Michael Bologna

665 Meadow Ln
Rochester PA, 15074

State College, PA 16801

September 28, 2015

Linda M. Hanagan, PhD, P.E.
AHC Inc.

Dear Dr. Hanagan,

The attached technical report covers the assigned topics for Structural Notebook Submission A.

Submission A is an in-depth analysis of the gravity and lateral loads present in the existing design of my thesis building. Also a list of documents used in preparation of the report is included. The report will investigate a cross section of the roof, floor, and exterior wall to detail the materials that contribute to the dead load of the building. In addition the submission will include snow drift calculations on a typical parapet. For the lateral loads, the analysis takes into consideration wind and seismic loads.

I appreciate your effort in reviewing my submission and I look forward to receiving feedback from you.

Sincerely,

Michael Bologna

Enclosed: Structural Notebook Submission A


**Jackson Crossing |** Located in Alexandria, VA

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# Technical Report 2

Michael Bologna

*Structural Option*

Advisor: Dr. Linda Hanagan

September 28, 2015

# Table of Contents

## Abstract

# Jackson Crossing - Alexandria, VA

Michael Bologna
Structural Option

Photos courtesy of Bonstra | Haresign Architects, LLP

### Building Statistics

**Building Height:** 54' 7 1/4"
**Number of Floors:** 5
**Gross Square Foot:** 107,740 sq. ft.
**Type of Building:** Multi-Family Residential
**Total Project Cost:** $16 Million
**Construction Dates:** 4/4/2014-12/17/2015

### Project Team

**Owner:** AHC, Inc.
**Construction Management:** Harkins Builders, Inc.
**Architect:** Bonstra | Haresign Architects, LLP
**Civil Engineer:** VIKA, Virginia, LLC
**Structural Engineer:** Rathgeber Goss Associates
**MEP Engineer:** Metropolitan Engineering, Inc.
**Landscape Architect:** Landscape Architectural Bureau
**Specifications Cons.:** Bethel Specifications Consulting

### Mechanical

-All aparment units have operable windows
-Typical floor houses a mounted vertical heat pump (DX Split System) and is provided with vibration isolation
-Roof houses condensing units
-Upper garage exhauts 12,000 CFM of air and supplies 17,250 CFM of air
-Lower Garage exhauts 5250 CFM of air

Photos courtesy of Bonstra | Haresign Architects, LLP

### Electrical

-Dominion Virgina Power Service supplies power into one pad mounted transformer
-2 1600A, 208/120V Feeders run from the transformer
-All units are individually metered

### Structural System

**Gravity System**
-18" deep wood trusses spaced at 24" o.c.
-Wood bearing walls
-12" Reinforced two-way concrete slab
-24"x16" Concrete columns typical

**Lateral System**
-Ordinary Reinforced Concrete Shear Walls
-Intermediate Reinforced Masonry Shear Walls
-Light Framed Walls Sheated with Wood Panels

Thesis Advisor: Linda M. Hanagan, PhD, P.E.
Website: http://www.engr.psu.edu/ae/thesis/portfolios/2016/mab6150/index.htm

## Executive Summary

Jackson Crossing is a development in Alexandria, Virginia by AHC, Inc. Offering one, two, and three-bedroom apartments, it is targeted at low-income residents with families. The structure is five floors and 107,740 square feet. Included in the building is an underground parking garage. The project will be completed by December 2015 and will come to a total project cost of sixteen million dollars.

The gravity system consists of four floors of wood floors with wood trusses and bearing walls. The wood members sit on two floors of concrete, one of which is below grade. The slab on the second floor is a reinforced two-way slab while the ground floor is a reinforced one-way slab with concrete beams.

The lateral system for the top four floors includes an Intermediate Reinforced Masonry Shear Wall, IRMSW, and a Light Framed Walls Sheathed with Wood Structural Panels, LFW. The LFW is anchored into the second floor slab while the IRMSW is integrated into Ordinary Reinforced Concrete Shear Walls, ORCSW, that extend down into the foundation.

