Rutgers University Law School

Building Addition and Renovation
Camden, NJ

Technical Assignment 1

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Structural Option
AE 481W Senior Thesis
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Executive Summary:

This report provides a detailed description of the existing structural conditions for the 68,000 GSF Rutgers University Law School Addition and Renovation in Camden, New Jersey. In addition, a preliminary analysis has been preformed to determine loading conditions which will affect the building system as a whole.

As part of the report, several spot checks were preformed using the IBC 2006 to compare the loads generated to those applied to the design of the building, generated from the IBC 2000. The resulting calculations and preliminary analysis provided slightly smaller members than those chosen for the design which may have resulted from a discrepancy in the building loads considered and the depth of the calculations preformed.

Introduction:

The Rutgers University Law School Building and Renovation consists of an east building addition, west building renovation and addition, and the development of a connecting bridge which is used to create a student lounge. As the west building additions are minimal, I will concentrate my efforts on the east building addition and bridge project.

The east building consists of two major sections, the primary classroom section, which will be referred to as the primary east addition (4 floors, with basement and penthouse, 75’-0” height) and a student law clinic, which will be referred to as the secondary east addition (2 floors, with basement, 36’-4” height). Connected to the west edge of the primary east addition is the bridge support system. This system creates several complicated analysis procedures which will be investigated in more depth later in this report.

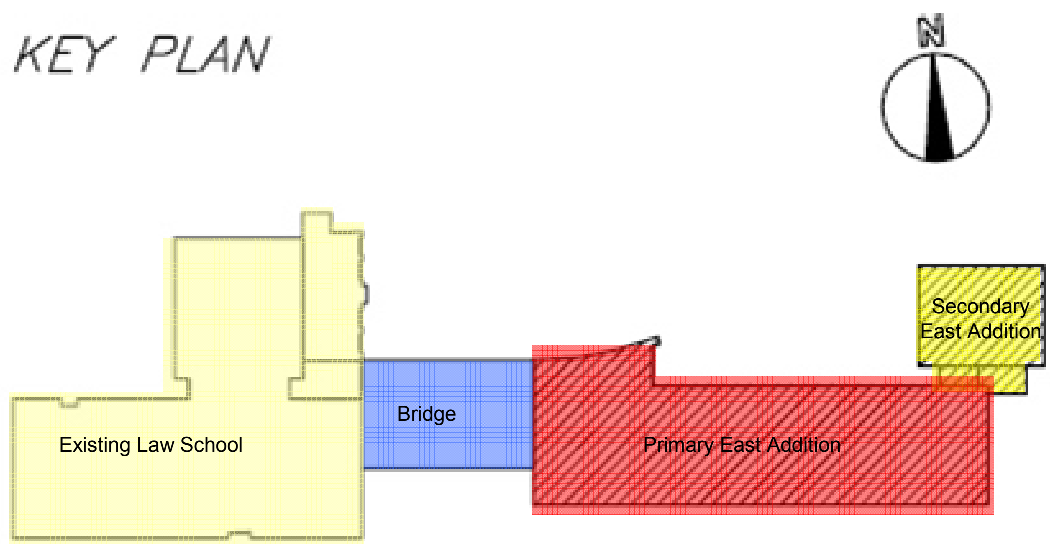


Figure 1: Plan illustrating different building components referenced in this report

Structural System:

The following sections will describe the structural elements incorporated in the design of the Rutgers University Law School Building.

Foundation System

The foundation system utilized to support the east building addition incorporates moment-resisting foundations, concrete pad foundations, and typical wall footing foundations. The foundation system supporting the bridge designed to cross Fifth Street incorporates drilled piles with pile caps along with a typical wall footing.

The moment-resisting foundations are 11'-0" x 11'-0" x 2'-6" concrete slab, reinforced with No. 8 rebar spaced at 12" on center each way, with a 40" x 40" reinforced pier to 10" below grade. In the smaller, three story section, of the east addition, the moment-resisting foundations are 7'-0" x 7'-0" x 2'0" spread footings with No. 7 rebar at 7" on center each way. Again, these foundations are supporting a 40" x 40" reinforced pier designed to transfer the moment to the ground. In addition, these spread footings have been designed to be supplemented by the displacement geopier system provided by Geostructures, Inc. to achieve an allowable bearing capacity of 5000 psf.

The typical wall footings designed around the east addition are 2'-0" wide x 1'0" deep strip footings reinforced with (3) No. 5 rebar longitudinal and No. 4 rebar spaced at 48" on center transversely. This wall footing is typical around the perimeter of the addition, where not influenced by the bridge system. In locations affected by the bridge assembly, the wall footings increase significantly in size, to 2'-6" x 1'-4" with (3) No. 5 rebar longitudinal and No. 5 rebar at 48" on center.

The final foundation system utilized in the Rutgers University Law School Addition is a drilled pile foundation located below the support of the bridge section of the building. A series of (24) 14" diameter piers are drilled to a depth of 65'-70'below grade, as required by the geotechnical report. In the east addition, the piles are capped with (4) 48" pile caps covering (6) piles each. To top off the pile caps, a grade beam, 2'-0" x 2'-0", has been designed to create a wall footing under the bridge addition.

The material properties for the foundations have been listed below:

$f^1_{c,\ foundation}$	4000 psi
$f^1_{c,\ pier/grade\ beam}$	4000 psi
f_y	60,000 psi
q_a	5000 psf

Table 1: General Foundation Properties

Columns

The typical framing system used in the Rutgers University Law School is steel moment frame construction. Typical columns fixed to the foundations are A992 Grade 50 W14X159 for the primary east addition creating typical bays of 20'-0" by 46'-8", and A992 Grade 50 W14X82 for the secondary east addition which create 41'0" by 22'8" typical bays. Optional column splices have been located above the third floor for value engineering options.

Floor Systems

There are several different types of floor systems used throughout the Law School Building. Each system incorporates a composite floor slab (3/4" X 5" shear studs) with typical A992 Grade 50 steel framing systems.

