Nicholas Reed
Structural Option

Seneca Allegany Casino Hotel Addition

AE Senior Thesis 2013

Courtesy of Jim Boje, PE

Building Introduction
Existing Structure
Thesis Goals
Structural Depth
Architectural Study
Conclusion
Q&A

Bing Maps

Casino
Event Center
Hotel
Parking Deck

Wikipedia

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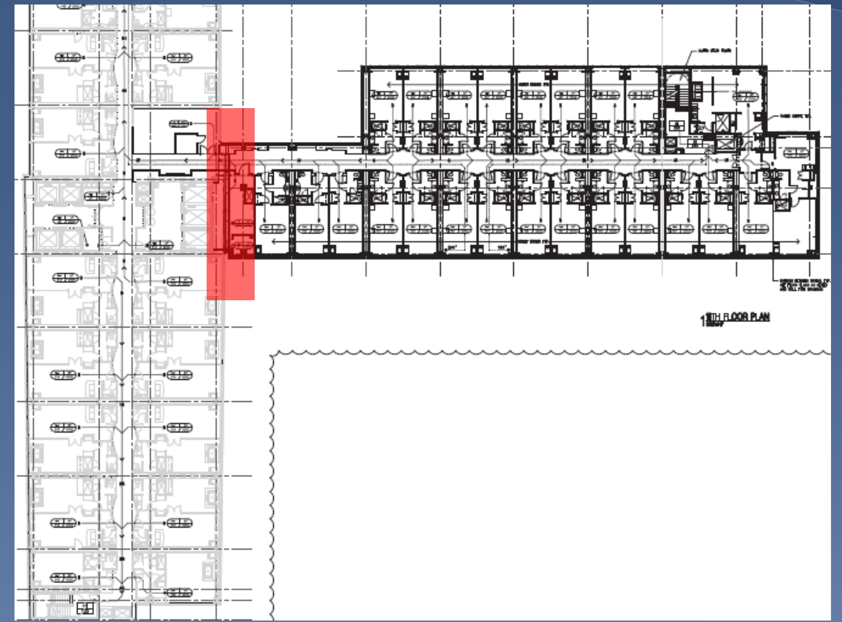
Building Statistics

11 stories
153 feet tall
165,000 sq. ft. (~15,000 per floor)
200 hotel rooms
Ties into existing hotel tower with expansion joint



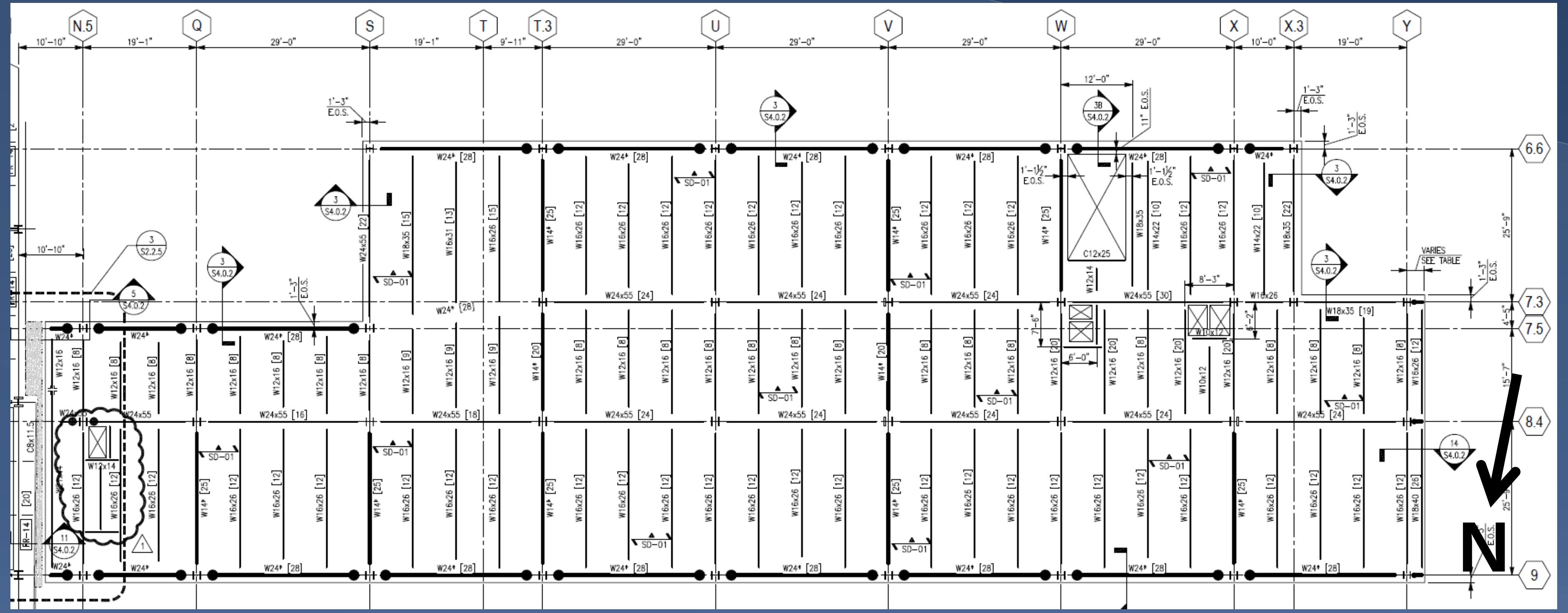
JCJ Architecture

Courtesy of Jim Boje, PE

Project Team

Owner: Seneca Gaming Corporation
Architect: JCJ Architecture
Structural & Civil Site: Wendel
MEP: M/E Engineering P.C.
CM: Seneca Construction Management Corporation

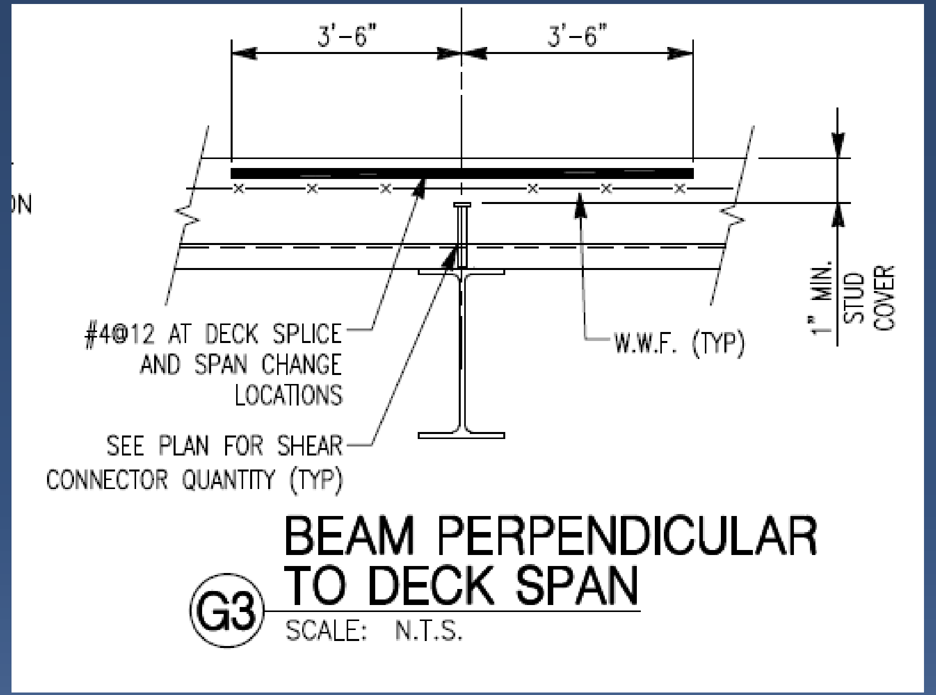
Existing Structure



JCJ Architecture

Typical Floor Plan (4^{th} floor to roof)

Composite metal deck
20 gauge
Normal weight concrete, f'c 3500 psi
6.5" total depth
6x6 welded wire reinforcement



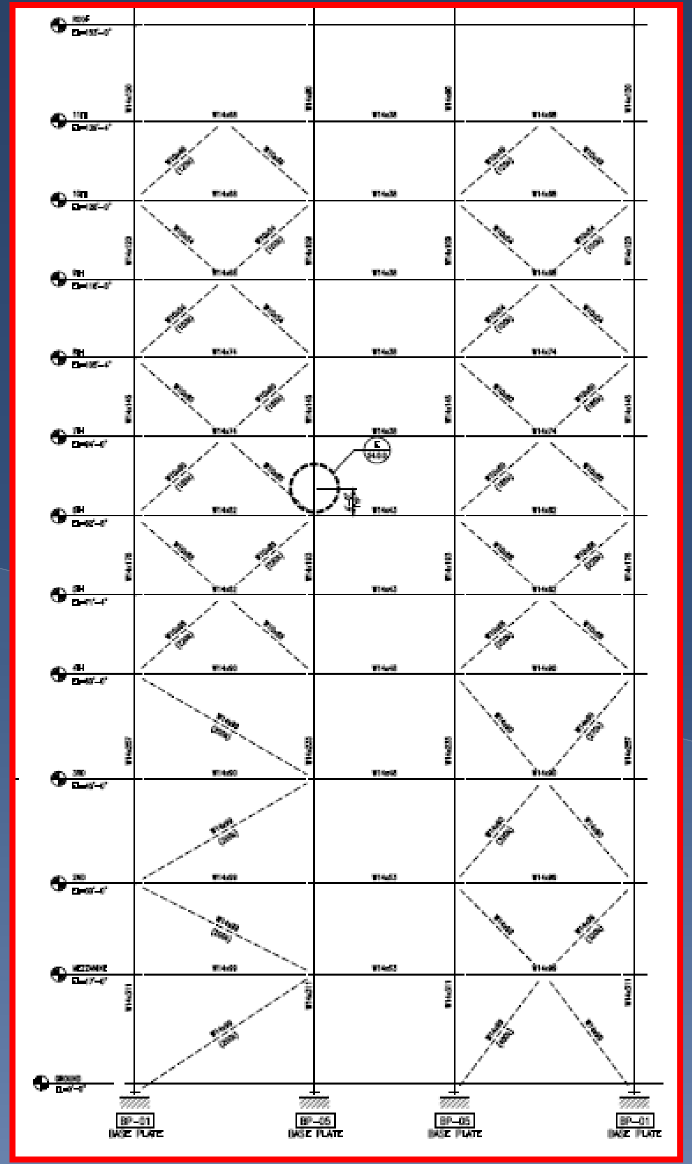
JCJ Architecture

Lateral

JCJ Architecture

Typical Floor Plan (4[th] floor to roof)

Braced frames N-S (red)
Perimeter moment connections E-W (green)



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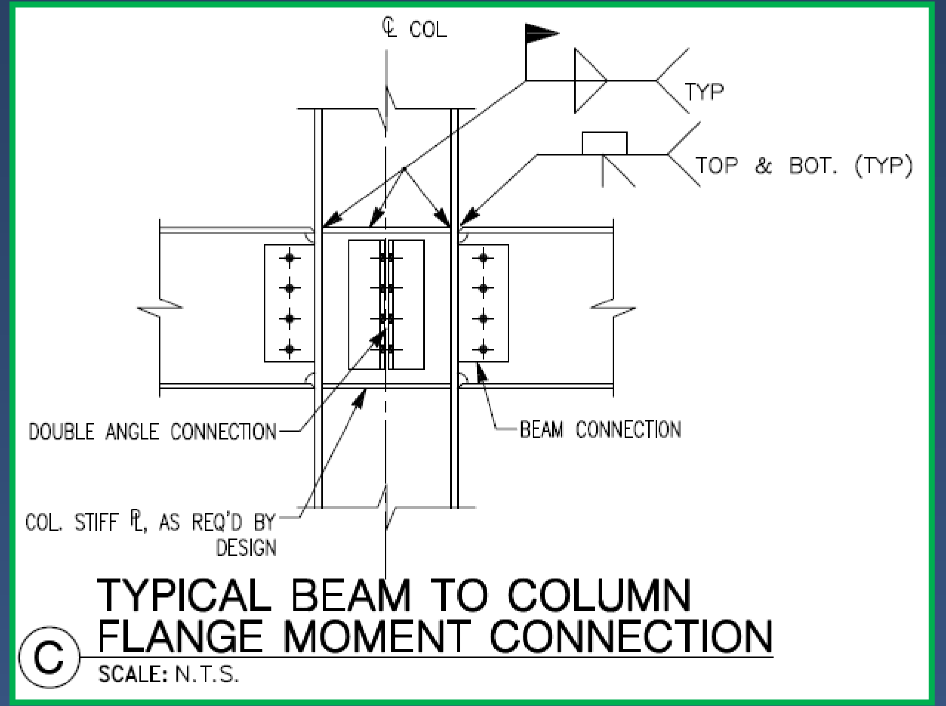

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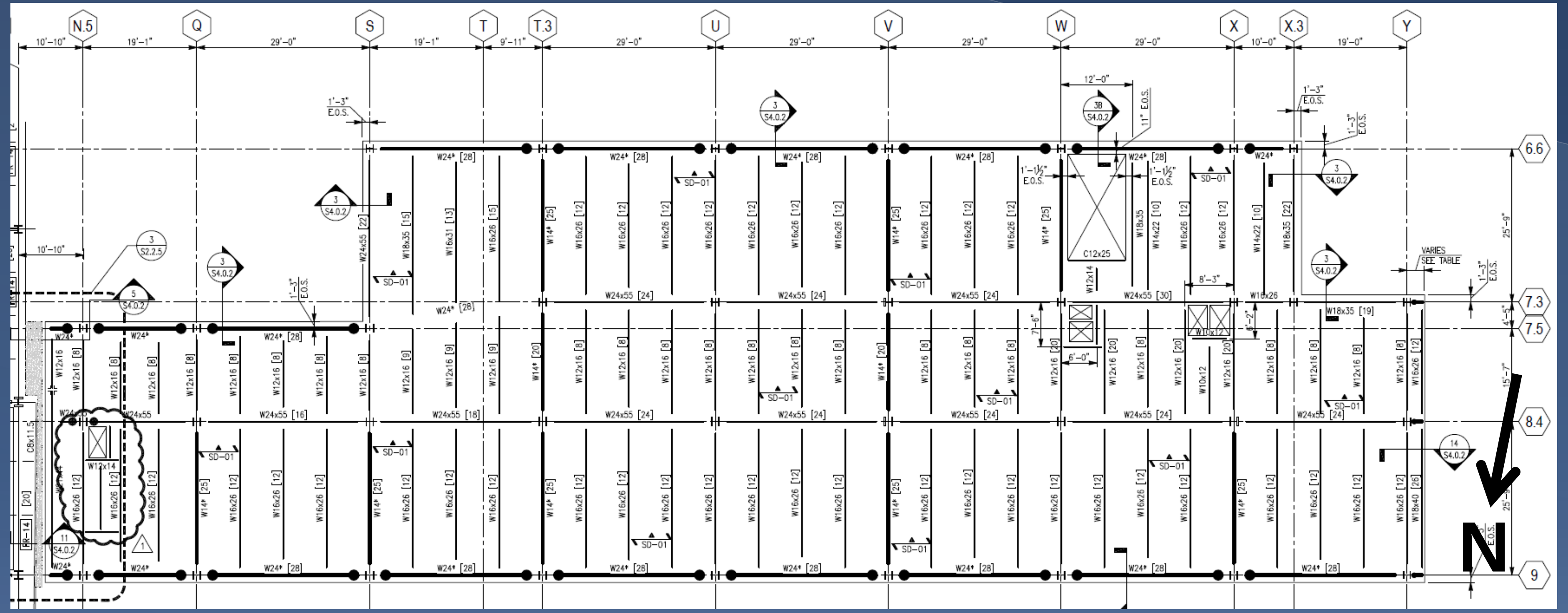
Courtesy of Jim Boje, PE

