TECHNICAL REPORT II

Daniel Goff
Structural Option

Faculty Advisor
Linda M. Hanagan

Letter of Transmittal

Daniel Goff
Structural Option
September 25, 2014

Dr. Hanagan
Advisor
The Pennsylvania State University

Dear Dr. Hanagan,

The following technical report was prepared to meet requirements from AE 481W. The report includes a thorough structural analysis of The Primary Health Networks Medical Office Building in Sharon, Pa. The building was analyzed for roof loads, floor loads, snow loads, wind pressures and seismic forces.

Thank you for taking the time to review this report, I look forward to reviewing your feedback.

Sincerely,

Daniel E. Goff

Executive Summary

The Primary Health Networks Medical Office Building is located in Sharon, Pa in between Pitt and E Silver streets next to the Shenango River. It will be a 5 story structure rising 85 feet, having four elevated floors and a roof. The building offers 78,000 square feet of occupiable space and will cost approximately $10 million.

The site soil was found to have a bearing capacity of 2500psi allowing for concrete spread and mat footings to serve as a foundation for the building. The building is primarily a steel framed structure with steel columns supporting wide flange steel girders and steel bar joists. Typical sizes for floor joists and girders range from 10 inch to a maximum depth of 24 inches. The floor structure is concrete on metal deck for all four elevated floors, whereas the first floor is concrete slab on grade. Typical bay sizes range from 30'x26' to 33'-10"x30'.

The building's lateral force resisting system is comprised of three Ivany block shear walls. Ivany block is a concrete masonry unit with pre-determined locations for the rebar and having an f'm of 3000psi. The shearwalls are located around stairwells throughout the building.

Typical shear and moment connections are to be designed by the steel fabricator. Other connections typical to this building discussed in detail include joist to ivany block wall connections and concrete slab on metal deck to ivany block to wall connections.

The building was designed using the International Building code (IBC) edition 2009 which references the American Society of Civil Engineers (ASCE) document 7-05. The exception to this is the lateral loads on the building, which were determined with and designed to the IBC 2012 -edition which adopts ASCE 7-10.

Table of Contents

Building Abstract

The Primary Health Network's Medical Office Building
Sharon, PA

General Information

Height: 82ft
Size: 78,000 sq. ft.
Cost: $10 million
Construction: November 2014-January 2016
Project Delivery Method: Design-Build

Project Team

Owner: The Primary Health Network
Architect: John N Guitza Associates, Inc.
Structural Engineer: Taylor Structural Engineers
MEP Engineer: BDA Engineering
Construction Manager: Hudson Construction
Civil Engineer: Professional Service Industries, Inc.

Architecture

The primary architectural goal was to create a modern look with a strong focus on economy. This was accomplished by methods such as incorporating an exterior finish/insulation system.

Mechanical System

Variable Air Volume system comprised of (2) 65 ton units and (1) 30 ton unit

Lighting and Electrical Systems

(5) 120/208V 3 Phase panel boards
(6) 480/277V 3 Phase panel boards

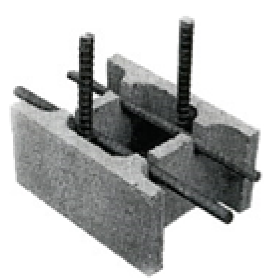
Low voltage dual technology occupancy sensors are used to increase efficiency

Structural System

Foundation: Slab on grade with concrete spread and Mat footings

Gravity: Steel columns and wide flange girders, steel bar joists, and normal weight concrete on metal deck floors