The floor system used in the primary east addition consist of W21X68 wide flange beams spanning 46'-8", with intermediate bracing of W8X18 members spanning the 10'-0" spacing between the beams, which frame into W24X55 girders spanning 20'-0". The typical floor slab consists of 4-1/2" normal weight concrete (f^1_c = 4000 psi), reinforced with 6X6 W2.9 X W2.9 WWF, on 3"-16ga metal floor decking which spans 10'-0". This floor system is used, with slight variations of beam sizes for all levels of the primary east addition, as well as for the secondary east addition.

In the bridge section of the building, rolled wide flange beams, W21X62, span 43'-0" to W40X235 girders spanning the 67'4" across Fifth Street. The floor slab consists of 4-1/2" normal weight concrete (f^1_c = 5000 psi) reinforced with 6X6 W2.9 X W2.9 WWF on 3"-16ga metal floor decking spanning 11'-2" to the W21X62 beams.

Lateral Force Resisting System

The lateral support for the entire east building addition is developed through the use of moment-resisting frames, as an open plan was key in the architectural design of the building. There are (6) frames spaced at 20'-0" on center for the primary east addition, and (4) frames spaced at 11'-4" on center for the secondary east addition. For the bridge addition, (2) lateral wind resisting frames are required to withstand the load, these frames are spaced at 67'-4" on center. Each of the lateral support frames are created through beam-column moment connections.

Roof Framing System

The roof framing system designed for the entire east building addition and bridge section of the Rutgers University Law School consists of W18 beams spaced at 10'-0" or less on center framing into W18 girders with 3"-18ga galvanized roof decking.

Building Codes:

The following codes were used in the design of Rutgers University Law School:

Primary Building Code:

New Jersey International Building Code (IBC) 2000

Referenced Building Codes:

ACI 318-99: Building Code Requirements for Structural Concrete
ACI 530.1-99: Building Code Requirements for Masonry Structures
AISC Manual for Steel Construction 9th ed. (ASD)
ASCE 7-98: Minimum Design Loads for Buildings and Other Structures

The following codes will be used in the analysis of the building, possibly creating errors from new code additions or changes; however, it has been determined to be more beneficial to the student to apply the current applicable codes.

Primary Building Code:

International Building Code (IBC) 2006

Referenced Building Codes:

ACI 318-05: Building Code Requirements for Structural Concrete
ACI 530.1-05: Building Code Requirements for Masonry Structures
AISC Manual for Steel Construction 13th ed. (ASD/LRFD)
ASCE 7-05: Minimum Design Loads for Buildings and Other Structures

Design Theory:

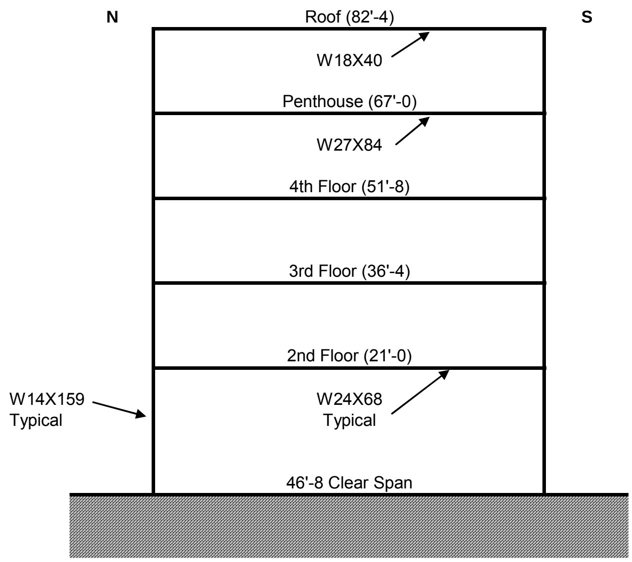
The primary design concept used in the design of the Rutgers University Law School was steel framing. The choice for steel framing came as a result of the need for large clear spans, 46’-8”, in the first floor plan, and the goal of providing the overall appearance of a law office. This required the use of intricate finishes on the interior surfaces of the building rather than exposed concrete or typical finishes associated with concrete construction.

As clear spans have created a clear need for steel framing, I will try to investigate several different floor systems which may have made this possible, and, I will try to push the limits of concrete design to examine feasibility of generating an equally appealing system. To continue with the free plan required as part of the program, no shear walls or braced frames have been implemented in the design of this structure.

Typical Framing Plans:

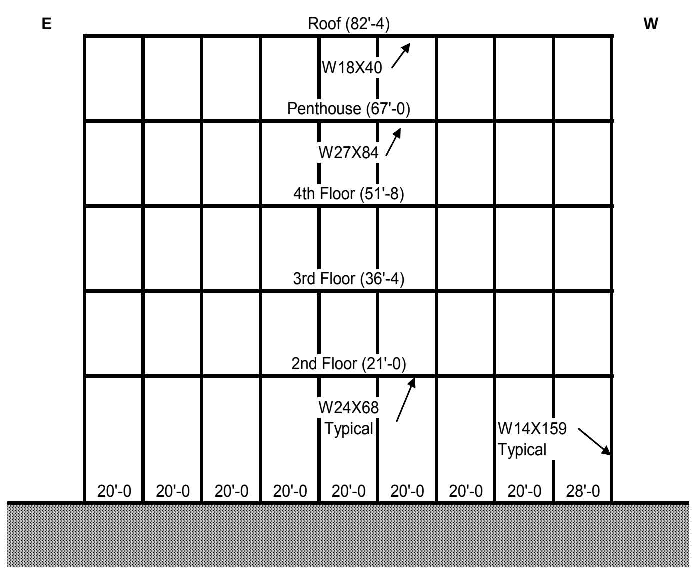
The framing plan for the primary east addition of the Rutgers University Law School is typical for floors 2 through the penthouse, with minor modifications for roof framing. Below are several diagrams illustrating the framing system designed for the building.

