CBD Chemical
Production Building

Virginia, USA

Christina DiPaolo | Structural Option

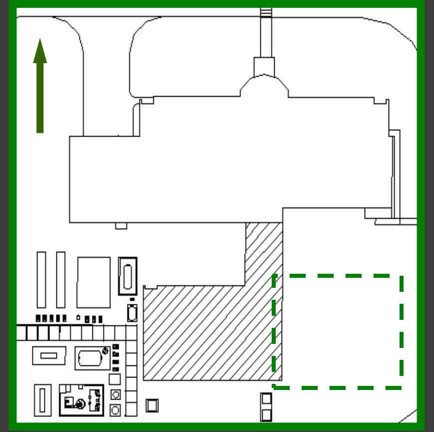
CBD Chemical

Production Building

Virginia, USA

Building Statistics

Function/Occupant Type:	High Hazard, Chemical Manufacturing Plant
Size:	55,000 GSF
Stories:	5 floors, a mezzanine in the first floor, and a penthouse
Primary Project Team:	Withheld at request of Engineers and Contractors
Dates of Construction:	April 2008 – January 2009
Cost Information:	$125 Million
Project Delivery Method:	Design-Bid-Build with a Negotiated Guaranteed Max Contract



Site Plan

CBD Chemical

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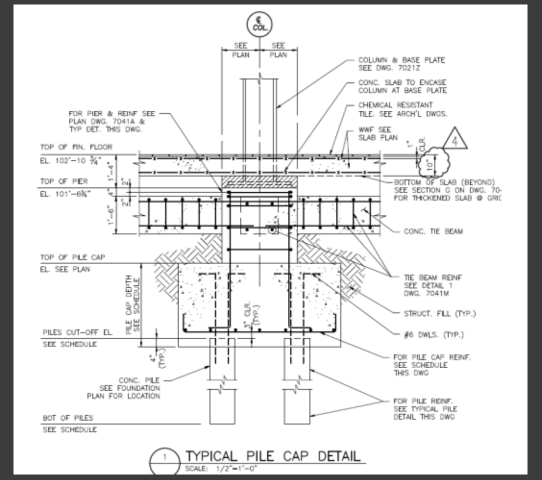
Structural Overview

Foundation System

- 12 inch x12 inch precast piles
- Tie beams between each column
- 100-ton capacity each



Typical pile cap detail

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Structural Overview

Floor System

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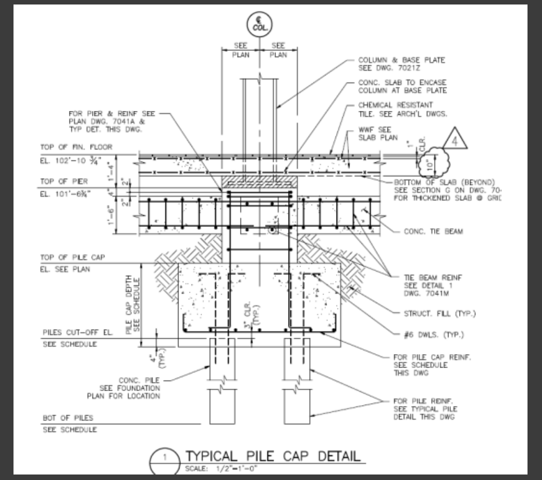

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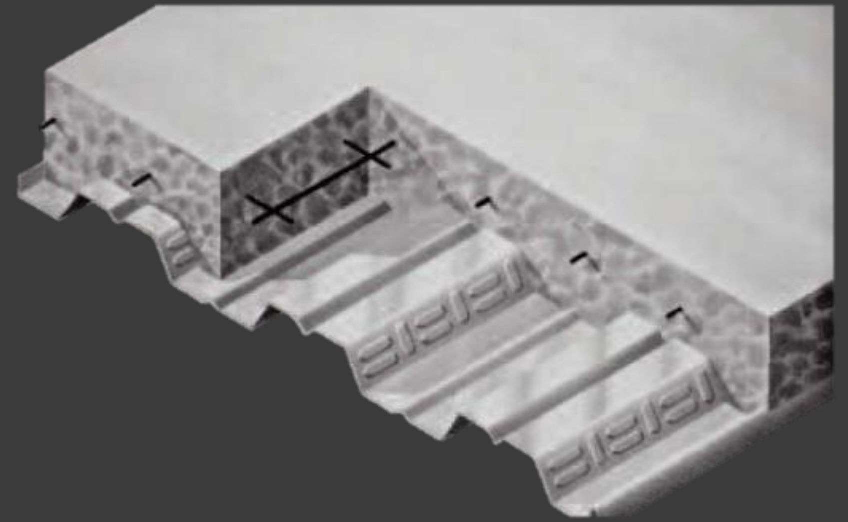

Vulcraft 3VLI18 extrusion

- 7 ½ inches of normal weight concrete on 3VLI18
- roof has 6 inches of normal weight concrete on 3VLI18

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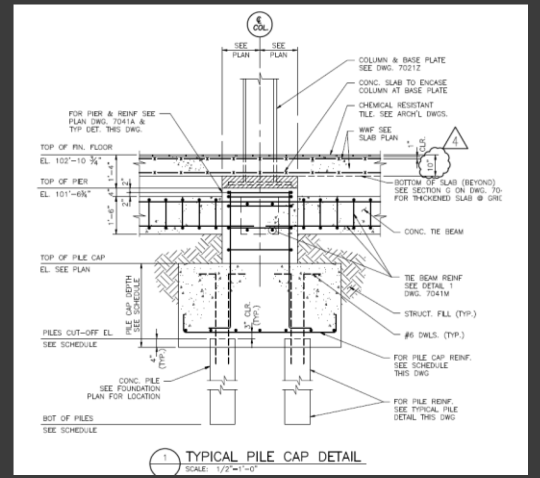
Structural Overview

Framing System

- 12 inch x12 inch precast piles
- Tie beams between each column
- 100-ton capacity each



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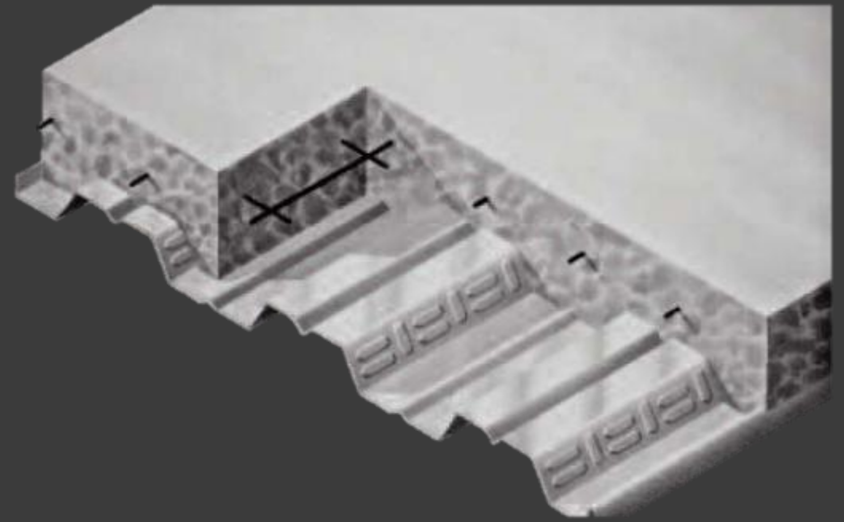

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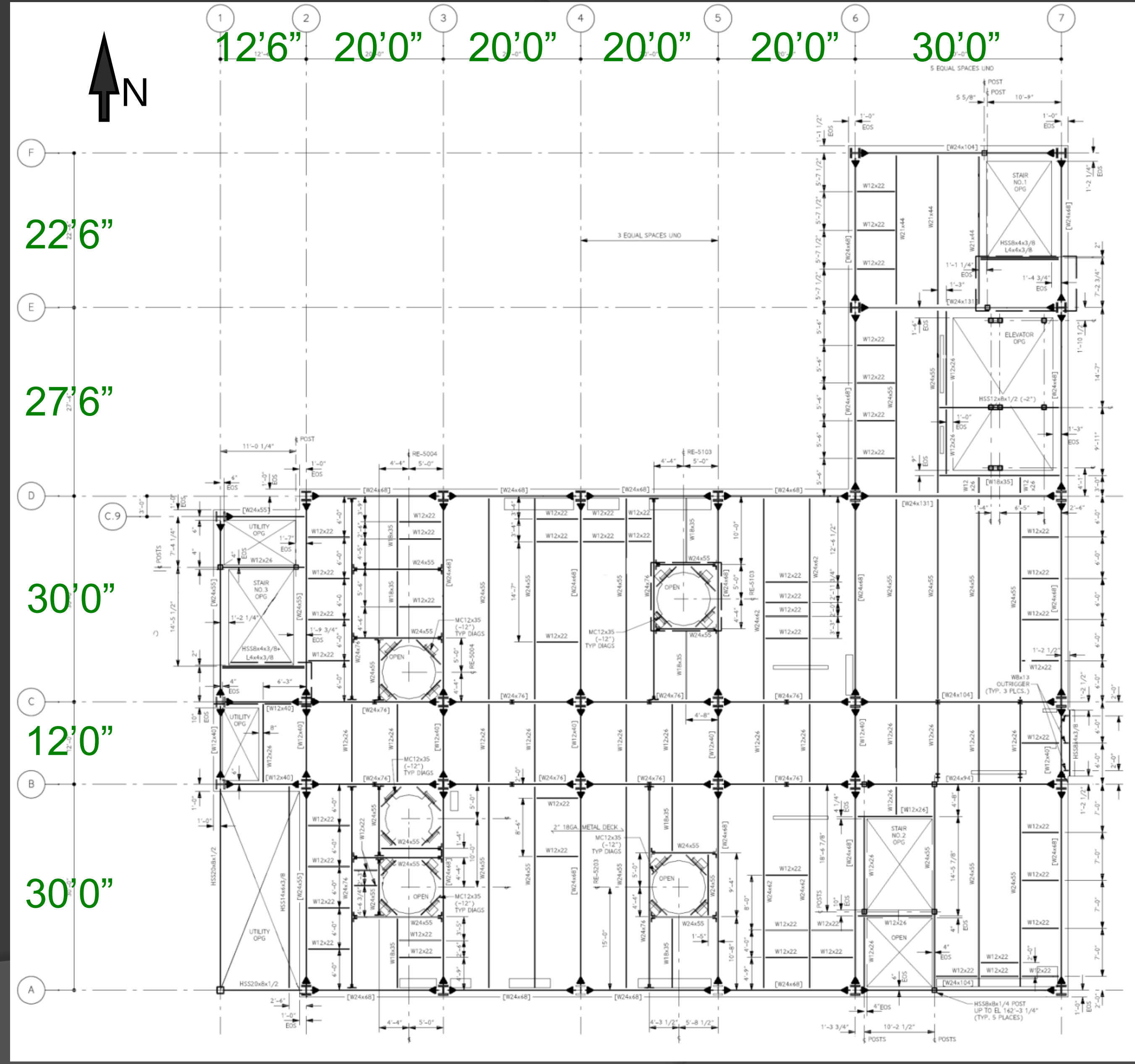