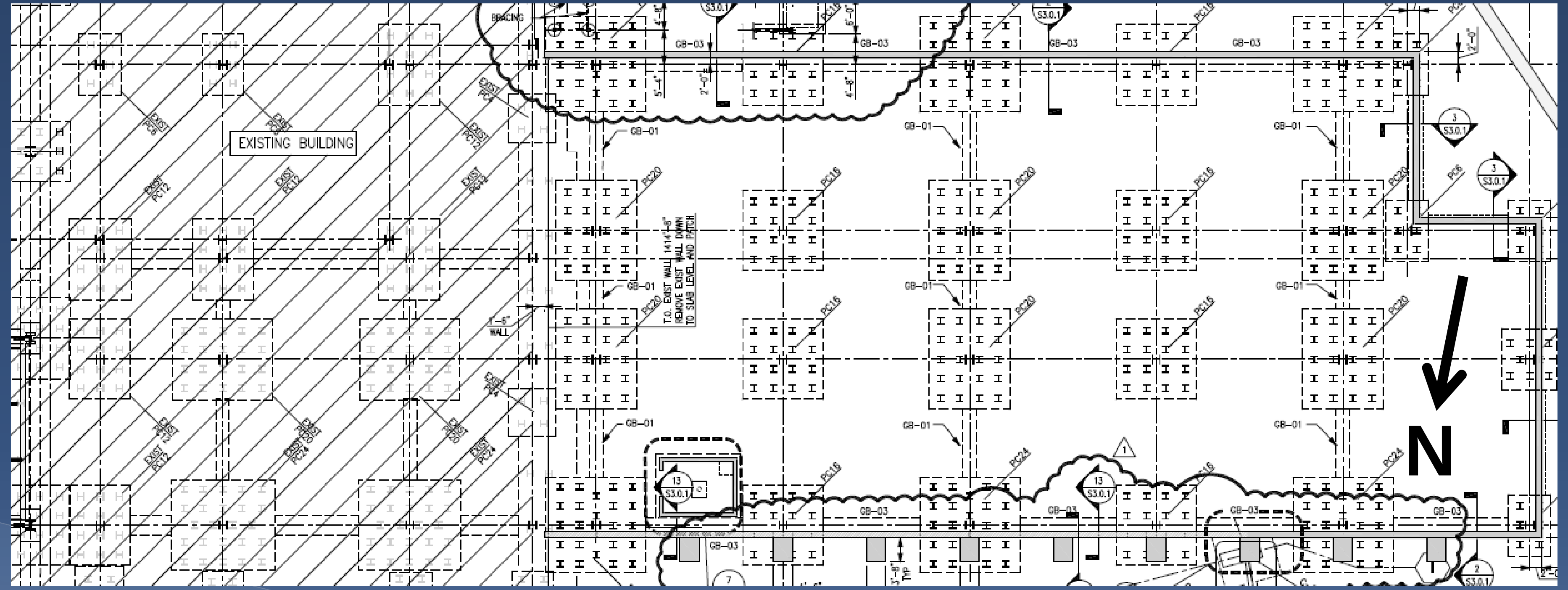
Foundation



JCJ Architecture

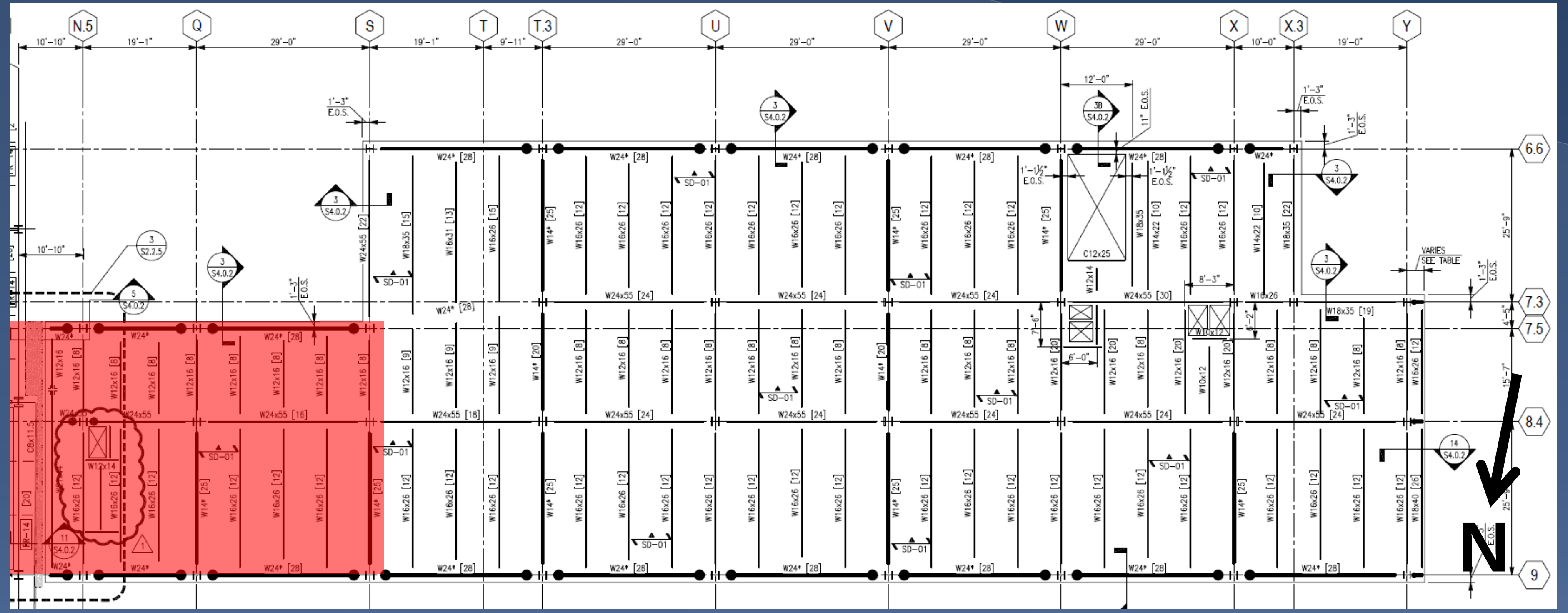
Steel piles driven to bedrock
HP 12x53's, 200 kip capacity
Varying pile cap sizes

- Largest: 72" thick, #11 bars, 24 piles
- Smallest: 50" thick, #9 bars, 6 piles



JCJ Architecture

Foundation



JCJ Architecture

Steel piles driven to bedrock
HP 12x53's, 200 kip capacity
Varying pile cap sizes

- Largest: 72" thick, #11 bars, 24 piles
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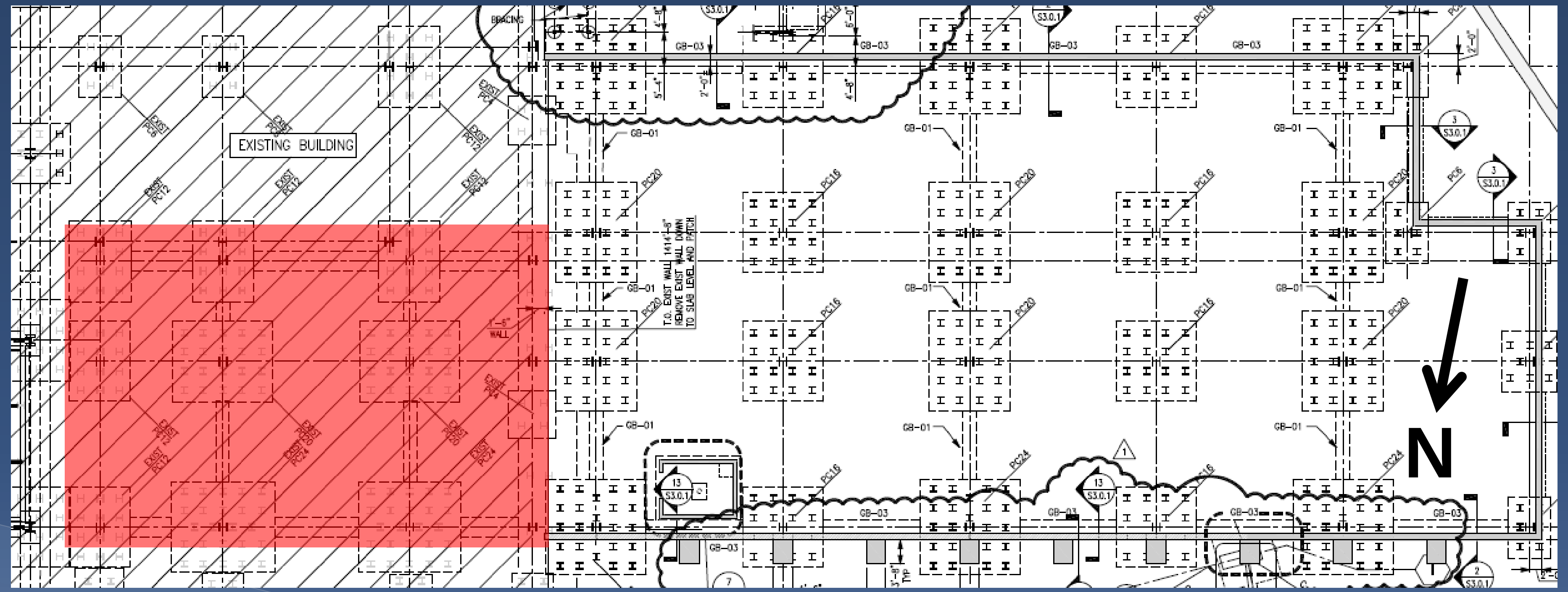
Outlined in red, 4th floor and above rest on existing structure
This area previously designed with new addition's load in mind



JCJ Architecture

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Structural

Design and implement a staggered truss system to act as the gravity and N-S lateral system

- Replace metal deck with hollow-core precast concrete planks
- Determine preliminary member sizes then check with computer model
- Adjust truss members

Advantages

- Remove interior columns
- Repetitive floor plan
- Faster construction

Potential Disadvantages

- Close coordination with other disciplines
- Fit with existing structure

Architectural Study

Trusses spanning entire width of hotel addition could impact interior spaces, requiring a look at possible redesigns of hotel rooms or overall building geometry

Construction Management Study

Converting to an almost completely prefabricated structural system would impact the construction process, requiring a study of the site logistics during the erection process.

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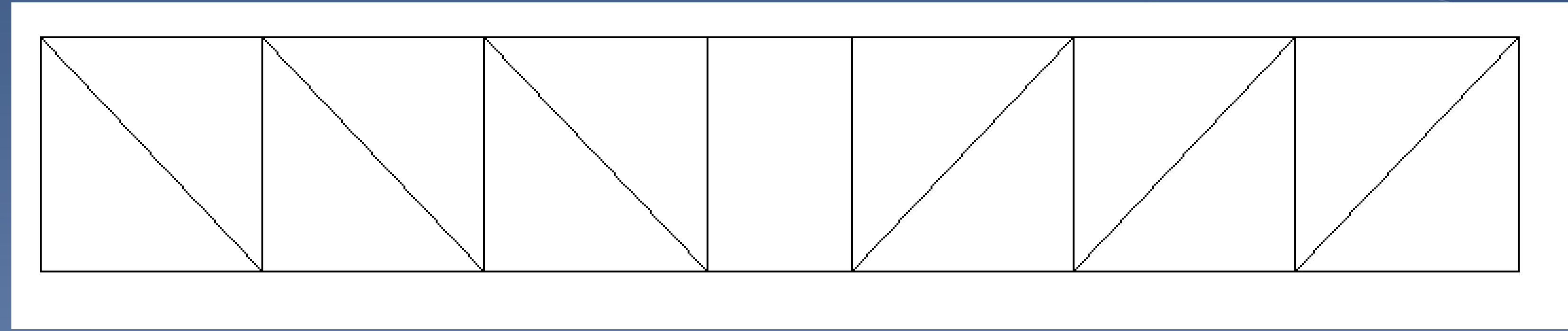
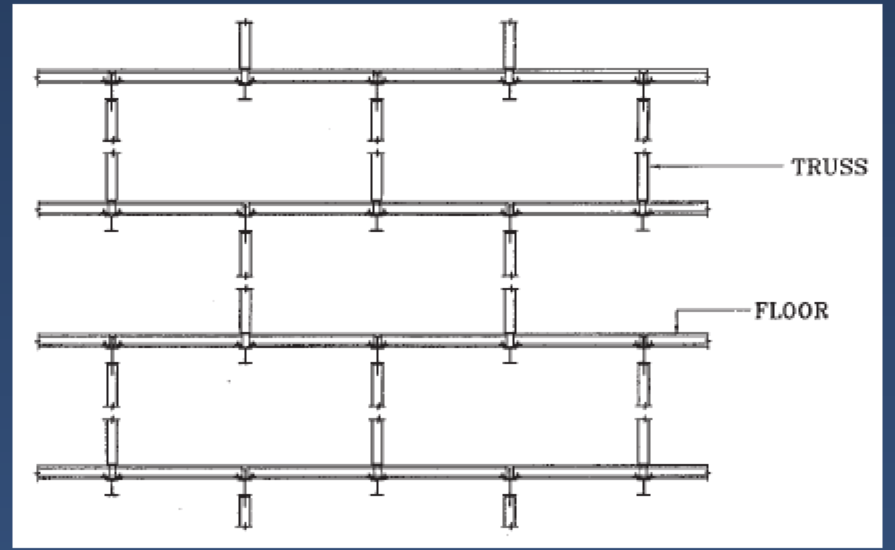
Staggered Truss