Typical North-South Frame



*All beam-column moment connections for wind resistance

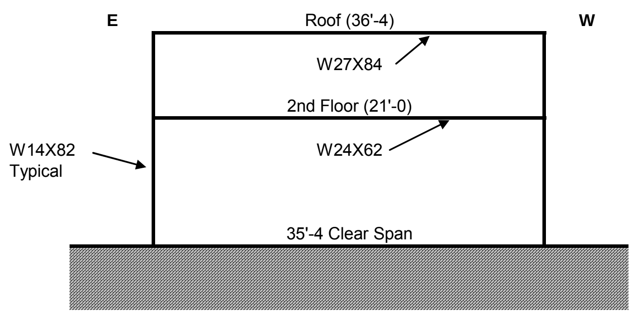
Typical East-West Frame



*All beam-column moment connections for wind resistance

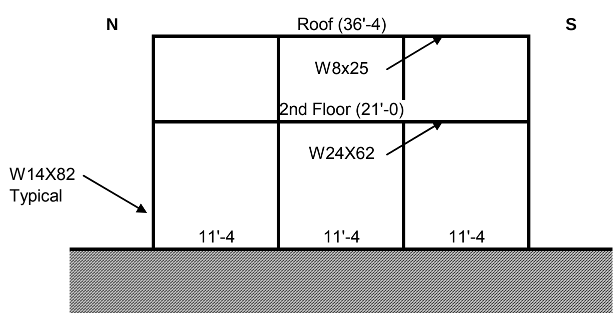
The framing plan for the secondary east addition is designed very similarly to that of the primary east addition. Below are the framing plans and member sizes as were designed for this section of the building.

Typical East-West Frame



*All beam-column moment connections for wind resistance

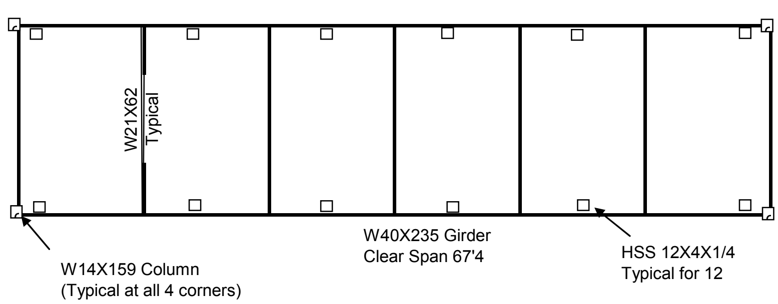
Typical North-South Frame



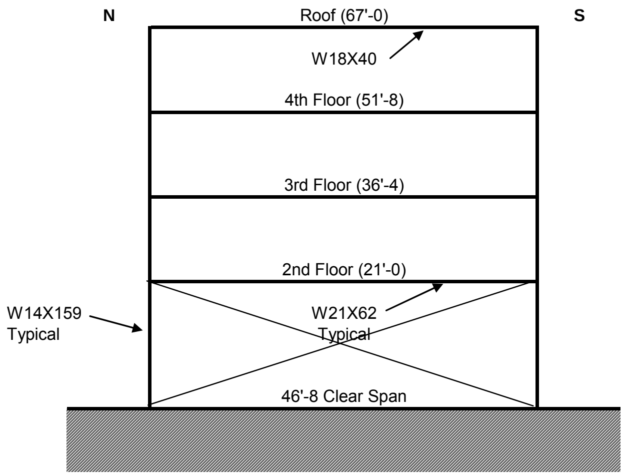
*All beam-column moment connections for wind resistance

The framing plan for the bridge is shown below for future reference. The bridge has not been considered in depth within this report.

Bridge Framing Plan



Typical North-South Frame



*All beam-column moment connections for wind resistance

The framing system associated with the bridge crossing Fifth Street includes many complex connection systems, some of which are still being manipulated to suit existing conditions; however, the main bridge structure is illustrated through these simplified plans. No East-West frame was shown as it is more clearly labeled using the plan view. Wind in the East-West direction need not be considered, as the bridge will not exist without both parts of the building supporting it.

Building Loads:

The following building loads have been calculated following the procedures listed in ASCE 7-05 as referenced by the IBC 2006.

Dead Load

Building Material Dead Loads:

Typical Floor System

	Unit Weight (psf/in)	Total Weight (psf)
16 Ga. Metal Floor Decking	N/A	3.50
4-1/2" Concrete	12.50	56.25
Finish Material Surcharge	5.00	5.00
		64.75

Roofing System

	Unit Weight (psf/in)	Total Weight (psf)
18 Ga. Roof Decking	N/A	3.00
5/8" Gypsum Board	4.40	2.75
2" Thick Isocyanurate	1.50	3.00
1/2" Gypsum Cover Board	4.40	2.20
0.060 Reinforced FR EPDM	N/A	1.00
		11.95

Wall Systems
(Assume 30% of wall weight from window)

	Unit Weight (psf/in)	Total Weight (psf)
8" CMU Wall	N/A	47.00
4" Brick Veneer	N/A	32.00
Glass and Window Openings	N/A	10.00
		55.60

Miscellaneous Loads

	Unit Weight (psf/in)	Total Weight (psf)
M/E/P Surcharge	N/A	10.00
		10.00

Live Load

Roof Live Load:	Design	IBC 2006
Flat roof:	30 psf	20 psf

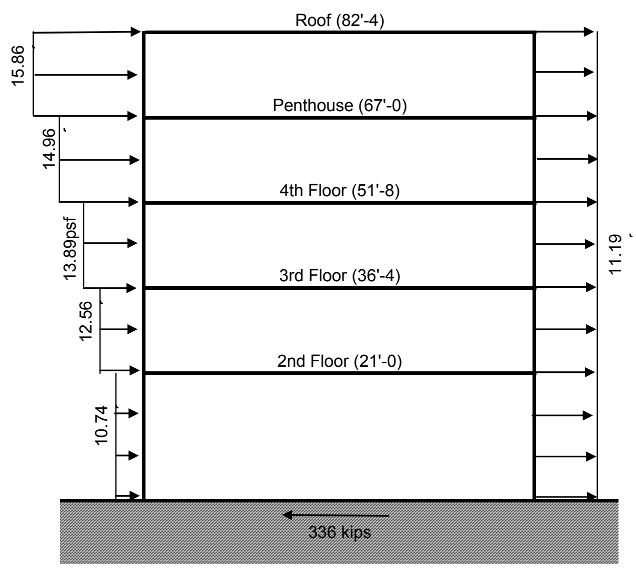
Floor Live Load:	Design	IBC 2006
Typical Room/Office:	60 psf	50 psf
Corridors:	100 psf	100 psf
Corridors above first floor:	100 psf	80 psf
Lobbies:	100 psf	100 psf
Stairwells and exit ways:	100 psf	100 psf
Mechanical Penthouse	150 psf	150 psf