Third floor framing plan

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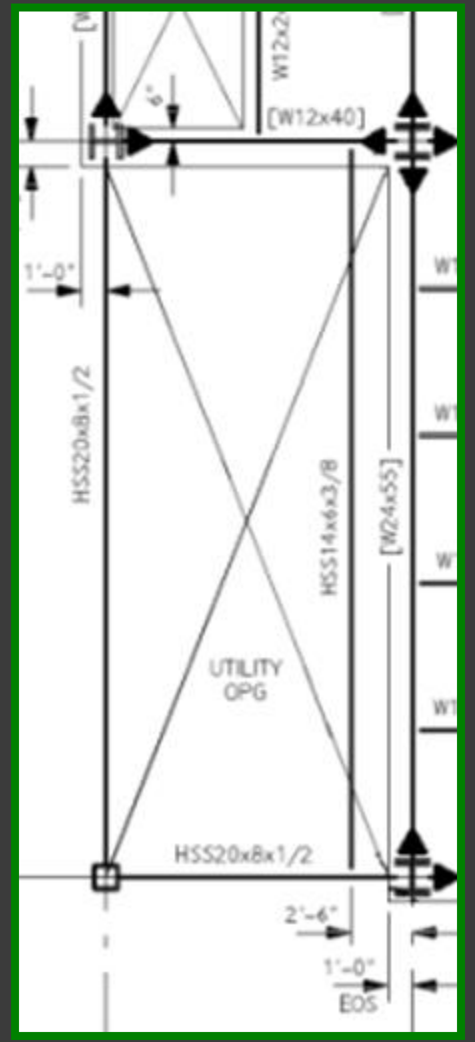
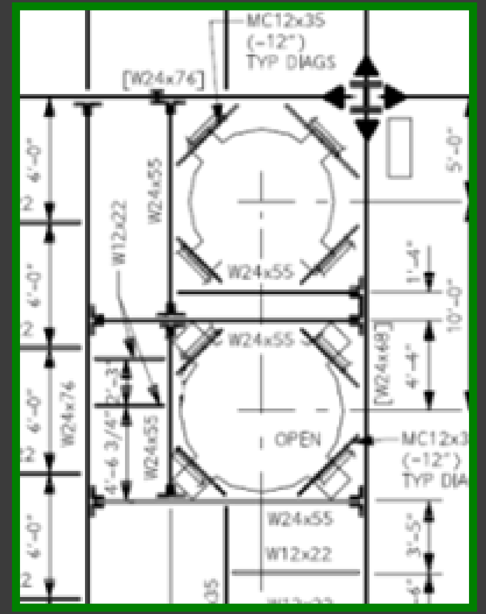
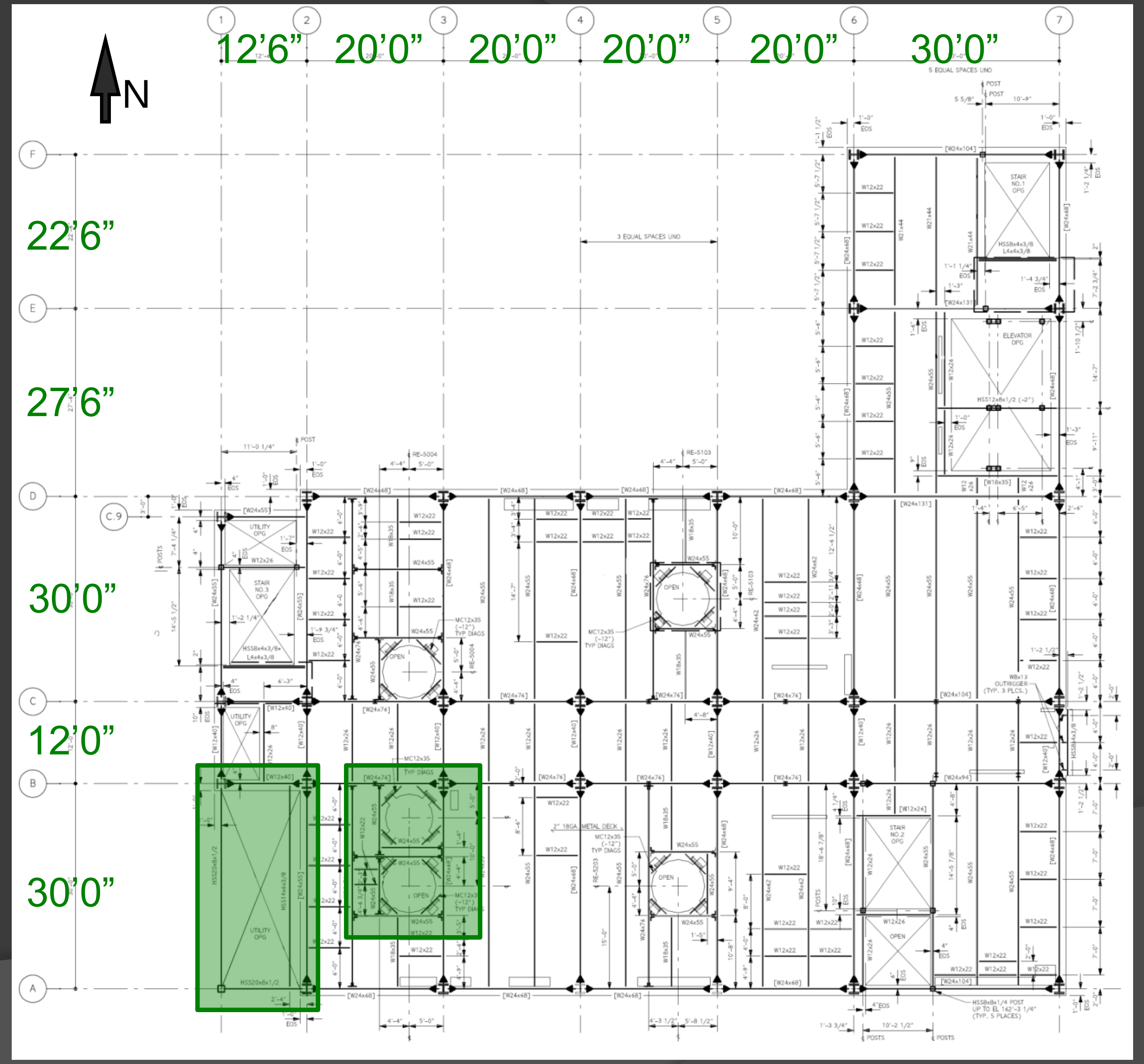
Structural Overview

Framing System







Third floor framing plan

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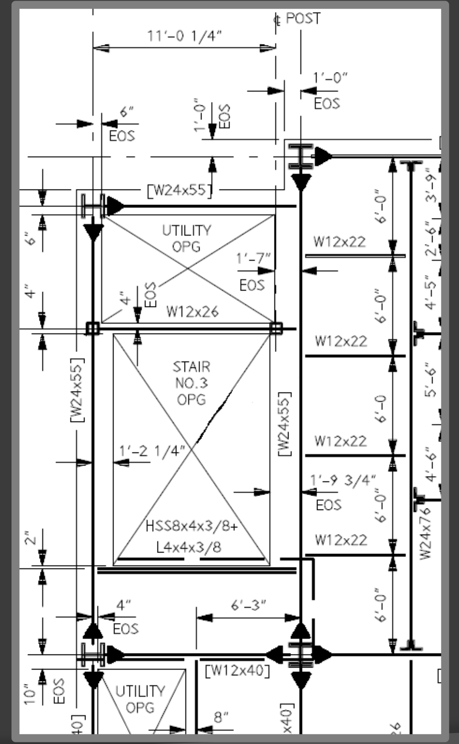
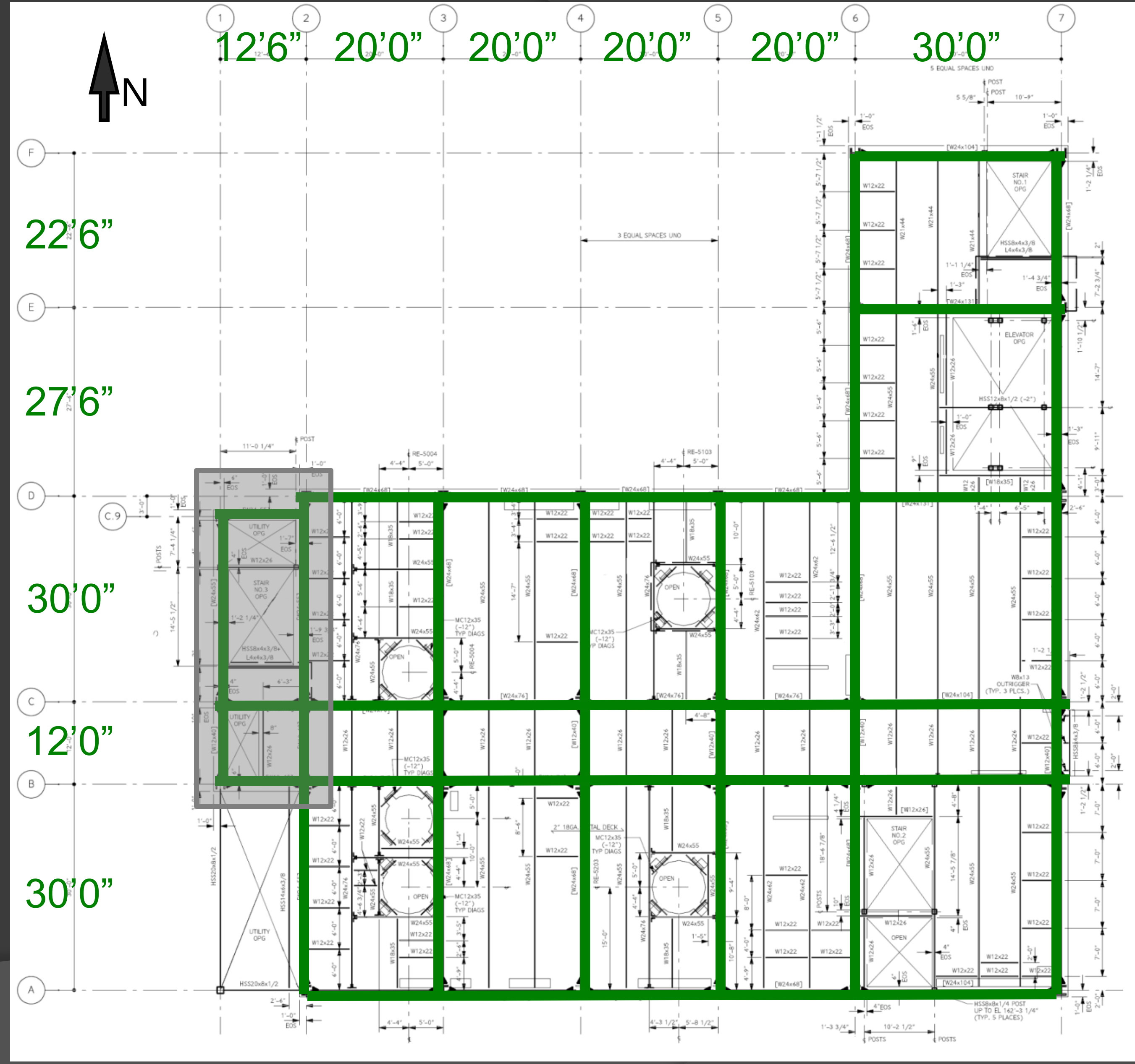
Structural Overview

Lateral System

- Moment frame in both N-S and E-W
- Odd column rotation





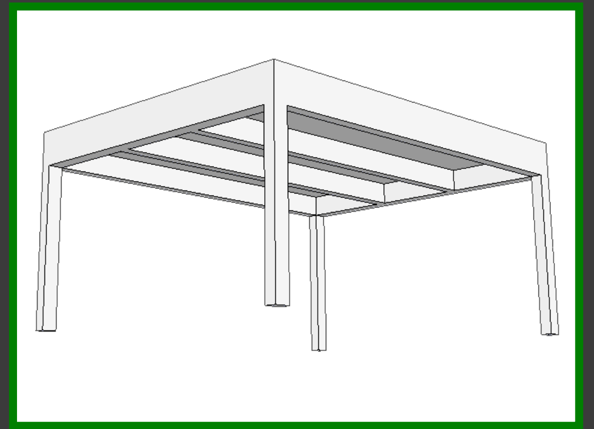
Third floor framing plan

Outline

- Thesis Goals
- Structural Depth (MAE Requirement)
- Construction Management Breadth
- Conclusions
- Questions / Comments

Structural Depth

- Optimize the steel for the same assumptions
- Design a concrete beam and girder system for these constraints
- Compare steel and concrete systems
- Analyze impact on deep foundation system



A sketchup model of the layout of the one-way slab system.

