TECHNICAL REPORT 1

University Academic Center

Eastern USA

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Structural Option

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Executive Summary

The goal of this report is to gain and understanding of the structural systems utilized in the construction of the University Academic Center, located in eastern United States. This was accomplished through analysis of these systems with current codes and standards including ASCE7-10, IBC 2009, the 14th Edition AISC Steel Manual, and Vulcraft steel deck catalog.

An overview of the building systems is first presented to establish a base of understanding into the design of the University Academic Center. This includes an overall building description, followed by foundation, floor and roofing, framing, and lateral system details and images. Analysis is then done for various loading scenarios to compare with actual building design. Codes used in both the design of the University Academic Center as indicated on the plans and used in this report for analysis purposes are listed on page 12. Minor differences in calculated values and those provided in plans will be accredited to the code differences if any.

Dead loads and live loads were determined using ASCE7-10 and compared to those used in the actual design as indicated in plan. The larger of these two sets of numbers would be the basis of all values in further calculations.

An analysis of snow loads was calculated along with a preliminary drift analysis at several areas of potential drift. The results of this exercise show the designer's use of 20 psf flat roof snow load to be greater than the calculated 15.75 psf and therefore safe for snow. However, during snow drift analysis a maximum drift load of 62.71 psf at location 11 as indicated on page 13 is cause for concern and requires a more detailed inspection.

Seismic analysis done using ASCE7-10 required a estimate of building self weight be determined. This was then used to calculate a base shear of 377 kips and an overturning moment of 17,892 kip-ft. These values compared well with the base shear value of 363 kips given on the plans as designed with a difference of only 4%.

The MWFRS Directional Procedure was used for wind analysis as found in ASCE7-10. A simplified building shape was chose based on elevation profiles from the plans. This resulted in a base shear of 1013.7 kips and an overturning moment of 87,357.2 kip-ft. These values are assumed higher than actual values due to the fact that most walls are rotated on angles and would not see the full effects of wind forces simultaneously.

Several spot checks were done to verify the sizes of members used in the University Academic Center under gravity loadings. These include a slab check for deck type specification, a composite beam used to support said deck, and a ground floor column supporting a typical bay. The slab was determined to be adequate to support the typical classroom loading of 40 psf specified as 3 1/4” LWC with 6”x6”, W1.4xW1.4 WWF on 2” - 18 gage decking. This comparison was made to 2VLI18 deck capabilities found in the Vulcraft deck catalog. Design of the beam showed it to be partially composite with the limiting factor being the shear capacity determined by shear studs of 464.4 kips. Values for size determination were taken from the AISC steel manual this along with deflection checks showed the beams to be safe as designed. Finally a column check was done which resulted in an acceptably sized column after live load reduction was implemented.

Introduction

Located in the eastern United State and placed in a quiet suburban setting, the University Academic Center is a 192,000 square foot building designed to house a library resource center, dining area, 45 classrooms, and over 120 offices. Other key features include a 5-story atrium and multiple roof gardens.

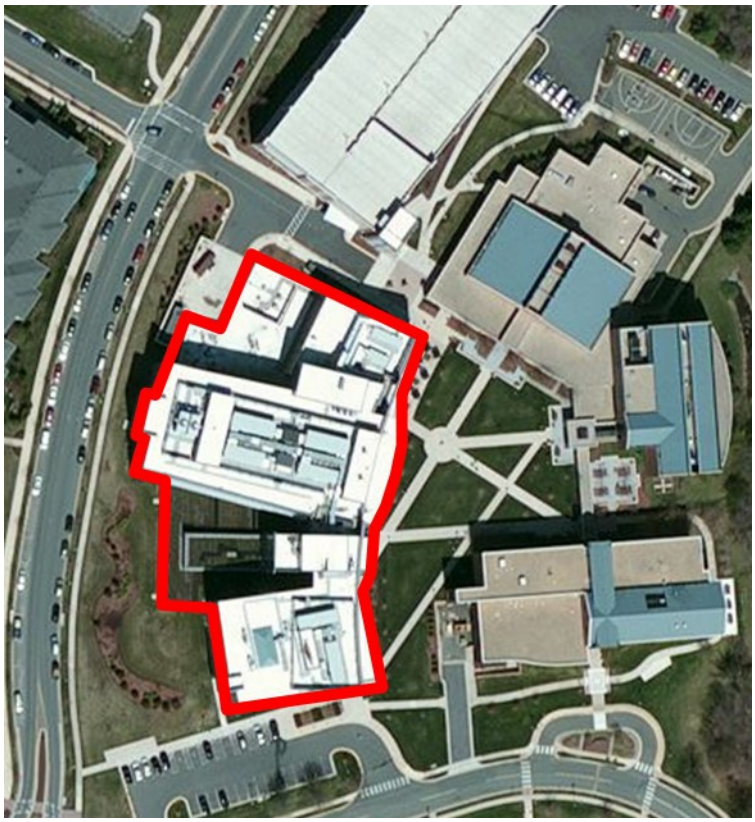


Photo taken from Bing Maps

The layout of the building consists three main sections. The northern 3-story section contains of mostly dining and classroom areas. In the center of the building, a 4 story section houses the library and the majority of classrooms, as well as acting as the main entrance. The southern end of the building consists almost entirely of office spaces. Between the 4 and 5-story sections of the building is the main vertical circulation for the building. This space also provides access to the roof garden.

There are 4 main types of building façade implemented in this building. The 3 and 5-story sections of the building have a brick façade with cast stone bands running horizontally across the brick surface. Glass curtain walls are used in the vertical circulation located on either side of

the 4-story section. The 4-story section's façade is mostly metal panels. There is also glazed CMU used to accent the other façade types at various places.

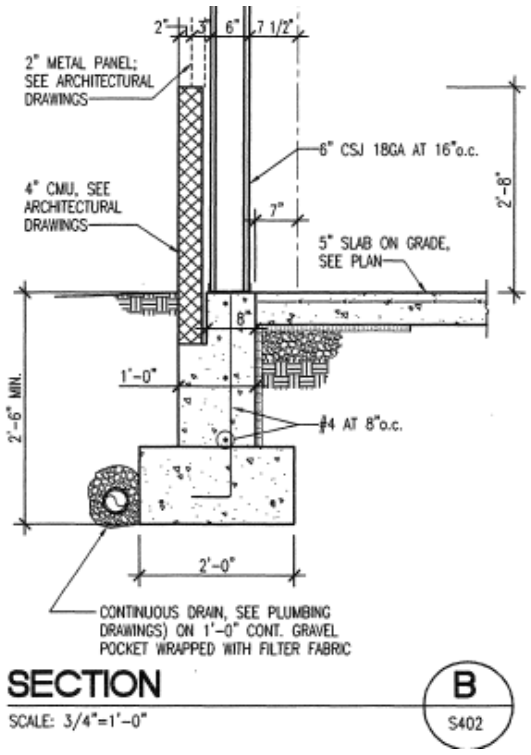
Through the use of multiple energy saving techniques the University Academic Center holds a LEED gold rating. This includes site design to minimize storm water runoff and the use of recyclable and local materials. Energy efficient HVAC equipment and the use of natural day lighting as well as shading devices also help minimize energy consumption. All these features, along with the roof gardens, provide a "green" learning environment.

Structural Overview

The University Academic Center is a steel framed building with composite metal decking all sitting atop a foundation of spread footings and slab-on-grade. The building is supported from lateral forces by a combination of braced and moment frames. In the case of gravity loads, the floor and roof systems will take the force from dead and live loading and distribute it to beams and girders. These loads are then transferred into the columns which then transfer the loads into the foundation and ultimately into the earth. In the case of lateral loading, forces work to overturn the building. Wind forces are taken by the façade into beams and girders. These forces must meet some resistance in the form of lateral bracing via braced or moment connections otherwise the forces will cause failure when they reach the columns. Similarly, seismic forces will cause lateral movement of the earth beneath the building and if connections are not properly braced failure will occur.

