November 20, 2013

Heather Sustersic
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Dear Professor Sustersic,

The following technical report was written to fulfill the requirements specified in the Structural Technical Report 4 assignment that was handed out on October 23, 2013.

Technical report 4 includes a complete lateral analysis of the New Library at the University of Virginia's College at Wise, located in Wise, Virginia. This analysis includes information gathered using 3D modeling software, critical member spot checks for strength, maximum drift and story drift checks under wind and seismic loading, and overturning moment/foundation impact.

Thank you for reviewing this report. I look forward to discussing it with you in the future.

Sincerely,

Macenzie Ceglar

Enclosed: Technical Report 4

Technical Report 4

University of Virginia's College at Wise New Library

Macenzie Ceglar
Structural Option
Advisor: Heather Sustersic
20 November 2013

Executive Summary

The New Library at the University of Virginia's College at Wise will serve as a main link between the upper and lower campus areas, which are currently divided by a steep 60 foot hill. The new 6 story, 68,000 ft^2, library will be integrated into the hillside, and will provide students with an easier and safer path across campus. The architectural design of the façade incorporates traditional materials found on campus, such as brick and stone. Construction on the New Library began in August 2012 and will be completed in August 2015.

Soil loads caused the foundation system for the New Library to be unique in its design. The foundation system utilizes a temporary leave-in-place soil retention system and foundation walls which are designed to resist future lateral soil loads. Other parts of the foundation system include piers, footings, and slabs-on-grade.

All six stories of the building have composite floor framing involving both composite steel wide flange members and composite decking. Framing layout in the building is fairly typical with bay sizes ranging between 25'-4" x 25'4" and 31'-0" x 25'-4". Steel wide flange columns are used as the vertical framing system and shear walls make up the building's lateral system.

Loading conditions considered in the building's design include live loads, gravity loads, snow loads, wind loads, seismic loads, and lateral soil loads.

The Virginia Uniform Statewide Building Code (USBC); along with "Facility Design Guidelines", governs the design of all buildings on the campus. The USBC adopts chapters 2-35 of International Building Code (IBC) 2009, which references codes and standards which include American Society of Civil Engineers (ASCE) 7-05, American Concrete Institute (ACI) 318-08, and the 13th edition of the Steel Construction Manual.

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University of Virginia's College at Wise - New Library

Wise, VA

General Information

Full Height: 119'
Number of Stories: 6
Size: 68,000 GSF
Cost: $43 Million
Date of Construction: Aug 2012 – Aug 2015
Project Delivery Method: Design-Bid-Build

Project Team

Owner:	UVA at Wise
Architect:	Cannon Design
Structural:	Cannon Design
MEP:	Thompson and Litton
Lighting:	Lafleur Associates
Construction:	Quesenberrys, Inc.
Civil:	Thompson and Litton
Landscape:	Hill Studio
AV/Acoustics:	Shen Milsom Wilke
Foodservice:	Culinary Advisors

Project Sponsor: CANNONDESIGN

Architecture

The goal of the façade design was to give the impression that the older existing buildings' architecture was based on the New Library's. This was achieved through use of materials such as brick and stone commonly found on the surrounding buildings.

Construction

Limited site area due to existing campus buildings impacted the construction by requiring offset staging and storage areas, along with the construction of a 500 foot service road.

Structural Systems

Foundation:	Slab on grade with column piers, footings and foundation walls
Framing:	Steel frame, composite wide flange steel members, and normal weight composite deck flooring
Lateral:	9 Reinforced concrete shear walls
Soil Retention:	Temporary Leave-In-Place Soil Retention System, which includes the use of soil nails and shotcrete covering.

Mechanical

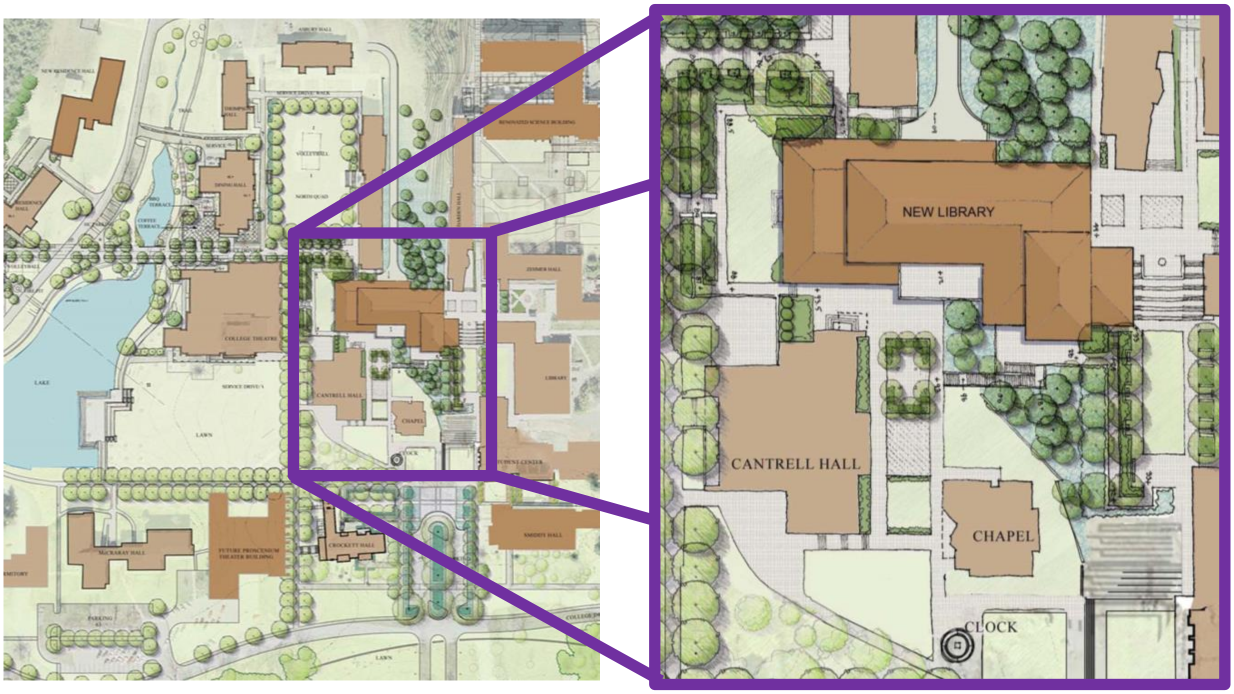
VAV system with a roof mounted chilled-water AHU and 145.9 ton chiller providing 41,300 CFM, and an economizer and an a heat recovery unit

Electrical/Lighting

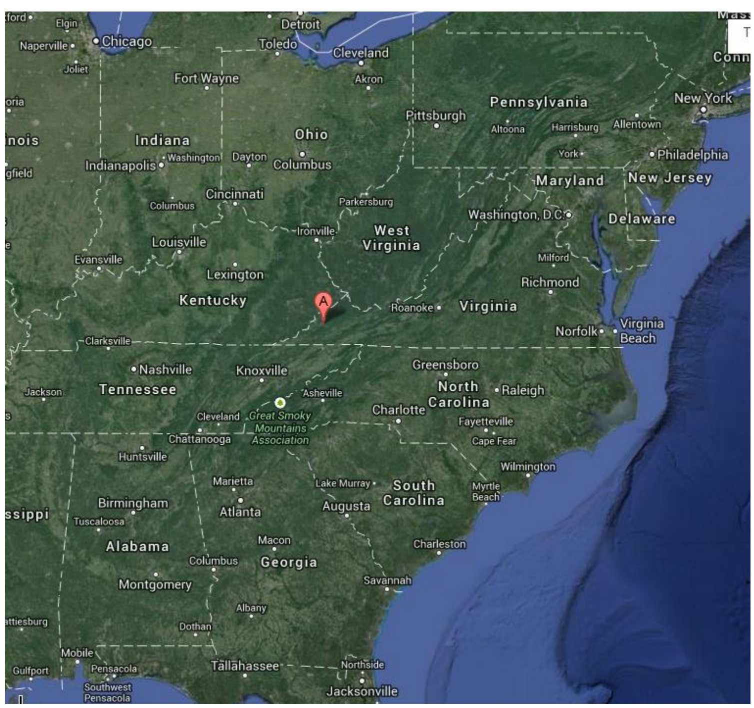
Five 480/277 3-phase panel boards
Nine 280/120 3-phase panel boards

Wall switch and low voltage occupancy sensors used for lighting control

Site Plan



Location Plan



Documents Used in Preparation of Report

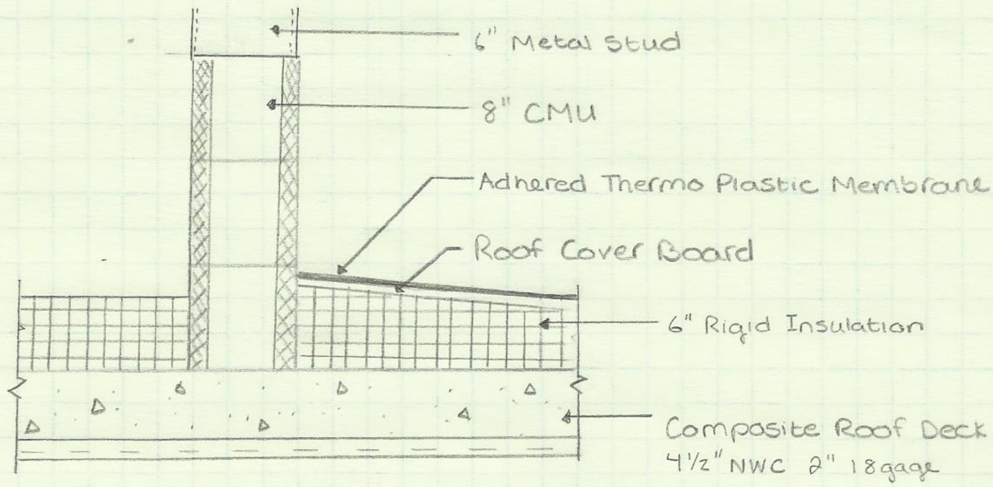
Below is a list of the design codes and standards used in the structural analysis of the New Library at the University of Virginia's College at Wise.

- **International Code Council**
  - International Building Code 2009 (Chapters 2-35 Adopted by Virginia Uniform Statewide Building Code)
- **American Society of Civil Engineers**
  - ASCE 7-05: Minimum Design Loads for Buildings and Other Structures
- **American Concrete Institute**
  - ACI 318-11: Building Code Requirements for Structural Concrete
- **American Institute of Steel Construction**
  - Steel Construction Manual 13th Edition – LRFD
- **Concrete Reinforcing Steel Institute**
  - CRSI Handbook 2008
- **Reinforced Concrete Mechanics and Design 6th Edition**
  - By: James K. Wight, James G. MacGregor
- **Vulcraft Deck Catalog**
- **University of Virginia Facilities Management and University Building Official**
  - Facility Design Guidelines
- **University of Virginia's College at Wise – New Library**
  - Construction Documents
  - Specifications

Gravity Loads from Technical Report 2

Typical Roof Bay Dead Loading

Cross section of lower roof construction



Uniformly Distributed Dead Loads

Composite roof deck = 69 psf

6" Rigid Insulation = 9 psf

Roof cover board = 2 psf

Adheared Membrane = 2 psf

Superimposed misc:

ceiling = 5 psf

Mechanical = 10 psf

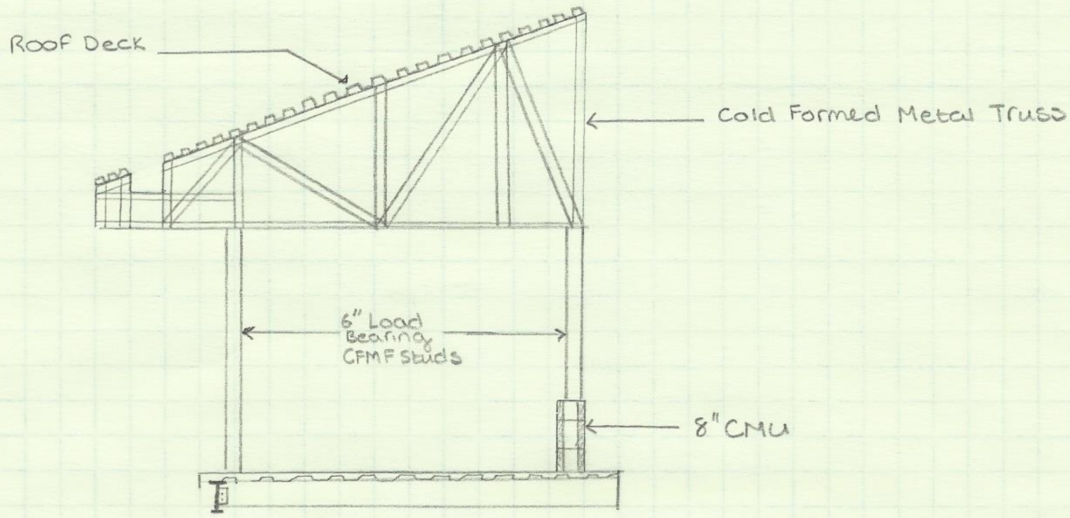
Sprinklers = 10 psf

Framing Alowance = 10 psf

Total = 117 psf

Distributed Line Loads on Roof

Cross section of upper roof construction



Distributed line load from CMU wall bearing trusses

Cold Formed Metal Trusses = 2psf

Spacing = 12" o.c.

Truss Length = 23.1'

2psf x 23.1 = 46.2 plf

Load on CMU wall = $\frac{46.2}{2}$ = 23.1 plf

8" CMU = 55psf

wall height = 2ft

Load from CMU wall = 55 x 2 = 110plf

Total = 134 plf

Typical Roof Bay Live Loading

LOADS	Design Value	Code Minimum
Minimum Roof Live Load	30 psf	20 psf
Roof Area Below Sloped Roof	30 psf	-
Roof Mechanical Area	150 psf	-

Reason for Differences

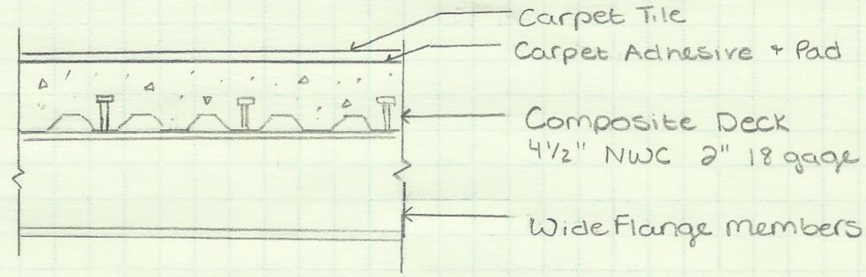
Minimum Roof Live Load: UVA Facility Guidelines specifies a minimum roof live load which overrules ASCE7-05

Roof Area Below Sloped Roof: unlikely that this area will see a live load so a minimum was used

Roof Mechanical Area: Final mechanical system was unknown so design team provided a large enough allowance

Typical Floor Bay Dead Loading

Cross Section of Floor Calculation



Uniformly Distributed Dead Loads

Composite Deck = 69 psf

Carpet Tile = 1 psf

Pad + Adhesive = 0.5 psf

Super imposed misc:

Ceiling = 5 psf

Mechanical = 10 psf

Sprinklers = 10 psf

Framing Allowance = 10 psf

Total = 105.5 psf ⇒ 106 psf

Non-Typical Dead Loads

Loads	Location	Value	Justification
Roof Deck 1½" 20gage	upper roof	2.16 psf	Vulcraft Catalog Pg 9 (1.5A Roof Deck)
Composite Deck 8½" NWC 2" 18g	Level 4 supporting vestible area	105 psf	Vulcraft Catalog Pg 52 (6psf / 0.5" of topping)
3/16" Terrazzo Tile 24"x24"	Level 4 vestible and in stair wells	2 psf	ASCE 7-10 Pg 402

AMPAD

Typical Floor Bay Live Loading

Loads	Design Value	Code Minimum	Justification
Offices	50	50	ASCE7-05
Corridor (Not First Floor)	80	Same as area served	Office + Partitions ≃ 80
Partitions	27	–	Cannon Design Standard

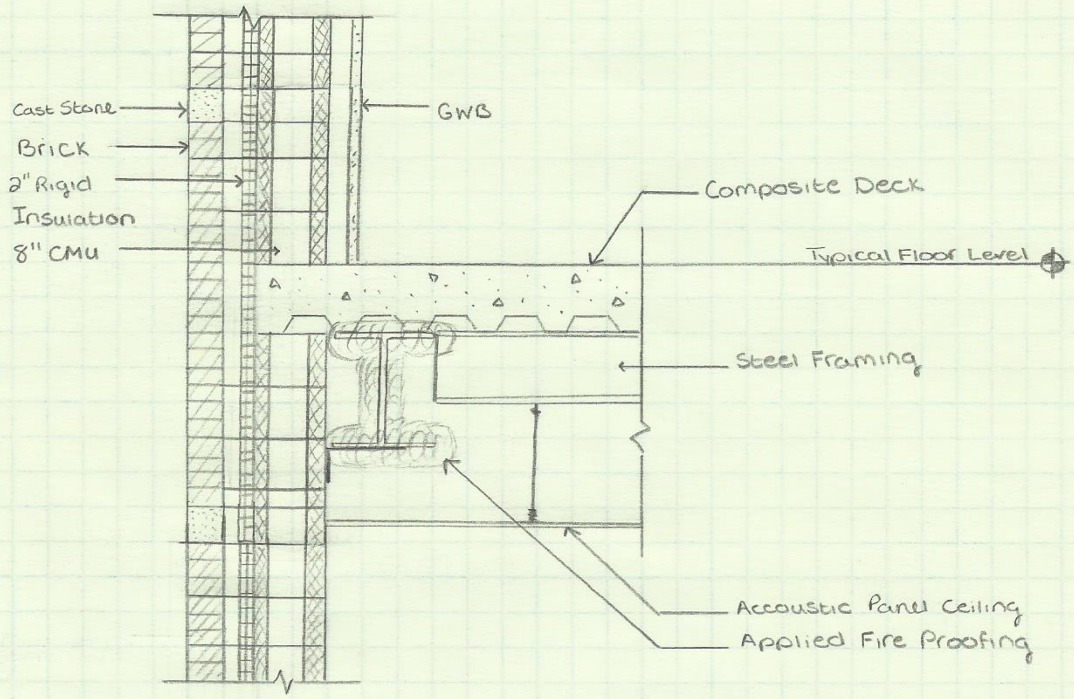
⇒ These loads pertain to the typical bay specified in Technically Report 1. They are found in a large majority of the building. Library Stacks make up a large part of the live loading, but are not located in the specified bay.

Non-Typical Live Loads

Loads	Location	Design Value	Code Min.	Justification
Library Stack Rooms	Level 2,3,4,5,6 in various locations	150psf	150psf	ASCE 7-05
Mechanical Rooms	Level 2, lower roof	250psf	—	Design load based on equipment weight
High Density Storage	Level 1	250psf	250 psf	ASCE 7-05
Stairs	center, east corner, and south corner of building	100psf	100psf	ASCE 7-05

Typical Exterior Wall Loading

Cross Section of Typical Exterior Wall



Wall Loads (loads provided by cannon design)

Brick + 8" CMU = 95psf x 16' (typical floor-to-floor height) = 1520 plf

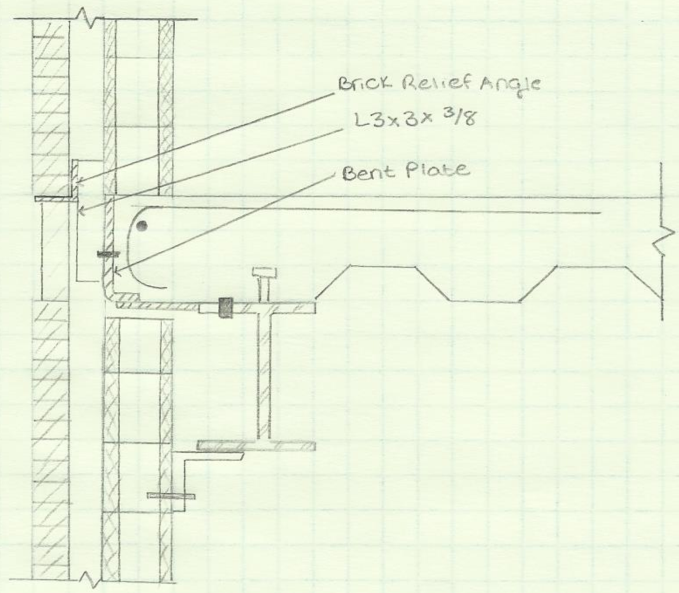
2" rigid insulation = 3 psf x 16' = 48 plf

Water proofing Allowance = 1 psf x 16' = 16 psf

Total = 1584 plf

Load Path

Exterior Wall Detail



The exterior brick load is taken by the relief angle and transferred into the L3x3x 3/8. From there the load goes into the bent plate at the slab edge and into wide flange beam. The CMU load is also transferred into the beam through the bent plate. From there the load is transferred into columns and down into the foundation.

Other notes are that the angle under the beam is a lateral stability clip and the hooked rebar keeps the small slab cantilever from cracking.

Snow Loads

Lower Roof – Flat

$P_f = 0.7\, C_e C_t I p_g$

$C_e = 1.0$ (Partially Exposed Roof, Exposure B)

$C_t = 1.0$

$I = 1.1$ (Occupancy Catagory 3)

$P_g = 30$ psf

$P_f = 0.7(1.0)(1.0)(1.1)(30) = 23.1$ psf

Upper Roof – Sloped

$P_s = C_s p_f$

$C_e = 1.0$ (contains large mechanical equipment)

$C_t = 1.1$

$I = 1.1$

$P_g = 30$

$p_f = 0.7(1.0)(1.1)(1.1)(30) = 25.4$ psf

$C_s = 1.0$ (cold roof, roof surface obstructed)

$P_s = 1.0(25.4) = 25.4$ psf

⇒ Design was conservative and used a design snow load of 26 psf for both the lower flat roof and upper sloped roof.

Snow drifts are calculated for the smaller roof section on the west (true North-west) end of the building and for drifts that may occur on the interior of the upper roof.

