440 FIRST STREET, NW
WASHIGNTON, D.C.

TECHNICAL REPORT II

YEMI OSITELU
STRUCTURAL OPTION
ADVISOR | ALY SAID
28 SEPTEMBER 2015

Letter of Transmittal

September 28, 2015.

Aly Said
Structural Thesis Advisor
The Pennsylvania State University
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Dear Dr. Said,

The following technical report fulfills the requirements specified in the structural Technical Report II assigned by the faculty for senior thesis.

Technical Report II includes a detailed structural analysis of the loads used in the construction and renovation of 440 First Street, NW in Washington, D.C. This includes calculations of roof and floor loads, exterior wall loads, snow loads and snow drift, wind pressures and seismic story forces.

Thank you for reviewing this report. I will kindly appreciate your feedback.

Sincerely,

Yemi A. Ositelu.

Enclosed: Technical Report II

EXECUTIVE SUMMARY

440 First Street is a mixed use building located in Washington, D.C. The existing 8-story building, constructed in the early 80's began renovation in 2012 and was completed in 2013. Three stories were added to the building, including a penthouse, resulting in a 20.6 foot increase in building height and a total gross square footage of about 142000 GSF. The new 10-story architectural design provided a seamless transformation of the existing building into a more modern, state-of-the-art building, well on its way to a platinum LEED certification.

The existing building, floors 1 to 7, comprises of a frame assembly of cast-in-place concrete structural slabs and column, with low story heights. The foundation system is mainly supported by the spread footings. The new, additional framing (8th floor and above) uses composite framing, with wide flange steel shapes used in the majority of the added structural system.

Building codes and design standards typically used in the project include the ASCE and the IBC, with gravity, lateral, and seismic loads all considered.

This report will cover the codes, design loads, existing framing, framing renovations and additional framing in more detail and in a wider perspective.

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440 FIRST STREET

YEMI A. OSITELU | STRUCTURAL OPTION
ADVISOR: DR. ALY SAID

GENERAL DESCRIPTION

LOCATION	WASHINGTON, D.C.
OCCUPANCY	OFFICE/ RETAIL
SIZE	141,929 SQUARE FT.
NUMBER OF STORIES	11 (ABOVE GRADE)
ACTUAL COST INFO.	$20,000,000 (RENO.)

PROJECT TEAM

NEW CONSTRUCTION

OWNER	FP FIRST STREET, LLC
GENERAL CONTRACTOR	SIGAL CONSTRUCTION
ARCHITECT	FOX ARCHITECTS
CIVIL ENGINEER	VIKA
STRUCTURAL ENGINEER	RGA
MEP ENGINEER	VANDERWEIL
LIGHTING CONSULTANT	C.M KLING & ASSOC.
SPECS. WRITER	BETHEL SPECS.
LEED CONSULTANT	LORAX
CODE CONSULTANT	AON RISK SOLUTIONS

EXISTING CONSTRUCTION

ARCHITECT	VLASTMIL KOUBEK, AIA
STRUCTURAL ENGINEER	BASKAM & JURCZYK
MECHANICAL & ELECTRICAL	THE OFFICE OF LEE KENDRICK

ARCHITECTURE

440 First Street, NW, is located between D and E Streets in downtown Washington, D.C. The existing 8-story building was constructed in 1982 and renovation was initiated in 2012. It has 10 stories + a mechanical penthouse, and there are two existing below grade parking garages, which were repaired and utilized as a valet parking facility. The new façade is a combined glass-and-metal curtain wall system, which allows for outstanding views and more importantly, natural daylighting.

STRUCTURAL SYSTEM

FRAMING SYSTEM

EXISTING	*Cast-in-place concrete with two-way structural concrete slabs and reinforced concrete columns and beams.*
NEW	*Composite steel framing with 5 1/4" slabs*

LATERAL SYSTEM

EXISTING	*Slab-Column Concrete Frames*
NEW	*Steel Moment Frames*

FOUNDATION

Walls and columns are supported by spread footings.

MECHANICAL SYSTEM

During the renovation of 440 First Street, the primary mechanical (DOAS) systems were replaced and resulted in a 25% reduction in energy usage. It consists of 3 mechanical rooms housed in the penthouse and 2 cooling towers on the penthouse roof.

Openings were created in the steel beams and girders

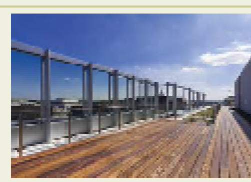
SUSTAINABILITY

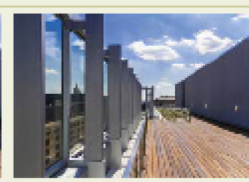
- Majority of the building 's structural elements will be reused
- Green Roof will have local plants that require minimal watering and also reduces storm water overflow and minimizes "heat island" effect
- Recycled materials are used and are obtained regionally
- The building has achieved LEED Platinum Certification

LIGHTING/ELECTRICAL SYSYTEM

The curtain wall and the many windows in the façade provide the building with natural daylighting, improving energy efficiency.

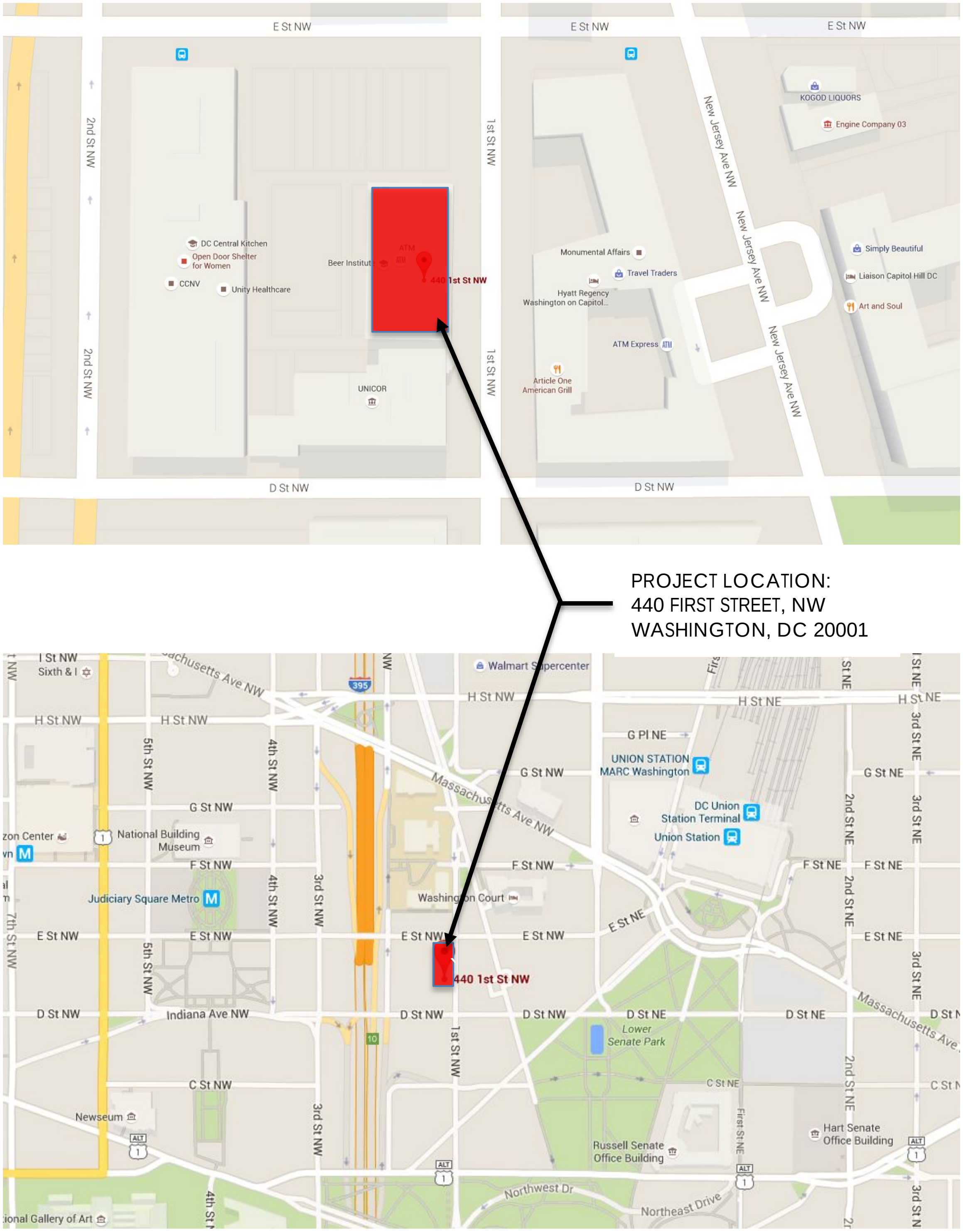
The interiors are well lit with LED fixtures and other various energy efficient light fixtures