Construction Management Breadth

- Compare cost of two structural systems
- Compare schedules of two structural systems

Outline

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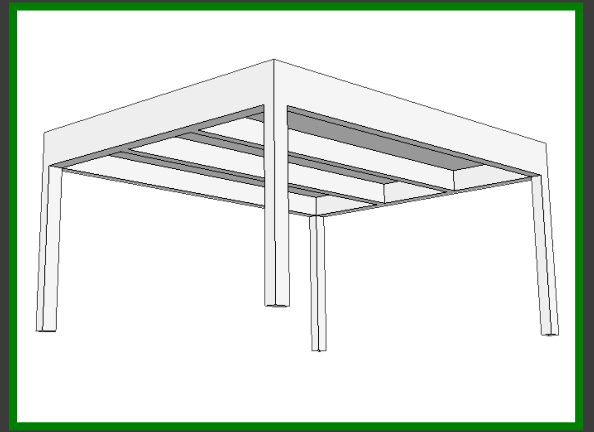

A sketchup model of the layout of the one-way slab system.

Construction Management Breadth

- Compare cost of two structural systems
- Compare schedules of two structural systems

MAE Course Material

- 3D lateral modeling in ETABS from AE 597A

PV/Electrical Breadth

- Analyze potential output of photovoltaic panels on roof
- Size wiring for panels and inverter
- Cost benefit analysis / payback period

Steel Optimization

- ¾" shear studs spaced 1' o.c. on all beams
- All beams designed non-compositely
- Redesign using these shear studs already in place

E–STRUCTURAL STEEL

1. THE STRUCTURAL STEEL FABRICATOR SHALL FOLLOW THE AISC QUALITY CERTIFICATION PROGRAM FOR CATEGORY–1 CONVENTIONAL STEEL STRUCTURES.
2. FABRICATE AND ERECT ALL STRUCTURAL STEEL IN ACCORDANCE WITH THE DRAWINGS, THE THIRD EDITION OF THE AISC MANUAL OF STEEL CONSTRUCTION LRFD AND STRUCTURAL STEELWORK SPECIFICATION No. 05120.
3. ROLLED STEEL WIDE FLANGE SHAPES, BASE PLATES, STIFFENER AND WEB PLATES SHALL BE ASTM A992 OR A572 GRADE 50 (FY=50ksi)
4. ROLLED STEEL CHANNELS, ANGLES AND BARS SHALL BE ASTM A36.
5. STEEL PIPE SHALL BE ASTM A53, TYPE E, GRADE B, FY=35 KSI. ALL PIPE SHALL BE STANDARD SCHEDULE 40 WEIGHT UNLESS NOTED OTHERWISE AND IS CALLED OUT BY NOMINAL DIAMETER.
6. ALL STEEL TUBING SHALL BE ASTM A500, GRADE C, FY=46 KSI.
7. SHOP AND FIELD CONNECTIONS:
   BOLTS: 3/4" DIAMETER ASTM A325–N UNLESS NOTED OTHERWISE.
   WELDS: E70XX ELECTRODES
8. SIMPLE BEAM BOLTED CONNECTIONS SHALL BE SINGLE ANGLE FRAMED CONNECTION WITH THE FOLLOWING MIN. ROWS OF BOLTS. UNO

W8, W10	2 ROWS
W12, W14	3 ROWS
W16, W18	4 ROWS
W21, W24	5 ROWS
W27, W30	6 ROWS
W33, W36	7 ROWS

SEE TYPICAL DETAIL 7 DRAWING 7020Y
ANY VARIATION FROM THE ABOVE SCHEDULE MUST BE APPROVED BY THE ENGINEER.

9. THE METHOD TO BE USED FOR TIGHTENING BOLTS SHALL BE TURN–OF–NUT–TIGHTENING.

11. SHEAR STUDS SHALL BE 3/4" DIAMETER HEAD STEEL STUDS IN ACCORDANCE WITH ASTM A108, GRADE 1015 OR 1020, COLD FINISH CARBON STEEL WITH DIMENSIONS COMPLYING WITH ASTM SPECIFICATIONS AND SHALL BE INSTALLED WITH WELDING GUNS INTENDED FOR THAT PURPOSE. PROVIDE 5" LONG STUDS AT 1'–0" ON CENTER ON ALL BEAMS

12. CLEAN STEEL BY COMMERCIAL BLAST IN ACCORDANCE WITH SSPC SP6 AND PAINT AS PER SPECIFICATION No. 05120. TOUCH UP WELDS AND BOLTED CONNECTIONS IN THE FIELD WITH SAME OR COMPATIBLE PAINT. STEEL THAT WILL RECEIVE FIREPROOFING SHALL NOT BE PAINTED.

Structural notes from drawings

Outline

- Thesis Goals
- **Structural Depth (MAE Requirement)**
- Construction Management Breadth
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Steel Optimization

- ¾" shear studs spaced 1' o.c. on all beams
- All beams designed non-compositely
- Redesign using these shear studs already in place

Original Design

Size	# of studs / ft	linear feet	plf	Price/ft	Total wt	Total Price
W24x55	1	3600	55	$71.41	198000	$ 257,076.00
W12x26	1	720	26	$36.23	18720	$ 26,085.60
				∑ =	216720	$ 283,161.60

New Design

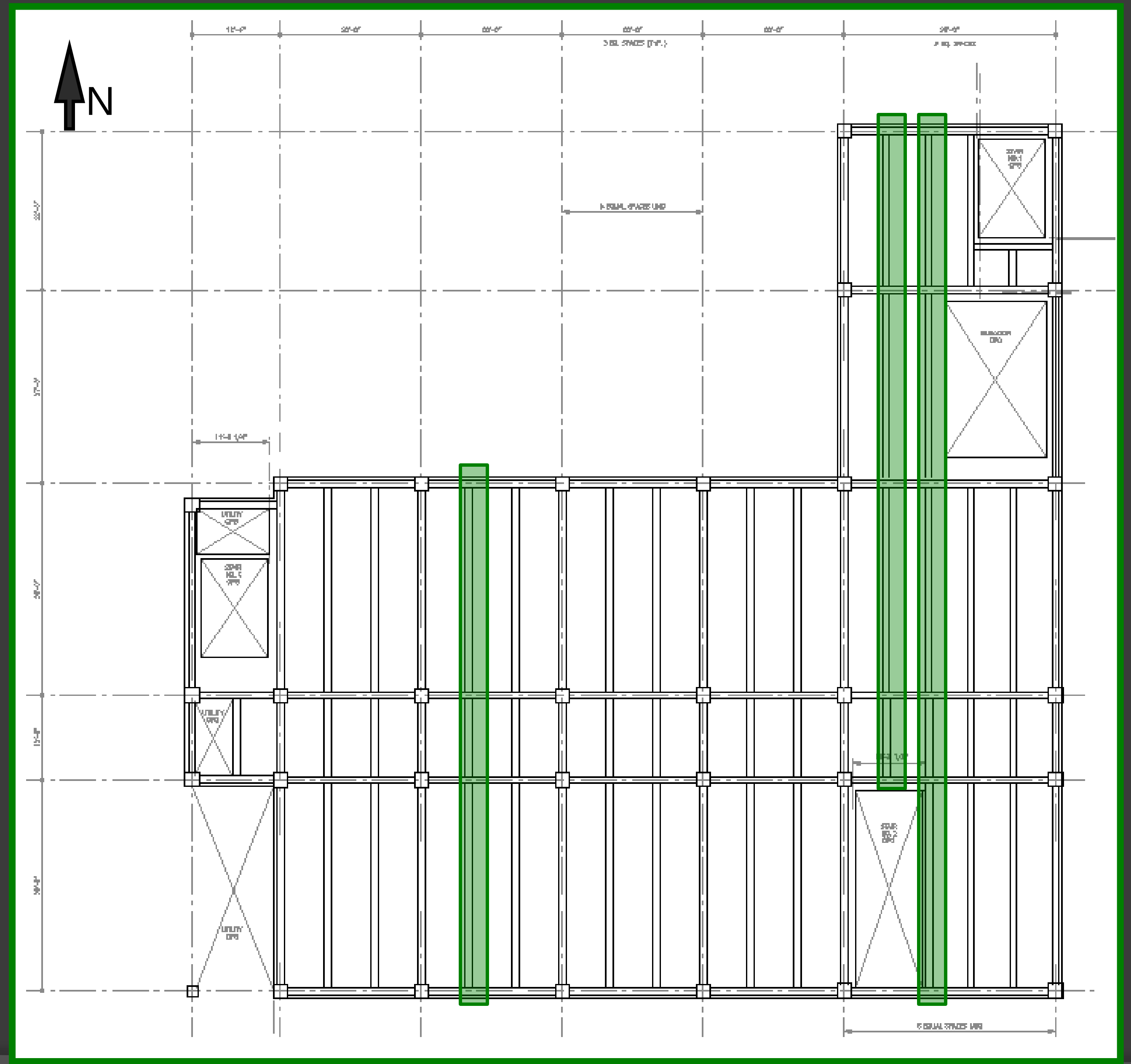
Size	# of studs / ft	linear feet	plf	Price/ft	Total wt	Total Price
W16x31	1	3600	31	$42.13	111600	$ 151,668.00
W12x14	1	720	14	$24.08	10080	$ 17,337.60
				∑ =	121680	$ 169,005.60

Total Weight Savings: 95,040 lbs

Total Cost Savings: $114,156

Gravity Design

- Loads
- Gravity Beams



Floor Dead Loads above Ground Floor	
7½” slab on 2VLI18 Deck (NWC)	82 psf
Equipment Pads (NWC)	50 psf
Steel Framing	18 psf
MEP	20 psf
Partitions	10 psf
Total	180 psf
Roof Dead Load	
6” slab on 2VLI18 Deck (NWC)	63 psf
Equipment Pads (NWC)	50 psf
Steel Framing	18 psf
MEP	20 psf
Roofing	4 psf
Misc Dead	5 psf
Total	160 psf