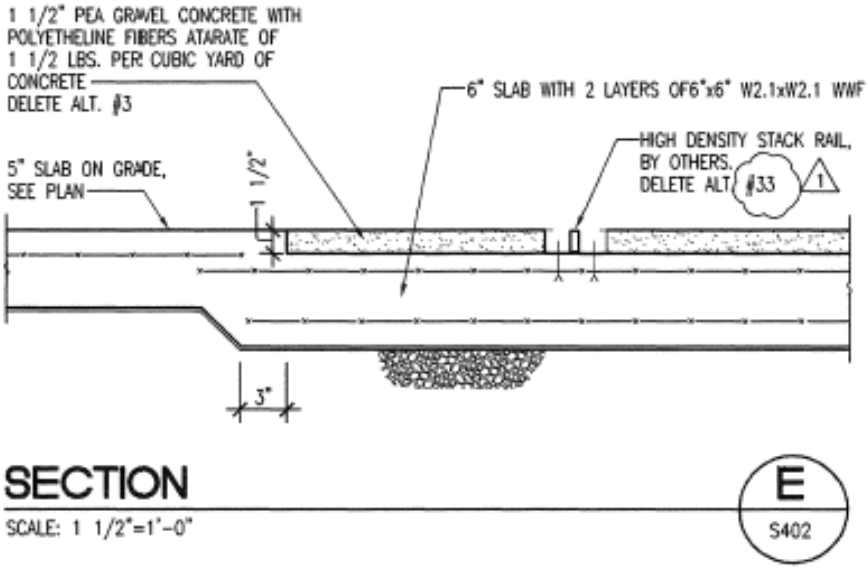
Foundation

Based on the 2002 geotechnical report taken, footings for University Academic Center are designed for an allowable bearing capacity of 3000 psf. Footings are placed on undisturbed soil or on structurally compacted fill. The bottom of exterior footings shall be 2'-6" below grade.

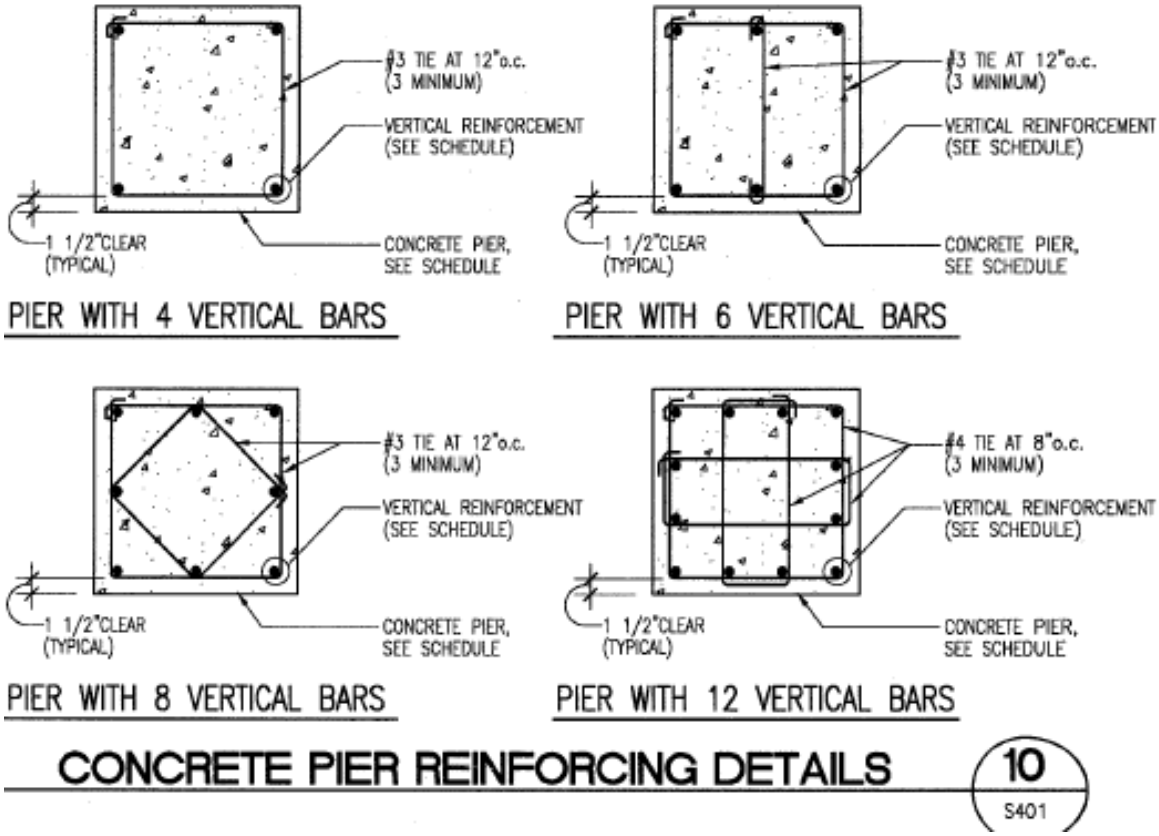


Drawings provided by Skanska

Slab-on-grade sits on a coarse granular fill material compacted to 95% of maximum density as defined by ASTM D1557 modified proctor test. The slab-on-grade is designed as 5" thick concrete reinforced with 6"x6", W1.4xW1.4 WWF. This encompasses all slab-on-grade except for the area located under the library stacks which is 6" thick concrete reinforced with 2 layers of 6"x6", W2.1xW2.1 WWF.



Drawings provided by Skanska

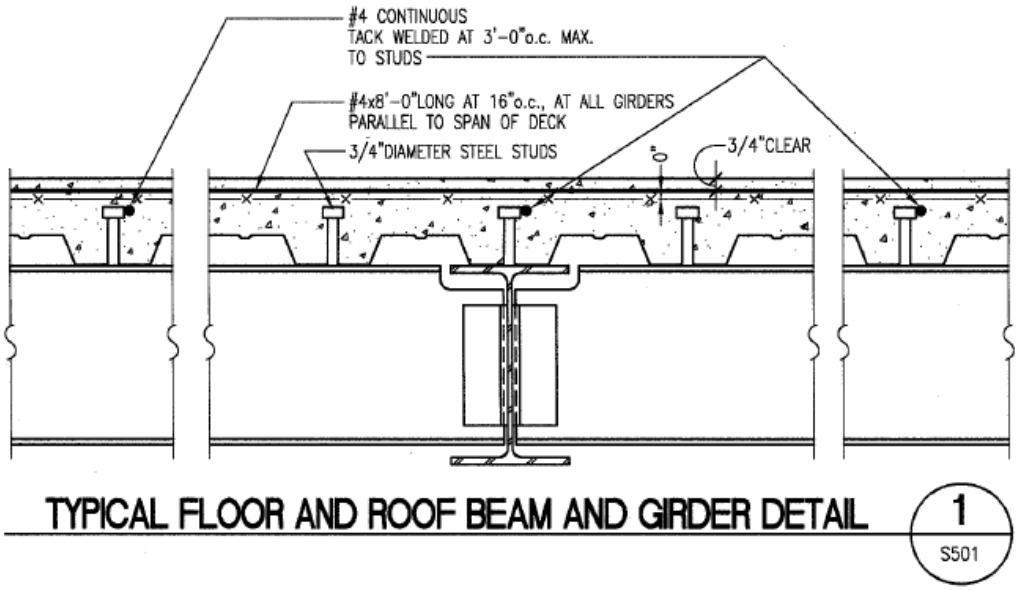


Drawings provided by Skanska

The columns in the University Academic Center rest on piers and footings ranging in size depending on loading and connection type. The columns are embedded 8” in concrete then anchored to a base plate which rests on the pier. These piers are a minimum of 8” ranging to a maximum depth of 3’-9”. The piers come in 4 types: 4, 6, 8, and 12 vertical bar piers. Footings also range in size under the columns with a maximum 19’x19’ under a single column.

