September 27, 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 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 $ft^2$, 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.

# Table of Contents

# 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

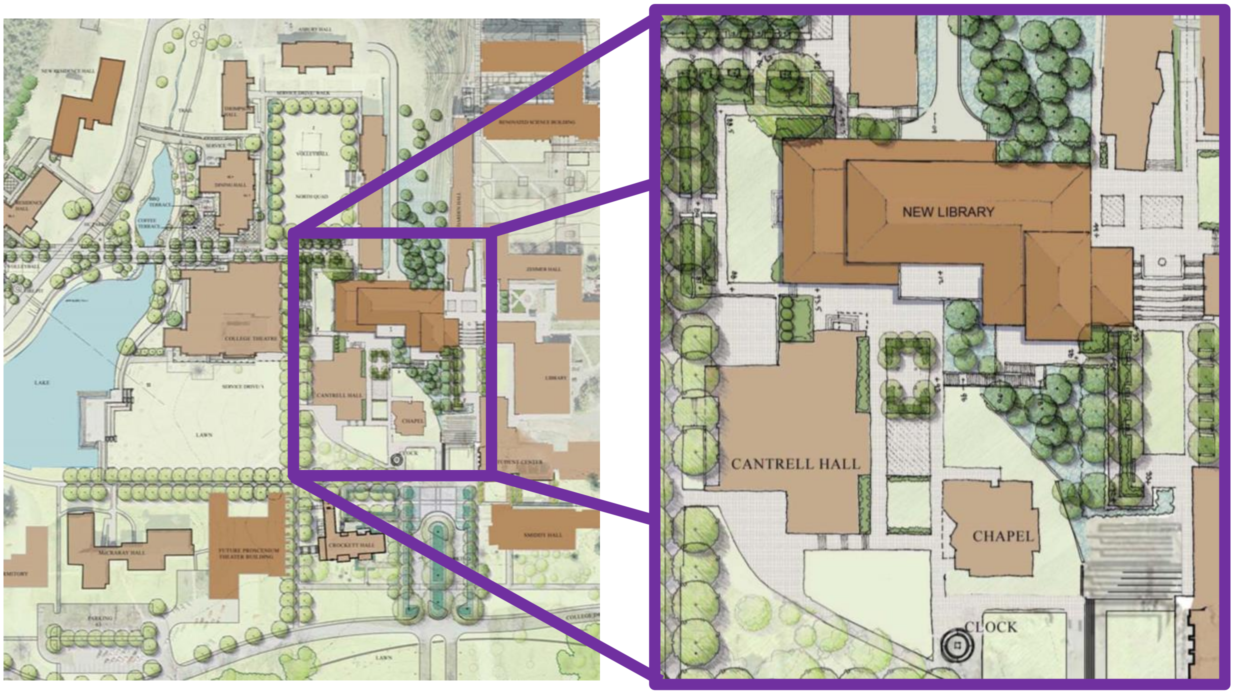
VAV system with a roof mounted chilled-water AHU and 145.9 ton chiller providing 41,300 CFM, and an economizer and an a heat recovery unit

## Electrical/Lighting

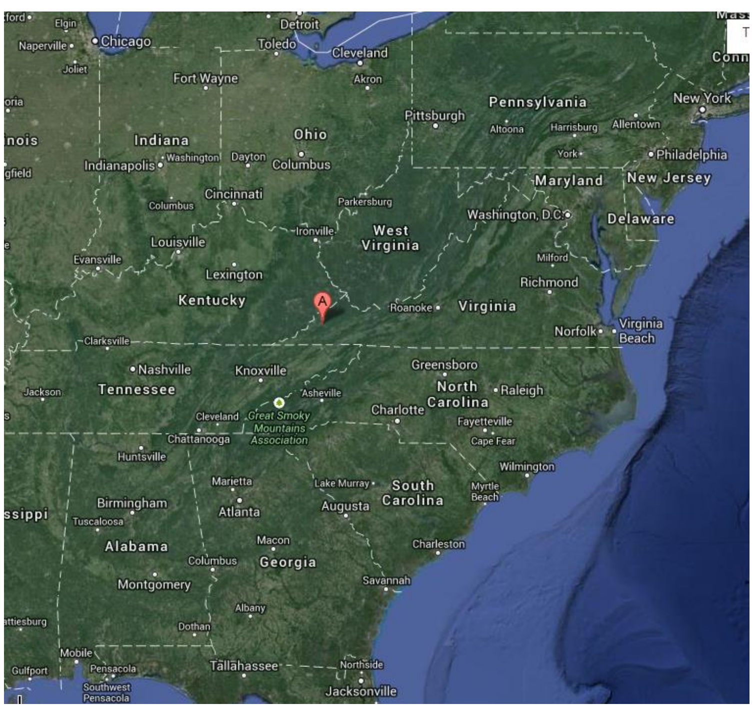
Five 480/277 3-phase panel boards
Nine 280/120 3-phase panel boards

