September 27, 2013

Heather Sustersic
had132@psu.edu

Dear Professor Sustersic,

The following technical report was written to fulfill the requirements specified in the Structural Technical Report 2 assignment that was handed out on September 13, 2013.

Technical report 2 includes a detailed structural analysis of the New Library at the University of Virginia’s College at Wise, located in Wise, Virginia. This analysis includes calculations of roof loads, floor loads, exterior wall loads, snow loads, snow drifts, wind pressures, and seismic story forces.

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

Sincerely,

Macenzie Ceglar

Enclosed: Technical Report 2
Technical Report 2

University of Virginia’s College at Wise
New Library

Macenzie Ceglar
Structural Option
Advisor: Heather Sustersic
27 September 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 ft², 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.
# Table of Contents

Executive Summary ........................................................................................................................................... 2  
Table of Contents ........................................................................................................................................... 3  
Building Abstract ........................................................................................................................................... 4  
Site Plan and Location of Building ................................................................................................................. 5  
List of Documents used in Preparation of Report ............................................................................................ 6  
Roof Loads ...................................................................................................................................................... 7  
  Roof Dead Loads ........................................................................................................................................... 7  
  Roof Live Loads .......................................................................................................................................... 9  
Floor Loads ..................................................................................................................................................... 10  
  Floor Dead Loads ....................................................................................................................................... 10  
  Floor Live Loads ....................................................................................................................................... 12  
Exterior Wall Loads ........................................................................................................................................ 14  
Snow Loads .................................................................................................................................................... 15  
Snow Drifts .................................................................................................................................................... 16  
Wind Loads .................................................................................................................................................... 18  
Seismic Loads ................................................................................................................................................. 31
University of Virginia’s College at Wise - New Library
Wise, VA

General Information

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

Project Team

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

Mechanical

VAV system with a rooftop-mounted chilled-water air handling unit with a 145.9 ton chiller providing
41,500 CFM and 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

Architecture

The building’s design was to bring a sense of
cohesion to the existing buildings, as it is to be
located directly between the existing upper and
lower campuses. The goal was to give the impression
that the older existing building’s 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.
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
- **University of Virginia Facilities Management and University Building Official**
  - Facility Design Guidelines
- **University of Virginia’s College at Wise – New Library**
  - Construction Documents
  - Specifications
- **Vulcraft Deck Catalog**
Typical Roof Bay Dead Loading

Cross section of lower roof construction

- 6" Metal Stud
- 8" CMU
- Adhered Thermo Plastic Membrane
- Roof Cover Board
- 6" Rigid Insulation
- Composite Roof Deck

Uniformly Distributed Dead Loads

- Composite roof deck = 69 psf
- 6" Rigid Insulation = 9 psf
- Roof cover board = 2 psf
- Adhered Membrane = 2 psf
- Superimposed misc:
  - Ceiling = 5 psf
  - Mechanical = 10 psf
  - Sprinklers = 10 psf
  - Framing Allowance = 10 psf

Total = 117 psf
Distributed line load from CMU wall bearing trusses

Cold Formed Metal Trusses = 3 psf

Spacing = 12" o.c.

Truss Length = 23.1' 

3 psf x 23.1 = 46.2 plf

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

8" CMU = 55 psf

Wall height = 2\, \text{ft}

Load from CMU wall = 55 \times 2 = 110 \, \text{plf}

Total = 133.1 \, \text{plf}
### Typical Roof Gay Live Loading

<table>
<thead>
<tr>
<th>LOADS</th>
<th>Design Value</th>
<th>Code Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Roof Live Load</td>
<td>20 psf</td>
<td>20 psf</td>
</tr>
<tr>
<td>Roof Area Below Sloped Roof</td>
<td>30 psf</td>
<td>-</td>
</tr>
<tr>
<td>Roof Mechanical Area</td>
<td>150 psf</td>
<td>-</td>
</tr>
</tbody>
</table>

**Reason for Differences**

- **Minimum Roof Live Load**: UVA Facility Guidelines specifies a minimum roof live load which overrides 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