Lower Roof

Determine if snow drift calculation is required

If $h_c/h_b < 0.2$ drift loads not applicable

$h_c = 51.9'$ (measured from balanced snow load to top of exterior wall along Column Line 3)

$h_b = p_s/\gamma$

$p_s = 26$ psf (see snow load calc)

$\gamma = 0.13 p_g + 14 < 30$ pcf

$= 0.13(30) + 14$

$= 17.9$ pcf

$= 26/17.9 = 1.45$ ft

$h_c/h_b = 51.9/1.45 = 35.79 > 0.2$

⇒ Snow drifts must be considered

Leeward

h_d:

$p_g = 30$

$l_u \Rightarrow 147$

$h_d = 4$

Windward

h_d:

$p_g = 30$

$l_u = 25'4''$

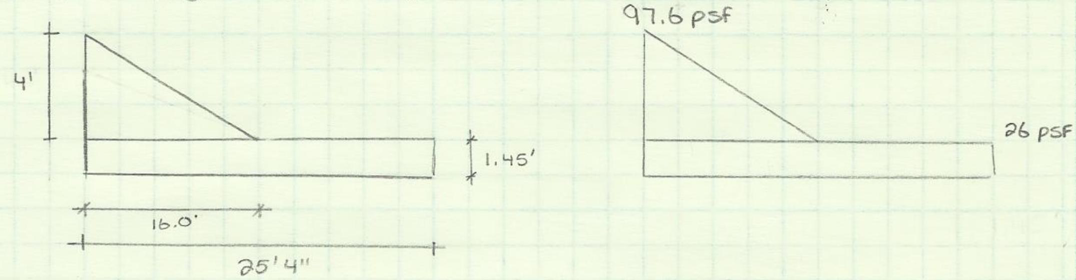
$h_d = 3/4(1.5) = 1.125$ ft

⇒ The larger h_d shall be used in design ⇒ 4 ft

Lower Roof Cont

$h_d = 4$ ft $< h_c = 53'4''$

$w = 4h_d = 4(4) = 16$



Snow drift on interior walls of fake Mansard Roof

$h_c = 16'11''$
$h_b = 1.45$

$h_c/h_b = 16'11''/1.45 = 11.67 > 0.2$ ⇒ Snow drift must be considered.

leeward

h_d:

$p_g = 30$
$l_u = 25$ ⇒ no roof upwind of drift so $l_u = 25$ft used per Figure 7-9.

$h_d = 1.5$ ft

windward (worst case ⇒ largest l_u)

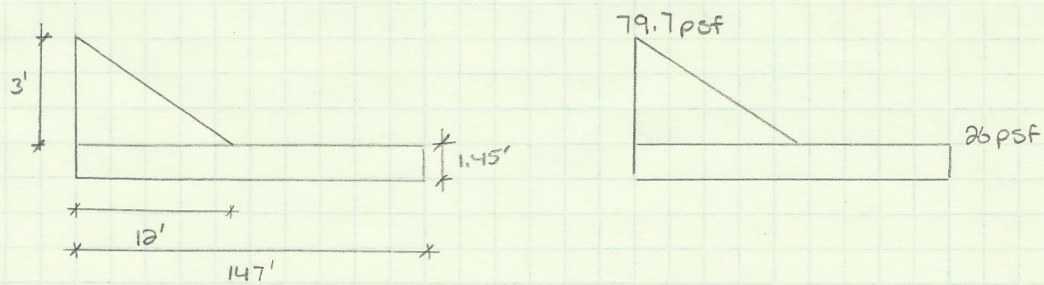
h_d:

$p_g = 30$
$l_u = 147$

$h_d = 3/4(4) = 3$

$h_d = 3$ ft $< 16'11''$

$w = 4(3) = 12'$



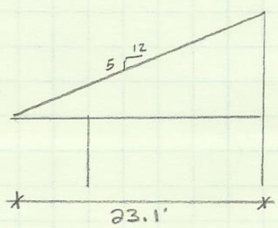
Sliding snow is calculated for the smaller roof section on the west (true North-West) end of building.

- non-slippery (snow rails)
- sliding snow is calculated when slope > 2/12

Actual Slope = 5/12 ⇒ Sliding snow must be calculated

Total Sliding Snow per Unit Length

$= 0.4\, p_f W$



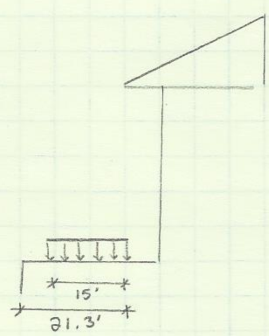
$p_f = 25.4\text{ psf}$

$w = 23.1\text{ ft}$

$= 0.4\,(25.4)(23.1)$

$= 234.7\text{ plf}$

⇒ Load per unit length is to be distributed over a distance of 15 ft from the upper roof eave



⇒ $S_s = 234.7\text{ plf} / 15' = 15.6\text{ psf}$

Wind Loads from Technical Report 2

Shear wall 1 (At CL 6.8) - NS

$A_B \cong (173' \times 51') + (42' \times 72') = 11{,}847\ ft^2$

$H = 102'$

$h_i = 102'$

$A_i = \frac{12''}{12} \times 14' = 14\ ft^2$

$D_i = 14'$

$$\left(\frac{102}{102}\right)^2 \frac{14}{\left[1 + 0.83\left(\frac{102}{14}\right)^2\right]} = 0.311$$

Shear Wall 2 (At CL B.2) - EW

$H = 102'$

$h_i = 102'$

$A_i = \frac{12''}{12} \times 21' = 21\ ft^2$

$D_i = 21'$

$$\left(\frac{102}{102}\right)^2 \frac{21}{\left[1 + 0.83\left(\frac{102}{14}\right)^2\right]} = 0.466$$

Shear Wall 3 (At west stair wall) - NS

$H = 102'$

$h_i = 68$

$A_i = \frac{12''}{12} \times 8.6' = 8.6\ ft^2$

$D_i = 8.6'$

$$\left(\frac{102}{68}\right)^2 \frac{8.6}{\left[1 + 0.83\left(\frac{68}{8.6'}\right)^2\right]} = 0.366$$

Shear Wall 4 (At South Stair wall) - EW

$H = 102'$

$h_i = 102'$

$A_i = \frac{12''}{12} \times 20.33' = 20.33\ ft^2$

$D_i = 20.33'$

$$\left(\frac{102}{102}\right)^2 \frac{20.33}{\left[1 + 0.83\left(\frac{102}{20.33}\right)^2\right]} = 0.929$$

Wind Load Calculation

⇒ ASCE 7-05 Chapter 6.5 Method 2 - Analytical Method

1. Occupancy Category (Table 1-1)

⇒ III [Buildings and other structures with a capacity greater than 500 for colleges or adult educational facilities]

2. Determine the wind load importance factor (Table 6-1)

⇒ $I = 1.15$ [Occupancy Catagory III, non-hurricane prone]

3. Determine Basic Wind Speed (Fig 6-1)

⇒ $V = 90$ MPH

4. Determine Wind Load Parameters

a. Wind Directionality Factor K_d (Table 6-4)

⇒ $K_d = 0.85$

b. Exposure Catagory (6.5.6.3)

⇒ B

c. Topographic Factor, K_{zt} (Fig 6-4)

⇒ 1.0

D. Gust Effect Factor G (6.5.8)

i) Determine natural frequency, n_a (C6.5.8)

- Building meets requirements
  1. Building height < 300ft
  2. Building height < $4L_{eff}$

$$n_a = 385 (C_w)^{0.5} / H$$

$$C_w = \frac{100}{A_B} \sum_{i=1}^{n} \left(\frac{H}{h_i}\right)^2 \frac{A_i}{\left[1 + 0.83\left(\frac{h_i}{D_i}\right)^2\right]}$$

Shear Wall 5 (At CL5) - NS

$H = 102'$
$h_i = 102'$
$A_i = \frac{12''}{12} \times 12' = 12ft^2$
$D_i = 12'$

$$\left(\frac{102}{102}\right)^2 \frac{12}{\left[1+0.83\left(\frac{102}{12}\right)^2\right]} = 0.197$$

Shear Wall 6 (At CL D) - EW

$H = 102'$
$h_i = 102'$
$A_i = \frac{12''}{12} \times 25.2 = 25.2ft^2$
$D_i = 25.2'$

$$\left(\frac{102}{102}\right)^2 \frac{25.2}{\left[1+0.83\left(\frac{102}{25.2}\right)^2\right]} = 1.726$$

Shear Wall 7 (At CL 4) - NS

$H = 102'$
$h_i = 102'$
$A_i = \frac{12''}{12} \times 20' = 20ft^2$
$D_i = 20'$

$$\left(\frac{102}{102}\right) \frac{20}{\left[1+0.83\left(\frac{102}{20}\right)^2\right]} = 0.885$$

Shear Wall 8 (At East Stair Wall) - NS

$H = 102'$
$h_i = 34'$
$A_i = \frac{12''}{12} \times 10' = 10ft^2$
$D_i = 10'$

$$\left(\frac{102}{34'}\right)^2 \frac{10}{\left[1+0.83\left(\frac{34}{10}\right)^2\right]} = 8.495$$

Shear Wall 9 (At CL E) - EW

$H = 102'$
$h_i = 34'$
$A_i = \frac{12''}{12} \times 23.3' = 23.3 ft^2$
$D_i = 23.3'$

$$\left(\frac{102}{34}\right)^2 \frac{23.3}{\left[1 + 0.83\left(\frac{34}{23.3}\right)^2\right]} = 75.776$$

North - South

$$\sum (H/h_i)^2 \frac{A_i}{\left[1+0.83\left(\frac{h_i}{D_i}\right)^2\right]} = 0.311 + 0.366 + 0.197 + 0.885 + 8.495$$
$$= 10.254$$

$$C_{w,NS} = \frac{100}{11,847}(10.254) = 0.0866$$

$$n_{a,NS} = 385(0.0866)^{0.5}/102 = \underline{\underline{1.11\ Hz}}$$

East - West

$$\sum (H/h_i)^2 \frac{A_i}{\left[1+0.83\left(h_i/D_i\right)^2\right]} = 0.466 + 0.929 + 1.726 + 75.776$$
$$= 78.897$$

$$C_{w,EW} = \frac{100}{11,847}(78.897) = 0.6660$$

$$n_{a,EW} = 385(0.6660)^{0.5}/102 = \underline{\underline{3.08\ Hz}}$$

⇒ $n_a > 1.0$ Hz in both directions ⇒ Rigid Structure

Wind in E-W Direction (windward)

$h/L = 110.5/147 = 0.75 \Rightarrow 0.5 < 0.75 < 1.0$

interpolate ⇒

	25	26.1	30
0.5	-0.3	-0.278	-0.2
0.75		-0.367	
1.0	-0.5	-0.456	-0.3

	25	26.1	30
0.5	0.2	0.2	0.2
0.75		0.122	
1.0	0	0.044	0.2

$C_{p,w} = -0.367, 0.122$

Wind in E-W Direction (leeward)

$\theta = 26.1 > 20$

$C_{p,l} = -0.6$

Summary of Cp values

		Walls	Roof
NS Direction	windward	0.8	-0.456, 0.044
	leeward	-0.5	-0.6
EW Direction	windward	0.8	-0.367, 0.122
	leeward	-0.388	-0.6

iv) Rigid Buildings (6.5.8.1)

$$G = 0.925\left(\frac{(1+1.7g_Q I_{\bar{z}} Q)}{1+1.7g_v I_{\bar{z}}}\right)$$

$g_Q = 3.4$
$g_v = 3.4$

$$I_{\bar{z}} = c\left(\frac{33}{\bar{z}}\right)^{1/6} = 0.30\left(\frac{33}{0.6(102)}\right)^{1/6} = 0.271$$ * $\bar{z} > z_{min} = 30'$

N-S Direction ⇒ $$Q = \sqrt{\frac{1}{1+0.63\left(\frac{B+h}{L_{\bar{z}}}\right)^{0.63}}}$$

$B = 147'$
$h = 83.33'$

$$L_{\bar{z}} = \ell\left(\frac{\bar{z}}{33}\right)^{\bar{\epsilon}} = 320\left(\frac{0.6(102)}{33}\right)^{1/3} = 393.15$$

$$Q = \sqrt{\frac{1}{1+0.63\left(\frac{147+102}{393.15}\right)^{0.63}}} = \underline{\underline{0.824}} \text{ (N-S)}$$

E-W Direction ⇒ $B = 94.33'$
$h = 102$
$L_{\bar{z}} = 393.15$

$$Q = \sqrt{\frac{1}{1+0.63\left(\frac{94.33+102}{393.15}\right)^{0.63}}} = \underline{\underline{0.843}} \text{ (E-W)}$$

N-S Direction ⇒ $$G = 0.925\left(\frac{(1+1.7(3.4)(0.280)(0.824))}{1+1.7(3.4)(0.280)}\right) = \underline{0.824} \text{ (N-S)}$$

E-W Direction ⇒ $$G = 0.925\left(\frac{(1+1.7(3.4)(0.280)(0.843))}{1+1.7(3.4)(0.280)}\right) = \underline{0.835} \text{ (E-W)}$$

E. Enclosure Classification (6.5.9)

⇒ Enclosed (6.2)

F. Internal Pressure Coefficients (Fig 6-5)

⇒ $GC_{pi} = \pm 0.18$

5 Determine velocity Pressure exposure coefficient K_z or K_h (Table 6-3)

$Z_g = 1200 \quad \alpha = 7.0$

$K_z(18') = 2.01\,(18/1200)^{2/7} = 0.61$

$K_z(36') = 2.01\,(36/1200)^{2/7} = 0.74$

$K_z(52') = 2.01\,(52/1200)^{2/7} = 0.82$

$K_z(68') = 2.01\,(68/1200)^{2/7} = 0.89$

$K_z(84') = 2.01\,(84/1200)^{2/7} = 0.94$

$K_z(102') = 2.01\,(102/1200)^{2/7} = 0.99$

6 Determine Velocity Pressure (6.5.10)

$q_z = 0.00256\, K_z K_{zt} K_d V^2 I$

$K_{zt} = 1.0$
$K_d = 0.85$
$V^2 = 8100$
$I = 1.15$

$q_z = 0.00256\, K_z (0.85)(8100)(1.15) = 20.27\, K_z$

$q_z(18) = 12.36$
$q_z(36) = 15.00$
$q_z(52) = 16.62$
$q_z(68) = 18.04$
$q_z(84) = 19.05$
$q_z(102) = 20.07$

7 Determine External Pressure Coefficient, C_p (Fig 6-6 to 6-8)

$C_{p,w} = 0.8$

Wind in N-S Direction

$\frac{L}{B} = \frac{94.67'}{147'} = 0.64$

$C_{p,\ell} = -0.5$

Wind in E-W Direction

$\frac{L}{B} = \frac{147}{94.67} = 1.56$

$C_{p,\ell} \Rightarrow \frac{2-1}{-0.3+0.5} = \frac{2-1.56}{-0.3-x} \Rightarrow x = -0.388$

Roof Pressure Coefficients

$\theta = \tan^{-1}(5/12) = 26.1° > 10°$

Wind in N-S Direction (windward)

$h/L = 110.5/94.67' = 1.17 \geq 1.0$

interpolate ⇒

25	26.1	30
-0.5	x	-0.3
0	y	0.2

x = -0.456
y = 0.044

$C_{p,w} = -0.456, 0.044$

Wind in N-S Direction (Leeward)

$\theta = 26.1 > 20°$

$C_{p,\ell} = -0.6$

* For mansard roofs, the top horizontal surface and leeward inclined surface shall be treated as leeward surfaces from table (Table 6-6 Note 8)

8. Calculate wind Pressure P on each surface

wind Pressure for walls

⇒ See excel sheet for pressures.

Wind Pressure for Roof

$p = q_h G C_p$

$q_h = q_z(110.5) = 0.00256\left[2.01\left(\frac{110.5}{1200}\right)^{2/7}\right](0.85)(8100)(1.15)$

$= 20.6$

N-S Direction - windward

$p = (20.6)(0.824)(-0.456) = -7.74$ psf

$p = (20.6)(0.824)(0.044) = 0.75$ psf

N-S Direction - leeward

$p = (20.6)(0.824)(-0.6) = -10.18$ psf

E-W Direction - windward

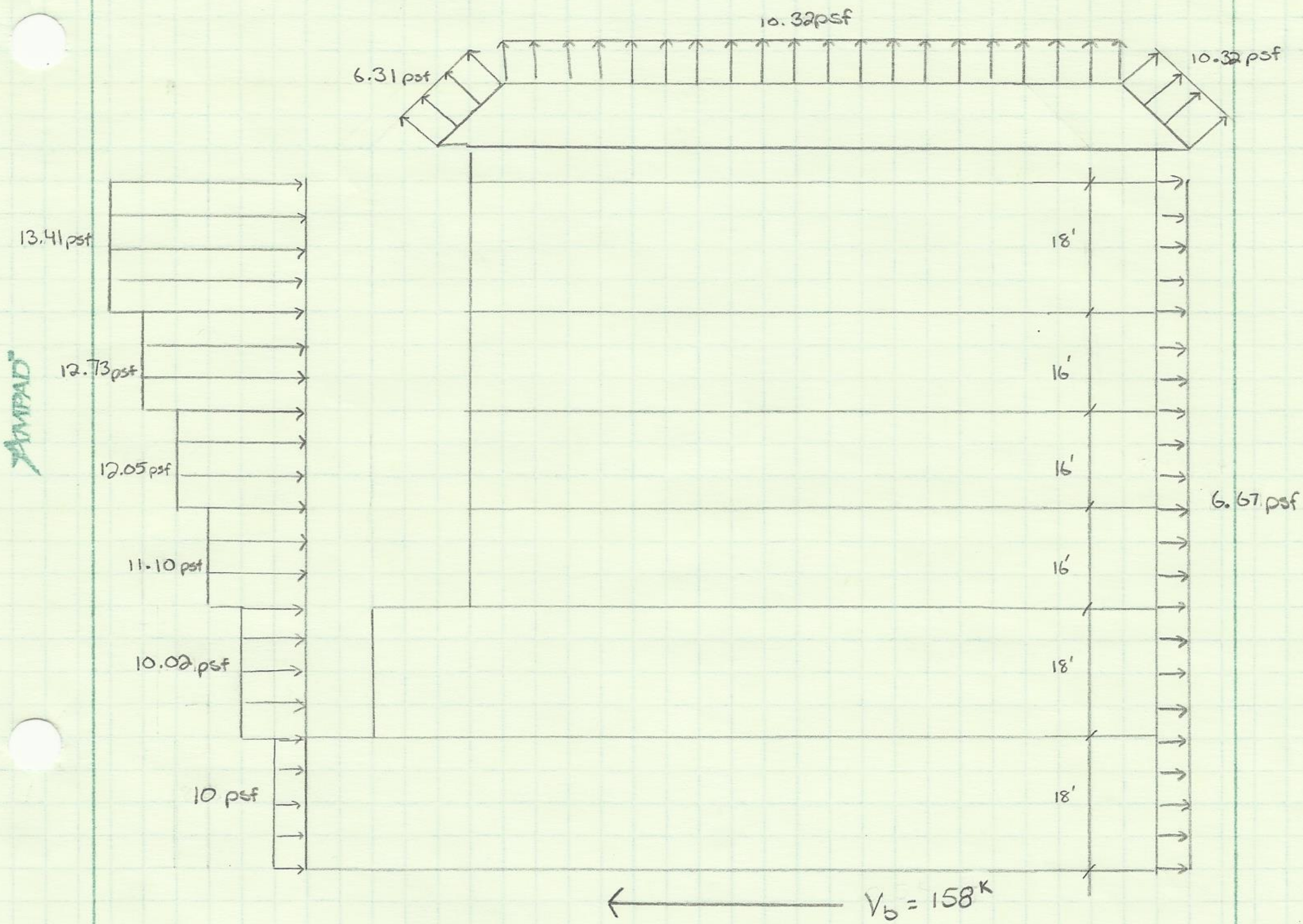
$p = (20.6)(0.835)(-0.367) = -6.31$ psf

$p = (20.6)(0.835)(0.122) = 2.10$ psf

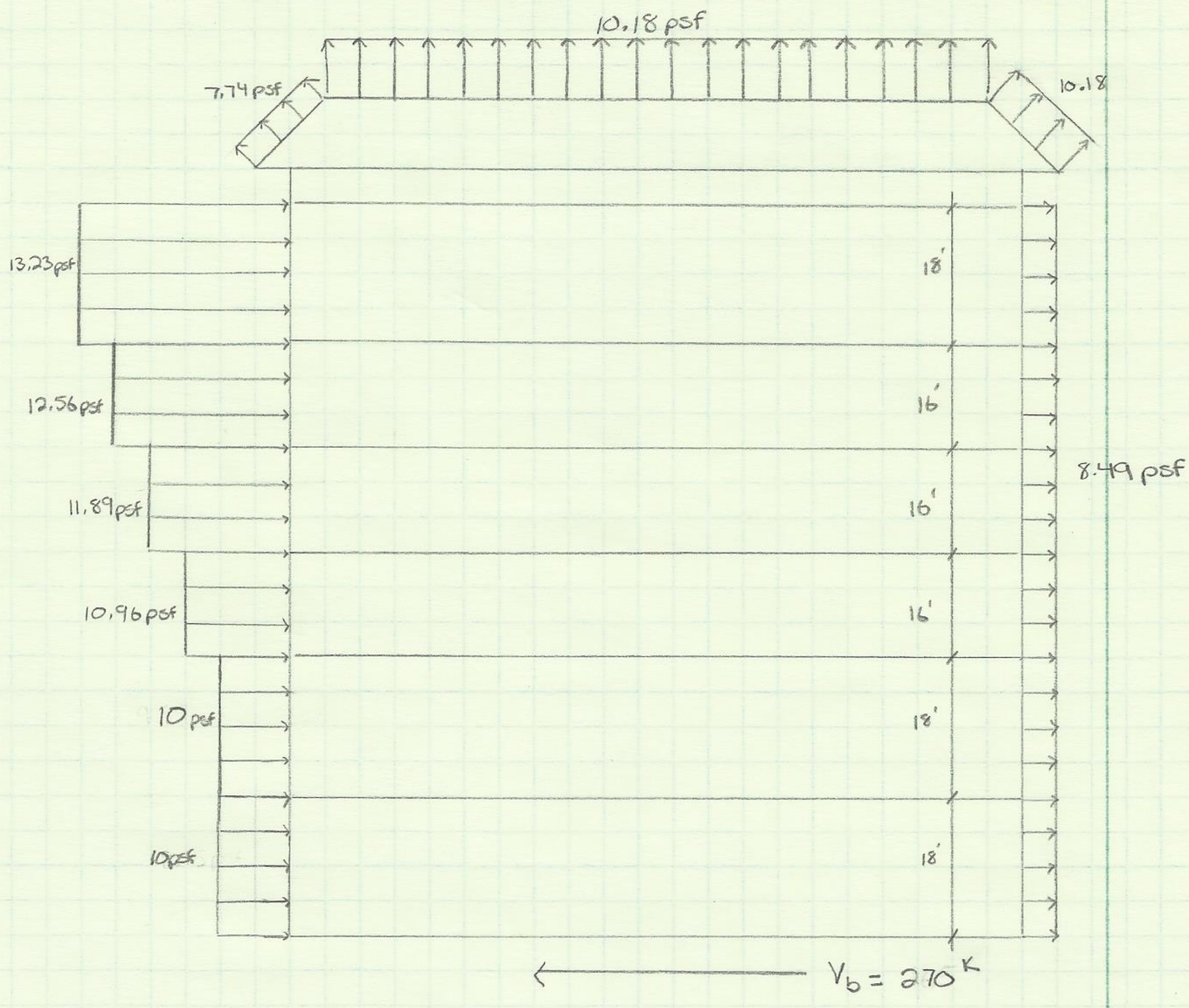
E-W Direction - leeward

$p = (20.6)(0.835)(-0.6) = -10.32$ psf

Wind Pressure Diagram - EW Direction



Wind Pressure - NS Direction



Seismic Loads from Technical Report 2

Seismic Load Calculation

1.) Exemptions (11.1.2)

