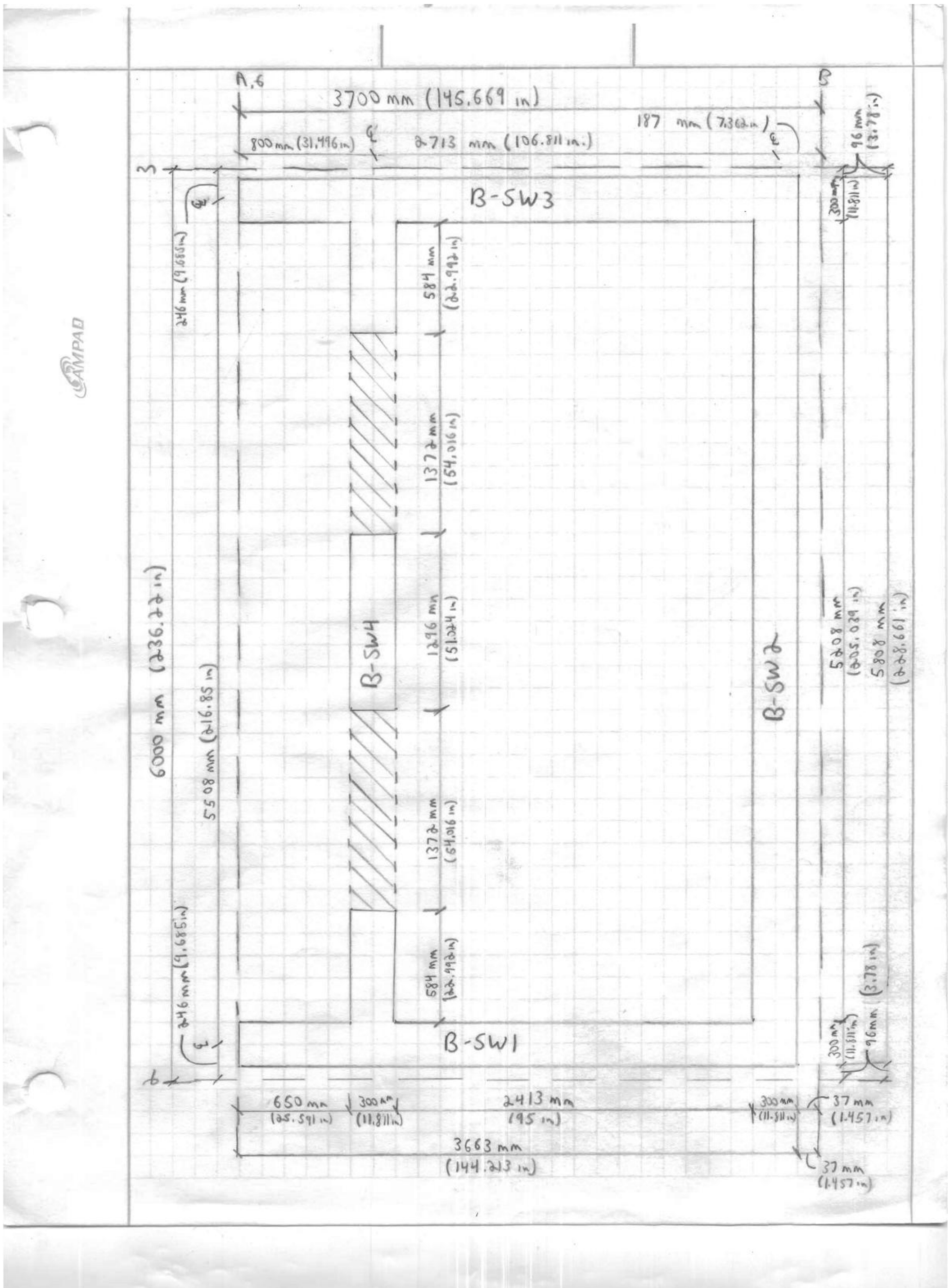
Appendix B: Seismic Loads

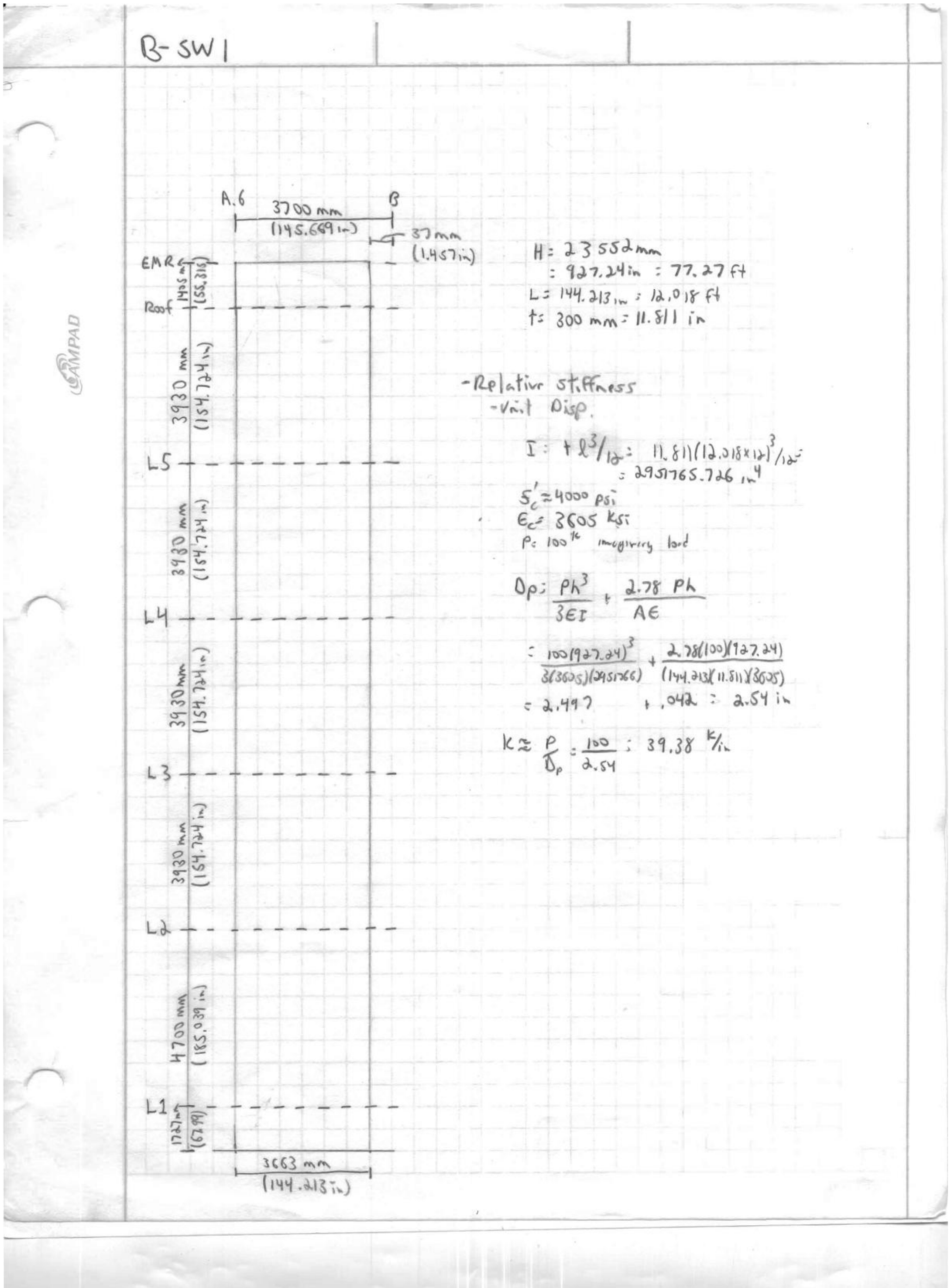
Seismic Design Variables			(ASCE 7-05 Ref.)
Soil Classification		C	
Occupancy		II	(Table 1-1)
Structural System		Building Frame System: Ordinary reinforce concrete shear walls	(Table 12.2-1)
Spectral Response Acceleration, short	S_s	0.155	(USGS)
Spectral Response Acceleration, 1 s	S_1	0.05	(USGS)
Site Coefficient	Fa	1.2	(Table 11.4-1)
Site Coefficient	Fv	1.7	(Table 11.4-2)
Soil Modified Accelerationd, short	S_{ms}	0.186	(Eq. 11.4-1)
Soil Modified Accelerationd, 1 s	S_{m1}	0.085	(Eq. 11.4-2)
Design Spectral Acceleration, short	S_{DS}	0.124	(Eq. 11.4-3)
Design Spectral Acceleration, 1 s	S_{D1}	0.057	(Eq. 11.4-4)
Approximate Period Parameter	C_t	0.002	(Table 12.8-2)
Approximate Period Parameter	x	0.750	(Table 12.8-2)
Building height (above grade)	h_n	70.14 ft	
Approximate Fundamental Period	T_a	0.485	(Eq. 12.8-7)
Fundamental Period	T_s	0.460	
80% of Fundamental Period	$.8T_s$	0.368	
Seismic Design Category	S_{DC}	A	(Table 11.6-1)
Seismic Response Coefficient	C_s	0.012	(Eq 12.8-3)
Structure Period Exponet	k	1.250	(Sec. 12.8.3)
Seismic Base Shear	V	270.3 kips	(Eq. 12.8-1)

Seismic Loads								
Level	Story Weight w_x (kips)	Height h_x (ft)	h_x^k	$w_x h_x^k$	C_{vx}	Lateral Force F_x (Kips)	Base Shear (kips)	
2	4683	15.82	31.55	147752	0.06	15.21		
3	4647	28.31	65.30	303457	0.12	31.24		
4	4647	41.2	104.38	485059	0.18	49.94		
5	4647	54.09	146.69	681662	0.26	70.17		
Roof	5129	66.98	191.62	982798	0.37	101.18		
PH	100	82.61	249.05	24905	0.01	2.56		
						$\Sigma F_x = V_x =$	**270**	**kips**

Appendix C: Shear Wall Information

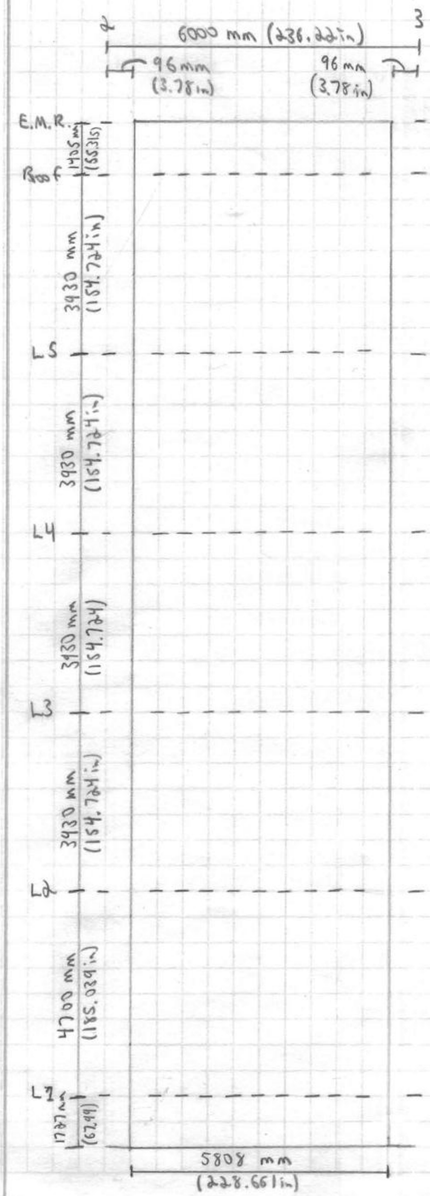



3700 mm (145.669 in)
B-SW3
B-SW4
B-SW2
B-SW1
6000 mm (236.22 in)
5508 mm (216.85 in)
584 mm
1372 mm (54.016 in)
1296 mm (51.024 in)
1372 mm (54.016 in)
584 mm
650 mm
300 mm
2413 mm (95 in)
3663 mm (144.213 in)
37 mm



B- SW1
A.6
B
3700 mm
(145.669 in)
37 mm
(1.457 in)
EMR
Roof
L5
L4
L3
L2
L1
3930 mm
(154.724 in)
4700 mm
(185.039 in)
3663 mm
(144.213 in)
H = 23552 mm
= 927.24 in = 77.27 ft
L = 144.213 in = 12.018 ft
t = 300 mm = 11.811 in
-Relative stiffness
-Unit Disp.
I = tl³/12 = 11.811(12.018×12)³/12 = 2951765.726 in⁴
f'c = 4000 psi
Ec = 3605 ksi
P = 100k imaginary load
Δp = Ph³/3EI + 2.78 Ph/AE
= 100(927.24)³/3(3605)(2951766) + 2.78(100)(927.24)/(144.213)(11.811)(3605)
= 2.497 + .042 = 2.54 in
K ≈ P/Δp = 100/2.54 = 39.38 k/in

B-SW2



H = 23522 mm
= 927.24 in = 77.27 ft
L = 228.661 in = 19.06 ft
t = 300 mm = 11.81 in

- Relative Stiffness
  - Unit Disp

$I = tl^3/12 = 11.81(228.661)^3/12$

$= 11767432.6\ in^4$

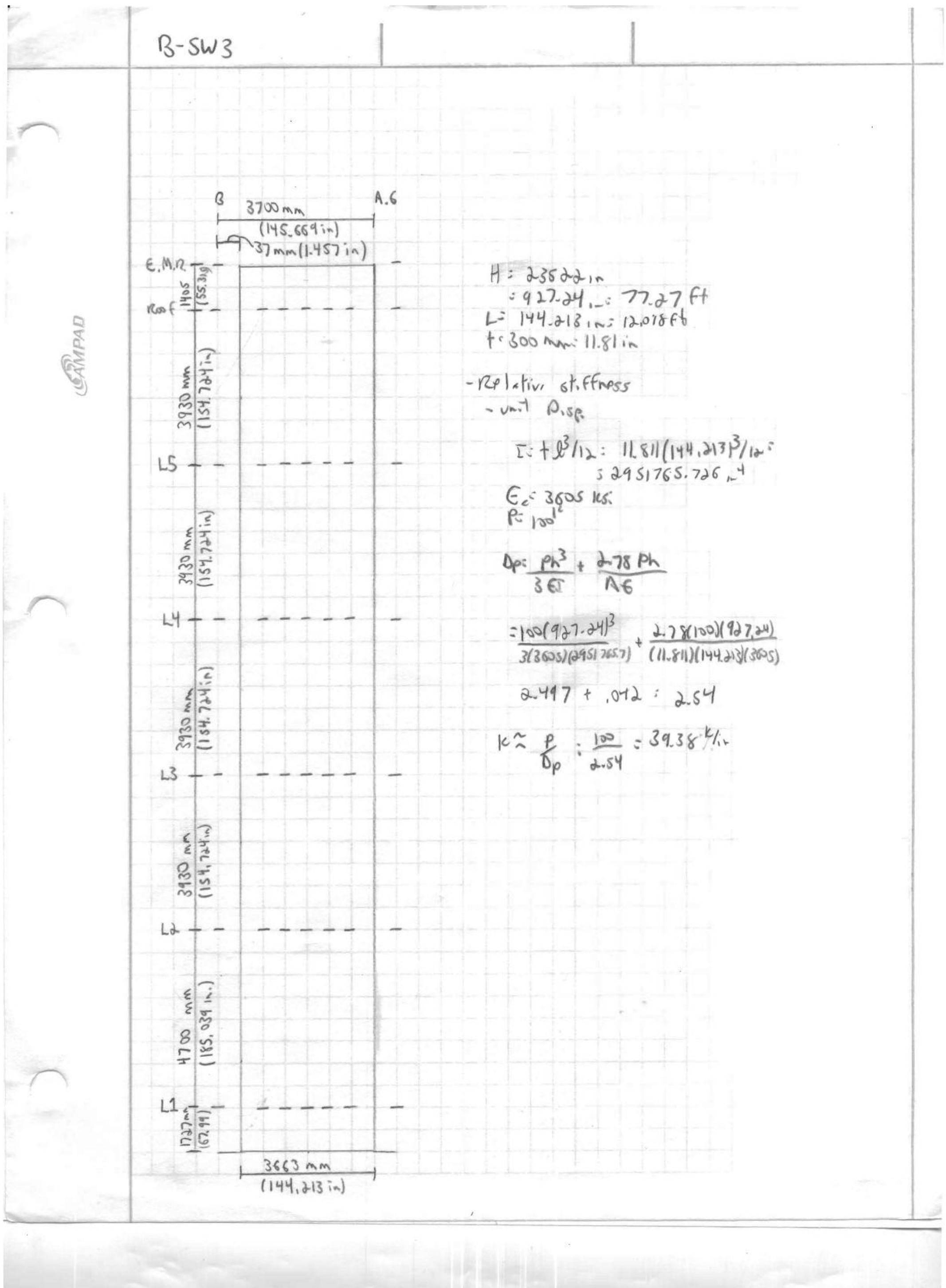
$f'_c = 4000\ psi$
$E_c = 3605\ ksi$
$P = 100^k$
$\Delta_p = \frac{Ph^3}{3EI} + \frac{2.78Ph}{AE}$