- Carpet Tile
- Carpet Adhesive + Pad
- Composite Deck
  - 4"1/2" NWC
  - 2" 16 ga.
- Wide Flange Members

Uniformly Distributed Dead Loads:

- Composite Deck = 69 psf
- Carpet Tile = 1 psf
- Pad + Adhesive = 0.5 psf

Superimposed misc.:

- Ceiling = 5 psf
- Mechanical = 10 psf
- Sprinklers = 10 psf
- Framing Allowance = 10 psf

Total = 105.5 psf
### Non-Typical Dead Loads

<table>
<thead>
<tr>
<th>Loads</th>
<th>Location</th>
<th>Value</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof Deck</td>
<td>upper rooftop</td>
<td>2.16 psf</td>
<td>VULCRAFT Catalog Pg 9</td>
</tr>
<tr>
<td>1½&quot; 29 gauge</td>
<td></td>
<td></td>
<td>(1.5A Roof Deck)</td>
</tr>
<tr>
<td>Composite Deck</td>
<td>Level 4</td>
<td>105 psf</td>
<td>VULCRAFT Catalog Pg 52</td>
</tr>
<tr>
<td>8½&quot; NNC 3&quot; 18g</td>
<td>Supporting</td>
<td></td>
<td>(6psf / 0.5&quot; of topping)</td>
</tr>
<tr>
<td>3½&quot; Terrazzo</td>
<td>Level 4</td>
<td>2 psf</td>
<td>ASCE 7-10, Pg 400</td>
</tr>
<tr>
<td>Tile 24&quot;x34&quot;</td>
<td>Vestible</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>and in Stair wells</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Typical Floor Bays, Live Loading

<table>
<thead>
<tr>
<th>Loads</th>
<th>Design Value</th>
<th>Code Minimum</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offices</td>
<td>50</td>
<td>50</td>
<td>ASCET-05</td>
</tr>
<tr>
<td>Corridor (Non-Prim. Floor)</td>
<td>80</td>
<td>Same as area served</td>
<td>Office + Partitions × 80</td>
</tr>
<tr>
<td>Partitions</td>
<td>87</td>
<td>-</td>
<td>Cannon Design Standard</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Loads</th>
<th>Location</th>
<th>Design Value</th>
<th>Code Min.</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Library Stock Rooms</td>
<td>Level 7, 3, 4, 5, 6 in various locations</td>
<td>150 psf</td>
<td>150 psf</td>
<td>ASCE 7-05</td>
</tr>
<tr>
<td>Mechanical Rooms</td>
<td>Level 2, lower roof</td>
<td>250 psf</td>
<td></td>
<td>Industry Standard for heavy Equipment</td>
</tr>
<tr>
<td>High Density Storage</td>
<td>Level 1</td>
<td>250 psf</td>
<td>250 psf</td>
<td>ASCE 7-05</td>
</tr>
<tr>
<td>Stairs</td>
<td>Center, east corner, and south corner of building</td>
<td>100 psf</td>
<td>100 psf</td>
<td>ASCE 7-05</td>
</tr>
</tbody>
</table>
Wall Loads (forces imposed by cannon design)

- Brick + 8" CMU = 95 psf x 16' (typical floor-to-floor height) = 1520 psf
- 2" rigid insulation = 3 psf x 16' = 48 psf
- Waterproofing Allowance = 1 psf x 16' = 16 psf

Total = 1584 psf

Load Path

The load due to the exterior wall is carried by the edge of the composite deck. The deck transfers the load to the wide flange members, which then transfer the load into steel columns. From there, the load is transferred to the foundation and distributed into bedrock.
Snow Loads

Lower Roof = Flat

\[ P_f = 0.1 C_e C_t I \rho_g \]

- \( C_e = 1.0 \) (Partially Exposed Roof, Exposure B)
- \( C_t = 1.0 \)
- \( I = 1.1 \) (Occupancy Category 3)
- \( \rho_g = 30 \text{ psf} \)

\[ P_f = 0.1 (1.0)(1.0)(1.1)(30) = 23.1 \text{ psf} \]

Upper Roof = Sloped

\[ P_s = C_e P_s \]

- \( C_e = 1.8 \) (Contains large mechanical equipment)
- \( C_t = 1.1 \)
- \( I = 1.1 \)
- \( \rho_g = 30 \)

\[ P_f = 0.1 (1.8)(1.1)(1.1)(30) = 28.4 \text{ psf} \]

- \( C_s = 1.0 \) (Cold roof, roof surface obstructed)
- \( P_s = 10 (28.4) = 284 \text{ psf} \)

Design was conservative and used a design snow load of 36 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 \( \frac{h_c}{h_b} < 0.2 \), drift loads not applicable.