⇒ Building is not exempt

2.) Design Spectral Responce Acceleration (11.4)

A. Site Class (11.4.2)

⇒ B

B. Acceleration Parameters (11.4.3 + Chp 22)

$S_S = 0.332g$
$S_1 = 0.094g$

C. Check to see if adjust for site class (11.4.2 + 11.4.3)

$S_S > 0.15$ + $S_1 > 0.04$ ⇒ Adjust for site class

$S_{MS} = F_a S_S = (1.0)(0.332g) = 0.332g$
$S_{M1} = F_v S_1 = (1.0)(0.094g) = 0.094g$

D. Determine Spectral Acceleration Parameters (11.4.4)

$S_{DS} = 2/3\, S_{MS} = 2/3(0.332g) = 0.221g$
$S_{D1} = 2/3\, S_{M1} = 2/3(0.094g) = 0.063g$

* cant use simplified b/c building doesnt meet requirements (12.14)

3) Seismic Design Catagory (11.6)

Occupancy Catagory III
$0.167 < S_{DS} < 0.33$ ⇒ B

4) Analysis Procedure Selection (Table 12.6-1)

⇒ Equivalent Lateral Force Analysis

5) Determine R (Table 12.2-1)

⇒ ordinary reinforced concrete shear walls ⇒ R = 4

6) Importance Factor (Table 11.5-1)

⇒ Occupancy Catagory III ⇒ I = 1.25

7) Find Period T (12.8.2.1)

$T_a = C_t h_n^x$

$h_n = 119$ ft
$C_t = 0.02$
$x = 0.75$

$T_a = (0.02)(119)^{0.75} = 0.721$

8) Determine TL (Fig 22-12 to 22-16)

$T_L = 12$ sec

9) Determine Seismic Responce Coefficient Cs (12.8.1.1)

$C_s = \frac{S_{DS}}{(R/I)} = \frac{0.221}{(4/1.25)} = 0.0691$

Check: $T_a = 0.721 < T_L = 6$

$C_s = \frac{S_{D1}}{T(R/I)} = \frac{0.063}{(.721)(4/1.25)} = 0.0273$

$C_s = \min \begin{cases} 0.0691 \\ 0.0273 \end{cases} \Rightarrow 0.0273 > 0.01$ ✓

$C_s = 0.0273$

10) Calculate Seismic Weight W

Roof

Typical Roof Bay Dead Load = 117 psf × 9905 sf × 1/1000
= 1158.9^k

Distributed Line Load = 133.1 plf × 357 ft × 1/1000
= 47.5^k

Mechanical Equipment: 15^k (chiller) + 50^k (AHU)
= 65^k

Total Load = 1271.4^k

Floor

Typical Floor Dead Loads = 105.5 psf
Partitions = 27 psf

Total Floor Dead Loads:

Level 2 = 132.5 × 12,859 / 1000 = 1703.8^k
Level 3 = 132.5 × 12,513 / 1000 = 1658.0^k
Level 4 = 132.5 × 11,115 / 1000 = 1472.7^k
Level 5 = 132.5 × 10,379 / 1000 = 1375.2^k
Level 6 = 132.5 × 10,258 / 1000 = 1359.2^k

11) Calculate Base Shear V (12.8.1)

$V = C_s W$

$= (0.0273)(19019)$ * See excel table on next page for weight calculations *

$= 519.2^k$

12) Vertical Distribution of Forces (12.8.3)

$$F_x = C_{vx} V = \left[\frac{w_x h_x^k}{\sum w_x h_x^k} \right] V$$

K: $T_a = 0.721 \Rightarrow 0.5 < 0.721 < 2.5$

$$\frac{2.5 - 0.5}{2 - 1} = \frac{2.5 - 0.721}{2 - K} \Rightarrow K = 1.11$$

⇒ See excel table table on next page

12. Vertical Distribution of Forces

k= 1.11
Vb= 519.2 Kips

Calculation of Story Forces										
Level	Floor-to-Floor Height (FT)	Floor Dead Loads (K)	Wall Loads (K)	Shear Wall Weights (K)	Column Loads (K)	Total Wieght = w_i (K)	h_i (FT)	$w_ih_i^k$ (K-FT)	C_{vx}	F (K)
Roof	9	1271	438	190	10	1911	102	744173	0.200	103.9
6	17	1430	828	365	20	2642	84	859716	0.231	120.1
5	16	1443	934	320	21	2719	68	701839	0.189	98.0
4	16	1481	1249	292	24	3047	52	591270	0.159	82.6
3	17	1756	1829	310	25	3921	36	520164	0.140	72.6
2	18	1722	2699	340	19	4780	18	300271	0.081	41.9
					Sum=	19019	Sum=	3717431	1.000	519.2

Calculations of Loads

Floor Weights

Roof	1271.4
6	1359.2
5	1375.2
4	1472.7
3	1658.0
2	1703.8

Calculation of Effective Seismic Weight				
Level	Area of General Collections (SF)	Live Load (PSF)	Total Load (K)	25% of Live Load (K)
Roof	0	150	0	0
6	3146	150	472	71
5	3034	150	455	68
4	372	150	56	8
3	4364	150	655	98
2	796	150	119	18

* ACSE 12.7.2 - General collections are considered as live load storage

Wall Weights

Typical exterior wall:	99 PSF
16" foundation wall:	200 PSF
24" foundation wall:	300 PSF
30" foundation wall:	375 PSF
33" foundation wall:	412.5 PSF

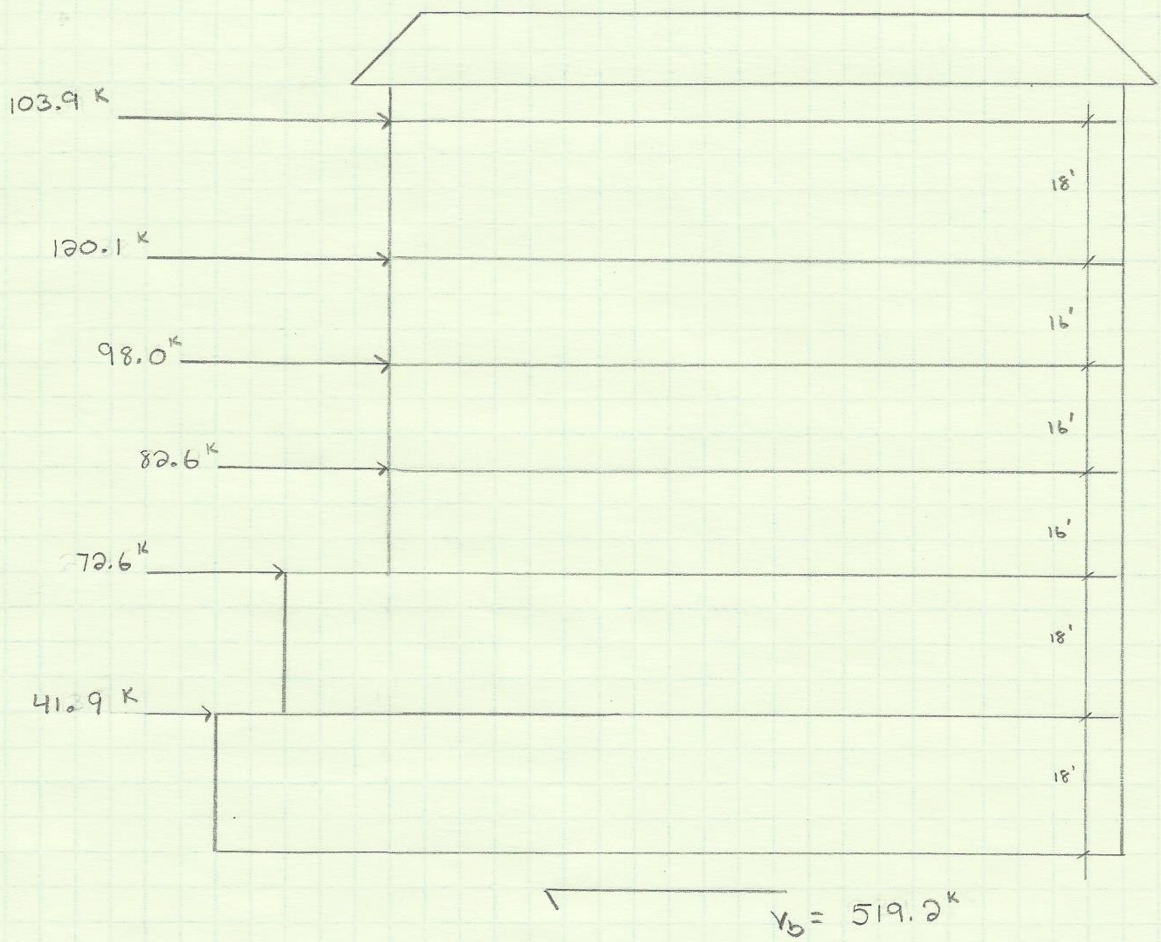
Calculation of Exterior Wall Weights															
Level	Wall Height Below (FT)	Wall Height Above (FT)	Length of Exterior Wall Below (FT)	Length of Exterior Wall Above (FT)	Length of 16" Foundation Wall Below (FT)	Length of 16" Foundation Wall Above (FT)	Length of 24" Foundation Wall Below (FT)	Length of 24" Foundation Wall Above (FT)	Length of 30" Foundation Wall Below (FT)	Length of 30" Foundation Wall Above (FT)	Length of 33" Foundation Wall Below (FT)	Length of 33" Foundation Wall Above (FT)	Weight of Exterior Wall (K)	Weight of Foundation Walls (K)	Total Wall Weight (K)
Roof	9	0	492	0	0	0	0	0	0	0	0	0	438	0	438
6	8	9	492	492	0	0	0	0	0	0	0	0	828	0	828
5	8	8	453	492	0	0	77	0	0	0	0	0	749	186	934
4	8	8	377	453	0	0	121	77	0	0	35	0	658	591	1249
3	9	8	270	377	13	0	172	121	31	0	79	35	539	1290	1829
2	9	9	54	270	258	13	173	172	90	31	79	79	288	2411	2699

Weight of Shear Wall: 150 PSF

Calculation of Shear Wall Weights																				
Level	Wall Height Below (FT)	Wall Height Above (FT)	Length of Shear Wall 1 Below (FT)	Length of Shear Wall 1 Above (FT)	Length of Shear Wall 2 Below (FT)	Length of Shear Wall 2 Above (FT)	Length of Shear Wall 3 Below (FT)	Length of Shear Wall 3 Above (FT)	Length of Shear Wall 4 Below (FT)	Length of Shear Wall 4 Above (FT)	Length of Shear Wall 5 Below (FT)	Length of Shear Wall 5 Above (FT)	Length of Shear Wall 6 Below (FT)	Length of Shear Wall 6 Above (FT)	Length of Shear Wall 7 Below (FT)	Length of Shear Wall 7 Above (FT)	Length of Shear Wall 8 Below (FT)	Length of Shear Wall 8 Above (FT)	Length of Shear Wall 9 Below (FT)	Length of Shear Wall 9 Above (FT)	Total Wall Weight (K)
Roof	9	0	14	0	21	0	0	0	15.2	0	12	0	25.6	0	20	0	10	0	23.3	0	190
6	8	9	14	14	21	21	0	0	19.3	15.2	12	12	25.6	25.6	20	20	10	10	23.3	23.3	365
5	8	8	14	14	21	21	8.6	0	20.3	19.3	12	12	25.6	25.6	20	20	0	10	0	23.3	320
4	8	8	14	14	21	21	8.6	8.6	20.3	20.3	12	12	25.6	25.6	20	20	0	0	0	0	292
3	9	8	14	14	21	21	8.6	8.6	20.3	20.3	12	12	25.6	25.6	20	20	0	0	0	0	310
2	9	9	14	14	30	21	8.6	8.6	20.3	20.3	12	12	25.6	25.6	20	20	0	0	0	0	340

Calculation of Column Weights					
Level	Column Height Below (FT)	Column Height Above (FT)	Column Wieght Below (PLF)	Column Wieght Above (PLF)	Column Wieght (K)
Roof	9	0	1162	0	10
6	8	9	1162	1162	20
5	8	8	1442	1162	21
4	8	8	1606	1442	24
3	9	8	1375	1606	25
2	9	9	701	1375	19

Story Forces Diagram



Lateral Analysis

Lateral Computer Model

For this technical report a 3D computer model was created using ETABS, and was used to distribute the story forces to each lateral element. This model was also used to determine the maximum drift and story drifts due to each load case.

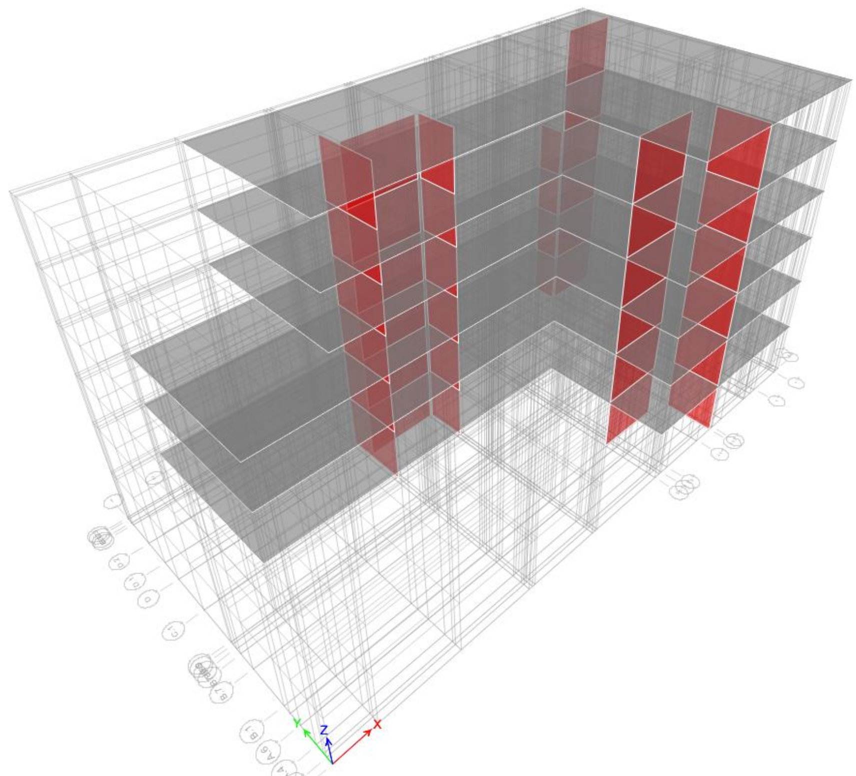


Figure 1: 3D View of ETABS Model

Overview

The lateral system used in the New Library is ordinary reinforced shear walls. The seven individual shear walls are shown in red in Figure 1 above, while the diaphragms for each level are shown in gray. These seven shear walls can be located on the floor plan provided in appendix A where they are numbered 1-7. All of the shear walls are 12”, with the exception of shear wall 1 and 2 which are 16” and 33” at the base level.

Modeling Decisions

Due to the large soil loads on the structure, the design involves a significant number of foundation walls. For this analysis, only the shear walls were modeled. This modification was made in order to be able to analyze the shear walls under the full lateral forces without the foundation walls providing increase lateral resistance. The foundation walls are designed to act as either a pined or fixed connection at the base with supports at each floor level. Due to this design, the soil forces were still used in the analysis of the building's lateral system, even though no foundation walls were modeled.

The shear walls were modeled as membranes. Membranes have no out-of-plane stiffness and therefore will take no out-of-plane shear forces.

Shear wall 1, 2, 5, 6, and 7 were modeled with pin supports at the base. In the structure these shear walls are supported either by strip footings with spread footings at each end, or just by strip footings. These base conditions do not justify the use of a fixed connection in the model.

Shear walls 3 and 4 were modeled with fixed supports at the base. In the structure these shear walls rest on a mat foundation that is located in the North-East corner of building. This base condition justifies the use of a fixed condition in the model.

The diaphragm was modeled as rigid. This allowed the transfer of lateral forces to the shear walls without providing extra resistance. The floor system in the New Library is a composite floor system which has limited flexibility and allows the lateral forces to be transferred to the shear walls.

The openings in the diaphragm and shear walls were not modeled. This was due to the complexity of modeling openings accurately, especially those which are located in close proximity to lateral elements. This decision had minimal negative impact on the model due to the fact that no masses were used in the model.

All of the wall sections were modeled to consider the effects of cracked sections on the deflection of the lateral system. Per ACI318-11 8.8.2, the member stiffness maybe modified through section properties which decreased the wall section stiffness by 65%.

Verification of Model

Before using the lateral model to distribute the shear forces to the shear walls, the model was checked to determine if it was reporting accurate data. This was done by applying a 1000 kip load in the x-direction to the center of mass at the roof level. The first verification was of the story forces and story moments, shown in Figure 2. This was done to make sure that each story was receiving 1000 kips and each story was receiving a moment equal to 1000 multiplied by the story's distance from the roof level.

Story Forces

1 of 6 Reload Apply

Story	Load Case/Combo	Location	P kip	VX kip	VY kip	T kip-ft	MX kip-ft	MY kip-ft
Roof	TEST - X	Bottom	0	-1000	0	54330	0	-18000
Level 6	TEST - X	Bottom	0	-1000	0	54330	0	-34000
Level 5	TEST - X	Bottom	0	-1000	0	54330	0	-50000
Level 4	TEST - X	Bottom	0	-1000	0	54330	0	-66000
Level 3	TEST - X	Bottom	0	-1000	0	54330	0	-84000
Level 2	TEST - X	Bottom	0	-1000	0	54330	0	-102000

Figure 2: Story Forces and Moments

The next verification was that of the in-plane shear force contours, shown in Figures 3 and 4. It was verified that the three shear walls acting in the x-direction had the largest contour lines due to the direct shear forces, while the remaining four shear walls had minimal contour lines due to torsional shear forces.

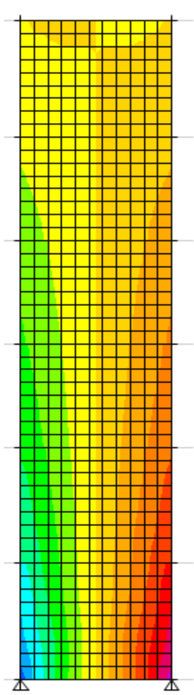


Figure 3: Shear Force Contours –In-Plane Shear Wall

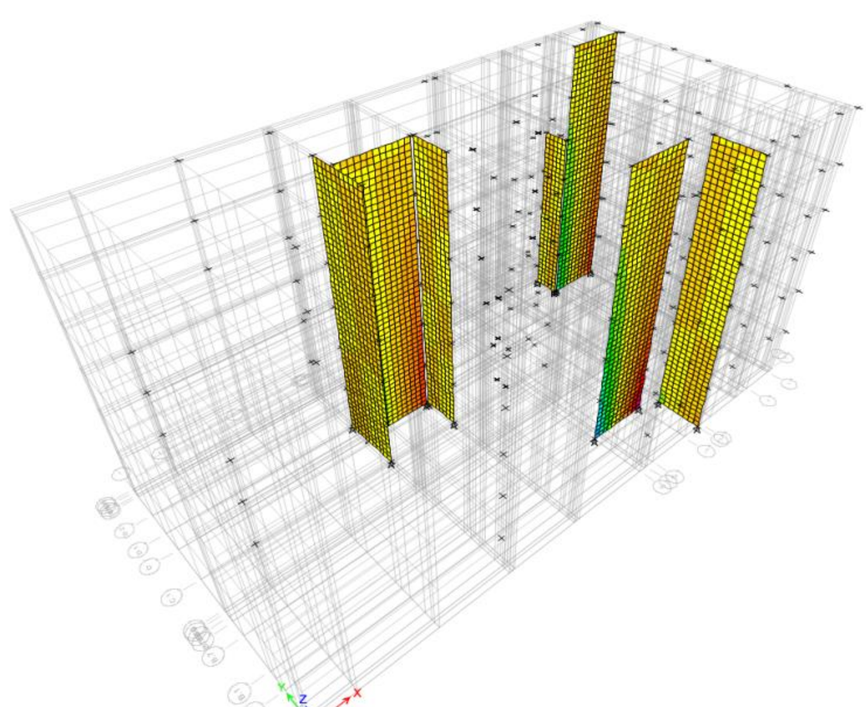


Figure 4: Shear Force Contours – Lateral System

The last verification was a brief check of the distribution of forces to each lateral element at level 2.

Distribution

In order to check the distribution of forces, the relative stiffness of each element was calculated. The tables below show the relative stiffness of each shear wall along with the forces from ETABS. Figure 5 below shows the direction of direct shear forces and torsional shear forces in shear walls 2, 4, and 6. Based on the relative stiffness of each shear wall, it is expected that SW2 would have the highest shear forces followed by SW 6 and 4 respectively. The shear forces from the model match this expectation. It is also important to notice that the torsional shears will cause the shear in SW2 to decrease while increasing the shear in SW4 and SW6. The shear forces from the model also match these expectations.