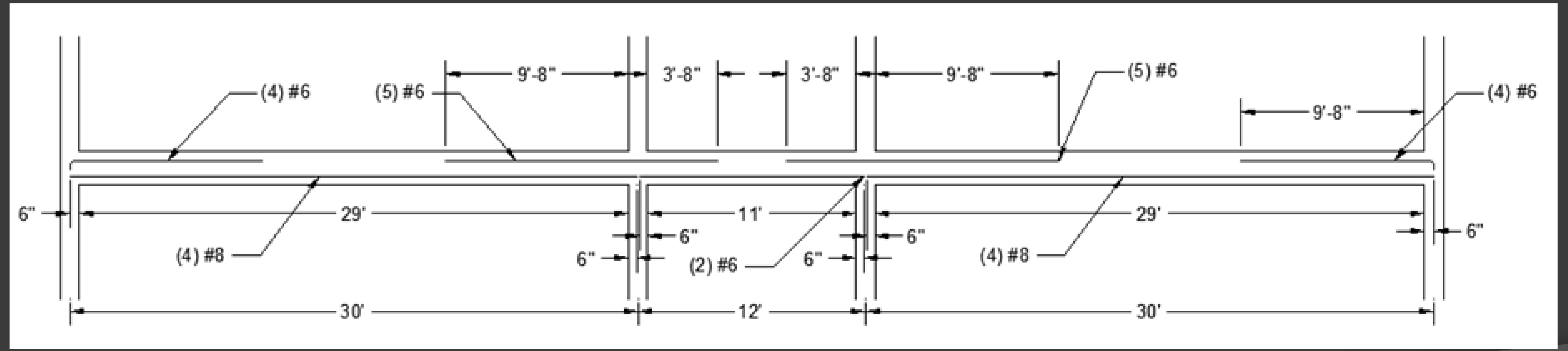
Live Loads	
Floor Live Load	200 psf
Roof Live Load	100 psf

Gravity Design

- Loads
- Gravity Beams

- 6” slab based on worst beam spacing
- All beams are 12x22 for constructability
- Gravity beams use only #6 and #8 bars
- Controlling load case: 1.2D + 1.6L

Concrete framing plan

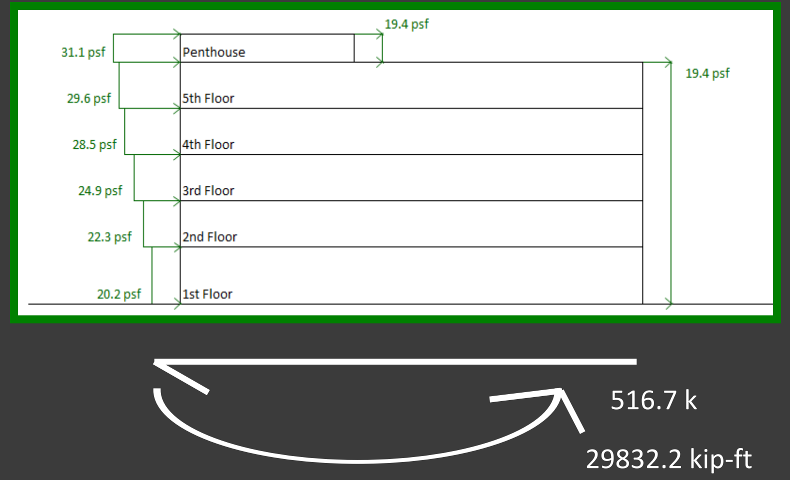


Detailing for gravity beam

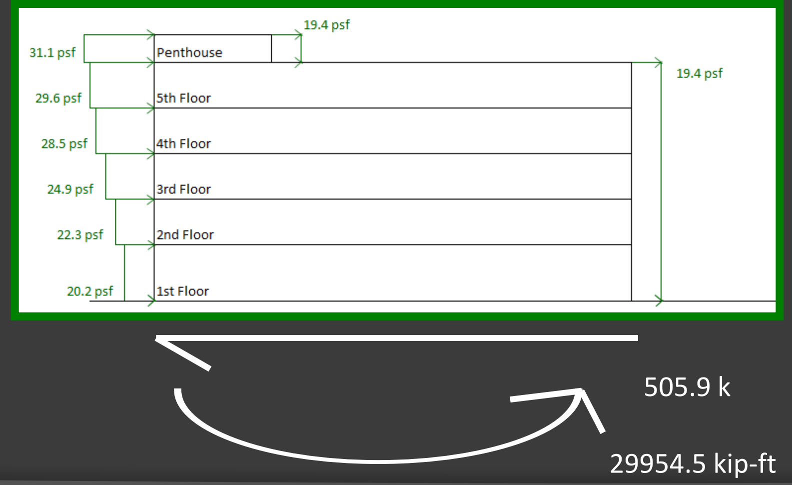
Lateral Design

- Lateral Loads / Recalculation of earthquake loads

East-West Wind Loads



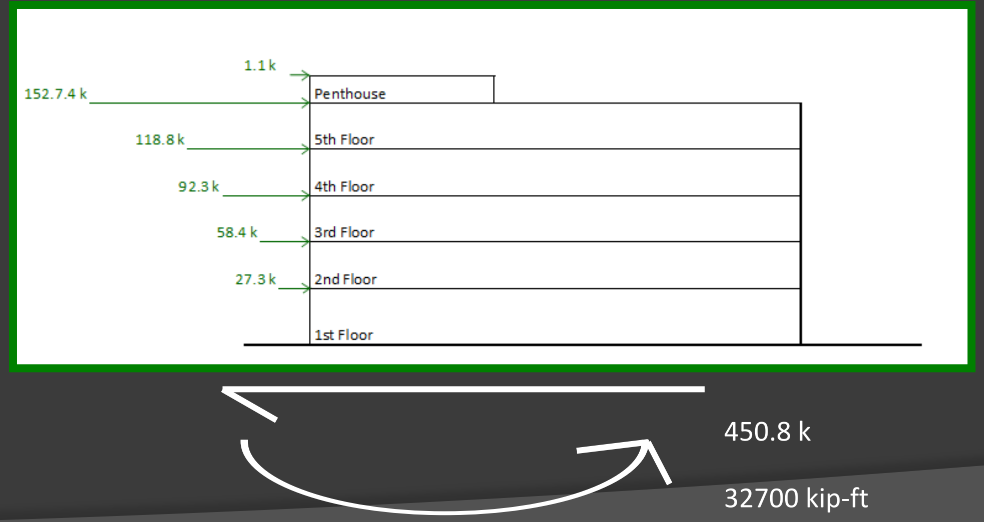
North-South Wind Loads



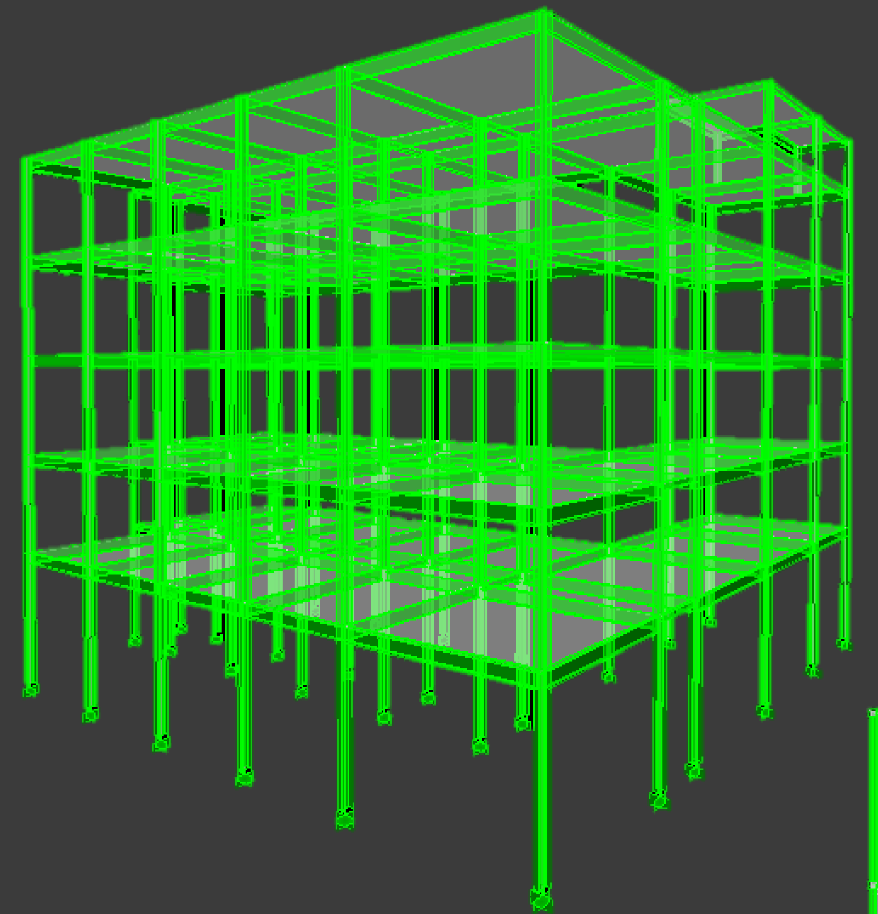
New Earthquake Loads

Floor	Total Weight (k)
1	3076
2	3025
3	3144
4	3134
5	2876
ROOF	2828
Penthouse	18.6

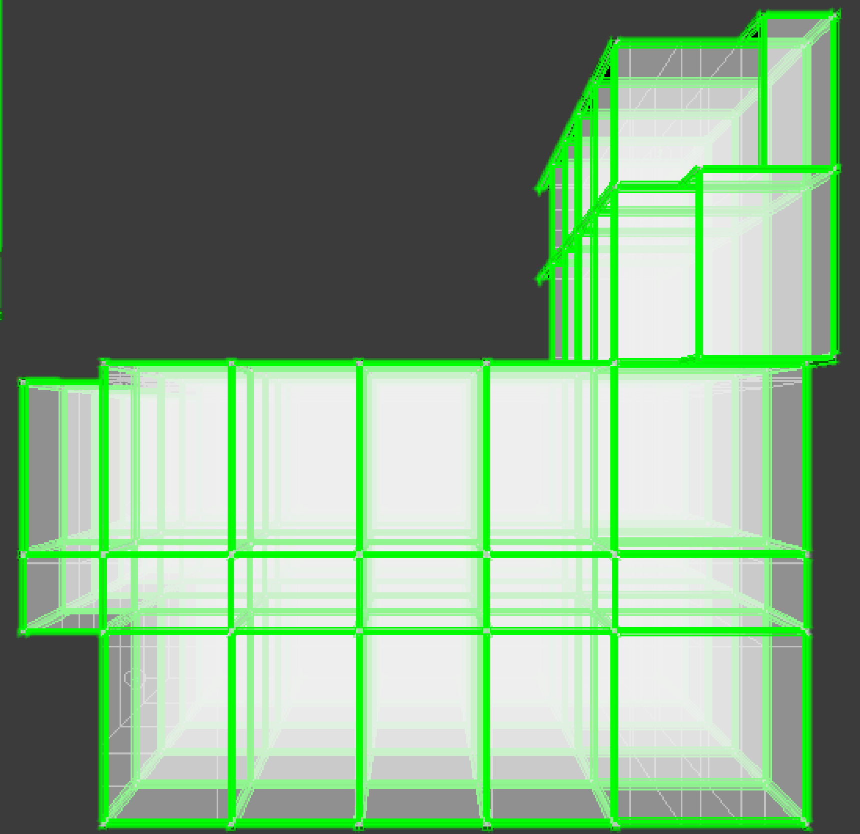
- Design Category C
- Must use at least Intermediate Moment Frame
- R value of 5