$= \frac{100(927.24)^3}{3(3605)(11767432.6)} + \frac{2.78(100)(927.24)}{(228.661)(11.81)(3605)}$

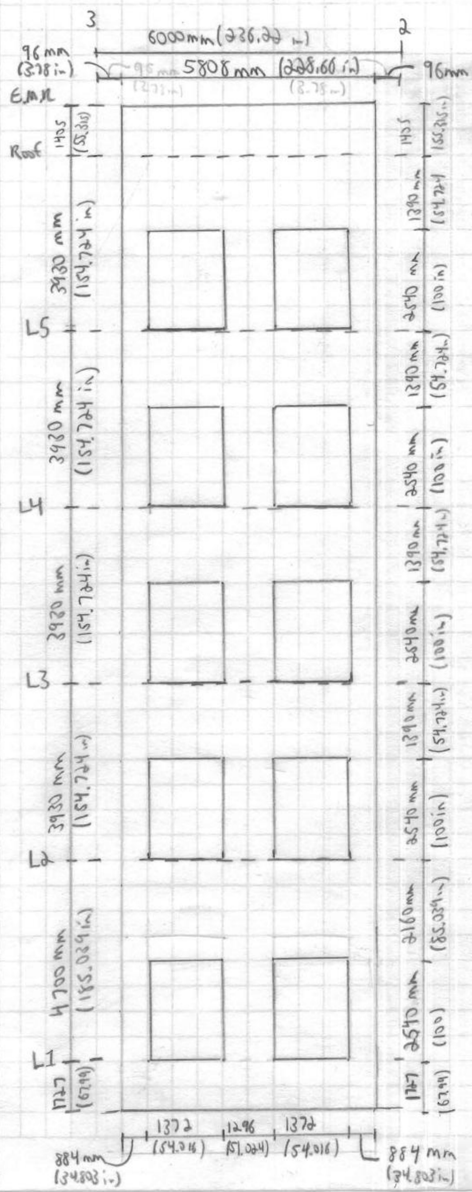
$= .626 + .0265 = .653\ in$

$k \approx \frac{P}{\Delta_p} = \frac{100}{.653} = 153.16\ k/in$

Technical Assignment #3



B-SW-4



H: 23522 mm
= 927.24 in = 77.27 ft
L: 5808 mm = 228.66 in = 19.06 ft
t: 300 mm = 11.81 in

- Relative stiffness of boundary element

$I = tl^3/12 = 11.811(34.803)^3/12$
$= 41491.15\ in^4$

$E_c = 3605$ ksi
$P = 100^k$

$\Delta_p = \dfrac{Ph^3}{3EI} + \dfrac{2.78Ph}{AE}$

$\dfrac{100(927.24)^3}{3(3605)(41491.15)} + \dfrac{2.78(100)(927.24)}{11.811(34.803)(3605)}$

$177.66 + .174 = 177.84$ in

$k = P/\Delta_p = 100/177.84 = .562\ ^k/in$

- Relative stiffness of core

$I = tl^3/12 = 11.811(51.024)^3/12$
$= 130746.156$

$E_c = 3605$ ksi
$P = 100^k$

$\Delta_p = \dfrac{Ph^3}{3EI} + \dfrac{2.78Ph}{AE}$

$= \dfrac{100(927.24)^3}{3(3605)(130746.16)} + \dfrac{2.78(100)(927.24)}{11.811(51.024)(3605)}$

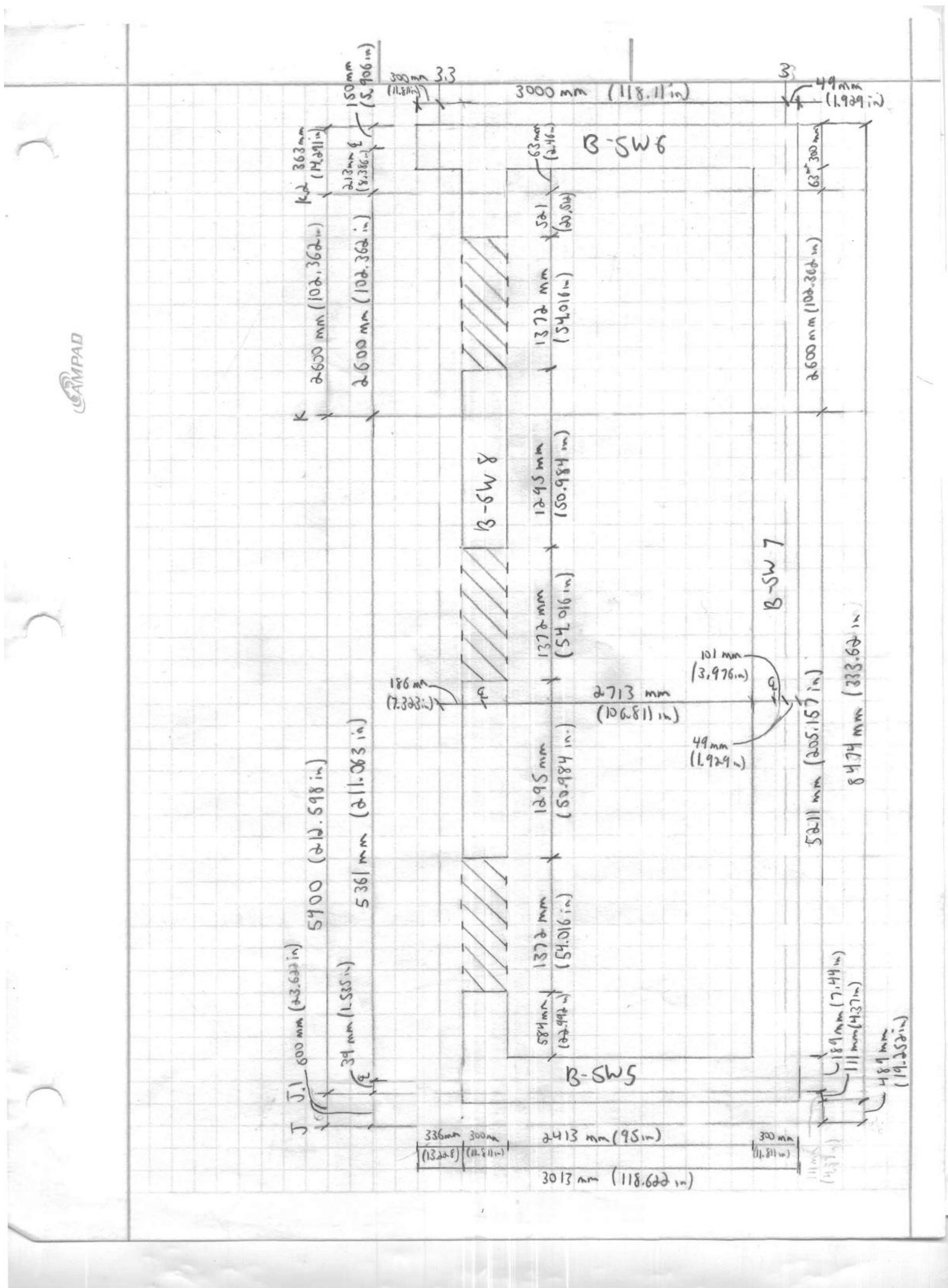
$56.38 + .119$ in $= 56.498$ in

$k = P/\Delta_p = 100/56.5 = 1.77\ ^k/in$

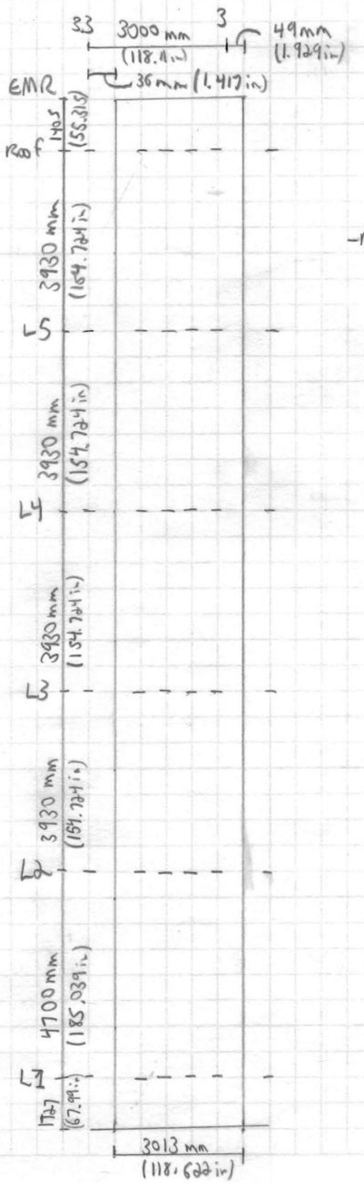
Approx stiffness if coupled shear wall as 3 piers

$k = 2.89\ ^k/in$

* This lower bound of stiffness would expect higher from computer model


3000 mm (118.11 in)
B-SW6
B-SW7
B-SW8
B-SW5
2713 mm (106.81 in)
2413 mm (95 in)
3013 mm (118.622 in)

B-SW5



H = 23522 mm
= 927.24 in = 77.27 ft
L = 118.622 in = 9.885 ft
t: 300 mm = 11.81 in

-Relative stiffness

$I = tl^3/12 = 11.811(118.622)^3/12 = 1642862.25 \text{ in}^4$

$E_c = 3605$ ksi

$P = 100^k$

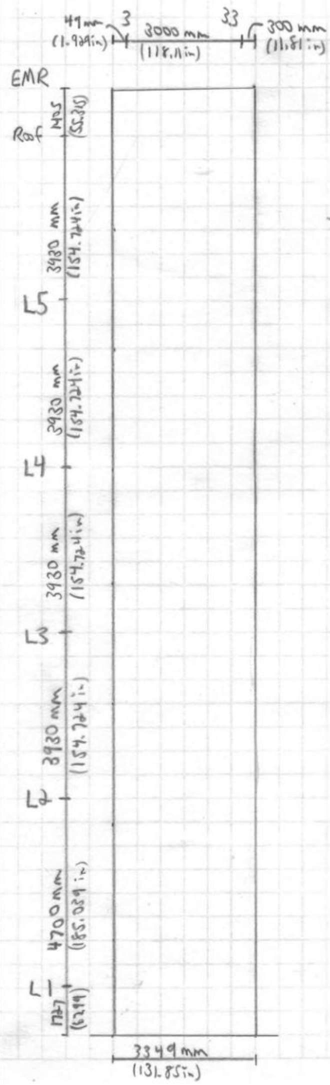
$\Delta_p = \frac{Ph^3}{3EI} + \frac{2.78Ph}{AE}$

$\frac{100(927.24)^3}{3(3605)(1642862.3)} + \frac{2.78(100)(927.24)}{11.81(118.622)(3605)}$

$4.487 + .051 = 4.538$ in

$k = P/\Delta_p = 100/4.538 = 22.04$ k/in

B-SW6



$H = 23522$ mm
$= 927.24$ in $= 77.27$ ft
$L = 131.85$ in $= 10.988$ ft
$t = 300$ mm $= 11.81$ in

- Relative stiffness

$I = tl^3/12 = 11.81(131.85)^3/12$
$= 2256034.96$ in^4

$E_c = 3605$ ksi

$P = 100^k$

$$D_p = \frac{Ph^3}{3EI} + \frac{2.78Ph}{AE}$$

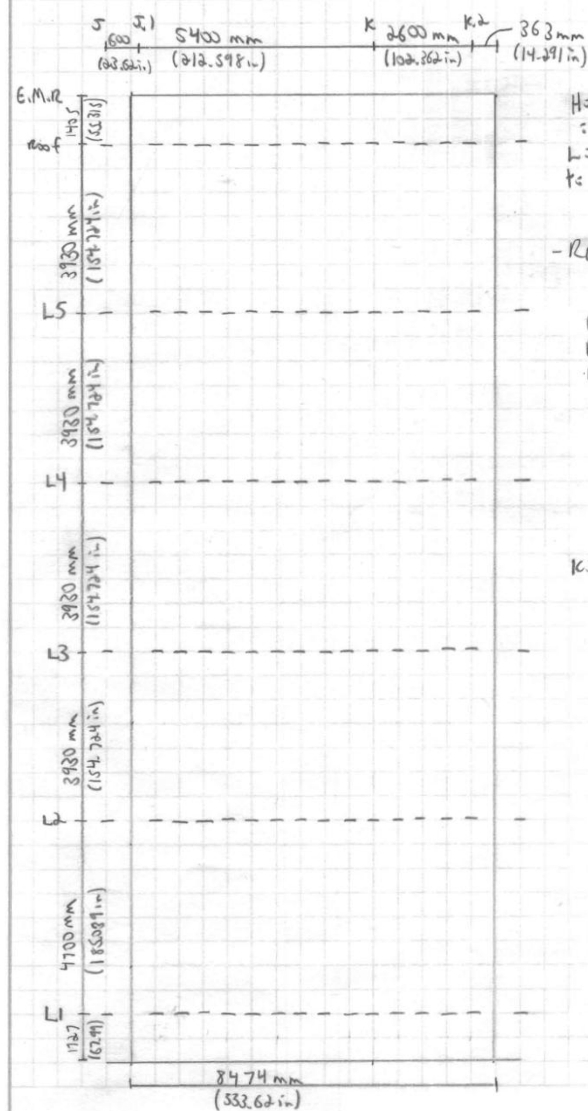
$$= \frac{100(927.24)^3}{3(3605)(2256034.96)} + \frac{2.78(100)(927.24)}{(11.81)(131.85)(3605)}$$