Relative Stiffness of Shear Walls

Shear Wall	E (ksi)	h (in)	b (in)	t (in)	k (K/in)	Relative K X–Direction
2	3605	216	260.0	33	38805	1
4	3605	216	238.3	12	12485	0.322
6	3605	216	280.0	12	15599	0.402

Shear Forces from ETABS

Shear Wall	Shear Force (k)
2	450.148
4	249.338
6	300.514

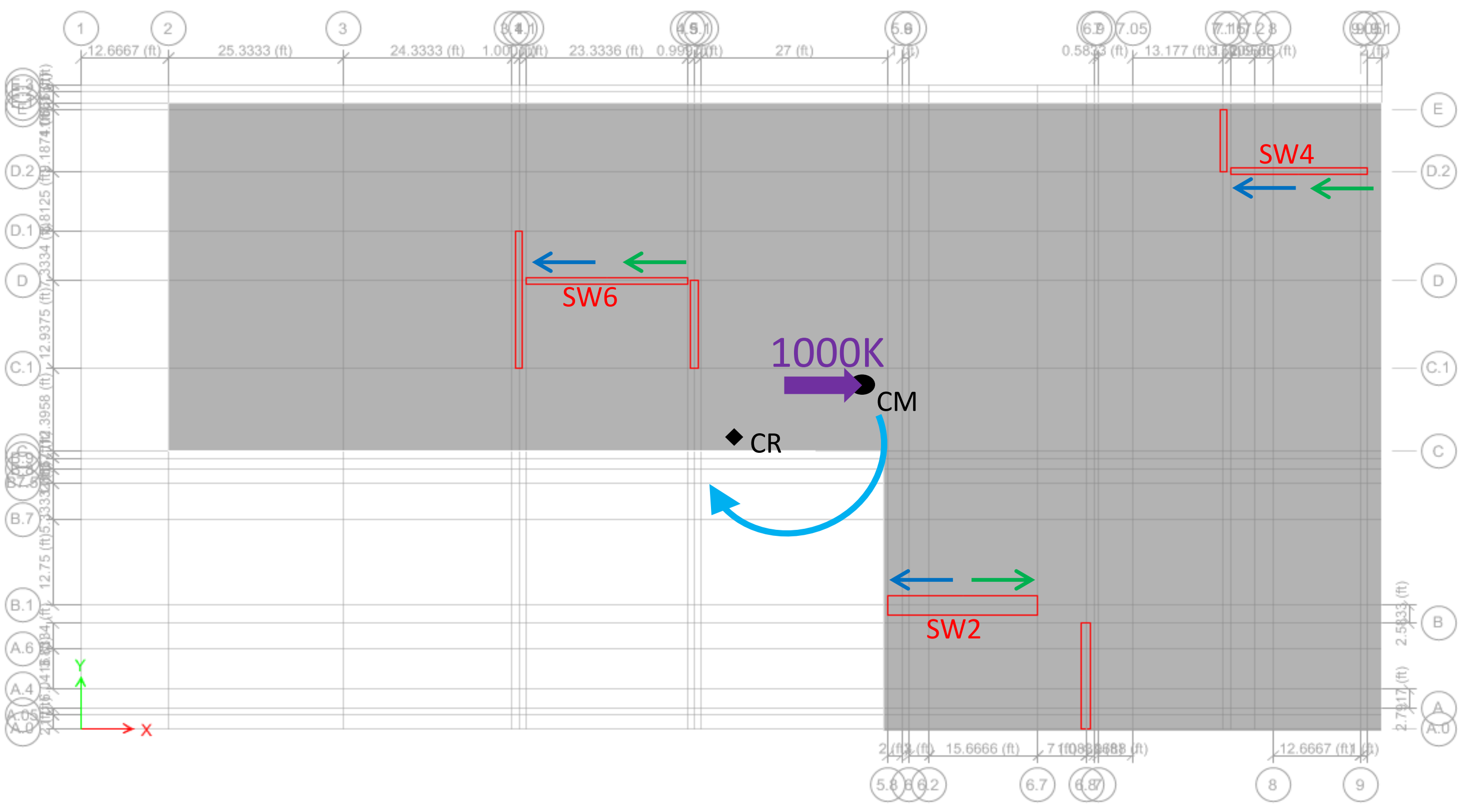


Figure 5: Direction of Shear Forces

Summation of Forces

The equilibrium of the model was then verified in both the x and y directions. Figure 6 below shows the shear forces in each shear wall in the model.

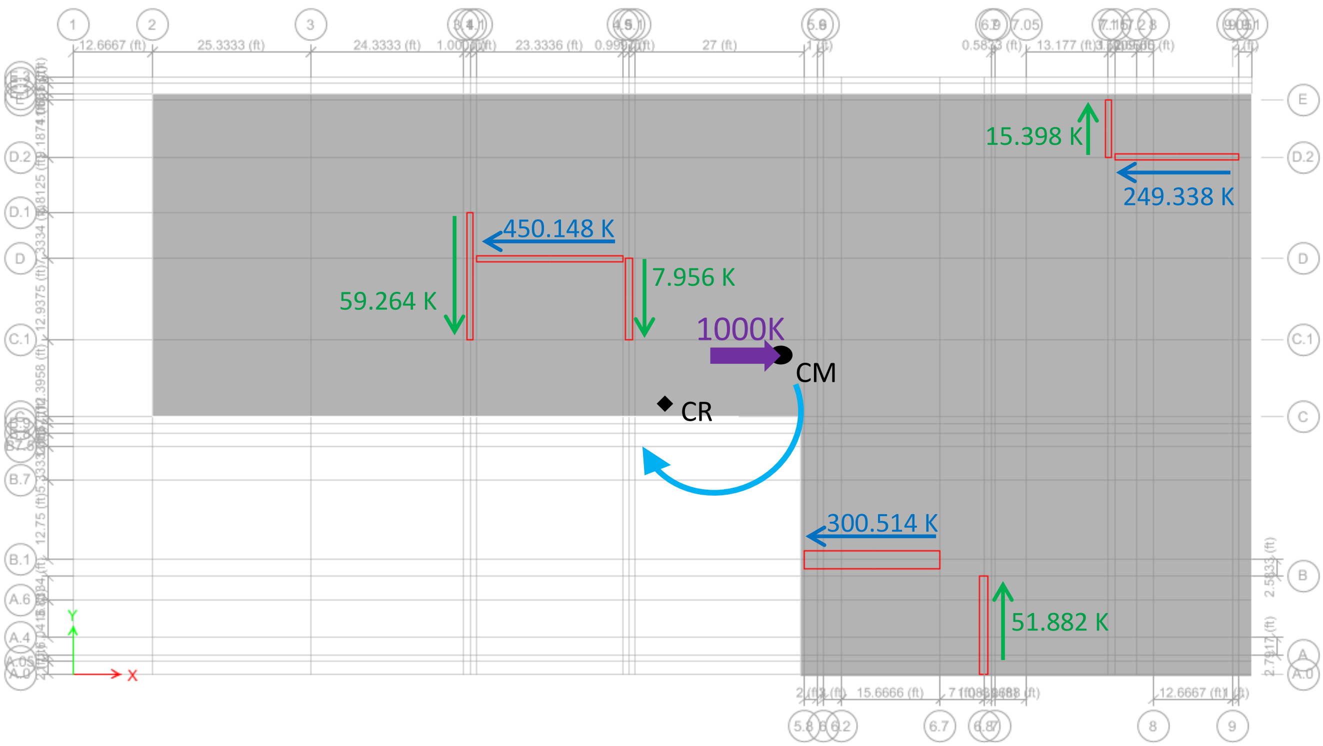


Figure 6: Direction of Shear Forces

$\sum F_x = 1000 - 450.148 - 249.338 - 300.514 = 0$

$\sum F_y = -59.264 - 7.956 + 15.398 + 51.882 = 0$

Torsional Forces (With Respect to CR)

It was also important to notice that the torsional shears were in the correct direction with respect to the center of rigidity. The offset between the center of mass and center of rigidity will cause a clockwise rotation. All shears to the left of the CR are in the –Y direction and all shears to the right of the CR are in the +Y direction.

Building Properties

Below is a table showing the location of the center of mass for each level of the New Library. The center of mass for each level was calculated by hand, and the excel spread sheets are included in appendix B. ETABS is able to calculate the center of mass for the structure, but this requires the mass of the structure to be included in the program. Due to the fact that this was strictly a lateral model, and no gravity elements were included, no masses were to be added to the model. The center of mass was used in the application of seismic forces.

Center of Mass		
Level	X-Direction	Y-Direction
Roof	121.72	54.00
6	125.67	54.62
5	122.09	56.01
4	120.31	59.34
3	110.01	59.04
2	113.20	54.33

Below is a table showing the location of the center of rigidity for each level of the New Library. ETABS calculates the center of rigidity of each level in the model. A spot check of the center of rigidity is included in appendix B of this report.

Center of Rigidity		
Level	X-Direction	Y-Direction
Roof	94.3337	50.0655
6	94.8591	49.1726
5	95.367	48.0842
4	96.0189	46.5582
3	97.0962	44.51
2	100.0302	41.9675

Below is a table showing the location of the center of rigidity for each level of the New Library. ETABS calculates this location automatically when a wind load is applied, and the locations were verified.

Center of Pressure		
Level	X-Direction	Y-Direction
Roof	113	46.344
6	113	46.344
5	113	46.344
4	100.333	46.344
3	100.333	46.344
2	100.333	46.344

Wind Loads

A lateral analysis under wind loading conditions was completed for tech report 4. As part of this analysis ASCE7-05 requires four different wind cases to be applied to the building in order to account to quartering winds and torsion effects. Below are tables showing the resulting forces for each wind case along with the corresponding images from ASCE7-05.

Note: ASCE7-05 requires a minimum wind pressure of 10 PSF in the windward direction.

Case 1:

Wind Pressures (E-W Direction)					
Floor Height	Wall Length	Windward Pressure (PSF)	Leeward Pressure (PSF)	Trib Area (SF)	Force (K)
18	94.33	10.00	-6.67	1698	28
36	94.33	10.02	-6.67	1604	27
52	94.33	11.10	-6.67	1509	27
68	94.33	12.05	-6.67	1509	28
84	94.33	12.73	-6.67	1604	31
102	94.33	13.41	-6.67	849	17
			Base Shear=		158

Wind Pressures (N-S Direction)					
Floor Height	Wall Length	Windward Pressure (PSF)	Leeward Pressure (PSF)	Trib Area (SF)	Force (K)
18	147	10.00	-8.49	2646	49
36	147	10.00	-8.49	2499	46
52	147	10.96	-8.49	2352	46
68	121.67	11.89	-8.49	1947	40
84	121.67	12.56	-8.49	2068	44
102	121.67	13.23	-8.49	1095	24
			Base Shear=		248

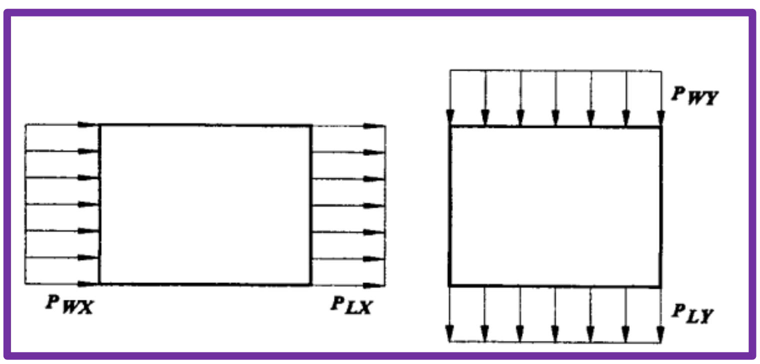


Figure 7: Wind Load Case 1

Case 2:

Wind Pressures (E-W Direction)								
Floor Height	Wall Length	Windward Pressure (PSF)	Leeward Pressure (PSF)	Trib Area (SF)	Force (K)	B_x (FT)	(±)e_x (FT)	(±)M_x (Ft-K)
18	94.33	10.00	-5.01	1698	25	94.33	14.1	361
36	94.33	10.00	-5.01	1604	24	94.33	14.1	340
52	94.33	10.00	-5.01	1509	23	94.33	14.1	320
68	94.33	10.00	-5.01	1509	23	94.33	14.1	320
84	94.33	10.00	-5.01	1604	24	94.33	14.1	340
102	94.33	10.06	-5.01	849	13	94.33	14.1	181
			Base Shear=		132			

Wind Pressures (N-S Direction)								
Floor Height	Wall Length	Windward Pressure (PSF)	Leeward Pressure (PSF)	Trib Area (SF)	Force (K)	B_y (FT)	(±)e_y (FT)	(±)M_y (Ft-K)
18	147	10.00	-6.37	2646	43	147	22.1	955
36	147	10.00	-6.37	2499	41	147	22.1	902
52	147	10.00	-6.37	2352	38	147	22.1	849
68	121.67	10.00	-6.37	1947	32	121.67	18.3	581
84	121.67	10.00	-6.37	2068	34	121.67	18.3	618
102	121.67	10.00	-6.37	1095	18	121.67	18.3	327
			Base Shear=		206			

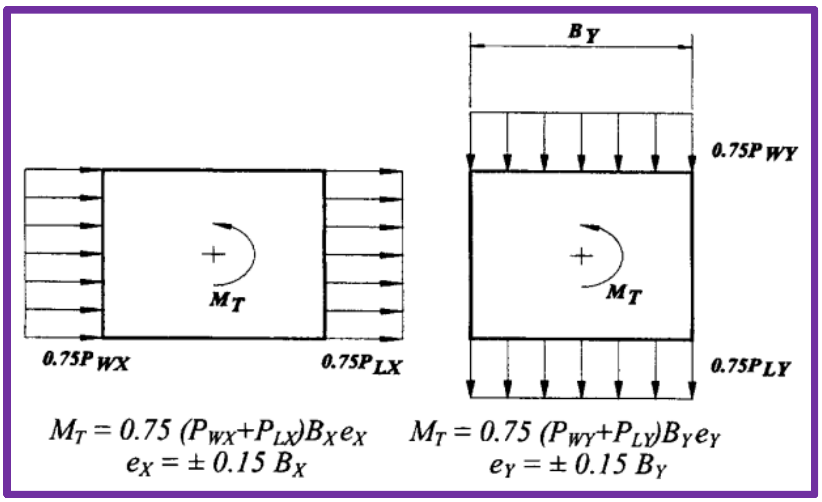


Figure 8: Wind Load Case 2

Case 3:

Note: Pressures in the X-Direction and Y-Direction are applied simultaneously.

Wind Pressures (E-W Direction)					
Floor Height	Wall Length	Windward Pressure(PSF)	Leeward Pressure (PSF)	Trib Area (SF)	Force (K)
18	94.33	10.00	-5.01	1698	25
36	94.33	10.00	-5.01	1604	24
52	94.33	10.00	-5.01	1509	23
68	94.33	10.00	-5.01	1509	23
84	94.33	10.00	-5.01	1604	24
102	94.33	10.06	-5.01	849	13
				Base Shear=	132

Wind Pressures (N-S Direction)					
Floor Height	Wall Length	Windward Pressure (PSF)	Leeward Pressure (PSF)	Trib Area (SF)	Force (K)
18	147	10.00	-6.37	2646	43
36	147	10.00	-6.37	2499	41
52	147	10.00	-6.37	2352	38
68	121.67	10.00	-6.37	1947	32
84	121.67	10.00	-6.37	2068	34
102	121.67	10.00	-6.37	1095	18
				Base Shear=	206

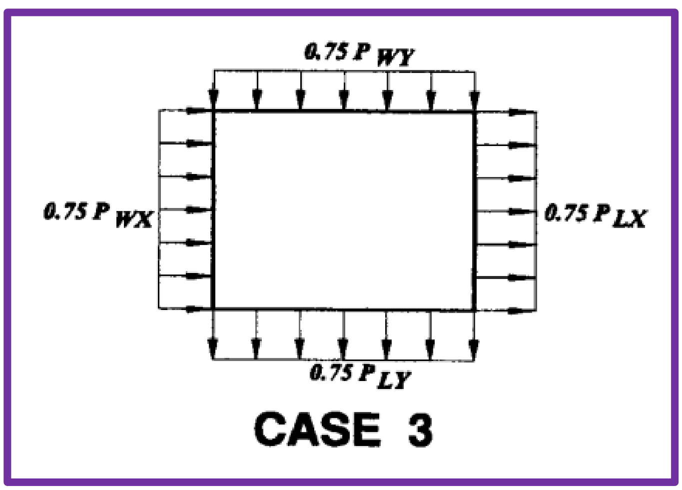


Figure 9: Wind Load Case 3

Case 4:

Note: Moments in the X-Direction and Y-Direction are applied at the same time.

Wind Pressures (E-W Direction)					
Floor Height	Wall Length	Windward Pressure (PSF)	Leeward Pressure (PSF)	Trib Area (SF)	Force (K)
18	94.33	10.00	-3.76	1698	23
36	94.33	10.00	-3.76	1604	22
52	94.33	10.00	-3.76	1509	21
68	94.33	10.00	-3.76	1509	21
84	94.33	10.00	-3.76	1604	22
102	94.33	10.00	-3.76	849	12
				Base Shear=	121

Wind Pressures (N-S Direction)					
Floor Height	Wall Length	Windward Pressure (PSF)	Leeward Pressure (PSF)	Trib Area (SF)	Force (K)
18	147	10.00	-4.78	2646	39
36	147	10.00	-4.78	2499	37
52	147	10.00	-4.78	2352	35
68	121.67	10.00	-4.78	1947	29
84	121.67	10.00	-4.78	2068	31
102	121.67	10.00	-4.78	1095	16
				Base Shear=	186

Wind Pressures (N-S Direction)								
Floor Height	Force - X (K)	Force - Y (K)	B_x (FT)	(±)e_x (FT)	B_y (FT)	(±)e_y (FT)	(±) M of same sign	(±) M of opposite sign
18	23	39	94.33	14.1	147	22.1	1193	532
36	22	37	94.33	14.1	147	22.1	1126	502
52	21	35	94.33	14.1	147	22.1	1060	473
68	21	29	94.33	14.1	121.67	18.3	819	231
84	22	31	94.33	14.1	121.67	18.3	870	246
102	12	16	94.33	14.1	121.67	18.3	461	130

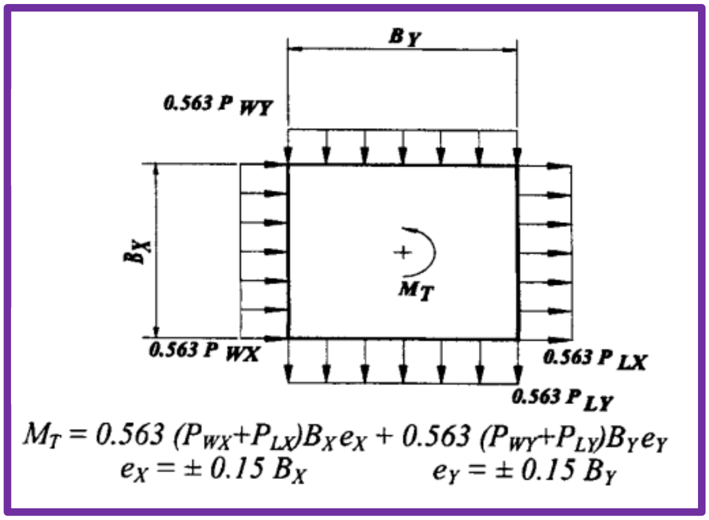


Figure 10: Wind Load Case 4

Seismic Forces

The seismic forces determined in technical report 2 were expanded upon to include accidental torsion. ASCE7-05 12.8.4.2 requires that when the diaphragm is not flexible, the design for seismic forces shall include the accidental torsional moment caused by the assumed displacement of the center of mass each way from its actual location by a distance equal to 5 percent of the dimension of the structure perpendicular to the direction of the applied forces. Due to the fact that the building is assigned to seismic category B, ACSE7-05 12.5.2 states that seismic forces are permitted to be applied independently in each of two orthogonal directions and orthogonal interaction effects are permitted to be neglected. The amplification factor Ax is also taken as 1.0 due to the building being assigned to seismic category B. Below are tables showing both the applied forces and moments.

Calculation of Story Forces - EW-Direction

Level	Height (FT)	Total Weight (K)	$w_i h_i^k$ (K-FT)	C_{vx}	f_i (K)	V_i (K)	B_y (Ft)	5% B_y (FT)	A_x (K)	M_z (Ft-K)
Roof	102	1911	744173	0.200	104	104	94.3	4.7	1.0	490
6	84	2642	859716	0.231	120	224	94.3	4.7	1.0	566
5	68	2719	701839	0.189	98	322	94.3	4.7	1.0	462
4	52	3047	591270	0.159	83	405	94.3	4.7	1.0	389
3	36	3921	520164	0.140	73	477	94.3	4.7	1.0	343
2	18	4780	300271	0.081	42	519	94.3	4.7	1.0	198
	SUM:	19019	3717431	1.000	519					2449

Calculation of Story Forces - NS-Direction

Level	Height (FT)	Total Weight (K)	$w_i h_i^k$ (K-FT)	C_{vx}	f_i (K)	V_i (K)	B_x (Ft)	5% B_x (FT)	A_x (K)	M_z (Ft-K)
Roof	102	1911	744173	0.200	104	104	147.0	7.4	1.0	764
6	84	2642	859716	0.231	120	224	147.0	7.4	1.0	883
5	68	2719	701839	0.189	98	322	147.0	7.4	1.0	720
4	52	3047	591270	0.159	83	405	121.7	6.1	1.0	502
3	36	3921	520164	0.140	73	477	121.7	6.1	1.0	442
2	18	4780	300271	0.081	42	519	121.7	6.1	1.0	255
	SUM:	19019	3717431	1.000	519					3566

Building Irregularities

The New Library was inspected for vertical and horizontal irregularities. It was determined that no vertical structural irregularities applied, but horizontal irregularity Type 1b and Type 4 did apply (shown in Figure 11 below).