ALL IMAGES COURTESY OF JEFF GOLDBERG OF ESTO PHOTOGRAPHY FOR FOX ARCHITECTS

SITE AND LOCATION PLAN



DOCUMENTS USED DURING THE PREPARATION OF REPORT

The following is a list of the structural codes and design standards used in the structural analysis of 440 First Street, NW, Washington, D.C.

I. **International Code Council**
   - International Building Code 2006

II. **American Society of Civil Engineers**
   - ASCE 7-05: Minimum Design Loads for Buildings and Other Structures

III. **Vulcraft Deck Catalog**

IV. **Previous AE Course Notes**

GRAVITY LOADS

Roof Loads

This section includes the calculations of the penthouse and main roof loads; dead, roof live and snow loads.

Figure 3 and Figure 4 show cross-sections through the main roof and penthouse roof respectively.

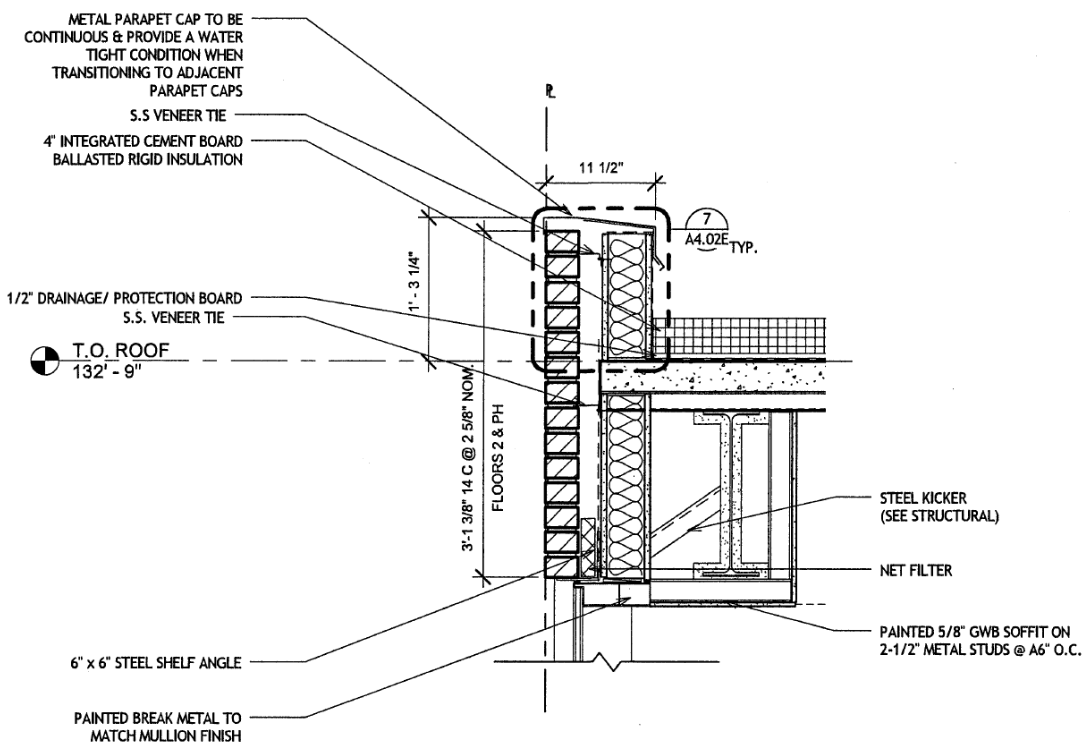


Figure 3: Section Detail At Main Roof Level

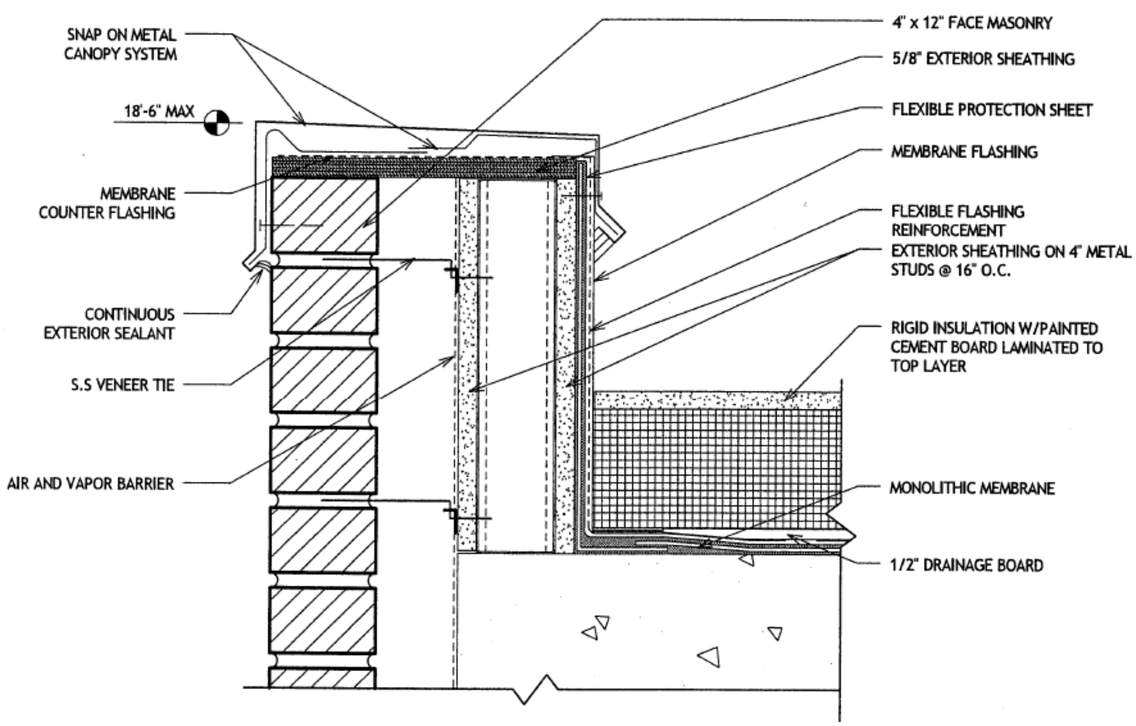


Figure 4: Section Detail At Penthouse Roof Level

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GRAVITY LOADS [ROOF]

