Wangjae You
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September 26, 2014

Dr. Aly Said
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210 Engineering Unit A

Dear Dr. Aly Said,
This report was prepared to be summated for Structural Technical Report 2 for AE 481W.

Structural Technical Report 2 includes a comprehensive design evaluation of structural system of the building. This analysis includes calculations of roof loads, floor loads, exterior wall loads, snow loads, wind loads and seismic loads. The report was prepared using a combination of hand calculations and spreadsheets.

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

Sincerely,

Wangjae You

Enclosed: Structural Technical Report 2

Structural Technical Report 2

LIFE SCIENCES BUILDING
BUILDING CODES, SPECIFICATIONS, AND LOADS

Prepared for: Dr. Aly M. Said | Dr. Thomas Boothby | Professor Kevin Parfitt | Dr. Charles D. Cox
Prepared by: Wangjae You | Structural Option
September 26, 2014

Table of Contents

LIFE SCIENCES BUILDING - NORTH EAST OF THE U.S.

General Information

Full Height: 91 ft
Number of Stories: 5 stories
Size: 174,500 square-foot
Cost: $91.6 million
Date of Construction: September 2008 - August 2011
Project Delivery Method: Design-bid-build

Project Team

Owner: Education Institutes
Architect: Bohlin Cywinski Jackson
Structural: Ryan-Biggs Associates, P.C.
MEP/Lighting: vanZelm Heywood & Shadford, Inc.
Construction: Bond Brothers, Inc
Project Manager: PML Project Management
Sustainability: Atelier Ten

Project Sponsor: Ryan-Biggs Associates, P.C.

Architecture

The main concept of design in floor plan is to promote the interaction of idea and technique between people using the building. To place laboratories in the first floor provides easy accessibility to whom uses this building.

Structural Systems

Foundation**:** cast-in-place concrete spread and strip footings

Framing**:** Structural Steel Frame with composite concrete slabs on metal deck

Lateral**:** Structural Steel Braced Frames

Sustainability Features

This building is certified as a LEED Platinum. Greenhouse on the roof improves building performance in energy throughout the year.

Mechanical

**Mechanical drawings have been requested to Ryan-Biggs and waiting for the response.

Electrical/Lighting

**Electrical drawings have been requested to Ryan-Biggs and waiting for the response.

EXECUTIVE SUMMARY

Life Sciences Building is located in north east of the United States (A generic information of building is requested by the owner). The goal of this project was to create a national model of sustainable design for laboratory buildings and the building was awarded LEED Platinum. The building is a 5 stories and 174,500 square feet. The geometry of building is L-shape and considered as long span structure. The building is divided into three section and each section perform its own function. A greenhouse is placed in the roof to serve research space and provide building energy performance. This technical report provides the summary of the structural existing conditions and explores potential alternatives of the system, especially in structure, throughout the course.

The foundation system consists of cast-in concrete spread and strip footings to support a system of wide flange steel columns. The building is design as a composite steel floor system. Typically, 7 1/2" reinforced concrete slab on 3" 20 gauge metal deck supports floor loads and transfer them to wide flange beams with shear stud connection. Web openings in wide flange steel beams resolve the coordination issues with mechanical, electrical and plumbing systems.

The lateral system is designed by structural steel braced frames. Due to architectural versatility, the layout of braced frames is carefully determined. Hollow Structural Section (HSS) is used as braces with varying its thickness according to the lateral loads.

Life Sciences Building was designed in accordance with the states codes, which is compliant to the International Building Code 2006 Edition (IBC 2006) and American Society of Civil Engineering (ASCE) 7-05 for load provisions. Due to the placement of a greenhouse in the roof, the structure was carefully considered in larger design loads. The coordination of MEP systems and structure system was a challenge of the design