AISC Design Guide 14 – Staggered Truss Framing Systems provided procedure for hand calculations

Trusses encased within interior walls
Central Vierendeel panel for corridor
W-shape chords
HSS-shape verticals and diagonals



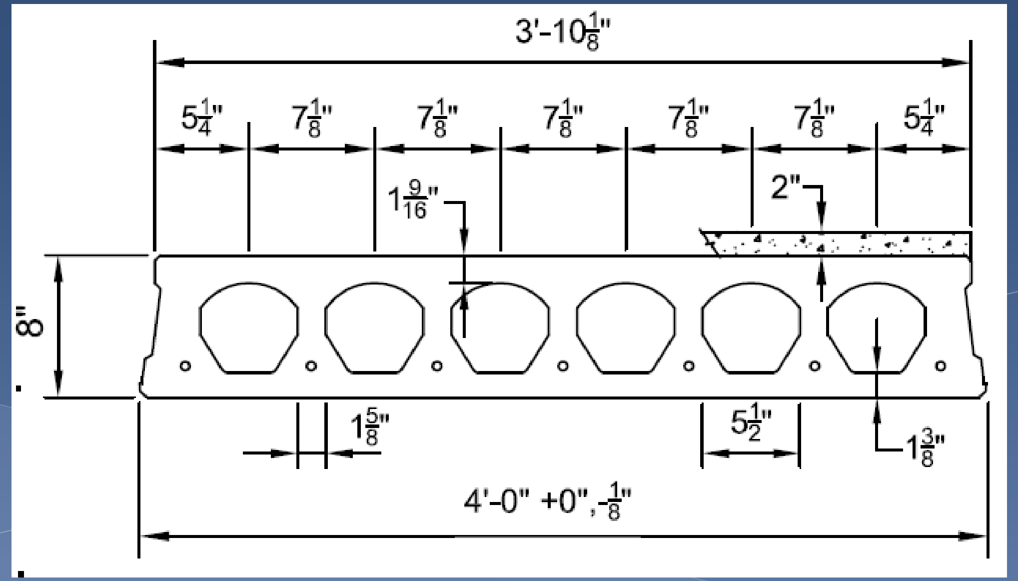
Typical truss, spanning 71.5’ addition width and 7’ central corridor



AISC Design Guide 14

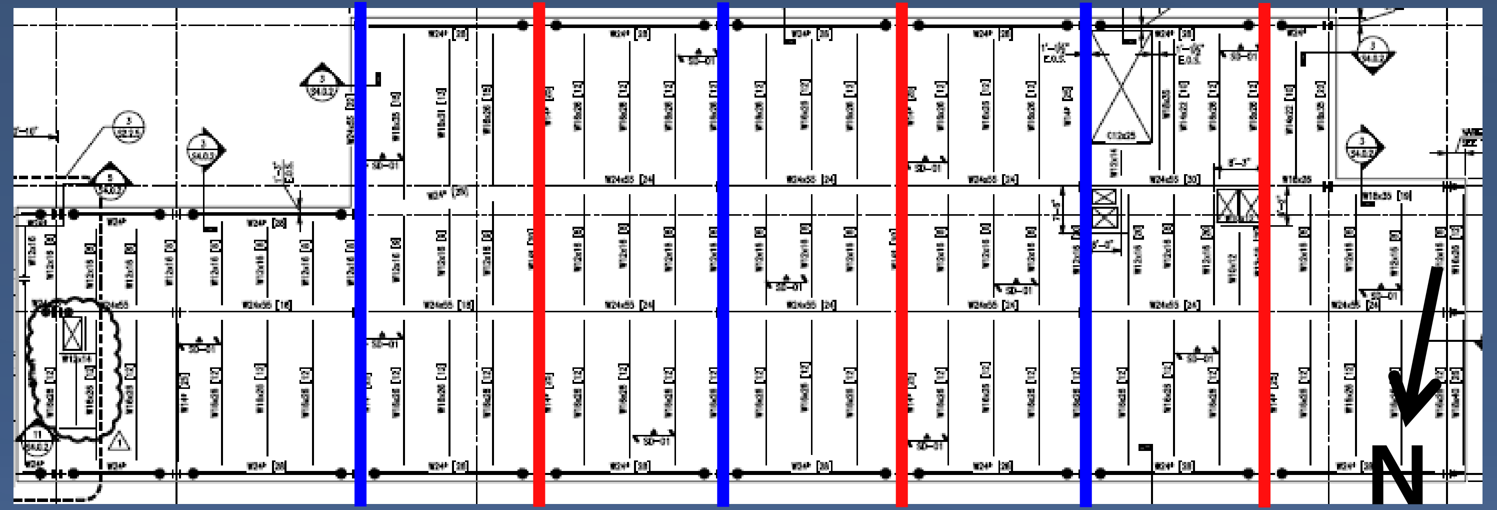
Staggering of truss locations per floor, eliminating need for interior columns

Section of Hollow-core planks used for floor system



Nitterhouse Concrete Products

Member Design



JCJ Architecture

Truss locations

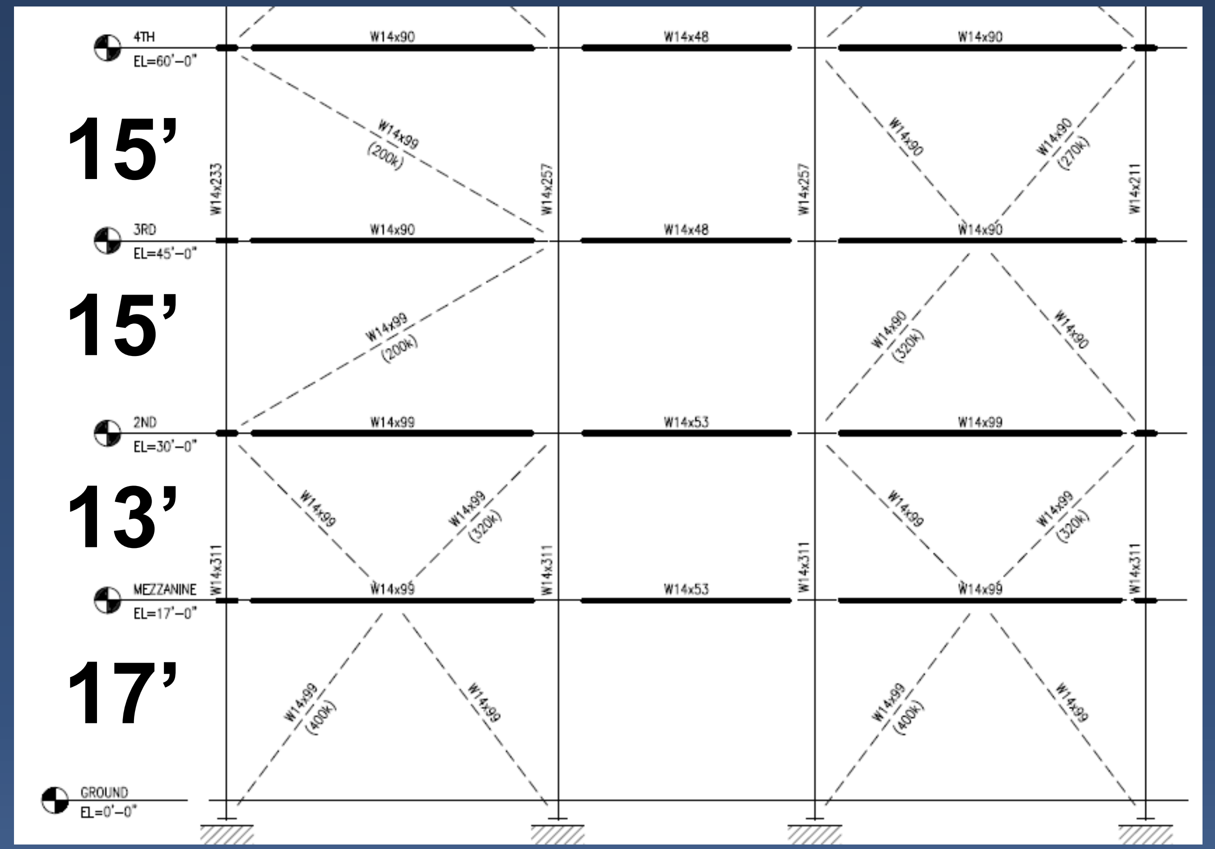
Dead Loads		
Superimposed	15 psf	Partitions/Façade Estimate
MEP	10 psf	Specs
Ceiling	5 psf	Specs
8" Plank, 2" topping	86.25 psf	Nitterhouse
10" Plank, 2" topping	93 psf	Nitterhouse

Live Loads		
	Design Loads	*ASCE 7-05*
Ground Floor	250 psf	
Typical Hotel Rooms	80 psf	40 psf
Hotel 2nd Floor	125 psf	
11th Floor Suites	125 psf	40 psf
Roof and Mezzanine	200 psf	20 psf
Corridors, Stairs, Lobbies	100 psf	100 psf
Mechanical Rooms	200 psf	

All design loads were used in calculations

Large live loads on certain floors required two sizes of hollow-core planks

- 8”, (6) ½” Ø strands, 2” topping
- 10”, (7) ½” Ø strands, 2” topping

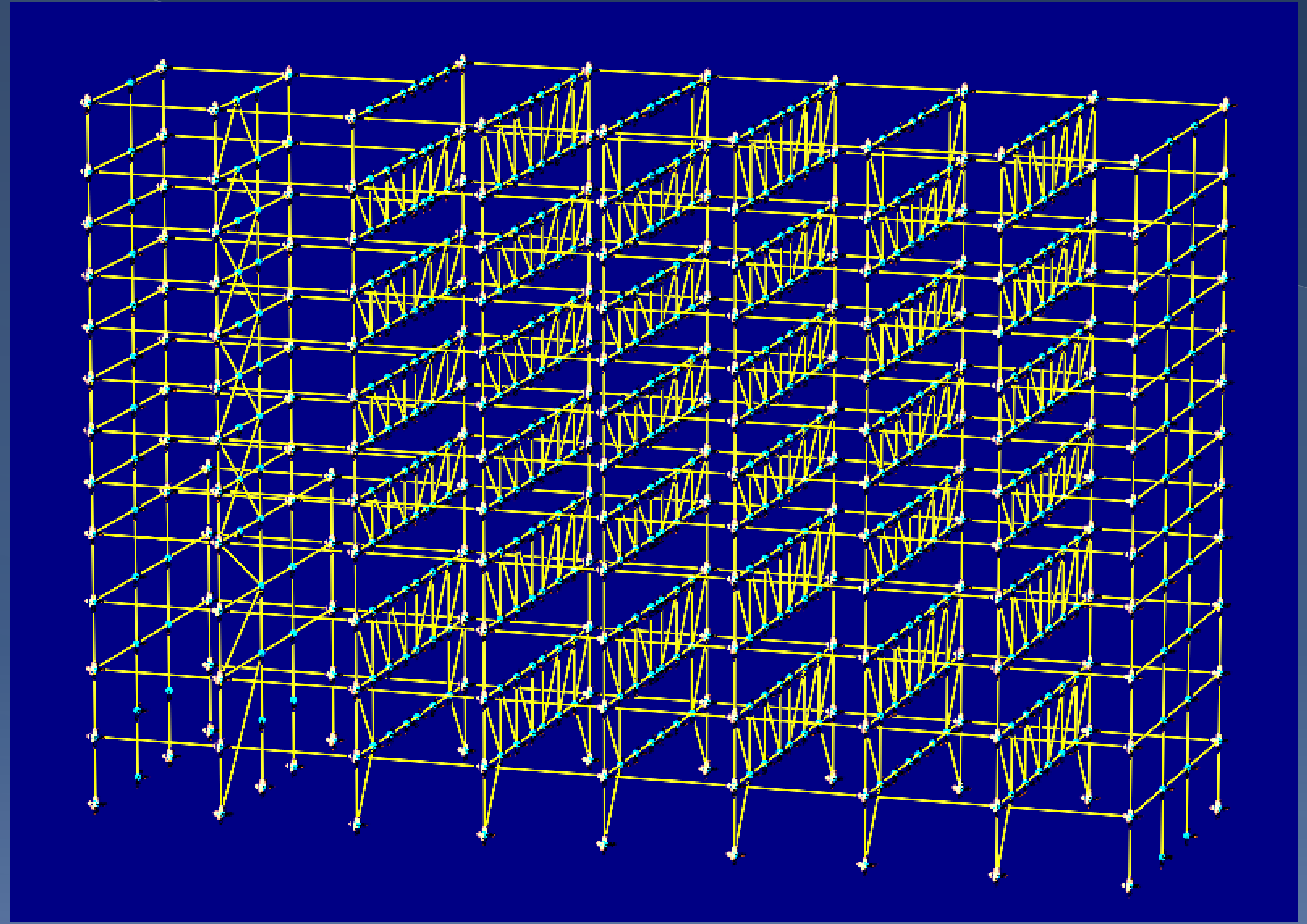


JCJ Architecture

Lower 4 stories have varying floor heights

In order to better analyze truss members, these 4 stories and 11th story were adjusted to be 15’ in height

Member Design

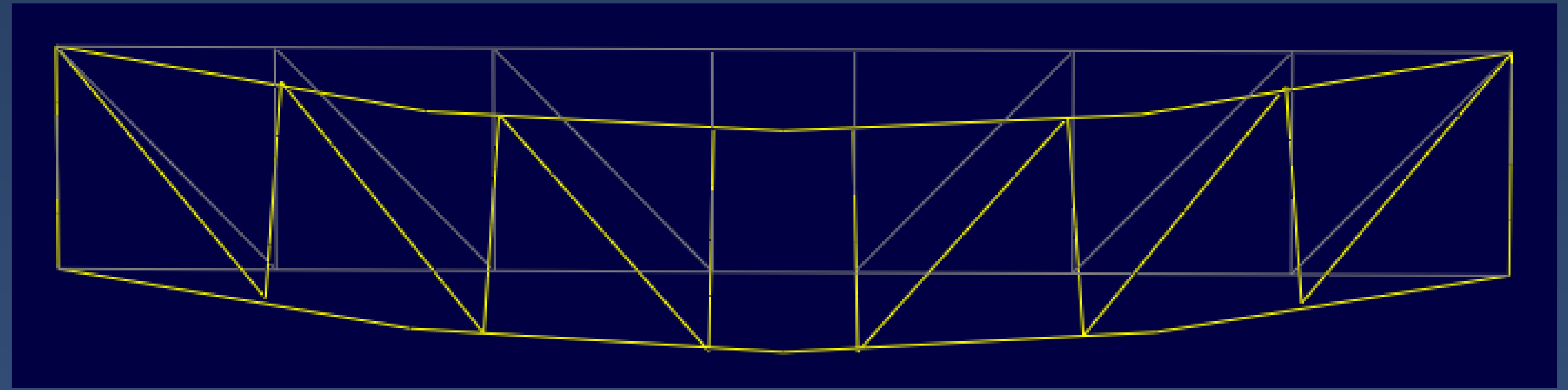


RAM Elements Model

Two separate truss designs were performed in order to determine preliminary member sizes