## Location Plan


*Figure 1 (Courtesy of Google Maps)*

## Site Plan

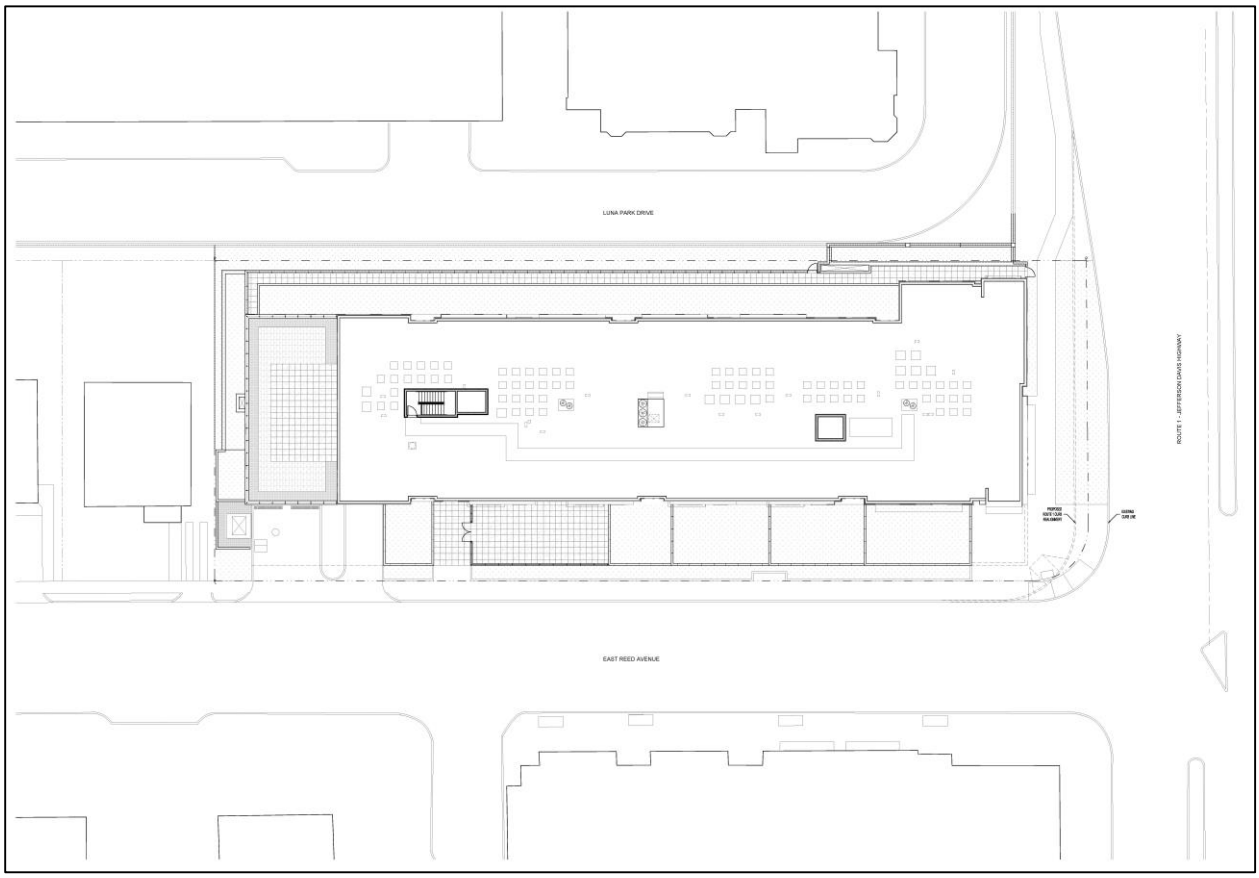



*Figure 2*

**List of Documents Used in Report**

AISC, *Steel Construction Manual*, Fourteenth Edition

Breyer, Donald, Kelly Cobeen, Kenneth Fridley, and David Pollock, *Design of Wood Structures ASD/LRFD*, 7th Edition

Usg.com, DUROCK Cement Board

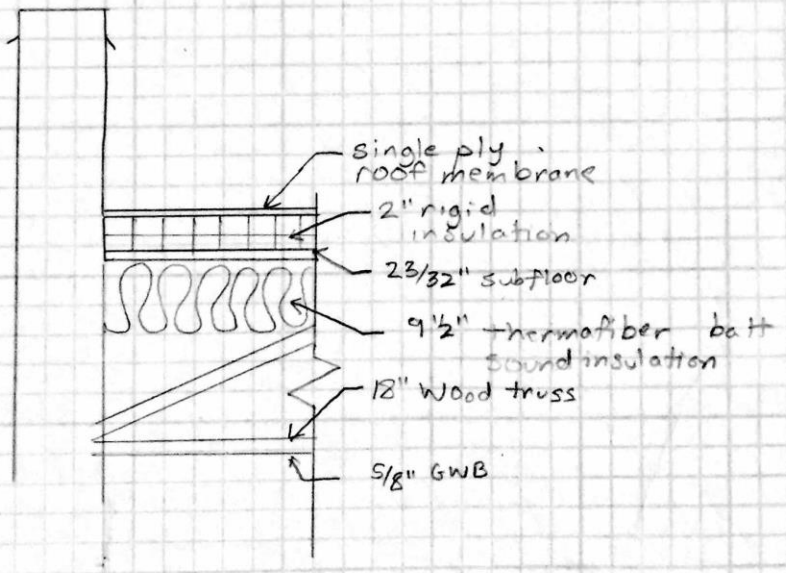
Minimum Design Loads for Buildings and Other Structures (ASCE 7-10)