Floor and Roof Systems

The University Academic Center utilizes a composite metal deck flooring system. This includes 2” composite 20 gage deck with ribs 12” o.c. and 1.5” type B, wide rib 20 gage deck. All metal deck is designed to be continuous over 3 spans. Floor system also includes shear studs and lightweight concrete topping varying based on location and loading.

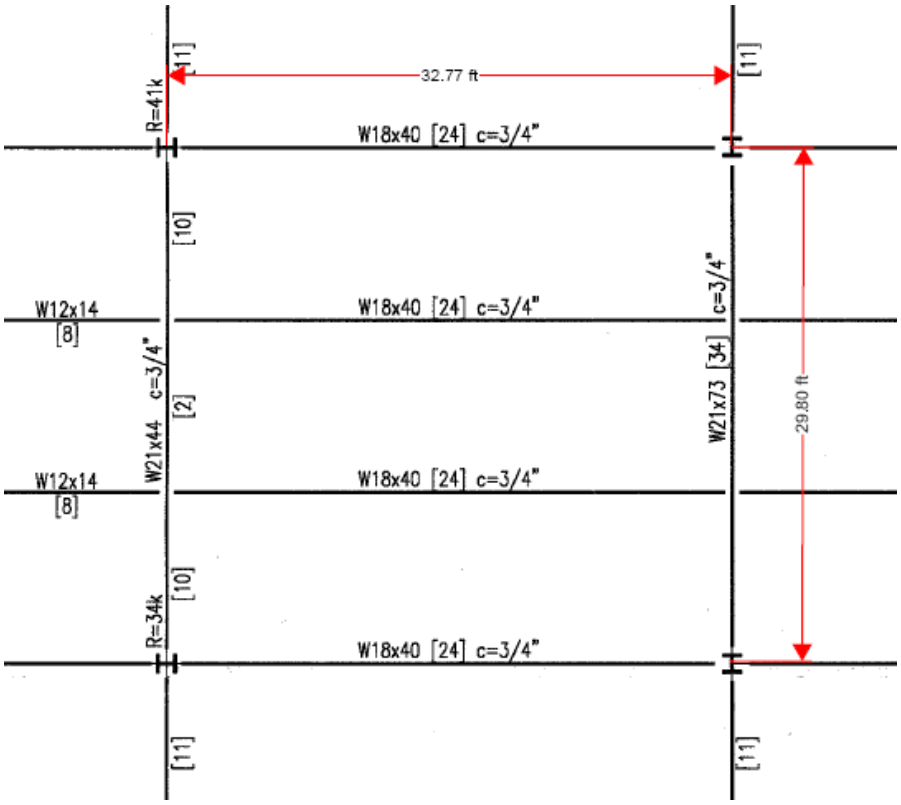


Drawings provided by Skanska

Roofing systems also varies due to some areas like the roof gardens and mechanical areas of greater loading. Decking for roofs includes both 2” composite 18 gage deck with ribs 12” o.c. and 1.5” type B, wide rib 20 gage deck.

Framing System

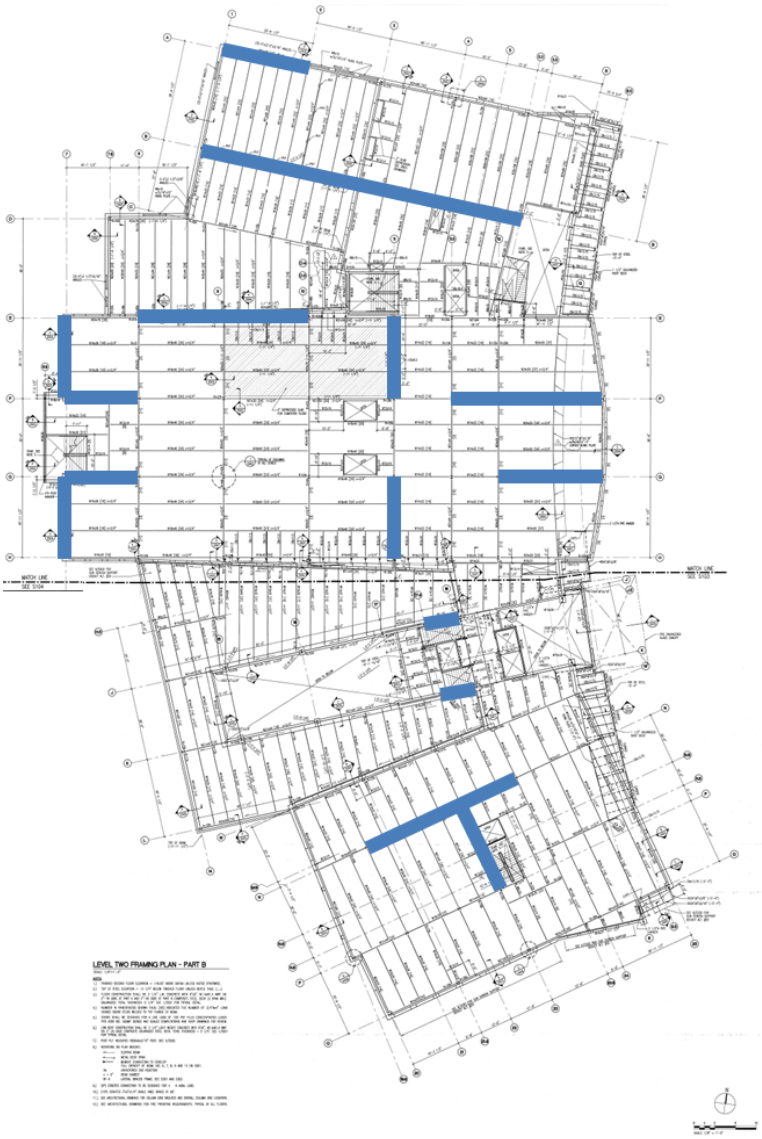
The framing system for the University Academic Center is complex and varies greatly due to the differing roof heights and use of spaces. Steel members used throughout the building include C-shapes, HSS members, and Wide Flange members with the majority being W-shapes. Gridlines are set at multiple angles and bay sizes vary throughout the building. The only areas with a typical framing are those located in the classroom areas in the central section of the building and the office spaces on the south side.



Drawings provided by Skanska

Lateral System

The lateral system for this building is also complex with braced frames of varying heights and styles located throughout the building. To the right is a plan view of University Academic Center with the 15 lateral braced frames shown in blue. Elevations of each frame can be found in the Appendix.



Drawings provided by Skanska

Design Codes

As Designed:

- 2000 ICC International Building Code
- 2000 ICC International Mechanical Code
- 2000 ICC International Plumbing Code
- 2000 ICC International Fuel-Gas Code
- 2000 ICC International Fire Code
- 2000 ICC International Energy Conservation Code
- 2000 NFPA Life Safety Code
- 2000 Americans with Disabilities Act – Accessibility Code
- 1999 National Electrical Code

Thesis Calculations:

- 2009 International Building Code
- American Society of Civil Engineers (ASCE) 7-10
- AISC Steel Construction Manual, 14th Edition
- Vulcraft deck catalog

Design Loads

Dead Loads

Dead loads were determined based on assumptions since no values were given on drawings except for weights of rooftop units which range from 8,000-45,000 lbs. Deck weight was compared to similar weights in Vulcraft catalog based on topping thickness and deck type. Roofing weights were based off in class examples. Façade weights was based off the weight of 4” brick.