TYPICAL ROOF BAY LOADING (DEAD)

PENTHOUSE ROOF	LOAD [PSF]
JOIST/BEAM ALLOWANCE	10
ROOFING SYSTEM	7
ROOF DECKING	10
	27

MAIN/PENTHOUSE FLOOR ROOF	LOAD [PSF]
3¼" LW CONC OVER 2" DEEP METAL DECK	42
JOIST/BEAM ALLOWANCE	10
4" RIGID INSULATION	3
CEILING	5
MEP	15
SPRINKLERS	3
ROOF TOP CONCRETE PAVERS	25
	103

TYPICAL ROOF BAY LOADING (LIVE)

PENTHOUSE ROOF — 30 PSF [DESIGN VALUE]
CODE MINIMUM IS (20 PSF) AS PER ASCE 7-05 TABLE 4-1 FOR ROOFS, ORDINARY FLAT

MAIN/PENTHOUSE FLOOR ROOF — 100 PSF [DESIGN VALUE]
CODE MINIMUM IS (100 PSF) AS PER ASCE 7-05 TABLE 4-1 FOR ROOFS USED FOR ROOF GARDENS OR ASSEMBLY PURPOSES

NOTE: SHEET S0-01 REQUIRES THAT SNOW LOAD SHOULD BE USED FOR AREAS LARGER THAN 30 PSF

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TYPICAL ROOF BAY LOADING (SNOW)

AS PER ASCE 7-05 CHAPTER 7, SECTION 7.3

$P_f = 0.7 C_e C_t I P_g$ WHERE,

$P_g = 25$ PSF

$C_e = 1.0$

$C_t = 1.0$

$I = 1.0$

$P_f = 0.7(1.0)(1.0)(1.0)(25) = 17.5$ PSF

MINIMUM P_f WHERE P_g EXCEEDS 20 PSF = 20 I

$\therefore P_f = 20 \times 1.0 = \underline{20\text{ PSF}}$ [DESIGN SNOW LOAD]

NOTE: DESIGN VALUE DOES NOT EXCEED 30 PSF, THEREFORE P_f = 20 PSF SHOULD BE USED

SNOW DRIFT [SECTION 7.7 - DRIFTS ON LOWER ROOFS]

$\gamma = 0.13 p_g + 14$ WHERE $p_g = 25$ PSF ; $0.13(25) + 14 = 17.25$ PCF

$h_b = P_s / \gamma$; WHERE $P_s = C_s P_f = 1.0 \times 20 = 20$; $h_b = 20/17.25 = 1.16$

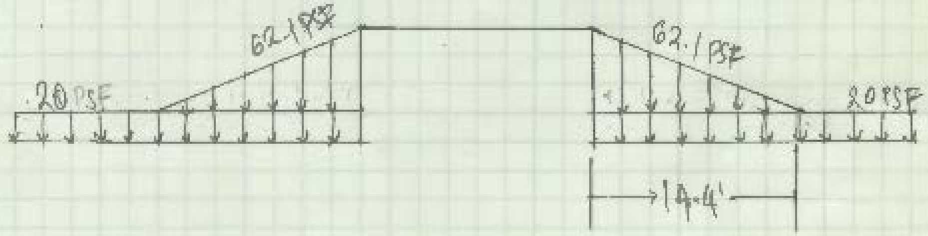
$h_c = 18.5'$ $\therefore$ $h_c / h_b = \frac{18.5}{1.16} > 0.2$ [DRIFT REQD]

$l_u = 115'$ (WINDWARD); $h_d = 3.6$ [FIG 7-9] (USE LARGER)

$l_u = 55'$ (LEEWARD); $h_d = 2.5$ [FIG 7-9]

$h_d < h_c = 18.5$ $\therefore$ $W = 4 \times 3.6 = 14.4'$

$P_d = h_d \gamma = 3.6(17.25) = \boxed{62.1\text{ PSF}}$



GRAVITY LOADS

Floor Loads

This section includes calculations of dead and live loads for the floors of the original cast-in-place concrete design and the new addition.

Figure 5 shows a section through a typical cast-in-place concrete slab in the existing building, and Figure 6 shows a section through a typical new floor.