SITE PLAN AND LOCATION PLAN

Figure 1 | Building Perspective from North

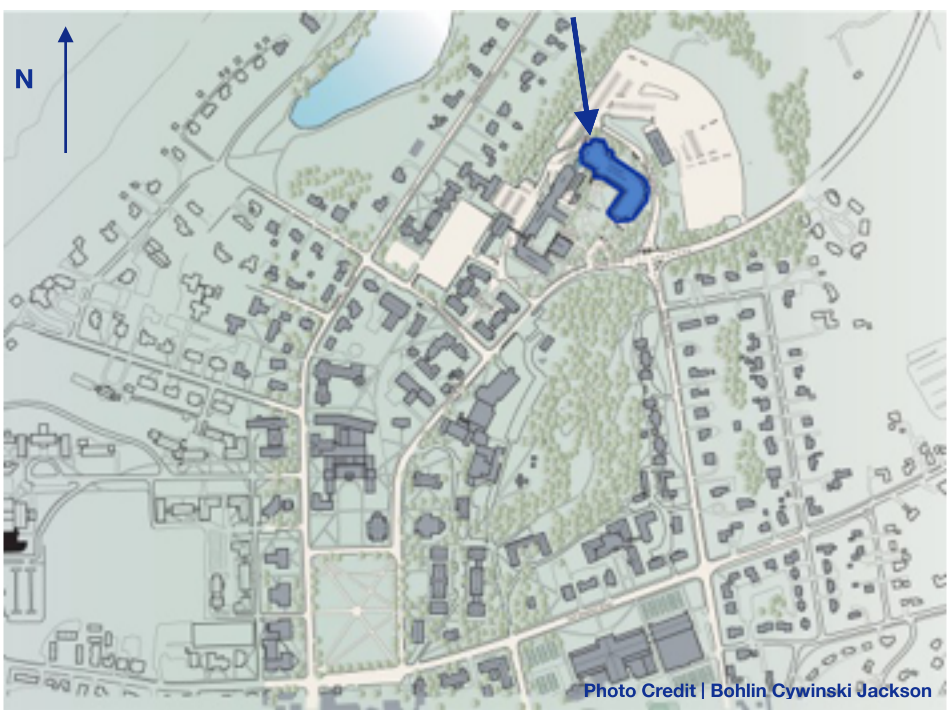


Figure 2 | Buildings Site Plan

DOCUMENTS REFERENCED

Codes and Standards

International Code Council

International Code Council 2006 Editions

International Building Code 2000 Edition

American Society of Civil Engineering

ASCE 7-05 - Minimum Design Loads of Buildings and Other Structures

ASCE 7-10 - Minimum Design Loads of Buildings and Other Structures

Vulcraft Deck Catalog

Construction Documents and Specifications of the Project

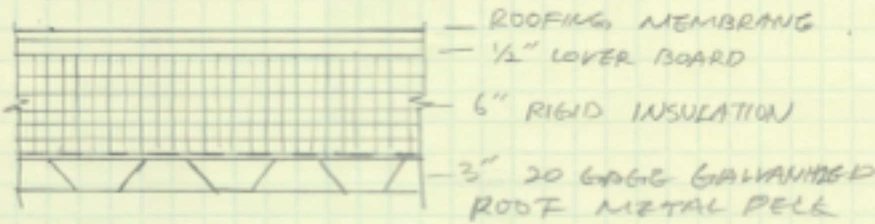
New York State Department of Transportation

NYSDOT - Standard Specification for Construction and Materials

GRAVITY LOADS

TYPICAL ROOF BAY

Typical Roof Bay Loading



Dead Load

- ROOFING MEMBRANE = 2 psf
- ½" COVER BOARD = 2 psf
- 6" RIGID INSULATION = $\frac{1.5 \text{ psf}}{1"} \times 6" = 9$ psf
- 3" 20 GAGE METAL DECK = 2.71 psf
- FRAMING ALLOWANCE = 10 psf
- MISC
  - M/E/P EQUIP = 5 psf
  - SPRINKLERS = 10 psf
  - LIGHTING = 5 psf
  - CEILING = 3 psf

TOTAL DEAD LOAD = 48.71 psf

vs.

LOAD USED IN DESIGN = 30 psf

Live Load

- Roof Live Load = 20 psf (ASCE 7-05 TABLE 4-1)
- No design roof live load was provided.

ROOF SNOW LOAD

Snow Load

ASCE 7-05 Chapter 7 - Figure 7-1

- Ground snow load, $P_g = 60$ psf
- Flat Roof Snow Load, P_f

$P_f = 0.7\, C_e \cdot C_t \cdot I_p$ Eqn 7-1.