Dead Loads	
Description	Load (psf)
Framing	10
Superimposed DL	10
MEP	5
Composite Deck	
3.25” LWC topping	42
4.75” LWC topping	50
5” NWC topping	70
Roof Garden	80
Partitions	20
Façade	
Brick	40
Glass	10
Metal Panel	15

Live loads

Live load values were given on the drawings. These values can be shown along with the values given in ASCE7-10 in the table on the following page. Where values are not given in one source the value from the other source will be used in future calculations. Likewise, when differing values are present the larger of the two will be adopted in future calculations.

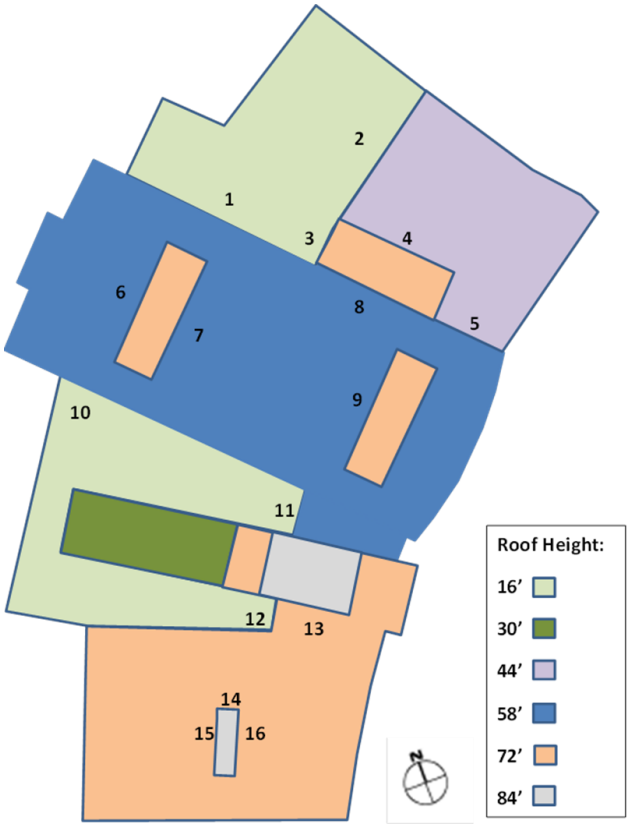
Live Loads		
Description	Designed Load (psf)	ASCE7-10 Load (psf)
Slab on grade	100	N/A
Library slab on grade	150	150
Storage	125	125
Offices	50 +20 (partition allowance)	50
Classrooms	40 +20 (partition allowance)	40
Corridors (elevated floors)	80	80
Lobbies	100	100
Recreational areas	100	100
Mechanical/Electrical	125	N/A
Stairs	100	100
Chiller room	150 + equipment	N/A
Boiler room	200 + equipment	N/A
Roof	30	20
Roof Garden	N/A	100

Snow Loads

With the use of flat roofs on 6 different levels the snow loading for the University Academic Center will prove to be an important consideration when designing the roof members. Both typical uniform snow loading and drifting have to be factored in.

Using ASCE7-10 to confirm the design loads used on the building were efficient, a flat roof snow load of 15.75 psf was calculated. According to the plans the building was designed for a snow load of 20 psf conservatively so.

Basic snow drift calculations were also done to find total snow load at 16 key locations of maximum drift as well as when l_u = 20', the minimum length when accounting for drift is necessary as defined by 7.7.1. Assumptions have been made based on presence of parapet walls along all sides of all roofs that snow will not drift from one roof to another and only drift on lower level roofs against walls will need to be calculated. Because of presence of parapet walls, drift can be estimated for these based on drift heights found in calculations. Sample snow calculation can be found in the Appendix.



Snow Drift Calculation					
Location	**l_u (ft)**	**h_d (ft)**	**p_d (psf)**	**w (ft)**	**p_{tot} (psf)**
-	20	1.00	17.32	4.02	33.07
1	100	2.52	43.40	10.06	59.15
2	62	1.98	34.15	7.92	49.90
3	90	2.39	41.23	9.56	56.98
4	61	1.96	33.86	7.85	49.61
5	80	2.25	38.90	9.02	54.65
6	46	1.69	29.08	6.74	44.83
7	109	2.62	45.23	10.49	60.98
8	94	2.44	42.12	9.77	57.87
9	109	2.62	45.23	10.49	60.98
10	103	2.55	44.02	10.21	59.77
11	118	2.72	46.96	10.89	62.71
12	116	2.70	46.59	10.80	62.34
13	101	2.53	43.61	10.11	59.36
14	33	1.39	24.00	5.56	39.75
15	63	2.00	34.44	7.98	50.19
16	49	1.75	30.11	6.98	45.86

Seismic Loads

Seismic loading was designed using the Equivalent Lateral Force Procedure to mimic the process used on the University Academic Center as stated in the drawings. Several design values were also given which, when compared to the values calculated based on ASCE7-10, differed. However, the base shear values turned out to be within 4% so the differing values are assumed to be a differing in code.

Building weight was calculated based on dead loads listed previously and shown in more detail along with a seismic loading diagram in the Appendix.

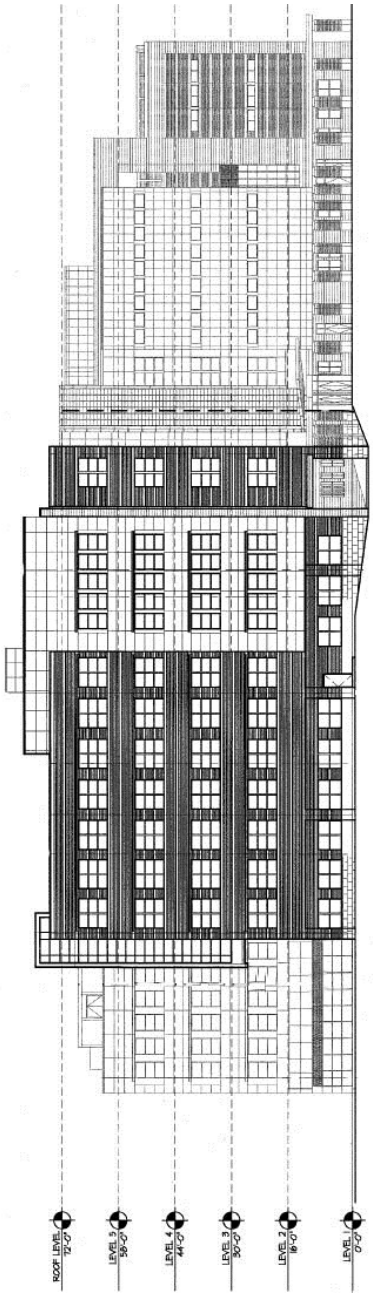
Seismic Load Calculation						
Floor	**Weight w_x (kip)**	**Height h_x (ft)**	**C_{vx}**	**Story Force F_x (kip)**	**Story Shear (kip)**	**Overturning Moment (kip-ft)**
Ground	3618	0	0	0	377	0
2	3953	16	0.11	41.47	377	663.52
3	3269	30	0.18	67.86	335.53	2035.8
4	2966	44	0.24	90.48	267.67	3981.12
5	2995	58	0.31	116.87	117.19	6778.46
6	1084	72	0.14	52.78	60.32	3800.16
Roof	104	84	0.02	7.54	7.54	633.36
Total	17989	-	1	377	-	17892.42
Base Shear = 377 kip				Overturing Moment = 17,892 kip-ft		