Small Truss (11’ 4” floor to floor height)
- Chords W10 x 33
- Diagonals and Verticals HSS9 x 7 x 5/8

Large Truss (15’ floor to floor height)
- Chords W10 x 60
- Diagonals and Verticals HSS14 x 10 x 5/8

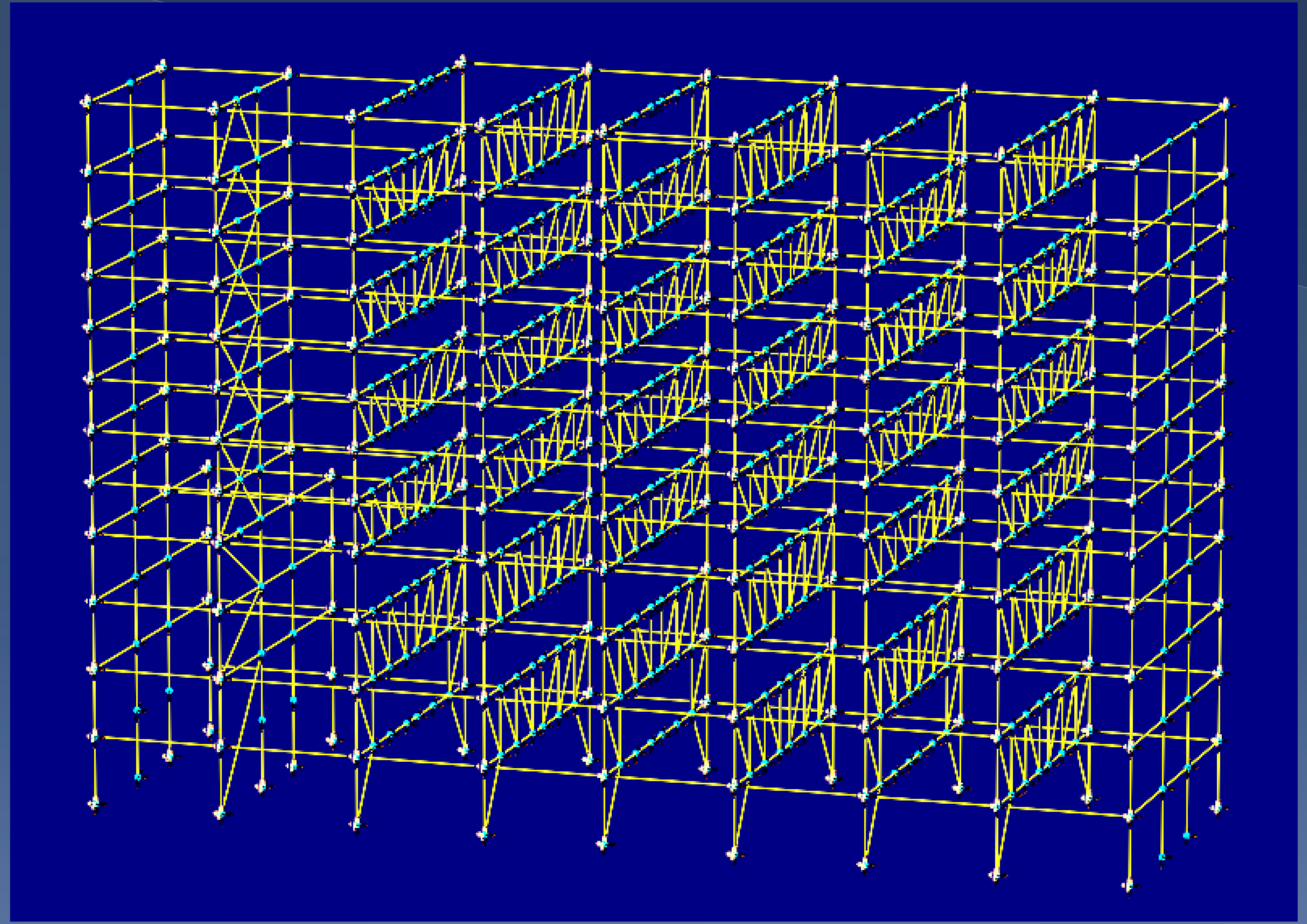


Computer model used to check preliminary member size performance.
1.2D + 1.6L produced largest deflections

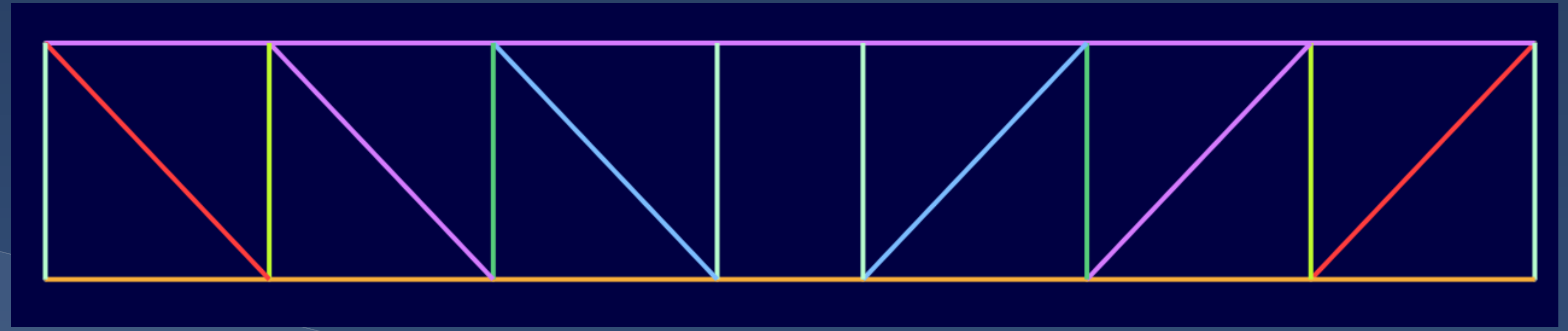
Deflection limit = l/240 = 3.6”

Large Truss δ = 0.85”
Small Truss δ = 1.60”

Member Design



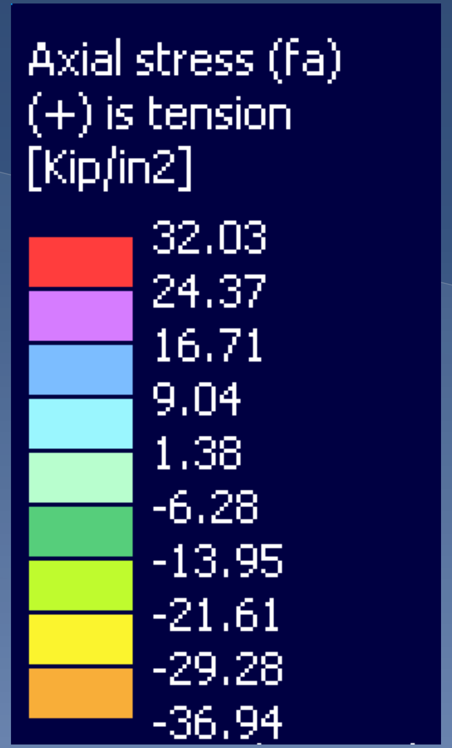
RAM Elements Model

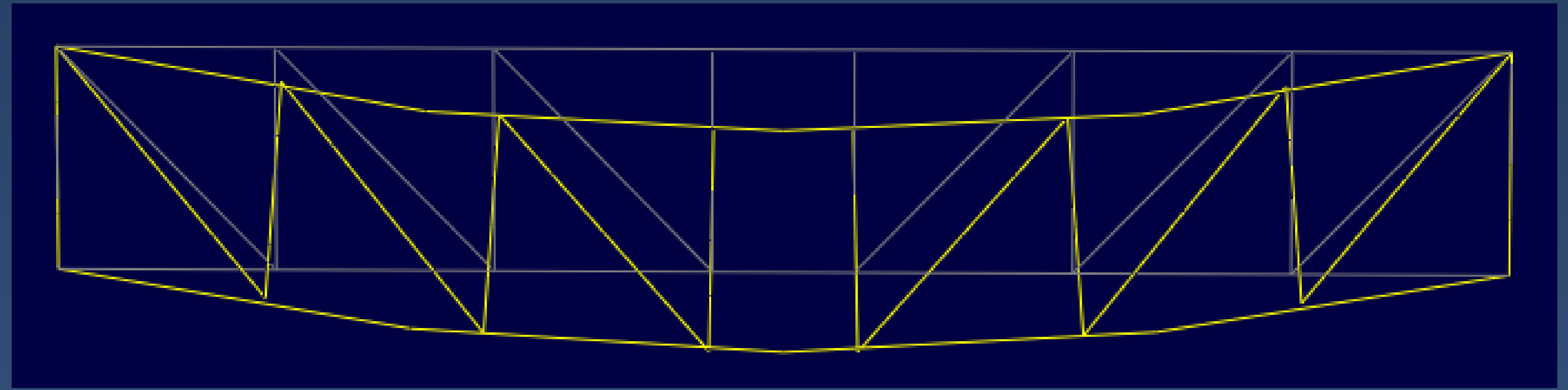


Member were checked for appropriate tension and compression stress

Exterior diagonals found to take the most load as expected

Top chord and verticals in compression
Bottom chord and diagonals in tension





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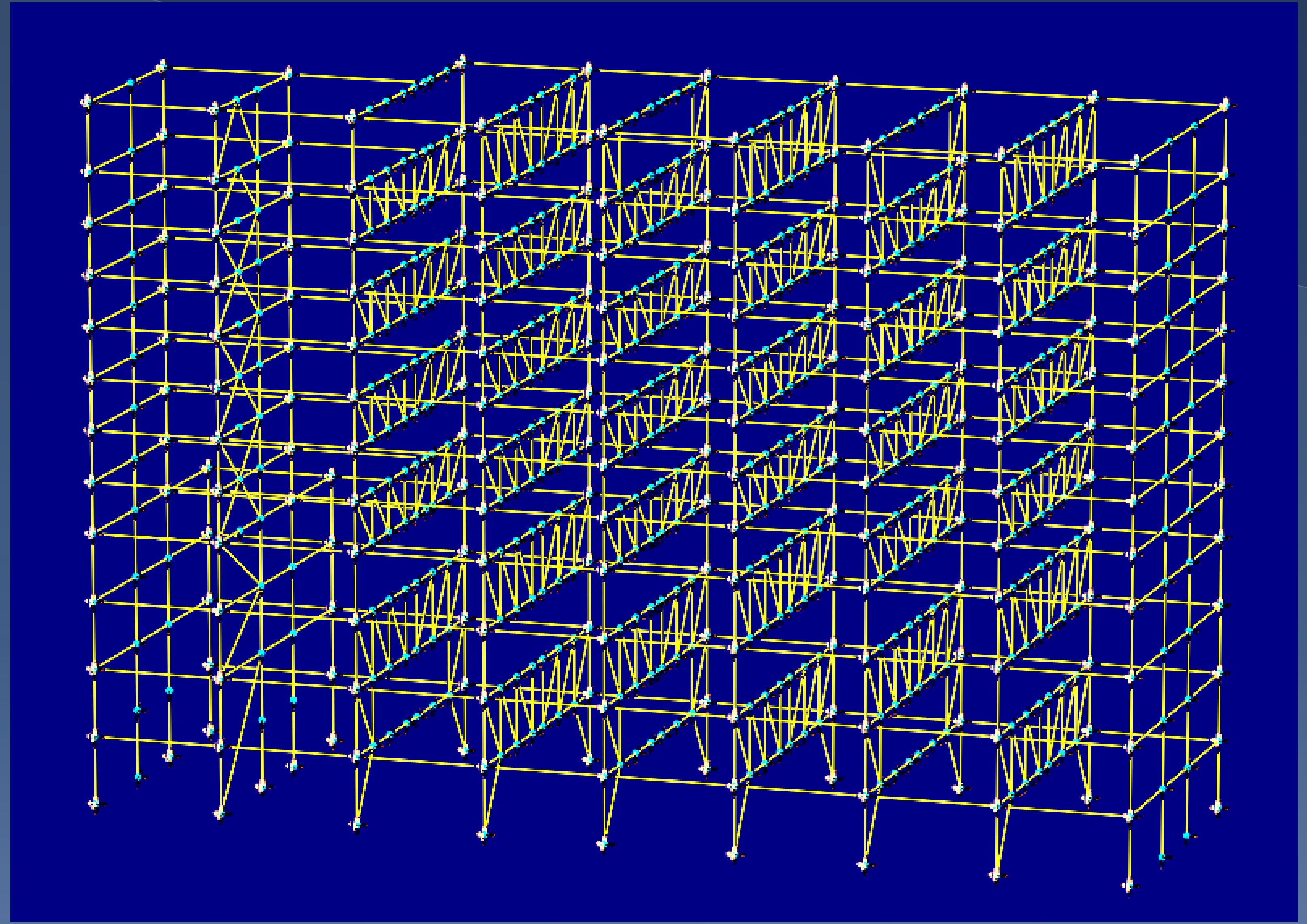
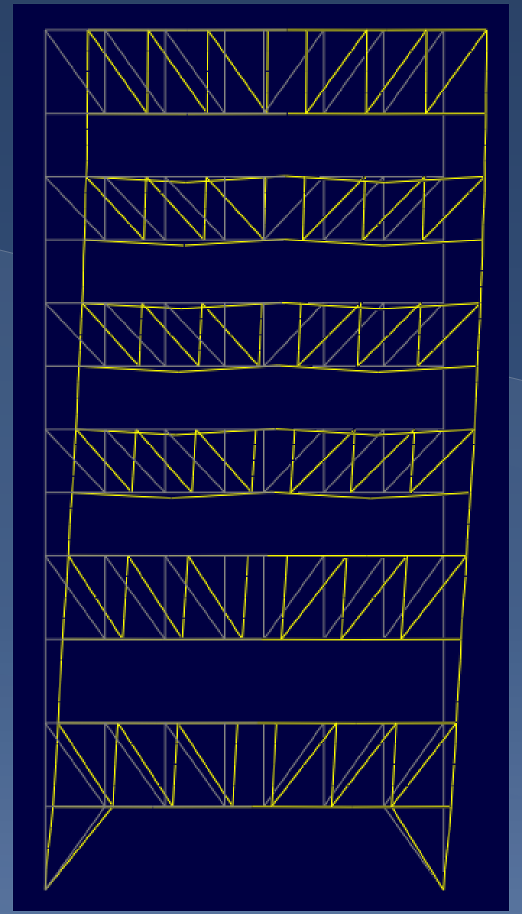
Lateral