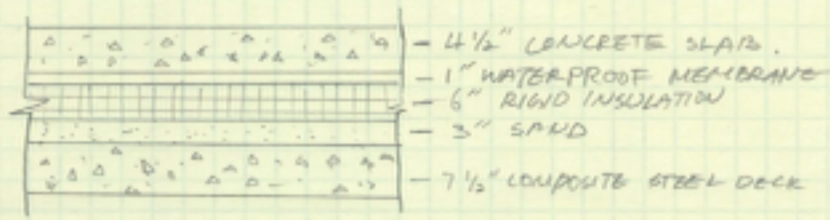
- Exposure Factor, $C_e = 0.9$
  - Terrain Category B
  - Fully exposed.
- Thermal Factor $C_t = 1.0$
  - Although the building has a greenhouse on the roof, it is only part of the roof. Therefore, using 1.0 would be conservative than 0.85.
- Importance Factor, $I_p = 1.1$
  - Building Occupancy Category III.

$\therefore P_f = (0.7)(0.9)(1.0)(1.1)(60) = 41.58$ psf ≈ 42 psf.

Original Design load = 50 psf (51.0)

GREENHOUSE FLOOR

Greenhouse Floor Construction



Dead Load.

- 4 1/2" CONCRETE SLAB : 150pcf (4.5/12) = 56.25 psf
- 1" WATERPROOF MEMBRANE = 1.5 psf
- 6" RIGID INSULATION : $\frac{1.5 \text{ psf}}{1''}$ x 6" = 9 psf
- 3" SAND : $\frac{8 \text{ psf}}{1''}$ x 3" = 24 psf
- 7 1/2" COMPOSITE STEEL DECK = 75 psf
- FRAMING ALLOWANCE = 10 psf
- MISC
  - MEP = 5 psf
  - SPRINKLER = 10 psf
  - LIGHTING = 5 psf
  - CEILING = 3 psf

TOTAL DEAD LOAD = 198.75 psf

vs

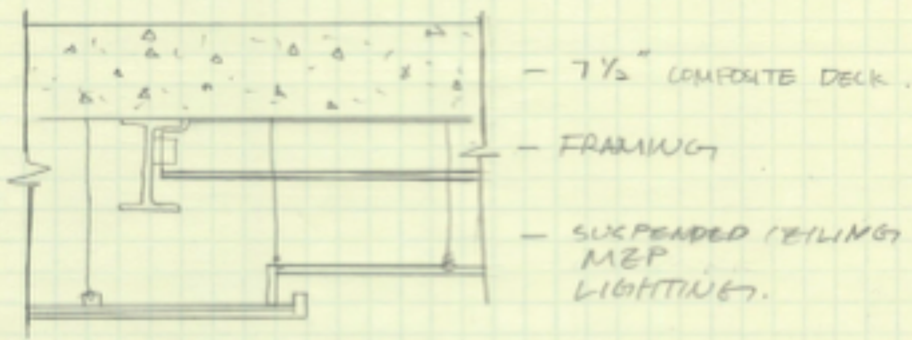
LOAD USED IN DESIGN = 160 psf

Live Load

- Greenhouse Live Load = 150 psf
  (ASCE 7-05 TABLE C4-1)

TYPICAL FLOOR BAY

Typical Floor Bay Loading



Dead Load

- 7 1/2" COMPOSITE DECK = 75 psf
- FRAMING ALLOWANCE = 10 psf
- SUSPENDED CEILING = 3 psf
- MEP = 5 psf
- LIGHTING = 5 psf
- SPLINKLER = 10 psf

TOTAL DEAD LOAD = 108 psf

VS.

LOAD USED IN DESIGN = 110 psf

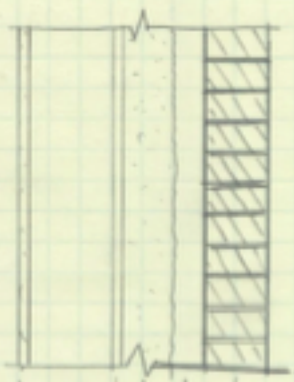
Live Load

Laboratories = 100 psf (ASCE 7-05 TABLE C4-1)

LOAD USED IN DESIGN = 125 psf.

TYPICAL EXTERIOR WALL DETAIL

Typical Exterior Wall Detail



4" BRICK WITH BRICK TIES 16" O.C. BOTH WAYS.
2" AIR SPACE
3" SPRAY APPLIED POLYURETHANE FOAM INSULATION
1/2" EXTERIOR GYPSUM BOARD
6" COLD FORMED METAL FRAMING
5/8" GYPSUM WALL BOARD

Dead Load.