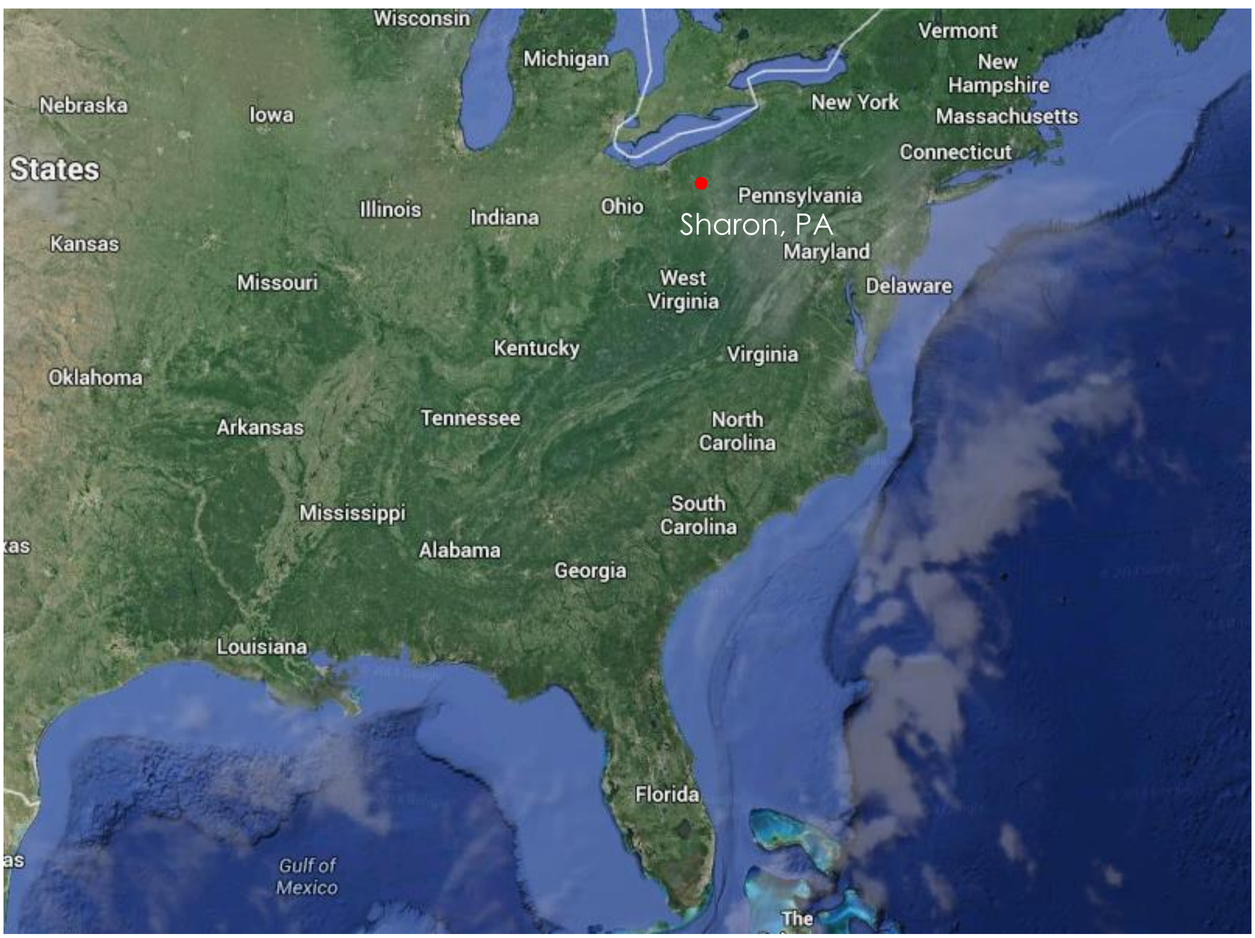
Lateral: 3 Ivany block shear walls



Daniel Goff I Structural Option www.engr.psu.edu/ae/thesis/portfolios/2015/deg5164