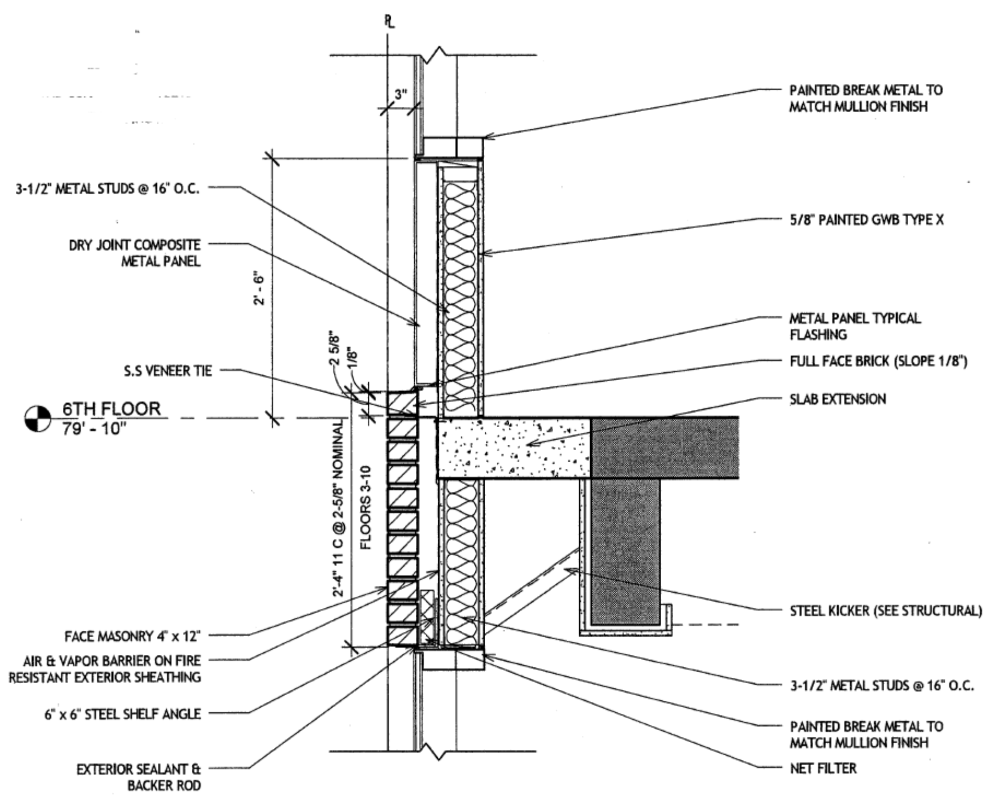


Figure 5: Section Detail Through Typical Existing Floor

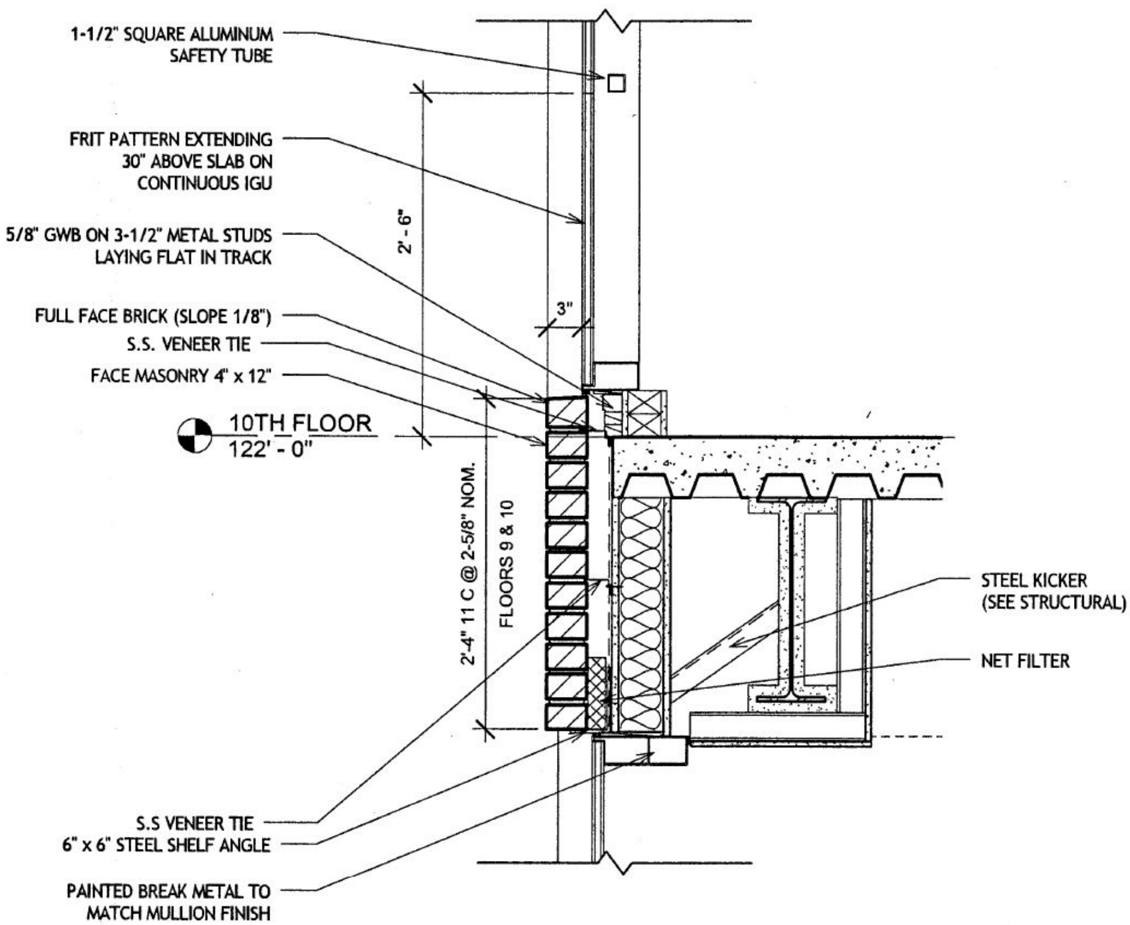


Figure 6: Section Detail Through Typical New Floor

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

GRAVITY LOADS [FLOOR]

TYPICAL FLOOR BAY LOADING (DEAD)

CAST-IN-PLACE CONCRETE FLOOR	LOAD (PSF)
CONCRETE – 7" x 145/12	85
9 1/2" x 145/12	115
CEILING	5
MEP	15
SPRINKLERS	3
TOTAL LOAD (7" SLAB) =	108
TOTAL LOAD (9 1/2" SLAB) =	138 ← Controls

STRUCTURAL STEEL FRAMED FLOORS	LOAD (PSF)
3 1/4" LW CONC OVER 2" DEEP METAL DECK	42
BEAM/GIRDER ALLOWANCE	15
CEILING	5
MEP	15
SPRINKLERS	3
	80

TYPICAL FLOOR BAY LOADING (LIVE)

LIVE LOAD REDUCTION APPLIED AS PER ASCE 7-05

AREA	LOAD (PSF)	CODE MINIMUM
OFFICE + PARTITIONS	100	80
LOBBIES/STAIRS/EXITS	100	100
PENTHOUSE FLOOR	100	100
CORRIDORS ABOVE 1ST FLOOR	80	40
PARKING	50	40

EXTERIOR WALL LOADS

This section includes calculations of the exterior wall loads.

Figure 7 shows a cross-section of typical exterior wall detail, and Figure 8 shows a cross-section through the curtain wall on the east façade of the building.