- 4" BRICK WITH BRICK TIES = 38 psf
- 3" SPRAY POLYURETHANE FOAM INSULATION = 3 psf
- 1/2" GYPSUM BOARD = 2.2 psf
- 6" COLD FORMED MTL FRAMING = 2 psf
- 5/8" GYPSUM BOARD = 2.75 psf

47.95 psf

Load Path

Brick is sitting on the angle relief and connected with anchor bolt to cold formed metal framing. Cold formed metal framing is supported on concrete slab on the floor deck.
Brick facade load transferred to the foundation.

TABLE OF NON-TYPICAL LOAD

Table of Non-typical Load.

- ROOF GARDENS & TERRACES = 170 psf
- ROOF OVER CONNECTOR = 200 psf
- CONCENTRATED LIVE LOADS
  - FLOORS, ROOF GARDENS AND TERRACES = 2000 lbs
  - STAIR TREADS = 300 lbs
  - ROOF = 300 lbs.

SNOW LOAD

Snow Drift

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

$h_c = 19 - 1.927 = 17.073$

$P_s = C_s \cdot P_f$

$C_s = 1.0$ ⇐ slope of the greenhouse truss is 27°.

$P_s = (1.0)(42)$

$= 42$ psf.

$h_b = P_s/\gamma$ $P_s = 42$ psf

$\gamma = 0.13\,p_g + 14$

$= 42/21.8$ $= 0.13(60) + 14$

$= 1.927$ $= 21.8$ psf < 30 ✓

$h_c/h_b = 17.07/1.927 = 8.86 > 0.2$

∴ Snow Drift must be considered.

Leeward

$P_g = 60$ psf ⇒ $h_d = 0.43\sqrt[3]{l_u} \cdot \sqrt[4]{P_g + 10} - 1.5$

$l_u = 52$ ft $= 0.43(52)^{1/3} \cdot (60+10)^{1/4} - 1.5$

Windward $= 3.14$ → use.

$P_g = 60$ psf ⇒ $h_d = 0.43(36.3)^{1/3}(60+10)^{1/4} - 1.5$

$l_u = 36.3$ ft $= 2.62$

Drift Load

$h_d < h_c$, $3.14 < 17.073$

$P_d = \gamma \cdot h_d = (21.8)(3.14) = 68.452$ psf

WIND LOADS

Wind Load:

ASCE 7-05 Section 6.5 - Method 2 - Analytical Procedure.

Basic Wind Speed:

$V = 90$ mph (Figure 6-1)

Wind Directionality Factor, K_d:

$K_d = 0.85$ (Table 6-4)

⇒ Buildings: Main Wind Force Resisting System

Importance Factor, I:

$I = 1.15$ (Table 6-1)

⇒ Building Occupancy Category III.

Exposure Category:

Exposure B.

Topographic Factor, K_{zt}:

$K_{zt} = 1.0$ (§ 6.5.7.2)

Gust Effect Factor G (§6.5.8.1 & (6.5.8))

Approximate Fundamental Period of Building (§12.8.2.1)

$T_a = C_t h_n^x$

h_n ≡ Height above the base to the highest Level of building = 91 ft

C_t & x are determined by Table 12.8-2

- Concentrically Braced Steel Frame ⇒ All others.

∴ $C_t = 0.02$, $x = 0.75$

$T_a = 0.02(91)^{0.75} = 0.589$

$f = \frac{1}{T_a} = \frac{1}{0.589} = 1.697$ sec

∴ Building is considered as rigid structure.

Gust Effect Factor, G

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

$g_Q = 3.4$
$g_v = 3.4$

$I_{\bar{z}} = c\left(\frac{33}{\bar{z}}\right)^{1/6} = 0.30\left(\frac{33}{0.6(91)}\right)^{1/6} = 0.276$

$\bar{z} = 0.6(91) = 54.6' > z_{min} = 30'$ ∴ ok.