RAM Elements Model



Controlling load case 1.2D + 1.6W + L

H/500 at roof level = 3.7”

Deflection at roof from model = 0.67”

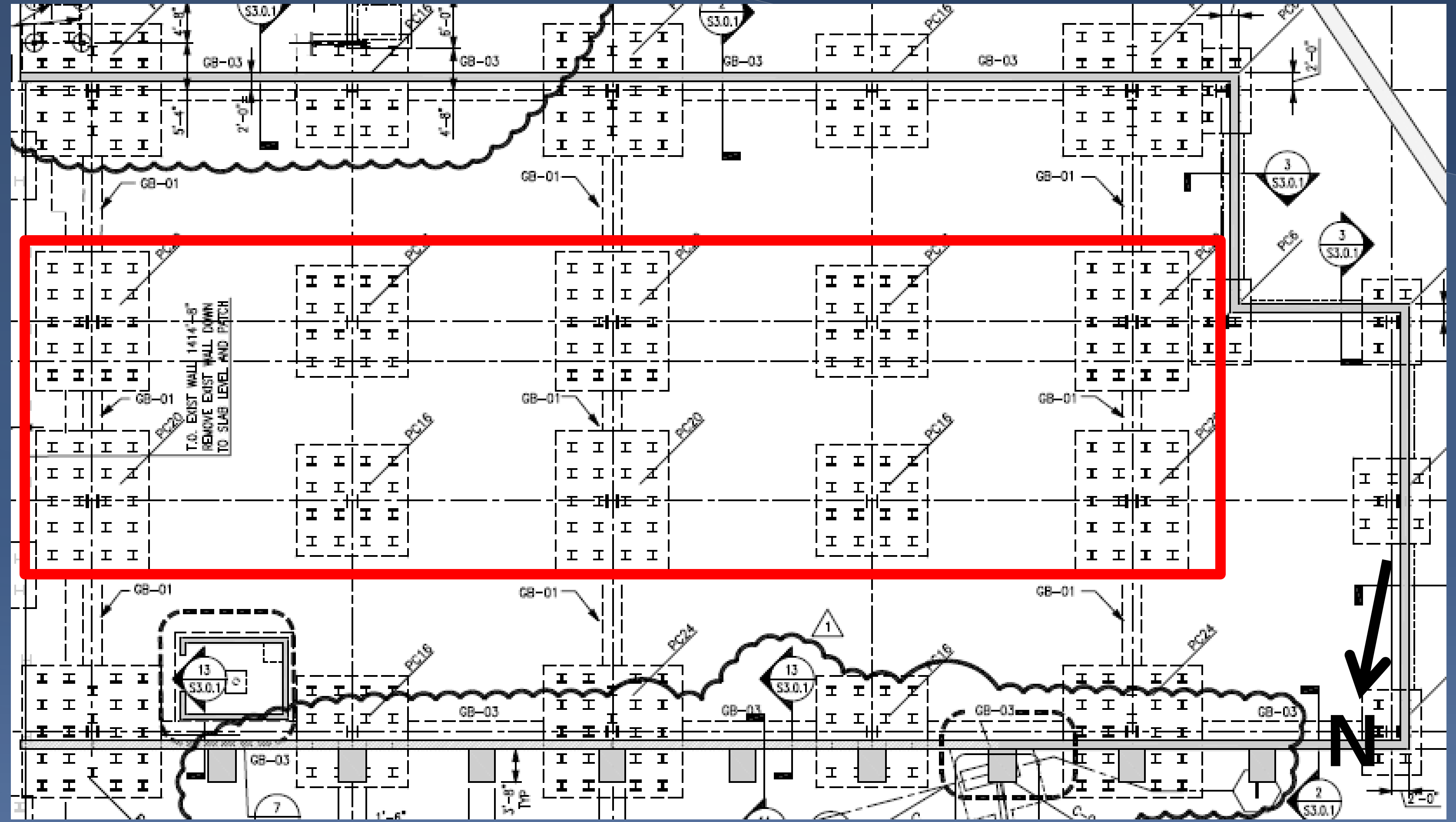
Seismic (N-S) (kips)	
1.2D+L+E	
Roof	69.5
11	74.3
10	68.4
9	61.4
8	56.7
7	51.6
6	45.1
5	39.2
4	32.8
3	24.0
2	14.7
Mezz	8.6
	546.3

Wind (N-S) (kips)	
1.2D+1.6W+L	
Roof	113.4
11	85.9
10	83.1
9	83.4
8	84.5
7	83.9
6	82.6
5	83.5
4	110.7
3	112.6
2	111.6
Mezz	113.0
	1148.2

N-S direction found to be controlled by wind in Technical Report 3

Seismic was checked with model to verify

Foundation



JCJ Architecture

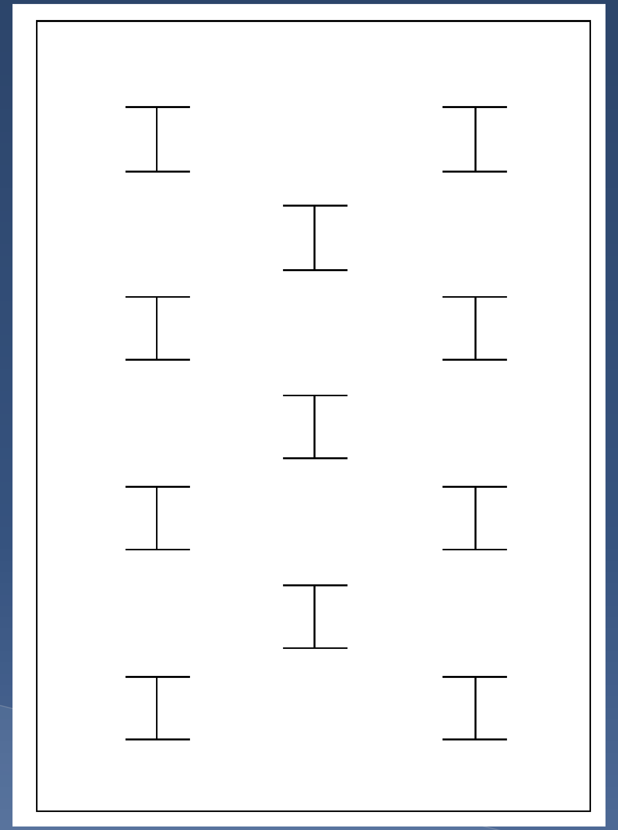
Removal of interior columns required a foundation redesign

Total amount of existing piles = 424

New pile-cap: 53” thick, 11 piles (HP 12x53)
Redesign total ~ 126

Drastic reduction but existing addition designed with ASD

With RAM model, all first story columns found to be in compression, thus uplift was not an issue



New pile cap approximate geometry

CRSI 2008 design table in appendix slides

Long direction oriented N-S to better resist wind loads

VIP Suite Conflict

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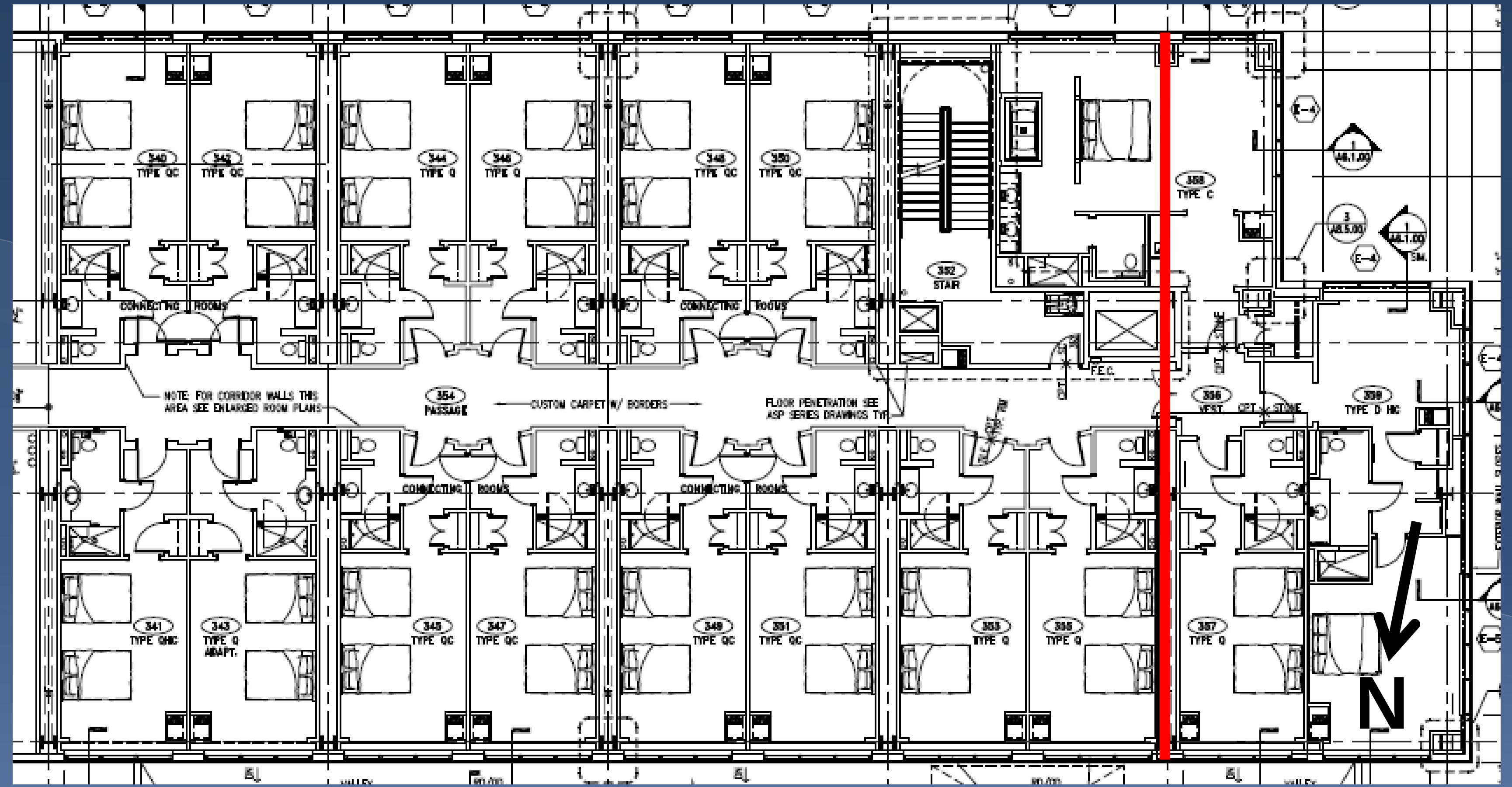