Site Plan

Location Plan

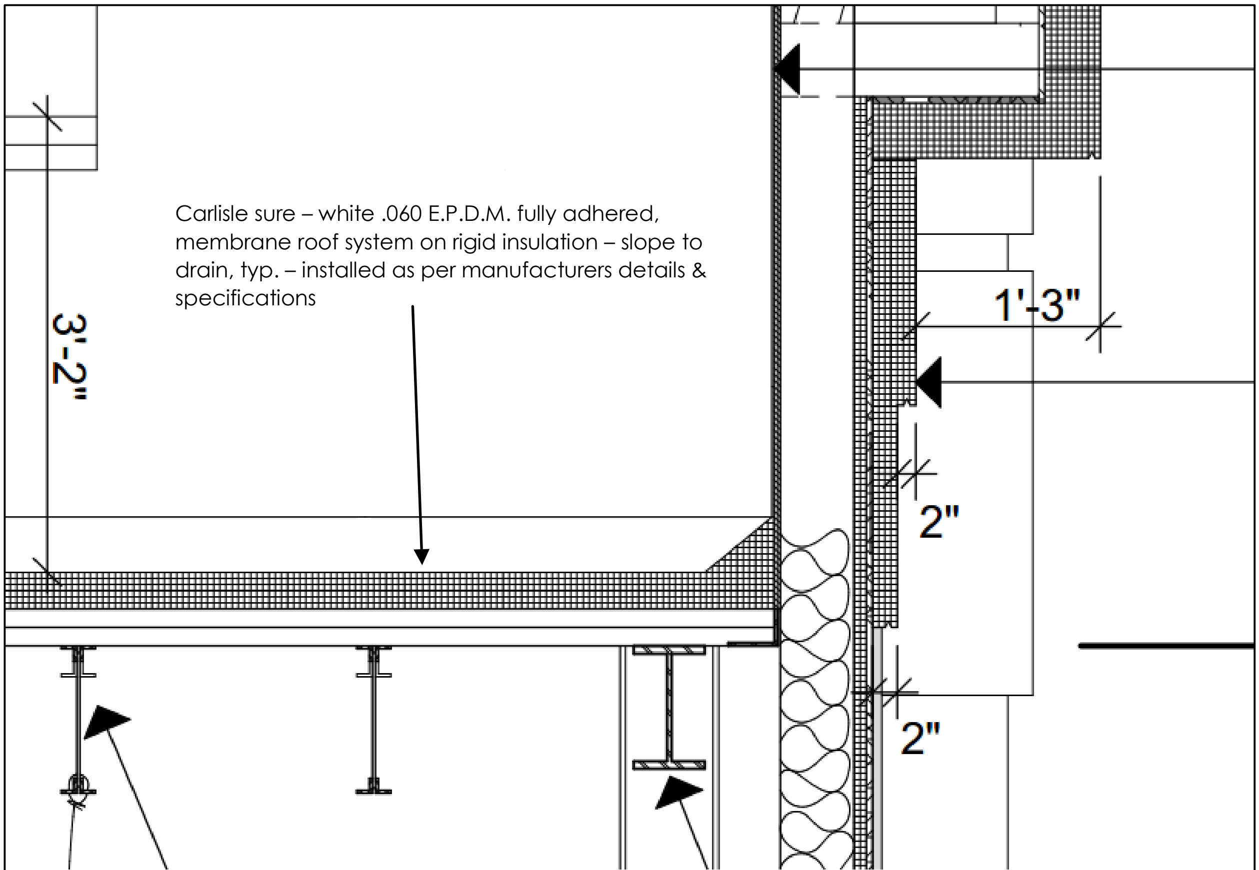


Preparatory Documents

Building Code:	2012 International Building Code (IBC)
Steel:	American Institute of Steel Construction (AISC)
Welding:	American Welding Society
Concrete:	American Concrete Institute (ACI)
Concrete Masonry:	American Concrete Institute (ACI)
	American Society of Civil Engineers (ASCE)
	ASCE 7-05
	ASCE 7-10 (for lateral loads only)

Gravity Loads

Typical Roof Loading



Typical roof section from section 1 drawing A-31

Roof Dead Loads:

Roofing/Membrane	1 psf	
Insulation:	8 psf	from carlisle
Deck:	2 psf	from vulcraft
Steel:	5 psf	from vulcraft
Miscellaneous/MEP:	4 psf	
Total roof dead load:	20 psf	

Roof Live Loads:

Basic roof live load: 20 psf per table 4-1 in ASCE 7-05
(30 psf was used in design)

Roof snow load: 21 psf
(21 psf was used in design)

Design snow load = $0.7*C_c*C_t*I*P_g$

C_c=1.0
C_t=1.0
I=1.0
P_g=30psf

Snow drift load:

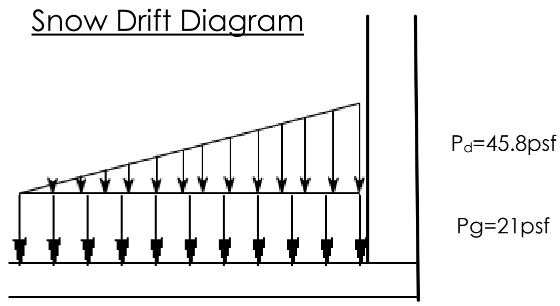
γ=0.13*30+14=17.9

hd=2.56' from eq. in figure 7-9

w=4*2.56=10.24'