$= 3.236 + .0459 = 3.28$ in

$k = P/D_p = 100/3.28 = 30.47$ k/in

Technical Assignment #3

B-SW7



$H = 23522$ mm
$= 927.24$ in $= 77.27$ ft
$L = 333.62$ in $= 27.802$ ft
$t = 300$ mm $= 11.81$ in

- Relative stiffness

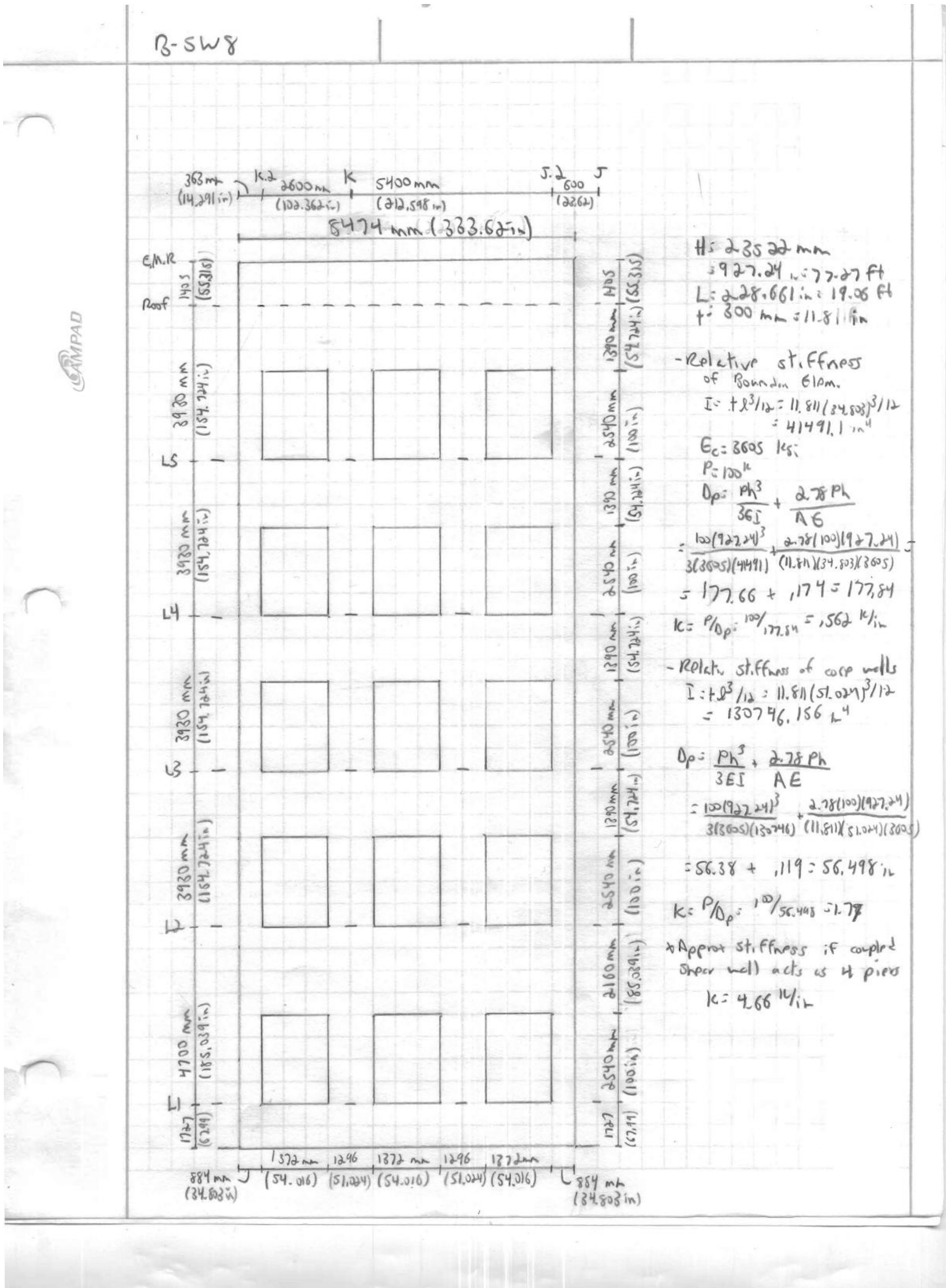
$I = t\ell^3/12 = 11.81(333.62)^3/12$
$= 36547835.17\ in^4$
$E_c = 3605$ ksi
$P = 100^k$

$$\Delta_p = \frac{Ph^3}{3EI} + \frac{2.78Ph}{A\epsilon}$$

$$= \frac{100(927.24)^3}{3(3605)(36547835.17)} + \frac{2.78(100)(927.24)}{(11.81)(333.621)(3605)}$$

$= .202 + .018$
$= .2198$ in

$k = P/\Delta_p = 100/.2198 = 454.96$ k/in


B-SW8
363 mm (14.291 in)
K.2
2600 mm (102.362 in)
K
5400 mm (212.598 in)
J.2
600 (23.62)
J
8474 mm (333.62 in)
EMR
Roof
L5
L4
L3
L2
L1
3930 mm (154.724 in)
4700 mm (185.039 in)
1390 mm (54.724 in)
2540 mm (100 in)
2160 mm (85.039 in)
1372 mm (54.016)
1296 (51.024)
884 mm (34.803 in)
H = 23522 mm = 927.24 in = 77.27 ft
L = 228.661 in = 19.05 ft
t = 300 mm = 11.811 in
- Relative stiffness of Boundary Elem.
I = tℓ³/12 = 11.811(34.803)³/12 = 41491.1 in⁴
Ec = 3605 ksi
P = 100k
Δp = Ph³/3EI + 2.78Ph/AE
= 100(927.24)³/3(3605)(41491) + 2.78(100)(927.24)/(11.811)(34.803)(3605)
= 177.66 + .174 = 177.84
k = P/Δp = 100/177.84 = .562 k/in
- Relative stiffness of core walls
I = tℓ³/12 = 11.811(51.024)³/12 = 130746.156 in⁴
Δp = Ph³/3EI + 2.78Ph/AE
= 100(927.24)³/3(3605)(130746) + 2.78(100)(927.24)/(11.811)(51.024)(3605)
= 56.38 + .119 = 56.498 in
k = P/Δp = 100/56.498 = 1.77
* Approx stiffness if coupled shear wall acts as 4 piers
k = 4.66 k/in

Appendix D: Center of Rigidity and Center of Mass

Shear Wall Stiffness: Modeled in SAP						
			Displ.	Stiffness	**Lateral Load Distrubution (%)**	
Shear Wall	Load Direction	Load (kips)	(in)	k (kips/ in)	**X**	**Y**
B-SW1	X	100	2.53849	39.393	**5.07**	0.00
B-SW2	Y	100	0.65098	153.615	0.00	**63.38**
B-SW3	X	100	2.53849	39.393	**5.07**	0.00
B-SW4	Y	100	2.75031	36.360	0.00	**15.00**
B-SW5	Y	100	4.52281	22.110	0.00	**9.12**
B-SW6	Y	100	3.30077	30.296	0.00	**12.50**
B-SW7	X	100	0.21979	454.980	**58.51**	0.00
B-SW8	X	100	0.410112	243.836	**31.36**	0.00

Center of Rigidity (Measured from the Work Point)				
Y Center of Rigidity (in.)				
	Yi	Ki		
B-SW1	340.394	39.393		
B-SW3	557.24	39.393		
B-SW7	570.91	454.980		
B-SW8	677.72	243.836		
YR			**592.03**	**in.**
YR			**15037.6**	**mm**
X Center of Rigidity (in.)				
	Xi	Ki		
B-SW2	354.213	153.615		
B-SW4	247.402	36.360		
B-SW5	2843.43	22.110		
B-SW6	3165.236	30.296		
XR			**916.6**	**in.**
XR			**23282.11**	**mm**

Torisional Rigidity			
Shear Wall	di (in)	k	Torisional Rigidity (K/in)ft^2
B-SW1	251.6383	39.393	17322.70
B-SW2	562.4057	153.615	337418.81
B-SW3	34.7923	39.393	331.15
B-SW4	669.2167	36.360	113080.94
B-SW5	1926.81	22.110	570042.12
B-SW6	2248.62	30.296	1063786.27
B-SW7	21.1223	454.980	1409.65
B-SW8	85.6877	243.836	12432.89
Total			**2115824.53**

Technical Assignment #3

Typical Floor Center of Mass

	Xi			Yi			Ai			Center of Floor Mass	
	mm	in	ft	mm	in	ft	mm^2	in^2	ft^2	Xi*Ai	Yi*Ai
A1	882.45	34.74213	2.895177	20698.4	814.8976	67.90814	5201961.38	8063.056	55.99345	162.1109	3802.411
A2	5789.35	227.9272	18.99393	19347.6	761.7165	63.47638	73035225.5	113204.8	786.1446	14931.98	49901.61
A3	11501.53	452.8161	37.73468	18852	742.2047	61.85039	21948648	34020.47	236.2533	8914.942	14612.36
A4	13684.9	538.7757	44.89798	13449.99	529.5271	44.12726	38879673.8	60263.61	418.4973	18789.68	18467.14
A5	5421.06	213.4276	17.78563	12366.07	486.853	40.57108	57211472.2	88677.96	615.8192	10952.73	24984.45
A6	2685.304	105.7206	8.810052	7941.292	312.6493	26.05411	1594330.17	2471.217	17.16123	151.1913	447.1205
A7	6608.609	260.1815	21.68179	7193.475	283.2077	23.60064	33081301.5	51276.12	356.0842	7720.541	8403.814
A8	11501.53	452.8161	37.73468	6297.988	247.9523	20.66269	13503208.3	20930.01	145.3473	5484.634	3003.267
A9	8265.554	325.4155	27.11796	4174.996	164.3699	13.69749	6112797.39	9474.855	65.7976	1784.297	901.2622
A10	12596.67	495.9318	41.32765	200	7.874016	0.656168	1650489.48	2558.264	17.76572	734.2155	11.6573
A11	41003.43	1614.308	134.5257	11700	460.6299	38.38583	1232789220	1910827	13269.63	1785106	509365.8
A12	68802.95	2708.778	225.7315	20383.35	802.4941	66.87451	17591594.5	27267.03	189.3543	42743.24	12662.98
A13	68802.95	2708.778	225.7315	16183.35	637.1398	53.09498	6900705.53	10696.11	74.27858	16767.01	3943.82
A14	68802.95	2708.778	225.7315	13329.35	524.7776	43.73146	9742395.48	15100.74	104.8663	23671.62	4585.956
A15	68802.95	2708.778	225.7315	10268.87	404.2861	33.69051	8104819.82	12562.5	87.23955	19692.71	2939.145
A16	68802.95	2708.778	225.7315	4439.516	174.7841	14.56534	25889034.7	40128.08	278.6673	62903.97	4058.884
A17	73247.18	2883.747	240.3123	11700	460.6299	38.38583	139761180	216630.3	1504.377	361520.2	57746.75
A18	80171.03	3156.34	263.0283	20381.95	802.439	66.86991	47534287.5	73678.29	511.6548	134579.7	34214.31
A19	78529.85	3091.727	257.6439	7475.45	294.3091	24.52575	67830364.4	105137.3	730.12	188110.9	17906.74
A20	82467.35	3246.746	270.5622	9225.438	363.2062	30.26719	37585943.7	58258.33	404.5717	109461.8	12245.25
A21	82768.48	3258.602	271.5501	200	7.874016	0.656168	1553840	2408.457	16.72539	4541.783	10.97467
A22	85476.55	3365.219	280.4349	4614.713	181.6816	15.14013	6099955.07	9454.949	65.65937	18413.18	994.0917
A23	87126.8	3430.189	285.8491	7364.725	289.9498	24.16248	19742838.6	30601.46	212.5101	60745.83	5134.773
A24	87896.79	3460.504	288.3753	13201.49	519.7437	43.31197	63640551.4	98643.05	685.0212	197543.2	29669.62
A25	87126.8	3430.189	285.8491	20400	803.1496	66.92913	36219300	56140.03	389.8613	111441.5	26093.08
A26	85497.42	3366.04	280.5034	32376.56	1274.668	106.2223	43375270.2	67231.8	466.8875	130963.5	49593.88
A27	87279.06	3436.183	286.3486	30704.16	1208.825	100.7354	17001459.9	26352.32	183.0022	52402.42	18434.8
									21889.29	3390235	914136