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

\[ h_b = P_3 / \gamma \]

\[ P_3 = 36 \text{pcf} \] (see snow load table)

\[ \gamma = 0.13 \times 30 + 14 < 30 \text{pcf} \]

\[ = 0.13 \times 30 + 14 \]

\[ = 17.9 \text{pcf} \]

\[ h_c / h_b = 51.9'' / 17.9 = 2.95 > 0.2 \]

⇒ Snow drifts must be considered

**LeeWARD**

\[ h_{d,3} = 20 \]

\[ I_u = 147 \]

\[ h_d = 4 \]

**Windward**

\[ h_{d,3} = 20 \]

\[ I_u = 25''4'' \]

\[ h_d = 3/4 (1.5) = 1.125 \text{ft} \]

⇒ The larger \( h_d \) shall be used in design ⇒ 4 ft
**Lower Roof Cont.**

\[ h_d = 9' \text{ ft} < h_c = 53'4" \]

\[ \omega = \frac{4h_d}{H} = 4(4') = 16 \]

\[ 4' \]

\[ 1.45' \]

\[ 16.4' \]

\[ 25'4" \]

**Snow drift on interior walls of false mansard roof**

\[ h_c = 16'11" \]

\[ h_o = 1.45 \]

\[ \frac{h_c}{h_o} = \frac{16'11"}{1.45} = 11.67 > 0.7 \Rightarrow \text{Snow drift must be considered} \]

**Leeward**

\[ h_d: \]

\[ \rho_g = 30 \]

\[ \mu = 25 \Rightarrow \text{no roof upwind of drift so} \]

\[ \mu = 25 \text{ ft used per Figure 7-9.} \]

\[ h_d = 1.5 \text{ ft} \]

**Windward (worst case = largest } \mu) \]

\[ h_d: \]

\[ \rho_g = 30 \]

\[ \mu = 14 \]

\[ h_d = 314'(3) = 3 \]

\[ h_d = 3'6" < 16'11" \]

\[ \omega = 4(3') = 12' \]

\[ 3' \]

\[ 1.45' \]

\[ 12' \]

\[ 147' \]
Wind Load Calculation

- ASCE7-05 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 Category III, non-hurricane prone]

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

   ⇒ V_1 = 90 MPH

4. Determine Wind Load Parameters

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

      ⇒ Kd = 0.85

   b. Exposure Category (6.5.6.3)

      ⇒ B

   c. Topographic Factor Kt (Eq. 6-4)

      ⇒ 1.0

   d. Gust Effect Factor G (6.5.8)

      1) Determine natural frequency \( n_a \) (6.5.8)

         - Building meets requirements:

           1) Building height > 300 ft
           2) Building height < 440 ft

         \[ n_a = 385 (C_w)_{0.5} / H \]

         \[ C_w = \frac{100}{A_0} \sum_{i=1}^{n} \left( \frac{H_i}{h_i} \right)^2 \left[ 1 + 0.25 \left( \frac{h_i}{A_i} \right)^2 \right] \]
Shear Wall 1 (At Cl. 6.2) - NS

\[ A_{G} \approx (173' \times 51') + (42' \times 72') = 11,847 \text{ ft}^2 \]

\[ H = 102' \]

\[ h_1 = 102' \]

\[ A_0 = \frac{12'' \times 14'}{12'} = 14 \text{ ft}^2 \]

\[ D_l = 14' \]

\[ \left( \frac{102'}{10.0} \right)^2 \left[ \frac{14}{1 + 0.83 \left( \frac{102'}{14} \right)^2} \right] = 0.311 \]