N-S Direction

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

$L_{\bar{z}} = \ell\left(\frac{\bar{z}}{33}\right)^{\bar{\epsilon}} = 320\left(\frac{0.6(91)}{33}\right)^{1/3} = 378.48$

$B = 252'$
$h = 80'$

$$= \sqrt{\frac{1}{1+0.63\left(\frac{252+80}{378.48}\right)^{0.63}}} = 0.7955$$

E-W Direction

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

$$L_{\bar{z}} = \ell\left(\frac{\bar{z}}{33}\right)^{\bar{\varepsilon}} = 378.48$$

B = 190.5'
h = 80'

$$Q = \sqrt{\frac{1}{1+0.63\left(\frac{190.5+80}{378.48}\right)^{0.63}}}$$

$$= 0.814.$$

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

$$= 0.925\left(\frac{1+(1.7)(3.4)(0.276)(0.7953)}{1+(1.7)(3.4)(0.276)}\right)$$

$$= 0.807$$

$$G(E\text{-}W) = 0.925\left(\frac{1+(1.7)(3.4)(0.276)(0.814)}{1+(1.7)(3.4)(0.276)}\right)$$

$$= 0.819$$

∴ Use G = 0.85 for conservative.

Enclosure Classification

Enclosed (§ 6.2)

Internal pressure Coefficient, GC_{pi}

$GC_{pi} = \pm 0.18$ (Figure 6-5)

External Pressure Coefficient, C_p or GC_{pe} (Figure 6-6 to 6-8)

Wall Pressure Coefficient C_p

Wind in N-S Direction.

- Windward : $C_p = 0.8$
- Leeward : $\frac{L}{B} = \frac{190.5'}{252'} = 0.76 \Rightarrow C_p = -0.5$
- Side : $C_p = -0.7$.

Wind in E-W Direction.

- Windward : $C_p = 0.8$
- Leeward : $\frac{L}{B} = \frac{252'}{190.5'} = 1.32$

$$\frac{2-1}{-0.3+0.5} = \frac{2-1.32}{-0.3-x}, \quad x = -0.436 \Rightarrow C_p = -0.436$$

- Side : $C_p = -0.7$

Roof Pressure Coefficient, Cp

*assumed the roof is flat (Figure 6-6)

Wind in N-S Direction

$\frac{h}{L} = \frac{80\ ft}{190.5\ ft} = 0.42 \leq 0.5$

Horizontal Distance from Windward Edge	Cp
0' to 40'	-0.9, -0.18
40' to 80'	-0.9, -0.18
80' to 160'	-0.5, -0.18
160' to 190.5'	-0.3, -0.18

Wind in E-W Direction

$\frac{h}{L} = \frac{80\ ft}{252\ ft} = 0.317 \leq 0.5$

Horizontal Distance from Windward Edge	Cp
0' to 40'	-0.9, -0.18
40' to 80'	-0.9, -0.18
80' to 160'	-0.5, -0.18
160' to 252'	-0.3, -0.18

Velocity Pressure Exposure Coefficient k_z

$k_z = 2.01 (z/z_g)^{2/\alpha}$ $z_g = 1200.00$ ft. $\alpha = 7$. (Table 6-2)

k_z at ELEV. 17' $= 2.01 \left(17'/1200' \right)^{2/7} = 0.596 \approx 0.60$

Velocity Pressure . q_z

$q_z = 0.00256 \cdot k_z \cdot k_{zt} \cdot k_d \cdot V^2 \cdot I$.

- k_z at elev. 17' $= 0.60$
- $k_{zt} = 1.0$
- $k_d = 0.85$
- $V = 90$ mph
- $I = 1.15$

q_z at elev. 17' $= 0.00256 (0.6)(1.0)(0.85)(90)^2 (1.15)$
$= 12.16$ psf.

$q_h = 0.00256 k_z \cdot k_{zt} \cdot k_d \cdot V^2 \cdot I$

$k_z = 2.01 \left(80/1200 \right)^{2/7.0} = 0.9272$

$q_h = 0.00256 (0.9272)(1.0)(0.85)(90)^2 (1.15)$
$= 18.794$ psf

Equations

Kz = 2.01 (z/z g)^(2/α)

qz = 0.00256*kz*kzt*kd*V^2*I

p = q*Gf*Cp - qi(GCpi)

Constants

Kzt	1
Kd	0.85
V	90
I	1.15
h	80 ft
G (N-S)	0.85
G (E-W)	0.85
(GCpi)	