ETABS Model



3D extruded view of ETABS model



A birds eye view of ETABS model

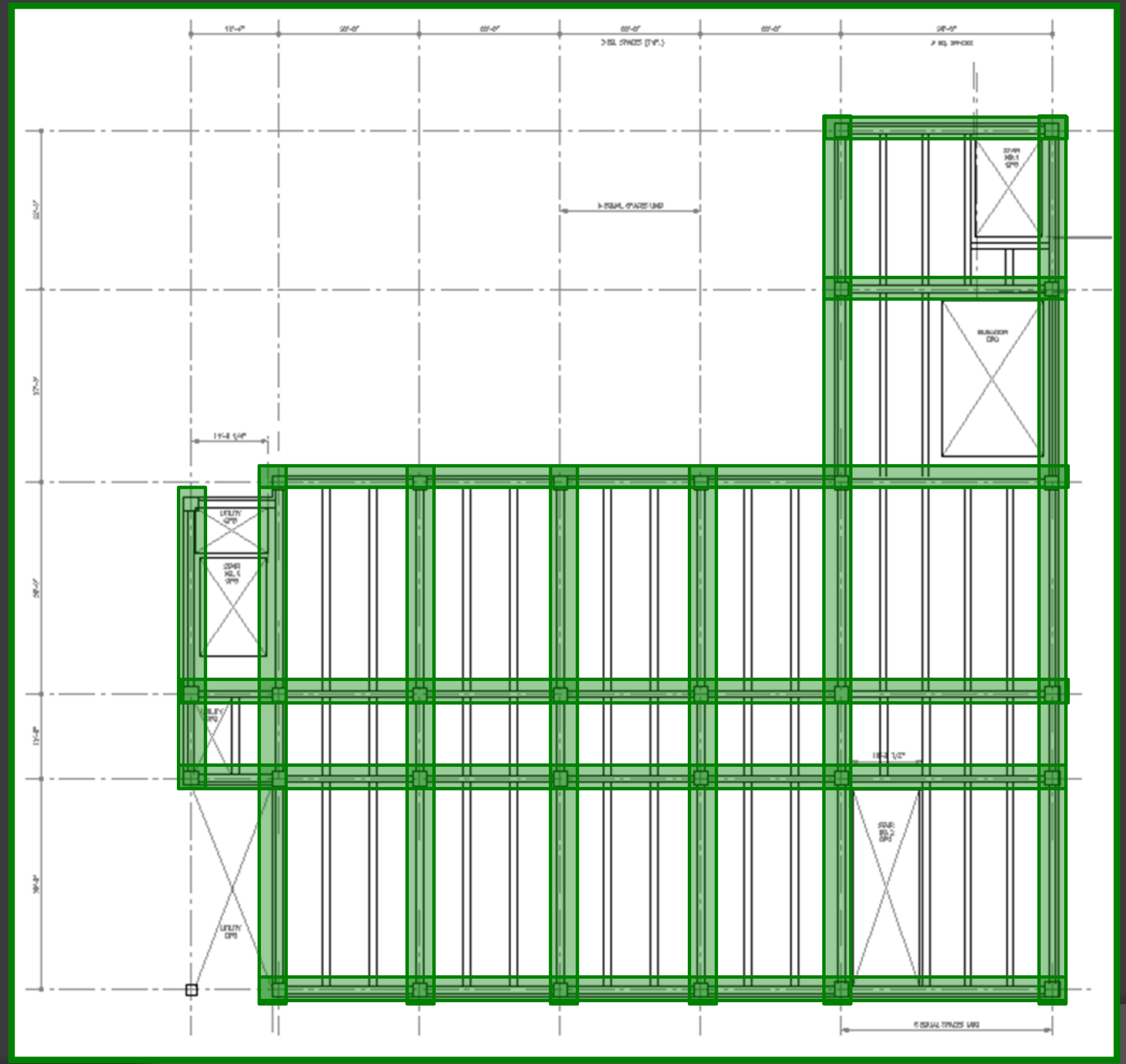
- Rigid end zones are applied to all beams with a reduction of 50%
- The slabs are considered to act as rigid diaphragms
- All self weights were applied as an additional area mass at the center of gravity of the diaphragms
- P-Δ effects are considered
- The moment of inertia for columns = 0.7Ig
- The moment of inertia for beams = 0.35Ig

Lateral Design

- Lateral Loads / Recalculation of earthquake loads
- ETABS model

Intermediate Moment Frame

- Positive moment capacity at supports must be at least 1/3 negative moment capacity
- Positive and negative moment capacity must be at least 1/5 the maximum moment capacity throughout entire length



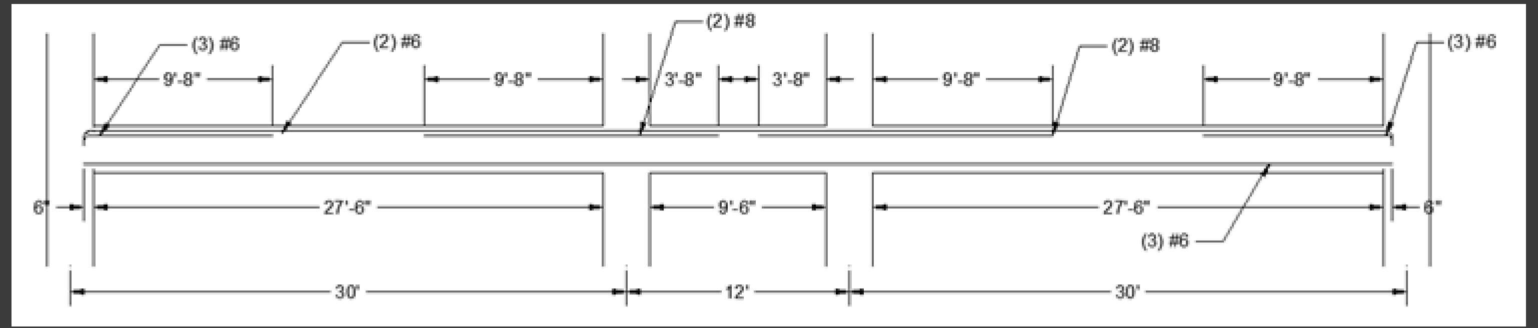
Concrete framing plan

Lateral Design

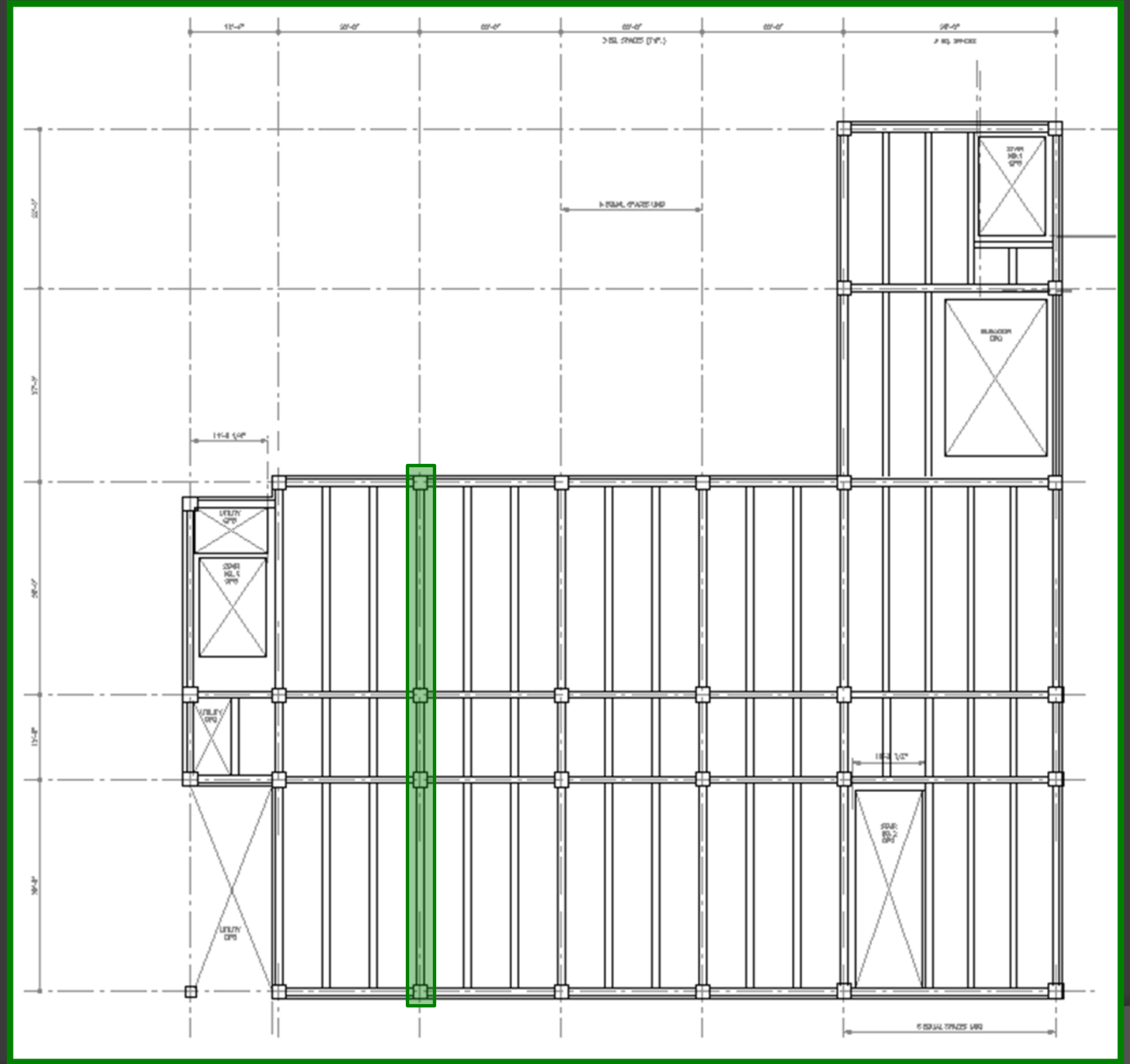
- Lateral Loads / Recalculation of earthquake loads
- ETABS model
- Lateral design