Wind Load

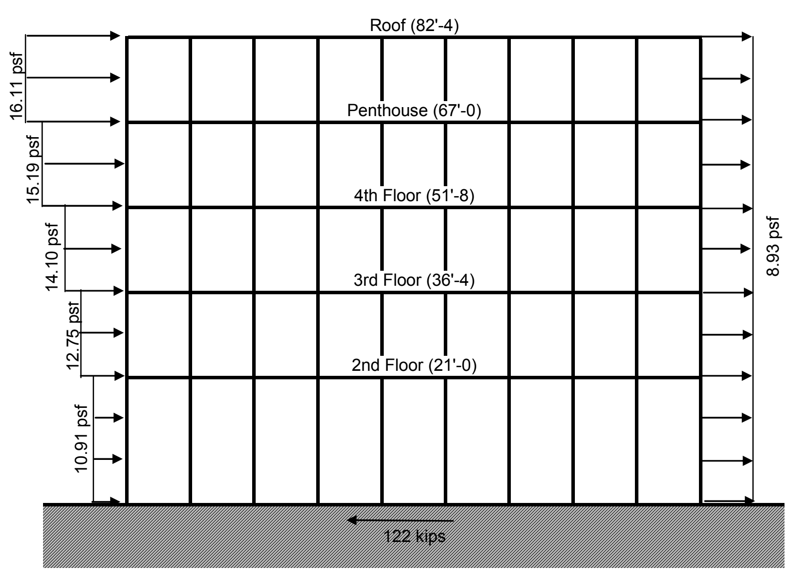
North-South Wind Pressures						
Floor	h (ft)	Floor Height	k_z	q_z	p Windward	p Leeward
1	21.0	21	0.633	12.82	10.74	-11.19
2	36.3	15.3	0.740	15.00	12.56	-11.19
3	51.6	15.3	0.818	16.58	13.89	-11.19
4	66.9	15.3	0.881	17.86	14.96	-11.19
Penthouse	82.2	15.3	0.934	18.94	15.86	-11.19

East-West Wind Pressures						
Floor	h above grade(ft)	Floor Height (ft)	k_z	q_z	p (psf) Windward	p (psf) Leeward
1	21.0	21	0.633	12.82	10.91	-8.93
2	36.3	15.3	0.740	15.00	12.75	-8.93
3	51.6	15.3	0.818	16.58	14.10	-8.93
4	66.9	15.3	0.881	17.86	15.19	-8.93
Penthouse	82.2	15.3	0.934	18.94	16.11	-8.93

Typical North-South Frame Wind Loading



Typical East-West Frame Wind Loading



Snow Load

Snow Load:
(Values Calculated from ASCE 7-05)

Ground Snow Load, p_g	30	psf	Fig. 7-1
Flat Roof Snow Load, p_f	**23.1**	psf	Eq. 7-1
Minimum p_f per ASCE 7-05	22.0	psf	
Exposure Factor, C_e	1.0		Table 7-2
Thermal Factor, C_t	1.0		Table 7-3
Importance Factor, I	1.1		Table 7-4

Note: Value in bold represents controlling snow load

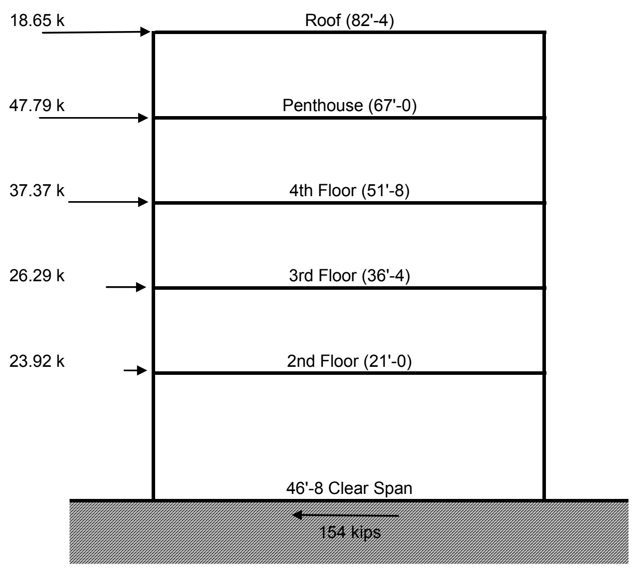
Seismic Load

Seismic Load:
(Values Calculated from ASCE 7-05)

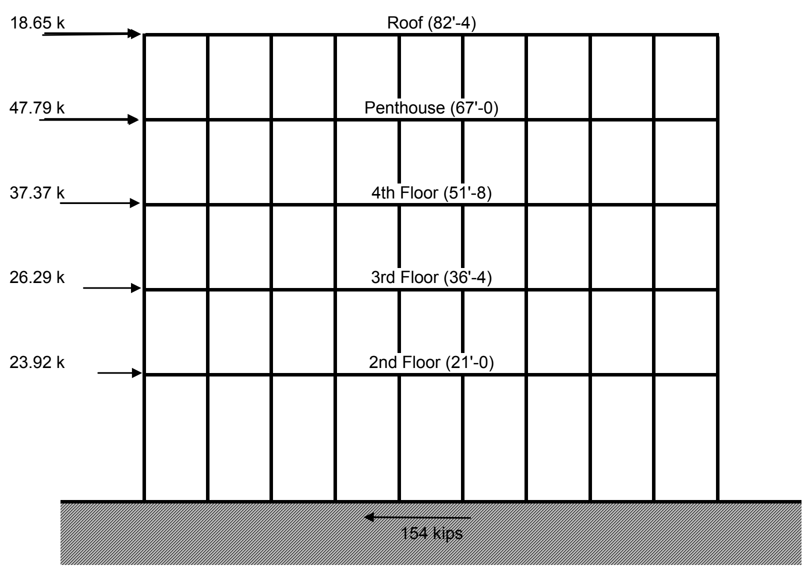
Equivalent Lateral Force Procedure
(As permitted by Table 12.6-1)