Calcualting Kz and qz

Floor	Height above ground (z)	Z g (ft)	α	k z	q z	q h
Top of Parapet	85.00	1200.00	7.00	0.94	19.12	18.79
Top of 4th Floor	75.00	1200.00	7.00	0.91	18.45	18.79
4th Floor	61.00	1200.00	7.00	0.86	17.39	18.79
3rd Floor	46.33	1200.00	7.00	0.79	16.08	18.79
2nd Floor	31.67	1200.00	7.00	0.71	14.42	18.79
1st Floor	17.00	1200.00	7.00	0.60	12.07	18.79
Lower A	0.00	1200.00	7.00	0.00	12.07	18.79

Cp, Roof | N-S Direction			
0 to 40 ft	40 to 80 ft	80 to 160 ft	160 to 190.5 ft
-0.9	-0.9	-0.5	-0.3

Cp, Roof | E-W Direction			
0 to 40 ft	40 to 80 ft	80 to 160 ft	160 to 252 ft
-0.9	-0.9	-0.5	-0.3

Constants	
Kzt	1
Kd	0.85
V	90
I	1.15
h	80 ft
G (N-S)	0.85
G (E-W)	0.85
(GCpi)	0.18

Wind Pressure - Roof | North - South Direction

Location on Roof	Cp	G	qh (psf)	Pressure (psf)
0 to 40 ft	-0.9	0.85	1515.37	-1159.26
40 to 80 ft	-0.9	0.85	1515.37	-1159.26
80 to 160 ft	-0.5	0.85	1515.37	-644.03
160 to 190.5 ft	-0.3	0.85	1515.37	-386.42

Wind Pressure - Roof | East - West Direction

Location on Roof	Cp	G	qh (psf)	Pressure (psf)
0 to 40 ft	-0.9	0.85	1515.37	-1159.26
40 to 80 ft	-0.9	0.85	1515.37	-1159.26
80 to 160 ft	-0.5	0.85	1515.37	-644.03
160 to 252 ft	-0.3	0.85	1515.37	-386.42

Wall | N-S Direction

Cp, Windward	0.8	
Cp, Leeward	-0.5	
L	190.5	ft
B	252	ft
L/B	0.756	
Kzt	1	
Kd	0.85	
V	90	
I	1.15	
h	80	ft
G (N-S)	0.85	
G (E-W)	0.85	
(GCpi)	0.18	