Wind Loads

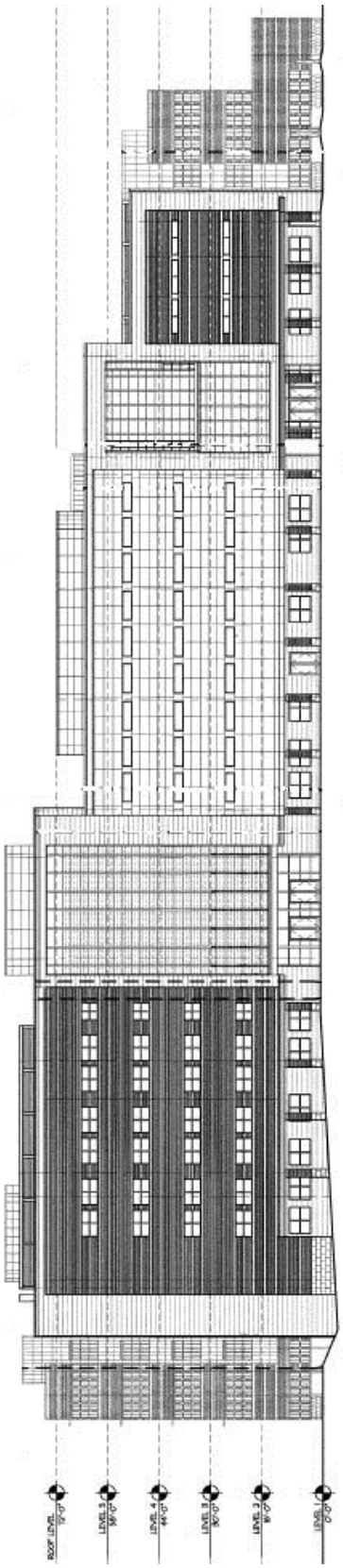
Wind loads were calculated using the Directional Procedure found in ASCE7-10 Chapter 27. Preliminary values taken from the drawings along with detailed calculations in determining wind loads and loading diagrams for wind forces can be found in the Appendix. An approximate building shape was taken for facilitating calculations based off the south and east elevations shown on the following page. This simplification still required the determining of wind pressures for three levels and roofs. A summary of wind analysis results can be seen below. Wind analysis concludes that the University Academic Center must be designed to resist an overturning moment of 87,357 kip-ft. This value surpasses that determined for seismic therefore wind controls the design of this building. This is logical given the relatively small seismic activity in the region.

Wind Loads

Floor	Elevation (ft)	Total Wind Pressure (psf)	Façade Area (sf)	Wind Force (kip)	Shear (kip)	Overturning Moment (kip-ft)
Roof	72	49.53	1574	78.0	100.9	7267.5
5	58	48.43	3652	176.9	317.5	18417.5
4	44	47.05	4566	214.8	544.0	23936.0
3	30	45.51	4976	226.5	758.8	22764.9
2	16	43.53	4976	216.6	935.7	14971.2
Ground	0	40.57	2488	100.9	1013.7	0.0
Total				1013.7		87357.2



Drawings provided by Skanska



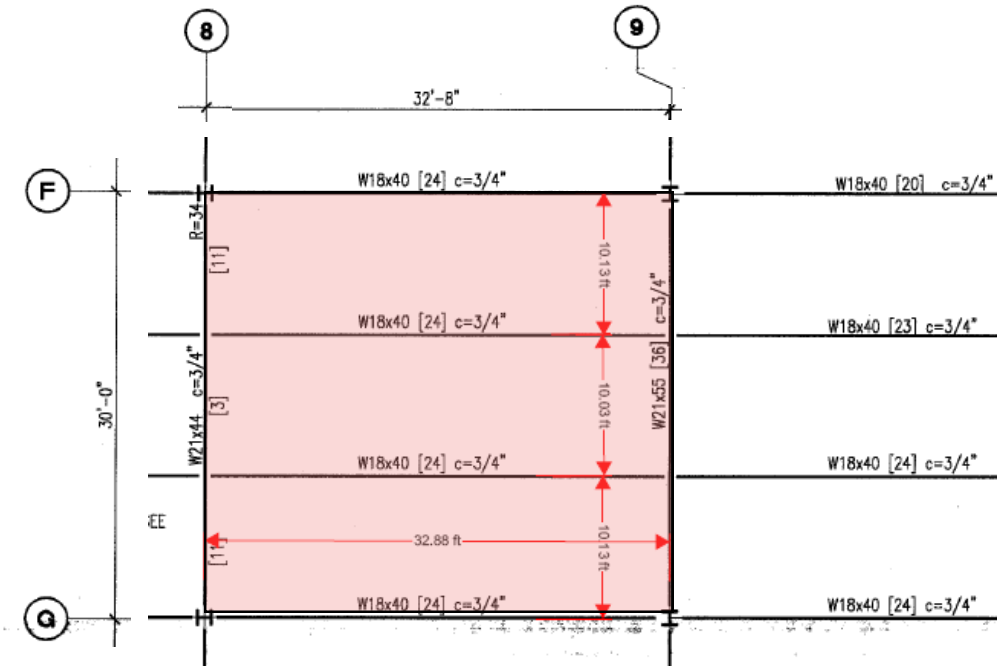
Drawings provided by Skanska

Spot Checks

To check the accuracy of assumed dead and live loads to the design of University Academic Center several spot checks are performed on a typical slab, beam, and column. The sizing of these members are compared to the designed sizes.

Slab Check

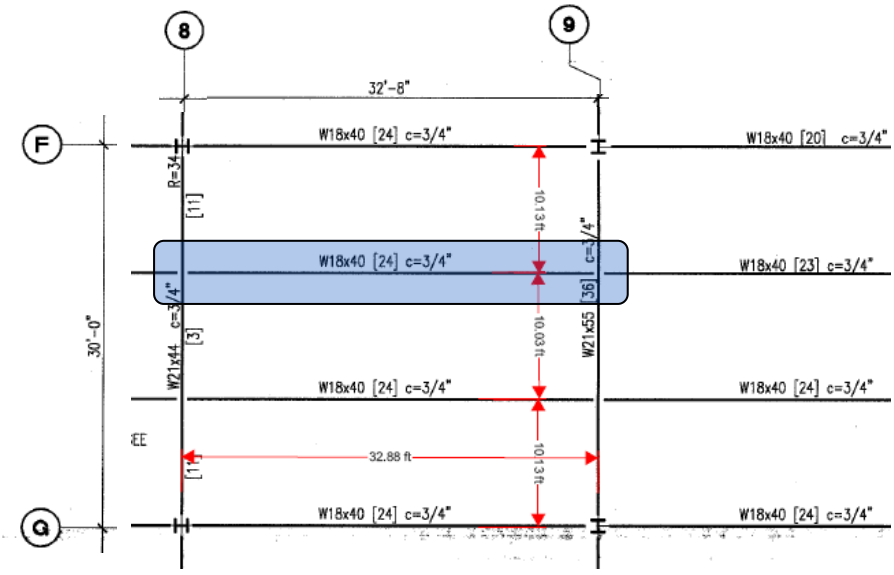
The location of the slab under examination can be seen below. Located on the 3rd floor in the center section of the building this slab is assumed to support classroom live load. According to the plans the slab is constructed of 3 1/4" LWC with 6"x6", W1.4xW1.4 WWF on 2" - 18 gage decking. Calculations found in the Appendix resulted in a 2VLI18 deck type meeting the specifications called out in the drawings and safely supporting the loading.



Drawings provided by Skanska

Beam Check

To keep consistent and minimize repeated calculations, one of the beams supporting the slab previously checked is also checked to verify size is sensible under designed loading. During check it was discovered beam is partially composite with shear strength controlling sizing. Knowing this a max moment was found using Table 3-19 in AISC manual. Beam size was also verified for live load deflection and unshored deflection. As designed the beam is capable of withstanding all these criteria as a W18x40.



Drawings provided by Skanska

Column Check

As with the previous checks a member in close proximity was used to allow for reuse of calculated loading. The column in question is located at the intersection of gridlines G and 9 this column supports 3 classroom style floors and the chiller room on the roof. In calculating loading the weight of all floors as well as the rooftop units are included. Calculations show the W12x87 column is sufficient to support the gravity loads after employing live load reduction. Appendix contains diagram of column in question and hand calculations.