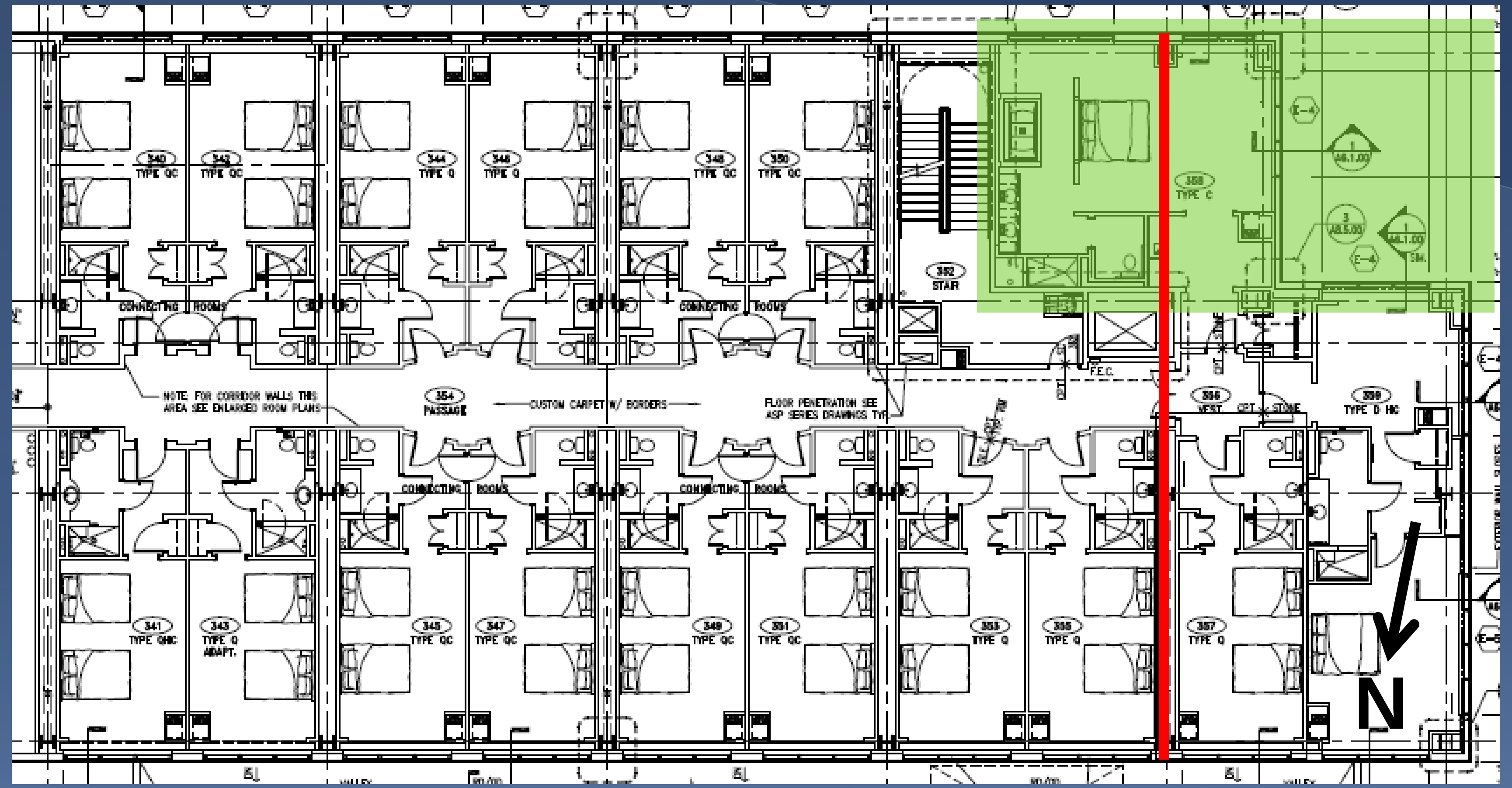
JCJ Architecture

3rd Floor Architectural Plan

Courtesy of Jim Boje, PE

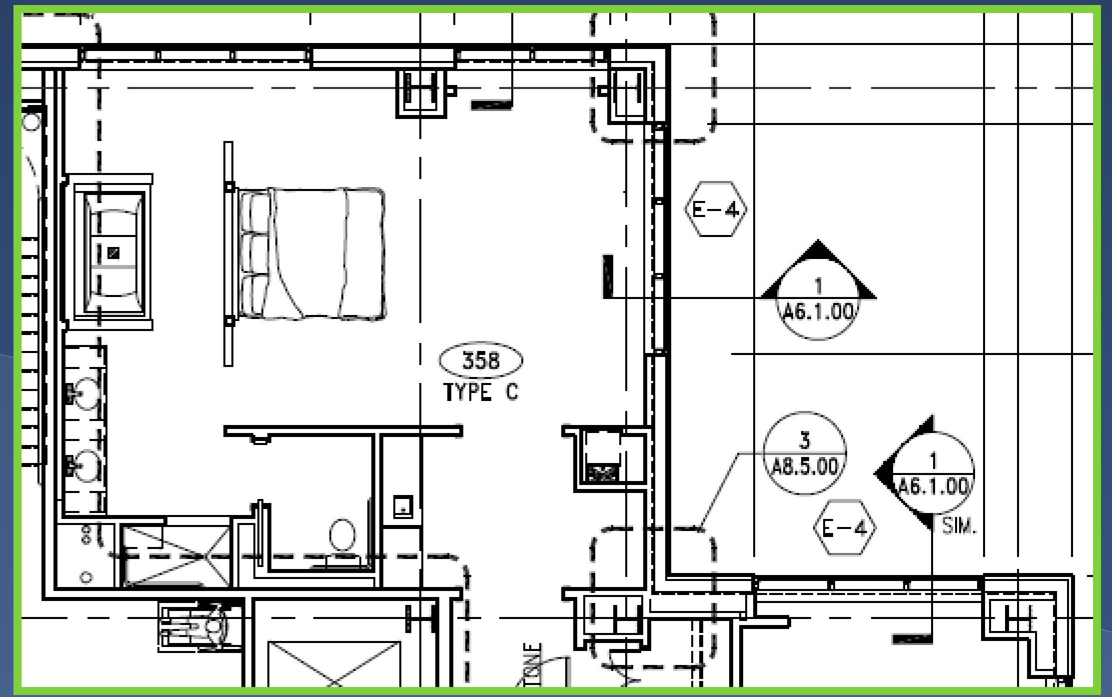
JCJ Architecture

VIP Suite Conflict



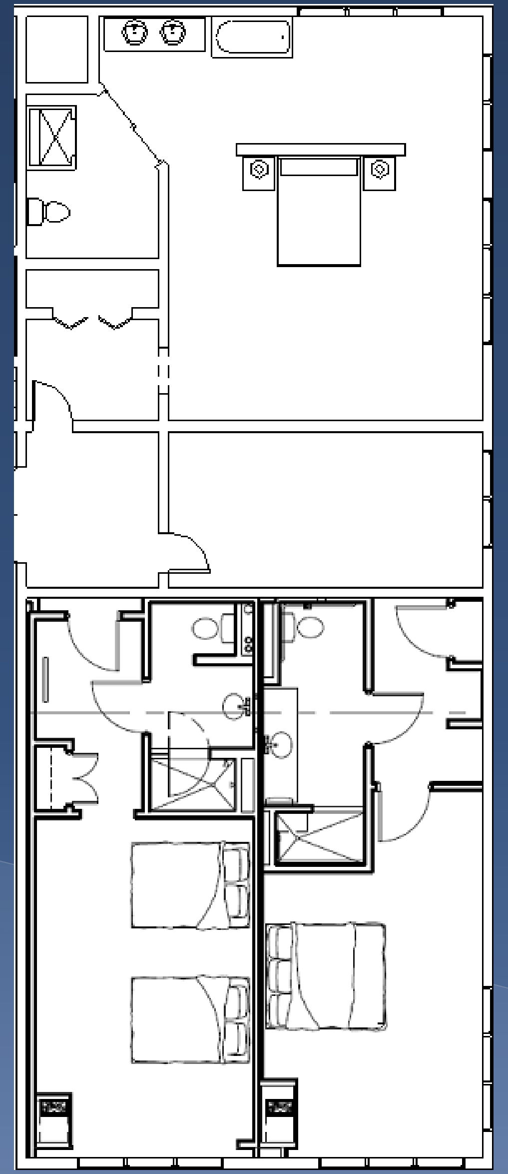
JCJ Architecture

3rd Floor Architectural Plan



JCJ Architecture

To avoid truss falling within master bedroom, notched corner is squared off to hide truss within wall



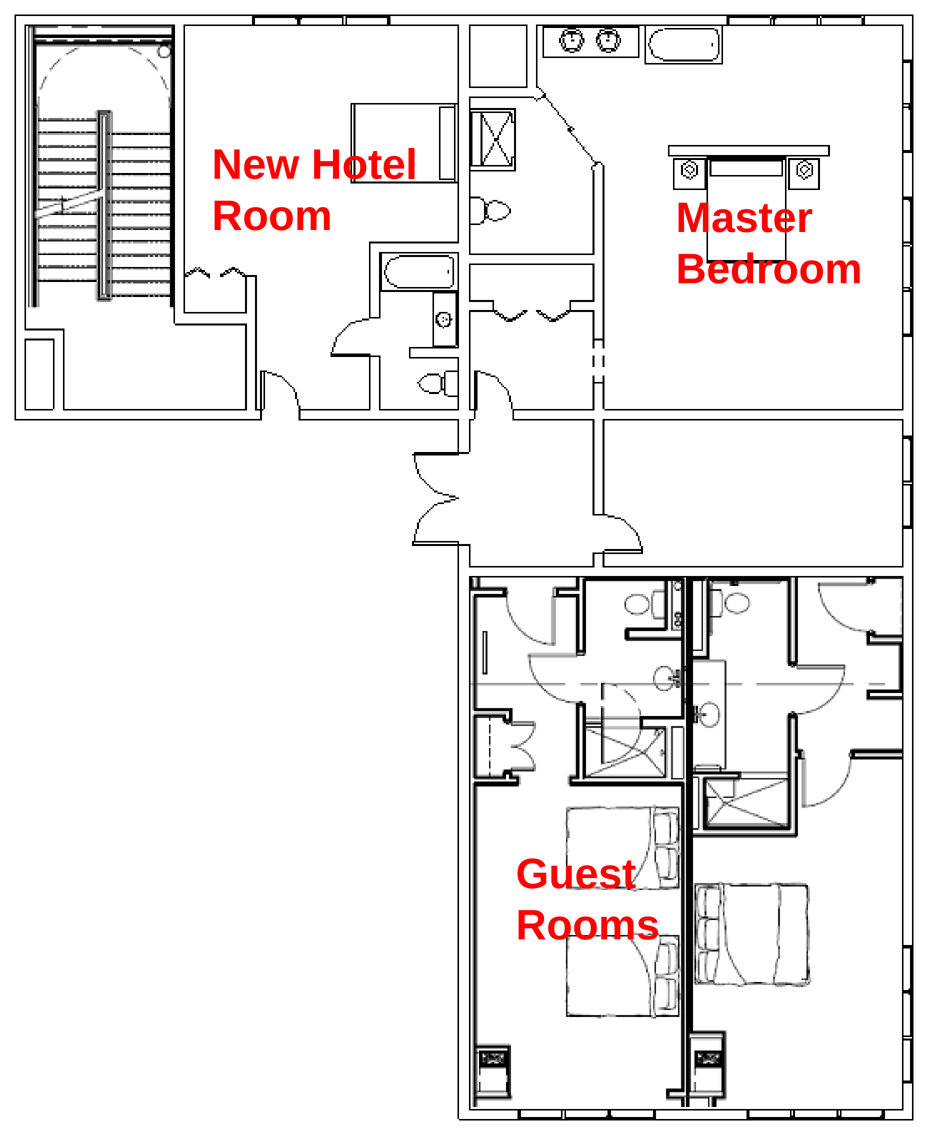
Squaring off corner produces extra floor space per floor

3 alternative designs for the interior space were investigated

VIP Suite Conflict

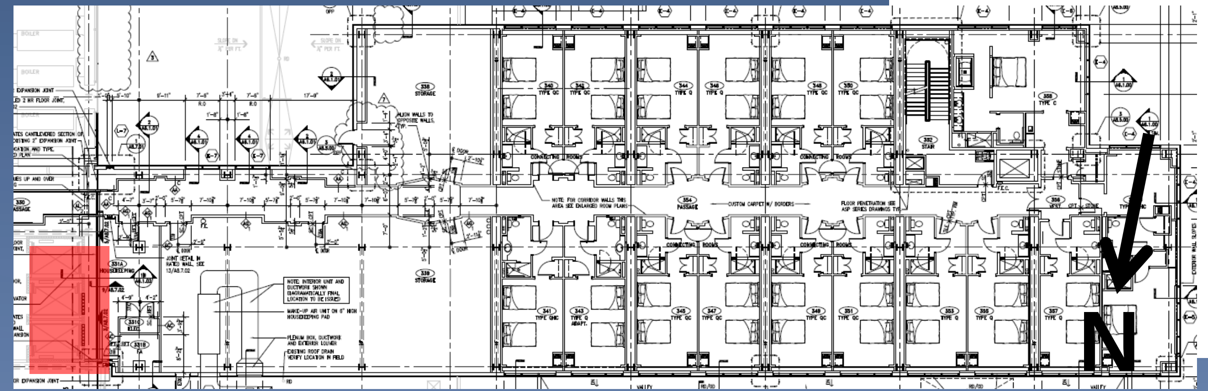
A new hotel room, increasing the total amount of rooms from 200 to 211

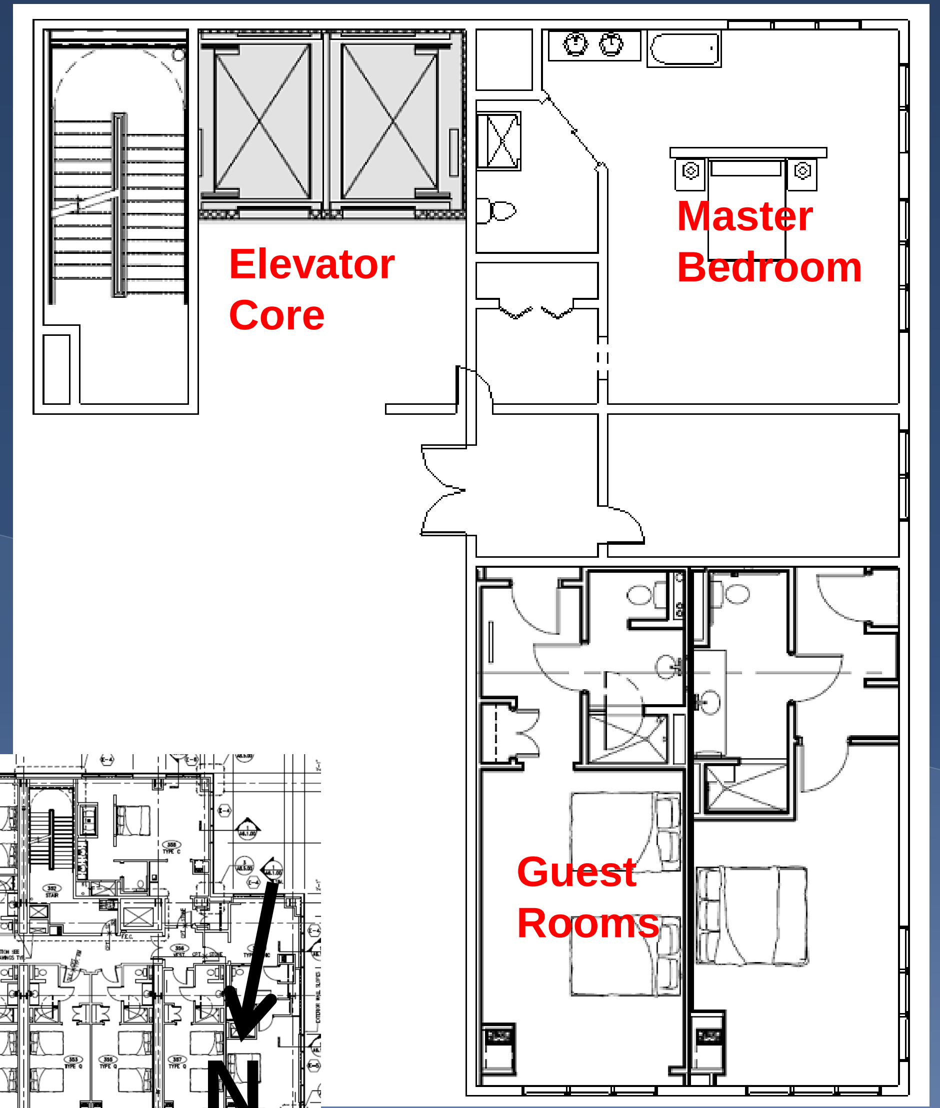
To maintain the vestibule leading to VIP Suite, new hotel room is almost half size of existing hotel rooms, with only one bed, difficulty aligning plumbing



New elevator core, only elevators servicing new addition in existing hotel ~180’ from VIP Suite