Xcom	Ycom
1706.544 in	501.1414 in
142.212 ft	41.76179 ft
43346.21 mm	12728.99 mm

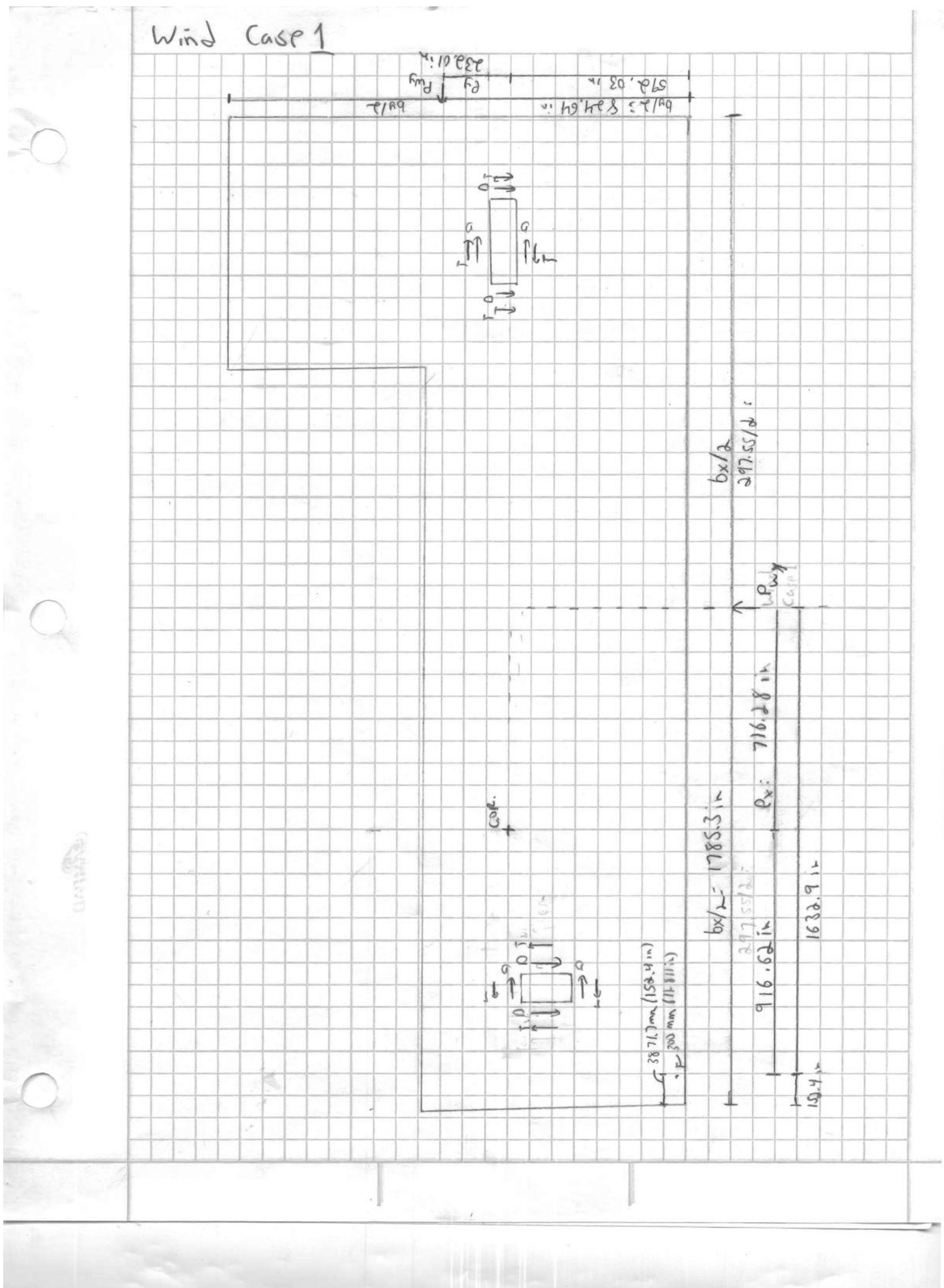
Roof Center of Mass

	Xi			Yi			Ai			Center of Floor Mass	
	mm	in	ft	mm	in	ft	mm^2	in^2	ft^2	Xi*Ai	Yi*Ai
A1	882.45	34.74213	2.895177	20698.4	814.8976	67.90814	5201961.38	8063.056	55.99345	162.1109	3802.411
A2	5789.35	227.9272	18.99393	19347.6	761.7165	63.47638	73035225.5	113204.8	786.1446	14931.98	49901.61
A3	11501.53	452.8161	37.73468	18852	742.2047	61.85039	21948648	34020.47	236.2533	8914.942	14612.36
A4	13684.9	538.7757	44.89798	13449.99	529.5271	44.12726	38879673.8	60263.61	418.4973	18789.68	18467.14
A5	5421.06	213.4276	17.78563	12366.07	486.853	40.57108	57211472.2	88677.96	615.8192	10952.73	24984.45
A6	2685.304	105.7206	8.810052	7941.292	312.6493	26.05411	1594330.17	2471.217	17.16123	151.1913	447.1205
A7	6608.609	260.1815	21.68179	7193.475	283.2077	23.60064	33081301.5	51276.12	356.0842	7720.541	8403.814
A8	11501.53	452.8161	37.73468	6297.988	247.9523	20.66269	13503208.3	20930.01	145.3473	5484.634	3003.267
A9	8265.554	325.4155	27.11796	4174.996	164.3699	13.69749	6112797.39	9474.855	65.7976	1784.297	901.2622
A10	12596.67	495.9318	41.32765	200	7.874016	0.656168	1650489.48	2558.264	17.76572	734.2155	11.6573
A11	41003.43	1614.308	134.5257	11700	460.6299	38.38583	1232789220	1910827	13269.63	1785106	509365.8
A12	68802.95	2708.778	225.7315	20383.35	802.4941	66.87451	17591594.5	27267.03	189.3543	42743.24	12662.98
A13	68802.95	2708.778	225.7315	16183.35	637.1398	53.09498	6900705.53	10696.11	74.27858	16767.01	3943.82
A14	68802.95	2708.778	225.7315	13329.35	524.7776	43.73146	9742395.48	15100.74	104.8663	23671.62	4585.956
A15	68802.95	2708.778	225.7315	10268.87	404.2861	33.69051	8104819.82	12562.5	87.23955	19692.71	2939.145
A16	68802.95	2708.778	225.7315	4439.516	174.7841	14.56534	25889034.7	40128.08	278.6673	62903.97	4058.884
A17	73247.18	2883.747	240.3123	11700	460.6299	38.38583	139761180	216630.3	1504.377	361520.2	57746.75
A18	80171.03	3156.34	263.0283	20381.95	802.439	66.86991	47534287.5	73678.29	511.6548	134579.7	34214.31
A19	78529.85	3091.727	257.6439	7475.45	294.3091	24.52575	67830364.4	105137.3	730.12	188110.9	17906.74
A20	82467.35	3246.746	270.5622	9225.438	363.2062	30.26719	37585943.7	58258.33	404.5717	109461.8	12245.25
A21	82768.48	3258.602	271.5501	200	7.874016	0.656168	1553840	2408.457	16.72539	4541.783	10.97467
A22	85476.55	3365.219	280.4349	4614.713	181.6816	15.14013	6099955.07	9454.949	65.65937	18413.18	994.0917
A23	87126.8	3430.189	285.8491	7364.725	289.9498	24.16248	19742838.6	30601.46	212.5101	60745.83	5134.773
A24	87896.79	3460.504	288.3753	13201.49	519.7437	43.31197	63640551.4	98643.05	685.0212	197543.2	29669.62
A25	87126.8	3430.189	285.8491	20400	803.1496	66.92913	36219300	56140.03	389.8613	111441.5	26093.08
A26	85497.42	3366.04	280.5034	32376.56	1274.668	106.2223	43375270.2	67231.8	466.8875	130963.5	49593.88
A27	87279.06	3436.183	286.3486	30704.16	1208.825	100.7354	17001459.9	26352.32	183.0022	52402.42	18434.8
A28	76359.91	3006.296	250.5246	32376.56	1274.668	106.2223	284715601	441310.1	3064.653	767771.2	325534.6
									24953.95	4158007	1239671

Xcom	Ycom
1847.499 in	596.14 in
153.9582 ft	49.67834 ft
46926.46 mm	15141.96 mm

Appendix E: Distribution of Forces

Wind Case 1



Design Wind Loads in N-S Direction			
	External Windward Load (kips)	External Leeward Loads (kips)	Story Shear (kips) 1.6W
Level 2	30.374	16.163	**74.460**
Level 3	32.008	14.721	**74.767**
Level 4	35.086	14.721	**79.692**
level 5	37.598	14.721	**83.710**
Roof	28.952	10.953	**63.848**
Base Shear			**376.477**

Design Wind Loads in E-W Direction			
	External Windward Load (kips)	External Leeward Loads (kips)	Base Shear (kips) 1.6W
Level 2	14.675	7.809	**35.974**
Level 3	15.464	7.112	**36.122**
Level 4	16.951	7.112	**38.502**
level 5	18.165	7.112	**40.443**
Roof	13.988	5.292	**30.847**
Base Shear			**181.888**

Eccentricity		
ex	**59.690**	**ft**
ey	**19.38**	**ft**

B-SW1				
K =	39.39349771		e =	19.38
∑K =	777.602579		d1 =	20.97
	Loads E-W (kips)	Direct Shear (kips)	Torisional Shear (kips)	Total Shear (kips)
Level 2	35.974	1.822	-0.27	**1.550**
Level 3	36.122	1.830	-0.27	**1.557**
Level 4	38.502	1.951	-0.29	**1.659**
Level 5	40.443	2.049	-0.31	**1.743**
Roof	30.847	1.563	-0.23	**1.329**

B-SW2				
K =	153.615		e =	59.690
∑K =	242.381		d2 =	46.87
	Loads N-S (kips)	Direct Shear (kips)	Torisional Shear (kips)	Total Shear (kips)
Level 2	74.460	47.191	-15.12	**32.068**
Level 3	74.767	47.385	-15.19	**32.200**
Level 4	79.692	50.507	-16.19	**34.321**
Level 5	83.710	53.054	-17.00	**36.051**
Roof	63.848	40.465	-12.97	**27.497**

B-SW3				
K =	39.393		e =	19.38
∑K =	777.60		d3 =	34.79
	Loads E-W (kips)	Direct Shear (kips)	Torisional Shear (kips)	Total Shear (kips)
Level 2	35.974	1.822	-0.45	**1.371**
Level 3	36.122	1.830	-0.45	**1.376**
Level 4	38.502	1.951	-0.48	**1.467**
Level 5	40.443	2.049	-0.51	**1.541**
Roof	30.847	1.563	-0.39	**1.175**

B-SW4				
K =	36.360		e =	59.690
∑K =	242.38		d4 =	55.77
	Loads N-S (kips)	Direct Shear (kips)	Torisional Shear (kips)	Total Shear (kips)
Level 2	74.460	11.170	-4.26	**6.910**
Level 3	74.767	11.216	-4.28	**6.939**
Level 4	79.692	11.955	-4.56	**7.396**
Level 5	83.710	12.557	-4.79	**7.769**
Roof	63.848	9.578	-3.65	**5.926**

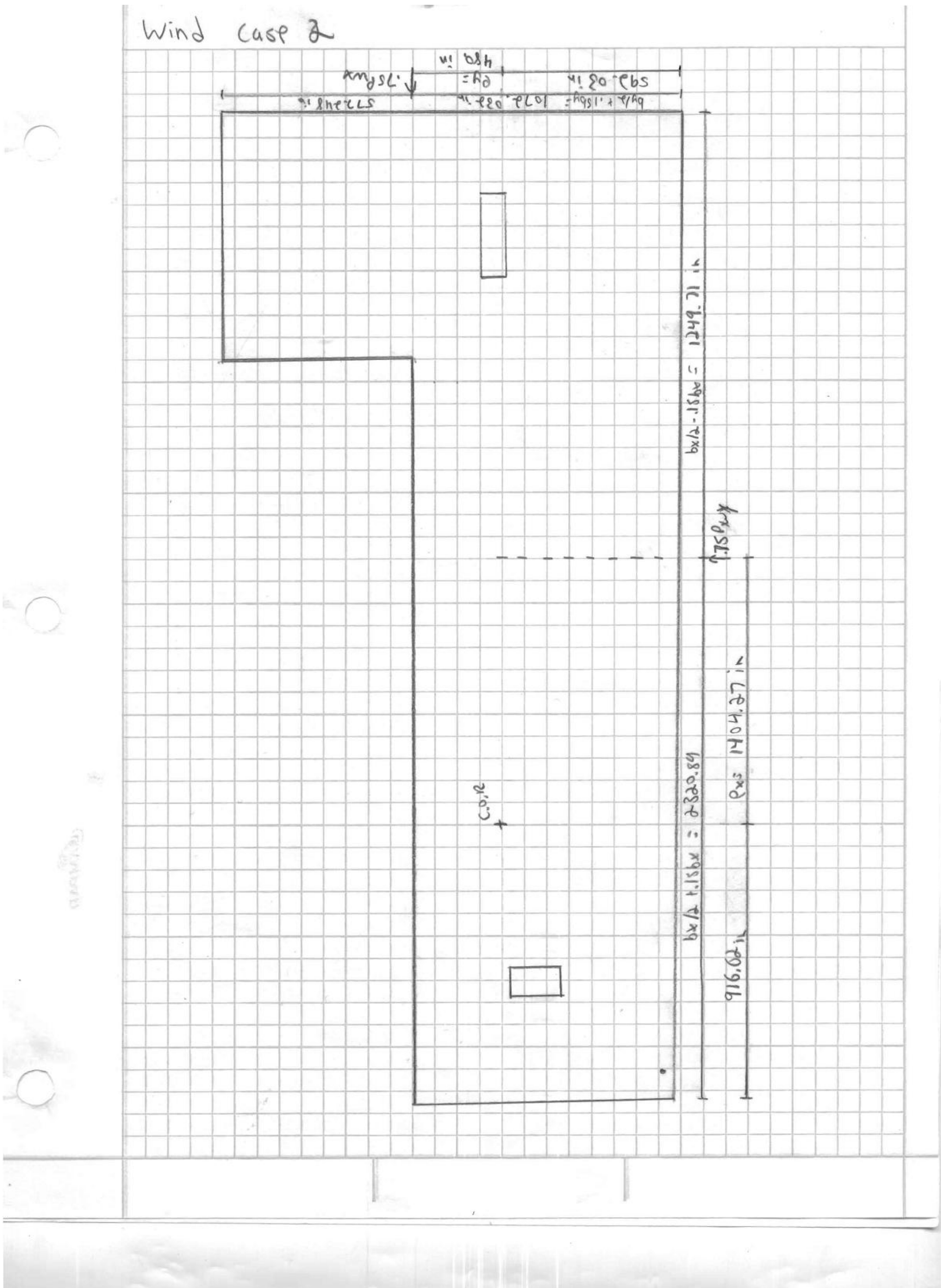
B-SW5				
K =	22.110		e =	59.690
∑K =	242.38		d5 =	160.57
	Loads N-S (kips)	Direct Shear (kips)	Torisional Shear (kips)	Total Shear (kips)
Level 2	74.460	6.792	7.46	**14.250**
Level 3	74.767	11.216	7.49	**18.704**
Level 4	79.692	11.955	7.98	**19.936**
Level 5	83.710	12.557	8.38	**20.941**
Roof	63.848	9.578	6.39	**15.973**

B-SW6				
K =	30.296		e =	59.690
∑K =	242.38		d6 =	187.39
	Loads N-S (kips)	Direct Shear (kips)	Torisional Shear (kips)	Total Shear (kips)
Level 2	74.460	9.307	11.93	**21.232**
Level 3	74.767	9.345	11.97	**21.320**
Level 4	79.692	9.961	12.76	**22.724**
Level 5	83.710	10.463	13.41	**23.870**
Roof	63.848	7.981	10.23	**18.206**

B-SW7				
K =	454.980		e =	19.380
∑K =	777.60		d7 =	1.76
	Loads E-W (kips)	Direct Shear (kips)	Torisional Shear (kips)	Total Shear (kips)
Level 2	35.974	21.049	-0.26	**20.785**
Level 3	36.122	21.135	-0.26	**20.870**
Level 4	38.502	22.528	-0.28	**22.245**
Level 5	40.443	23.664	-0.30	**23.367**
Roof	30.847	18.049	-0.23	**17.823**

B-SW8				
K =	243.836		e =	19.380
∑K =	777.60		d8 =	7.14
	Loads E-W (kips)	Direct Shear (kips)	Torisional Shear (kips)	Total Shear (kips)
Level 2	35.974	11.281	0.57	**11.854**
Level 3	36.122	11.327	0.58	**11.903**
Level 4	38.502	12.073	0.61	**12.687**
Level 5	40.443	12.682	0.64	**13.327**
Roof	30.847	9.673	0.49	**10.165**

Wind Case 2



Design Wind Loads in N-S Direction			
	External Windward Load (kips)	External Leeward Loads (kips)	Story Shear (kips) 1.6W
Level 2	30.374	16.163	**74.460**
Level 3	32.008	14.721	**74.767**
Level 4	35.086	14.721	**79.692**
level 5	37.598	14.721	**83.710**
Roof	28.952	10.953	**63.848**
Base Shear			**376.477**

Design Wind Loads in E-W Direction			
	External Windward Load (kips)	External Leeward Loads (kips)	Base Shear (kips) 1.6W
Level 2	14.675	7.809	**35.974**
Level 3	15.464	7.112	**36.122**
Level 4	16.951	7.112	**38.502**
level 5	18.165	7.112	**40.443**
Roof	13.988	5.292	**30.847**
Base Shear			**181.888**

Eccentricity		
ex	**117.020**	**ft**
ey	**40**	**ft**

B-SW1				
K =	39.39349771		e =	40
∑K =	777.602579		d1 =	20.97
	Loads E-W (kips)	Direct Shear (kips)	Torisional Shear (kips)	Total Shear (kips)
Level 2	35.974	1.822	-0.56	**1.261**
Level 3	36.122	1.830	-0.56	**1.266**
Level 4	38.502	1.951	-0.60	**1.349**
Level 5	40.443	2.049	-0.63	**1.417**
Roof	30.847	1.563	-0.48	**1.081**