Wall switch and low voltage occupancy sensors used for lighting control

# Site Plan




# Location Plan



# Documents Used in Preparation of Report

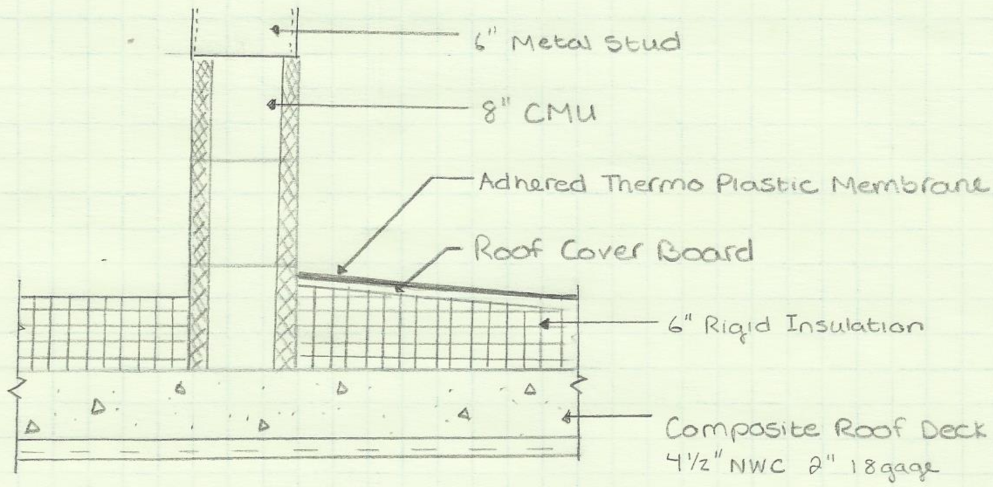
Below is a list of the design codes and standards used in the structural analysis of the New Library at the University of Virginia's College at Wise.

- **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
- **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**

# Roof Loads

## 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

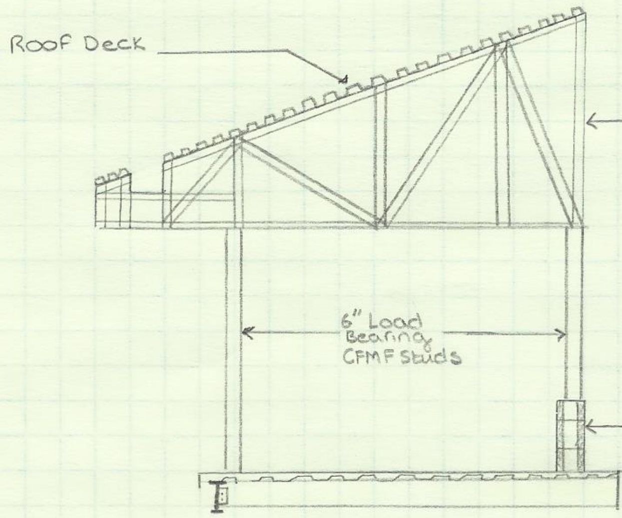
Sprinklers = 10 psf

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 = 55 psf

wall height = 2ft

Load from CMU wall = 55 x 2 = 110 plf

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

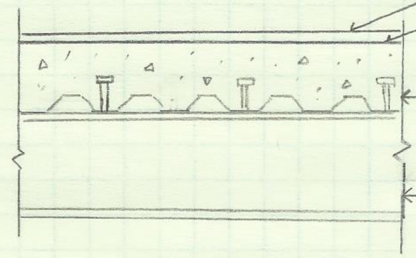
Roof Area Below Sloped Roof: unlikely that this area will see a live load so a minimum was used

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

# Floor Loads

## 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 |

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.