V	**154**	**k**	Equation 12.8-1
C_s	0.023		Equation 12.8-2
W	6738	k	
R	3.5		Table 12.2-1 (4.0 used by engineer in original design)
I	1.25		Table 11.5-1
T	1.51		Section 12.8.2
T_a	0.89		Equation 12.8-7
C_u	1.7		Table 12.8-1
C_t	0.028		Table 12.8-2
x	0.8		Table 12.8-2
h_n	75	ft	

Typical North-South Frame Wind Loading



Typical East-West Frame Wind Loading



Structural Spot Checks:

Column

In the gravity load analysis for column sizes used for primary framing members of the Rutgers University Law School building East Addition, I generated much smaller members than those which were used. This is most likely because I applied gravity loads only and this is a moment resisting frame; I will perform another calculation in the lateral element analysis.

Beam

In my analysis of a typical composite beam acting as the second floor framing of the Rutgers University Law School building East Addition, I selected the a smaller beam than was chosen by the designer. In my analysis, I first assumed the Plastic Neutral Axis to be located in Position 1, at T = C, giving me a W24X55. I then used the equivalent force supplied by the shear studs used by the designer for which I generated a W24X62 beam when the beam chosen was a W24X68. This may have been a result of more stringent deflection criteria than I used in my design, or a slightly higher dead load from miscellaneous materials. Overall, the beam design which I was able to generate was only one size different from that chosen by the design professional.

Lateral Force Resisting System

The lateral resisting system for the primary East Addition was checked using the portal frame method to determine approximate moments and forces in the typical members. I chose to consider all frames as equal stiffness and distribute the lateral forces respectively. As a result, when the beam was analyzed, I came up with a W24X62 rather than the prescribed W24X68, only one size different than the designed beam. Also, when I used an approximate method to compare the column size chosen, I generated a W14X120, three sizes below the designed W14X159. There are several possibilities for which these results differ, one of which is that the approximate method of finding force from wind load moments may have undersized my column. Another reason for the discrepancy could be in the dead loads used to calculate the force or possibly from the live load reductions taken in the calculation, as it appears many reductions were not taken in the original design.

Appendix:

General Material Properties

General Material Properties							
Concrete		Structural Steel					
$f^1_{c,footings}$	4000 psi	A992	F_y	50	ksi	Wide Flange Beams	
$f^1_{c,piers}$	4000 psi	A-36	F_y	36	ksi	Channels, Angles, and Plates	
$f^1_{c,walls}$	4000 psi		f_y	60	ksi	Reinforcing Steel	
$f^1_{c,typ. slab}$	4000 psi						
$f^1_{c,bridge slab}$	5000 psi						
Masonry		Foundation System					
f^1_m	1500 psi		q_a	5000	psi	Minimum Bearing Capacity	
				60	tons	Minimum Pile Capacity	

Figure 2: Material Properties Summary

Detailed Wind Load Calculations

Wind Load:
(Values Calculated from ASCE 7-05)

V	90 mph	Figure 6-1
Exposure Category	B	
k_d	0.85	Table 6-4
I	1.15	Table 6-1
k_{zt}	1.00	Section 6.5.7
z_g	1200	Table 6-2
α	7.0	Table 6-2

North-South Gust Factor

G_f	0.822	
I_z	0.281	
Q	0.818	
g_r	5.682	
g_q, g_v	3.4	
R	0.031	
z bar	49.32	ft
c	0.3	
B	166.0	ft
L	94.2	ft
h	82.2	ft
L_z	365.9	
ℓ	320	
ε	0.333	
n_1	0.664	
β	1.00	
N1	3.70	
Vz	65.68	
b bar	0.45	
α bar	0.25	
E	1.00	
R_n	0.061	
R_h	0.227	
R_B	0.121	
R_L	0.066	
η_{Rh}	3.824	
η_{Rb}	7.723	
η_{RL}	14.67	

East-West Gust Factor

G_f	0.838	
I_z	0.281	
Q	0.846	
g_r	5.682	
g_q, g_v	3.4	
R	0.039	
z bar	49.32	ft
c	0.3	
B	94.2	ft
L	166.0	ft
h	82.2	ft
L_z	365.9	
ℓ	320	
ε	0.333	
n_1	0.664	
β	1.00	
N1	3.70	
Vz	65.68	
b bar	0.45	
α bar	0.25	
E	1.00	
R_n	0.061	
R_h	0.227	
R_B	0.202	
R_L	0.038	
η_{Rh}	3.824	
η_{Rb}	4.383	
η_{RL}	25.86	

North-South Direction

L	94.2	ft
B	166.0	ft
h	82.2	ft
L/B	0.567	

Wall Pressures

	C_p
Windward	0.8
Leeward	-0.5
Side	-0.7

East-West Direction

L	166	ft
B	94.2	ft
h	82.2	ft
L/B	1.762	

Wall Pressures

	C_p
Windward	0.8
Leeward	-0.348
Side	-0.7

North-South Wind Pressures						
Floor	h (ft)	Floor Height	k_z	q_z	p Windward	p Leeward
1	21.0	21	0.633	12.82	10.74	-11.19
2	36.3	15.3	0.740	15.00	12.56	-11.19
3	51.6	15.3	0.818	16.58	13.89	-11.19
4	66.9	15.3	0.881	17.86	14.96	-11.19
Penthouse	82.2	15.3	0.934	18.94	15.86	-11.19