B-SW2				
K =	153.615		e =	117.020
∑K =	242.381		d2 =	46.87
	Loads N-S (kips)	Direct Shear (kips)	Torisional Shear (kips)	Total Shear (kips)
Level 2	74.460	47.191	-29.65	**17.542**
Level 3	74.767	47.385	-29.77	**17.614**
Level 4	79.692	50.507	-31.73	**18.775**
Level 5	83.710	53.054	-33.33	**19.722**
Roof	63.848	40.465	-25.42	**15.042**

B-SW3				
K =	39.393		e =	40
∑K =	777.60		d3 =	34.79
	Loads E-W (kips)	Direct Shear (kips)	Torisional Shear (kips)	Total Shear (kips)
Level 2	35.974	1.822	-0.93	**0.890**
Level 3	36.122	1.830	-0.94	**0.894**
Level 4	38.502	1.951	-1.00	**0.953**
Level 5	40.443	2.049	-1.05	**1.001**
Roof	30.847	1.563	-0.80	**0.763**

B-SW4				
K =	36.360		e =	117.020
∑K =	242.38		d4 =	55.77
	Loads N-S (kips)	Direct Shear (kips)	Torisional Shear (kips)	Total Shear (kips)
Level 2	74.460	11.170	-8.35	**2.819**
Level 3	74.767	11.216	-8.38	**2.831**
Level 4	79.692	11.955	-8.94	**3.017**
Level 5	83.710	12.557	-9.39	**3.170**
Roof	63.848	9.578	-7.16	**2.418**

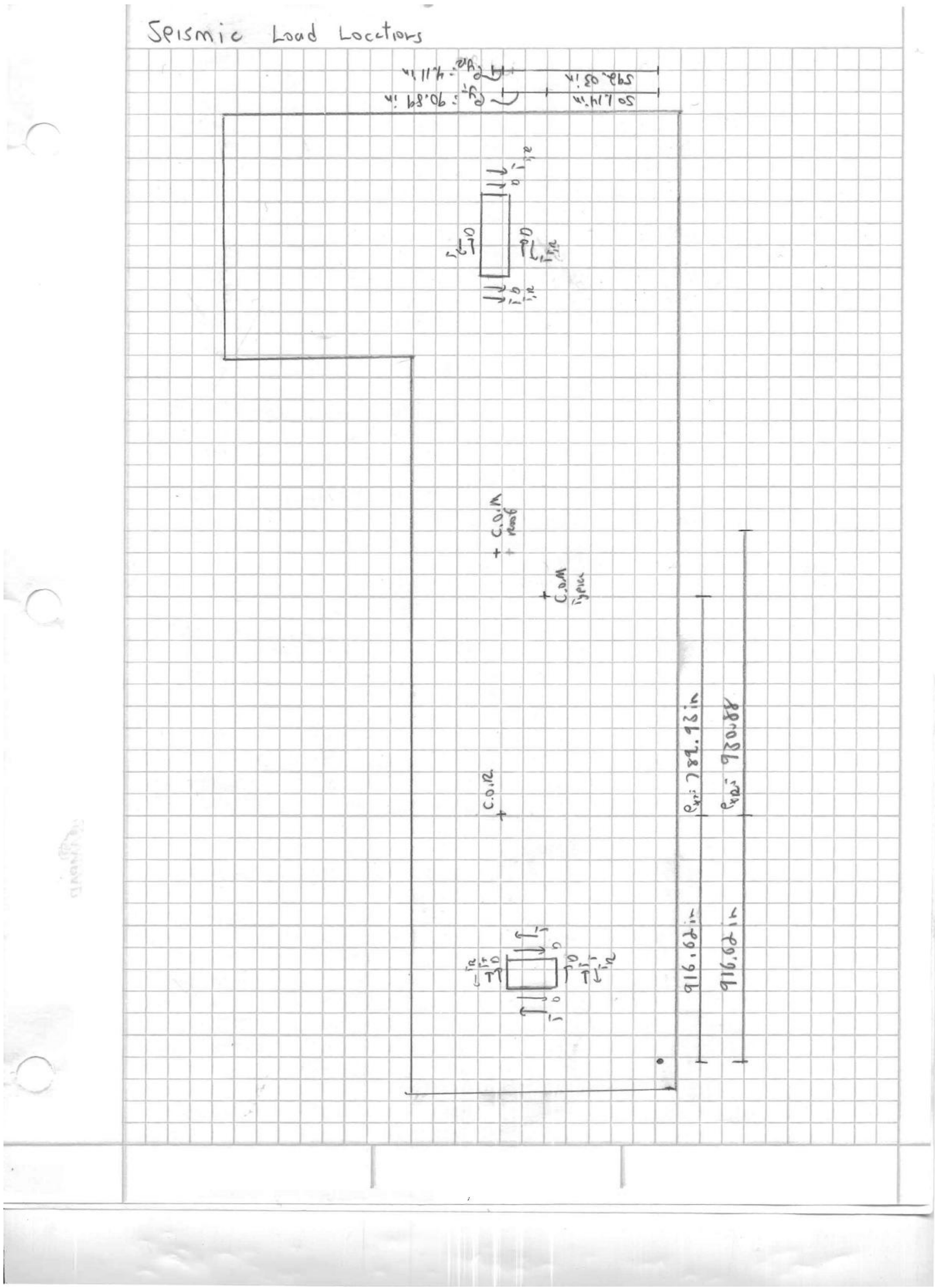
B-SW5				
K =	22.110		e =	117.020
∑K =	242.38		d5 =	160.57
	Loads N-S (kips)	Direct Shear (kips)	Torisional Shear (kips)	Total Shear (kips)
Level 2	74.460	6.792	14.62	**21.413**
Level 3	74.767	11.216	14.68	**25.896**
Level 4	79.692	11.955	15.65	**27.602**
Level 5	83.710	12.557	16.44	**28.994**
Roof	63.848	9.578	12.54	**22.114**

B-SW6				
K =	30.296		e =	117.020
∑K =	242.38		d6 =	187.39
	Loads N-S (kips)	Direct Shear (kips)	Torisional Shear (kips)	Total Shear (kips)
Level 2	74.460	9.307	23.38	**32.686**
Level 3	74.767	9.345	23.48	**32.821**
Level 4	79.692	9.961	25.02	**34.982**
Level 5	83.710	10.463	26.28	**36.747**
Roof	63.848	7.981	20.05	**28.028**

B-SW7				
K =	454.980		e =	40.000
∑K =	777.60		d7 =	1.76
	Loads E-W (kips)	Direct Shear (kips)	Torisional Shear (kips)	Total Shear (kips)
Level 2	35.974	21.049	-0.54	**20.504**
Level 3	36.122	21.135	-0.55	**20.588**
Level 4	38.502	22.528	-0.58	**21.945**
Level 5	40.443	23.664	-0.61	**23.051**
Roof	30.847	18.049	-0.47	**17.582**

B-SW8				
K =	243.836		e =	40.000
∑K =	777.60		d8 =	7.14
	Loads E-W (kips)	Direct Shear (kips)	Torisional Shear (kips)	Total Shear (kips)
Level 2	35.974	11.281	1.18	**12.465**
Level 3	36.122	11.327	1.19	**12.516**
Level 4	38.502	12.073	1.27	**13.340**
Level 5	40.443	12.682	1.33	**14.013**
Roof	30.847	9.673	1.02	**10.688**

Seismic Case



Design Seismic Loads		
	Seismic Load (kips)	Base Shear (kips)
Level 2	15.211	
Level 3	31.240	
Level 4	49.935	
level 5	70.175	
Roof	103.740	
Base Shear		**270.301**

Typical Floor Eccentricity			Roof Eccentricity		
ex	**65.828**	**ft**	**ex**	**77.570**	**ft**
ey	**7.574**	**ft**	**ey**	**0.3425**	**ft**

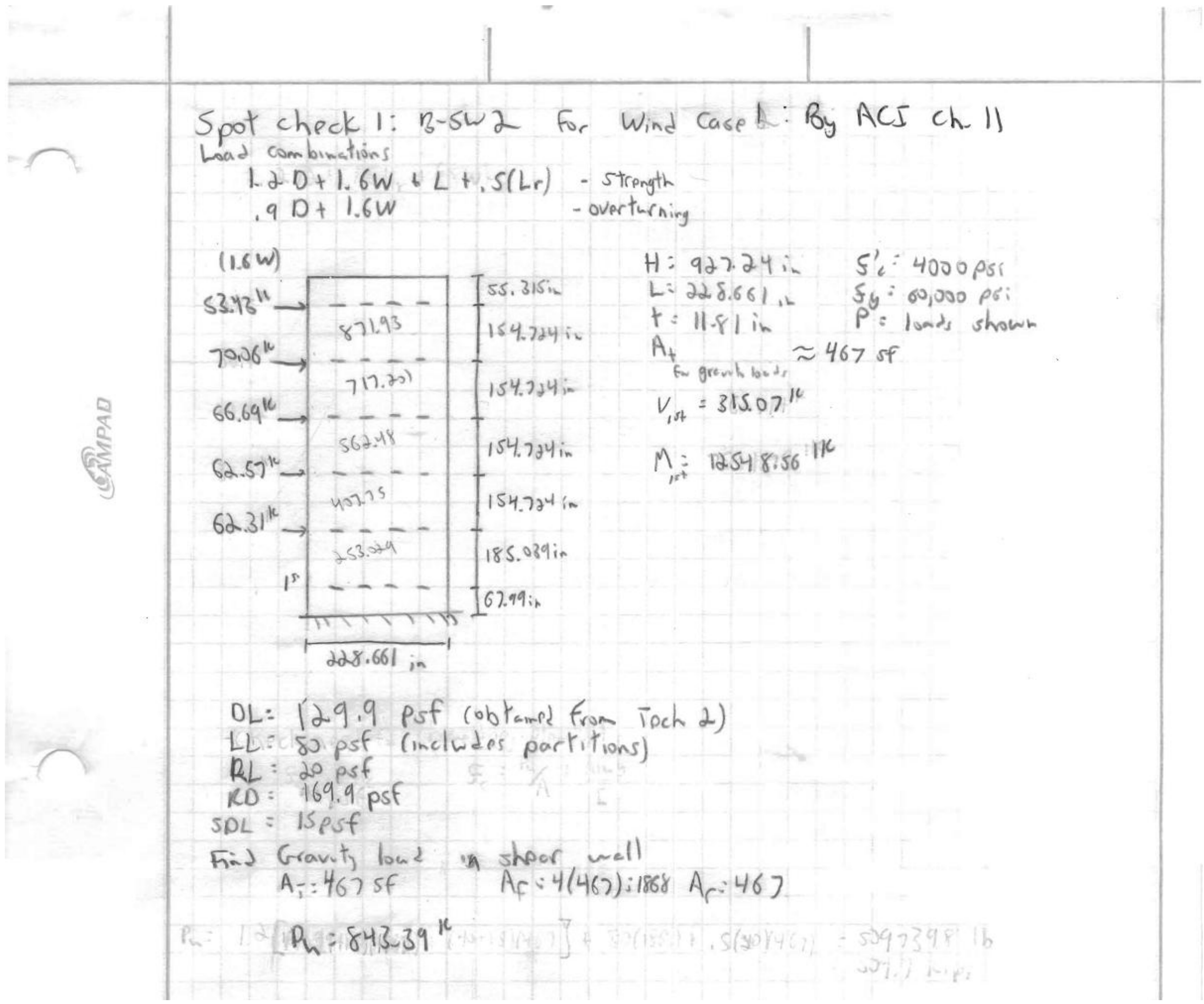
B-SW1				
K =	39.39349771		e =	7.574
∑K =	777.602579		d1 =	20.97
	Loads E-W (kips)	Direct Shear (kips)	Torisional Shear (kips)	Total Shear (kips)
Level 2	15.211	0.771	0.04	**0.816**
Level 3	31.240	1.583	0.09	**1.675**
Level 4	49.935	2.530	0.15	**2.677**
Level 5	70.175	3.555	0.21	**3.763**
Roof	103.740	5.255	-0.01	**5.242**

B-SW2				
K =	153.615		e =	65.828
∑K =	242.381		d2 =	46.87
	Loads N-S (kips)	Direct Shear (kips)	Torisional Shear (kips)	Total Shear (kips)
Level 2	15.211	9.640	-3.41	**6.233**
Level 3	31.240	19.799	-7.00	**12.802**
Level 4	49.935	31.648	-11.18	**20.463**
Level 5	70.175	44.475	-15.72	**28.757**
Roof	103.740	65.748	-27.38	**38.366**

B-SW3				
K =	39.393		e =	7.574
∑K =	777.60		d3 =	34.79
	Loads E-W (kips)	Direct Shear (kips)	Torisional Shear (kips)	Total Shear (kips)
Level 2	15.211	0.771	0.07	**0.845**
Level 3	31.240	1.583	0.15	**1.736**
Level 4	49.935	2.530	0.24	**2.775**
Level 5	70.175	3.555	0.34	**3.899**
Roof	103.740	5.255	-0.51	**4.747**

B-SW4				
K =	36.360		e =	65.828
∑K =	242.38		d4 =	55.77
	Loads N-S (kips)	Direct Shear (kips)	Torisional Shear (kips)	Total Shear (kips)
Level 2	15.211	2.282	-0.96	**1.322**
Level 3	31.240	4.686	-1.97	**2.716**
Level 4	49.935	7.491	-3.15	**4.341**
Level 5	70.175	10.527	-4.43	**6.100**
Roof	103.740	15.562	-7.71	**7.850**

Appendix F: Shear Wall Spot Check



Spot check 1: B-SW2 For Wind Case 1: By ACI ch. 11

Load combinations

1.2D + 1.6W + L + .5(Lr) - strength

.9D + 1.6W - overturning

(1.6W)

53.43k, 70.06k, 66.69k, 62.57k, 62.31k

871.93, 717.731, 562.48, 407.75, 253.329

55.315 in, 154.724 in, 154.724 in, 154.724 in, 154.724 in, 185.039 in, 67.99 in

1st

228.661 in

H: 927.24 in

L: 228.661 in

t: 11.81 in

A_t for gravity loads ≈ 467 sf

V_{1st} = 315.07 k

M_{1st}: 12548.56 ik

f'c: 4000 psi

fy: 60,000 psi

P: loads shown

DL: 129.9 psf (obtained from Tech 2)

LL: 80 psf (includes partitions)

RL: 20 psf

KD: 169.9 psf

SDL: 15 psf

Find Gravity load on shear wall

A_T: 467 sf A_I: 4(467): 1868 A_r: 467

P_u: 843.39 k

- Gravity Load

P_u:

LL: 80psf
$L_R L$: 20psf
DL: 129.9 psf (From Tech 2)
$D_R L$: 129.9 + 40 = 169.9 psf
SDL: 15psf

$A_t = 4(467) = 1868$ sf
A_r: 467 sf

$1.2D + 1.6W + L + .5L_r$

$1.2D: 1.2[(129.9+15)(1868) + (169.9+15)(467)] = 428425.8$ lbs
$= 428.43$ kips

$L: [(80)(1868)] = 149440$ lbs
$= 149.4$ kips

$.5L_r: .5[20(467)] = 4670$ lbs
$= 4.67$ kips

$P_u = 428.43 + 149.4 + 4.67 = 582.54$ kips

Selfweigh of shear wall

$1.2\left[150\left(\frac{11.811}{12}\right)\left(\frac{228.661}{12}\right)\left(\frac{927.24}{12}\right)\right] = 260855.32$ lbs
$= 260.86$ k

$P_u = 582.54 + 260.86 = 843.39$ kips

Spot check 1: B-SW2 cont.