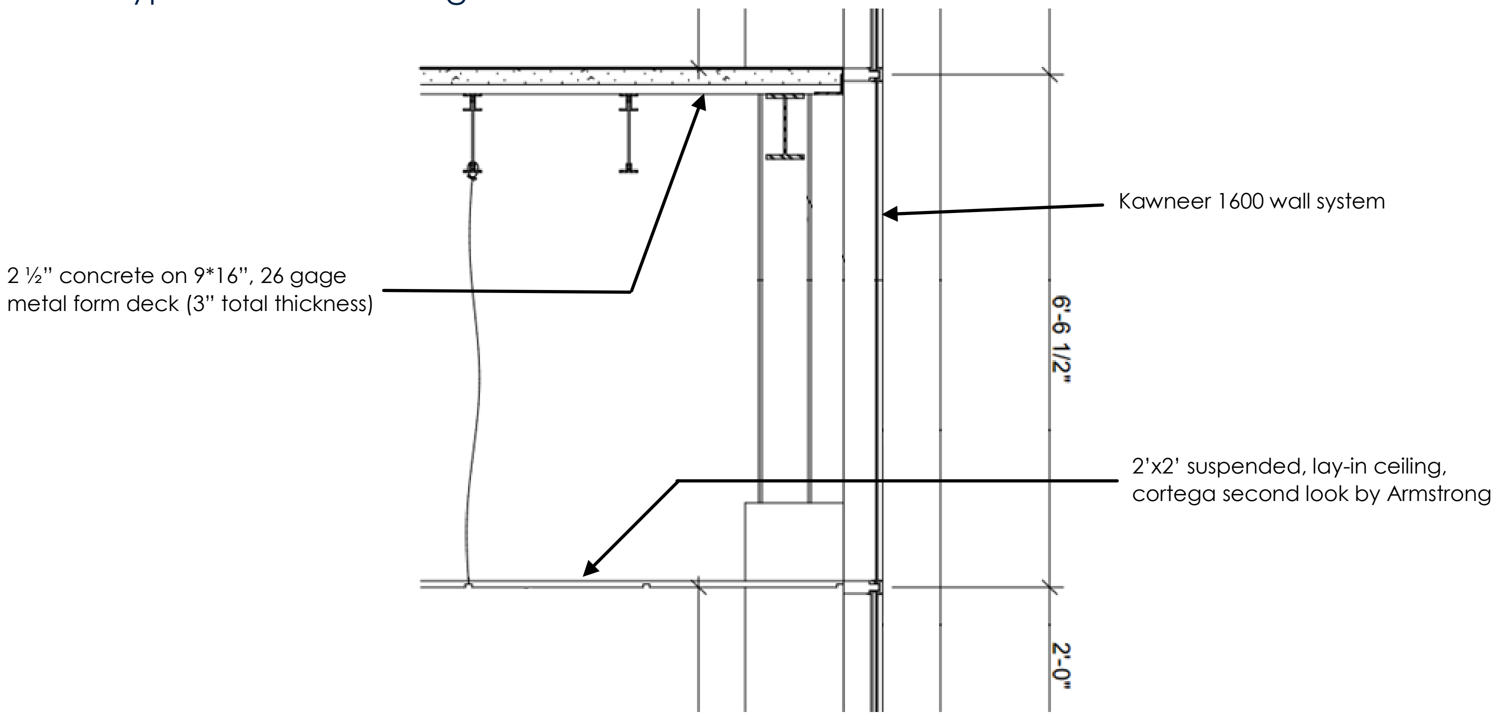
P_d=2.56*17.9=45.8psf

Snow Drift Diagram



Drift length w =10.24'

Typical Floor Loadings



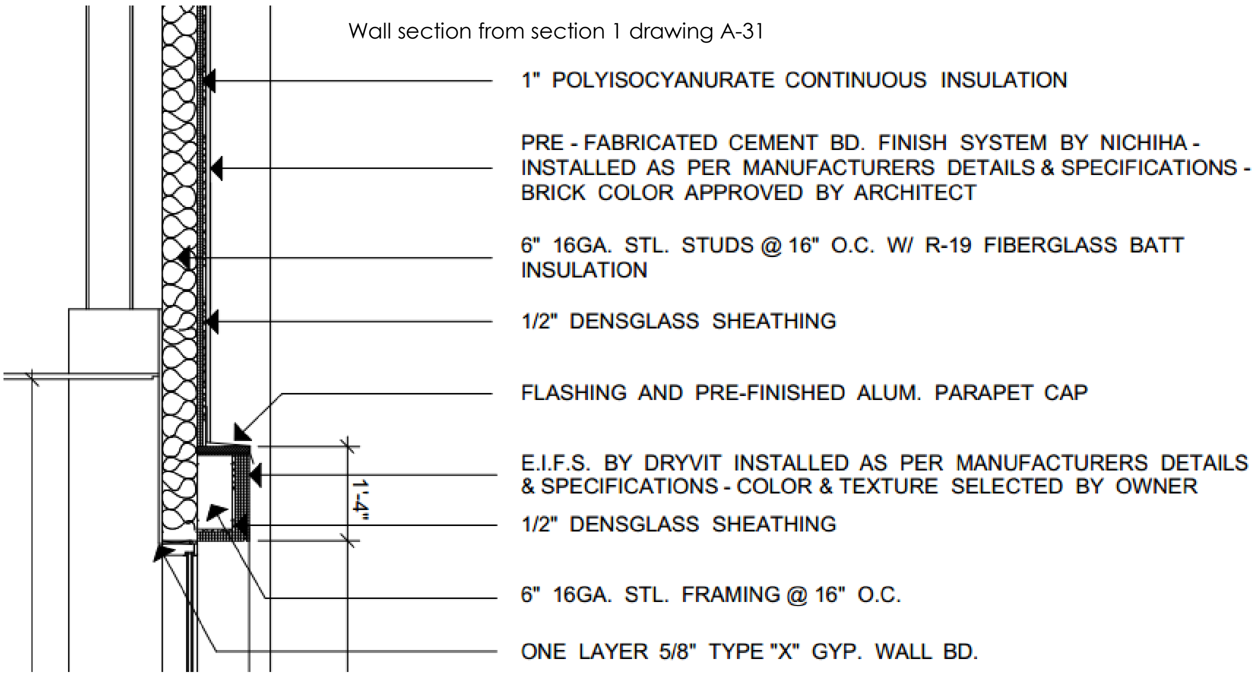
Floor Dead Load

Flooring:	1 psf	
Slab-on-deck	35 psf	- from vulcraft
Steel:	10 psf	- from vulcraft
Miscellaneous/MEP:	2 psf	
Exterior Wall:	10 psf	- from kawneer
Total floor dead load:	58 psf	