East-West Wind Pressures						
Floor	h above grade(ft)	Floor Height (ft)	k_z	q_z	p (psf) Windward	p (psf) Leeward
1	21.0	21	0.633	12.82	10.91	-8.93
2	36.3	15.3	0.740	15.00	12.75	-8.93
3	51.6	15.3	0.818	16.58	14.10	-8.93
4	66.9	15.3	0.881	17.86	15.19	-8.93
Penthouse	82.2	15.3	0.934	18.94	16.11	-8.93

Overturning Moment:

Level	Height (ft)	h_{total}	North-South Direction Width (ft)	North-South Direction Area (sf)	North-South Direction M_o (ft*k)	East-West Direction Width (ft)	East-West Direction Area (sf)	East-West Direction M_o (ft*k)
Roof	7.6	82.2	166	1261.6	2274.7	46.7	354.9	578.7
Penthouse	15.3	67.0	166	2539.8	4041.9	46.7	714.5	1038.0
4th Floor	15.3	51.6	166	2539.8	3286.9	46.7	714.5	849.1
3rd Floor	15.3	36.3	166	2539.8	2410.9	46.7	714.5	625.5
2nd Floor	18.2	21.0	166	3021.2	1716.6	46.7	849.9	446.9
1st Floor	10.5	0.0	166	1743.0	0.0	46.7	490.4	0.0
					13731.1			**3538.2**

Detailed Seismic Load Calculations

Seismic Load:
(Values Calculated from ASCE 7-05)

S_s	0.30	Figure 22-1	S_{MS}	0.480	Equation 11.4-1
S_1	0.04	Figure 22-2	S_{M1}	0.096	Equation 11.4-2
F_a	1.6	Table 11.4-1	S_{ds}	0.320	Equation 11.4-3
F_v	2.4	Table 11.4-2	S_{d1}	0.064	Equation 11.4-4

Site Class: D
Seismic Design Category: B Table 11.6-1

Seismic Load:
(Values Calculated from ASCE 7-05)

Equivalent Lateral Force Procedure
(As permitted by Table 12.6-1)

V	**154 k**	Equation 12.8-1
C_s	0.023	Equation 12.8-2
W	6738 k	
R	3.5	Table 12.2-1 (4.0 used by engineer in original design)
I	1.25	Table 11.5-1
T	1.51	Section 12.8.2
T_a	0.89	Equation 12.8-7
C_u	1.7	Table 12.8-1
C_t	0.028	Table 12.8-2
x	0.8	Table 12.8-2
h_n	75 ft	

Building Weight:

(As prescribed by ASCE 7-05 Section 12.7.2)

Level	Height (ft)	h_{total}	Wall Weight Perimeter (ft)	Area (sf)	Weight (k)	Floor Weight Area (sf)	Weight (k)	Total Weight (k)
Roof	7.6	82.2	590	4484	249.31	7580	90.58	339.89
Penthouse	15.3	67.0	590	9027	501.90	7580	566.61	1068.51
4th Floor	15.3	51.6	590	9027	501.90	7800	583.05	1084.95
3rd Floor	15.3	36.3	590	9027	501.90	7800	583.05	1084.95
2nd Floor	18.2	21.0	590	10738	597.03	14840	1109.29	1706.32
1st Floor	10.5	0.0	590	6195	344.44	14840	1109.29	1453.73
								6738.35

Seismic Force Distribution:

(As prescribed by ASCE 7-05 Section 12.8.3)

Level	C_{vx}	F_x (k)	Mo (ft*k)
Roof	0.1211	18.65	1533.05
Penthouse	0.3103	47.79	3201.85
4th Floor	0.2426	37.37	1928.34
3rd Floor	0.1707	26.29	954.327
2nd Floor	0.1553	23.92	502
1st Floor	0.0000	0.00	0
	1.00	154.02	8119.88

Column Spot Check Calculations

TECHNICAL ASSIGNMENT #1 | GRAVITY LOAD ANALYSIS | NATE REYNOLDS

COLUMN LOAD (FIRST FLOOR COLUMN, TYP. BAY)

$A_T = 470$ SF
$A_I = 1880$ SF

DEAD LOAD TO COLUMN

$D = D_{ROOF} + 4\,D_{FLOOR} + D_{WALL}$

$D_{ROOF} = 12\text{ PSF}\,(470\text{ SF}) = 5.64^{K}$

$D_{FLOOR} = 75\text{ PSF}\,(470\text{ SF}) = 35.25^{K}$

$D_{WALL} = 56\text{ PLF}\,(20') = 1.12^{K}$

$D = 147.76^{k}$

LIVE LOAD TO COLUMN

ROOF LIVE LOAD REDUCTION
(NOT TAKEN IN DESIGN)

$L_r = L_0 R_1 R_2 = 20\text{ PSF}\,(1.2 - 0.001(470\text{ SF})) = 14.6\text{ PSF}$

PENTHOUSE LIVE LOAD CANNOT BE REDUCED

$L > 100\text{ PSF}$

TYPICAL FLOOR

$A_I = 4(3 \cdot 470\text{ SF}) = 5640\text{ SF}$

$L = 100\text{ PSF}\left(0.25 + \frac{15}{\sqrt{5640}}\right) = 0.19\,L_0$, USE $0.4L_0$

$L = 0.4(100\text{ PSF}) = 40\text{ PSF}$

$L_R = 14.6\text{ PSF}\,(470\text{ SF}) = 6.86^{K}$

$L = 150\text{ PSF}\,(470\text{ SF}) + 40\text{ PSF}\,(3 \cdot 470\text{ SF}) = 126.9^{K}$

GRAVITY CHECK: $1.2D + 1.6L + 0.5L_R$

$P = 1.2(147.76^{K}) + 1.6(126.9^{K}) + 0.5(6.86^{K}) = 383.8^{K}$

$M = 90.8'^{K}$

$P_{eq} = 383.8^{K} + \frac{24}{14}(90.8'^{K}) = 540^{K}$ @ 21'-0"