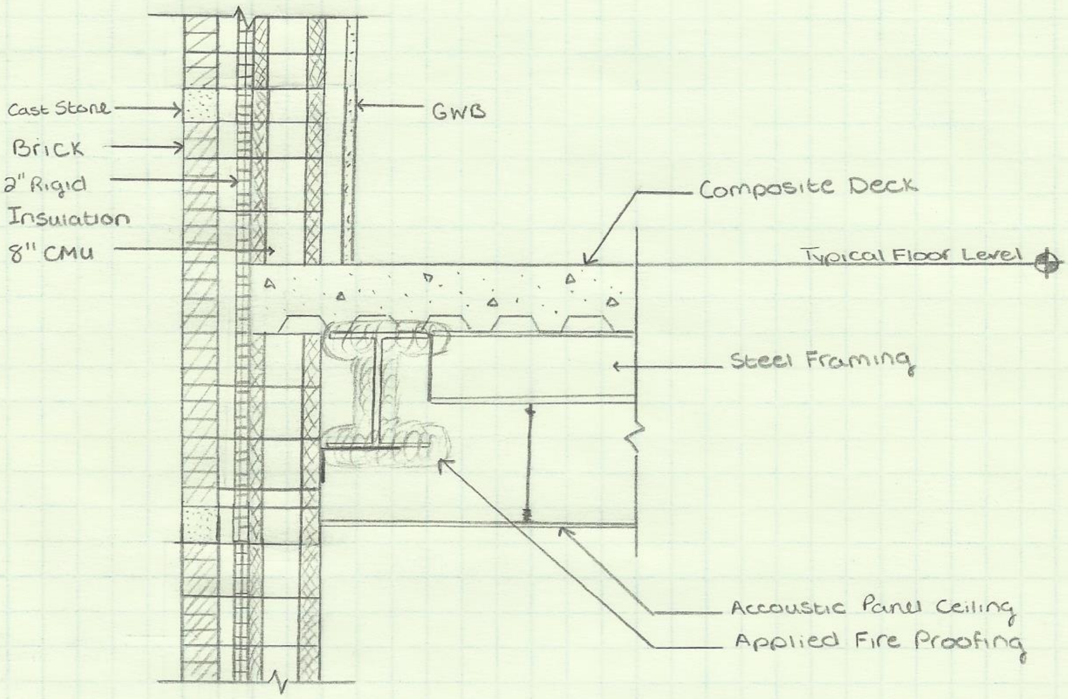
Non-Typical Live Loads

| 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 |

# Exterior Wall Loads

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

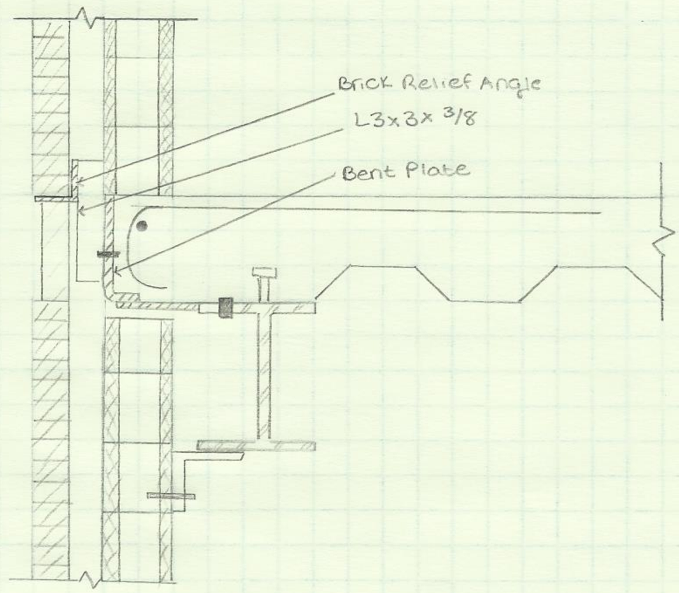
2" rigid insulation = 3 psf x 16' = 48 plf

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

## 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)

$p_g = 30\text{psf}$

$P_f = 0.7(1.0)(1.0)(1.1)(30) = 23.1\text{ psf}$

### Upper Roof - Sloped

$P_s = C_s\, p_f$

$C_e = 1.0$ (contains large mechanical equipment)

$C_t = 1.1$

$I = 1.1$

$p_g = 30$

$p_f = 0.7(1.0)(1.1)(1.1)(30) = 25.4\text{ psf}$

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

$P_s = 1.0(25.4) = 25.4\text{ psf}$

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

# Snow Drift

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

$h_d$:

$p_g = 30$
$l_u = 25'4''$

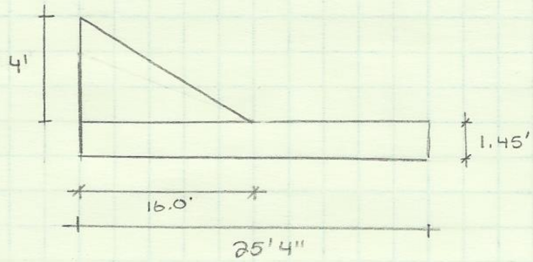
$h_d = 3/4(1.5) = 1.125$ ft

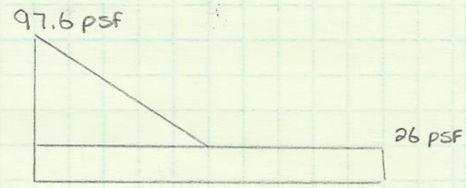
⇒ The larger $h_d$ shall be used in design ⇒ 4 ft

## 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 $l_u$)

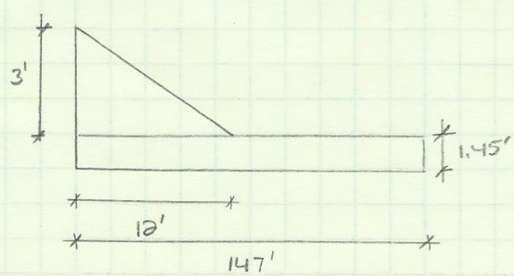
$h_d$:

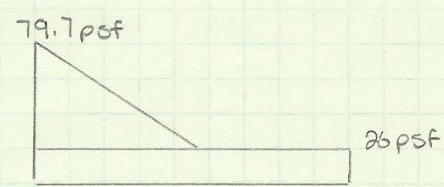
$p_g = 30$
$l_u = 147$

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

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

$w = 4(3) = 12'$



# Sliding Snow

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

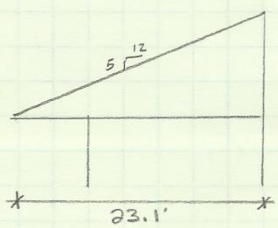
Actual Slope = 5/12 ⇒ Sliding snow must be calculated