Wind Pressure - Wall | North - South Direction

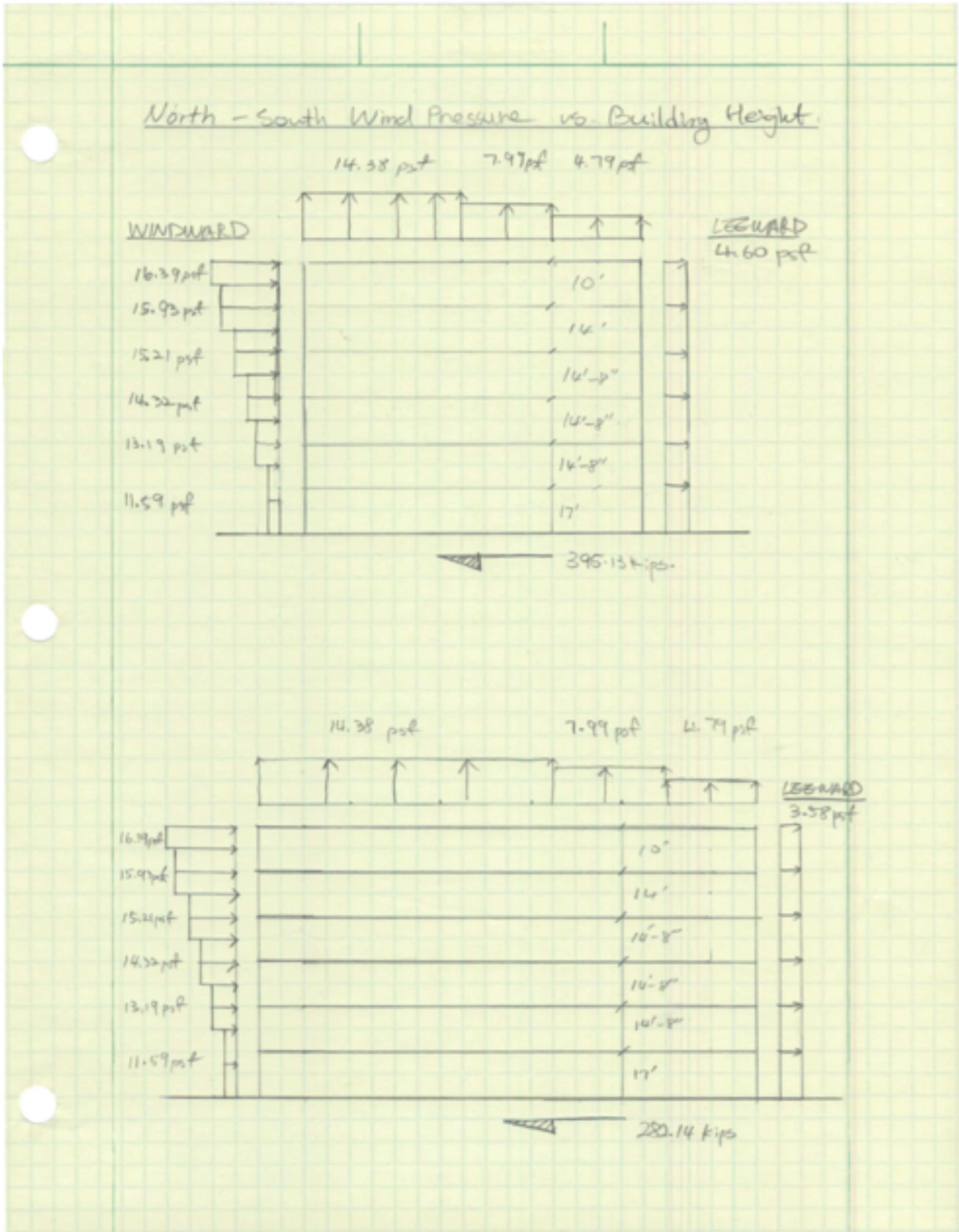
Floor	Height above Ground, z (ft)	qz (psf)	qh (psf)	Windward (psf)	Leeward (psf)	Tributary Height (ft)	Tributary Area (sq-ft)	Force (k)	Story Shear (k)	Overturning Moment (ft-k)
Top of Parapet	85.00	19.12	18.79	16.39	-4.60	5.00	1260.00	26.45	26.45	
Top of 4th Floor	75.00	18.45	18.79	15.93	-4.60	12.00	3024.00	62.09	88.54	4657.00
4th Floor	61.00	17.39	18.79	15.21	-4.60	14.33	3612.00	71.57	160.11	4365.73
3rd Floor	46.33	16.08	18.79	14.32	-4.60	14.67	3696.00	69.93	230.04	3240.11
2nd Floor	31.67	14.42	18.79	13.19	-4.60	14.67	3696.00	65.77	295.81	2082.61
1st Floor	17.00	12.07	18.79	11.59	-4.60	15.83	3990.00	64.63	360.43	1098.66
Lower A	0.00	12.07	18.79	11.59	-4.60	8.50	2142.00	34.69	395.13	0.00
										15444.11
Base Shear (k)		395.13								
Total Overturning Moment (ft-k)		15444.11								

Wall | E-W Direction

Cp, Windward	0.8	
Cp, Leeward	-0.436	
L	252	ft
B	190.5	ft
L/B	1.323	
Kzt	1	
Kd	0.85	
V	90	
I	1.15	
h	80	ft
G (N-S)	0.85	
G (E-W)	0.85	
(GCpi)	0.18	

Wind Pressure - Wall | East - West Direction

Floor	Height above Ground, z (ft)	qz (psf)	qh (psf)	Windward (psf)	Leeward (psf)	Tributary Height (ft)	Tributary Area (sq-ft)	Force (k)	Story Shear (k)	Overturning Moment (ft-k)
Top of Parapet	85.00	19.12	18.79	16.39	-3.58	5.00	952.50	19.02	19.02	
Top of 4th Floor	75.00	18.45	18.79	15.93	-3.58	12.00	2286.00	44.60	63.62	3345.19
4th Floor	61.00	17.39	18.79	15.21	-3.58	14.33	2730.50	51.31	114.93	3130.00
3rd Floor	46.33	16.08	18.79	14.32	-3.58	14.67	2794.00	50.01	164.94	2317.02
2nd Floor	31.67	14.42	18.79	13.19	-3.58	14.67	2794.00	46.86	211.80	1483.90
1st Floor	17.00	12.07	18.79	11.59	-3.58	15.83	3016.25	45.77	257.57	778.11
Lower A	0.00	12.07	18.79	11.59	-3.58	8.50	1619.25	24.57	282.14	0.00
										11054.21
Base Shear		282.14 kips								
Total Overturning Moment		11054.21 ft-kips								