Shear Wall 2 (At Cl. 0.3) - EW

\[ H = 102' \]

\[ h_1 = 102' \]

\[ A_0 = \frac{12'' \times 21}{12'} = 21 \text{ ft}^2 \]

\[ D_l = 21' \]

\[ \left( \frac{102'}{10.0} \right)^2 \left[ \frac{21}{1 + 0.83 \left( \frac{102'}{14} \right)^2} \right] = 0.466 \]

Shear Wall 3 (At west shear wall) - NS

\[ H = 102' \]

\[ h_1 = 69' \]

\[ A_0 = \frac{12'' \times 22.6'}{12'} = 8.6 \text{ ft}^2 \]

\[ D_l = 8.6' \]

\[ \left( \frac{102'}{69} \right)^2 \left[ \frac{8.6}{1 + 0.83 \left( \frac{102'}{8.6} \right)^2} \right] = 0.366 \]

Shear Wall 4 (At South shear wall) - EW

\[ H = 102' \]

\[ h_1 = 102' \]

\[ A_0 = \frac{12'' \times 20.33'}{12'} = 20.33 \text{ ft}^2 \]

\[ D_l = 20.33' \]

\[ \left( \frac{102'}{20.33} \right)^2 \left[ \frac{20.33}{1 + 0.83 \left( \frac{102'}{20.33} \right)^2} \right] = 0.939 \]
Shear Wall 5 (At Cl.5) - NS

$H = 102\text{'}$

$h_l = 102\text{'}$

$A_l = \frac{12''}{12} \times 12\text{'} = 12\text{ft}^2$

$D_l = 12\text{'}$

$\left(\frac{102}{102}\right)^2 \frac{12}{1 + 0.25 \left(\frac{102}{12}\right)^2} = 0.197$

Shear Wall 6 (At Cl.0) - EW

$H = 102\text{'}$

$h_l = 102\text{'}$

$A_l = \frac{12''}{12} \times 25.2 = 25.2\text{ft}^2$

$D_l = 25.2\text{'}$

$\left(\frac{102}{102}\right)^2 \frac{25.2}{1 + 0.32 \left(\frac{102}{25.2}\right)} = 1.776$

Shear Wall 7 (At Cl.4) - NS

$H = 103\text{'}$

$h_l = 103\text{'}$

$A_l = \frac{12''}{12} \times 20 = 20\text{ft}^2$

$D_l = 20\text{'}$

$\left(\frac{103}{103}\right)^2 \frac{20}{1 + 0.25 \left(\frac{103}{20}\right)} = 0.885$

Shear Wall 8 (At East Shear Wall) - NS

$H = 103\text{'}$

$h_l = 34\text{'}$

$A_l = \frac{12''}{12} \times 10 = 10\text{ft}^2$

$D_l = 10\text{'}$

$\left(\frac{103}{34}\right)^2 \frac{10}{1 + 0.83 \left(\frac{34}{10}\right)} = 8.495$
Shear Wall 9 (At C.L.E.) - EW

\[
H = 102' \\
\frac{h_i}{h_i} = 34' \\
A_i = \frac{12'' \times 93.3'}{12} = 23.3 ft^2 \\
D_i = 23.3' \\
\left(\frac{H}{h_i}\right)^2 \frac{A_i}{1 + 0.33 \left(\frac{h_i}{D_i}\right)^2} = 75.176
\]

North - South

\[
\sum \left(\frac{H}{h_i}\right)^2 \left(\frac{A_i}{1 + 0.33 \left(\frac{h_i}{D_i}\right)^2}\right) = 0.311 + 0.366 + 0.197 + 0.785 + 8.495 \\
= 10.254
\]

\[C_{w, NS} = \frac{100}{10.254} = 0.0986\]

\[N_{0, NS} = 385 (0.0860)^{0.5}/100 = 1.11 \text{ Hz}\]

East - West

\[
\sum \left(\frac{H}{h_i}\right)^2 \left(\frac{A_i}{1 + 0.33 \left(\frac{h_i}{D_i}\right)^2}\right) = 0.416 + 0.929 + 1.726 + 75.176 \\
= 78.297
\]

\[C_{w, EW} = \frac{100}{78.297} = 0.6660\]

\[N_{0, EW} = 385 (0.6660)^{0.5}/100 = 3.08 \text{ Hz}\]