Floor Live Load (Table 4-1 ASCE 7-05)

Area	As Designed (psf)	ASCE 7-05 (psf)
Office	80	50
First Floor Corridors	100	100
Corridors above first floor	80	80
Stairs	100	100
Partitions	15	15

Non-typical Loadings



Insulation:	1 psf
Cement Finish:	6 psf
Densglass Sheathing:	2 psf
Studs:	2 psf
Total	11 psf

The load of the cement finish, sheathing and insulation is transferred into the light gage steel studs. These in turn send the load into steel angles which transfer it into the columns and finally to the foundations.

Other Non-typical loadings

There are there roof top units on The Primary Health Networks Medical Office building. The worst case of these being a 11,000lb unit occupying a 33ft. by 9ft. space. This essentially superimposes a 37 psf dead load on all other loads already being applied to this space.

Wind Loads

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Wind Analysis

ASCE 7-10 Chapter 27

1.) risk category II — Table 1.4-1

2) $V_u = 115$ mpH — Figure 26.5-1A
$I = 1.0$

3) $K_d = 0.85$ — Table 26.6-1

exposure B — Section 26.7

$K_{zt} = 1.0$ — Table 26.8-1

Gust effect, $G = 0.85$ — Section 26.9

Enclosed Structure — Section 26.10

$GC_{pi} = +/- 0.18$ — Table 26.11-1

4) $K(15') = 0.57$ — Table 27.3-1

$K(30') = 0.70$

$K(45') = 0.79$

$K(60') = 0.85$

$K(75') = 0.91$

$K(85') = 0.95$

Building natural frequency will be determined using eq 26.9-4 $n_a = \frac{75}{75'} = 1$ → Rigid

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5) Q_z or Q_h $q_h = 0.00256(K_z)(K_{zt})(K_d)(V^2)$ EQ 27.3-1

$K_{zt} = 1.0$

$q_{15'} = 0.00256(0.85)(0.57)(115\,psf)^2 = 16.4\,psf$

$q_{30'} = 0.00256(0.85)(0.70)(115\,psf)^2 = 20.14\,psf$

$q_{45'} = 0.00256(0.85)(0.79)(115\,psf)^2 = 22.73\,psf$

$q_{60'} = 0.00256(0.85)(0.85)(115\,psf)^2 = 24.46\,psf$

$q_{75'} = 0.00256(0.85)(0.91)(115\,psf)^2 = 26.19\,psf$

$q_{85'} = 0.00256(0.85)(0.95)(115\,psf)^2 = 27.34\,psf$

6) $C_p = 0.8$ for windward walls Figure 27.4-1

$C_p = -0.5$ for leeward walls

↳ $L/B = 144'/120' = 1.2$ $C_p = -.46$ by interpolation. use -0.5 for all directions

Roof

$q = .00256(0.93)(0.85)(115)^2 = 26.7\,psf$

$p = 26.7[-0.9-0.18] = 28.8\,psf$

net $= 0.7W - 0.6D = 20.16 - 4.8 = 15.36\,psf$

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7) $+GC_{pi}$ Case

@ H = 15'   27.4-1

$P_{windward} = (16.4\,psf)(0.85)(0.8) - (27.3)(0.18) = 6.24\,psf$

$P_{leeward} = (27.3)(0.85)(-0.5) - (27.3)(0.18) = -16.52\,psf$

$\Sigma P = 22.76\,psf$

@ H = 30'

$P_{windward} = (20.1\,psf)(0.85)(0.8) - (27.3)(0.18) = 8.75\,psf$

$P_{leeward} = (27.3)(0.85)(-0.5) - (27.3)(0.18) = -16.52\,psf$

$\Sigma P = 25.27\,psf$

@ H = 45'

$P_{windward} = (22.7\,psf)(0.85)(0.8) - (27.3)(0.18) = 10.52\,psf$

$P_{leeward} = (27.3)(0.85)(-0.5) - (27.3)(0.18) = -16.52\,psf$

$\Sigma P = 27.04\,psf$

@ H = 60'