North - South Wind Pressure vs. Building Height
14.38 psf
7.99 psf
4.79 psf
WINDWARD
LEEWARD
4.60 psf
16.39 psf
15.93 psf
15.21 psf
14.32 psf
13.19 psf
11.59 psf
10'
14'
14'-8"
14'-8"
14'-8"
17'
395.13 kips
14.38 psf
7.99 psf
4.79 psf
LEEWARD
3.58 psf
16.39 psf
15.93 psf
15.21 psf
14.32 psf
13.19 psf
11.59 psf
10'
14'
14'-8"
14'-8"
14'-8"
17'
282.14 kips

SEISMIC LOADS

Seismic Load

- Building not exempt — § 11.1.2
- Design Spectral Response Acceleration — § 11.4
  - Site Classification = D
  - Acceleration Parameter.

    $S_S = 0.309\ g$

    $S_1 = 0.083\ g$
  - Site Class Effect.

    $F_a = 1.4$

    $F_v = 2.4$

    $S_{MS} = (1.4)(0.309g) = 0.4326\ g$

    $S_{M1} = (2.4)(0.083\ g) = 0.1992\ g$.
  - Spectral Acceleration Parameters. — § 11.4.4

    $S_{DS} = 2/3 \cdot S_{MS}$

    $= 2/3\,(0.4326g) = 0.2884\ g$

    $S_{D1} = 2/3\ S_{M1}$

    $= 2/3\,(0.1992g) = 0.1328\ g$.
- Seismic Design Category
  - Occupancy Category III
  - $I = 1.25$
  - $S_{DS} = 0.2884g$

    $0.167 \le 0.2884g < 0.33$

  ∴ Seismic Design Category B.

- Analysis Procedure

  ⇒ Equivalent Lateral Force Procedure (TABLE 12.6-1)

- Response Modification Factor

  Steel system not specifically detailed for seismic resistance.

  $R = 3$.

- Approximate Fundamental Period

  $T_a = C_t \cdot h_n^x$

  $C_t = 0.02$

  $x = 0.75$

  $h = 91$

  $T_a = (0.02)(91)^{0.75}$

  $= 0.5893$ sec.

- Long Term Transition Period, T_L

  $T_L = 6$ sec

- Seismic Response Coefficient, C_s

  $C_s = \dfrac{S_{DS}}{\left(\frac{R}{I}\right)} = \dfrac{0.2884g}{\left(\frac{3}{1.25}\right)} = 0.1202$.

  $T_a = 0.5893 \text{ sec} < T_L = 6 \text{ sec}$

  $C_s = \dfrac{S_{D1}}{T_a (R/I)} = \dfrac{0.1328g}{0.5893(3/1.25)} = 0.0939$

  $C_s = \min \begin{vmatrix} 0.1202 \\ 0.0939 \end{vmatrix} = 0.0939 > 0.01$. OK.

  $\therefore C_s = 0.0939$.

Floor	Dead Load (psf)	Partition Load (psf)	Total Weight (psf)	Floor Area (sq ft)	Weights (kips)
Penthouse Roof	48.71	0.00	48.71	31110.03	1515.37
4th Floor	108.00	20.00	128.00	19002.68	2432.34
Greenhouse Floor	198.75	20.00	218.75	6777.45	1482.57
3rd Floor	108.00	20.00	128.00	33428.03	4278.79
2nd Floor	108.00	20.00	128.00	37249.15	4767.89
1st Floor	108.00	20.00	128.00	37249.15	4767.89
				Total Weight	19244.85

Story Forces

Floor	hi (ft)	h (ft)	W (kips)	w*h^k	Cvx	Story Forces Fi (kips)
Penthouse Roof	10.00	85.00	1515.37	950990.11	0.19	349.44
4th Floor	14.00	75.00	2432.34	1273103.34	0.26	467.79
Greenhouse Floor	14.67	61.00	1482.57	575099.04	0.12	211.32
3rd Floor	14.67	46.33	4278.79	1113951.79	0.23	409.32
2nd Floor	14.67	31.67	4767.89	714825.02	0.15	262.66
1st Floor	17.00	17.00	4767.89	290052.94	0.06	106.58
Total			19244.85	4918022.24	Base Shear	1807.10