Conclusion

This report was designed to gain a better understanding of the University Academic Center and the design of its structural systems. Specifically through the analysis of gravity and lateral systems under dead, live, snow, wind, and seismic loading. More close calculations were done to verify sizing of several framing members as well. The initial findings in this report will provide a solid foundation for future exploration into the structure. Comparing code and standards to applied practice is an important first step to making educated decisions when designing new systems in future reports.

Appendix

- **Snow Loads (24)**
- **Seismic Loads (25-28)**
- **Wind Loads (29-33)**
- **Spot Checks (34-37)**

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Snow Load

Flat Roof Snow Load, P_f

$P_f = 0.7 C_e C_t I_s P_g$

$P_g = 25$ psf (Fig 7-1)

$C_e = 0.9$ (Table 7-2)

$C_t = 1.0$ (Table 7-3)

$I_s = 1.0$ (Table 1.5-2)

$P_f = 0.7(0.9)(1.0)(1.0)(25)$

$P_f = 15.75$ psf (Calculated)

$P_f = 20$ psf (As Designed)

Snow Drift

$\gamma = 0.13 P_g + 14 = 17.25$ pcf

$h_b = \frac{P_s}{\gamma} = \frac{15.75}{17.25} = 0.91' > 0.2$

∴ calculate drift

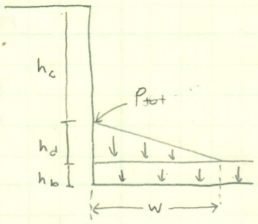
→ Sample Calc for Snow drift

Location 1

$l_u = 100'$

$h_d = 0.43 \sqrt[3]{l_u} \sqrt[4]{P_g + 10} - 1.5 = 2.52'$

(l_u = 100', P_g = 25 psf)



Not to scale

$P_d = h_d \gamma = 2.52'(17.25 \text{ pcf}) = 43.47$ psf

$P_{tot} = P_f + P_d = 15.75 + 43.47 = 59.22$ psf

$h_c \sim 42' > h_d \rightarrow w = 4 h_d = 10.08'$

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Seismic Load

Data Given in Drawings

Seismic use group: I

S_{DS} : 0.21 S_{D1} : 0.11

Site class: D

seismic-force-resisting system: special steel concentrically braced frames

design base shear (V): 363 kips

analysis procedure: equivalent lateral force method

Equivalent Lateral Force Procedure (per ASCE 7-10)

$V = C_s W$ (12.8-1)

$C_s = \frac{S_{DS}}{\left(\frac{R}{I_e}\right)}$ (12.8-2)

$I_e = 1.0$ (Table 1.5-2)

$R = 6$ (Table 12.2-1)

$S_{DS} = \frac{2}{3} S_{MS}$ (11.4-3)

$S_{MS} = F_a S_s$ (11.4-1)

$S_s = 0.12$ (Fig 22-1)

$F_a = 1.6$ (Table 11.4-1)

↳ $S_{MS} = 0.192$

↳ $S_{DS} = 0.128$

↳ $C_s = 0.021$

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Seismic (cont'd)

$C_s \leq C_s^* = \frac{S_{D1}}{T\left(\frac{R}{I_e}\right)}$ for $T \leq T_L$ (12.8-3)

$T \cong T_a = C_t h_n^x$ (12.8-7)

$h_n = 72'$

$C_t = 0.02$ (Table 12.8-2)

$x = 0.75$ (Table 12.8-2)

↳ $T = T_a = 0.494_s$

$T_L = 8\,s$ (Figure 22-12)

$S_{D1} = \frac{2}{3} S_{M1}$ (11.4-4)

$S_{M1} = F_v S_1$ (11.4-2)

$S_1 = 0.05$ (Figure 22-2)

$F_v = 2.4$ (Table 11.4-2)

↳ $S_{M1} = 0.12$

↳ $S_{D1} = 0.08$

↳ $C_s^* = 0.027 > C_s = 0.21$ ✓ ok

$C_s = 0.044 S_{DS} I_e \geq 0.01$ (12.8-5)

$C_s = 0.021 > 0.01$ ✓ ok

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Seismic (cont'd)

Calculation of building weight (W)

Level 1 : W = 55,000 sf (5")(150 pcf) slab on grade ≃ 3,618 kip
1,130' (16')(20 psf) $\frac{1}{2}$ façade

Level 2 : W = 7000 sf (80 psf) green roof
7,000 sf (40 psf) typ. roof
41,000 sf (42 + 10 + 5 + 10) psf floor ≃ 3,953 kip
1130' (16')(20 psf) $\frac{1}{2}$
1320' (14')(20 psf) $\frac{1}{2}$ facade

Level 3 : W = 1,900 sf (80 psf) green roof
41,000 sf (42 + 10 + 5 + 10) psf floor ≃ 3269 kip
1320' (14') (20 psf) facade

Level 4 : W = 5,700 sf (40 psf) typ roof
35,300 sf (42 + 10 + 5 + 10) psf floor ≃ 2966 kip
1320' (14')(20 psf) $\frac{1}{2}$
1180' (14') (20 psf) $\frac{1}{2}$ facade
(8000 + 15000) Roof units

Level 5 : W = 19,300 sf (70 psf) roof
16,000 sf (42 + 10 + 5 + 10) psf floor ≃ 2995 kip
1180' (14') (20 psf) $\frac{1}{2}$
1000' (14') (20 psf) $\frac{1}{2}$ facade
16,000(2) + 25,000 + 40,000(3) + 45,000(2) roof units

Level 6 : W = 14,000 sf (50 psf) roof
2,000 sf (42 + 10 + 5 + 10) psf floor
1000' (14')(20 psf) $\frac{1}{2}$ ≃ 1084 kip
200' (12')(20 psf) $\frac{1}{2}$ facade
18000(2) + 25,000(2) roof units

Roof : W = 2,000 sf (40 psf) typ. roof ≃ 104 kip
200' (12') (20 psf) $\frac{1}{2}$ facade

Total : W = 17989 kip

Base Shear : $V = C_s W = 0.021(17989) = 377$ kip

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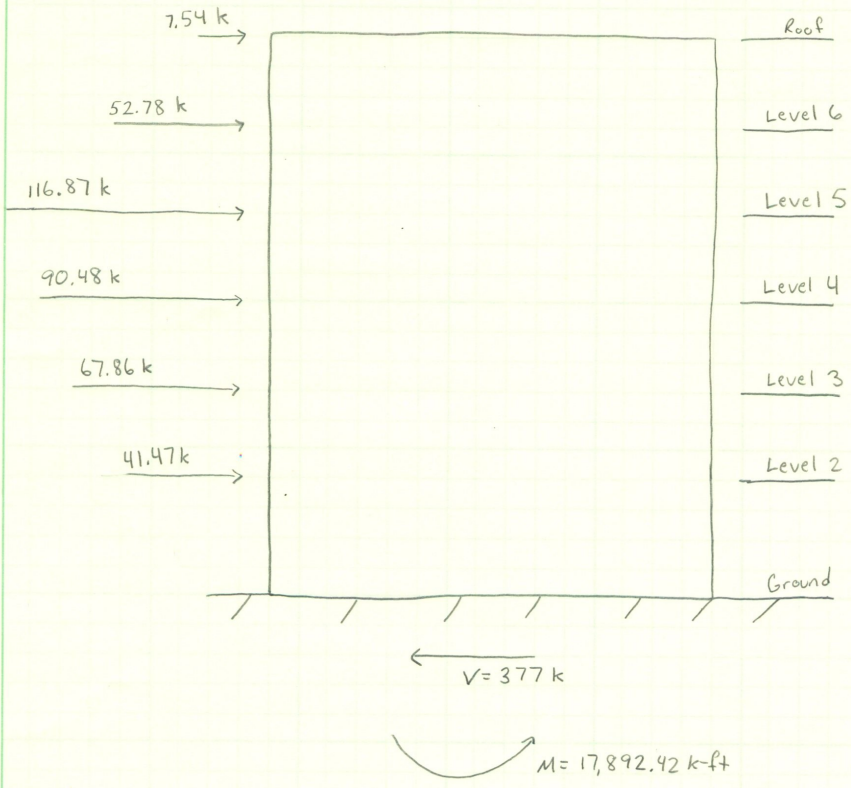
Seismic (cont'd)