BEAMS 2/3/4/5									
Trib Width=	6.7 ft.		b = 12		h = 30		d = 27.5		
	Beam 1			Beam 2			Beam 3		
	ext. support	midspan	int. support	int. support	midspan	int. support	int. support	midspan	int. support
Span	30 -	-		12 -	-		30 -	-	
l_n (ft) =	27.5	27.5	18.5	18.5	9.5	18.5	18.5	27.5	27.5
w_u (klf) =	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
$w_u l_n^2$ =	2218	2218	1004	1004	265	1004	1004	2218	2218
C_m =	-0.0417	0.0714	-0.100	-0.0909	0.0625	-0.0909	-0.1000	0.0714286	-0.0417
$M_{uG} = C_m W_u L_n^2$ =	-92.4	158.5	-100.4	-91.3	16.5	-91.3	-100.4	158.5	-92.4
M_{uE} =	-150.6	0.0	-144.5	-282.3	0.0	-282.3	-144.5	0.0	-150.6
M_{utot} =	-243.0	158.5	-244.9	-373.6	16.5	-373.6	-244.9	158.5	-243.0
b_{eff} (in) =	39.5	12	55.5	55.5	12	55.5	55.5	12	40
$A_{s(req'd)}$ (in.) =	2.060865167	1.311277	2.107409095	3.2146967	0.136925	3.2146967	2.10740909	1.3112769	2.06086517
a =	2.588235294	1.294118	3.352941176	3.35294118	1.294118	3.35294118	3.35294118	1.2941176	2.58823529
t-beam?	NO	NO	NO	NO	NO	NO	NO	NO	NO
$A_{s(prov'd)}$ (in.) =	2.2 (5) #6	1.32 (3) #6	2.46 (2)#6, (2)#8	2.46 (2)#6, (2)#8	1.32 (3) #6	2.46 (2)#6, (2)#8	2.46 (2)#6, (2)#8	1.32 (3) #6	2.2 (5) #6
A_s' (in.) =	1.32 (3) #6	0.88 (2) #6	1.32 (3) #6	1.32 (3) #6	0.88 (2) #6	1.32 (3) #6	1.32 (3) #6	0.88 (2) #6	1.32 (3) #6
Φ=	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
ΦMn =	356.1	205.3	413.4	413.4	205.3	413.4	413.4	205.3	356.1
OK?	OK	OK	OK	OK	OK	OK	OK	OK	OK
ρ =	0.0067	0.0040	0.0075	0.0075	0.0040	0.0075	0.0075	0.0040	0.0067
OK?	OK	OK	OK	OK	OK	OK	OK	OK	OK
capacity ratio:	0.683	0.772	0.592	0.904	0.081	0.904	0.592	0.772	0.683

Calcs for lateral beam



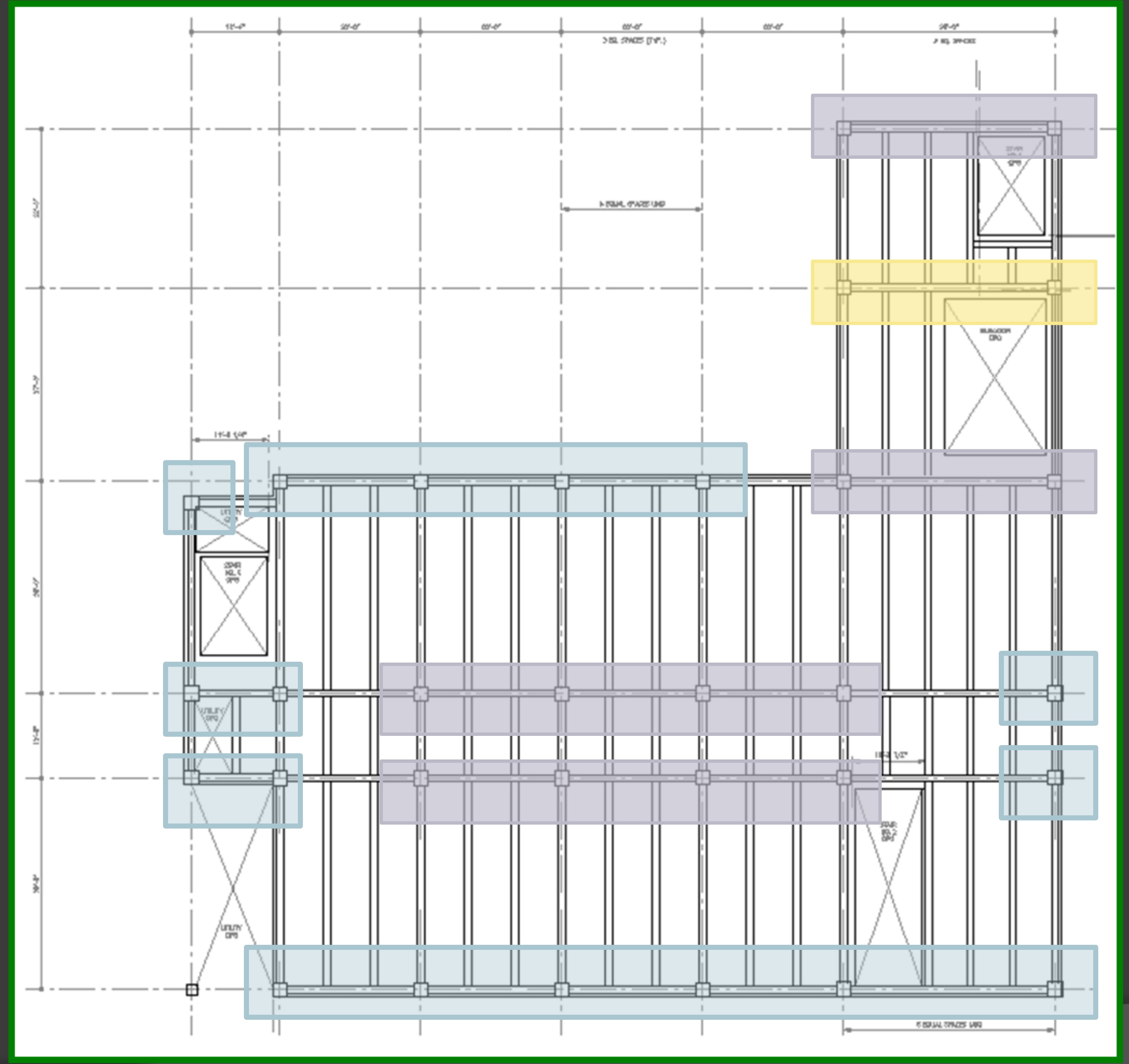
Detailing for lateral beam



Concrete framing plan

Column Design

- All columns are 30x30 for ease of construction
- Controlling Load Case: 1.2D+1.0W+L+.5S
- Three rebar configurations:
  - (12) #8
  - (12) #10
  - (16) #10



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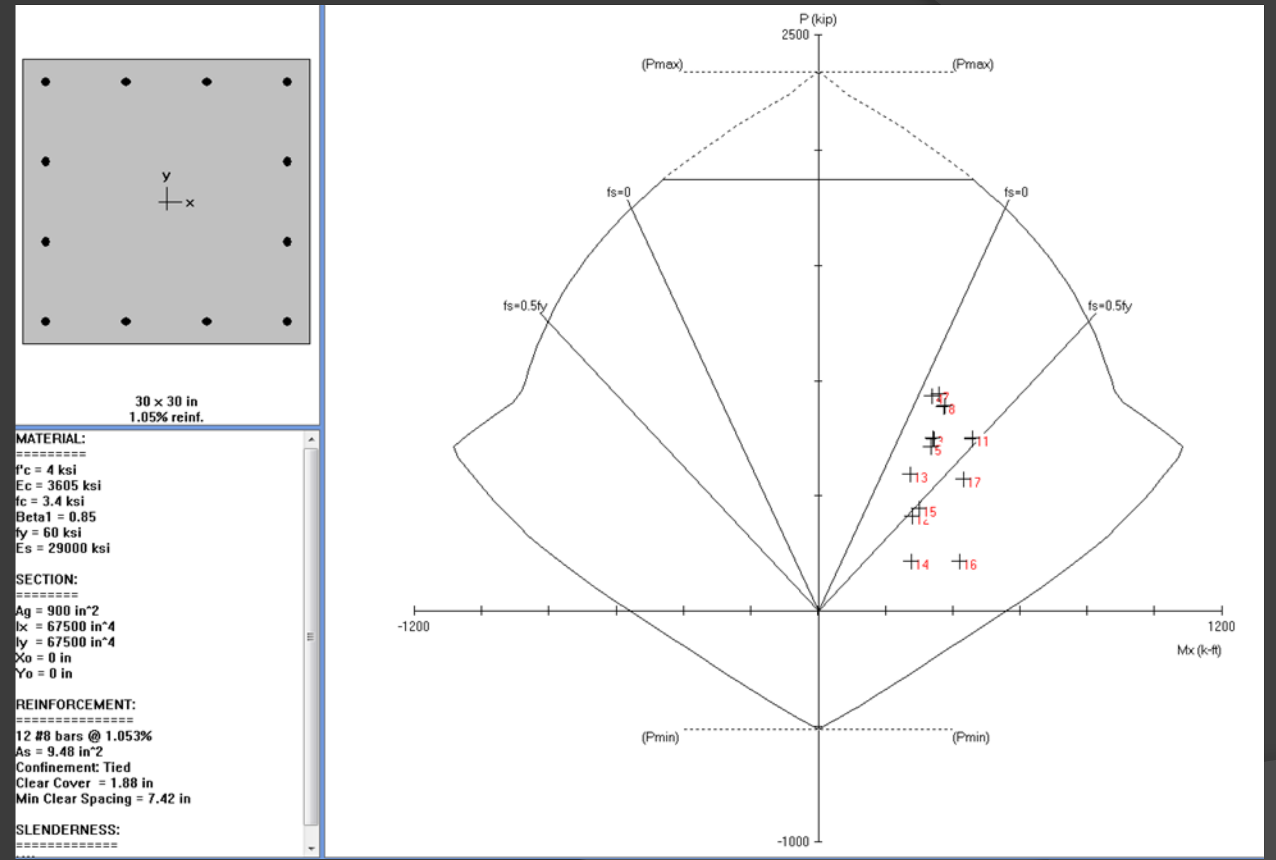

spColumn Output for the columns shaded in purple

Drift Checks

- Wind loads were checked against h/400
- Earthquake loads were checked against .015 for category III buildings
- All drifts acceptable

Drift (in.)							
Floor	Height (ft)	WIND ANALYSIS				Allow	Pass?
		WIND - E/W		WIND - N/S			
		x-dir	y-dir	x-dir	y-dir		
Penthouse	15	0.07	0.04	0.12	0.09	0.45	YES
Story 5	18	0.19	0.08	0.10	0.20	0.54	YES
Story 4	18	0.30	0.13	0.14	0.32	0.54	YES
Story 3	18	0.40	0.16	0.20	0.43	0.54	YES
Story 2	18	0.46	0.18	0.24	0.51	0.54	YES
Story 1	24	0.44	0.12	0.23	0.66	0.72	YES

Drift (in.)							
Floor	Height (ft)	EARTHQUAKE ANALYSIS				Allow	Pass?
		EQ - E/W		EQ - N/S			
		x-dir	y-dir	x-dir	y-dir		
Penthouse	15	0.19	0.05	0.06	0.06	2.7	YES
Story 5	18	0.59	0.10	0.14	0.61	3.24	YES
Story 4	18	0.93	0.17	0.26	0.95	3.24	YES
Story 3	18	1.19	0.21	0.30	1.17	3.24	YES
Story 2	18	1.27	0.22	0.33	1.27	3.24	YES
Story 1	24	0.85	0.13	0.22	0.87	4.32	YES

Lateral Design

- Lateral Loads / Recalculation of earthquake loads
- ETABS model
- Lateral design
- Drift checks

Foundation Impact

- Each pile has a 100-ton capacity

Column	P D+.75(.6W)+.75L+.75S	P D+L	Existing Cassions in Steel Design	Needed Cassions in Conc Design
A.2	345.5	356.3	3	3
A.3	657.5	712.5	4	4
A.4	658.1	712.5	4	4
A.5	659.1	712.5	4	4
A.6	820.6	890.7	4	5
A.7	507.3	534.4	4	4
B.1	137.2	89.1	3	3
B.2	584.8	587.8	4	4
B.3	954.0	997.5	4	5
B.4	950.3	997.5	4	5
B.5	954.0	997.5	4	5
B.6	1183.8	1246.9	6	7
B.7	736.2	748.2	6	6
C.1	340.6	311.8	3	3
C.2	788.2	810.6	4	5
C.3	954.0	997.5	4	5
C.4	950.3	997.5	4	5
C.5	954.0	997.5	4	5
C.6	1184.7	1246.9	6	7
C.7	737.2	748.2	6	6
C9.1	184.4	193.1	3	3
D.2	498.6	534.4	4	4
D.3	657.5	712.5	4	4
D.4	658.1	712.5	4	4
D.5	658.9	712.5	4	4
D.6	1185.5	1291.6	6	7
D.7	865.0	935.2	6	6
E.6	829.1	890.7	4	5
E.7	829.1	890.7	4	5
F.6	385.8	400.9	4	4
F.7	385.8	400.9	4	4
		Σ =	132	145

A simplified approach to the number of piles needed for each column.