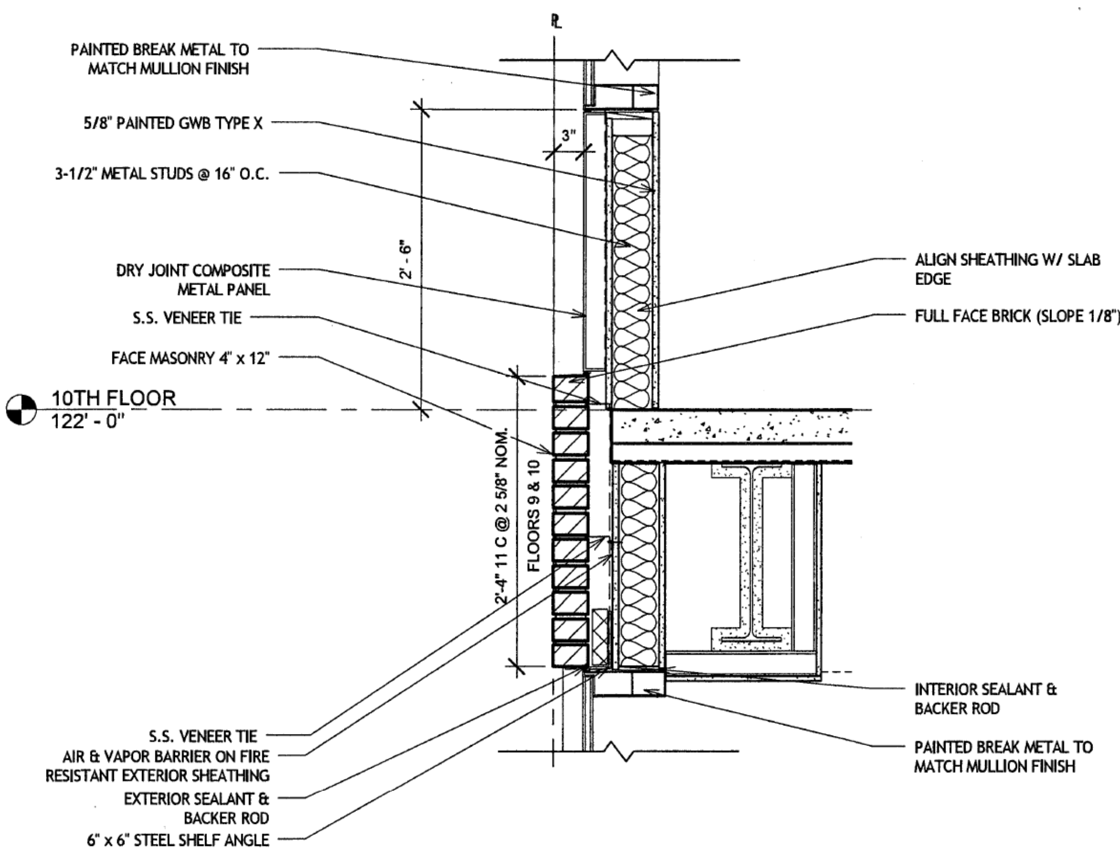

Figure 7: Section Detail Of A Typical Exterior Wall

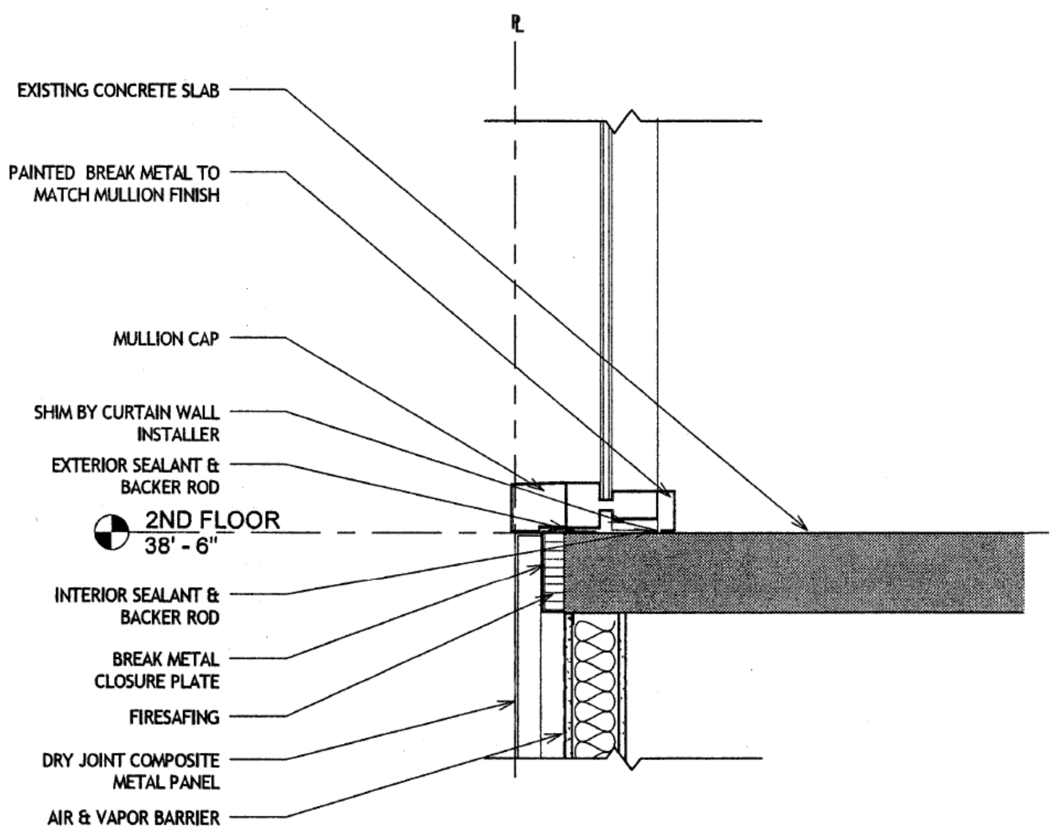

Figure 8: Section Detail Through The Curtain Wall

Notes

I. Weights of building materials shown in cross-section were assumed using typical weights of materials.
II. The north, south and west façades consist of windows as well as masonry, but the greatest wall load will occur through a fully face masonry section.

Load Path

Load is typically carried by the composite deck. The deck transfers load to the steel wide flange members and concrete beams, which then transfers the load to the steel/concrete columns. The load is ultimately transferred to the foundation

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

EXTERIOR WALL LOADS

TYPICAL EXT MASONRY WALL DEAD LOAD

GYPSUM WALL BOARD – 5/8" × 4 PSF/in × 10.25' = 25.6 PLF
SEMI-RIGID INSULATION – 1.0 PSF × 10.25' = 10.25 PLF
FACE MASONRY – 39 PSF × 10.25' = 400 PLF
= 436 PLF

TYPICAL CURTAIN WALL DEAD LOAD

CURTAIN WALL SYSTEM – 10 PSF × 10.25' = 102.5 PLF

LATERAL LOADS

Wind Loads

This section includes wind load calculations for 440 First Street in the two orthogonal directions, according to ASCE 7-05: Chapter 6.5; Method 2.

Microsoft Excel was used in programming equations for optimum efficiency.

Notes

I. C_p values were calculated through interpolation of values in Figure 6.6 of the ASCE 7-05: Chapter 6.5
II. The velocity pressure exposure coefficients for the building at the different heights are shown in Table 1 below
   - K_z values are obtained through interpolation of values in Table 6-3 of ASCE 7-05: Chapter 6, using Exposure B – Case 2.

TABLE 1: Velocity Pressure Exposure Coefficients

Height (ft)	Kz	**q_z or q_h**
15	0.57	**10.05**
25.33	0.66	**11.63**
35.67	0.73	**12.87**
46	0.79	**13.92**
56.33	0.84	**14.81**
66.67	0.88	**15.51**
77	0.92	**16.22**
87.75	0.95	**16.74**
98.5	0.99	**17.45**
109.25	1.01	**17.8**
118.5	1.04	**18.33**
127.25	1.06	**18.68**

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LATERAL LOAD – WIND

ASCE 7-05: CHAPTER 6.5; METHOD 2 – ANALYTICAL DESIGN PROCEDURE FROM SECTION 6.5.3

WIND FORCE DETERMINATION – [N–S DIRECTION]

1. Building Information

   B = 87' L = 160.25' h = 118.5'

2. Basic Wind Speed (V) – 90 MPH [FIG 6-1]
3. Directionality factor (Kd) – 0.85 [TABLE 6-4]
4. Determining the Importance Factor (I)

   Occupancy Category – II [TABLE 1-1]
   Importance Factor – 1 [TABLE 6-1]

5. Exposure Category – B [S0-01 OF DRAWINGS]
6. VELOCITY PRESSURE EXPOSURE COEFFICIENT

   + Using EXPOSURE B; CASE 2 FOR MWFRS
   + Kz values obtained through interpolation
   + For Breakdown, See TABLE 1

7. TOPOGRAPHIC FACTOR (K_{zt}) – 1.0 [S0-01 OF DRAWINGS]
8. GUST EFFECT FACTOR (G_f) – 0.85 [SEC 6.5.8.1]
9. ENCLOSURE CLASSIFICATION – Enclosed [SEC 6.5.9]
10. Internal Pressure Coefficient

    $GC_{pi} = +/- 0.18$ [FIG. 6-5]

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11. EXTERNAL PRESSURE COEFFICIENTS

Windward Wall	$C_p = 0.8$	[FIG 6-6]
Leeward Wall	$C_p = -0.325$	[FIG 6-6]
Side Wall	$C_p = -0.7$	[FIG 6.6]
Roof (0' to 59.25')	$C_p = -0.90$	[FIG 6.6]
Roof (59.25 to 118.5')	$C_p = -0.80$	[FIG 6.6]
Roof (118.5' to 180.25)	$C_p = -0.60$	[FIG 6.6]