\(\Rightarrow N_0 > 1.0 \text{ Hz; in both directions} \Rightarrow \text{Rigid Structure}\)
Wind Load | Tech Report 2 | Macenzie (eglar)

\[ G = 0.925 \left( \frac{(1 + 1.7 \cdot p_l \cdot 0)}{1 + 1.7} \right) \]

- \( p_l = 3.4 \)
- \( p_v = 3.4 \)

\[ I_z = \frac{1}{2} \left( \frac{33}{33} \right) = 0.60 \]

\[ \frac{33}{60 \cdot (0.6)} \]

\[ Q = 0.30 \]

\[ Q = \left( \frac{33}{33} \right) \]

\[ Q = 0.30 \cdot 0.271 = 0.081 \]

**N-S Direction**

\[ Q = \frac{1}{1 + 0.43 \left( \frac{Q}{L_z} \right)^{0.63}} \]

- \( Q = 1.47 \)
- \( h = 23.33 \)

\[ L_z = \frac{1}{1 + 0.43 \left( \frac{Q}{L_z} \right)^{0.63}} = 39.15 \]

**E-W Direction**

- \( B = 94.33 \)
- \( h = 102 \)
- \( L_z = 39.15 \)

\[ Q = \frac{1}{1 + 0.43 \left( \frac{Q}{L_z} \right)^{0.63}} = 0.843 \]

**N-S Direction**

\[ G = 0.925 \left( \frac{(1 + 1.7 \cdot p_l \cdot 0.30 \cdot 0.824)}{1 + 1.7} \right) = 0.824 \]

**E-W Direction**

\[ G = 0.925 \left( \frac{(1 + 1.7 \cdot p_l \cdot 0.270 \cdot 0.824)}{1 + 1.7} \right) = 0.835 \]
E. Enclosure Classification (6.6.9)

\[ E = \text{Enclosed} \ (6.9) \]

F. Internal Pressure Coefficients (Fig 6-5)

\[ G_{\text{Cp}} = 0.18 \]

5 Determine Velocity Pressure exposure coefficient \( k_z \) or \( k_n \) (Table 6-3)

\[ Z_0 = 1200 \quad d = 7.0 \]

\[ k_z (18') = 2.01 \left( \frac{18}{1200} \right)^{0.57} = 0.61 \]

\[ k_z (36') = 2.01 \left( \frac{36}{1200} \right)^{0.77} = 0.74 \]

\[ k_z (52') = 2.01 \left( \frac{52}{1200} \right)^{0.71} = 0.82 \]

\[ k_z (68') = 2.01 \left( \frac{68}{1200} \right)^{0.71} = 0.89 \]

\[ k_z (84') = 2.01 \left( \frac{84}{1200} \right)^{0.71} = 0.94 \]

\[ k_z (100') = 2.01 \left( \frac{100}{1200} \right)^{0.71} = 0.99 \]

*Using some \( k_z \) for both directions to be conservative*

6 Determine Velocity Pressure (6.5.10)

\[ q_z = 0.00025k_zk_2k_4V^2I \]

\[ k_z = 1.0 \]

\[ k_2 = 0.85 \]

\[ V^2 = 2100 \]

\[ I = 1.15 \]

\[ q_z = 0.00025k_z (0.85 \times 2100 \times 1.15) = 20.27 k_z \]

\[ q_z (18') = 12.36 \]

\[ q_z (36') = 15.00 \]

\[ q_z (52') = 18.69 \]

\[ q_z (68') = 18.04 \]

\[ q_z (84') = 19.05 \]

\[ q_z (100') = 20.07 \]
Determine External Pressure Coefficient \( C_p \) (Fig. 6-6 to 6-8)

\[ C_{p,w} = 0.8 \]

**wind in N-S direction**
\[
\frac{L}{B} = \frac{94.67}{147} = 0.64
\]

\[ C_{p,L} = -0.5 \]