Minimum Design Loads for Buildings and Other Structures (ASCE 7-05)

## GRAVITY LOADS

- ROOF
  - Existing Design Loads (from General notes)
    *SUPERIMPOSED INCL. STRUCTURE
  - DEAD LOAD
    ⇒ 20psf (15psf top chord / 5psf bottom chord)
  - ROOF LIVE LOAD
    ⇒ 30psf min (unless snow load greater)
  - ROOF SNOW LOAD
    ⇒ $P_f$ = 17.5psf
    - values to find $P_f$
      - $P_g$ = 25psf
      - $C_e$ = 1.0
      - $C_t$ = 1.0
      - I = 1.0

TYPICAL PARAPET DETAIL



WEIGHT OF DETAILS

- SINGLE PLY ROOF MEMBRANE => 5½ psf (3 ply felt & gravel)
- 2" RIGID INSULATION => $\frac{1\frac{1}{2}\text{ psf}}{1"} \cdot 2" = 3\text{psf}$
- 23/32" WOOD SUBFLOOR => $\frac{3\text{psf}}{3/4"} \cdot 4/3" \cdot \frac{23}{32}" = 2.875\text{psf}$ (wood sheathing)
- 9½" BATT INSULATION => $\frac{1/2\text{psf}}{1"} \cdot 9.5" = 4.75\text{psf}$ (loose insulation)
- 5/8" GWB => 2½psf (5/8" dry wall)

TOTAL = 18.625psf w/o truss self weight

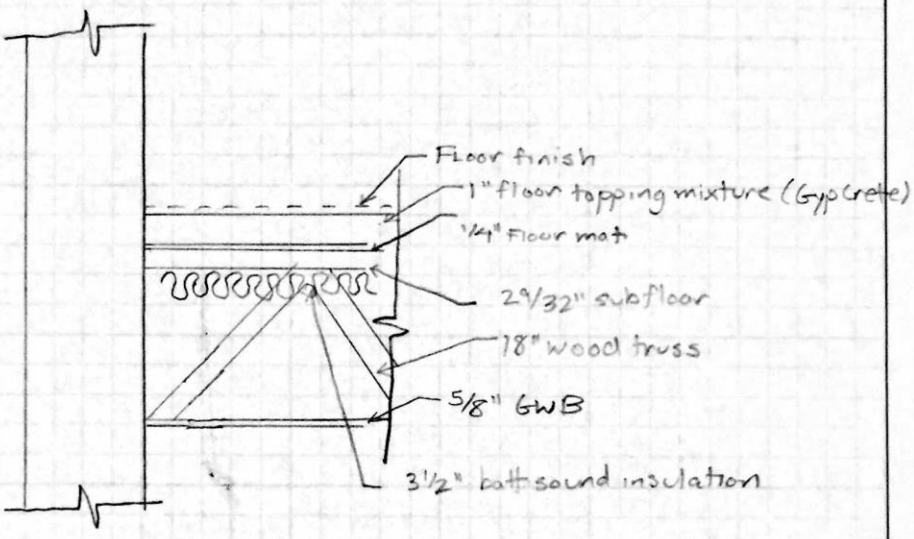
* WEIGHTS FROM TABLE 17-13 OF STEEL MANUAL

- TYPICAL WOOD FLOOR

- EXISTING DESIGN LOADS (from General Notes)
  &SUPERIMPOSED INCL. STRUCTURE

- DEAD LOAD
  ⇒ 25 psf (20 psf top chord/5 psf bottom chord)

TYPICAL WOOD LEVEL DETAIL




WEIGHT OF DETAILS

- GYPCRETE ⇒ 6.9 psf / 3/4" · 4/8" = 9.2 psf

- 1/4" FLOOR MAT ⇒ 3 psf / 1" · 1/4" = 0.75 psf (plywood)

- 29/32" SUBFLOOR ⇒ 3 psf / 3/4" · 4/3", 23/32" = 2.875 (wood sheathing)

- 5/8" GWB ⇒ 2 1/2 psf (5/8" drywall)

- 3 1/2" BATT INSULATION ⇒ 1/2 psf / 1" ; 3 1/2" = 1.75 psf (loose insulation)