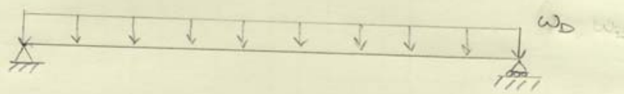
W14 x 82 FOR GRAVITY ONLY

Beam Spot Check Calculations

TECHNICAL ASSIGNMENT #1 | FLOOR SYSTEM SPOT CHECK | NATE REYNOLDS

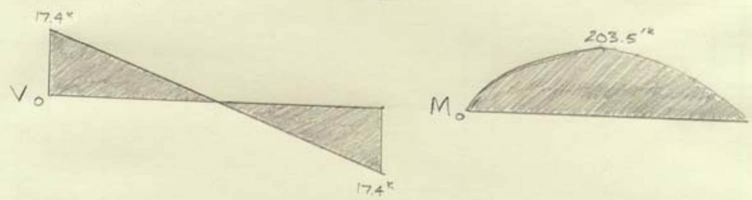
COMPOSITE BEAM DESIGN (SECOND FLOOR, SIMPLY SUPPORTED BEAM)

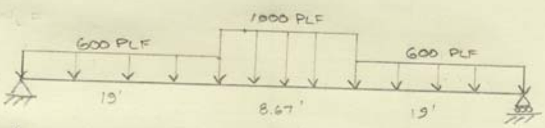
SPAN: 46'-8"
TRIB. WIDTH: 10'-0"
ω_D = 74.75 PSF · 10' = 747.5 PLF



$$M_{max,D} = \frac{\omega_D l^2}{8} = \frac{747.5\ PLF\ (46.67')^2}{8} = 203.5^{'k}$$

$$V_{max,D} = \frac{\omega_D l}{2} = \frac{747.5\ PLF \cdot (46.67')}{2} = 17.4^{k}$$





$M_{max,L} = 240^{'k}$

$V_{max,L} = 15.7^{k}$

LOAD COMBINATION

$1.2D + 1.6L = 1.2(203.5^{'k}) + 1.6(240^{'k}) = 628.2^{'k}$

CHECK LIVE LOAD DEFLECTION

ASSUMPTION: 1000 PLF ACROSS FULL BEAM, FOR EASE OF CALCULATION, CONSERVATIVE ANALYSIS

$$\frac{L}{360} = \frac{46.67' \cdot 12''/'}{360} = 1.54 \text{ IN}$$

$$\Delta_{LL} = \frac{5wl^4}{384EI} = \frac{5(1000 \text{ PLF})(46.67')^4(1728 \text{ IN}^3/\text{FT}^3)}{384(29000 \text{ KSI})(1000 \text{ LB}/\text{K})\, I}$$

$$I \geq 2360 \text{ IN}^4$$

CHECK TOTAL LOAD DEFLECTION

$$\frac{L}{240} = \frac{46.67' \cdot 12''/'}{240} = 2.33 \text{ IN}$$

$$\Delta_{TL} = \frac{5wl^4}{384EI} = \frac{5(1750 \text{ PLF})(46.67')^4(1728 \text{ IN}^3/\text{FT}^3)}{384(29000 \text{ KSI})(1000 \text{ LB}/\text{K})\, I}$$

$$I \geq 2765 \text{ IN}^4$$

MEMBER SELECTION

ASSUMPTION: $T = C$

$Y_2 = 4.0$

CHOOSE * W24X55 $\phi M_n = 959'^K$ $I = 3370 \text{ IN}^4$ $\Sigma Q_n = 810^K$

W21X68 $\phi M_n = 1090'^K$ $I = 3600 \text{ IN}^4$ $\Sigma Q_n = 1000^K$

* # OF SHEAR STUDS REQUIRED: $\frac{810^K}{21} = 39 = 40$ STUDS $= 80$ STUDS

SHEAR STUD CAPACITY SPECIFIED IN DRAWINGS: 20 STUDS $\cdot 21^K = 410^K$

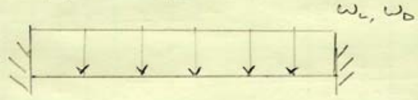
THIS WILL REQUIRE PNA TO BE POSITION 6 OR 7

CHOOSE W24X62 $\phi M_n = 891'^K$ $I = 2850 \text{ IN}^4$ $\Sigma Q_n = 362^K$

TECHNICAL ASSIGNMENT #1 | FLOOR SYSTEM SPOT CHECK | NATE REYNOLDS

COMPOSITE BEAM DESIGN (SECOND FLOOR, MOMENT FRAME BEAM)
[USED IN LATERAL FRAME ANALYSIS]

SPAN: 46'-8"
TRIB WIDTH: 10'-0"
ω_D = 747.5 PLF
ω_L = 1000 PLF



ASSUME LIVE LOAD IS UNIFORM

$$M_{MAX,D} = \frac{\omega l^2}{12} = \frac{0.75\ KLF\ (46.67')^2}{12} = 136.1'^{K} \text{ AT ENDS}$$