TABLE 12.3-1 HORIZONTAL STRUCTURAL IRREGULARITIES

	Irregularity Type and Description	Reference Section	Seismic Design Category Application
1a.	**Torsional Irregularity** is defined to exist where the maximum story drift, computed including accidental torsion, at one end of the structure transverse to an axis is more than 1.2 times the average of the story drifts at the two ends of the structure. Torsional irregularity requirements in the reference sections apply only to structures in which the diaphragms are rigid or semirigid.	12.3.3.4 12.8.4.3 12.7.3 12.12.1 Table 12.6-1 Section 16.2.2	D, E, and F C, D, E, and F B, C, D, E, and F C, D, E, and F D, E, and F B, C, D, E, and F
1b.	**Extreme Torsional Irregularity** is defined to exist where the maximum story drift, computed including accidental torsion, at one end of the structure transverse to an axis is more than 1.4 times the average of the story drifts at the two ends of the structure. Extreme torsional irregularity requirements in the reference sections apply only to structures in which the diaphragms are rigid or semirigid.	12.3.3.1 12.3.3.4 12.7.3 12.8.4.3 12.12.1 Table 12.6-1 Section 16.2.2	E and F D B, C, and D C and D C and D D B, C, and D
2.	**Reentrant Corner Irregularity** is defined to exist where both plan projections of the structure beyond a reentrant corner are greater than 15% of the plan dimension of the structure in the given direction.	12.3.3.4 Table 12.6-1	D, E, and F D, E, and F
3.	**Diaphragm Discontinuity Irregularity** is defined to exist where there are diaphragms with abrupt discontinuities or variations in stiffness, including those having cutout or open areas greater than 50% of the gross enclosed diaphragm area, or changes in effective diaphragm stiffness of more than 50% from one story to the next.	12.3.3.4 Table 12.6-1	D, E, and F D, E, and F
4.	**Out-of-Plane Offsets Irregularity** is defined to exist where there are discontinuities in a lateral force-resistance path, such as out-of-plane offsets of the vertical elements.	12.3.3.4 12.3.3.3 12.7.3 Table 12.6-1 16.2.2	D, E, and F B, C, D, E, and F B, C, D, E, and F D, E, and F B, C, D, E, and F
5.	**Nonparallel Systems-Irregularity** is defined to exist where the vertical lateral force-resisting elements are not parallel to or symmetric about the major orthogonal axes of the seismic force–resisting system.	12.5.3 12.7.3 Table 12.6-1 Section 16.2.2	C, D, E, and F B, C, D, E, and F D, E, and F B, C, D, E, and F

Figure 11: Horizontal Structural Irregularities

The impact of these irregularities was considered to an extent for this report, but will have to be considered and further expanded upon in the spring semester proposal. One thing to further explore would be the foundation walls impact on the story drifts. These walls add a significant amount of stiffness to the structure and may eliminate the extreme torsional irregularity.

Lateral Earth Pressures

The Library at the University of Wise Virginia's College at Wise has a unique condition in which it is integrated into the existing 60 foot hillside. For this technical report the impact of the soil loads on the structures lateral system were considered using an equivalent fluid pressure of 47 PCF provided in the geotechnical report. Below are tables showing the applied soil loads, and detailed tables are provided in appendix C.

It is also important to note that in this report the soil loads were strictly used as an applied lateral load. They do not serve a role in aiding the building it terms of drift control, and were not considered to be causing drift.

East Elevation:

Lateral Soil Forces(K)				
Level	Column Line A-C	Column Line C-C1	Column Line C1-D1	Column Line D-E2
5	0	0	0	42
4	62	54	105	338
3	541	224	279	729
2	1179	427	485	1188

North Elevation:

Lateral Soil Forces(K)					
Level	Column Line 1-3	Column Line 3-5	Column Line 5-7	Column Line 7-8	Column Line 8-9.2
5	0	0	0	152	25
4	0	0	0	496	201
3	0	0	111	900	446
2	72	386	888	152	705

South Elevation:

Lateral Soil Forces(K)					
Level	Column Line 1-3	Column Line 3-6	Column Line 6-7	Column Line 7-8	Column Line 8-9.2
5	0	0	0	0	0
4	0	0	0	0	25
3	0	0	52	172	113
2	0	155	416	557	127

Member Spot Checks for Strength

As part of the lateral analysis of the New Library the lateral system was spot checked for strength. Shear walls that were critical members, those taking the highest amount of shear force, where to be checked. The largest shear forces occurred at the base level of the shear walls, so each shear wall was checked for each load case at this level. These comparisons can be seen in the excel tables in appendix D. It was determined that shear wall 2 was the wall with the highest shear forces. The concern with this wall was that even though it takes the most shear force it is also significantly thicker than the common shear walls. Thus, shear wall 6 was also checked due to the fact that it had the second highest shear forces and a typical thickness of 12".

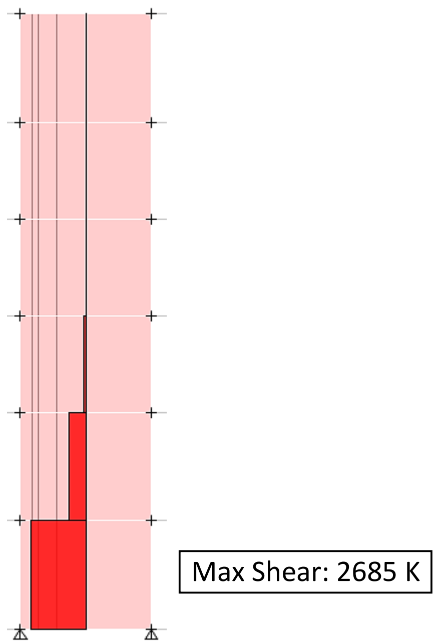


Figure 12: Moment Diagram for Shear Wall 2

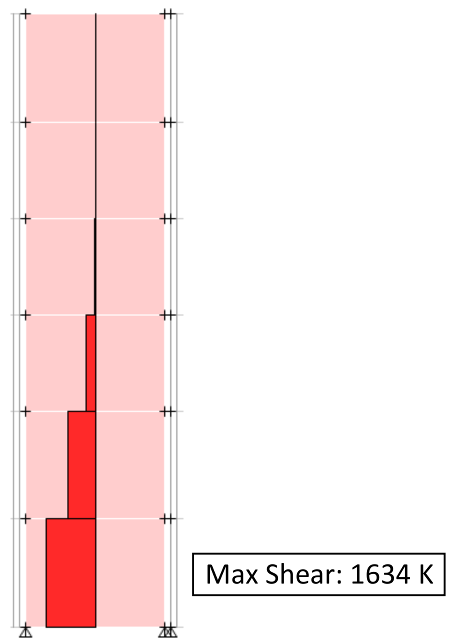


Figure 13: Moment Diagram for Shear Wall 6

The largest shear forces in both the x-direction and y-direction were caused by soil loads. Thus, soil loads dictated the controlling load combination for the analysis of the shear walls. It was determined that load combination 7 from IBC 2009 was the controlling combination:

$$0.9D + 1.0E + 1.6H$$

The following pages show the hand calculations for determining the controlling load combination along with the member spot checks.

Determine Controlling Load Combination (ASCE 7-05)

Shear Wall 2

(2) 1.2(D + F + T) + 1.6(L + H) + 0.5(Lr or S or R)

(6) 0.9D + 1.6W + 1.6H

(7) 0.9D + 1.0E + 1.6H

⇒ Either load combination (6) or (7) will be the controlling load combination of SW2 due to the lateral forces being the critical wall forces.

Determine dead Load

Roof = [(117 psf)(335 ft²)/1000 = 39.2^k
Level 6 = [(106 psf)(129.2 ft²) + (21.667)(12/12)(18)(150)]/1000 = 72.2^k
Level 5 = [(106 psf)(129.2 ft²) + (21.667)(12/12)(16)(150)]/1000 = 65.7^k
Level 4 = [(106 psf)(129.2 ft²) + (21.667)(12/12)(16)(150)]/1000 = 65.7^k
Level 3 = [(106 psf)(129.2 ft²) + (21.667)(12/12)(16)(150)]/1000 = 65.7^k
Level 2 = [(106 psf)(129.2 ft²) + (21.667)(33/12)(18)(150)]/1000 = 174.6^k

Total P = 483.1^k

Determine wind Load

W = 157.989^k (see excel sheet in appendix)

Determine Seismic Load

$E = E_h - E_v$ (ASCE 7-05 12.4.2)

$E_h = Q_E \rho$ ⇒ $\rho = 1.0$ for seismic catagory B

= (288.393)(1.0)

= 288.393

$E_v = 0.2 S_{DS} D$

= 0.2(0.221)(483.1)

= 21.4

Determine controlling load combination cont.

(6) $P_u = 0.9(483.1) + 1.0(21.4) = 456.2^k$

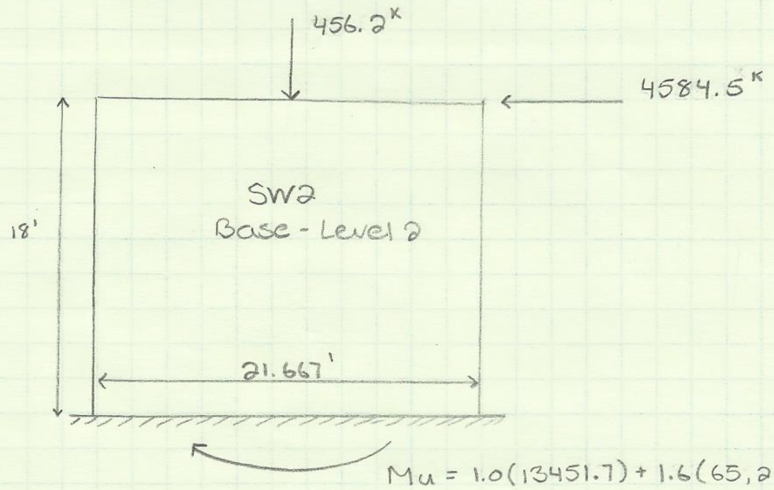
$V_u = 1.6(157.989) + 1.6(2685.04) = 4548.8^k$

(7) $P_u = 0.9(483.1) + 1.0(21.4) = 456.2^k$

$V_u = 1.0(288.393) + 1.6(2685.04) = 4584.5^k$

⇒ Load Case 7 controls

$$\boxed{0.9D + 1.0E + 1.6H}$$



$M_u = 1.0(13451.7) + 1.6(65,213.6) = 117793.5^{'k}$

Check Strength of Shear Wall - SW2

$\phi V_n > V_u = 4584.5^k$

$V_n = V_c + V_s$

Determine Vc

$V_c = 3.3\lambda\sqrt{f'c}\,hd + (N_u d/4l_w)$ (ACI 318-11 Eq 11-27)

$\lambda = 1.0$
$f'c = 4000psi$
$h = 33"$
$d = 0.8l_w = 0.8(21.667\times12) = 0.8(260) = 208"$
$N_u = 456.2^k$

$= [3.3(1.0)\sqrt{4000}(33)(208) + (456.2^k(208)/4(260))]/1000$

$= 1432.7$

$$V_c = \left[0.6\lambda\sqrt{f'c} + \frac{l_w(1.25\lambda\sqrt{f'c} + 0.2\,N_u/l_w h)}{\frac{M_u}{V_u} - \frac{l_w}{2}}\right]hd \quad \text{(eq 11-28)}$$

* Check to see if equation applies

$\frac{M_u}{V_u} - \frac{l_w}{2} = \frac{11793.5^{k}(12)}{4584.5} - \frac{260"}{2} = 178.3" > 0$ so eqn applies

$$= \left[0.6(1)\sqrt{4000} + \frac{260(1.25(1)\sqrt{4000} + 0.2(456.2/(260)(33)))}{178.3}\right](33)(208)/1000$$

$= 1051.9^k$

$V_c = \min\begin{cases}1432.6^k \\ 1051.9^k\end{cases} \Rightarrow 1051.9^k$

* $1051.9(.75) = 789.0^k < 4584.5^k$

⇒ Wall w/o shear reinforcement not adequate for shear strength.

Determine Vs

$$V_s = \frac{A_v f_y d}{S}$$

Reinforcement = #8 @ 18" each face

$$A_v = \left(\frac{18'(12)}{18''} + 1\right)(.79)(2) = 20.54$$

$f_y = 60^{ksi}$
$d = 260''$
$S = 18''$

$$= \frac{(20.54\,in^2)(60^{ksi})(260\,in)}{(18\,in)}$$

$$= 17801^{K}$$

Determine if strength is adequate

$$\phi V_n = 0.75(1051.9 + 17801) = 14{,}140^{K}$$

$$\Rightarrow 14{,}140^{K} > 4584.5^{K} \checkmark$$

⇒ Shear wall w/ shear reinforcement adequate for shear strength

Determine Controlling Load Combination

Shear Wall 6

(6) $0.9D + 1.6W + 1.6H$

(7) $0.9D + 1.0E + 1.6H$

Determine Dead Load

* Shear wall 6 carries very little dead load due to the large number of openings around it

Roof = (117 psf)(296.37 SF)/1000 = 34.7^k
Level 6 = [(106 psf)(18.02 SF) + (23.333)(12/12)(18)(150)]/1000 = 64.9^k
Level 5 = [(106 psf)(18.02 SF) + (23.333)(12/12)(16)(150)]/1000 = 57.9^k
Level 4 = [(106 psf)(18.02 SF) + (23.333)(12/12)(16)(150)]/1000 = 57.9^k
Level 3 = [(106 psf)(18.02 SF) + (23.333)(12/12)(16)(150)/1000 = 57.9^k
Level 2 = [(106 psf)(64.75 SF) + (23.333)(12/12)(18)(150)/1000 = 64.9^k

Total P = 344.2^k

Determine Wind Load

W = 47.766^k (see excel sheet in appendix)

Determine Seismic Load

$E = E_h - E_v$ (ASCE 7-05 12.4.2)

$E_h = Q_E \rho \Rightarrow \rho = 0$

$= 114.146^k$

$E_v = 0.2 S_{DS} D$

$= 0.2(.221)(344.2)$

$= 15.2^k$

Determine controlling load combination cont.

(6) $P_u = 0.9(344.2) + 1.0(15.2) = 325.0^k$

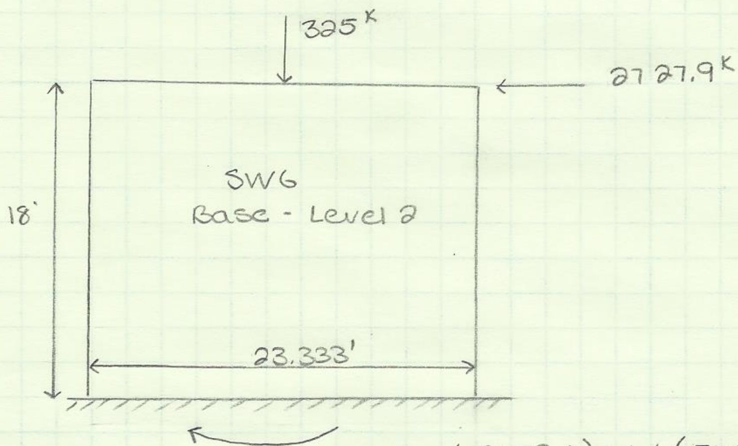
$V_u = 1.6(47.766) + 1.6(1633.579) = 2690.2^k$

(7) $P_u = 0.9(344.2) + 1.0(15.2) = 325.0^k$

$V_u = 1.0(114.146) + 1.6(1633.579) = 2727.9^k$

⇒ Load case 7 controls

0.9D + 1.0E + 1.6H



$M_u = 1.0(12402.1) + 1.6(51193.9) = 94312.3^{1k}$

Check Strength of Shear Wall - SW6

$\phi V_n > V_u = 2727.9^k$

$V_n = V_c + V_s$

Determine V_c

$V_c = 3.3\lambda\sqrt{f'c}\,hd + (N_u d/4\ell_w)$

$\lambda = 1.0$
$f'c = 4000psi$
$h = 12''$
$d = 0.8\,\ell_w = 0.8(23.333' \times 12) = 0.8(279.996) = 224''$
$N_u = 309.8$

$= [3.3(1.0)\sqrt{4000}(12)(224) + (325(224)/4(279.996))]/1000$

$= 561.1^k$

$$V_c = \left[0.6\lambda\sqrt{f'c} + \frac{\ell_w(1.25\lambda\sqrt{f'c} + 0.2\,N_u/\ell_w h)}{\frac{M_u}{V_u} - \frac{\ell_w}{2}}\right] hd$$

* Check to see if equation applies

$\frac{M_u}{V_u} - \frac{\ell_w}{2} = \frac{94312.3(12)}{2727.9} - \frac{279.996}{2} = 274.9 > 0$ so eqn applies

$$= \left[0.6(1)\sqrt{4000} + \frac{279.996(1.25(1)\sqrt{4000} + 0.2(325/(279.996)(12)))}{274.9}\right](12)(224)/1000$$

$= 318.5^k$

$V_c = \min \begin{cases} 561.1^k \\ 318.5^k \end{cases} \Rightarrow 318.5^k$

* $318.5(.75) = 238.9^k < 2725.7^k$

⇒ wall w/o shear reinforcement not adequate for shear strength

Determine V_s

$$V_s = \frac{A_v f_y d}{S}$$

Reinforcement = #5 @ 18"

$$A_v = \left(\frac{18'(12)}{18} + 1\right)(.31)(2) = 8.06$$

$f_y = 60$

$d = 224$

$$= \frac{(8.06)(60)(224)}{18}$$

$$= 6018^{k}$$

Determine if strength is adequate

$$\phi V_n = 0.75\,(318.5 + 6018) = 4752.4^{k}$$

$$\Rightarrow 4752.4^{k} > 2725.7^{k} \checkmark$$

⇒ Shear wall w/ reinforcement adequate for shear strength

Drift Checks

Drift Due to Wind

A check of the maximum drift of the structure under service wind loads was checked based on the industry accepted value of H/400. The overall height of the structure is 102 feet resulting in an allowable drift of 3.06 in. The following table shows the maximum drift due to each load case produced by the ETABS model and its comparison to the standard. The maximum drift of the structure was at the roof level.

Wind Load Cases			
Load Case	Maximum Drift (in)	Allowable Drift (in)	Pass/Fail
Wind Case 1 X-Direction	0.588931	3.06	PASS
Wind Case 1 Y-Direction	2.618755	3.06	PASS
Wind Case 2 X-Direction (+M)	0.680642	3.06	PASS
Wind Case 2 X-Direction (-M)	0.544755	3.06	PASS
Wind Case 2 Y-Direction (+M)	2.843785	3.06	PASS
Wind Case 2 Y-Direction (-M)	1.511819	3.06	PASS
Wind Case 3	2.142169	3.06	PASS
Wind Case 4 (+Moments in Same Direction)	3.006926	3.06	PASS
Wind Case 4 (-Moments in Same Direction)	1.472554	3.06	PASS
Wind Case 4 (+Moments in Opposite Direction)	2.286839	3.06	PASS
Wind Case 4 (-Moments in Opposite Direction)	1.594228	3.06	PASS

Discussion of Results:

The lateral system passes for all of the applied wind loading cases, and is adequate to resist the wind loads based on the serviceability criteria of H/400. This was expected due to the fact that wind loads were not the controlling load case. One thing to notice about the result is that the largest drift is due to shear wall 4 (seen on plan in appendix). This particular shear wall is connected to one of the foundation walls that were not modeled. If the other wall was modeled it would have provided increased stiffness to this wall and the drift in this wall would have been decreased.

Drift Due to Seismic

A check of the maximum drift of the structure under service seismic loads was checked based on the ACSE7-05 Table 12.12-1, shown in Figure X below.

TABLE 12.12-1 ALLOWABLE STORY DRIFT, $\Delta_a^{a,b}$

Structure	Occupancy Category		
	I or II	III	IV
Structures, other than masonry shear wall structures, 4 stories or less with interior walls, partitions, ceilings and exterior wall systems that have been designed to accommodate the story drifts.	$0.025h_{sx}^{c}$	$0.020h_{sx}$	$0.015h_{sx}$
Masonry cantilever shear wall structures [d]	$0.010h_{sx}$	$0.010h_{sx}$	$0.010h_{sx}$
Other masonry shear wall structures	$0.007h_{sx}$	$0.007h_{sx}$	$0.007h_{sx}$
All other structures	$0.020h_{sx}$	$0.015h_{sx}$	$0.010h_{sx}$

[a] h_{sx} is the story height below Level x.

Figure 14: ASCE 7-05 Allowable Story Drift

The building's occupancy category is category III which gives an allowable story drift of 1.5% of the story height below the given level. The following tables compare the actual drift percentage given by the ETABS model to the 1.5% allowable drift.

Seismic: X-Direction Loading (+Eccentricity)

Story	Story Height	Story Drift X-Direction	Story Drift (%)	Allowable Drift (%)	Pass/ Fail	Story Drift Y-Direction	Story Drift (%)	Allowable Drift (%)	Pass/ Fail
Roof	18	0.002592	0.259	1.5	PASS	3.60E-05	0.004	1.5	PASS
6	16	0.002512	0.251	1.5	PASS	2.50E-05	0.003	1.5	PASS
5	16	0.00235	0.23	1.5	PASS	6.80E-05	0.007	1.5	PASS
4	16	0.002031	0.203	1.5	PASS	0.000188	0.019	1.5	PASS
3	18	0.001462	0.146	1.5	PASS	0.000348	0.035	1.5	PASS
2	18	0.000581	0.058	1.5	PASS	0.000259	0.026	1.5	PASS

Seismic: X-Direction Loading (-Eccentricity)

Story	Story Height	Story Drift X-Direction	Story Drift (%)	Allowable Drift (%)	Pass/ Fail	Story Drift Y-Direction	Story Drift (%)	Allowable Drift (%)	Pass/ Fail
Roof	102	0.003312	0.331	1.5	PASS	0.001603	0.160	1.5	PASS
6	84	0.003227	0.322	1.5	PASS	0.001579	0.158	1.5	PASS
5	68	0.003011	0.301	1.5	PASS	0.001513	0.151	1.5	PASS
4	52	0.002598	0.259	1.5	PASS	0.0014	0.140	1.5	PASS
3	36	0.001866	0.186	1.5	PASS	0.001157	0.116	1.5	PASS
2	18	0.00074	0.074	1.5	PASS	0.000539	0.054	1.5	PASS

Seismic: Y-Direction Loading (+Eccentricity)									
Story	Story Height	Story Drift X-Direction	Story Drift (%)	Allowable Drift (%)	Pass/ Fail	Story Drift Y-Direction	Story Drift (%)	Allowable Drift (%)	Pass/ Fail
Roof	102	0.003394	0.339	1.5	PASS	0.011975	1.198	1.5	PASS
6	84	0.003269	0.326	1.5	PASS	0.011591	1.159	1.5	PASS
5	68	0.002923	0.292	1.5	PASS	0.010562	1.056	1.5	PASS
4	52	0.002392	0.239	1.5	PASS	0.008896	0.890	1.5	PASS
3	36	0.00147	0.147	1.5	PASS	0.006007	0.601	1.5	PASS
2	18	0.000522	0.052	1.5	PASS	0.002141	0.214	1.5	PASS

Seismic: Y-Direction Loading (-Eccentricity)									
Story	Story Height	Story Drift X-Direction	Story Drift (%)	Allowable Drift (%)	Pass/ Fail	Story Drift Y-Direction	Story Drift (%)	Allowable Drift (%)	Pass/ Fail
Roof	102	0.002031	0.203	1.5	PASS	0.009468	0.947	1.5	PASS
6	84	0.001953	0.195	1.5	PASS	0.009168	0.917	1.5	PASS
5	68	0.001729	0.172	1.5	PASS	0.008358	0.836	1.5	PASS
4	52	0.001409	0.140	1.5	PASS	0.007055	0.706	1.5	PASS
3	36	0.000844	0.084	1.5	PASS	0.004784	0.478	1.5	PASS
2	18	0.000284	0.028	1.5	PASS	0.001721	0.172	1.5	PASS

Discussion of Results:

The lateral system passes for all of the applied seismic loading cases for the criteria of story drift. The largest story drift takes place at the roof level, which is expected.