- FLOOR FINISH ⇒ 2 psf

TOTAL = 19.075 w/o Truss selfweight

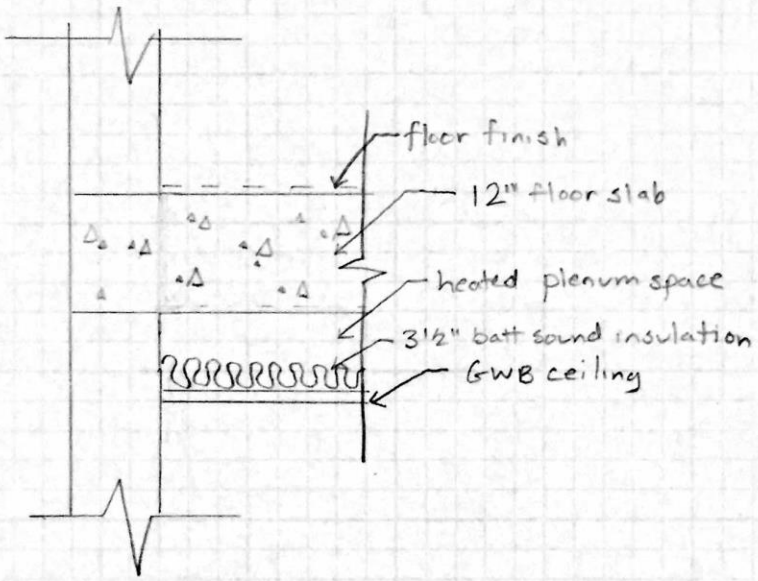
★ WEIGHTS FROM - TABLE 17-13 OF STEEL MANUAL
- APPENDIX B OF DESIGN OF WOOD STRUCTURES

- TYPICAL CONCRETE LEVEL

- EXISTING DESIGN LOADS (from General Notes)
  *SUPERIMPOSED INCL. STRUCTURE

- DEAD LOAD
  ⇒ 15 psf

- TYPICAL CONCRETE LEVEL DETAIL

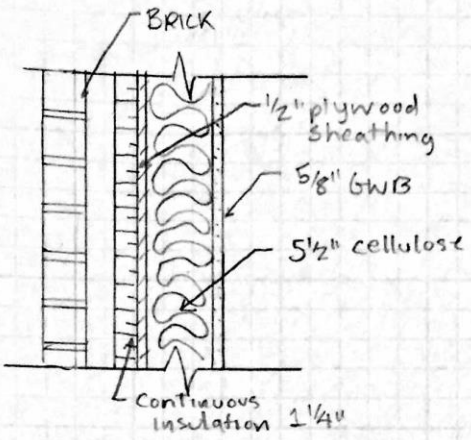



- WEIGHT OF DETAILS

- FLOOR FINISH = 2 psf
- 3½" BATT INSULATION = ½ psf/1" · 3½" = 1.75 psf (loose insulation)
- GWB ceiling = 2½ psf (⅝ drywall)

TOTAL = 6.25 psf w/o slab self weight

TYPICAL EXTERIOR WALL DETAIL (BRICK)




WEIGHT OF DETAILS

4" BRICK => 40psf

1/2" PLYWOOD => 1.5psf

1 1/4" CONTINUOUS INSULATION => 1.88psf

5/8" GWB => 2 1/2 psf

5 1/2" CELLULOSE INSULATION => 10psf

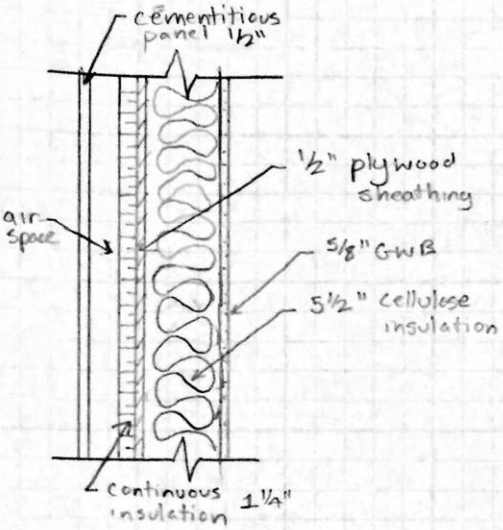
TOTAL = 55.88psf

*WEIGHTS FROM TABLE 17-13 OF STEEL MANUAL

LOAD PATH DESCRIPTION

AT THE TOP FOUR LEVELS, GRAVITY LOADS ARE APPLIED TO THE WOOD TRUSSES. THE WOOD TRUSSES TRANSFER THEIR LOADS TO THE EXTERIOR AND INTERIOR BEARING WALLS. THEN THE BEARING WALLS REST THEIR LOADS ON A TRANSFER SLAB AT THE 2ND FLOOR.