Seismic Loading Diagram (Not drawn to scale)



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Wind Loads → MWFRS (Directional Procedure) Analysis will be used [Steps outlined in Table 27.2-1]

Values given on drawings

basic wind speed (V) = 90 MPH

wind load importance factor (I_w) = 1.15

risk category II

wind exposure C

internal pressure coefficient = 0.18

[Values are base on and older version of ASCE standard
Calculations are based off current version ASCE7-10
Values will differ from design]

Basic Wind Parameters:

[Step 1] Risk Category II

[Step 2] V = 115 MPH

[Step 3] K_d = 0.85

Exposure C

K_{zt} = 1 [Assumed based on lack of topographic concern on site]

G = 0.85

Enclosure = Fully Enclosed

GC_{pi} = ±0.18

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Wind (cont'd)

$G = 0.85$ if rigid or $G = 0.925\left(\frac{1+1.7 g_Q I_{\bar{z}} Q}{1+1.7 g_v I_{\bar{z}}}\right)$ (26.9-6)

Determination if rigid:

$h < 300'$ ✓

$h < 4 L_{eff} \rightarrow L_{eff} = \frac{\sum h_i L_i}{\sum h_i}$

N-S

$L_{eff} = \frac{174'(72') + 237'(58') + 260'(44')}{72' + 58' + 44'} = 216.7'$

E-W

$L_{eff} = \frac{233'(72') + 293'(58') + 362'(44') + 382'(16')}{72' + 58' + 44' + 16'} = 293.7'$

$h < 216.7'(4)$

$72' < 866.8'$ ✓ $\rightarrow$ n_a can be used

$n_a = 22.2/h^{0.8} = 22.2/50^{0.8} = 1.0 \rightarrow$ Rigid Building $\rightarrow G = 0.85$

min $n_a = 75/h = 75/50 = 1.5$

[Step 4]

K_z	Roof heights (ft)
0.86	16
0.98	30
1.06	44
1.122	58
1.178	72
1.222	84
$K_h = 1.09$	$h = 50$

q_z (psf)	Roof heights (ft)
24.75	16
28.20	30
30.50	44
32.29	58
33.90	72
35.17	84
$q_h = 31.86$	50

[Step 5] $q_z = 0.00256 K_z K_{zt} K_d V^2$ (psf) (27.3-1)

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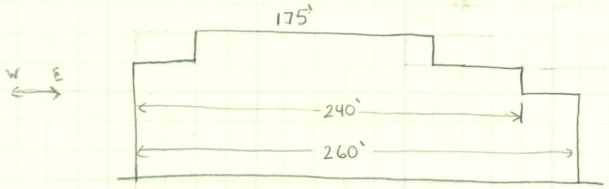
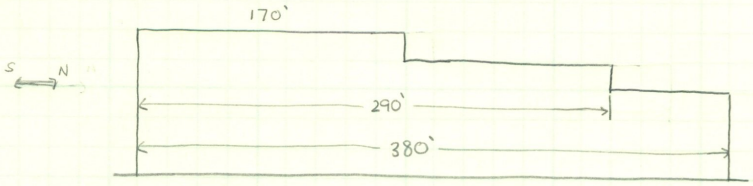
Wind (cont'd)

[Assumed shape of building based off elevations]



South Elevation



East Elevation

[Step 6] (Figure 27.4-1)

[Step 7]

$$p = qGC_p - q_i(GC_{pi}) \text{ (psf)} \qquad (27.4\text{-}1)$$

Sample Calc:

N-S Windward Ground level

$$p = 24.75(0.85)(0.8) - 24.75(-0.18) = 21.285 \text{ psf}$$

N-S Leeward 5-story section

$$p = 31.86(0.85)(-0.5) - 31.86(+0.18) = -19.28 \text{ psf}$$

N-S Upper Roof 0-36'

$$p = 31.86(0.85)(-0.9) - 31.86(+0.18) = -30.11 \text{ psf}$$

Wind Pressures (E-W)						
Location	**Level**	**Distance**	**Kz**	**qz**	**qh**	**p**
Windward	Ground	0	0.86	24.75	31.86	21.29
	2	16	0.98	28.2	31.86	24.25
	3	30	1.06	30.5	31.86	26.23
	4	44	1.122	32.29	31.86	27.77
	5	58	1.178	33.9	31.86	29.15
	Roof	72	1.222	35.17	31.86	30.25
Leeward	5-story	0-72	1.222	35.17	31.86	-19.28
	4-story	0-58	1.222	35.17	31.86	-19.28
	3-story	0-44	1.222	35.17	31.86	-19.28
Side		0-72	1.222	35.17	31.86	-24.69
Roof	Upper	0-36	1.222	35.17	31.86	-30.11
		36-72	1.222	35.17	31.86	-30.11
		72-144	1.222	35.17	31.86	-19.28
		>144	1.222	35.17	31.86	-19.28
	Mid	0-29	1.178	33.9	31.86	-30.11
		29-58	1.178	33.9	31.86	-19.28
		>116	1.178	33.9	31.86	-13.86
	Lower	>88	1.122	32.29	31.86	-13.86

Wind Pressures (N-S)						
Location	**Level**	**Distance**	**Kz**	**qz**	**qh**	**p**
Windward	Ground	0	0.86	24.75	31.86	21.29
	2	16	0.98	28.2	31.86	24.25
	3	30	1.06	30.5	31.86	26.23
	4	44	1.122	32.29	31.86	27.77
	5	58	1.178	33.9	31.86	29.15
	Roof	72	1.222	35.17	31.86	30.25
Leeward	5-story	0-72	1.222	35.17	31.86	-19.28
	4-story	0-58	1.222	35.17	31.86	-18.19
	3-story	0-44	1.222	35.17	31.86	-16.84
Side		0-72	1.222	35.17	31.86	-24.69
Roof	Upper	0-36	1.222	35.17	31.86	-30.11
		36-72	1.222	35.17	31.86	-30.11
		72-144	1.222	35.17	31.86	-19.28
		>144	1.222	35.17	31.86	-19.28
	Mid	0-29	1.178	33.9	31.86	-30.11
		29-58	1.178	33.9	31.86	-19.28
		>116	1.178	33.9	31.86	-13.86
	Lower	>88	1.122	32.29	31.86	-13.86