TABLE 2: Wind Pressures in the North-South Direction

Wind Pressure Chart (N-S)								
Location	z	qz or qh	Cp	Gf	Gcpi	qiGCpi	Net Pressure (PSF)	
							qzGfCp-qi(+Gcpi)	qzGfCp-qi(-Gcpi)
Windward	15	10.05	0.8	0.85	0.18	1.809	5.03	**8.64**
	25.33	11.63	0.8	0.85	0.18	2.0934	5.82	**10.00**
	35.67	12.87	0.8	0.85	0.18	2.3166	6.44	**11.07**
	46	13.92	0.8	0.85	0.18	2.5056	6.96	**11.97**
	56.33	14.81	0.8	0.85	0.18	2.6658	7.41	**12.74**
	66.67	15.51	0.8	0.85	0.18	2.7918	7.76	**13.34**
	77	16.22	0.8	0.85	0.18	2.9196	8.11	**13.95**
	87.75	16.74	0.8	0.85	0.18	3.0132	8.37	**14.40**
	98.5	17.45	0.8	0.85	0.18	3.141	8.73	**15.01**
	109.25	17.8	0.8	0.85	0.18	3.204	8.90	**15.31**
	118.5	18.33	0.8	0.85	0.18	3.2994	9.17	**15.76**
Leeward	All	18.68	-0.325	0.85	0.18	3.3624	**-8.52**	-1.80
Side	All	18.68	-0.7	0.85	0.18	3.3624	**-14.48**	-7.75
Roof (0 to 59.25)	118.5	18.68	-0.98	0.85	0.18	3.3624	**-18.92**	-12.20
Roof (59.25 to 118.5)	118.5	18.68	-0.8	0.85	0.18	3.3624	**-16.06**	-9.34
Roof (118.5 to 160.25)	118.5	18.68	-0.6	0.85	0.18	3.3624	**-12.89**	-6.16
Low Parapet WW	110.5	17.98			1.5	26.97		**26.97**
Low Parapet LW	110.5	17.98			-1.0	-17.98		**-17.98**
High Parapet WW	127.25	18.68			1.5	28.02		**28.02**
High Parapet LW	127.25	18.68			-1.0	-18.68		**-18.68**

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WIND FORCE DETERMINATION [E-W DIRECTION]

1. Building Information

   B = 160.25' L = 87' h = 118.5'

2. Basic Wind Speed (V) — 90 MPH [FIG 6-1]
3. Directionality Factor (K_d) — 0.85 [TABLE 6-4]
4. Determining the Importance Factor (I)

   - Occupancy Category – II [TABLE 1-1]
   - Importance Factor – 1 [TABLE 6-1]

5. Exposure Category – B [S0-01 OF DRAWINGS]
6. Velocity Pressure Exposure Coefficient

   As Calculated Previously (Shown in TABLE 1)

7. Topographic Factor (K_{zt}) – 1 [S0-01 OF DRAWINGS]
8. Gust Effect Factor (G_f) – 0.85 [SEC 6.5.8.1]
9. Enclosure Classification – Enclosed [SEC 6.5.9]
10. Internal Pressure Coefficient

    $GC_{pi} = +/-0.18$ [FIG 6.5]

11. External Pressure Coefficient

Windward Wall	$C_p = 0.8$	[FIG 6-6]
Leeward Wall	$C_p = -0.5$	[FIG 6-6]
Side Wall	$C_p = -0.7$	[FIG 6-6]
Roof (0-59.25')	$C_p = -1.04$	[FIG 6-6]
Roof (59.25-87')	$C_p = -0.7$	[FIG 6-6]

Base shear calculations

The base shear was calculated for the two orthogonal directions and determined by multiplying the story height by the net wind pressure at that level and by the width of the building perpendicular to the direction of the wind.

The total base shear in both orthogonal directions are shown in Table 3.

Width (N-S) – 87’

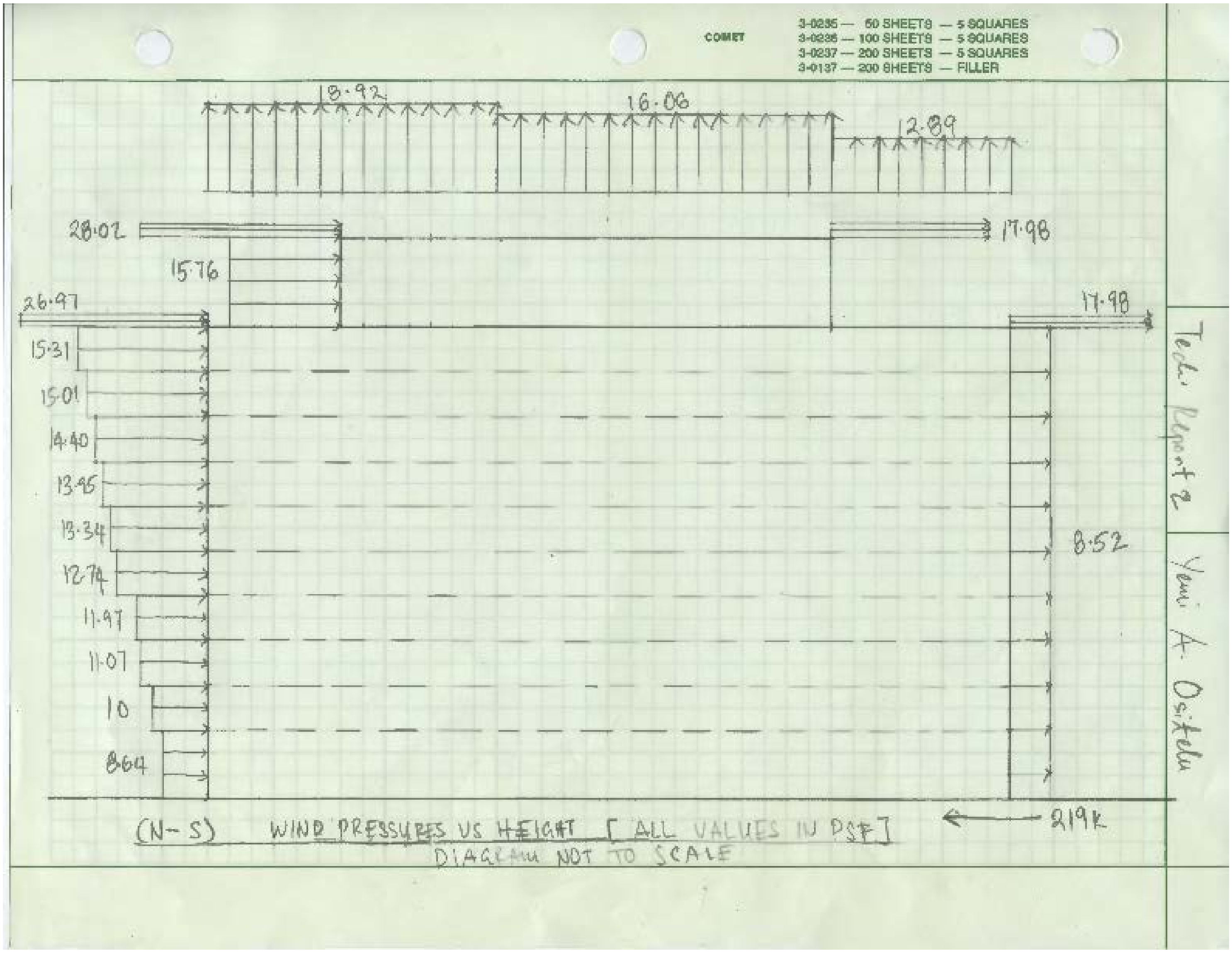
Width (E-W) – 160.25

TABLE 3: Base Shear Calculations

Story Height (ft)	Story Trib. Height x Net Pressure x Trib. Width	
	Wind (N-S)	**Wind (E-W)**
15	**22.39**	**41.25**
25.33	**16.64**	**30.66**
35.67	**17.61**	**32.45**
46	**18.42**	**33.94**
56.33	**19.11**	**35.19**
66.67	**19.65**	**36.19**
77	**20.19**	**37.20**
87.75	**20.60**	**37.94**
98.5	**21.15**	**38.95**
109.25	**21.42**	**39.45**
127.25	**21.82**	**40.19**
Base Shear	**219.00**	**403.40**