Overturning and Foundation Impact

Overturning moments and their impact on the foundation of the New Library were considered in the lateral analysis of the building. Below is a table showing the base shear and overturning moment due to each applied load case. It can be seen that soil loads cause the largest overturning moment. The resisting moment was calculated by multiplying the total building weight by the distance from the buildings center of mass to the building's exterior. A factor of safety of 2/3 was used based on the industry standard minimum of $M_{overturn}/M_{resist}$ = 1.5.Due to the larger overturning moment being in the direction of the larger moment arm, both directions were checked to ensure that the resisting moment was adequate in both directions.

Base Shear and Overturning Moment				
Load Case	Base Shear X-Direction	Overturning Moment Y-Direction	Base Shear Y-Direction	Overturning Moment X-Direction
Wind Case 1 X-Direction	158	6278	0	0
Wind Case 1 Y-Direction	0	0	249	9312
Wind Case 2 X-Direction (+M)	132	5040	0	0
Wind Case 2 X-Direction (-M)	132	5040	0	0
Wind Case 2 Y-Direction (+M)	0	0	206	7386
Wind Case 2 Y-Direction (-M)	0	0	206	7386
Wind Case 3	132	5040	206	7386
Wind Case 4 (+M Same Direction)	121	4620	187	6696
Wind Case 4 (-M Same Direction)	121	4620	187	6696
Wind Case 4 (+M Opposite Direction)	121	4620	187	6696
Wind Case 4 (-M Opposite Direction)	121	4620	187	6696
Seismic X-Direction (+M)	519	25669	0	0
Seismic X-Direction (-M)	519	25669	0	0
Seismic Y-Direction (+M)	0	0	519	25669
Seismic Y-Direction (-M)	0	0	519	25669
Soil X-Direction	5653	154774	0	0
Soil Y-Direction	0	0	2693	73764

Resisting Moment X-Direction:

M_{resist} = (19019 K)*(36.4 FT)*(2/3)
= 461528 K-FT

461,528 K-FT > 73,764 K-FT

Resisting Moment Y-Direction:

M_{resist} = (19019 K)*(118 FT)*(2/3)
=1496161 K-FT

1,496,161 K-FT > 154,774 K-FT

Impact on Foundations:

The foundation of the New Library consists of individual spread footings and continuous strip footings, both of which will bear on bedrock. The foundation would be to be checked for base shear and overturning moment due to the maximum load condition. The controlling load combination for the foundation design would most likely be load combination 7 from IBC 2009:

$$0.9D + 1.0E + 1.6H$$

This is due to the fact that the soil loads cause the largest base shear and overturning moment, while seismic loads cause the second largest base shear and overturning moment.

The foundation walls in the New Library had little impact on this technical report, but the soil loads had the largest impact of all the load cases. It is also important to note that the soil loads impacted the strength and overturning moment checks, but were not considered in the drift checks. This is important because often the drift/deflection is what often controls a design. These results are a prime example of why the unique condition of the hillside cannot be overlooked in the foundation design.

Conclusion

Technical report 4 consisted of a lateral systems analysis of the New Library at the University of Virginia's College at Wise Virginia. The content consisted of an overview of the lateral model used for the distribution of forces, lateral wind, seismic, and soil forces, member spot checks, drift checks, and overturning/foundation considerations.

ETABS was used to create a lateral model which was used to distribute the forces to each lateral element. The building's design includes a large number of foundation walls, but in order to analyze the shear walls under the full lateral load the foundation walls were not included in the model. The model was verified including spot checks of shear contours and shear force distribution.

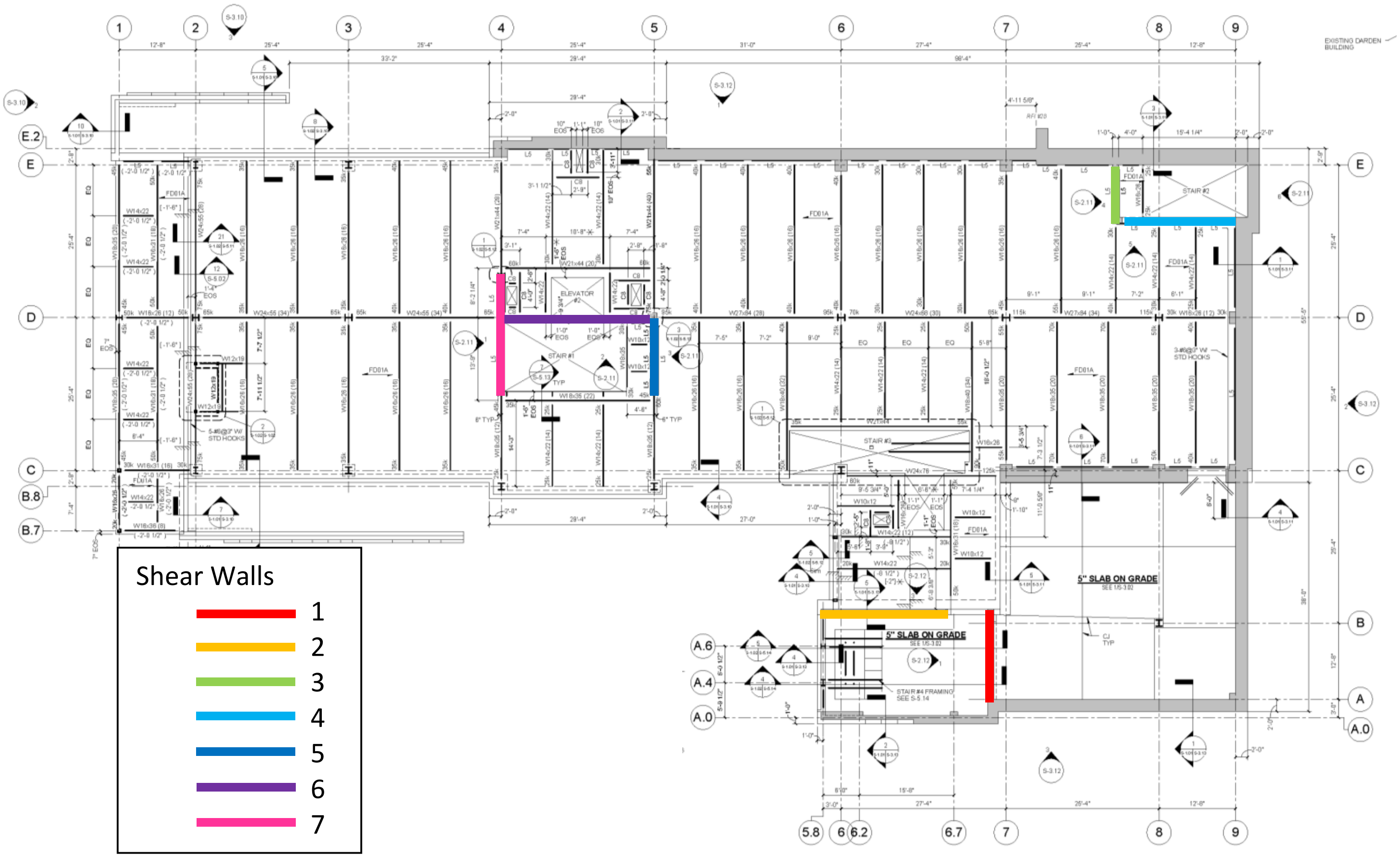
The lateral system was checked under wind, seismic, and soil loads. Soil loads resulted in the largest shear forces in the shear walls in both the x and y directions. Member spot checks were completed for two critical shear walls for the criteria of strength. Load combination seven from ASCE7-05 was determined to be the controlling load combination for both shear walls. Both shear walls passed the spot checks. Drift checks were completed for both wind and seismic service loading conditions. The lateral system passed for both checks.

Overturning moments and the impact on the foundation of the building was considered. Soil loads resulted in the largest over turning moment in both the x and y directions. It was verified that the resisting moment of the building was sufficient in both directions. Due to the large soil loads, it was determined that they will have a significant impact on the foundation. This confirmed the use of a significant amount of foundation walls used in the foundation design of the new library.

After completing a lateral system analysis of the New Library it was determined that the lateral system is sufficient to resist all lateral loading conditions.

Appendix A – Location of Shear Walls

Location of Shear Walls



Appendix B – Building Properties

Center of Mass Calculation for Level 2

Surface	Location	Thickness (in)	Length (FT)	Height (FT)	Area (FT^2)	Weight (lbs)	X Distance from (A.0, 1) Corner (FT)	Y Distance from (A.0, 1) Corner (FT)	Weight * X Distance	Weight * Y Distance
Floor System										
Floor System	1-4	-	63.3	50.7	3209	340167	31.7	66.3	10772055	22563826.83
	4-5	-	25.3	57	1444	153044	76.0	66.8	11631027	10228426.21
	5-9.05	-	97.3	50.7	4932	522779	137.3	66.3	71794979	34676826.49
	9.05-9.1	-	2.0	10.2	20	2162	187.0	87.6	404369	189354.2321
	6-9.05	-	66.3	22.8	1509	159963	152.8	29.6	24447643	4738896.556
	5.8-6.8	-	28.7	18.3	523	55456	131.0	9.1	7265720	506038.8424
	6.8-9.05	-	40.7	16.3	661	70049	165.7	10.1	11603602	707493.9658
Shear Walls										
SW1	6.8 - Level 1	16	18.3	9	164.3	32850	144.3	9.1	4740255	299756
	6.8 - Level 2	12	18.3	9	164.3	24638	144.3	9.1	3555191	224817
SW2	B.1 -Level 1	33	28.7	9	258.0	106424	131.0	18.3	13941481	1942231
	B.1 -Level 2	12	21.7	9	195.0	29255	127.5	18.3	3729949	533895
SW3	7.1	12	9.2	18	165.4	24806	165.1	87.1	4096603	2159929
SW4	D.2	12	22.9	18	411.4	61706	176.6	82.5	10895667	5089490
SW5	5	12	12.9	18	232.9	34931	88.7	59.9	3097239	2091144
SW6	D	12	25.3	18	456.0	68400	76.0	66.3	5198397	4537192
SW7	4	12	20.3	18	364.9	54731	63.3	63.5	3466328	3477156
SW8	-	-	-	-	-	-	-	-	-	-
SW9	-	-	-	-	-	-	-	-	-	-
Foundation Walls										
FW E.2	E.2 - Level 1	24	25.3	9	228.0	68399	76.0	94.3	5198332	6452313
	E.2 - Level 2	16	25.3	9	228.0	45599	76.0	94.3	3465554	4301542
FW 4	4 - Level 1	24	2.7	9	24.0	7201	66.3	93.0	477659	669683
	4 - Level 2	16	2.7	9	24.0	4801	66.3	93.0	318440	446455
FW 5	4 - Level 1	24	2.7	9	24.0	7201	88.7	93.0	638480	669683
	4 - Level 2	16	2.7	9	24.0	4801	88.7	93.0	425653	446455
FW E	E - Level 1 (1-4)	16	63.3	9	570.0	114000	31.7	91.7	3609996	10449998
	E - Level 1 (5-7.05)	24	63.3	9	569.7	170916	120.3	91.7	20564189	15667275
	E - Level 1 (7.05-9.1)	33	36.0	9	324.3	133766	170.0	91.7	22738104	12261872
	E - Level 2 (5-7.05)	16	63.3	9	569.7	113944	120.3	91.7	13709459	10444850
	E - Level 2 (7.05-9.1)	33	36.0	9	324.3	133766	170.0	91.7	22738104	12261872
FW 9.1	9.1 - Level 1	24	10.2	9	91.7	27506	188.0	87.6	5171175	2408803
	9.1 - Level 2	24	10.2	9	91.7	27506	188.0	87.6	5171175	2408803
FW 9.05	9.05 - Level 1 (B.9-D.2)	30	42.5	9	382.3	143367	186.0	61.2	26666318	8779756
	9.05 - Level 1 (A.05-B.9)	24	38.0	9	342.0	102600	186.0	21.0	19083600	2154600
	9.05 - Level 2 (B.9-D.2)	24	42.5	9	382.3	114694	186.0	61.2	21333054	7023805
	9.05 - Level 2 (A.05-B.9)	24	38.0	9	342.0	102600	186.0	21.0	19083600	2154600
FW B.9	B.9 - Level 1	30	39.6	9	356.2	133594	166.2	40.0	22204378	5343746
	B.9 - Level 2	30	39.6	9	356.2	133594	166.2	40.0	22204378	5343746
FW A.05	A.05 - Level 1	24	39.0	9	351.0	105300	166.5	2.0	17532450	210600
	A.05 - Level 2	24	39.0	9	351.0	105300	166.5	2.0	17532450	210600
FW A.0	A.0 - Level 1	16	28.7	9	258.0	51600	131.0	0.0	6759584	0
	A.0 - Level 2	16	28.7	9	258.0	51600	131.0	0.0	6759584	0
FW 6.8	6.8 - Level 1	30	21.8	9	195.8	73406	146.4	29.1	10747901	2137957
FW 5.8	5.8 - Level 1	16	18.3	9	164.7	32940	116.7	9.1	3843001	300578
FW 6	6 - Level 1	16	22.8	9	205.2	41040	119.7	29.6	4911121	1215810
FW B.9	B.9 - Level 1 (2-4)	16	50.7	9	456.0	91201	38.0	41.0	3465623	3739225
	B.9 - Level 1 (5-6)	16	31.0	9	279.0	55800	104.2	41.0	5812502	2287800
FW 4	4 - Level 1	16	2.7	9	24.0	4801	66.3	39.7	318440	190424
FW 5	5 - Level 1	16	2.7	9	24.3	4860	88.7	39.7	430920	192780
FW B.8	B.8 - Level 1	16	25.3	9	228.0	45599	76.0	38.3	3465554	1747975
Exterior Walls										
EW 1	1 - Level 1	-	52.7	9	474.0	46926	0.0	66.3	0	3112761
EW 2	2 - Level 2	-	50.7	9	456.0	45144	12.7	66.3	571843	2994572
EW B.9	B.9 - Level 1	-	12.7	9	114.0	11286	6.3	40.0	71482	451452
	C - Level 2 (2-4)	-	50.7	9	456.0	45144	38.0	41.0	1715483	1850916
	C - Level 2 (5-6)	-	31.0	9	279.0	27621	104.2	41.0	2877188	1132461
EW B.8	B.8 - Level 2 (4-5)	-	25.3	9	228.0	22572	76.0	38.3	1715449	865248
EW 4	4 - Level 2	-	2.7	9	24.0	2376	66.3	39.7	157628	94260
EW 5	5 - Level 2	-	2.7	9	24.3	2406	88.7	39.7	213305	95426
EW 6	6 - Level 2 (B.1-C)	-	22.8	9	204.8	20270	119.7	29.6	2425674	600506
EW 5.8	5.8 - Level 2 (A-B.1)	-	18.3	9	164.3	16261	116.7	9.1	1897088	148379
EW E	E - Level 2 (2-4)	-	50.7	9	456.0	45144	38.0	91.7	1715483	4138224
Openings										
Opening 1	Elevator Btw 4 and 5	-	-	-	44.6	-4731	75.9	69.5	-359145	-328986
Opening 2	Column Line 4	-	-	-	-	-	-	-	-	-
Opening 3	Column Line 5	-	-	-	-	-	-	-	-	-
Opening 4	Stair Btw 4 and 5	-	-	-	273.8	-29018	75.2	59.7	-2181150	-1731378
Opening 5	Column Line 6	-	-	-	-	-	-	-	-	-
Opening 6	Elevator Btw 6 and 7	-	-	-	65.8	-6978	133.4	34.1	-930688	-237833
Opening 7	Stair Btw 6 and 7	-	-	-	-	-	-	-	-	-
Opening 8	Stair Btw 7 and 9	-	-	-	141.3	-14979	178.2	87.2	-2669357	-1306281
Opening 9	Along C	-	-	-	217.0	-23002	125.2	44.5	-2879084	-1023589
					SUM=	4201104		SUM=	511362484	226746218

Center of Mass	
X-Direction	121.7
Y-Direction	54.0

Center of Mass Calculation for Level 3

Surface	Location	Thickness (in)	Length (FT)	Height (FT)	Area (FT^2)	Weight (lbs)	X Distance from (A.0, 1) Corner (FT)	Y Distance from (A.0, 1) Corner (FT)	Weight * X Distance	Weight * Y Distance
Floor System										
Floor System	2-4	-	50.7	50.7	2567	272133	38.0	66.3	10341072	18051075.71
	4-5	-	25.3	57	1444	153044	76.0	66.8	11631027	10228426.21
	5-9.05	-	97.3	50.7	4932	522779	137.3	66.3	71794979	34676826.49
	9.05-9.1	-	2.0	10.2	20	2162	187.0	87.6	404369	189354.2321
	6-9.05	-	66.3	22.8	1509	159963	152.8	29.6	24447643	4738896.556
	5.8-6.8	-	28.7	18.3	523	55456	131.0	9.1	7265720	506038.8424
	6.8-9.05	-	40.7	16.3	661	70049	165.7	10.1	11603602	707493.9658
Shear Walls										
SW1	6.8	12	18.3	17	310.3	46538	145.3	9.1	6763434	424655
SW2	B.1	12	21.7	17	368.4	55259	127.5	18.3	7045459	1008468
SW3	7.1	12	9.2	17	156.2	23428	165.1	87.1	3869014	2039933
SW4	D.2	12	22.9	17	388.5	58278	176.6	82.5	10290353	4806740
SW5	5	12	12.9	17	219.9	32991	88.7	59.9	2925170	1974969
SW6	D	12	25.3	17	430.7	64600	76.0	66.3	4909597	4285126
SW7	4	12	20.3	17	344.6	51691	63.3	63.5	3273754	3283981
SW8	-	-	-	-	-	-	-	-	-	-
SW9	-	-	-	-	-	-	-	-	-	-
Foundation Walls										
FW E.2	E.2 - Level 2	16	25.3	9	228.0	45599	76.0	94.3	3465554	4301542
FW 4	4 - Level 2	16	2.7	9	24.0	4801	66.3	93.0	318440	446455
FW 5	4 - Level 2	16	2.7	9	24.0	4801	88.7	93.0	425653	446455
FW E	E - Level 2 (5-7.05)	16	63.3	9	569.7	113944	120.3	91.7	13709459	10444850
	E - Level 2 (7.05-9.1)	33	36.0	9	324.3	133766	170.0	91.7	22738104	12261872
	E - Level 3	30	36.0	8	288.2	108094	170.0	91.7	18374226	9908584
FW 9.1	9.1 - Level 2	24	10.2	9	91.7	27506	188.0	87.6	5171175	2408803
	9.1 - Level 3	24	10.2	8	81.5	24450	188.0	87.6	4596600	2141159
FW 9.05	9.05 - Level 2 (B.9-D.2)	24	42.5	9	382.3	114694	186.0	61.2	21333054	7023805
	9.05 - Level 2 (A.05-B.9)	24	38.0	9	342.0	102600	186.0	21.0	19083600	2154600
	9.05 - Level 3	24	80.5	8	643.8	193150	186.0	42.2	35925915	8158582
FW B.9	B.9 - Level 2	30	39.6	9	356.2	133594	166.2	40.0	22204378	5343746
FW A.05	A.05 - Level 2	24	39.0	9	351.0	105300	166.5	2.0	17532450	210600
	A.05 - Level 3	24	39.0	8	312.0	93600	166.5	2.0	15584400	187200
FW A.0	A.0 - Level 2	16	28.7	9	258.0	51600	131.0	0.0	6759584	0
Exterior Walls										
EW 2	2 - Level 2	-	50.7	9	456.0	45144	12.7	66.3	571843	2994572
	2 - Level 3	-	50.7	8	405.3	40128	12.7	66.3	508305	2661842
EW B.9	C - Level 2 (2-4)	-	50.7	9	456.0	45144	38.0	41.0	1715483	1850916
	C - Level 2 (5-6)	-	31.0	9	279.0	27621	104.2	41.0	2877188	1132461
	C - Level 3 (2-4)	-	50.7	8	405.3	40128	38.0	41.0	1524874	1645259
	C - Level 3 (5-6)	-	31.0	8	248.0	24552	104.2	41.0	2557501	1006632
EW B.8	B.8 - Level 2 (4-5)	-	25.3	9	228.0	22572	76.0	38.3	1715449	865248
	B.8 - Level 3 (4-5)	-	25.3	8	202.7	20064	76.0	38.3	1524844	769109
EW 4 (Bottom)	4 - Level 2	-	2.7	9	24.0	2376	66.3	39.7	157628	94260
	4 - Level 3	-	2.7	8	21.3	2112	66.3	39.7	140113	83787
EW 5 (Bottom)	5 - Level 2	-	2.7	9	24.3	2406	88.7	39.7	213305	95426
	5 - Level 3	-	2.7	8	21.6	2138	88.7	39.7	189605	84823
EW 6	6 - Level 2 (B.1-C)	-	22.8	9	204.8	20270	119.7	29.6	2425674	600506
	6 - Level 3 (B.1-C)	-	22.8	8	182.0	18018	119.7	29.6	2156155	533783
EW 5.8	5.8 - Level 2 (A-B.1)	-	18.3	9	164.3	16261	116.7	9.1	1897088	148379
	5.8 - Level 3 (A-B.1)	-	18.3	8	146.0	14454	116.7	9.1	1686300	131893
EW A.0	A.0 - Level 3 (5.8 -6.8)	-	28.7	8	229.3	22704	131.0	0.0	2974183	0
EW E	E - Level 2 (2-4)	-	50.7	9	456.0	45144	38.0	91.7	1715483	4138224
	E - Level 3 (2-4)	-	50.7	8	405.3	40128	38.0	91.7	1524874	3678422
	E - Level 3 (5-7.05)	-	63.3	8	506.4	50135	120.3	91.7	6032162	4595729
EW E.2	E.2 - Level 3	-	25.3	8	202.7	20064	76.0	94.3	1524844	1892678
EW 4 (Top)	4 - Level 3	-	2.7	8	21.3	2112	66.3	93.0	140098	196418
EW 5 (Top)	5 - Level 3	-	2.7	8	21.3	2112	88.7	93.0	187266	196418
Openings										
Opening 1	Elevator Btw 4 and 5	-	-	-	44.6	-4731	75.9	69.5	-359145	-328986
Opening 2	Column Line 4	-	-	-	40.7	-4313	67.8	69.5	-292395	-299943
Opening 3	Column Line 5	-	-	-	44.63	-4731	84.4	69.5	-399357	-328986
Opening 4	Stair Btw 4 and 5	-	-	-	273.8	-29018	75.2	59.7	-2181150	-1731378
Opening 5	Column Line 6	-	-	-	58.9	-6243	125.0	32.0	-780165	-199528
Opening 6	Elevator Btw 6 and 7	-	-	-	65.8	-6978	133.4	34.1	-930688	-237833
Opening 7	Stair Btw 6 and 7	-	-	-	366.01	-38797	127.5	9.2	-4947838	-356349
Opening 8	Stair Btw 7 and 9	-	-	-	112.1	-11878	172.5	87.2	-2049512	-1035892
Opening 9	Along C	-	-	-	-	-	-	-	-	-
					SUM=	3244967		SUM=	407807802	177238126