**wind in E-W direction**
\[
\frac{g}{h} = \frac{147}{94.67} = 1.56
\]

\[ C_{p,L} = \frac{g-1}{g} = 2.156 \Rightarrow x = -0.388 \]

**Roof Pressure Coefficients**

\[
\Theta = \tan^{-1}(\frac{5}{10}) = 26.1^\circ > 10^\circ
\]

**wind in N-S direction (windward)**
\[
\frac{h}{L} = \frac{110.5}{94.67} = 1.17 \geq 1.0
\]

interpolate \( \delta \)

<table>
<thead>
<tr>
<th>( \delta )</th>
<th>( 25 )</th>
<th>( 26.1 )</th>
<th>( 30 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( X )</td>
<td>-0.5</td>
<td>-0.3</td>
<td>0</td>
</tr>
<tr>
<td>( Y )</td>
<td>0.456</td>
<td>0.044</td>
<td>0.2</td>
</tr>
</tbody>
</table>

\[ C_{p,w} = -0.456, 0.044 \]

**wind in N-S direction (leeward)**
\[ \Theta = 26.1^\circ > 20^\circ \]

\[ C_{p,L} = -0.6 \]

* For Mansard roofs, the top horizontal surface and leeward inclined surface shall be treated as leeward surfaces from Table (Table 6-6 Note 2)
Wind Loads | Tech Report | Macenzie Ceglar

**Wind in E-W direction (windward)**

\[
\frac{h/L}{0.3} = \frac{h/3}{L} = 0.75 \Rightarrow 0.5 < 0.75 < 1.0
\]

Interpolate \( B \)

<table>
<thead>
<tr>
<th>( B )</th>
<th>25</th>
<th>26.1</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>-0.3</td>
<td>-0.29</td>
<td>-0.3</td>
</tr>
<tr>
<td>0.75</td>
<td>-0.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>-0.2</td>
<td>-0.15</td>
<td>-0.2</td>
</tr>
</tbody>
</table>

| \( C_p \), \( w \) | -0.367, 0.133 |

wind in E-W direction (leeward)

\( \theta = 26.1 > 30 \)

\( C_p, L = -0.6 \)

**Summary of \( C_p \) values**

<table>
<thead>
<tr>
<th>NS direction</th>
<th>WallS</th>
<th>Roof</th>
</tr>
</thead>
<tbody>
<tr>
<td>windward</td>
<td>0.8</td>
<td>-0.458, 0.044</td>
</tr>
<tr>
<td>leeward</td>
<td>-0.5</td>
<td>-0.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EW direction</th>
<th>WallS</th>
<th>Roof</th>
</tr>
</thead>
<tbody>
<tr>
<td>windward</td>
<td>0.8</td>
<td>-0.367, 0.133</td>
</tr>
<tr>
<td>leeward</td>
<td>-0.388</td>
<td>-0.6</td>
</tr>
</tbody>
</table>
% Calculate wind pressure $P$ on each surface

wind Pressure for walls

* See excel sheet for pressures
8. Calculate Wind Pressure, P, on each surface

Equation: \( p = qGC_{pl} \)

Constants:

- \( G(\text{NS}) = 0.824 \)
- \( G(\text{EW}) = 0.835 \)
- \( q_h = 20.6 \)
- Building Width NS = 147'
- Building Width EW = 94.33'

<table>
<thead>
<tr>
<th>Floor Height</th>
<th>( q_z )</th>
<th>Windward Pressure (PSF)</th>
<th>Leeward Pressure (PSF)</th>
<th>Trib Area (SF)</th>
<th>Force (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>12.36</td>
<td>8.15</td>
<td>-8.49</td>
<td></td>
<td>2646</td>
</tr>
<tr>
<td>36</td>
<td>15</td>
<td>9.89</td>
<td>-8.49</td>
<td></td>
<td>2499</td>
</tr>
<tr>
<td>52</td>
<td>16.62</td>
<td>10.96</td>
<td>-8.49</td>
<td></td>
<td>2352</td>
</tr>
<tr>
<td>68</td>
<td>18.04</td>
<td>11.89</td>
<td>-8.49</td>
<td></td>
<td>2352</td>
</tr>
<tr>
<td>84</td>
<td>19.05</td>
<td>12.56</td>
<td>-8.49</td>
<td></td>
<td>2499</td>
</tr>
<tr>
<td>102</td>
<td>20.07</td>
<td>13.23</td>
<td>-8.49</td>
<td></td>
<td>1323</td>
</tr>
</tbody>
</table>