Total Sliding Snow per Unit Length

$= 0.4 \, p_f \, W$

$p_f = 25.4 \text{ psf}$

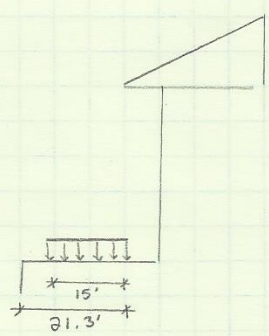
$w = 23.1 \text{ ft}$




$= 0.4(25.4)(23.1)$

$= 234.7 \text{ plf}$

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




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

# Wind Loads

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 Kd (Table 6-4)

⇒ $K_d = 0.85$

b. Exposure Catagory (6.5.6.3)

⇒ B

c. Topographic Factor, Kzt (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 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

$H = 102'$

$h_i = 102'$

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

$D_i = 20.33'$

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

Shear Wall 5 (At CL5) - NS

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

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

Shear Wall 6 (At CL D) - EW

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

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

Shear Wall 7 (At CL 4) - NS

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

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

Shear Wall 8 (At East Stair Wall) - NS

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

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

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

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

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

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

East - West

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

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

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

$\Rightarrow n_a > 1.0 Hz$ in both directions $\Rightarrow$ Rigid Structure

ii) Rigid Buildings (6.5.8.1)

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

$g_Q = 3.4$

$g_v = 3.4$

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

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

$B = 147'$

$h = 83.33'$

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

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

E-W Direction ⇒ $B = 94.33'$

$h = 102$

$L_{\bar{z}} = 393.15$

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

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

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

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)

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 |

8. Calculate wind Pressure P on each surface

wind Pressure for Walls

⇒ See excel sheet for pressures.

## 8. Calulate Wind Pressure, P, on each surface

**Equation:** $p=qGC_{pi}$

**Constants:**

G(NS) = 0.824
G(EW)= 0.835
$q_h$= 20.6
Building Width NS= 147'
Building Width EW= 94.33'

| **Wind Pressures (N-S Direction)** | | | | | |
|---|---|---|---|---|---|
| Floor Height | $q_z$ | Windward Pressure (PSF) | Leeward Pressure (PSF) | Trib Area (SF) | Force (K) |
| 18 | 12.36 | 10.00 | -8.49 | 2646 | 49 |
| 36 | 15 | 10.00 | -8.49 | 2499 | 46 |
| 52 | 16.62 | 10.96 | -8.49 | 2352 | 46 |
| 68 | 18.04 | 11.89 | -8.49 | 2352 | 48 |
| 84 | 19.05 | 12.56 | -8.49 | 2499 | 53 |
| 102 | 20.07 | 13.23 | -8.49 | 1323 | 29 |
| | | | | Base Shear= | 270 |

| **Wind Pressures (E-W Direction)** | | | | | |
|---|---|---|---|---|---|
| Floor Height | $q_z$ | Windward Pressure (PSF) | Leeward Pressure (PSF) | Trib Area (SF) | Force (K) |
| 18 | 12.36 | 10.00 | -6.67 | 1698 | 28 |
| 36 | 15.00 | 10.02 | -6.67 | 1604 | 27 |
| 52 | 16.62 | 11.10 | -6.67 | 1509 | 27 |
| 68 | 18.04 | 12.05 | -6.67 | 1509 | 28 |
| 84 | 19.05 | 12.73 | -6.67 | 1604 | 31 |
| 102 | 20.07 | 13.41 | -6.67 | 849 | 17 |
| | | | | Base Shear= | 158 |

NOTE: ASCE 7 Section 6.1.4.1 sepecifies that wind pressures must be greater than 10psf