TYPICAL EXTERIOR WALL DETAIL (CEMENTITOUS PANEL)




WEIGHT OF DETAILS

5 1/2" CELLULOSE INSULATION => $\frac{2\ psf}{1"} \cdot 5\frac{1}{2}" = 10\ psf$ (poured insulation)

1 1/4" CONTINUOUS INSULATION => $\frac{1\frac{1}{2}\ psf}{1"} \cdot 1\frac{1}{4}" = 1.88\ psf$ (rigid insulation)

1/2" PLYWOOD => $\frac{3\ psf}{1"} \cdot \frac{1}{2}" = 1.5\ psf$

5/8" GWB => 2 1/2 psf

1/2" CEMENTITOUS PANEL => 2.9 psf

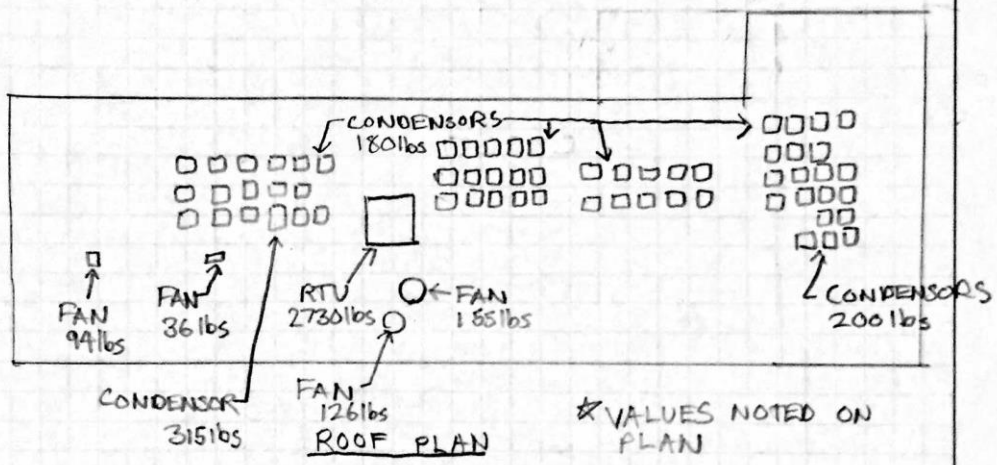
TOTAL = 18.28 psf

* WEIGHTS FROM TABLE 17-13 OF STEEL MANUAL & USG.COM FOR DUROCK CEMENT BOARD AS AN ESTIMATE FOR CEMENTITIOUS PANEL

DESIGN LIVE LOADS

| AREA | PSF | ASCE 7-10 MIN. (PSF) |
|---|---|---|
| LIVING UNITS | 40 | 40 |
| LOBBIES/STAIRS/EXITS | 100 | 100 |
| MECHANICAL | AS NOTED | |
| CORRIDORS ABOVE 1ST FLOOR | 80 | 40 |
| PARKING DECKS | 40 | 40 |
| PARKING DECKS (TOP LEVEL) | 70 (40LL+30 SNOW) | |
| ROOF TERRACE | 100 | 100 |
| LOADING DOCK | 250 | |