Base Shear= 265

Wind Pressures (E-W Direction)

<table>
<thead>
<tr>
<th>Floor Height</th>
<th>( q_z )</th>
<th>Windward Pressure (PSF)</th>
<th>Leeward Pressure (PSF)</th>
<th>Trib Area (SF)</th>
<th>Force (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>12.36</td>
<td>8.26</td>
<td>-6.67</td>
<td></td>
<td>1698</td>
</tr>
<tr>
<td>36</td>
<td>15.00</td>
<td>10.02</td>
<td>-6.67</td>
<td></td>
<td>1604</td>
</tr>
<tr>
<td>52</td>
<td>16.62</td>
<td>11.10</td>
<td>-6.67</td>
<td></td>
<td>1509</td>
</tr>
<tr>
<td>68</td>
<td>18.04</td>
<td>12.05</td>
<td>-6.67</td>
<td></td>
<td>1509</td>
</tr>
<tr>
<td>84</td>
<td>19.05</td>
<td>12.73</td>
<td>-6.67</td>
<td></td>
<td>1604</td>
</tr>
<tr>
<td>102</td>
<td>20.07</td>
<td>13.41</td>
<td>-6.67</td>
<td></td>
<td>849</td>
</tr>
</tbody>
</table>

Base Shear= 155
wind Pressure for Roof

\[ P = q_n \cdot G \cdot C_p \]

\[ q_n = q_2(10.5) = 0.0035\% \left[ 2.01 \left( \frac{10^5}{1200} \right)^{0.85} \right] 0.85(8100)(1.15) \]

= 20.6

N-S Direction - windward

\[ P = (20.6)(0.824)(-0.456) = -11.14 \text{ psf} \]

\[ P = (20.6)(0.824)(0.044) = 0.75 \text{ psf} \]

N-S Direction - leeward

\[ P = (20.6)(0.824)(0.16) = -10.14 \text{ psf} \]

E-W Direction - windward

\[ P = (20.6)(0.824)(0.35) = -6.31 \text{ psf} \]

\[ P = (20.6)(0.824)(0.183) = 2.10 \text{ psf} \]

E-W Direction - leeward

\[ P = (20.6)(0.824)(-0.6) = -10.32 \text{ psf} \]
Wind loads | Tech Report 2 | Mcenzue Cecylad

Wind Pressure - NS Direction

Vb = 265 k
Seismic Load Calculation

1) Exemptions (11.1.2)

 ⇒ Building is not exempt

2) Design Spectral Response Acceleration (11.4)

A. Site Class (11.4.2)

 ⇒ B

B. Acceleration Parameters (11.4.3 + Chp 20)

\[ S_d = 0.332g \]
\[ S_s = 0.094g \]

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

\[ S_d > 0.15 + S_s > 0.04 ⇒ Adjust for site class \]

\[ S_{sd} = Fa S_d = (1.0)(0.332g) = 0.332g \]
\[ S_{sm} = Fu S_s = (1.0)(0.094g) = 0.094g \]

D. Determine Spectral Acceleration Parameters (11.4.4)

\[ S_{bsd} = 2/3 S_{sd} = \frac{2}{3}(0.332g) = 0.221g \]
\[ S_{bsm} = 2/3 S_{sm} = \frac{2}{3}(0.094g) = 0.062g \]

* Can use simplified b/c building doesn't meet requirements (17.1.4)

3) Seismic Design Category (11.6)

Occupancy Category III

\[ 0.167 < S_{bsd} < 0.33 \ ⇒ B \]

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 1.5-1)

⇒ Occupancy Category III ⇒ I = 1.25
1) Find Period T (12.8.2.1)

\[ T_a = \frac{C_e h_n}{T_r} \]