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

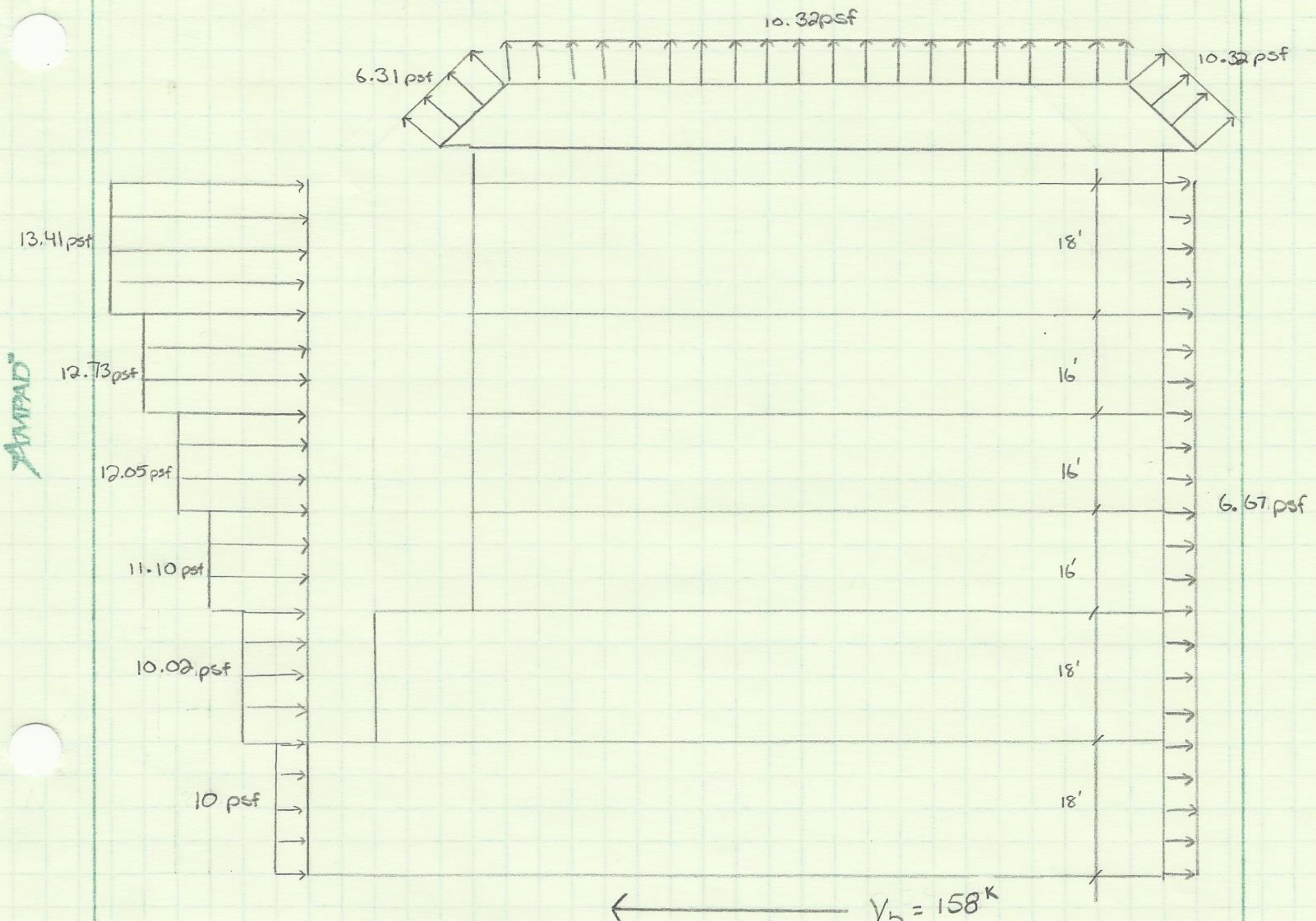
$p = (20.6)(0.835)(-0.367) = -6.31$ psf

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

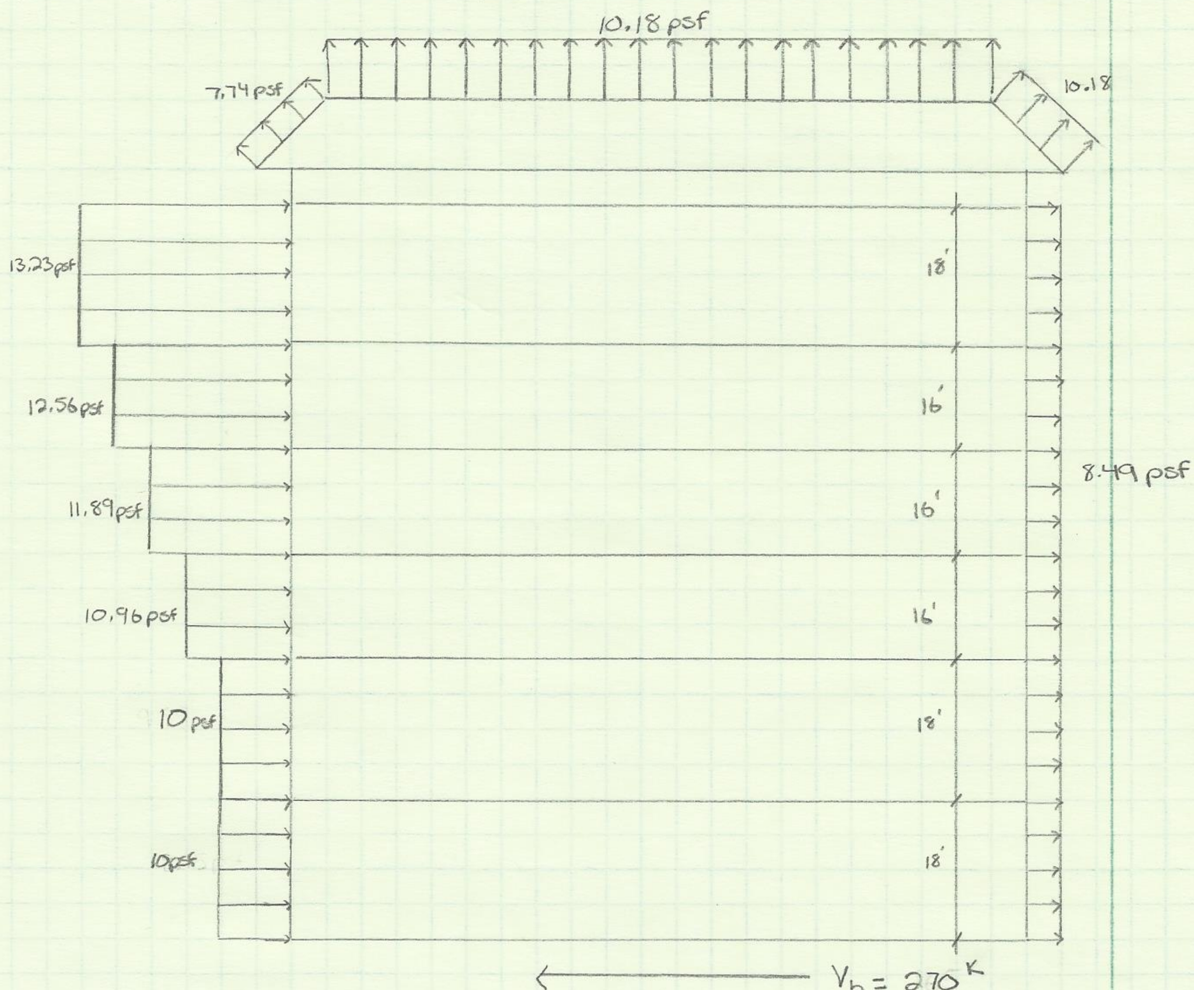
E-W Direction - leeward

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

Wind Pressure Diagram - EW Direction



Wind Pressure - NS Direction



# Seismic Loads

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)

TL = 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 = $ | 0.0691
min | 0.0273

$\Rightarrow 0.0273 > 0.01$ ✓

$C_s = 0.0273$

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) | $w_i h_i^k$ (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