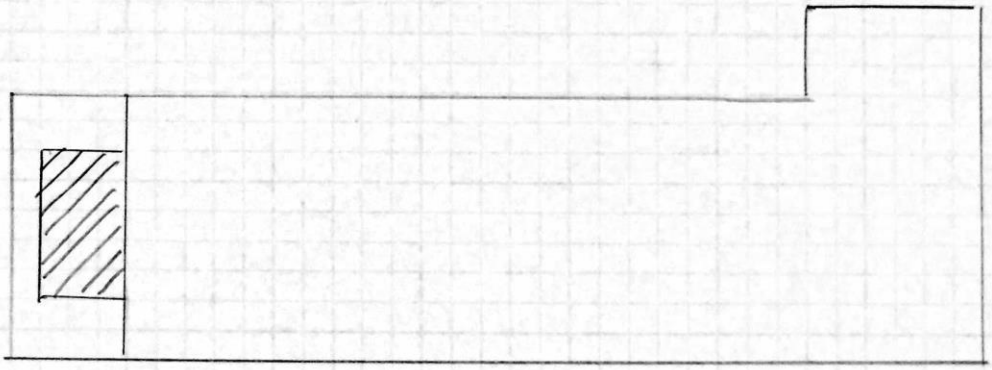
NON TYPICAL LOADS ON ROOF




ROOF PLAN

☆VALUES NOTED ON PLAN

NON TYPICAL LOADS ON 4TH FLOOR



4TH FLOOR

▨ ROOF TERRACE
- DEAD LOAD: 40 PSF TOP CHORD
  5 PSF BOTTOM CHORD
- LIVE LOAD: 100 PSF

☆VALUES NOTED IN GENERAL NOTES

## FLAT ROOF SNOW LOAD + DRIFT

FROM GENERAL NOTES

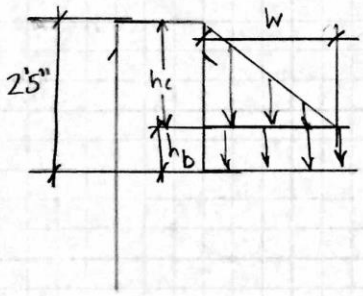
$P_g = 25\ psf$
$C_e = 1.0$
$I = 1.0$
$C_t = 1.0$
$\Big\}\ P_f = 0.7\, C_e\, C_t\, I\, p_g$

$p_f = 0.7 \cdot 1 \cdot 1 \cdot 1 \cdot 25\ psf$

$p_f = 17.5\ psf$

$p_{f\,min} = 20 \cdot I = 20 \cdot 1 = 20\ psf \Rightarrow$ controls

DRIFT AT PARAPET




$\gamma = 0.13\, p_g + 14 = 0.13 \cdot 25 + 14 = 17.25\ pcf < 30\ pcf$ ✓

$h_b = 20\ psf / 17.25\ pcf = 1.16\ ft$ $\quad h_c = 2.42 - 1.16 = 1.26\ ft$

Using $l_u = 0'$ for upper roof $\Rightarrow h_d = 1.5\ ft$

Using $l_u = 60'$ for lower roof $\Rightarrow h_d = 2.5\ ft$

3/4 1.5ft = 1.125ft, 2.5ft } USE 2.5ft AS DRIFT HEIGHT

★ EXCEEDS $h_c \Rightarrow \underline{h_d = h_c}$

DRIFT WIDTH, $w = 4\,\frac{h_d^2}{h_c} = 4 \cdot \frac{1.26ft^2}{1.26ft} = 5.04ft < 8\,h_c$

# WIND LOADS

VARIABLES FROM GENERAL NOTES

BASIC WIND SPEED: 90 MPH
IMPORTANCE FACTOR: 1.0
EXPOSURE CATEGORY: B

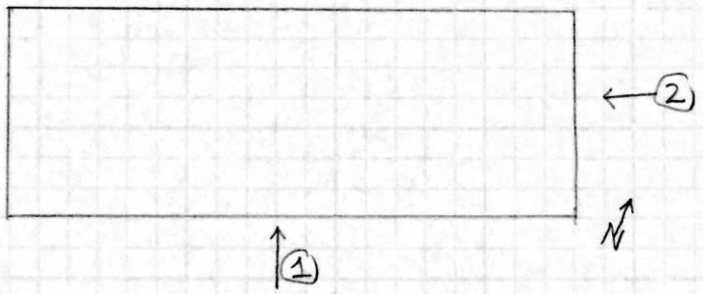
BUILDING HEIGHT: 34' 7 1/4"
- ☆ I WILL USE THE ANALYTICAL PROCEDURE EVEN THOUGH THE SIMPLIFIED PROCUDERE, 6.4.2, MAY BE USED.
- ☆ I WILL USE ASCE-7-05 AS GENERAL NOTES INDICATES

6.5.1 SCOPE

1. REGULAR SHAPED ✓
2. ✓

6.5.3

1. BASIC WIND SPEED: 90MPH
2. IMPORTANCE FACTOR I: 1.0
3. WIND DIRECTIONS CONSIDERED:




SURFACE ROUGHNESS CATEGORY: B
EXPOSURE CATEGORY: B

TABLE 6-3

| | z | $K_z$* |
|---|---|---|
| 2ND FLOOR: | 14.5ft | 0.57 |
| 3RD FLOOR: | 24.17ft | 0.62 |
| 4TH FLOOR: | 33.83ft | 0.72 |
| 5TH FLOOR: | 43.5ft | 0.78 |
| ROOF: | 54.6ft | 0.83 |