- \( h_n = 119 \text{ ft} \)
- \( C_e = 0.02 \)
- \( T_r = 0.75 \)

\[ T_a = \frac{(0.02)(119)}{0.75} = 1.21 \text{ sec} \]

2) Determine TL (Fig. 22-12 to 22-14)

\[ TL = 1.2 \text{ sec} \]

3) Determine Seismic Response Coefficient \( C_s \) (12.8.1.1)

\[ C_s = \frac{S_{500}}{R/I} \]

\[ C_s = \frac{0.221}{4/1.5} = 0.063 \]

Check: \( T_a = 1.21 < T_L = 6 \)

\[ C_s = \frac{S_{500}}{T(R/I)} \]

\[ C_s = \frac{0.063}{0.721(4/1.5)} = 0.0273 \]

\[ C_s = 0.0273 \]

4) Calculate Seismic Weight \( W \)

Roof

Typical Roof Bay Dead Load = 117.0 psf x 9905 sf x \( \frac{1}{1000} \)

= 1158.9 k

Distributed Line Load = 133.1 psf x 367 ft x \( \frac{1}{1000} \)

= 47.5 k

Total Roof Weight = 1206.4 k
Typical Floor Dead Loads = 105.5 psf
Partitions = 21.0 psf

Total Floor Dead Loads:
Level 2 = 132.5 x 12,259 / 1000 = 1703.8 k
Level 3 = 132.5 x 12,513 / 1000 = 1658.0 k
Level 4 = 132.5 x 11,115 / 1000 = 1472.7 k
Level 5 = 132.5 x 10,379 / 1000 = 1315.2 k
Level 6 = 132.5 x 10,258 / 1000 = 1309.2 k

Total Weight = 8775.3 k

ii) Calculate Base Shear V (12.8.1)

\[ V = C_b W = (0.0373 \times 8775.3) \]
\[ = 239.57 \text{k} \]

iii) Vertical Distribution of Forces (12.8.3)

\[ F_k = C_{vx} V = \left[ \frac{w \times h_x}{\sum w \times h_x} \right] V \]

\[ K : T_a = 0.721 \Rightarrow 0.5 < 0.721 < 2.5 \]
\[ \frac{2.5 - 0.5}{2} = \frac{2.5 - 0.721}{2 - k} \Rightarrow k = 1.11 \]

⇒ See excel table table on next page.
# 12. Vertical Distribution of Forces

\[ k = 1.11 \]
\[ V_b = 239.57 \text{ K} \]

<table>
<thead>
<tr>
<th>Level</th>
<th>( w_i \text{ (K)} )</th>
<th>( h_i \text{ (FT)} )</th>
<th>( w_i h_i^k \text{ (K-FT)} )</th>
<th>( C_{vx} )</th>
<th>( F \text{ (K)} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof</td>
<td>1206.4</td>
<td>102</td>
<td>446685.20</td>
<td>0.256</td>
<td>61.27</td>
</tr>
<tr>
<td>6</td>
<td>1359.2</td>
<td>84</td>
<td>411049.90</td>
<td>0.235</td>
<td>56.38</td>
</tr>
<tr>
<td>5</td>
<td>1375.2</td>
<td>68</td>
<td>329360.11</td>
<td>0.189</td>
<td>45.18</td>
</tr>
<tr>
<td>4</td>
<td>1472.7</td>
<td>52</td>
<td>263858.18</td>
<td>0.151</td>
<td>36.19</td>
</tr>
<tr>
<td>3</td>
<td>1658.0</td>
<td>36</td>
<td>200094.25</td>
<td>0.115</td>
<td>27.45</td>
</tr>
<tr>
<td>2</td>
<td>1703.8</td>
<td>18</td>
<td>95549.22</td>
<td>0.055</td>
<td>13.11</td>
</tr>
</tbody>
</table>

\[ \text{Sum} = 1746596.86 \]
\[ \text{1.000} \]
\[ \text{239.57} \]
Seismic Loads | Tech Report | Macenzie Ceglar

Story Forces Diagram

$V_0 = 329.57 \text{kN}$