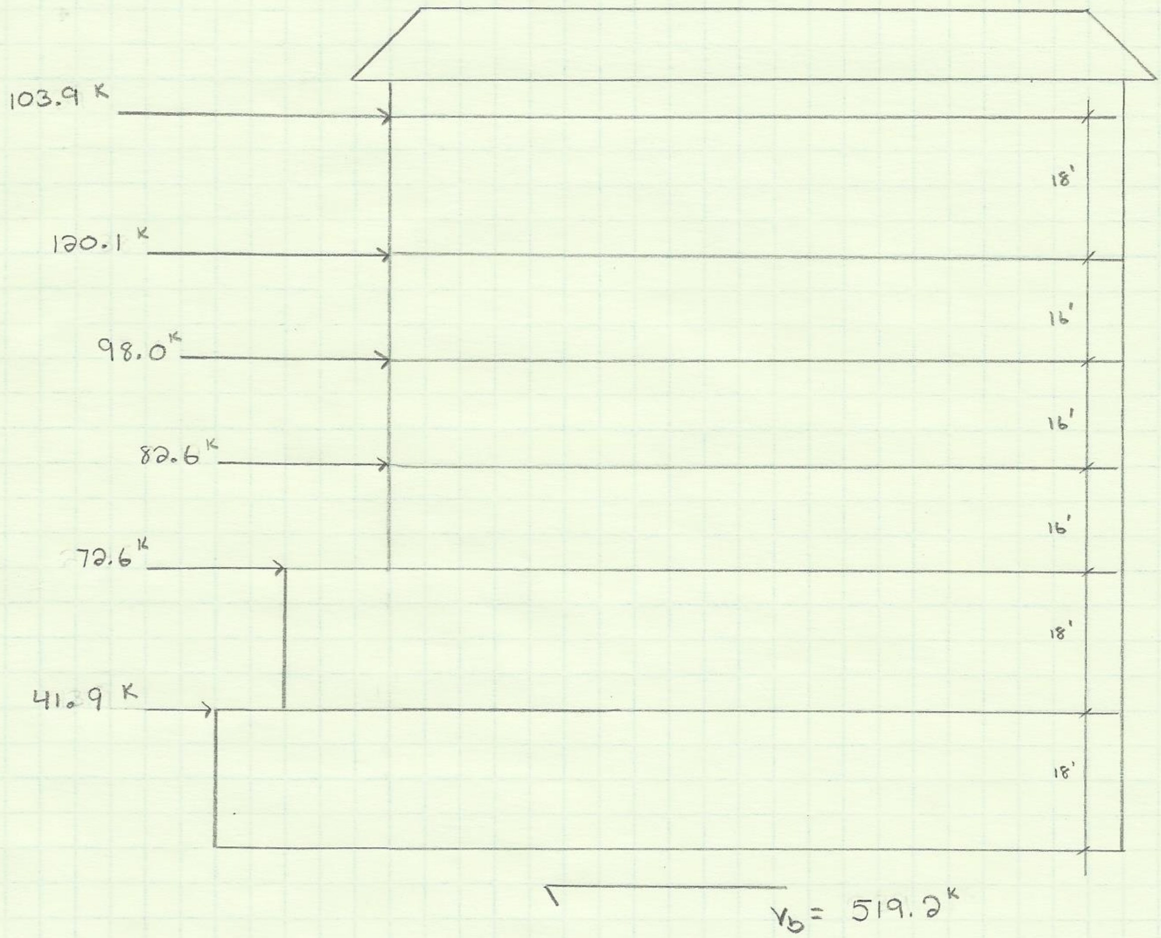
**Calculation of Shear Wall Weights**

| 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 |

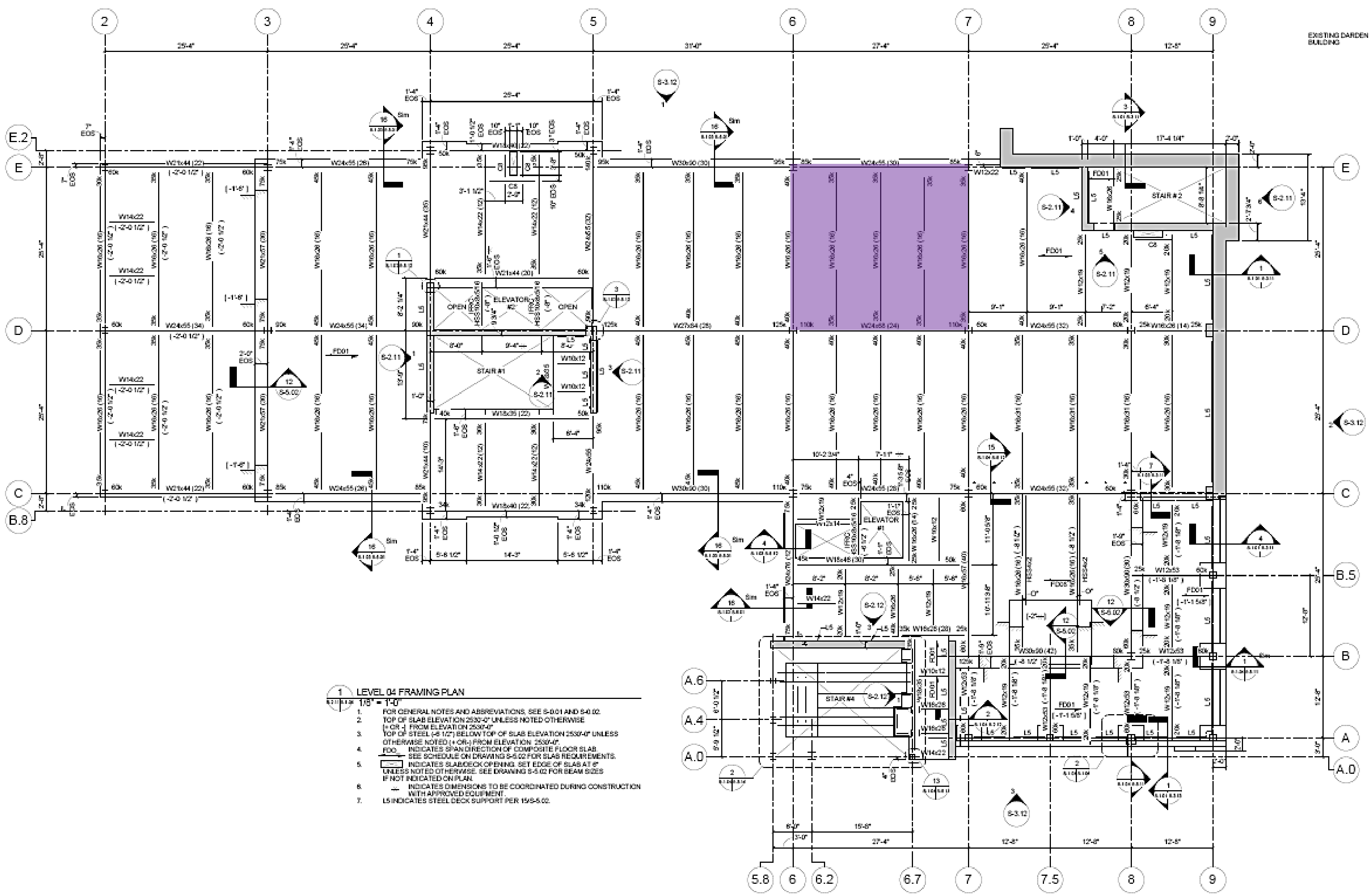
**Calculation of Column Weights**

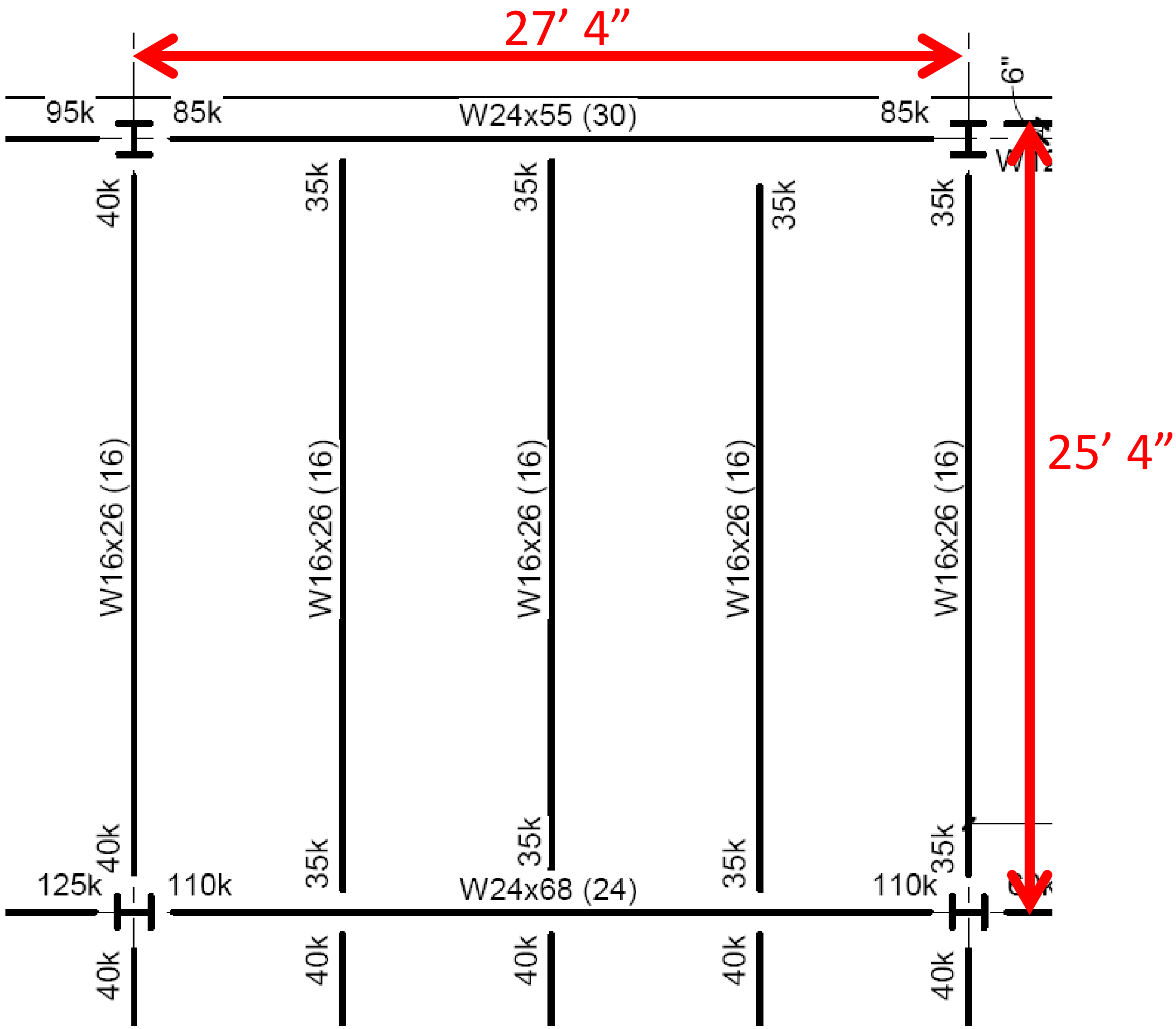
| Level | Column Height Below (FT) | Column Height Above (FT) | Column Wieght Below (PLF) | Column Wieght Above (PLF) | Column Wieght (K) |
|---|---|---|---|---|---|
| Roof | 9 | 0 | 1162 | 0 | 10 |
| 6 | 8 | 9 | 1162 | 1162 | 20 |
| 5 | 8 | 8 | 1442 | 1162 | 21 |