1. Check max permitted shear strength

$V_u \leq \phi V_{max} = \phi\, 10\sqrt{f'_c}\, h d \qquad d = .8 l_w$

$= .75(10)\sqrt{4000}(12)(.8)(228.66)/1000 = 1041.2^k > 315.07^k$ ok

2. Shear strength by conc.

$a = \frac{l_w}{2} = 228.66/2 = 114.33 \text{ in} = 9.53 \text{ ft}$

$M_u = V_u(927.24 - 114.33)/1 = 812.91 V_u$

$V_c = 2\sqrt{f'_c}\, h d = 2\sqrt{4000}(12)(.8)(228.66)/1000 = 277.7^k$

or

$V_c = 3.3\sqrt{f'_c}\, h d + \frac{N_u d}{4 l_w}$

$= 3.3\sqrt{4000}(12)(.8)(228.66) = 4523^k$

$= \left[.6\sqrt{f'_c} + \frac{l_w(1.25\sqrt{f'_c} + .2\frac{N_u}{l_w h})}{\frac{M_u}{V_u} - \frac{l_w}{2}}\right] h d$

$= \left[.6\sqrt{4000} + \frac{(228.66)(1.25\sqrt{4000} + 0)}{\frac{812.91 V_u}{V_u} - \frac{228.66}{2}}\right] \frac{12(.8)(228.66)}{1000} = 140.1^k$

3. Req'd Horiz shear.

$V_u > \frac{1}{2}\phi V_c \qquad \frac{1}{2}\phi V_c = \frac{1}{2}(.75)(140.1) = 52.5^k < V_u$ use chp 11

$V_u \leq \phi V_n = \phi(V_c + V_s)$

$315.07 = .75(140.1 + V_s) \quad V_s = 279.99^k \qquad V_s = \frac{A_v f_y d}{s}$

$\frac{A_v}{s} = \frac{V_s}{f_y d} = \frac{279.99}{(60)(.8)(228.66)} = .0255$

$s = \frac{A_v}{.0255} = \frac{2(.2)}{.0255} = 15.68''$ ∴ Try (2) #4 @ 14" o.c.

Check ρ_t

$\rho_t = \frac{A_v}{s h} = \frac{2(.2)}{14(12)} = .024 > .0025$ ok

use (2) #4 @ 14" o.c.

Spot check 1: B-SW2 cont.

4. Req. vert shear

$\rho_v = \frac{A_v}{s h} \geq .0025 + .5(2.5 - \frac{h_w}{l_w})(\rho_h - .0025)$

$.0025 + .5(2.5 - \frac{927.24}{228.66})(.024 - .0025) = -.0052 < .0025$

$\rho_v = .0025$

Try (2) #4

$\rho_v = \frac{A_v}{s h}$ $s = \frac{2(.2)}{.0025(12)} = 12.8''$ use $12'' < 18''$ ok

use (2) #4 @ 12'' spac for vert reinf

5. Design for Flexural

$M_u = 12548.56^{\text{'k}}$

$M_n = A_s f_y(d - a/2) = A_s f_y(jd)$ $jd = .9d = .9(.8(228.66)) = 164.64\text{ in}$

$C = T \Rightarrow .85 f'_c ab = A_s f_y$

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

$12548.56(12000) = .9 A_s (60,000)(164.64)$ $A_s = 16.94\text{ in}^2$

Solve for a

$.85 f'_c ab = A_s f_y$

$.85(4000)(a)(12) = 16.94(60,000)$ $a = 24.91\text{ in}$

$jd = d - a/2$

$= .8(228.66) - \frac{24.91}{2} = 170.5\text{ in} \approx 164.6\text{ in}$

use (22) #8 for flexural steel at each end

Appendix G: Overturning Check

Overturning check: B-SW2

$.9D + 1.6W \qquad M_u = 12548.56\ ^{\text{'k}}$

$$.9D = .9\left[(129.9+15)(1868) + (169.9+15)\,467\right] + .9\left[150\left(\frac{11.811}{12}\right)\left(\frac{228.661}{12}\right)\left(\frac{927.24}{12}\right)\right]$$

$$= (321319.35 + 195641.49)/1000 = 516.97\ ^{\text{k}}$$

Tension (uplift due to wind)

$$T = \frac{M_u}{d} = \frac{12548.56}{.8\left(\frac{228.66}{12}\right)} = 823.2\ ^{\text{k}}$$ uplift exceeds dead load

* The uplift due to wind loading exceeds the forces of dead loads.

- In this shear wall the esccentric effects are large which cause large overturning moment, an error in the calculation of the COM or COR could have led to an error
- The geopiers may take uplift resistance, but at this time it is unknown.

Appendix H: Deflection Calculations by Excel

Deflections for Wind Load Case 1

B-SW1 Deflection Analysis of Wind Case 1								
Level	Load Appliead at Level			Deflection at Level due to Load Applied at Each Level				
		b (in.)	a (in.)	Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	1.309	253.029	674.211	0.0009	0.0017	0.0018	0.0006	-0.0025
Level 3	1.315	407.75	519.49	0.0017	0.0040	0.0061	0.0077	0.0079
Level 4	1.401	562.48	364.76	0.0020	0.0066	0.0112	0.0156	0.0194
Level 5	1.472	717.201	210.039	0.0007	0.0086	0.0164	0.0243	0.0320
Roof	1.123	871.93	55.31	-0.0022	0.0067	0.0156	0.0244	0.0333
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	2066236.008	in^4		**0.0032**	**0.0275**	**0.0511**	**0.0727**	**0.0901**

B-SW2 Deflection Analysis of Wind Case 1								
Level	Load Appliead at Level			Deflection at Level due to Load Applied at Each Level				
		b (in.)	a (in.)	Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	38.946	253.029	674.211	0.0071	0.0128	0.0136	0.0047	-0.0188
Level 3	39.107	407.75	519.49	0.0128	0.0298	0.0459	0.0571	0.0586
Level 4	41.683	562.48	364.76	0.0146	0.0489	0.0833	0.1168	0.1450
Level 5	43.785	717.201	210.039	0.0053	0.0640	0.1226	0.1813	0.2391
Roof	33.396	871.93	55.31	-0.0161	0.0501	0.1162	0.1824	0.2485
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	8237376	in^4		**0.0237**	**0.2055**	**0.3816**	**0.5423**	**0.6725**

B-SW3 Deflection Analysis of Wind Case 1								
Level	Load Appliead at Level			Deflection at Level due to Load Applied at Each Level				
		b (in.)	a (in.)	Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	1.421	253.029	674.211	0.0010	0.0019	0.0020	0.0007	-0.0027
Level 3	1.427	407.75	519.49	0.0019	0.0043	0.0067	0.0083	0.0085
Level 4	1.521	562.48	364.76	0.0021	0.0071	0.0121	0.0170	0.0211
Level 5	1.598	717.201	210.039	0.0008	0.0093	0.0178	0.0264	0.0348
Roof	1.219	871.93	55.31	-0.0023	0.0073	0.0169	0.0265	0.0362
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	2066236.008	in^4		**0.0034**	**0.0299**	**0.0555**	**0.0789**	**0.0978**

B-SW4 Deflection Analysis of Wind Case 1								
Level	Load Appliead at Level			Deflection at Level due to Load Applied at Each Level				
		b (in.)	a (in.)	Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	9.643	253.029	674.211	0.0076	0.0138	0.0146	0.0051	-0.0202
Level 3	9.683	407.75	519.49	0.0138	0.0321	0.0494	0.0615	0.0631
Level 4	10.321	562.48	364.76	0.0157	0.0527	0.0897	0.1257	0.1562
Level 5	10.841	717.201	210.039	0.0057	0.0689	0.1321	0.1953	0.2575
Roof	8.269	871.93	55.31	-0.0173	0.0539	0.1252	0.1964	0.2676
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	1893792.083	in^4		**0.0255**	**0.2213**	**0.4110**	**0.5840**	**0.7243**

B-SW5 Deflection Analysis of Wind Case 1								
Level	Load Appliead at Level			Deflection at Level due to Load Applied at Each Level				
		b (in.)	a (in.)	Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	8.906	253.029	674.211	0.0116	0.0209	0.0223	0.0077	-0.0307
Level 3	11.690	407.75	519.49	0.0275	0.0637	0.0982	0.1223	0.1255
Level 4	12.460	562.48	364.76	0.0312	0.1047	0.1783	0.2500	0.3106
Level 5	13.088	717.201	210.039	0.0113	0.1370	0.2626	0.3882	0.5119
Roof	9.983	871.93	55.31	-0.0344	0.1072	0.2488	0.3904	0.5321
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	1150003.575	in^4		**0.0471**	**0.4335**	**0.8102**	**1.1587**	**1.4494**

B-SW6 Deflection Analysis of Wind Case 1								
Level	Load Appliead at Level			Deflection at Level due to Load Applied at Each Level				
		b (in.)	a (in.)	Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	13.270	253.029	674.211	0.0126	0.0227	0.0242	0.0084	-0.0333
Level 3	13.325	407.75	519.49	0.0228	0.0529	0.0816	0.1015	0.1042
Level 4	14.203	562.48	364.76	0.0259	0.0869	0.1480	0.2075	0.2578
Level 5	14.919	717.201	210.039	0.0094	0.1137	0.2180	0.3222	0.4249
Roof	11.379	871.93	55.31	-0.0286	0.0890	0.2065	0.3241	0.4416
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	1579224.472	in^4		**0.0421**	**0.3652**	**0.6782**	**0.9637**	**1.1952**

B-SW7 Deflection Analysis of Wind Case 1								
Level	Load Appliead at Level			Deflection at Level due to Load Applied at Each Level				
		b (in.)	a (in.)	Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	13.320	253.029	674.211	0.0008	0.0014	0.0015	0.0005	-0.0021
Level 3	13.375	407.75	519.49	0.0014	0.0033	0.0051	0.0063	0.0065
Level 4	14.256	562.48	364.76	0.0016	0.0054	0.0092	0.0129	0.0160
Level 5	14.975	717.201	210.039	0.0006	0.0070	0.0135	0.0200	0.0263
Roof	11.422	871.93	55.31	-0.0018	0.0055	0.0128	0.0201	0.0274
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	25583484.62	in^4		**0.0026**	**0.0226**	**0.0420**	**0.0597**	**0.0741**

B-SW8 Deflection Analysis of Wind Case 1								
Level	Load Appliead at Level			Deflection at Level due to Load Applied at Each Level				
		b (in.)	a (in.)	Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	7.409	253.029	674.211	0.0008	0.0015	0.0016	0.0006	-0.0022
Level 3	7.439	407.75	519.49	0.0015	0.0035	0.0055	0.0068	0.0070
Level 4	7.929	562.48	364.76	0.0017	0.0058	0.0099	0.0139	0.0173
Level 5	8.329	717.201	210.039	0.0006	0.0076	0.0146	0.0216	0.0285
Roof	6.353	871.93	55.31	-0.0019	0.0060	0.0138	0.0217	0.0296
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	13164372.15	in^4		**0.0028**	**0.0245**	**0.0454**	**0.0645**	**0.0801**

Deflections for Wind Load Case 2

B-SW1 Deflection Analysis of Wind Case 2								
Level	Load Appliead at Level			Deflection at Level due to Load Applied at Each Level				
		b (in.)	a (in.)	Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	1.118	253.029	674.211	0.0008	0.0015	0.0016	0.0005	-0.0021
Level 3	1.122	407.75	519.49	0.0015	0.0034	0.0052	0.0065	0.0067
Level 4	1.196	562.48	364.76	0.0017	0.0056	0.0095	0.0134	0.0166
Level 5	1.256	717.201	210.039	0.0006	0.0073	0.0140	0.0207	0.0274
Roof	0.958	871.93	55.31	-0.0018	0.0057	0.0133	0.0209	0.0284
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	2066236.01	in^4		**0.0027**	**0.0235**	**0.0437**	**0.0620**	**0.0769**

B-SW2 Deflection Analysis of Wind Case 2								
Level	Load Appliead at Level			Deflection at Level due to Load Applied at Each Level				
		b (in.)	a (in.)	Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	36.019	253.029	674.211	0.0065	0.0118	0.0126	0.0044	-0.0173
Level 3	36.167	407.75	519.49	0.0119	0.0275	0.0424	0.0528	0.0542
Level 4	38.549	562.48	364.76	0.0135	0.0452	0.0770	0.1080	0.1341
Level 5	40.493	717.201	210.039	0.0049	0.0592	0.1134	0.1677	0.2211
Roof	30.885	871.93	55.31	-0.0149	0.0463	0.1075	0.1686	0.2298
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	8237376	in^4		**0.0219**	**0.1900**	**0.3529**	**0.5015**	**0.6219**

B-SW3 Deflection Analysis of Wind Case 2								
Level	Load Appliead at Level			Deflection at Level due to Load Applied at Each Level				
		b (in.)	a (in.)	Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	1.291	253.029	674.211	0.0009	0.0017	0.0018	0.0006	-0.0025
Level 3	1.297	407.75	519.49	0.0017	0.0039	0.0061	0.0076	0.0077
Level 4	1.382	562.48	364.76	0.0019	0.0065	0.0110	0.0154	0.0192
Level 5	1.452	717.201	210.039	0.0007	0.0085	0.0162	0.0240	0.0316
Roof	1.107	871.93	55.31	-0.0021	0.0066	0.0154	0.0241	0.0328
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	2066236.01	in^4		**0.0031**	**0.0272**	**0.0504**	**0.0717**	**0.0889**

B-SW4 Deflection Analysis of Wind Case 2								
Level	Load Appliead at Level			Deflection at Level due to Load Applied at Each Level				
		b (in.)	a (in.)	Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	5.236	253.029	674.211	0.0041	0.0075	0.0080	0.0028	-0.0110
Level 3	9.188	407.75	519.49	0.0131	0.0304	0.0469	0.0584	0.0599
Level 4	9.793	562.48	364.76	0.0149	0.0500	0.0851	0.1193	0.1482
Level 5	10.287	717.201	210.039	0.0054	0.0654	0.1253	0.1853	0.2443
Roof	7.846	871.93	55.31	-0.0164	0.0512	0.1188	0.1863	0.2539
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	1893792.08	in^4		**0.0211**	**0.2044**	**0.3840**	**0.5521**	**0.6954**

B-SW5 Deflection Analysis of Wind Case 2								
Level	Load Appliead at Level	b (in.)	a (in.)	Deflection at Level due to Load Applied at Each Level				
				Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	10.037	253.029	674.211	0.0131	0.0236	0.0251	0.0087	-0.0346
Level 3	12.139	407.75	519.49	0.0285	0.0662	0.1020	0.1270	0.1303
Level 4	12.938	562.48	364.76	0.0324	0.1087	0.1851	0.2596	0.3225
Level 5	13.591	717.201	210.039	0.0118	0.1422	0.2727	0.4031	0.5316
Roof	10.366	871.93	55.31	-0.0358	0.1113	0.2584	0.4054	0.5525
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	1150003.58	in^4		**0.0500**	**0.4520**	**0.8433**	**1.2039**	**1.5023**