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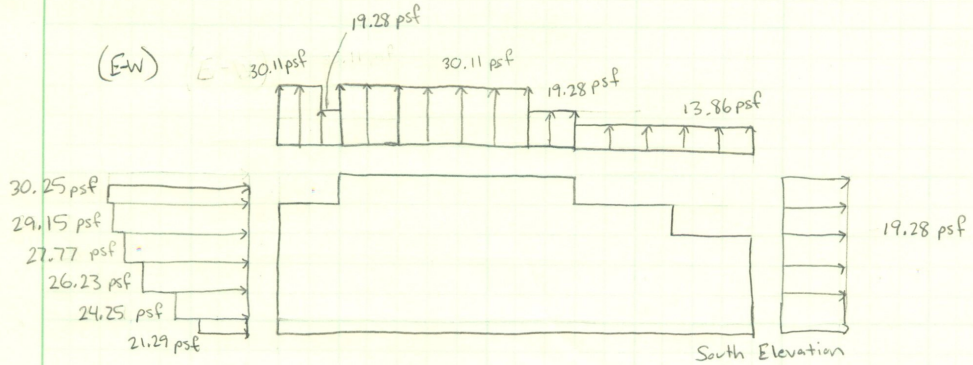
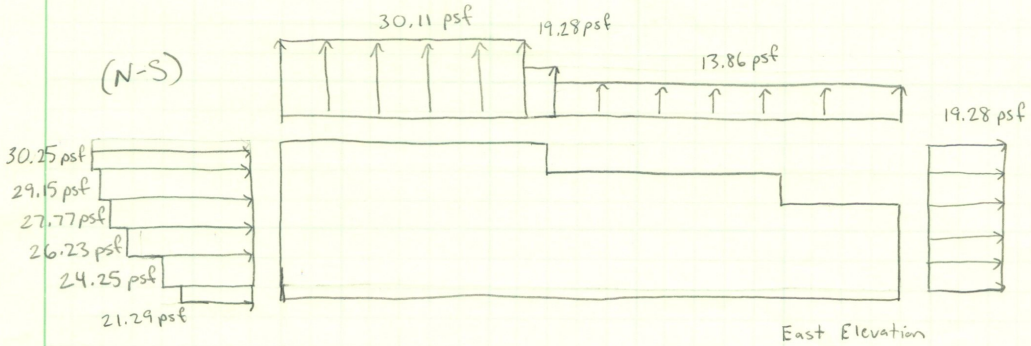
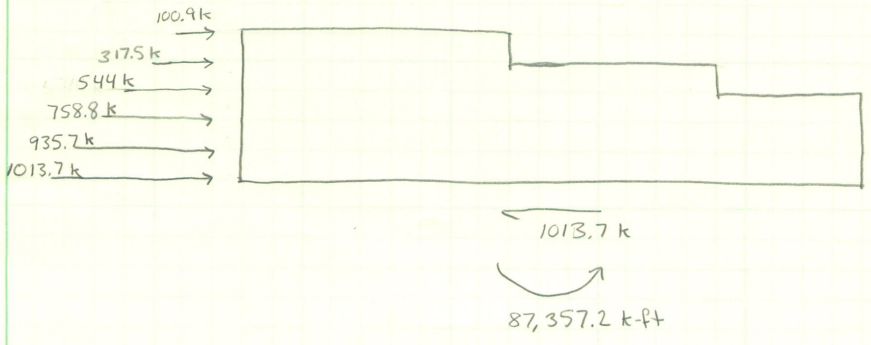
Wind (cont'd)

(E-W)



(N-S)





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Spot Checks

Slab check

Loads:

DL	10 psf	framing
	10 psf	Superimposed DL
	5 psf	MEP
	20 psf	Partitions
LL	40 psf	Classroom

- 3 ¼" LWC topping
- 2" 18 gage deck
- 5 ¼" total thickness
- 10' span
- 40 psf LL

Using Vulcraft Catalog → 2VLI18 deck 42 psf

- 3 ¼" LWC ✓
- 2" 18 gage ✓
- 5 ¼" thick ✓
- 12'-7" Max 3 span > 10' ✓
- LL at 10' = 205 psf > 40 psf ✓

2VLI18 deck OK to use

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Spot Checks (cont'd)

Beam Check

Given: W18×40 [24] shear studs (as per design)

$I_x = 612\ in^4$
$A_s = 11.8\ in^2$
$f_y = 50\ ksi$
$f_c' = 3000\ psi$
$I_{LB} = 1600\ in^4$

Loads:

slab/deck	42 psf
superimposed DL	10 psf
MEP	5 psf
self-wt	5 psf
Partitions	20 psf
LL	40 psf

LL Reduction

$A_T = 10'(32.67') = 326.7\ ft^2$

$K_{LL} = 2$ → $653.4\ ft^2 > 400\ ft^2$ Reduce

$$L = 40\left(0.25 + \frac{15}{\sqrt{653.4}}\right) = 33.47 \simeq 33.5\ psf$$

$w_u = 1.2(82) + 1.6(33.5) = 152$

$w_u = 152(10') = 1.52\ k/ft$

$$M_u = \frac{w_u l^2}{8} = \frac{1.52(32.67)^2}{8} = 202.8\ k\text{-}ft$$

$$V_u = \frac{w_u l}{2} = \frac{1.52(32.67)}{2} = 24.8\ k$$

Deck ⊥, weak studs, 1, ¾ϕ (assumed from plans)

$Q_n = 17.2\ k$ (Table 3-21)

$\Sigma Q_n = 24(17.2) = 464.4\ k$

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Spot Checks (cont'd)

Beam check (cont'd)

$b_{eff} = \min \left| \frac{span}{4} = \frac{32.67}{4} \cong 8' \leftarrow \text{controls} \right.$

$\left. spacing = 10' \right|$

PNA location:

$V'_c = 0.85(f'_c)(b_{eff})(t) = 0.85(3000)(8')(12")(3.25") = 795.6\ k$

$V'_s = A_s f_y = 11.8(50) = 590\ k$

$V'_q = \Sigma Q_n = 464.4\ k \quad \therefore$ partially composite

$a = \frac{464.4}{0.85(3)(96")} = 1.9"$ $\qquad Y_2 = 5.25 - \frac{1.9}{2} = 4.3$ ← Use 4" for conservative

Using Table 3-19 ↘

$\phi M_n = 573\ k\text{-ft} > M_u = 202.8\ k\text{-ft}$ ✓ OK

Δ check

$\Delta_{LL} = \frac{5wl^4}{384EI} = \frac{5(10)(40)(32.67)^4(1728)}{1000(384)(29000)(1600)} = 0.22\ in$

$\Delta_{LL} < \frac{l}{360} = \frac{32.67(12)}{360} = 1.09\ in > 0.22\ in$ ✓ OK

$\Delta_{WC} = \frac{5w_{WC}(32.67)^4(1728)}{384(29000)612} \Rightarrow w_{WC} = 42(10') + 40 = 0.46\ k/ft$

$\Delta_{WC} = 0.66\ in$

$\Delta_{LL} = \frac{32.67(12)}{240} = 1.63\ in > 0.66\ in$ ✓ OK

W18×40 [24] is OK

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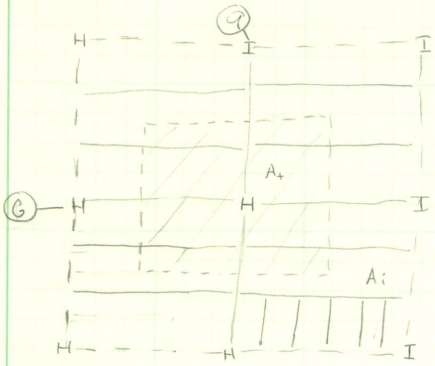
Spot check (cont'd)

Column check

Interior column Ground floor W12×87



$A_t = 30(30.67) = 920.1\ ft^2$

$A_i = 61.34(60) = 3680.4\ ft^2$

SL = 20 psf * assumed no drift

LL = 150 psf (chiller room) + 40 psf (3)

LL = 270 psf (920.1) = 248.4 kip

DL = (42+10+5+10) psf (3) + 70 psf

DL = 271 psf (920.1) + 16,000(2) + 25,000 + 40,000 + 80000(2)

DL = 382.3 kip

LL Reduction

$L = 40\left(0.25 + \frac{15}{\sqrt{3680}}\right) \cong 20\ psf$

DL + Col Wt = DL

$382.3 + \frac{33(87)}{1000} + \frac{25(65)}{1000} = 387\ kip$

$1.2(387) + 1.6(193.2) + 20(0.5) = 784\ k$

At KL = 16', $\phi P_n = 865\ k > 784\ k$ ✓ ok

USE W12×87