TABLE 4: Wind Pressures in the East-West Direction

Wind Pressure Chart (E-W)								
Location	z	qz or qh	Cp	Gf	Gcpi	qiGCpi	Net Pressure (PSF)	
							qzGfCp-qi(+Gcpi)	qzGfCp-qi(-Gcpi)
Windward	15	10.05	0.8	0.85	0.18	1.81	5.03	**8.64**
	25.33	11.63	0.8	0.85	0.18	2.09	5.82	**10.00**
	35.67	12.87	0.8	0.85	0.18	2.32	6.44	**11.07**
	46	13.92	0.8	0.85	0.18	2.51	6.96	**11.97**
	56.33	14.81	0.8	0.85	0.18	2.67	7.41	**12.74**
	66.67	15.51	0.8	0.85	0.18	2.79	7.76	**13.34**
	77	16.22	0.8	0.85	0.18	2.92	8.11	**13.95**
	87.75	16.74	0.8	0.85	0.18	3.01	8.37	**14.40**
	98.5	17.45	0.8	0.85	0.18	3.14	8.73	**15.01**
	109.25	17.8	0.8	0.85	0.18	3.20	8.90	**15.31**
	118.5	18.33	0.8	0.85	0.18	3.30	9.17	**15.76**
Leeward	All	18.68	-0.5	0.85	0.18	3.36	**-11.30**	-4.58
Side	All	18.68	-0.7	0.85	0.18	3.36	**-14.48**	-7.75
Roof (0 to 59.25)	118.5	18.68	-1.04	0.85	0.18	3.36	**-19.88**	-13.15
Roof (59.25 to 87)	118.5	18.68	-0.7	0.85	0.18	3.36	**-14.48**	-7.75
Low Parapet WW	110.5	17.98			1.5	26.97		**26.97**
Low Parapet LW	110.5	17.98			-1.0	-17.98		**-17.98**
High Parapet WW	127.25	18.68			1.5	28.02		**28.02**
High Parapet LW	127.25	18.68			-1.0	-18.68		**-18.68**


18.92
16.06
12.89
28.02
17.98
15.76
26.97
17.98
15.31
15.01
14.40
13.95
13.34
12.74
11.97
11.07
10
8.64
8.52
219k
(N-S) WIND PRESSURES VS HEIGHT [ALL VALUES IN PSF]
DIAGRAM NOT TO SCALE
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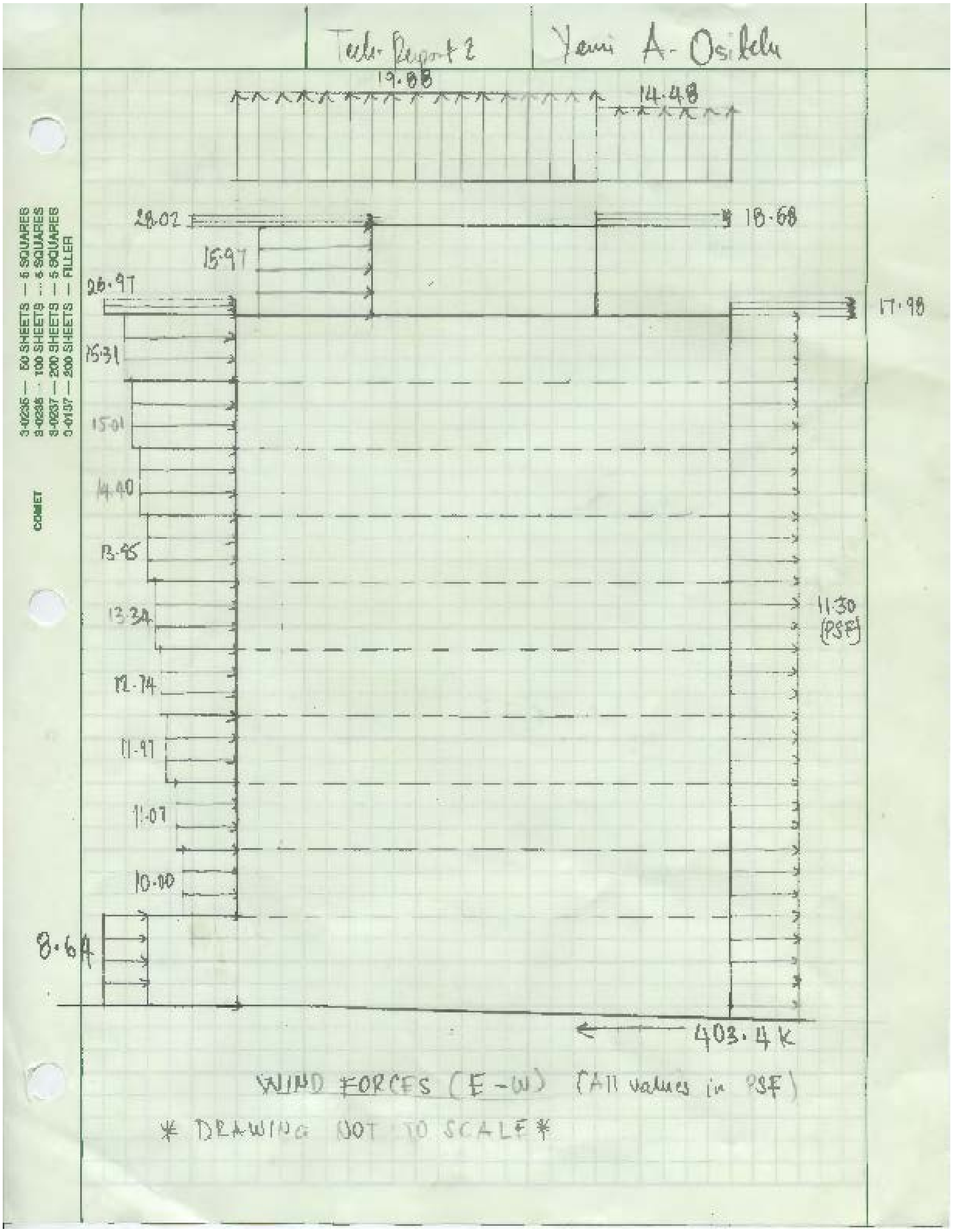
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19.88
14.48
28.02
18.68
15.97
26.97
17.98
15.31
15.01
14.40
13.85
13.34
11.30 (PSF)
12.74
11.97
11.07
10.00
8.64
403.4K
WIND FORCES (E-W) (All values in PSF)
* DRAWING NOT TO SCALE *

LATERAL LOAD

Seismic Loads

This sections outlines the seismic load calculations, in accordance to ASCE 7-05: Chapter 11 and 12.