Center of Mass	
X-Direction	125.7
Y-Direction	54.6

Center of Mass Calculation for Level 4

Surface	Location	Thickness (in)	Length (FT)	Height (FT)	Area (FT^2)	Weight (lbs)	X Distance from (A.0, 1) Corner (FT)	Y Distance from (A.0, 1) Corner (FT)	Weight * X Distance	Weight * Y Distance
Floor System										
Floor System	2-4	-	50.7	50.7	2567	272133	38.0	66.3	10341072	18051075.71
	4-5	-	25.3	57	1444	153044	76.0	66.8	11631027	10228426.21
	5-9.05	-	97.3	50.7	4932	522779	137.3	66.3	71794979	34676826.49
	9.05-9.1	-	2.0	10.2	20	2162	187.0	87.6	404369	189354.2321
	6-9.05	-	66.3	22.8	1509	159963	152.8	29.6	24447643	4738896.556
	5.8-6.8	-	28.7	18.3	523	55456	131.0	9.1	7265720	506038.8424
	6.8-9.05	-	40.7	16.3	661	70049	165.7	10.1	11603602	707493.9658
Shear Walls										
SW1	6.8	12	18.3	16	292.0	43800	145.3	9.1	6365585	399675
SW2	B.1	12	21.7	16	346.7	52008	127.5	18.3	6631020	949146
SW3	7.1	12	9.2	16	147.0	22050	165.1	87.1	3641425	1919937
SW4	D.2	12	22.9	16	365.7	54850	176.6	82.5	9685038	4523991
SW5	5	12	12.9	16	207.0	31050	88.7	59.9	2753101	1858794
SW6	D	12	25.3	16	405.3	60800	76.0	66.3	4620797	4033059
SW7	4	12	20.3	16	324.3	48650	63.3	63.5	3081180	3090805
SW8	-	-	-	-	-	-	-	-	-	-
SW9	-	-	-	-	-	-	-	-	-	-
Foundation Walls										
FW E	E - Level 3	30	36.0	8	288.2	108094	170.0	91.7	18374226	9908584
	E - Level 4	16	36.0	8	288.2	57650	170.0	91.7	9799587	5284578
FW 9.1	9.1 - Level 3	24	10.2	8	81.5	24450	188.0	87.6	4596600	2141159
	9.1 - Level 4	24	10.2	8	81.5	24450	188.0	87.6	4596600	2141159
FW 9.05	9.05 - Level 3	24	80.5	8	643.8	193150	186.0	42.2	35925915	8158582
	9.05 - Level 4	24	41.5	8	331.8	99550	186.0	61.7	18516315	6146182
FW A.05	A.05 - Level 3	24	39.0	8	312.0	93600	166.5	2.0	15584400	187200
Exterior Walls										
EW 2	2 - Level 3	-	50.7	8	405.3	40128	12.7	66.3	508305	2661842
	3 - Level 4	-	50.7	8	405.3	40128	38.0	66.3	1524874	2661842
EW B.9	C - Level 3 (2-4)	-	50.7	8	405.3	40128	38.0	41.0	1524874	1645259
	C - Level 3 (5-6)	-	31.0	8	248.0	24552	104.2	41.0	2557501	1006632
	C - Level 4 (3-4)	-	25.3	8	202.7	20064	50.7	41.0	1016576	822623
	C - Level 4 (5-6)	-	31.0	8	248.0	24552	104.2	41.0	2557501	1006632
EW B.8	B.8 - Level 3 (4-5)	-	25.3	8	202.7	20064	76.0	38.3	1524844	769109
	B.8 - Level 4 (4-5)	-	25.3	8	202.7	20064	76.0	38.3	1524844	769109
EW 4 (Bottom)	4 - Level 3	-	2.7	8	21.3	2112	66.3	39.7	140113	83787
	4 - Level 4	-	2.7	8	21.3	2112	66.3	39.7	140113	83787
EW 5 (Bottom)	5 - Level 3	-	2.7	8	21.6	2138	88.7	39.7	189605	84823
	5 - Level 4	-	2.7	8	21.6	2138	88.7	39.7	189605	84823
EW 6	6 - Level 3 (B.1-C)	-	22.8	8	182.0	18018	119.7	29.6	2156155	533783
	6 - Level 4 (B.1-C)	-	22.8	8	182.0	18018	119.7	29.6	2156155	533783
EW 5.8	5.8 - Level 3 (A-B.1)	-	18.3	8	146.0	14454	116.7	9.1	1686300	131893
	5.8 - Level 4 (A-B.1)	-	18.3	8	146.0	14454	116.7	9.1	1686300	131893
EW A.0	A.0 - Level 3 (5.8 -6.8)	-	28.7	8	229.3	22704	131.0	0.0	2974183	0
	A.0 - Level 4 (5.8 -6.8)	-	28.7	8	229.3	22704	131.0	0.0	2974183	0
EW E	E - Level 3 (2-4)	-	50.7	8	405.3	40128	38.0	91.7	1524874	3678422
	E - Level 3 (5-7.05)	-	63.3	8	506.4	50135	120.3	91.7	6032162	4595729
	E - Level 4 (3-4)	-	25.3	8	202.7	20064	50.7	91.7	1016563	1839174
	E - Level 4 (5-7.05)	-	63.3	8	506.4	50135	120.3	91.7	6032162	4595729
EW E.2	E.2 - Level 3	-	25.3	8	202.7	20064	76.0	94.3	1524844	1892678
	E.2 - Level 4	-	25.3	8	202.7	20064	76.0	94.3	1524844	1892678
EW 4 (Top)	4 - Level 3	-	2.7	8	21.3	2112	66.3	93.0	140098	196418
	4 - Level 4	-	2.7	8	21.3	2112	66.3	93.0	140098	196418
EW 5 (Top)	5 - Level 3	-	2.7	8	21.3	2112	88.7	93.0	187266	196418
	5 - Level 4	-	2.7	8	21.3	2112	88.7	93.0	187266	196418
EW B	B - Level 4	-	40.7	8	325.3	32208	165.7	15.7	5335796	504603
EW 9.05	9.05 - Level 4	-	25.3	8	202.7	20064	186.0	28.3	3731899	568480
Openings										
Opening 1	Elevator Btw 4 and 5	-	-	-	44.6	-4731	75.9	69.5	-359145	-328986
Opening 2	Column Line 4	-	-	-	40.7	-4313	67.8	69.5	-292395	-299943
Opening 3	Column Line 5	-	-	-	44.63	-4731	84.4	69.5	-399357	-328986
Opening 4	Stair Btw 4 and 5	-	-	-	273.8	-29018	75.2	59.7	-2181150	-1731378
Opening 5	Column Line 6	-	-	-	58.9	-6243	125.0	32.0	-780165	-199528
Opening 6	Elevator Btw 6 and 7	-	-	-	65.8	-6978	133.4	34.1	-930688	-237833
Opening 7	Stair Btw 6 and 7	-	-	-	366.01	-38797	127.5	9.2	-4947838	-356349
Opening 8	Stair Btw 7 and 9	-	-	-	141.3	-14979	178.2	87.2	-2669357	-1306281
Opening 9	Along C	-	-	-	-	-	-	-	-	-
					SUM=	2649792		SUM=	323510009	148416464

Center of Mass	
X-Direction	122.1
Y-Direction	56.0

Center of Mass Calculation for Level 5

Surface	Location	Thickness (in)	Length (FT)	Height (FT)	Area (FT^2)	Weight (lbs)	X Distance from (A.0, 1) Corner (FT)	Y Distance from (A.0, 1) Corner (FT)	Weight * X Distance	Weight * Y Distance
Floor System										
Floor System	3-4	-	25.3	50.7	1283	136048	50.7	66.3	6892869	9024290.9
	4-5	-	25.3	57	1444	153044	76.0	66.8	11631027	10228426.2
	5-9.05	-	97.3	50.7	4932	522779	137.3	66.3	71794979	34676826.5
	9.05-9.1	-	2.0	10.2	20	2162	187.0	87.6	404369	189354.2
	6-9.05	-	66.3	22.8	1509	159963	152.8	29.6	24447643	4738896.6
	5.8-6.8	-	28.7	18.3	523	55456	131.0	9.1	7265720	506038.8
	6.8-9.05	-	40.7	2.6	105	11135	165.7	17.0	1844437	188822.9
Shear Walls										
SW1	6.8	12	18.3	16	292.0	43800	145.3	9.1	6365585	399675
SW2	B.1	12	21.7	16	346.7	52008	127.5	18.3	6631020	949146
SW3	7.1	12	9.2	8	73.5	11025	165.1	87.1	1820713	959968
SW4	D.2	12	22.9	16	365.7	54850	176.6	82.5	9685038	4523991
SW5	5	12	12.9	16	207.0	31050	88.7	59.9	2753101	1858794
SW6	D	12	25.3	16	405.3	60800	76.0	66.3	4620797	4033059
SW7	4	12	20.3	16	324.3	48650	63.3	63.5	3081180	3090805
SW8	9.1 - Level 5	12	10.2	8	81.5	12225	188.0	87.6	2298300	1070579
SW9	E.1 - Level 5	12	22.3	8	178.0	26705	176.9	92.7	4723398	2474668
Foundation Walls										
FW E	E - Level 4	16	36.0	8	288.2	57650	170.0	91.7	9799587	5284578
FW 9.1	9.1 - Level 4	24	10.2	8	81.5	24450	188.0	87.6	4596600	2141159
FW 9.05	9.05 - Level 4	24	41.5	8	331.8	99550	186.0	61.7	18516315	6146182
Exterior Walls										
EW 2	3 - Level 4	-	50.7	8	405.3	40128	38.0	66.3	1524874	2661842
	3 - Level 5	-	50.7	8	405.3	40128	38.0	66.3	1524874	2661842
EW B.9	C - Level 4 (3-4)	-	25.3	8	202.7	20064	50.7	41.0	1016576	822623
	C - Level 4 (5-6)	-	31.0	8	248.0	24552	104.2	41.0	2557501	1006632
	C - Level 5 (3-4)	-	25.3	8	202.7	20064	50.7	41.0	1016576	822623
	C - Level 5 (5-6)	-	31.0	8	248.0	24552	104.2	41.0	2557501	1006632
EW B.8	B.8 - Level 4 (4-5)	-	25.3	8	202.7	20064	76.0	38.3	1524844	769109
	B.8 - Level 5 (4-5)	-	25.3	8	202.7	20064	76.0	38.3	1524844	769109
EW 4 (Bottom)	4 - Level 4	-	2.7	8	21.3	2112	66.3	39.7	140113	83787
	4 - Level 5	-	2.7	8	21.3	2112	66.3	39.7	140113	83787
EW 5 (Bottom)	5 - Level 4	-	2.7	8	21.6	2138	88.7	39.7	189605	84823
	5 - Level 5	-	2.7	8	21.6	2138	88.7	39.7	189605	84823
EW 6	6 - Level 4 (B.1-C)	-	22.8	8	182.0	18018	119.7	29.6	2156155	533783
	6 - Level 5 (B.1-C)	-	22.8	8	182.0	18018	119.7	29.6	2156155	533783
EW 5.8	5.8 - Level 4 (A-B.1)	-	18.3	8	146.0	14454	116.7	9.1	1686300	131893
	5.8 - Level 5 (A-B.1)	-	18.3	8	146.0	14454	116.7	9.1	1686300	131893
EW A.0	A.0 - Level 4 (5.8 -6.8)	-	28.7	8	229.3	22704	131.0	0.0	2974183	0
	A.0 - Level 5 (5.8 -6.8)	-	28.7	8	229.3	22704	131.0	0.0	2974183	0
EW E	E - Level 4 (3-4)	-	25.3	8	202.7	20064	50.7	91.7	1016563	1839174
	E - Level 4 (5-7.05)	-	63.3	8	506.4	50135	120.3	91.7	6032162	4595729
	E - Level 5 (3-4)	-	25.3	8	202.7	20064	50.7	91.7	1016563	1839174
	E - Level 5 (5-7.1)	-	76.5	8	611.8	60571	127.5	91.7	7723181	5552357
EW E.2	E.2 - Level 4	-	25.3	8	202.7	20064	76.0	94.3	1524844	1892678
	E.2 - Level 5	-	25.3	8	202.7	20064	76.0	94.3	1524844	1892678
EW 4 (Top)	4 - Level 4	-	2.7	8	21.3	2112	66.3	93.0	140098	196418
	4 - Level 5	-	2.7	8	21.3	2112	66.3	93.0	140098	196418
EW 5 (Top)	5 - Level 4	-	2.7	8	21.3	2112	88.7	93.0	187266	196418
	5 - Level 5	-	2.7	8	21.3	2112	88.7	93.0	187266	196418
EW B	B - Level 4	-	40.7	8	325.3	32208	165.7	15.7	5335796	504603
	B - Level 5	-	27.0	8	216.0	21384	158.8	15.7	3396491	335023
EW 8	8 - Level 5	-	25.3	8	202.7	20064	28.3	172.3	568480	3457691
EW C	C - Level 5	-	12.7	8	101.3	10032	178.7	41.0	1792387	411313
EW 9.05	9.05 - Level 4	-	25.3	8	202.7	20064	186.0	28.3	3731899	568480
	9.05 - Level 5	-	41.5	8	331.8	32852	186.0	61.7	6110384	2028240
Openings										
Opening 1	Elevator Btw 4 and 5	-	-	-	44.6	-4731	75.9	69.5	-359145	-328986
Opening 2	Column Line 4	-	-	-	40.7	-4313	67.8	69.5	-292395	-299943
Opening 3	Column Line 5	-	-	-	44.63	-4731	84.4	69.5	-399357	-328986
Opening 4	Stair Btw 4 and 5	-	-	-	273.8	-29018	75.2	59.7	-2181150	-1731378
Opening 5	Column Line 6	-	-	-	58.9	-6243	125.0	32.0	-780165	-199528
Opening 6	Elevator Btw 6 and 7	-	-	-	65.8	-6978	133.4	34.1	-930688	-237833
Opening 7	Stair Btw 6 and 7	-	-	-	366.01	-38797	127.5	9.2	-4947838	-356349
Opening 8	Stair Btw 7 and 9	-	-	-	112.1	-11878	172.5	87.2	-2049512	-1035892
Opening 9	Along C	-	-	-	-	-	-	-	-	-
					SUM=	2121143		SUM=	255201053	125858164

Center of Mass	
X-Direction	120.3
Y-Direction	59.3

Center of Mass Calculation for Level 6

Surface	Location	Thickness (in)	Length (FT)	Height (FT)	Area (FT^2)	Weight (lbs)	X Distance from (A.0, 1) Corner (FT)	Y Distance from (A.0, 1) Corner (FT)	Weight * X Distance	Weight * Y Distance
Floor System										
Floor System	3-4	-	50.7	50.7	2567	272133	38.0	66.3	10341072	18051075.7
	4-5	-	25.3	57	1444	153044	76.0	66.8	11631027	10228426.2
	5-9.05	-	97.3	50.7	4932	522779	137.3	66.3	71794979	34676826.5
	9.05-9.1	-	2.0	10.2	20	2162	187.0	87.6	404369	189354.2
	6-8	-	52.7	22.8	1198	127006	146.0	29.6	18542839	3762545.3
	5.8-6.8	-	28.7	18.3	523	55456	131.0	9.1	7265720	506038.8
	6.8-8	-	27.0	2.6	70	7393	158.8	17.0	1174182	125365.0
Shear Walls										
SW1	6.8	12	18.3	17	310.3	46538	145.3	9.1	6763434	424655
SW2	B.1	12	21.7	17	368.4	55259	127.5	18.3	7045459	1008468
SW3	-	-	-	-	-	-	-	-	-	-
SW4	D.2 - Level 5	12	22.9	8	182.8	27425	176.6	82.5	4842519	2261995
	D.2 - Level 6	12	18.3	9	165.0	24750	178.8	82.5	4426117	2041356
SW5	5	12	12.9	17	219.9	32991	88.7	59.9	2925170	1974969
SW6	D	12	25.3	17	430.7	64600	76.0	66.3	4909597	4285126
SW7	4	12	20.3	17	344.6	51691	63.3	63.5	3273754	3283981
SW8	9.1	12	10.2	17	173.2	25978	188.0	87.6	4883888	2274981
SW9	E.1 - Level 5	12	22.3	17	378.3	56748	176.9	92.7	10037220	5258669
Foundation Walls										
-	-	-	-	-	-	-	-	-	-	-
Exterior Walls										
EW 2	3 - Level 5	-	50.7	8	405.3	40128	38.0	66.3	1524874	2661842
	3 - Level 6	-	50.7	9	456.0	45144	38.0	66.3	1715483	2994572
EW B.9	C - Level 5 (3-4)	-	25.3	8	202.7	20064	50.7	41.0	1016576	822623
	C - Level 5 (5-6)	-	31.0	8	248.0	24552	104.2	41.0	2557501	1006632
	C - Level 6 (3-4)	-	25.3	9	228.0	22572	50.7	41.0	1143648	925451
	C - Level 6 (5-6)	-	31.0	9	279.0	27621	104.2	41.0	2877188	1132461
EW B.8	B.8 - Level 5 (4-5)	-	25.3	8	202.7	20064	76.0	38.3	1524844	769109
	B.8 - Level 6 (4-5)	-	25.3	9	228.0	22572	76.0	38.3	1715449	865248
EW 4 (Bottom)	4 - Level 5	-	2.7	8	21.3	2112	66.3	39.7	140113	83787
	4 - Level 6	-	2.7	9	24.0	2376	66.3	39.7	157628	94260
EW 5 (Bottom)	5 - Level 5	-	2.7	8	21.6	2138	88.7	39.7	189605	84823
	5 - Level 6	-	2.7	9	24.3	2406	88.7	39.7	213305	95426
EW 6	6 - Level 5 (B.1-C)	-	22.8	8	182.0	18018	119.7	29.6	2156155	533783
	6 - Level 6 (B.1-C)	-	22.8	9	204.8	20270	119.7	29.6	2425674	600506
EW 5.8	5.8 - Level 5 (A-B.1)	-	18.3	8	146.0	14454	116.7	9.1	1686300	131893
	5.8 - Level 6 (A-B.1)	-	18.3	9	164.3	16261	116.7	9.1	1897088	148379
EW A.0	A.0 - Level 5 (5.8 -6.8)	-	28.7	8	229.3	22704	131.0	0.0	2974183	0
	A.0 - Level 6 (5.8 -6.8)	-	28.7	9	258.0	25542	131.0	0.0	3345955	0
EW E	E - Level 5 (3-4)	-	25.3	8	202.7	20064	50.7	91.7	1016563	1839174
	E - Level 5 (5-7.1)	-	76.5	8	611.8	60571	127.5	91.7	7723181	5552357
	E - Level 6 (3-4)	-	25.3	9	228.0	22572	50.7	91.7	1143634	2069071
	E - Level 6 (5-7.1)	-	76.5	9	688.3	68143	127.5	91.7	8688578	6246401
EW E.2	E.2 - Level 5	-	25.3	8	202.7	20064	76.0	94.3	1524844	1892678
	E.2 - Level 6	-	25.3	9	228.0	22572	76.0	94.3	1715449	2129263
EW 4 (Top)	4 - Level 5	-	2.7	8	21.3	2112	66.3	93.0	140098	196418
	4 - Level 6	-	2.7	9	24.0	2376	66.3	93.0	157610	220971
EW 5 (Top)	5 - Level 5	-	2.7	8	21.3	2112	88.7	93.0	187266	196418
	5 - Level 6	-	2.7	9	24.0	2376	88.7	93.0	210675	220971
EW B	B - Level 5	-	27.0	8	216.0	21384	158.8	15.7	3396491	335023
EW A	A - Level 6		39.7	9	357.0	35343	165.2	3	5837489.816	106029
EW 8	8 - Level 5	-	25.3	8	202.7	20064	28.3	172.3	568480	3457691
EW 9.05	9.05 - Level 5	-	41.5	8	331.8	32852	186.0	61.7	6110384	2028240
	9.05 - Level 6	-	79.5	9	715.3	70816	186.0	42.7	13171770	3026646
Openings										
Opening 1	Elevator Btw 4 and 5	-	-	-	44.6	-4731	75.9	69.5	-359145	-328986
Opening 2	Column Line 4	-	-	-	40.7	-4313	67.8	69.5	-292395	-299943
Opening 3	Column Line 5	-	-	-	44.63	-4731	84.4	69.5	-399357	-328986
Opening 4	Stair Btw 4 and 5	-	-	-	273.8	-29018	75.2	59.7	-2181150	-1731378
Opening 5	Column Line 6	-	-	-	58.9	-6243	125.0	32.0	-780165	-199528
Opening 6	Elevator Btw 6 and 7	-	-	-	65.8	-6978	133.4	34.1	-930688	-237833
Opening 7	Stair Btw 6 and 7	-	-	-	366.01	-38797	127.5	9.2	-4947838	-356349
Opening 8	Stair Btw 7 and 9	-	-	-	141.3	-14979	178.2	87.2	-2669357	-1306281
Opening 9	Along C	-	-	-	-	-	-	-	-	-
					SUM=	2168580		SUM=	238555335	128032694