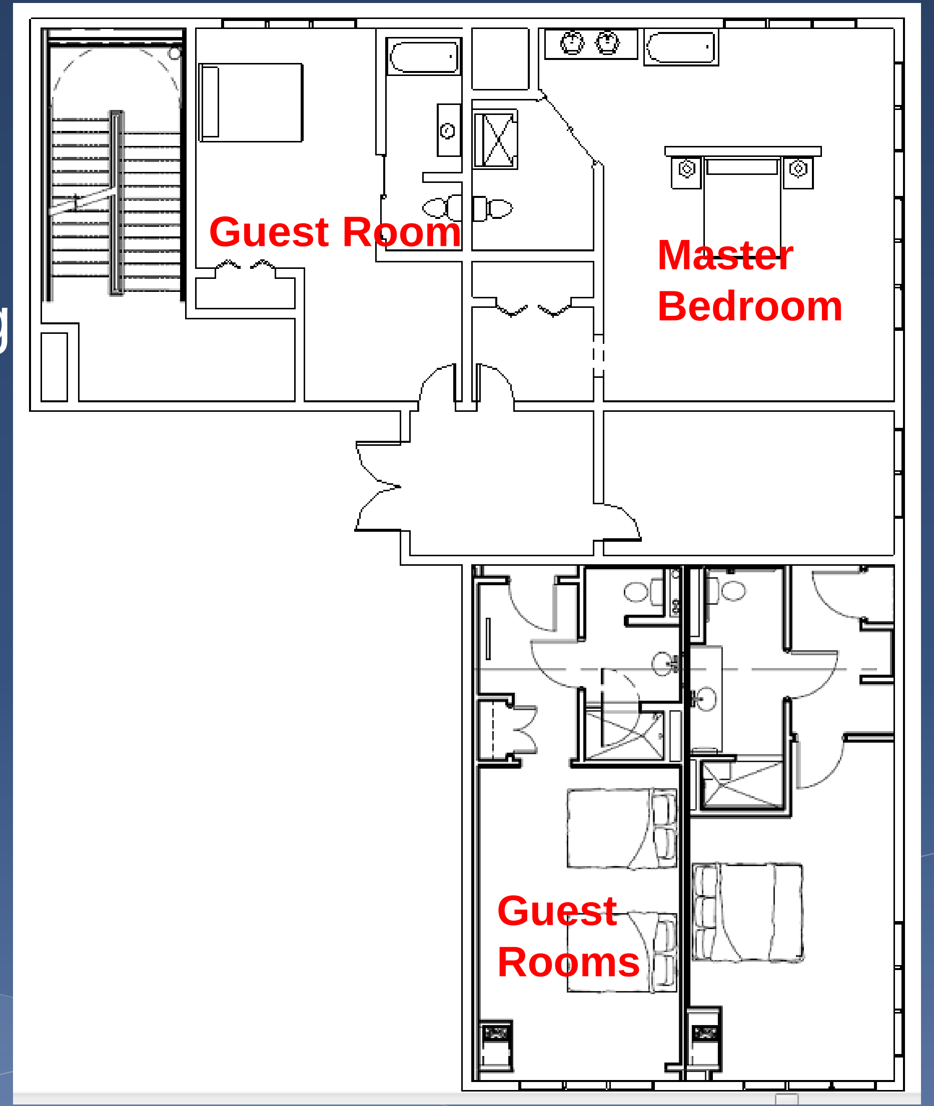
Trusses alone would most likely not support a stairwell and elevators



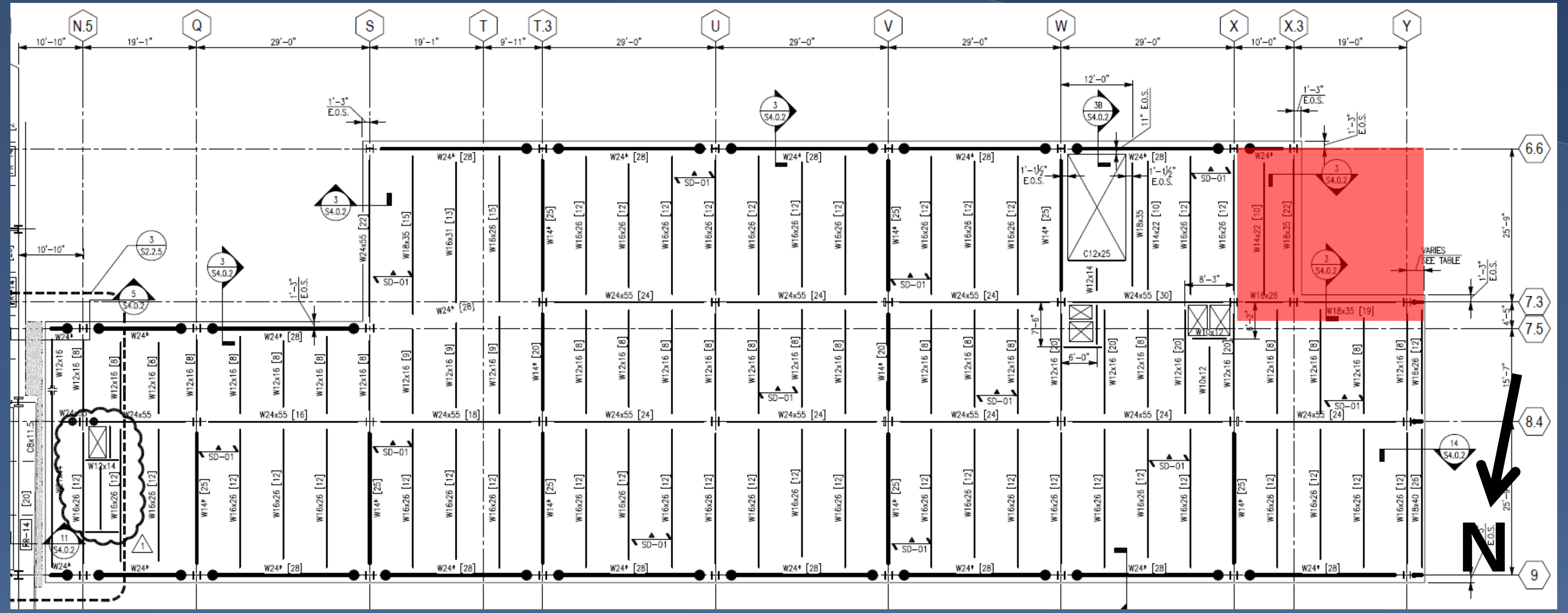


Extra guest bedroom added to the VIP Suite, increasing overall suite and maintaining private entrance

Small room again, does not add to overall hotel room amount

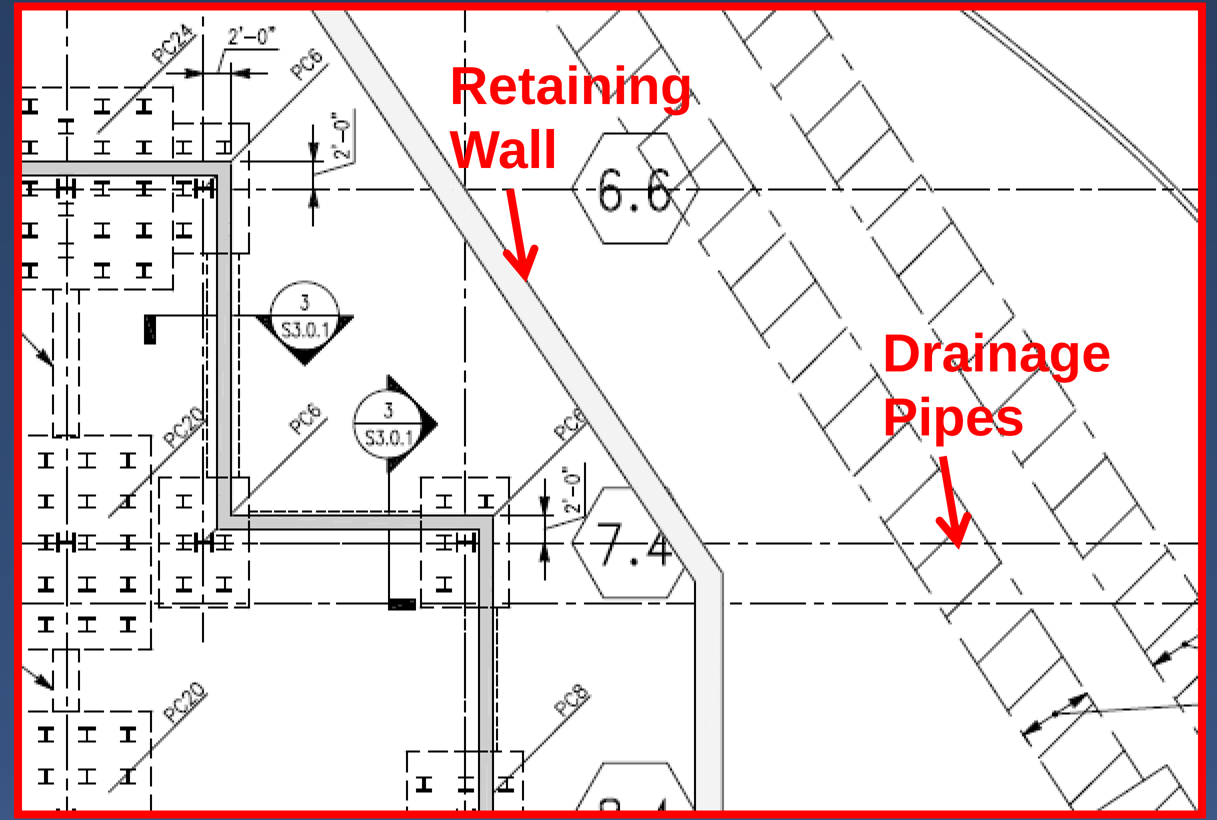


NE Corner Redesign Conflict



JCJ Architecture

Courtesy of Jim Boje, PE



JCJ Architecture

Squaring off corner conflicts with existing retaining wall

Demolishing retaining wall would require moving large drainage pipes

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Structural

Staggered truss system successfully designed to resist gravity loads and wind loads in the N-S direction

Precast concrete planks viable replacement for floor

Reduction of piles needed for foundation

Gained a better understanding of truss design

Architectural

Squaring off NE corner allows for truss to hide within VIP Suite wall

Creates more floor space

Conflict with retaining wall and drainage pipes makes this specific building not a good candidate

Construction

Reduction of piles would speed up schedule

Prefabricated members would allow quicker erection

MEP

Close coordination with MEP design

Truss conflicts with AHU on 3^{rd} floor mechanical room (appendix slide)

Questions?

Courtesy of Jim Boje, PE

Column Loads				
Floor	A_t (ft^2)	DL (psf)	LL (psf)	RLL (psf)
Roof	1036.8	101	200	200
11	1036.8	101	80	38.6
10	1036.8	101	80	38.6
9	1036.8	101	80	38.6
8	1036.8	101	80	38.6
7	1036.8	101	80	38.6
6	1036.8	101	80	38.6
5	1036.8	101	80	38.6
4	1036.8	101	80	38.6
3	1036.8	101	125	125
2	1036.8	101	125	125
Mezz	1036.8	101	200	200

Column Capacities					
Floor	Pu (k)	∑Pu (k)	Member	ΦPn (k)	Unbraced Length (ft)
Roof	487	487	W12x79	809	15
11	190	677	W12x79	910	11.33
10	190	867	W12x96	1110	11.33
9	190	1057	W12x96	1110	11.33
8	190	1247	W12x136	1580	11.33
7	190	1437	W12x136	1580	11.33
6	190	1627	W12x170	1990	11.33
5	190	1817	W12x170	1990	11.33
4	190	2007	W12x230	2710	11.33
3	342	2349	W12x210	2450	15
2	342	2691	W14x283	3270	15
Mezz	466	3157	W14x283	3270	15
∑	**3157**				

$f_c' = 3{,}000$ psi; $w = 150$ pcf
$f_y = 60$ ksi
Minimum Pile Diameter = 10 in. spaced at 3'-0"

100-TON STEEL PILES

capacity for unfactored, service $(D + L)$

Min. cover = 3"
d_e = 10"
Edge E = 21"
See Fig. 13-3

PILES	COLUMN		PILE CAP				REINFORCING BARS					SHEAR	
No. of Piles per cap	Max. Load P_u (net)	Min. Size *	Long A **	Short B **	D	Concrete **	Long A-Bars (1)	Min. A_s (2)	Short B-Bars (1)	Min. A_s (2)	Steel Wt. (3)	$V_u/\phi V_n$ Beam One-Way	$V_u/\phi V_n$ Slab Two-Way
	(kips)	(in.)	(ft-in.)	(ft-in.)	(in.)	(c.y.)	No.-Size	(in.²)	No.-Size	(in.²)	(tons)	Ratio	Ratio
2	621	13	6- 6	3- 6	41	2.9	6 H# 8	4.41	5 H# 4	N/A	0.069	0.991	N/A
3	933	18	6- 6	6- 2	42	4.1	6 H# 9	2.67	3-WAYS		0.130	0.542	0.923
			2- 1	2- 3									
4	1246	18	6- 6	6- 6	40	5.2	8 H# 9	7.91	8 H# 9	7.91	0.231	0.576	0.931
5	1548	20	7- 9	7- 9	43	8.0	13 H# 8	10.39	13 H# 8	10.39	0.315	0.532	0.956
6	1860	22	9- 6	6- 6	48	9.1	13 H# 8	10.41	10 H# 9	9.85	0.333	0.946	0.994
7	2148	27	9- 6	8- 9	55	14.1	13 H# 8	10.39	11 H# 9	11.29	0.389	0.421	0.981
8	2476	25	9- 6	8- 9	50	12.8	14 H# 9	14.15	15 H# 9	14.94	0.548	0.508	0.967
9	2778	27	9- 6	9- 6	56	15.6	17 H# 9	16.74	17 H# 9	16.74	0.665	0.459	1.000
10	3088	28	12- 6	8- 9	51	17.2	18 # 9	18.46	16 H# 9	15.67	0.660	0.727	0.973
11	3404	30	12- 6	8- 9	53	17.9	17 #10	22.02	20 H# 9	19.89	0.804	0.739	0.788
12	3702	31	12- 6	9- 6	58	21.3	18 #10	23.34	21 H# 9	20.71	0.875	0.732	0.695
13	4001	32	13- 11	9- 6	60	24.5	21 #10	26.89	23 # 8	18.63	0.883	0.583	0.595
14	4303	33	12- 6	11- 9	60	27.2	19 #10	23.67	24 # 9	24.58	0.950	0.622	0.997
15	4614	34	13- 11	12- 6	59	28.6	20 #10	25.98	27 # 9	27.76	1.128	0.570	0.803
			6- 2	8- 1									
16	4916	36	12- 6	12- 6	65	31.3	27 # 9	27.72	27 # 9	27.72	1.102	0.646	0.996
17	5254	37	13- 11	12- 6	59	28.6	26 #10	32.84	27 # 9	27.05	1.301	0.634	0.980
			6- 2	8- 1									
18	5558	38	13- 11	12- 6	58	31.1	29 #10	37.45	31 # 9	31.45	1.470	0.666	0.994
19	5844	39	14- 9	12- 6	64	36.4	29 #10	37.63	31 # 9	31.66	1.522	0.654	0.984
20	6132	40	15- 6	12- 6	69	41.3	24 #11	37.93	35 # 9	35.98	1.670	0.607	0.990