Lateral Design

- Lateral Loads / Recalculation of earthquake loads
- ETABS model
- Lateral design
- Drift checks
- Foundation Impact

Outline

- Thesis Goals
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Cost Analysis

- Cost information for existing structure obtained from Engineers
- Detailed concrete, formwork, and reinforcement takeoffs were done by hand
- RS Means used to obtain unit prices for concrete structure
- Comparison of steel versus concrete cost performed

Original Cost Estimate provided by project engineer

S0004	Structural Steel - Fabricate and Erect	$	6,000,000	$	4,599,899	41,381
S0005	Underground Piping and Utilities	$	430,000	$	534,211	5,108
S0006	Concrete Slabs	$	900,000	$	597,530	6,226

Sum = $5,197,429

Estimated Cost of Concrete Structure

Concrete Structual Element	Total-O&P	Total Price
Concrete	$ 1,810,613.96	$ 2,161,293.70
Finish	$ 3,612.00	$ 5,882.40
Formwork	$ 493,028.65	$ 748,430.13
Reinforcing	$ 1,273,313.64	$ 1,665,788.74
Total	$ 3,072,127.56	$ 3,930,836.88

Cost Analysis

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Formwork	$ 493,028.65	$ 748,430.13
Reinforcing	$ 1,273,313.64	$ 1,665,788.74
Total	$ 3,072,127.56	$ 3,930,836.88

- Cost information for existing structure obtained from Engineers
- Detailed concrete, formwork, and reinforcement takeoffs were done by hand
- RS Means used to obtain unit prices for concrete structure
- Comparison of steel versus concrete cost performed

Concrete is $1,266,592.12 cheaper

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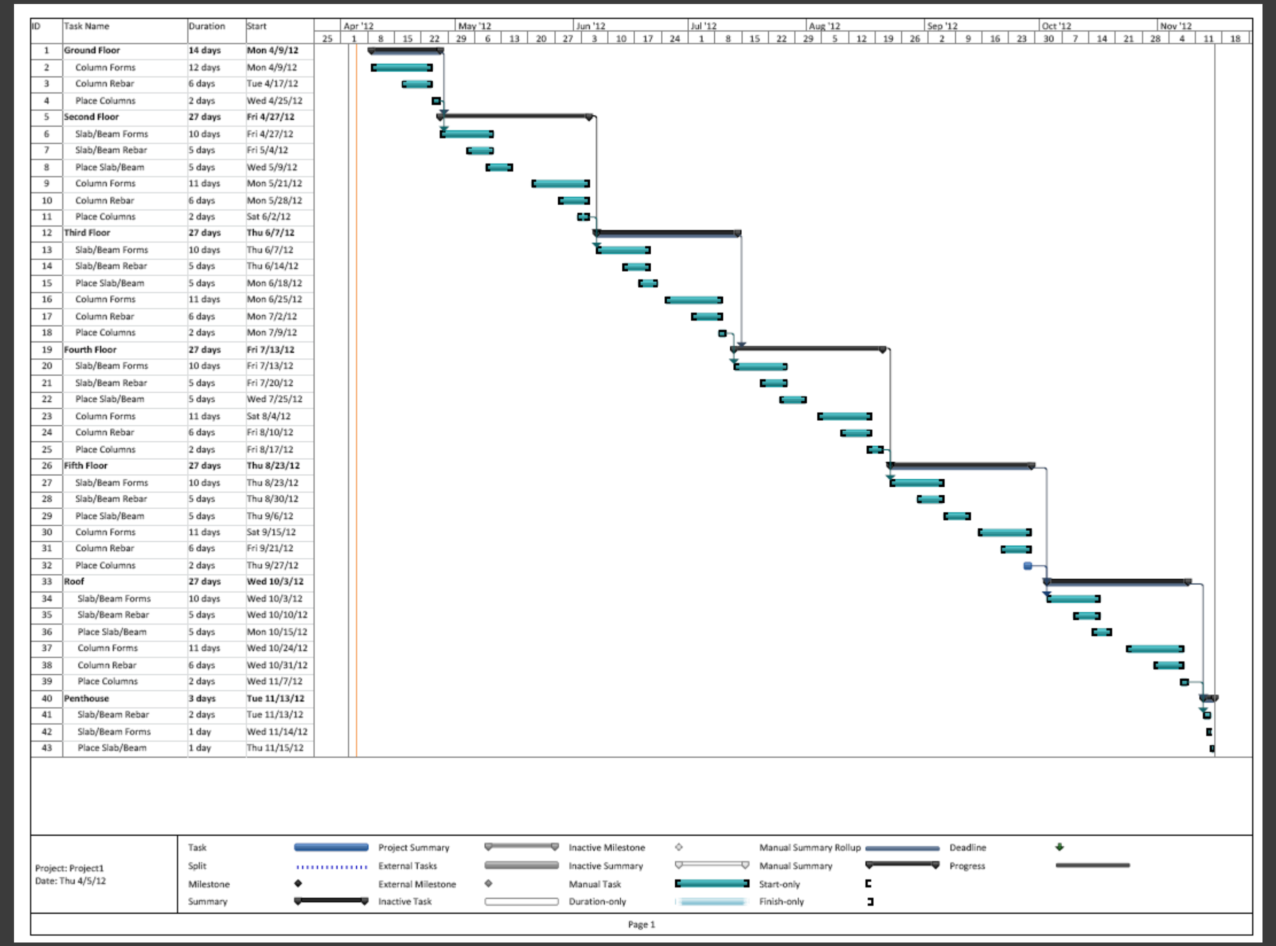
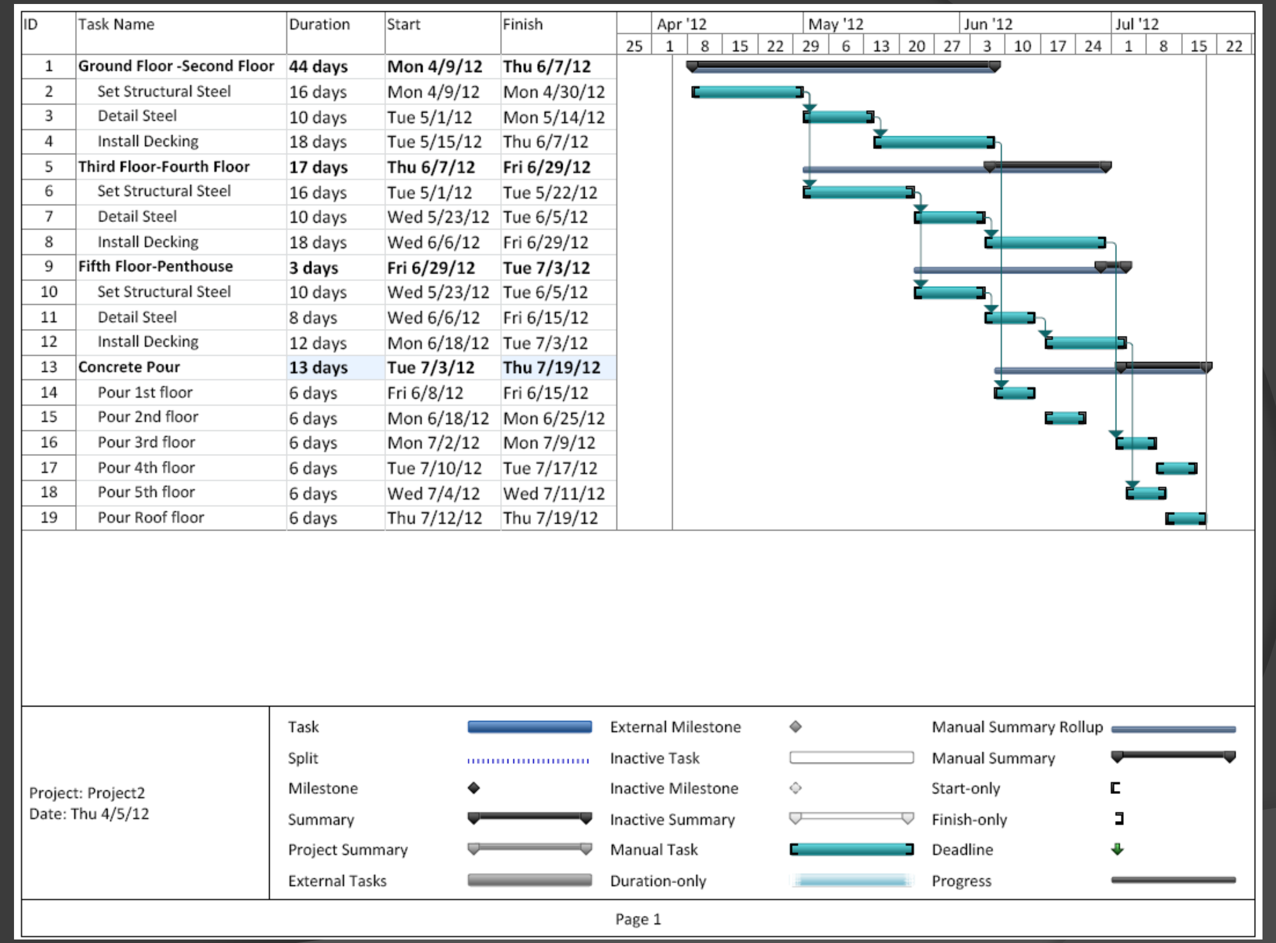
- Schedule Information from RS Means
- One schedule made for each structural system
- Concrete schedule took 107 days while steel took 223 days
- Saving over a hundred days may justify the more expensive structure



Concrete Schedule



Steel Schedule

Conclusions

- The concrete redesign is a viable solution
- The concrete system is significantly cheaper
- A longer construction schedule does pose a significant loss in income for CBD Chemical