| 4 | 8 | 8 | 1606 | 1442 | 24 |
| 3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

Story Forces Diagram



# Appendix


LEVEL 04 FRAMING PLAN
1/8" = 1'-0"
1. FOR GENERAL NOTES AND ABBREVIATIONS, SEE S-0.01 AND S-0.02.
2. TOP OF SLAB ELEVATION 2530'-0" UNLESS NOTED OTHERWISE (+ OR -) FROM ELEVATION 2530'-0"
3. TOP OF STEEL (-6 1/2") BELOW TOP OF SLAB ELEVATION 2530'-0" UNLESS OTHERWISE NOTED (+ OR -) FROM ELEVATION 2530'-0".
4. FDO INDICATES SPAN DIRECTION OF COMPOSITE FLOOR SLAB. SEE SCHEDULE ON DRAWING S-5.02 FOR SLAB REQUIREMENTS.
5. INDICATES SLAB/DECK OPENING. SET EDGE OF SLAB AT 6" UNLESS NOTED OTHERWISE. SEE DRAWING S-5.02 FOR BEAM SIZES IF NOT INDICATED ON PLAN.
6. INDICATES DIMENSIONS TO BE COORDINATED DURING CONSTRUCTION WITH APPROVED EQUIPMENT.
7. L5 INDICATES STEEL DECK SUPPORT PER 15/S-5.02.
STAIR #1
STAIR #2
STAIR #4
ELEVATOR #2
ELEVATOR #1
EXISTING DARDEN BUILDING


27' 4"
25' 4"
6"
95k
85k
W24x55 (30)
85k
40k
35k
35k
35k
35k
W16x26 (16)
W16x26 (16)
W16x26 (16)
W16x26 (16)
W16x26 (16)
40k
35k
35k
35k
35k
125k
110k
W24x68 (24)
110k
40k
40k
40k
40k
40k