B-SW6 Deflection Analysis of Wind Case 2								
Level	Load Appliead at Level	b (in.)	a (in.)	Deflection at Level due to Load Applied at Each Level				
				Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	15.322	253.029	674.211	0.0145	0.0262	0.0279	0.0097	-0.0385
Level 3	15.385	407.75	519.49	0.0263	0.0611	0.0942	0.1172	0.1203
Level 4	16.398	562.48	364.76	0.0299	0.1004	0.1709	0.2396	0.2976
Level 5	17.225	717.201	210.039	0.0109	0.1313	0.2517	0.3721	0.4906
Roof	13.138	871.93	55.31	-0.0330	0.1027	0.2385	0.3742	0.5099
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	1579224.47	in^4		**0.0486**	**0.4216**	**0.7830**	**1.1127**	**1.3800**

B-SW7 Deflection Analysis of Wind Case 2								
Level	Load Appliead at Level	b (in.)	a (in.)	Deflection at Level due to Load Applied at Each Level				
				Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	10.122	253.029	674.211	0.0006	0.0011	0.0011	0.0004	-0.0016
Level 3	10.164	407.75	519.49	0.0011	0.0025	0.0038	0.0048	0.0049
Level 4	10.833	562.48	364.76	0.0012	0.0041	0.0070	0.0098	0.0121
Level 5	11.379	717.201	210.039	0.0004	0.0054	0.0103	0.0152	0.0200
Roof	8.679	871.93	55.31	-0.0013	0.0042	0.0097	0.0153	0.0208
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	25583484.6	in^4		**0.0020**	**0.0172**	**0.0319**	**0.0454**	**0.0563**

B-SW8 Deflection Analysis of Wind Case 2								
Level	Load Appliead at Level	b (in.)	a (in.)	Deflection at Level due to Load Applied at Each Level				
				Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	5.843	253.029	674.211	0.0007	0.0012	0.0013	0.0004	-0.0018
Level 3	5.867	407.75	519.49	0.0012	0.0028	0.0043	0.0054	0.0055
Level 4	6.253	562.48	364.76	0.0014	0.0046	0.0078	0.0110	0.0136
Level 5	6.569	717.201	210.039	0.0005	0.0060	0.0115	0.0170	0.0224
Roof	5.010	871.93	55.31	-0.0015	0.0047	0.0109	0.0171	0.0233
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	13164372.2	in^4		**0.0022**	**0.0193**	**0.0358**	**0.0509**	**0.0631**

Deflections for Seismic Load Case

B-SW1 Deflection Analysis of Seismic Case								
Level	Load Appliead at Level	b (in.)	a (in.)	Deflection at Level due to Load Applied at Each Level				
				Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	0.816	253.029	674.211	0.0006	0.0011	0.0011	0.0004	-0.0016
Level 3	1.675	407.75	519.49	0.0022	0.0051	0.0078	0.0098	0.0100
Level 4	2.677	562.48	364.76	0.0037	0.0125	0.0213	0.0299	0.0371
Level 5	3.763	717.201	210.039	0.0018	0.0219	0.0420	0.0621	0.0819
Roof	5.269	871.93	55.31	-0.0101	0.0315	0.0731	0.1147	0.1563
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	2066236.01	in^4		**-0.0018**	**0.0721**	**0.1454**	**0.2169**	**0.2838**

B-SW2 Deflection Analysis of Siesmic Case								
Level	Load Appliead at Level	b (in.)	a (in.)	Deflection at Level due to Load Applied at Each Level				
				Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	13.047	253.029	674.211	0.0024	0.0043	0.0046	0.0016	-0.0063
Level 3	26.797	407.75	519.49	0.0088	0.0204	0.0314	0.0391	0.0402
Level 4	42.833	562.48	364.76	0.0150	0.0503	0.0856	0.1200	0.1490
Level 5	60.194	717.201	210.039	0.0073	0.0879	0.1686	0.2493	0.3287
Roof	88.985	871.93	55.31	-0.0428	0.1334	0.3096	0.4859	0.6621
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	8237376	in^4		**-0.0095**	**0.2963**	**0.5998**	**0.8958**	**1.1737**

B-SW3 Deflection Analysis of Seismic Case								
Level	Load Appliead at Level	b (in.)	a (in.)	Deflection at Level due to Load Applied at Each Level				
				Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	0.845	253.029	674.211	0.0006	0.0011	0.0012	0.0004	-0.0016
Level 3	1.736	407.75	519.49	0.0023	0.0053	0.0081	0.0101	0.0104
Level 4	2.775	562.48	364.76	0.0039	0.0130	0.0221	0.0310	0.0385
Level 5	3.899	717.201	210.039	0.0019	0.0227	0.0435	0.0644	0.0849
Roof	5.764	871.93	55.31	-0.0111	0.0344	0.0800	0.1255	0.1710
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	2066236.01	in^4		**-0.0024**	**0.0765**	**0.1549**	**0.2314**	**0.3031**

B-SW4 Deflection Analysis of Seismic Case								
Level	Load Appliead at Level	b (in.)	a (in.)	Deflection at Level due to Load Applied at Each Level				
				Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	3.241	253.029	674.211	0.0026	0.0046	0.0049	0.0017	-0.0068
Level 3	6.657	407.75	519.49	0.0095	0.0220	0.0340	0.0423	0.0434
Level 4	10.641	562.48	364.76	0.0162	0.0543	0.0925	0.1296	0.1611
Level 5	14.954	717.201	210.039	0.0079	0.0950	0.1822	0.2694	0.3552
Roof	22.107	871.93	55.31	-0.0463	0.1441	0.3346	0.5250	0.7155
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	1893792.08	in^4		**-0.0102**	**0.3201**	**0.6481**	**0.9680**	**1.2683**

B-SW5 Deflection Analysis of Seismic Case								
Level	Load Appliead at Level	b (in.)	a (in.)	Deflection at Level due to Load Applied at Each Level				
				Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	3.068	253.029	674.211	0.0040	0.0072	0.0077	0.0027	-0.0106
Level 3	8.137	407.75	519.49	0.0191	0.0444	0.0684	0.0851	0.0874
Level 4	13.006	562.48	364.76	0.0325	0.1093	0.1861	0.2609	0.3242
Level 5	18.278	717.201	210.039	0.0158	0.1913	0.3667	0.5422	0.7149
Roof	29.064	871.93	55.31	-0.1002	0.3121	0.7244	1.1368	1.5491
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	1150003.58	in^4		**-0.0288**	**0.6642**	**1.3533**	**2.0277**	**2.6650**

B-SW6 Deflection Analysis of Seismic Case								
Level	Load Appliead at Level	b (in.)	a (in.)	Deflection at Level due to Load Applied at Each Level				
				Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	4.588	253.029	674.211	0.0044	0.0078	0.0084	0.0029	-0.0115
Level 3	9.423	407.75	519.49	0.0161	0.0374	0.0577	0.0718	0.0737
Level 4	15.061	562.48	364.76	0.0274	0.0922	0.1569	0.2200	0.2734
Level 5	21.166	717.201	210.039	0.0134	0.1613	0.3092	0.4572	0.6028
Roof	34.558	871.93	55.31	-0.0868	0.2702	0.6273	0.9843	1.3413
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	1579224.47	in^4		**-0.0256**	**0.5689**	**1.1594**	**1.7362**	**2.2797**

B-SW7 Deflection Analysis of Seismic Case								
Level	Load Appliead at Level	b (in.)	a (in.)	Deflection at Level due to Load Applied at Each Level				
				Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	8.944	253.029	674.211	0.0005	0.0009	0.0010	0.0003	-0.0014
Level 3	18.368	407.75	519.49	0.0019	0.0045	0.0069	0.0086	0.0089
Level 4	29.360	562.48	364.76	0.0033	0.0111	0.0189	0.0265	0.0329
Level 5	41.261	717.201	210.039	0.0016	0.0194	0.0372	0.0550	0.0725
Roof	60.996	871.93	55.31	-0.0095	0.0294	0.0683	0.1072	0.1461
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	25583484.6	in^4		**-0.0021**	**0.0654**	**0.1324**	**0.1977**	**0.2591**

B-SW8 Deflection Analysis of Seismic Case								
Level	Load Appliead at Level	b (in.)	a (in.)	Deflection at Level due to Load Applied at Each Level				
				Level 2	Level 3	Level 4	Level 5	Roof
				674.211	519.49	364.76	210.039	55.31
Level 2	4.865	253.029	674.211	0.0006	0.0010	0.0011	0.0004	-0.0015
Level 3	9.991	407.75	519.49	0.0020	0.0048	0.0073	0.0091	0.0094
Level 4	15.970	562.48	364.76	0.0035	0.0117	0.0200	0.0280	0.0348
Level 5	22.442	717.201	210.039	0.0017	0.0205	0.0393	0.0582	0.0767
Roof	33.177	871.93	55.31	-0.0100	0.0311	0.0722	0.1134	0.1545
				Total Deflection at Each Level (in.)				
				Level 2	Level 3	Level 4	Level 5	Roof
.7*I =	13164372.2	in^4		**-0.0022**	**0.0691**	**0.1399**	**0.2090**	**0.2738**

Appendix I: Results from SAP

TABLE: Joint Displacements B-SW1								
Joint	**OutputCase**	**CaseType**	**U1**	**U2**	**U3**	**R1**	**R2**	**R3**
Text	Text	Text	in	in	in	Radians	Radians	Radians
106	Wind Case 1	LinStatic	0.014115	0	1.8E-06	0	0.000097	0
106	Wind Case 2	LinStatic	0.012045	0	1.5E-06	0	0.000083	0
106	Seismic Case	LinStatic	0.037848	0	1.1E-06	0	0.000269	0
184	Wind Case 1	LinStatic	0.032262	0	5.5E-06	0	0.000131	0
184	Wind Case 2	LinStatic	0.027531	0	4.7E-06	0	0.000112	0
184	Seismic Case	LinStatic	0.08888	0	4.6E-06	0	0.000374	0
254	Wind Case 1	LinStatic	0.054267	0	9.3E-06	0	0.000149	0
254	Wind Case 2	LinStatic	0.046308	0	8E-06	0	0.000127	0
254	Seismic Case	LinStatic	0.152872	0	1.1E-05	0	0.000439	0
324	Wind Case 1	LinStatic	0.078144	0	1.3E-05	0	0.000157	0
324	Wind Case 2	LinStatic	0.066682	0	1.1E-05	0	0.000134	0
324	Seismic Case	LinStatic	0.224018	0	0.00002	0	0.000469	0
394	Wind Case 1	LinStatic	0.102611	0	2.3E-05	0	0.000158	0
394	Wind Case 2	LinStatic	0.087559	0	1.9E-05	0	0.000135	0
394	Seismic Case	LinStatic	0.297869	0	5.9E-05	0	0.000477	0

TABLE: Joint Displacements B-SW2								
Joint	**OutputCase**	**CaseType**	**U1**	**U2**	**U3**	**R1**	**R2**	**R3**
Text	Text	Text	in	in	in	Radians	Radians	Radians
1222	WindCase1	LinStatic	0.112597	0	3.9E-05	0	0.000754	0
1222	WindCase2	LinStatic	0.104132	0	3.6E-05	0	0.000697	0
1222	SeismicCase	LinStatic	0.164393	0	7.3E-06	0	0.001147	0
1248	WindCase1	LinStatic	0.25215	0	0.00017	0	0.000996	0
1248	WindCase2	LinStatic	0.233192	0	0.00015	0	0.000921	0
1248	SeismicCase	LinStatic	0.380533	0	6.2E-05	0	0.001581	0
1274	WindCase1	LinStatic	0.419513	0	0.00028	0	0.001128	0
1274	WindCase2	LinStatic	0.387973	0	0.00026	0	0.001043	0
1274	SeismicCase	LinStatic	0.649761	0	0.00016	0	0.00185	0
1300	WindCase1	LinStatic	0.599828	0	0.0004	0	0.001182	0
1300	WindCase2	LinStatic	0.55473	0	0.00037	0	0.001093	0
1300	SeismicCase	LinStatic	0.947814	0	0.0003	0	0.001983	0
1326	WindCase1	LinStatic	0.783581	0	0.00065	0	0.001203	0
1326	WindCase2	LinStatic	0.724668	0	0.00061	0	0.001112	0
1326	SeismicCase	LinStatic	1.255941	0	0.00088	0	0.002039	0

TABLE: Joint Displacements B-SW3								
Joint	**OutputCase**	**CaseType**	**U1**	**U2**	**U3**	**R1**	**R2**	**R3**
Text	Text	Text	in	in	in	Radians	Radians	Radians
106	Wind Case 1	LinStatic	0.015322	0	1.9E-06	0	0.000106	0
106	Wind Case 2	LinStatic	0.01392	0	1.8E-06	0	0.000096	0
106	Seismic Case	LinStatic	0.040277	0	1.1E-06	0	0.000287	0
184	Wind Case 1	LinStatic	0.035021	0	6E-06	0	0.000142	0
184	Wind Case 2	LinStatic	0.031817	0	5.4E-06	0	0.000129	0
184	Seismic Case	LinStatic	0.094648	0	4.7E-06	0	0.000399	0
254	Wind Case 1	LinStatic	0.058908	0	0.00001	0	0.000162	0
254	Wind Case 2	LinStatic	0.053518	0	9.2E-06	0	0.000147	0
254	Seismic Case	LinStatic	0.162901	0	1.1E-05	0	0.000468	0
324	Wind Case 1	LinStatic	0.084827	0	1.5E-05	0	0.00017	0
324	Wind Case 2	LinStatic	0.077064	0	1.3E-05	0	0.000154	0
324	Seismic Case	LinStatic	0.238871	0	0.00002	0	0.000501	0
394	Wind Case 1	LinStatic	0.111387	0	2.5E-05	0	0.000172	0
394	Wind Case 2	LinStatic	0.101193	0	2.2E-05	0	0.000156	0
394	Seismic Case	LinStatic	0.317794	0	6.3E-05	0	0.00051	0

TABLE: Joint Displacements B-SW4								
Joint	**OutputCase**	**CaseType**	**U1**	**U2**	**U3**	**R1**	**R2**	**R3**
Text	Text	Text	in	in	in	Radians	Radians	Radians
164	Wind Case 1	LinStatic	0.086718	0	-4.2E-05	0	0.000452	0
164	Wind Case 2	LinStatic	0.078004	0	-3.9E-05	0	0.000421	0
164	Seismic Case	LinStatic	0.11882	0	-0.00003	0	0.000668	0
227	Wind Case 1	LinStatic	0.193362	0	0.00013	0	0.000622	0
227	Wind Case 2	LinStatic	0.177553	0	5.4E-05	0	0.00058	0
227	Seismic Case	LinStatic	0.281026	0	9.1E-06	0	0.000995	0
293	Wind Case 1	LinStatic	0.31748	0	0.00036	0	0.000731	0
293	Wind Case 2	LinStatic	0.293793	0	0.00026	0	0.000684	0
293	Seismic Case	LinStatic	0.483515	0	0.00015	0	0.001225	0
359	Wind Case 1	LinStatic	0.446193	0	0.00065	0	0.000766	0
359	Wind Case 2	LinStatic	0.414389	0	0.00054	0	0.000717	0
359	Seismic Case	LinStatic	0.703467	0	0.00045	0	0.00132	0
425	Wind Case 1	LinStatic	0.571516	0	0.00093	0	0.000768	0
425	Wind Case 2	LinStatic	0.531768	0	0.0008	0	0.000719	0
425	Seismic Case	LinStatic	0.923103	0	0.00083	0	0.001311	0