$$M_{MIDSPAN,D} = \frac{\omega l^2}{24} = 68.1'^{K}$$

$$M_{MAX,L} = \frac{1.0\ KLF\ (46.67')^2}{12} = 181'^{K}$$

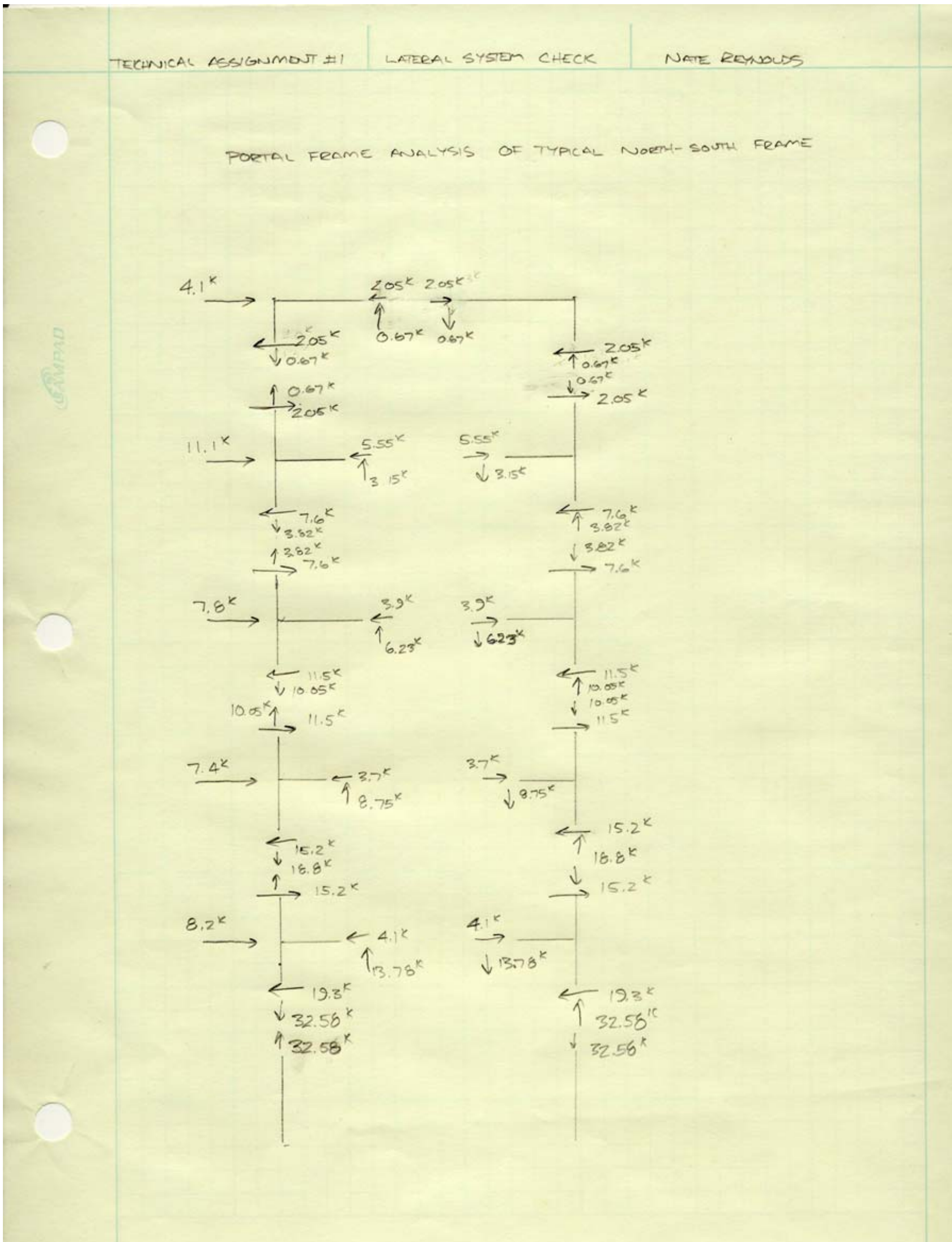
$$M_{MIDSPAN,L} = 90.8'^{K}$$

THESE MOMENTS WILL BE USED TO CALCULATE FORCES ON LATERAL RESISTING FRAME

ASSUME 1/2 MOMENT CARRIES INTO COLUMN

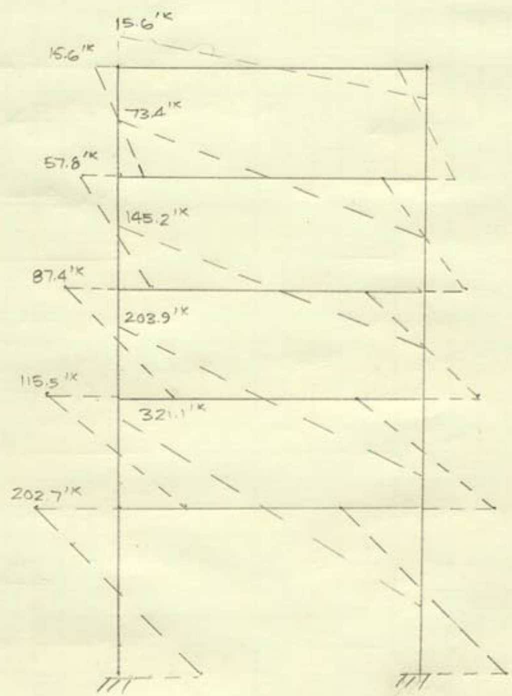
$$M_{COL} = 90.8'^{K}$$

Lateral-Resisting System Spot Check Calculations



TECHNICAL ASSIGNMENT #1 | LATERAL SYSTEM CHECK | NATE REYNOLDS

PORTAL FRAME MOMENTS OF TYPICAL NORTH-SOUTH FRAME



TECHNICAL ASSIGNMENT #1 | LATERAL SYSTEM CHECK | NATE REYNOLDS

COLUMN LOAD (FIRST FLOOR LATERAL LOAD)

$1.2D + 1.6W + L + 0.5S$

$D = 147.76^{k}$ FROM PREVIOUS CALCULATION

$L = 126.9^{k}$ FROM PREVIOUS CALCULATION

$S = 23.1\ PSF \cdot 470\ SF = 10.9^{k}$

$W = 32.6^{k}$ FROM PORTAL METHOD

$= 202.7^{'k}$ FROM PORTAL METHOD

$L_{mom} = 90.8^{'k}$ FROM BEAM CONNECTION

$P = 1.2(147.76^{k}) + 1.6(32.6^{k}) + 126.9^{k} + 0.5(10.9^{k})$

$P = 361.8^{k}$

$M = 90.8^{'k} + 1.6(202.7^{'k}) = 415.1^{'k}$

$P_{ecc} = 361.8^{k} + \frac{24}{14}(415.1^{'k}) = 1074^{k}$

CHOOSE W14×120 USING LIVE LOAD REDUCTION

BEAM MOMENT (SECOND FLOOR FRAMING)

$M = 1.2D + L + 1.6W$

$M = 1.2(136.1^{'k}) + 181^{'k} + 1.6 \cdot 321.1^{'k} = 858^{'k}$

REQUIRE W24×62 BEAM $\phi M_n = 891^{'k}$