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LATERAL LOAD – SEISMIC

AS PER ASCE 7-05, CHAP. 11 & 12 | SEISMIC DESIGN REQUIREMENTS FOR BUILDING STRUCTURES

1. EXEMPTIONS [SEC 11.1.2]
   BUILDING IS NOT EXEMPT

2. SITE CLASSIFICATION
   C [OBTAINED FROM SO-01]

3. MAPPED ACCELERATION PARAMETERS [SEC 11.4.1, FIG 22.1 TO 22.6)
   $S_s = 0.154$
   $S_1 = 0.05$ [OBTAINED FROM SO-01]

4. SPECTRAL RESPONSE COEFFICIENTS CALC
   TABLE 11.4-1, $S_s \le 0.25$, $F_a = 1.2$
   TABLE 11.4-2, $S_1 \le 0.1$, $F_v = 1.7$

   $S_{MS} = F_a S_s = 1.2(0.154) = 0.185g$, EQN 11.4-1
   $S_{M1} = F_v S_1 = 1.7(0.050) = 0.085g$, EQN 11.4-2

   $S_{DS} = 2/3\, S_{MS} = (2/3)(0.185) = 0.123g$, EQN 11.4-3
   $S_{D1} = 2/3\, S_{M1} = (2/3)(0.085) = 0.057g$, EQN 11.4-4

NOTE: S_{DS} AND S_{D1} VALUES MATCH DESIGN VALUES IN SO-01.

5. SEISMIC DESIGN CATEGORY [SEC 11.6, TABLE 11.6-1, 2]

   $S_{DS} < 0.167$ ⇒
   $S_{D1} < 0.067$ ⇒ **SEISMIC DESIGN CATEGORY A**

6. OCCUPANCY CATEGORY [SEISMIC USE GROUP]
   II

7. SEISMIC IMPORTANCE FACTOR
   $I_E = 1.0$

8. SEISMIC ANALYSIS PROCEDURE [SEC 11.7]

   $F_x = 0.01 W_x$ [FROM EQN 11.7-1]

NOTE: BUILDING CAN USE ABOVE FORMULA BECAUSE IT IS IN SEISMIC DESIGN CATEGORY A

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9. DETERMINE THE EFFECTIVE TOTAL SEISMIC WEIGHT

- DL + 20% SL [ON ROOF]
- DL [ON FLOORS]

STRUCTURAL STEEL FLOORS

$W = (160.25)(87)(80) + 2(160.25 + 87)(539)$

$= 1381875.5$ POUNDS

$= \underline{1382 \text{ KIPS}}$

CAST-IN-PLACE CONCRETE FLOORS

$W = (160.25)(87)(138 \text{ PSF}) + 2(160.25 + 87)(539)$

$= 2190497$

$= \underline{2190 \text{ KIPS}}$

PENTHOUSE ROOF

$W = (115.25)(54.8)(27 + 0.2(20)) + 2(115.25 + 54.8)(39 \times 18.5')$

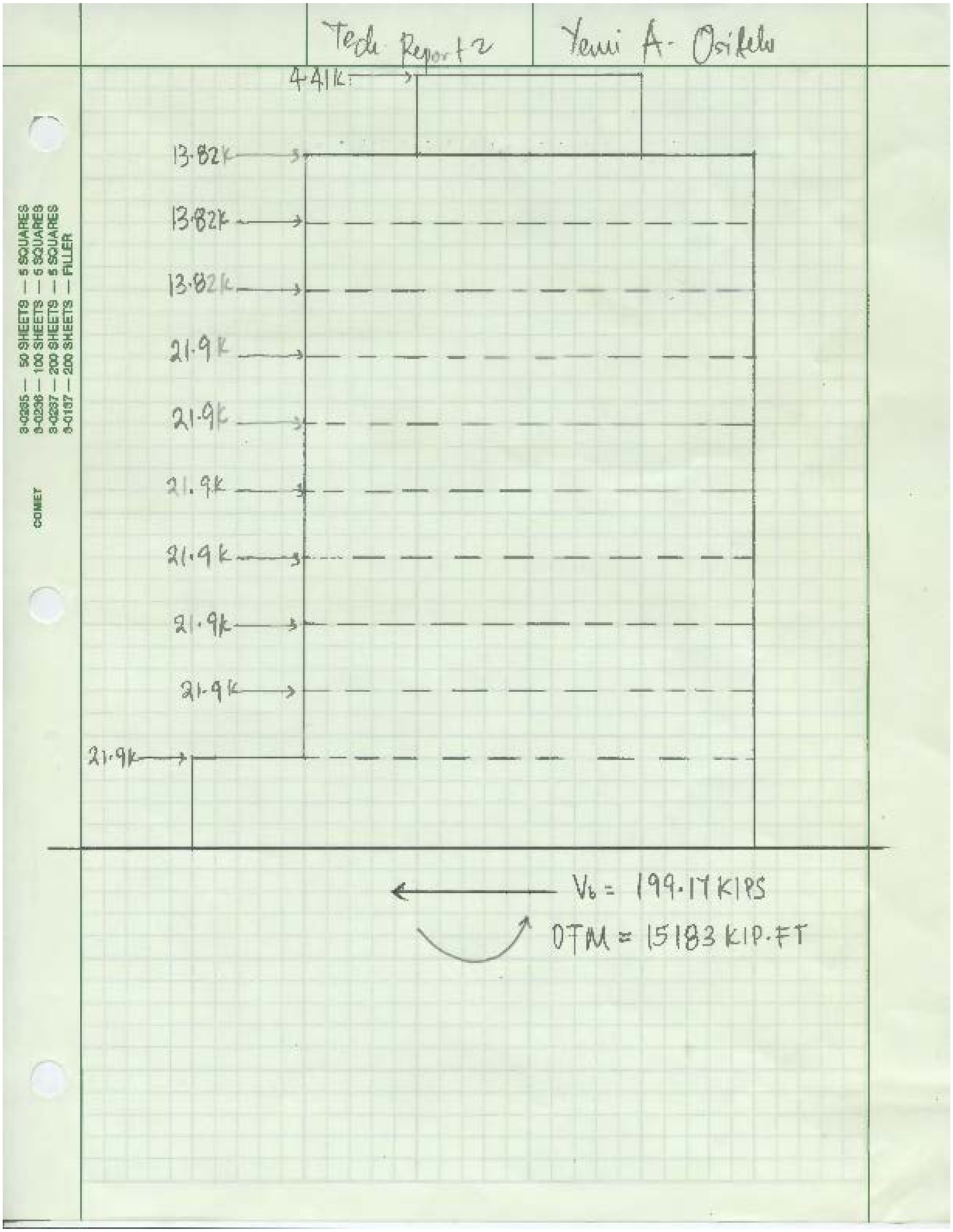
$= 441168.85$ POUNDS

$= \underline{441 \text{ KIPS}}$

TOTAL LOAD:

$W = 441 \text{ KIPS} + 7(2190) \text{ KIPS} + 3(1382) \text{ KIPS}$

$\boxed{W = 19917 \text{ KIPS}}$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4.41k
13.82k
13.82k
13.82k
21.9k
21.9k
21.9k
21.9k
21.9k
21.9k
21.9k
Vb = 199.17 KIPS
OTM = 15183 KIP-FT