$P_{windward} = (24.5)(0.85)(0.8) - (27.3)(0.18) = 11.75\,psf$

$P_{leeward} = (27.3)(0.85)(-0.5) - (27.3)(0.18) = -16.52\,psf$

$\Sigma P = 28.27\,psf$

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@ H = 75'

$P_{windward} = (26.2\,psf)(0.85)(0.8) - (27.3)(0.18) = 12.90\,psf$

$P_{leeward} = (27.3\,psf)(0.85)(-0.5) - (27.3)(0.18) = -16.52\,psf$

$\Sigma P = 29.42\,psf$

@ H = 85'

$P_{windward} = (27.3\,psf)(0.85)(0.8) - (27.3)(0.18) = 13.65\,psf$

$P_{leeward} = (27.3\,psf)(0.85)(-0.5) - (27.3)(0.18) = -16.52\,psf$

$\Sigma P = 30.17\,psf$

−GCpi Case

@ H = 15'

$P_{windward} = (16.4\,psf)(0.85)(0.8) + (27.3)(0.18) = 16.07\,psf$

$P_{leeward} = (27.3)(0.85)(-0.5) + (27.3)(0.18) = -6.69\,psf$

$\Sigma P = 22.75\,psf$

@ H = 30'

$P_{windward} = (20.1\,psf)(0.85)(0.8) + (27.3)(0.18) = 18.58\,psf$

$P_{leeward} = (27.3)(0.85)(-0.5) + (27.3)(0.18) = -6.69\,psf$

$\Sigma P = 25.27\,psf$

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DESIGNED BY: ____ DATE: ____
JOB NAME: ____

@ H=45'

$P_{windward} = (22.7psf)(0.85)(0.8) + (27.3)(0.18) = 20.35\ psf$

$P_{leeward} = (27.3)(0.85)(-0.5) + (27.3)(0.18) = -6.69\ psf$

$\Sigma P = 27.04\ psf$

@ H=60'

$P_{windward} = (24.5psf)(0.85)(0.8) + (27.3)(0.18) = 21.57\ psf$

$P_{leeward} = (27.3)(0.85)(-0.5) + (27.3)(0.18) = -6.69\ psf$

$\Sigma P = 28.26\ psf$

@ H=75'

$P_{windward} = (26.2psf)(0.85)(0.8) + (27.3)(0.18) = 22.73\ psf$

$P_{leeward} = (27.3)(0.85)(-0.5) + (27.3)(0.18) = -6.69\ psf$

$\Sigma P = 29.42\ psf$

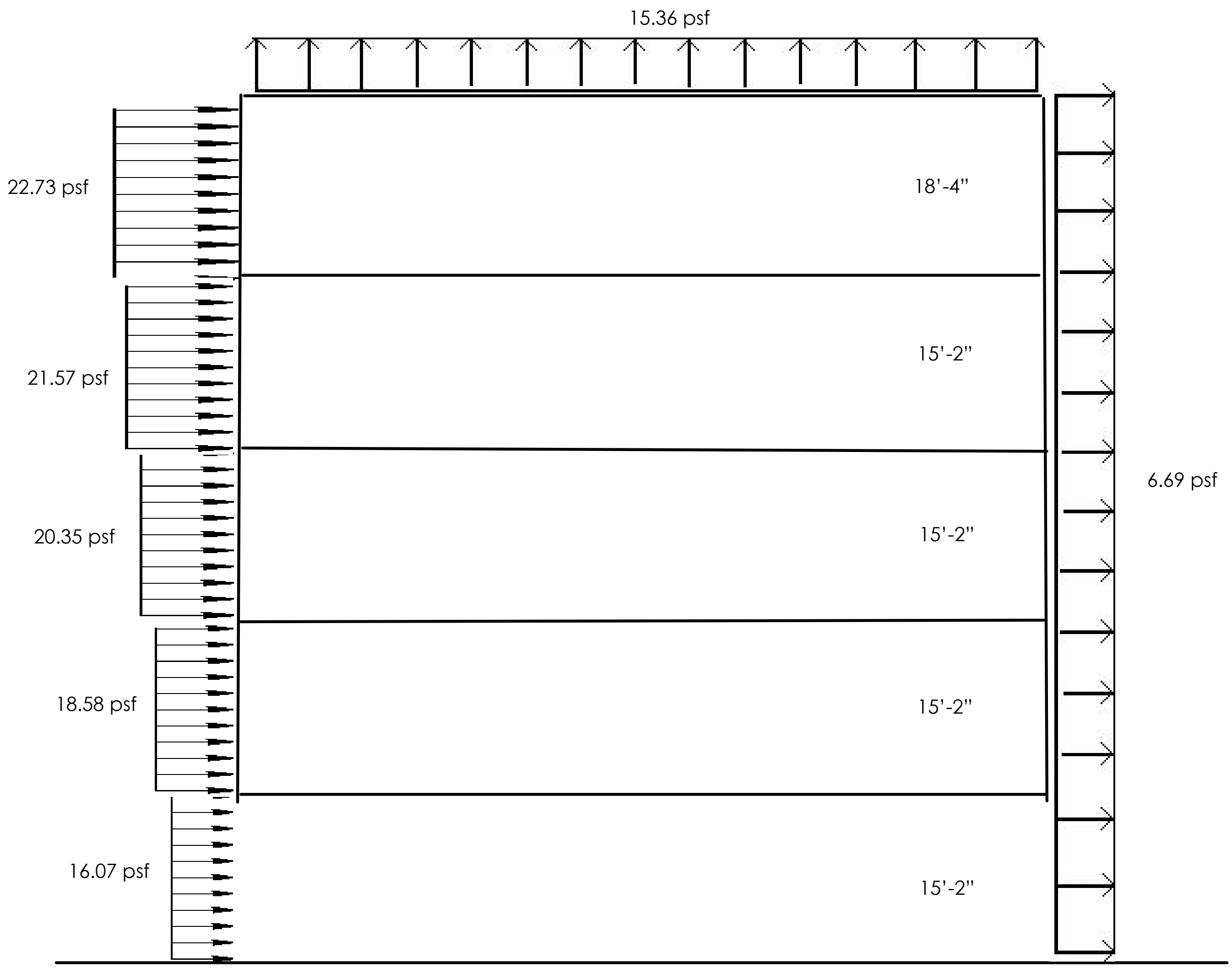
@ H=85'