TABLE: Joint Displacements B-SW5								
Joint	**OutputCase**	**CaseType**	**U1**	**U2**	**U3**	**R1**	**R2**	**R3**
Text	Text	Text	in	in	in	Radians	Radians	Radians
44	Wind Case 1	LinStatic	0.21717	0	1.3E-05	0	0.001522	0
44	Wind Case 2	LinStatic	0.226626	0	1.4E-05	0	0.001587	0
44	Seismic Case	LinStatic	0.345223	0	4.4E-06	0	0.002482	0
72	Wind Case 1	LinStatic	0.50138	0	4.2E-05	0	0.002059	0
72	Wind Case 2	LinStatic	0.522697	0	4.5E-05	0	0.002144	0
72	Seismic Case	LinStatic	0.816601	0	0.00002	0	0.003475	0
100	Wind Case 1	LinStatic	0.847671	0	7.5E-05	0	0.002354	0
100	Wind Case 2	LinStatic	0.883227	0	0.00008	0	0.00245	0
100	Seismic Case	LinStatic	1.410644	0	0.00005	0	0.004092	0
128	Wind Case 1	LinStatic	1.224373	0	0.00011	0	0.002479	0
128	Wind Case 2	LinStatic	1.275335	0	0.00012	0	0.002581	0
128	Seismic Case	LinStatic	2.073831	0	9.4E-05	0	0.004399	0
156	Wind Case 1	LinStatic	1.610954	0	0.00015	0	0.00251	0
156	Wind Case 2	LinStatic	1.677702	0	0.00015	0	0.002613	0
156	Seismic Case	LinStatic	2.76426	0	0.00017	0	0.004489	0

TABLE: Joint Displacements B-SW6								
Joint	**OutputCase**	**CaseType**	**U1**	**U2**	**U3**	**R1**	**R2**	**R3**
Text	Text	Text	in	in	in	Radians	Radians	Radians
44	Wind Case 1	LinStatic	0.184858	0	1.9E-05	0	0.001282	0
44	Wind Case 2	LinStatic	0.213433	0	2.2E-05	0	0.001481	0
44	Seismic Case	LinStatic	0.297925	0	6.6E-06	0	0.00213	0
66	Wind Case 1	LinStatic	0.424174	0	5.6E-05	0	0.001727	0
66	Wind Case 2	LinStatic	0.489741	0	6.5E-05	0	0.001994	0
66	Seismic Case	LinStatic	0.703045	0	2.6E-05	0	0.002979	0
84	Wind Case 1	LinStatic	0.71487	0	9.5E-05	0	0.001971	0
84	Wind Case 2	LinStatic	0.825371	0	0.00011	0	0.002276	0
84	Seismic Case	LinStatic	1.213281	0	0.00006	0	0.003509	0
102	Wind Case 1	LinStatic	1.030654	0	0.00014	0	0.002075	0
102	Wind Case 2	LinStatic	1.189966	0	0.00016	0	0.002396	0
102	Seismic Case	LinStatic	1.782843	0	0.00011	0	0.003773	0
120	Wind Case 1	LinStatic	1.354473	0	0.00018	0	0.002101	0
120	Wind Case 2	LinStatic	1.56384	0	0.0002	0	0.002425	0
120	Seismic Case	LinStatic	2.375711	0	0.0002	0	0.00385	0

TABLE: Joint Displacements B-SW7								
Joint	**OutputCase**	**CaseType**	**U1**	**U2**	**U3**	**R1**	**R2**	**R3**
Text	Text	Text	in	in	in	Radians	Radians	Radians
58	Wind Case 1	LinStatic	0.014016	0	2.6E-06	0	0.000082	0
58	Wind Case 2	LinStatic	0.010651	0	2E-06	0	0.000062	0
58	Seismic Case	LinStatic	0.040084	0	-1.1E-05	0	0.000249	0
92	Wind Case 1	LinStatic	0.030306	0	5.4E-05	0	0.00011	0
92	Wind Case 2	LinStatic	0.023029	0	4.1E-05	0	0.000083	0
92	Seismic Case	LinStatic	0.090267	0	2.4E-05	0	0.000345	0
126	Wind Case 1	LinStatic	0.049446	0	9.4E-05	0	0.000125	0
126	Wind Case 2	LinStatic	0.037573	0	7.2E-05	0	0.000095	0
126	Seismic Case	LinStatic	0.151879	0	8.7E-05	0	0.000405	0
160	Wind Case 1	LinStatic	0.069798	0	0.00014	0	0.000132	0
160	Wind Case 2	LinStatic	0.053038	0	0.00011	0	0.0001	0
160	Seismic Case	LinStatic	0.21942	0	0.00016	0	0.000436	0
194	Wind Case 1	LinStatic	0.090337	0	0.00023	0	0.000137	0
194	Wind Case 2	LinStatic	0.068645	0	0.00018	0	0.000104	0
194	Seismic Case	LinStatic	0.288645	0	0.00058	0	0.000464	0

TABLE: Joint Displacements B-SW8								
Joint	**OutputCase**	**CaseType**	**U1**	**U2**	**U3**	**R1**	**R2**	**R3**
Text	Text	Text	in	in	in	Radians	Radians	Radians
280	Wind Case 1	LinStatic	0.017615	0	-7.4E-05	0	0.000029	0
280	Wind Case 2	LinStatic	0.013892	0	-5.8E-05	0	0.000023	0
280	Seismic Case	LinStatic	0.046433	0	-8.6E-05	0	0.000103	0
407	Wind Case 1	LinStatic	0.036521	0	-4.2E-05	0	0.000043	0
407	Wind Case 2	LinStatic	0.028802	0	-3.3E-05	0	0.000034	0
407	Seismic Case	LinStatic	0.101682	0	-0.0001	0	0.000138	0
534	Wind Case 1	LinStatic	0.057137	0	-4.9E-06	0	0.00007	0
534	Wind Case 2	LinStatic	0.045061	0	-3.9E-06	0	0.000055	0
534	Seismic Case	LinStatic	0.166412	0	-9.3E-05	0	0.000214	0
661	Wind Case 1	LinStatic	0.077417	0	5.3E-05	0	0.000092	0
661	Wind Case 2	LinStatic	0.061055	0	4.2E-05	0	0.000073	0
661	Seismic Case	LinStatic	0.233536	0	-3.9E-07	0	0.00028	0
757	Wind Case 1	LinStatic	0.096413	0	0.00017	0	0.000119	0
757	Wind Case 2	LinStatic	0.076036	0	0.00013	0	0.000093	0
757	Seismic Case	LinStatic	0.298504	0	0.00045	0	0.000401	0

Appendix J: Comparison of Deflections

B-SW1 Deflection Anaylsis

	Level Height (in.)	Story Height (in.)	Wind Case 1 Defl. (in.)		Wind Case 2 Defl. (in.)		Seismic Case Defl. (in.)			
			Total Drift	Story Drift	Total Drift	Story Drift	Total Drift	=4.5*δ/1	Story Drift	=4.5*δ/1
Roof	871.925	154.724	0.1026	0.0245	0.0876	0.0209	0.2979	1.3404	0.0739	0.3323
Level 5	717.201	154.724	0.0781	0.0239	0.0667	0.0204	0.2240	1.0081	0.0711	0.3202
Level 4	562.477	154.724	0.0543	0.0220	0.0463	0.0188	0.1529	0.6879	0.0640	0.2880
Level 3	407.753	154.724	0.0323	0.0181	0.0275	0.0155	0.0889	0.4000	0.0510	0.2296
Level 2	253.029	185.039	0.0141	0.0141	0.0120	0.0120	0.0378	0.1703	0.0378	0.1703

B-SW2 Deflection Anaylsis

	Story Height (in.)	Level Height (in.)	Wind Case 1 Defl. (in.)		Wind Case 2 Defl. (in.)		Seismic Case Defl. (in.)			
			Total Drift	Story Drift	Total Drift	Story Drift	Total Drift	=4.5*δ/1	Story Drift	=4.5*δ/1
Roof	154.724	871.925	0.7836	0.1838	0.7247	0.1699	1.2559	5.6517	0.3081	1.3866
Level 5	154.724	717.201	0.5998	0.1803	0.5547	0.1668	0.9478	4.2652	0.2981	1.3412
Level 4	154.724	562.477	0.4195	0.1674	0.3880	0.1548	0.6498	2.9239	0.2692	1.2115
Level 3	154.724	407.753	0.2522	0.1396	0.2332	0.1291	0.3805	1.7124	0.2161	0.9726
Level 2	185.039	253.029	0.1126	0.1126	0.1041	0.1041	0.1644	0.7398	0.1644	0.7398

B-SW3 Deflection Anaylsis

	Story Height (in.)	Level Height (in.)	Wind Case 1 Defl. (in.)		Wind Case 2 Defl. (in.)		Seismic Case Defl. (in.)			
			Total Drift	Story Drift	Total Drift	Story Drift	Total Drift	=4.5*δ/1	Story Drift	=4.5*δ/1
Roof	154.724	871.925	0.1114	0.0266	0.1012	0.0241	0.3178	1.4301	0.0789	0.3552
Level 5	154.724	717.201	0.0848	0.0259	0.0771	0.0235	0.2389	1.0749	0.0760	0.3419
Level 4	154.724	562.477	0.0589	0.0239	0.0535	0.0217	0.1629	0.7331	0.0683	0.3071
Level 3	154.724	407.753	0.0350	0.0197	0.0318	0.0179	0.0946	0.4259	0.0544	0.2447
Level 2	185.039	253.029	0.0153	0.0153	0.0139	0.0139	0.0403	0.1812	0.0403	0.1812

B-SW4 Deflection Anaylsis

	Story Height (in.)	Level Height (in.)	Wind Case 1 Defl. (in.)		Wind Case 2 Defl. (in.)		Seismic Case Defl. (in.)			
			Total Drift	Story Drift	Total Drift	Story Drift	Total Drift	=4.5*δ/1	Story Drift	=4.5*δ/1
Roof	154.724	871.925	0.5715	0.1253	0.5318	0.1174	0.9231	4.1540	0.2196	0.9884
Level 5	154.724	717.201	0.4462	0.1287	0.4144	0.1206	0.7035	3.1656	0.2200	0.9898
Level 4	154.724	562.477	0.3175	0.1241	0.2938	0.1162	0.4835	2.1758	0.2025	0.9112
Level 3	154.724	407.753	0.1934	0.1154	0.1776	0.0995	0.2810	1.2646	0.1622	0.7299
Level 2	185.039	253.029	0.0780	0.0780	0.0780	0.0780	0.1188	0.5347	0.1188	0.5347

B-SW5 Deflection Anaylsis										
	Story Height (in.)	Level Height (in.)	Wind Case 1 Defl. (in.)		Wind Case 2 Defl. (in.)		Seismic Case Defl. (in.)			
			Total Drift	Story Drift	Total Drift	Story Drift	Total Drift	=4.5*δ/1	Story Drift	=4.5*δ/1
Roof	154.724	871.925	1.6110	0.3866	1.6777	0.4024	2.7643	12.4392	0.6904	3.1069
Level 5	154.724	717.201	1.2244	0.3767	1.2753	0.3921	2.0738	9.3322	0.6632	2.9843
Level 4	154.724	562.477	0.8477	0.3463	0.8832	0.3605	1.4106	6.3479	0.5940	2.6732
Level 3	154.724	407.753	0.5014	0.2842	0.5227	0.2961	0.8166	3.6747	0.4714	2.1212
Level 2	185.039	253.029	0.2172	0.2172	0.2266	0.2266	0.3452	1.5535	0.3452	1.5535

B-SW6 Deflection Anaylsis										
	Story Height (in.)	Level Height (in.)	Wind Case 1 Defl. (in.)		Wind Case 2 Defl. (in.)		Seismic Case Defl. (in.)			
			Total Drift	Story Drift	Total Drift	Story Drift	Total Drift	=4.5*δ/1	Story Drift	=4.5*δ/1
Roof	154.724	871.925	1.3545	0.3238	1.5638	0.3739	2.3757	10.6907	0.5929	2.6679
Level 5	154.724	717.201	1.0307	0.3158	1.1900	0.3646	1.7828	8.0228	0.5696	2.5630
Level 4	154.724	562.477	0.7149	0.2907	0.8254	0.3356	1.2133	5.4598	0.5102	2.2961
Level 3	154.724	407.753	0.4242	0.2393	0.4897	0.2763	0.7030	3.1637	0.4051	1.8230
Level 2	185.039	253.029	0.1849	0.1849	0.2134	0.2134	0.2979	1.3407	0.2979	1.3407

B-SW7 Deflection Anaylsis										
	Story Height (in.)	Level Height (in.)	Wind Case 1 Defl. (in.)		Wind Case 2 Defl. (in.)		Seismic Case Defl. (in.)			
			Total Drift	Story Drift	Total Drift	Story Drift	Total Drift	=4.5*δ/1	Story Drift	=4.5*δ/1
Roof	154.724	871.925	0.0903	0.0205	0.0686	0.0156	0.2886	1.2989	0.0692	0.3115
Level 5	154.724	717.201	0.0698	0.0204	0.0530	0.0155	0.2194	0.9874	0.0675	0.3039
Level 4	154.724	562.477	0.0494	0.0191	0.0376	0.0145	0.1519	0.6835	0.0616	0.2773
Level 3	154.724	407.753	0.0303	0.0163	0.0230	0.0124	0.0903	0.4062	0.0502	0.2258
Level 2	185.039	253.029	0.0140	0.0140	0.0107	0.0107	0.0401	0.1804	0.0401	0.1804

B-SW8 Deflection Anaylsis										
	Story Height (in.)	Level Height (in.)	Wind Case 1 Defl. (in.)		Wind Case 2 Defl. (in.)		Seismic Case Defl. (in.)			
			Total Drift	Story Drift	Total Drift	Story Drift	Total Drift	=4.5*δ/1	Story Drift	=4.5*δ/1
Roof	154.724	871.925	0.0964	0.0190	0.0760	0.0150	0.2985	1.3433	0.0650	0.2924
Level 5	154.724	717.201	0.0774	0.0203	0.0611	0.0160	0.2335	1.0509	0.0671	0.3021
Level 4	154.724	562.477	0.0571	0.0206	0.0451	0.0163	0.1664	0.7489	0.0647	0.2913
Level 3	154.724	407.753	0.0365	0.0189	0.0288	0.0149	0.1017	0.4576	0.0552	0.2486
Level 2	185.039	253.029	0.0176	0.0176	0.0139	0.0139	0.0464	0.2089	0.0464	0.2089

Allowable Drift Analysis						
			Allowable Wind defl. (in)		Allowable Seismic defl. (in)	
Level	Level Height	Story Height (in.)	Total Drift	Story Drift	Total Drift	Story Drift
			H/400	H/400	$.02H_{sx}$	$.02H_{sx}$
Roof	871.925	154.724	2.180	0.387	17.4385	3.09448
Level 5	717.201	154.724	1.793	0.387	14.34402	3.09448
Level 4	562.477	154.724	1.406	0.387	11.24954	3.09448
Level 3	407.753	154.724	1.019	0.387	8.15506	3.09448
Level 2	253.029	185.039	0.633	0.463	5.06058	3.70078