*CASE 2; EXPOSURE B, I WILL NOT DESIGN USING FIG 6-10

4.
6.5.7.1: NO APPLICABLE HILL OR ESCARPMENT
$\Rightarrow K_{ZT} = 1.$

5. ASSUME LOW-RISE BUILDING IS RIGID
$\Rightarrow G = 0.85$

6. BUILDING IS ENCLOSED

7. $GC_{pz} = \pm 0.18$, FIG 6-5

8. FIG 6-6 *NEGLECTING FIG 6-10 FOR LOW-RISE
WINDWARD: $C_p = 0.8$
LEEWARD: FOR DIRECTION (1) $L/B = 99' 7\frac{1}{2}'' / 256' 11\frac{5}{8}'' = 0.39$

$\Rightarrow C_p = -0.5$

(2) $L/B = 1/0.39 = 2.58$

$\Rightarrow C_p = -0.3$

SIDE WALLS: $C_p = -0.7$
ROOF: FOR DIRECTION (1) $h/L = 54.6' / 99' 7\frac{1}{2}'' = 0.55$
AREA $\geq 1000$ sqft FOR $0-h \Rightarrow C_p = -0.9$
$\Rightarrow$ USE REDUCTION $>h \Rightarrow C_p = -0.5$
OF 0.8 WHEN APPLICABLE (2) $h/L = 54.6' / 256' 11\frac{5}{8}'' = 0.21$
$0-h \Rightarrow C_p = -0.9$
$h-2h \Rightarrow C_p = -0.5$
$>2h \Rightarrow C_p = -0.3$

9 $q_z = 0.00256 K_z K_{ZT} K_d V^2 I$

$K_d = 0.85$

| | $q_z$ |
|---|---|
| 2ND FLOOR: | 10.0 |
| 3RD FLOOR: | 11.0 |
| 4TH FLOOR: | 12.7 |
| 5TH FLOOR: | 13.8 |
| ROOF: | 14.7 |

10. $p = qGC_p - q_i(GC_{pi})$ (psf)

FOR DIRECTION ①

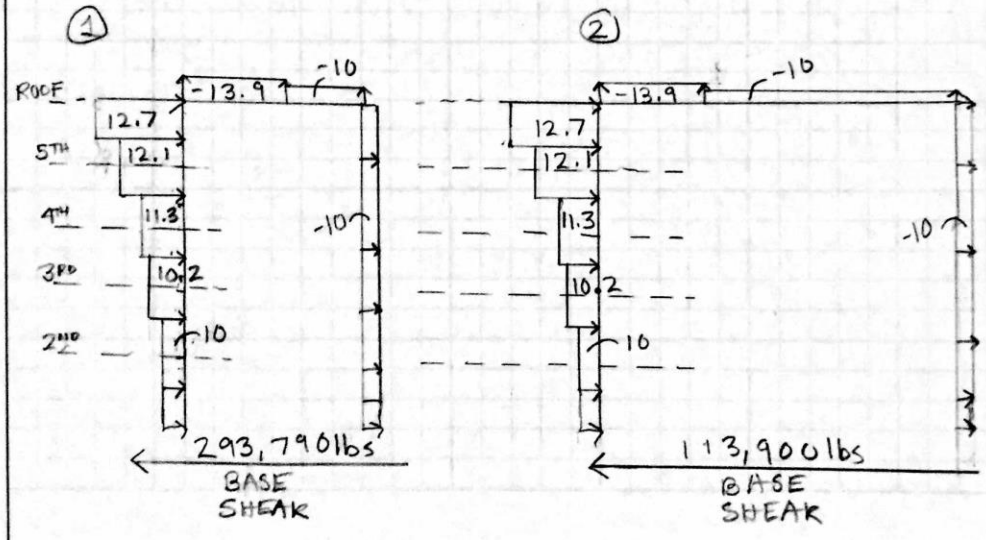
| | $p(+GC_{pi})$ (psf) | $p(-GC_{pi})$ (psf) |
|---|---|---|
| WINDWARD WALLS | | |
| 2ND FLOOR | 4.2 (10)* | 9.5 (10) |
| 3RD FLOOR | 4.9 (10) | 10.2 |
| 4TH FLOOR | 6.0 (10) | 11.3 |
| 5TH FLOOR | 6.8 (10) | 12.1 |
| ROOF | 7.4 (10) | 12.7 |
| LEEWARD WALLS | -8.9 (-10) | -3.6 (-10) |
| SIDE WALLS | -11.4 | -6.1 (-10) |
| 0-h | -13.9 | -8.6 (-10) |
| >h | -8.9 (-10) | -3.6 (-10) |