$P_{windward} = (27.3psf)(0.85)(0.8) + (27.3)(0.18) = 23.48\ psf$

$P_{leeward} = (27.3psf)(0.85)(-0.5) + (27.3)(0.18) = -6.69\ psf$

$\Sigma P = 30.17\ psf$

Wind Loading Diagram



Base Shear N-S direction

V=22.75psf(15.167'*144.167')+25.27 psf (15.167'*144.167')+27.04 psf (15.167'*144.167')+28.26 psf (15.167'*144.167')+29.42 psf (18.33'*144.167')

V=304kips

Base Shear E-W direction

V=22.75psf(15.167'*120.33')+25.27 psf (15.167'*120.33')+27.04 psf (15.167'*120.33')+28.26 psf (15.167'*120.33')+29.42 psf (18.33'*120.33')

V=254kips

Seismic Loads

PENNSTATE Engineering

CLASS: ____ SECTION: ____
SHEET NO: ____ OF ____
DESIGNED BY: ____ DATE: ____
JOB NAME: ____

Seismic Analysis

Risk Category II — Section 11.6

Seismic Importance Factor = 1.0

Seismic Site Class - assume C

$S_s = 0.170$ — Figure 22-1

$S_1 = 0.055$ — Figure 22-2

$F_a = 1.6$ — Table 11.4-1

$F_v = 2.4$ — Table 11.4-2

$S_{DS} = F_a S_s (2/3) = 0.181$ — 11.4-3

$S_{D1} = F_v S_1 (2/3) = 0.088$ — 11.4-4

Seismic Design Category B — Tables 11.6-1, 11.6-2

The building has Intermediate Reinforced Masonry Shear walls

$R = 4.0$ — Table 12.2-1

$T_a = 0.02(75)^{0.75} = 0.51$ — 12.8-7

$C_t = 0.02$ $x = 0.75$ — Table 12.8-2

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JOB NAME:

$C_s = \frac{0.181}{\left(\frac{4.0}{1.0}\right)} = 0.045$ 12.8-2

$C_{s\,max} = \frac{0.088}{0.51\left(\frac{4.0}{1.0}\right)} = 0.043$ 12.8-3 ✓

$C_{s\,min} = 0.044(0.181)(1.0) = 0.008$ 12.8-5 ✓

$C_s = 0.045$

Calculate Seismic Weight w

Roof

Dead load $= \frac{20psf\,(120.33' \times 144.167')}{1000} = 347^k$

Live load $= \frac{30psf\,(120.33' \times 144.167')}{1000\#} = 520^k$

total $= 867^k$

floor

Dead load floors 2-5 $= \frac{(58psf)(120.33')(144.167')(4)}{1000\,lb}$

$= 4025^k$

CLASS: SECTION:
SHEET NO: OF
DESIGNED BY: DATE:
JOB NAME:

Floor

Live load floors 2-5 $= \frac{(80)(120.33)(144.167)(4)}{1000\ \text{lb}}$

$= 5551^k$

total $= 9576^k$

Seismic weight $w = 10{,}443^k$

Base Shear

$V = C_s W$

$V = (0.045)(10{,}443) = 470^k$

Vertical Distribution

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

$T_a = 0.51 \rightarrow$ use $k = 1$

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CLASS:
SHEET NO:
DESIGNED BY:
JOB NAME:
SECTION:
OF
DATE:

	w_i	h_x	$w_i h_i$	C_{vx}
floor 2	2394	15'-2	36,310	.085
floor 3	2394	30'-4	72,610	.169
floor 4	2394	45'-6	108,927	.254
floor 5	2394	60'-8"	145,236	.339
Roof	867	75'	65,025	.152
Sum			428 108	

Story forces

floor 2 = 39.8^k

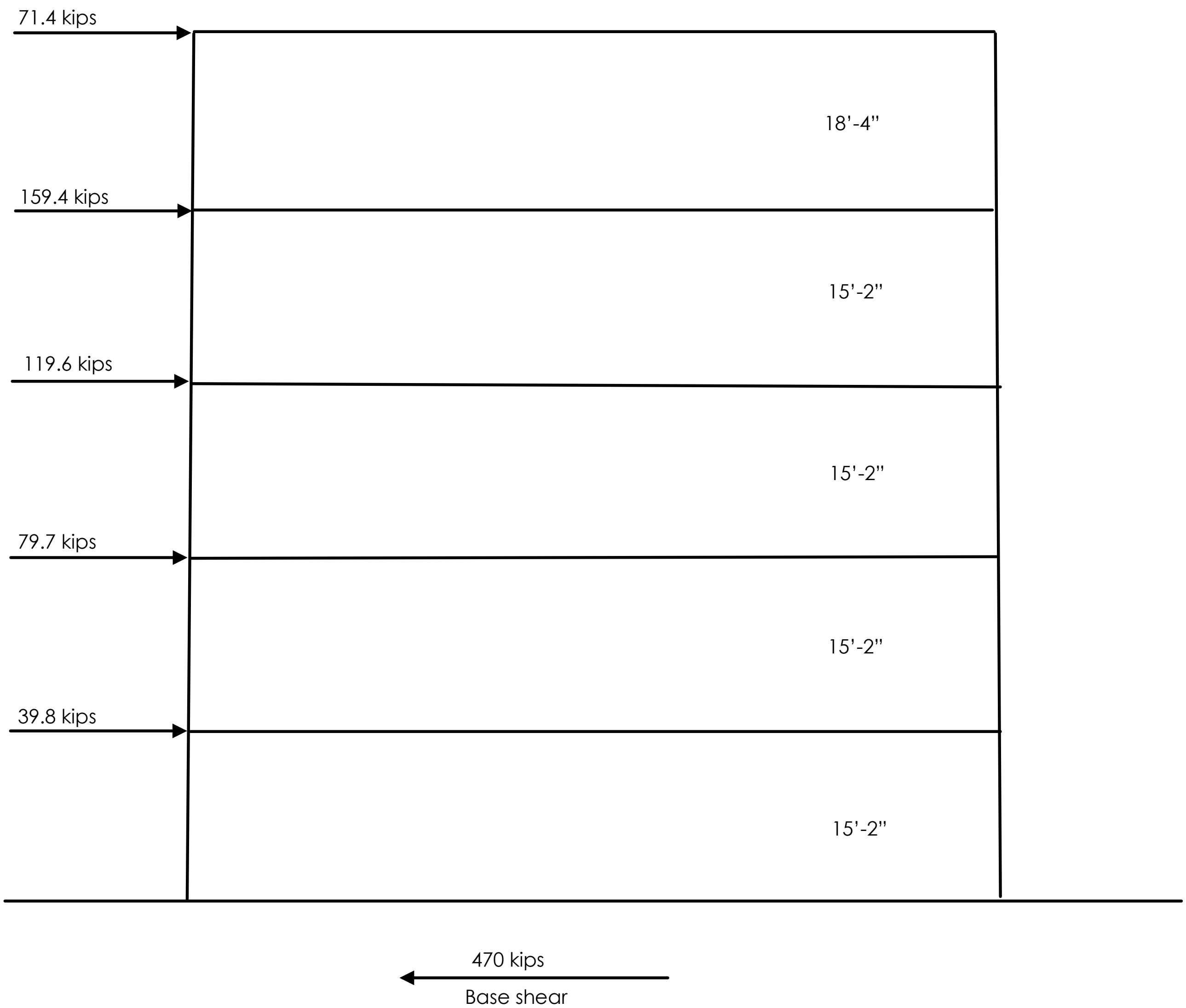
floor 3 = 79.7^k

floor 4 = 119.6^k

floor 5 = 159.4^k

Roof = 71.4^k

Seismic Loading Diagram



Base shear = 71.4kips+159.4kips+119.6kips+79.7kips+39.8kips = 470 kips

Appendix A

Typical Floor Plan