CONCRETE REINFORCING STEEL INSTITUTE

2.3.2 Basic Combinations. Structures, components, and foundations shall be designed so that their design strength equals or exceeds the effects of the factored loads in the following combinations:

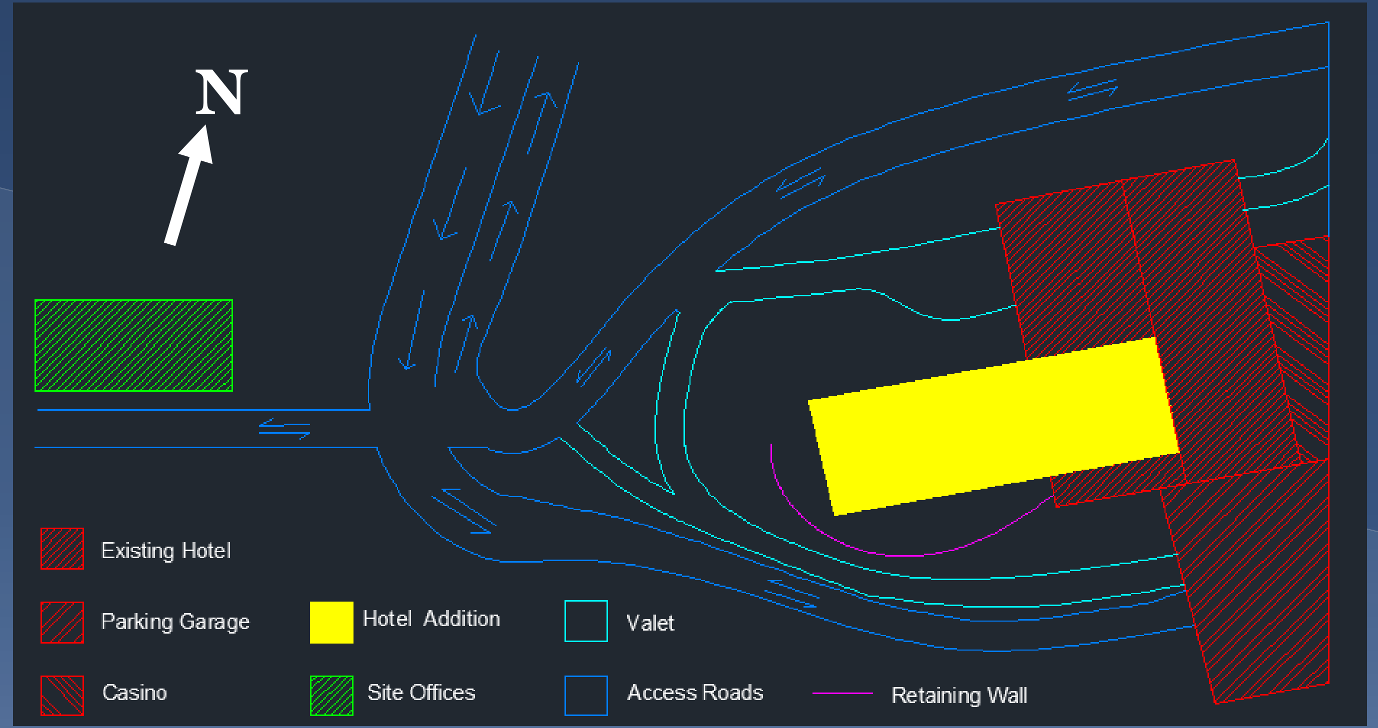
1. $1.4(D + F)$
2. $1.2(D + F + T) + 1.6(L + H) + 0.5(L_r \text{ or } S \text{ or } R)$
3. $1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (L \text{ or } 0.8W)$
4. $1.2D + 1.6W + L + 0.5(L_r \text{ or } S \text{ or } R)$
5. $1.2D + 1.0E + L + 0.2S$
6. $0.9D + 1.6W + 1.6H$
7. $0.9D + 1.0E + 1.6H$

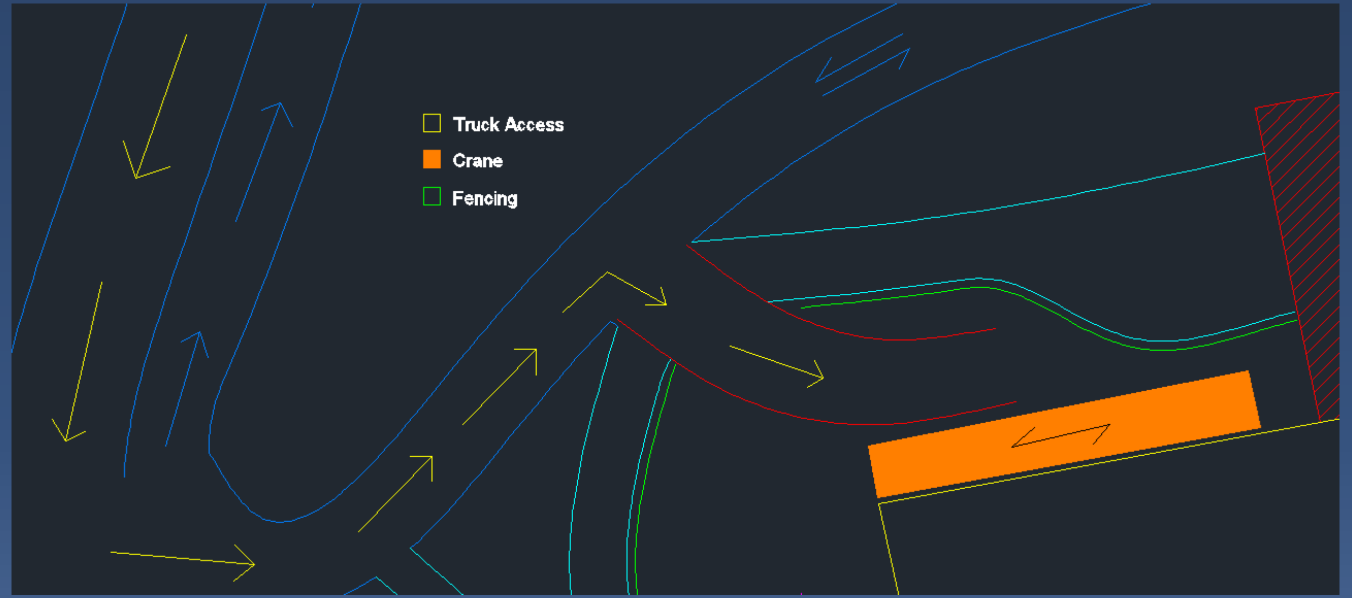
Approximate Truss Member Weights

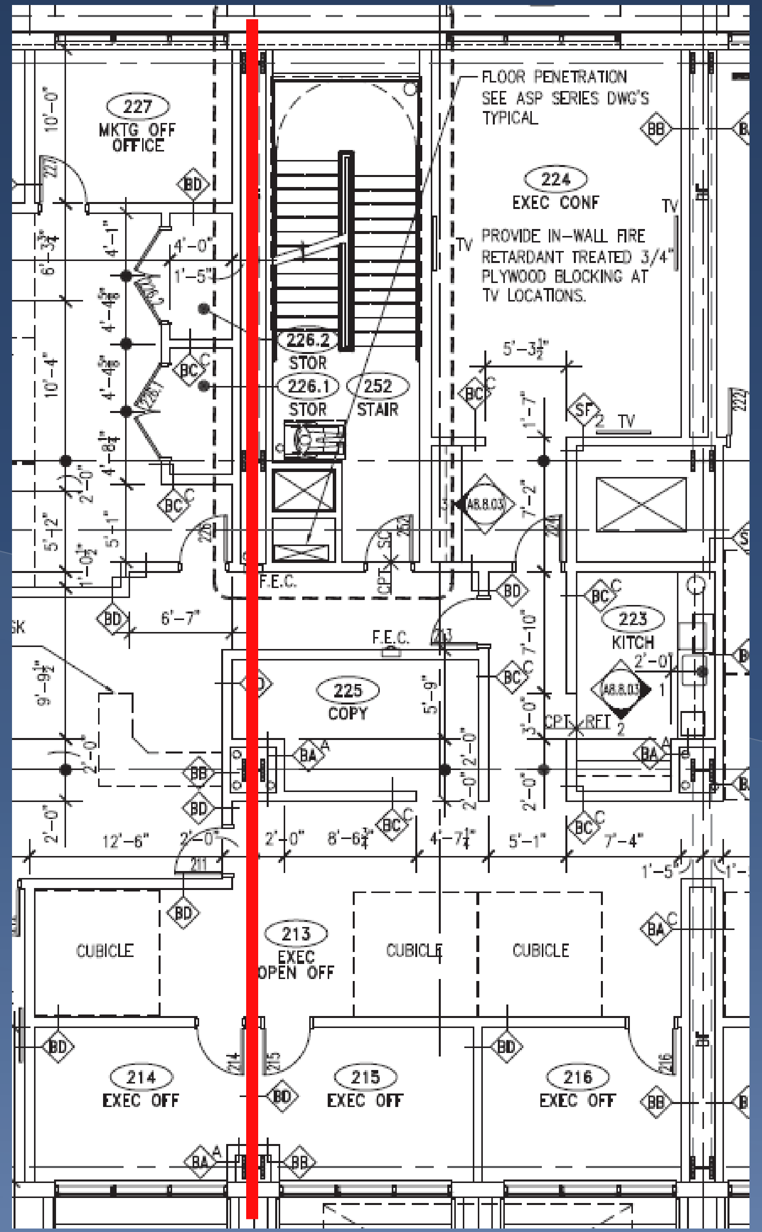
Small Truss					Large Truss				
	Member	Weight (plf)	Length (ft)	Weight (lb)		Member	Weight (plf)	Length (ft)	Weight (lb)
Top Chord	W10x33	33	71.5	2359.5	Top Chord	W10x54	54	71.5	3861
Bottom Chord	W10x33	33	71.5	2359.5	Bottom Chord	W10x60	60	71.5	4290
Diagonals (6)	HSS10x6x5/8	59.32	15.62	5559.5	Diagonals (6)	HSS16x12x5/8	110.36	18.5	12250
Verticals (6)	HSS10x6x5/8	59.32	11.33	4032.6	Verticals (6)	HSS16x12x5/8	110.36	15	9932.4
			∑	**14311**				∑	**30333.4**

Precast Concrete Planks

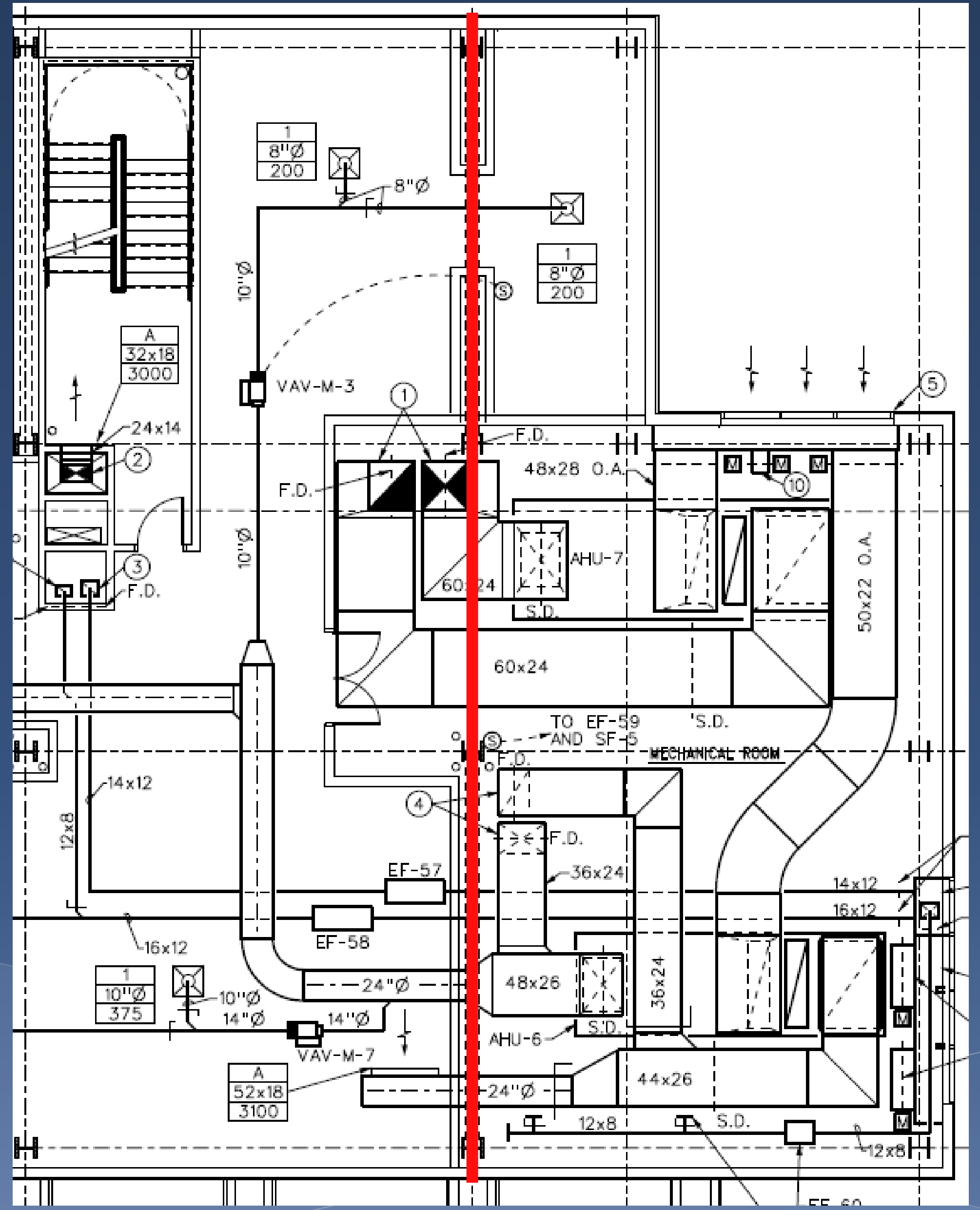
	Weight (plf)	Length (ft)	Weight (lb)
8"	245	29	7105
10"	272	29	7888







2nd Floor Offices



3rd Floor Mechanical Room