* 6.1.4.1 p > 10psf

FOR DIRECTION ②

| | $p(+GC_{pi})$ (psf) | $p(-GC_{pi})$ (psf) |
|---|---|---|
| WINDWARD WALLS | | |
| 2ND FLOOR | 4.2 (10) | 9.5 (10) |
| 3RD FLOOR | 4.9 (10) | 10.2 |
| 4TH FLOOR | 6.0 (10) | 11.3 |
| 5TH FLOOR | 6.8 (10) | 12.1 |
| ROOF | 7.4 (10) | 12.7 |
| LEEWARD WALLS | -6.4 (-10) | -1.1 (-10) |
| SIDE WALLS | -8.9 (-10) | -3.6 (-10) |
| 0-h | -13.9 | -8.6 (-10) |
| h-2h | -8.9 (-10) | -3.6 (-10) |
| >2h | -6.4 (-10) | -1.1 (-10) |

DIAGRAMS




3-0235 — 50 SHEETS — 5 SQUARES
3-0236 — 100 SHEETS — 5 SQUARES
3-0237 — 200 SHEETS — 5 SQUARES
3-0137 — 200 SHEETS — FILLER
COMET

# SEISMIC LOADS

## FROM GENERAL NOTES

OCCUPANCY CATEGORY: II
SEISMIC IMPORTANCE FACTOR: IE = 1.0
SS = 0.153
S1 = 0.050
SITE CLASS: D
SDS = 0.163
SD1 = 0.081
SEISMIC DESIGN CATEGORY: B
SEISMIC RESPONSE COEFFICIENTS:
CONCRETE SHEAR WALLS: CS = 0.041
MASONRY SHEAR WALLS: CS = 0.047
RESPONSE MODIFICATION FACTORS:
CONCRETE SHEAR WALLS: R = 4
MASONRY SHEAR WALLS: R = 3.5
WOOD SHEAR WALLS: R = 6.5

## EFFECTIVE SEISMIC WEIGHT

| | SQ FT. | DL(psf) | W(K) |
|---|---|---|---|
| ROOF | 14,000 | 20 | 280 |
| 5TH | 14,000 | 25 | 350 |
| 4TH | 16,460 | 25 | 411.5 |
| 3RD | 16,460 | 25 | 411.5 |
| 2ND | 16,460 | 15 | 246.9 |
| ROOF TERRACE (ON 4TH) | 704 | 45 | 31.68 |
| ON ROOF | | CONDENSERS | 14.5 |
| | | FANS | 0.3 |
| | | RTU | 2.73 |
| | | TOTAL W = | 1,750 Kips |

## EQUIVALENT LATERAL FORCE DESIGN (ASCE-7-05)

### N-S DIRECTION

APPROXIMATE FUNDAMENTAL PERIOD

$T_a = C_t h_n^x$

TABLE 12.8-2 $\Rightarrow$ $C_t = 0.02$, $x = 0.75$

$T_a = 0.02 \cdot 54.6\text{ft}^{0.75} = 0.4\text{s}$

$T_L = 8\text{s}$ FIG 22-15

$C_S = \frac{S_{DS}}{\left(\frac{R}{I}\right)}$ MOST STRINGENT R IN N-S DIRECTION ⇒ R = 3.5

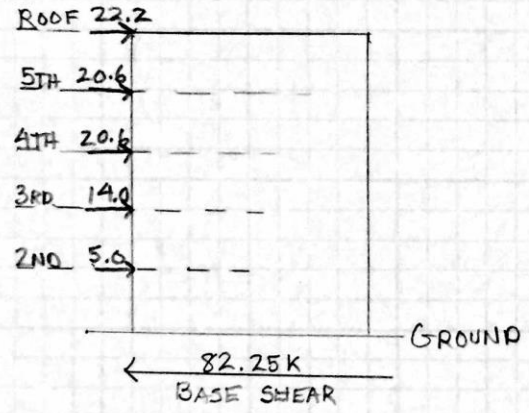
$C_S = \frac{0.163}{\left(\frac{3.5}{1}\right)} = 0.047$

$T \leq T_L \Rightarrow C_S \leq \frac{0.081}{0.4\left(\frac{3.5}{1}\right)} \leq 0.058$

$V = 1,750K \cdot 0.047 = 82.25K$

| STORY | $W_x h_x K^*$ | $C_{Vx}$ | $F_x$(K) |
|---|---|---|---|
| ROOF | 16,245 | 0.27 | 22.2 |
| 5TH | 15,225 | 0.25 | 20.6 |
| 4TH | 14,993 | 0.25 | 20.6 |
| 3RD | 9,946 | 0.17 | 14.0 |
| 2ND | 3,580 | 0.06 | 5.0 |
| | $\Sigma = 59,989$ | | |

*K=1




E-W DIRECTION

★ CONTROLLING R VALUE SAME AS N-S
FORCES DISTRIBUTED EQUAL TO N-S
BASE SHEAR VALUE EQUAL TO N-S