Center of Mass	
X-Direction	110.0
Y-Direction	59.0

Center of Mass Calculation for Level Roof

Surface	Location	Thickness (in)	Length (FT)	Height (FT)	Area (FT^2)	Weight (lbs)	X Distance from (A.0, 1) Corner (FT)	Y Distance from (A.0, 1) Corner (FT)	Weight * X Distance	Weight * Y Distance
Floor System										
Floor System	3-4	-	50.7	50.7	2567	300374	38.0	66.3	11414202	19924300.6
	4-5	-	25.3	57	1444	168926	76.0	66.8	12838021	11289866.7
	5-9.05	-	97.3	50.7	4932	577030	137.3	66.3	79245401	38275365.1
	9.05-9.1	-	2.0	10.2	20	2387	187.0	87.6	446332	209004.2
	6-9.05	-	66.3	22.8	1509	176563	152.8	29.6	26984663	5230668.8
	5.8-6.8	-	28.7	18.3	523	61211	131.0	9.1	8019709	558552.3
	6.8-9.05	-	40.7	16.3	661	77318	165.7	10.1	12807749	780913.2
Shear Walls										
SW1	6.8	12	18.3	9	164.3	24638	145.3	9.1	3580642	224817
SW2	B.1	12	21.7	9	195.0	29255	127.5	18.3	3729949	533895
SW3	-	-	-	-	-	-	-	-	-	-
SW4	D.2	12	18.3	9	165.0	24750	178.8	82.5	4426117	2041356
SW5	5	12	12.9	9	116.4	17466	88.7	59.9	1548619	1045572
SW6	D	12	25.3	9	228.0	34200	76.0	66.3	2599198	2268596
SW7	4	12	20.3	9	182.4	27366	63.3	63.5	1733164	1738578
SW8	9.1	12	10.2	9	91.7	13753	188.0	87.6	2585588	1204402
SW9	E.1 - Level 5	12	22.3	9	200.3	30043	176.9	92.7	5313823	2784001
Foundation Walls										
-	-	-	-	-	-	-	-	-	-	-
Exterior Walls										
EW 2	3 - Level 6	-	50.7	9	456.0	45144	38.0	66.3	1715483	2994572
EW B.9	C - Level 6 (3-4)	-	25.3	9	228.0	22572	50.7	41.0	1143648	925451
	C - Level 6 (5-6)	-	31.0	9	279.0	27621	104.2	41.0	2877188	1132461
EW B.8	B.8 - Level 6 (4-5)	-	25.3	9	228.0	22572	76.0	38.3	1715449	865248
EW 4 (Bottom)	4 - Level 6	-	2.7	9	24.0	2376	66.3	39.7	157628	94260
EW 5 (Bottom)	5 - Level 6	-	2.7	9	24.3	2406	88.7	39.7	213305	95426
EW 6	6 - Level 6 (B.1-C)	-	22.8	9	204.8	20270	119.7	29.6	2425674	600506
EW 5.8	5.8 - Level 6 (A-B.1)	-	18.3	9	164.3	16261	116.7	9.1	1897088	148379
EW A.0	A.0 - Level 5 (5.8 -6.8)	-	28.7	8	229.3	22704	131.0	0.0	2974183	0
	A.0 - Level 6 (5.8 -6.8)	-	28.7	9	258.0	25542	131.0	0.0	3345955	0
EW E	E - Level 6 (3-4)	-	25.3	9	228.0	22572	50.7	91.7	1143634	2069071
	E - Level 6 (5-7.1)	-	76.5	9	688.3	68143	127.5	91.7	8688578	6246401
EW E.2	E.2 - Level 6	-	25.3	9	228.0	22572	76.0	94.3	1715449	2129263
EW 4 (Top)	4 - Level 6	-	2.7	9	24.0	2376	66.3	93.0	157610	220971
EW 5 (Top)	5 - Level 6	-	2.7	9	24.0	2376	88.7	93.0	210675	220971
EW A	A - Level 6		39.7	9	357.0	35343	165.2	3	5837489.816	106029
EW 9.05	9.05 - Level 6	-	79.5	9	715.3	70816	186.0	42.7	13171770	3026646
Openings										
Opening 1	Elevator Btw 4 and 5	-	-	-	-	-	-	-	-	-
Opening 2	Column Line 4	-	-	-	40.7	-4761	67.8	69.5	-322738	-331069
Opening 3	Column Line 5	-	-	-	44.63	-5222	84.4	69.5	-440800	-363127
Opening 4	Stair Btw 4 and 5	-	-	-	-	-	-	-	-	-
Opening 5	Column Line 6	-	-	-	58.9	-6891	125.0	32.0	-861125	-220234
Opening 6	Elevator Btw 6 and 7	-	-	-	-	-	-	-	-	-
Opening 7	Stair Btw 6 and 7	-	-	-	-	-	-	-	-	-
Opening 8	Stair Btw 7 and 9	-	-	-	123.3	-14423	174.7	88.8	-2519314	-1280606
Opening 9	Along C	-	-	-	-	-	-	-	-	-
					SUM=	1965646		SUM=	222520008	106790508

Center of Mass	
X-Direction	113.2
Y-Direction	54.3

Center of Rigidity Spot Check - Level 2

Rigidity of Shear Walls

$$k = \frac{Et}{(h/b)^3 + 3(h/b)}$$

Shear Wall	E (ksi)	h (in)	b (in)	t (in)	k (K/in)	Relative K in the X	Relative K in the Y
1	3605	216	188.0	16	11621	-	0.904
2	3605	216	260.0	33	38805	1	-
3	3605	216	110.2	12	3229	-	0.251
4	3605	216	238.3	12	12485	0.322	-
5	3605	216	155.3	12	6300	-	0.490
6	3605	216	280.0	12	15599	0.402	-
7	3605	216	243.25	12	12859	-	1.000

Shear Wall	Relative Rigidity		Distance from Zero Reference		$R_X Y$	$R_Y X$
	X - Direction	Y - Direction	X - Direction	Y - Direction		
1	-	1	145.33	7.83	-	131.34
2	1.000	-	127.50	18.25	18.25	-
3	-	0.251	165.15	87.07	-	41.47
4	0.322	-	176.07	82.48	26.54	-
5	-	0.490	88.67	59.86	-	43.44
6	0.402	-	76.00	66.33	26.66	-
7	-	1	63.33	63.53	-	63.33
SUM:	1.724	3		SUM:	71.45	279.58

	X_r	Y_r
Calculated Center of Rigidity=	105.7124	41.4516
ETABS Center of Rigidity=	102.9497	42.5432
Percent Difference=	2.6	2.6

Appendix C – Soil Loads

Lateral Soil Forces

Equivalent Fluid Pressure: 47 PCF

East Elevation

Calculation of Lateral Soil Force - East Elevation (Column Line A-C)						
Level	Wall Height Below (FT)	Wall Height Above (FT)	Total Wall Height (FT)	Length of Surface (FT)	Depth of Min Pressure at Level (FT)	Force (K)
5	0	0	0	41	0	0
4	8	0	8	41	0	62
3	9	8	17	41	8	541
2	9	9	18	41	25	1179

Calculation of Lateral Soil Force - East Elevation (Column Line C-C1)						
Level	Wall Height Below (FT)	Wall Height Above (FT)	Total Wall Height (FT)	Length of Surface (FT)	Depth of Min Pressure at Level (FT)	Force (K)
5	0	0	0	12.83	0	0
4	8	5.33	13.33	12.83	0	54
3	9	8	17	12.83	13.33	224
2	9	9	18	12.83	30.33	427

Calculation of Lateral Soil Force - East Elevation (Column Line C1-D)						
Level	Wall Height Below (FT)	Wall Height Above (FT)	Total Wall Height (FT)	Length of Surface (FT)	Depth of Min Pressure at Level (FT)	Force (K)
5	0	0	0	12.83	0	0
4	8	10.67	18.67	12.83	0	105
3	9	8	17	12.83	18.67	279
2	9	9	18	12.83	35.67	485

Calculation of Lateral Soil Force - East Elevation (Column Line D-E2)						
Level	Wall Height Below (FT)	Wall Height Above (FT)	Total Wall Height (FT)	Length of Surface (FT)	Depth of Min Pressure at Level (FT)	Force (K)
5	8	0	8	28.08	0	42
4	8	8	16	28.08	8	338
3	9	8	17	28.08	24	729
2	9	9	18	28.08	41	1188

North Elevation

Calculation of Lateral Soil Force - North Elevation (Column Line 9.2-8)						
Level	Wall Height Below (FT)	Wall Height Above (FT)	Total Wall Height (FT)	Length of Surface (FT)	Depth of Min Pressure at Level (FT)	Force (K)
5	8	0	8	16.67	0	25
4	8	8	16	16.67	8	201
3	9	8	17	16.67	25	446
2	9	9	18	16.67	41	705

Calculation of Lateral Soil Force - North Elevation (Column Line 8-7)						
Level	Wall Height Below (FT)	Wall Height Above (FT)	Total Wall Height (FT)	Length of Surface (FT)	Depth of Min Pressure at Level (FT)	Force (K)
5	0	0	0	25.33	0	0
4	8	8	16	25.33	0	152
3	9	8	17	25.33	16	496
2	9	9	18	25.33	33	900

Calculation of Lateral Soil Force - North Elevation (Column Line 7-5)						
Level	Wall Height Below (FT)	Wall Height Above (FT)	Total Wall Height (FT)	Length of Surface (FT)	Depth of Min Pressure at Level (FT)	Force (K)
5	0	0	0	58.33	0	0
4	0	0	0	58.33	0	0
3	9	0	9	58.33	0	111
2	9	9	18	58.33	9	888

Calculation of Lateral Soil Force - North Elevation (Column Line 5-3)						
Level	Wall Height Below (FT)	Wall Height Above (FT)	Total Wall Height (FT)	Length of Surface (FT)	Depth of Min Pressure at Level (FT)	Force (K)
5	0	0	0	50.67	0	0
4	0	0	0	50.67	0	0
3	0	0	0	50.67	0	0
2	9	9	18	50.67	0	386

Calculation of Lateral Soil Force - North Elevation (Column Line 3-1)						
Level	Wall Height Below (FT)	Wall Height Above (FT)	Total Wall Height (FT)	Length of Surface (FT)	Depth of Min Pressure at Level (FT)	Force (K)
5	0	0	0	38.00	0	0
4	0	0	0	38.00	0	0
3	0	0	0	38.00	0	0
2	9	0	9	38.00	0	72

South Elevation

Calculation of Lateral Soil Force - South Elevation (Column Line 1-3)

Level	Wall Height Below (FT)	Wall Height Above (FT)	Total Wall Height (FT)	Length of Surface (FT)	Depth of Min Pressure at Level (FT)	Force (K)
4	0	0	0	38	0	0
3	0	0	0	38	0	0
2	0	0	0	38	0	0

Calculation of Lateral Soil Force - South Elevation (Column Line 3-6)

Level	Wall Height Below (FT)	Wall Height Above (FT)	Total Wall Height (FT)	Length of Surface (FT)	Depth of Min Pressure at Level (FT)	Force (K)
4	0	0	0	81.67	0	0
3	0	0	0	81.67	0	0
2	9	0	9	81.67	0	155

Calculation of Lateral Soil Force - South Elevation (Column Line 6-7)

Level	Wall Height Below (FT)	Wall Height Above (FT)	Total Wall Height (FT)	Length of Surface (FT)	Depth of Min Pressure at Level (FT)	Force (K)
4	0	0	0	27.33	0	0
3	9	0	9	27.33	0	52
2	9	9	18	27.33	9	416

Calculation of Lateral Soil Force - South Elevation (Column Line 7-8)

Level	Wall Height Below (FT)	Wall Height Above (FT)	Total Wall Height (FT)	Length of Surface (FT)	Depth of Min Pressure at Level (FT)	Force (K)
4	0	0	0	25.33	0	0
3	9	8	17	25.33	0	172
2	9	9	18	25.33	17	557

Calculation of Lateral Soil Force - South Elevation (Column Line 8-9.2)

Level	Wall Height Below (FT)	Wall Height Above (FT)	Total Wall Height (FT)	Length of Surface (FT)	Depth of Min Pressure at Level (FT)	Force (K)
4	8	0	8	16.67	0	25
3	9	8	17	16.67	0	113
2	9	9	18	16.67	0	127

Appendix D – Determination of Critical Shear Wall

Determine Worst Case Shear Wall and Controling Load Case

Shear Walls and Forces at Base			
Story	Pier	Load Case/Combo	V2 (Kips)
Level 2	SW1	Wind Case 1 X-Direction	-16.128
Level 2	SW1	Wind Case 1 Y-Direction	98.442
Level 2	SW1	Wind Case 2 X-Direction (-M)	-19.469
Level 2	SW1	Wind Case 2 Y-Direction (-M)	65.733
Level 2	SW1	Wind Case 2 X-Direction (+M)	-6.572
Level 2	SW1	Wind Case 2 Y-Direction (+M)	95.86
Level 2	SW1	Wind Case 3	67.776
Level 2	SW1	Wind Case 4 (-Moments Same Sign)	41.872
Level 2	SW1	Wind Case 4 (-Moments Opposite Sign)	53.699
Level 2	SW1	Wind Case 4 (+Moments Opposite Sign)	69.076
Level 2	SW1	Wind Case 4 (+Moments Same Sign)	80.902
Level 2	SW1	Seismic X-Direction (+M)	-73.303
Level 2	SW1	Seismic Y-Direction (+M)	249.059
Level 2	SW1	Seismic X-Direction (-M)	-88.976
Level 2	SW1	Seismic Y-Direction (-M)	226.547
Level 2	SW1	Soil Y-Direction	-1428.477
Level 2	SW1	Soil X-Direction	389.906

Maximium Shear =	1428.477
Controling Load Case =	Soil Y-Direction

Story	Pier	Load Case/Combo	V2 (Kips)
Level 2	SW2	Wind Case 1 X-Direction	110.96
Level 2	SW2	Wind Case 1 Y-Direction	10.436
Level 2	SW2	Wind Case 2 X-Direction (-M)	68.928
Level 2	SW2	Wind Case 2 Y-Direction (-M)	-42.601
Level 2	SW2	Wind Case 2 X-Direction (+M)	114.603
Level 2	SW2	Wind Case 2 Y-Direction (+M)	58.611
Level 2	SW2	Wind Case 3	99.77
Level 2	SW2	Wind Case 4 (-Moments Same Sign)	24.706
Level 2	SW2	Wind Case 4 (-Moments Opposite Sign)	66.593
Level 2	SW2	Wind Case 4 (+Moments Opposite Sign)	116.103
Level 2	SW2	Wind Case 4 (+Moments Same Sign)	157.989
Level 2	SW2	Seismic X-Direction (+M)	352.58
Level 2	SW2	Seismic Y-Direction (+M)	160.876
Level 2	SW2	Seismic X-Direction (-M)	288.393
Level 2	SW2	Seismic Y-Direction (-M)	66.37
Level 2	SW2	Soil Y-Direction	-1304.645
Level 2	SW2	Soil X-Direction	-2685.042

Maximium Shear =	2685.042
Controling Load Case =	Soil X-Direction

252.7824

Story	Pier	Load Case/Combo	V2 (Kips)
Level 2	SW3	Wind Case 1 X-Direction	-4.741
Level 2	SW3	Wind Case 1 Y-Direction	11.016
Level 2	SW3	Wind Case 2 X-Direction (-M)	-4.733
Level 2	SW3	Wind Case 2 Y-Direction (-M)	6.891
Level 2	SW3	Wind Case 2 X-Direction (+M)	-2.933
Level 2	SW3	Wind Case 2 Y-Direction (+M)	11.611
Level 2	SW3	Wind Case 3	5.418
Level 2	SW3	Wind Case 4 (-Moments Same Sign)	1.933
Level 2	SW3	Wind Case 4 (-Moments Opposite Sign)	3.583
Level 2	SW3	Wind Case 4 (+Moments Opposite Sign)	6.195
Level 2	SW3	Wind Case 4 (+Moments Same Sign)	7.844
Level 2	SW3	Seismic X-Direction (+M)	-19.738
Level 2	SW3	Seismic Y-Direction (+M)	22.841
Level 2	SW3	Seismic X-Direction (-M)	-21.075
Level 2	SW3	Seismic Y-Direction (-M)	21.131
Level 2	SW3	Soil Y-Direction	-275.039
Level 2	SW3	Soil X-Direction	103.683

Maximium Shear =	275.039
Controling Load Case =	Soil Y-Direction

Story	Pier	Load Case/Combo	V2 (Kips)
Level 2	SW4	Wind Case 1 X-Direction	23.861
Level 2	SW4	Wind Case 1 Y-Direction	-1.821
Level 2	SW4	Wind Case 2 X-Direction (-M)	30.766
Level 2	SW4	Wind Case 2 Y-Direction (-M)	22.495
Level 2	SW4	Wind Case 2 X-Direction (+M)	9.596
Level 2	SW4	Wind Case 2 Y-Direction (+M)	-25.162
Level 2	SW4	Wind Case 3	18.848
Level 2	SW4	Wind Case 4 (-Moments Same Sign)	48.527
Level 2	SW4	Wind Case 4 (-Moments Opposite Sign)	29.113
Level 2	SW4	Wind Case 4 (+Moments Opposite Sign)	5.492
Level 2	SW4	Wind Case 4 (+Moments Same Sign)	-13.921
Level 2	SW4	Seismic X-Direction (+M)	87.979
Level 2	SW4	Seismic Y-Direction (+M)	-63.821
Level 2	SW4	Seismic X-Direction (-M)	116.561
Level 2	SW4	Seismic Y-Direction (-M)	-22.012
Level 2	SW4	Soil Y-Direction	661.977
Level 2	SW4	Soil X-Direction	-1334.379

Maximium Shear =	1334.379
Controling Load Case =	Soil X-Direction

Story	Pier	Load Case/Combo	V2 (Kips)
Level 2	SW5	Wind Case 1 X-Direction	2.092
Level 2	SW5	Wind Case 1 Y-Direction	33.79
Level 2	SW5	Wind Case 2 X-Direction (-M)	2.777
Level 2	SW5	Wind Case 2 Y-Direction (-M)	30.548
Level 2	SW5	Wind Case 2 X-Direction (+M)	0.616
Level 2	SW5	Wind Case 2 Y-Direction (+M)	25.694
Level 2	SW5	Wind Case 3	29.817
Level 2	SW5	Wind Case 4 (-Moments Same Sign)	30.27
Level 2	SW5	Wind Case 4 (-Moments Opposite Sign)	28.288
Level 2	SW5	Wind Case 4 (+Moments Opposite Sign)	25.886
Level 2	SW5	Wind Case 4 (+Moments Same Sign)	23.904
Level 2	SW5	Seismic X-Direction (+M)	9.696
Level 2	SW5	Seismic Y-Direction (+M)	61.079
Level 2	SW5	Seismic X-Direction (-M)	12.581
Level 2	SW5	Seismic Y-Direction (-M)	65.316
Level 2	SW5	Soil Y-Direction	-344.623
Level 2	SW5	Soil X-Direction	-56.978

Maximium Shear =	344.623
Controling Load Case =	Soil Y-Direction

Story	Pier	Load Case/Combo	V2 (Kips)
Level 2	SW6	Wind Case 1 X-Direction	23.179
Level 2	SW6	Wind Case 1 Y-Direction	-8.615
Level 2	SW6	Wind Case 2 X-Direction (-M)	32.305
Level 2	SW6	Wind Case 2 Y-Direction (-M)	20.106
Level 2	SW6	Wind Case 2 X-Direction (+M)	7.801
Level 2	SW6	Wind Case 2 Y-Direction (+M)	-33.449
Level 2	SW6	Wind Case 3	13.382
Level 2	SW6	Wind Case 4 (-Moments Same Sign)	47.766
Level 2	SW6	Wind Case 4 (-Moments Opposite Sign)	25.294
Level 2	SW6	Wind Case 4 (+Moments Opposite Sign)	-0.595
Level 2	SW6	Wind Case 4 (+Moments Same Sign)	-23.068
Level 2	SW6	Seismic X-Direction (+M)	78.541
Level 2	SW6	Seismic Y-Direction (+M)	-97.056
Level 2	SW6	Seismic X-Direction (-M)	114.146
Level 2	SW6	Seismic Y-Direction (-M)	-44.358
Level 2	SW6	Soil Y-Direction	642.668
Level 2	SW6	Soil X-Direction	-1633.579

Maximium Shear =	1633.579
Controling Load Case =	Soil X-Direction

Story	Pier	Load Case/Combo	V2 (Kips)
Level 2	SW7	Wind Case 1 X-Direction	18.778
Level 2	SW7	Wind Case 1 Y-Direction	105.752
Level 2	SW7	Wind Case 2 X-Direction (-M)	21.424
Level 2	SW7	Wind Case 2 Y-Direction (-M)	102.828
Level 2	SW7	Wind Case 2 X-Direction (+M)	8.889
Level 2	SW7	Wind Case 2 Y-Direction (+M)	72.835
Level 2	SW7	Wind Case 3	102.989
Level 2	SW7	Wind Case 4 (-Moments Same Sign)	112.925
Level 2	SW7	Wind Case 4 (-Moments Opposite Sign)	101.431
Level 2	SW7	Wind Case 4 (+Moments Opposite Sign)	85.843
Level 2	SW7	Wind Case 4 (+Moments Same Sign)	74.349
Level 2	SW7	Seismic X-Direction (+M)	83.345
Level 2	SW7	Seismic Y-Direction (+M)	186.121
Level 2	SW7	Seismic X-Direction (-M)	97.469
Level 2	SW7	Seismic Y-Direction (-M)	206.106
Level 2	SW7	Soil Y-Direction	-644.862
Level 2	SW7	Soil X-Direction	-436.612

Maximium Shear =	644.862
Controling Load Case =	Soil Y-Direction

Determine the Shear Wall with the Highest Force

Largest Shear Force =	2685.042
Shear Wall=	SW2
Controling Load Case =	Soil X-Direction
Second Largest Shear Wall Force =	1633.579
Shear Wall =	SW6
Controlling Load Case =	Soil X-Direction