Outline

- Thesis Goals
- Structural Depth (MAE Requirement)
- Construction Management Breadth
- **Conclusions**
- Questions / Comments

Questions / Comments

Outline

- Thesis Goals
- Structural Depth (MAE Requirement)
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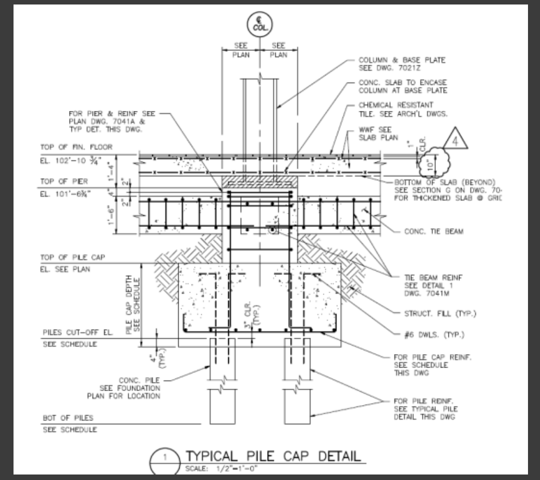
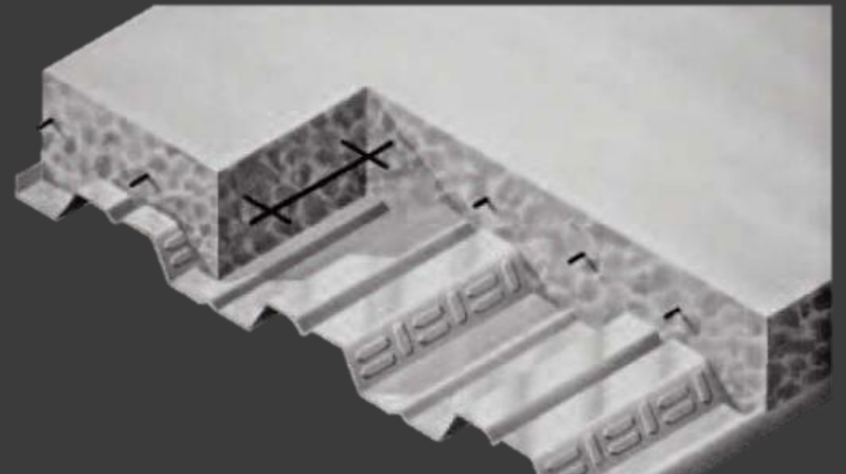
CBD Chemical
Production Building Virginia, USA

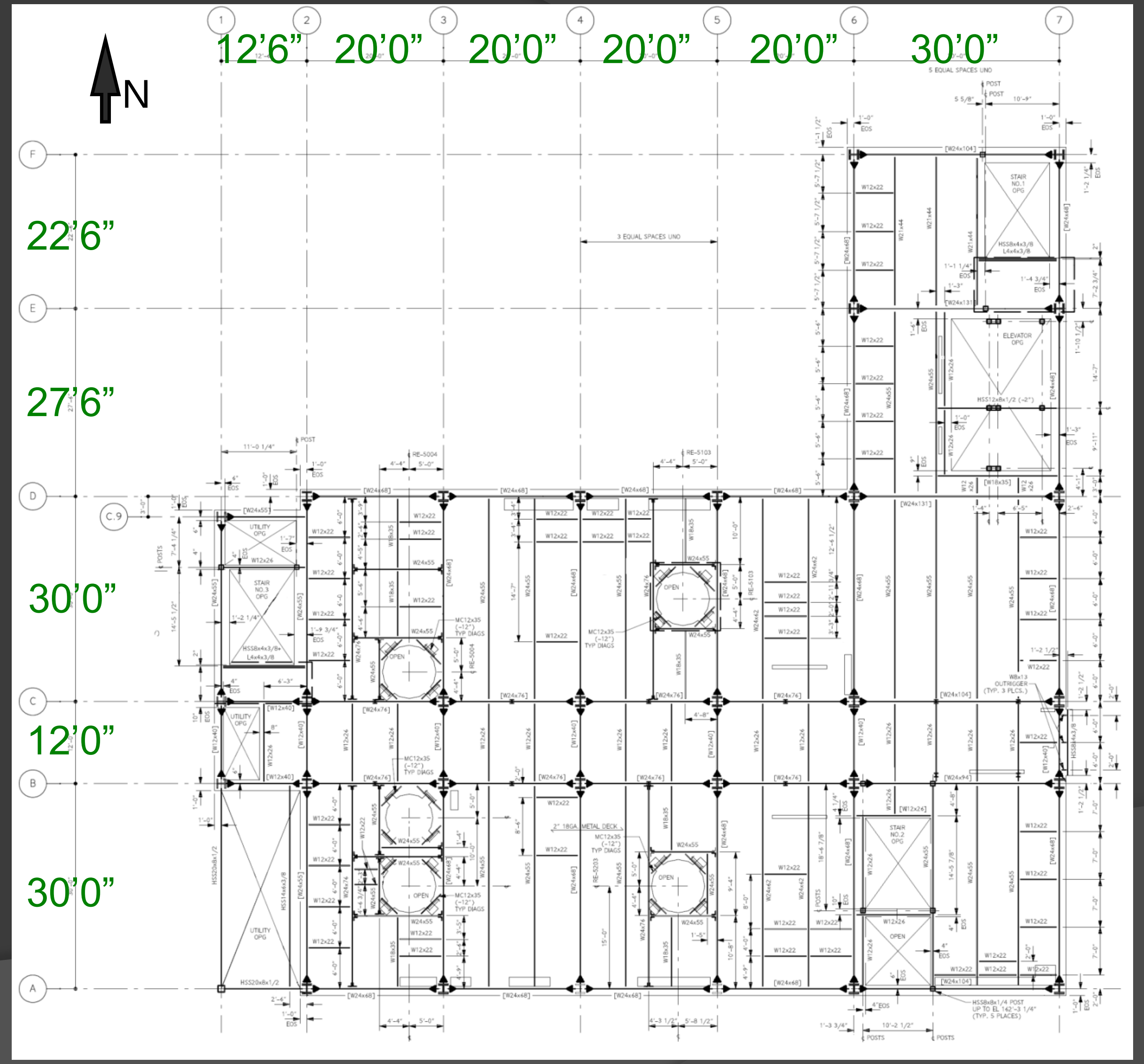
Structural Overview
Framing System

- 12 inch x12 inch precast piles
- Tie beams between each column
- 100-ton capacity each





- 7 ½ inches of normal weight concrete on 3VLI18
- roof has 6 inches of normal weight concrete on 3VLI18



Steel Optimization

- ¾” shear studs spaced 1‘ o.c. on all beams
- All beams designed non-compositely
- Redesign using these shear studs already in place

Original Design

Size	# of studs / ft	linear feet	plf	Price/ft	Total wt	Total Price
W24x55	1	3600	55	$71.41	198000	$ 257,076.00
W12x26	1	720	26	$36.23	18720	$ 26,085.60
				∑ =	216720	$ 283,161.60

New Design

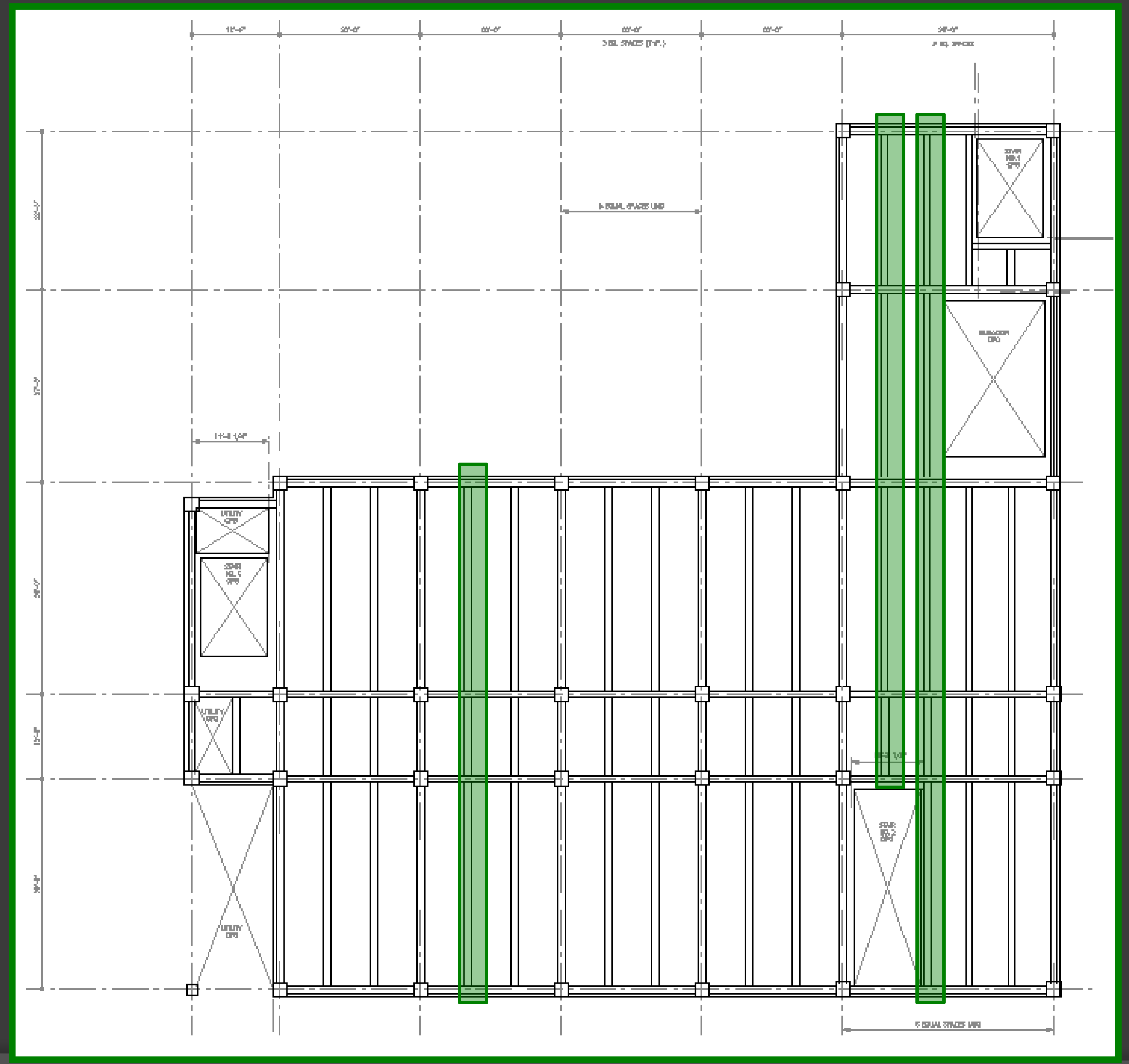
Size	# of studs / ft	linear feet	plf	Price/ft	Total wt	Total Price
W16x31	1	3600	31	$42.13	111600	$ 151,668.00
W12x14	1	720	14	$24.08	10080	$ 17,337.60
				∑ =	121680	$ 169,005.60

Total Weight Savings: 95,040 lbs

Total Cost Savings: $114,156

Gravity Design

- Loads
- Gravity Beams



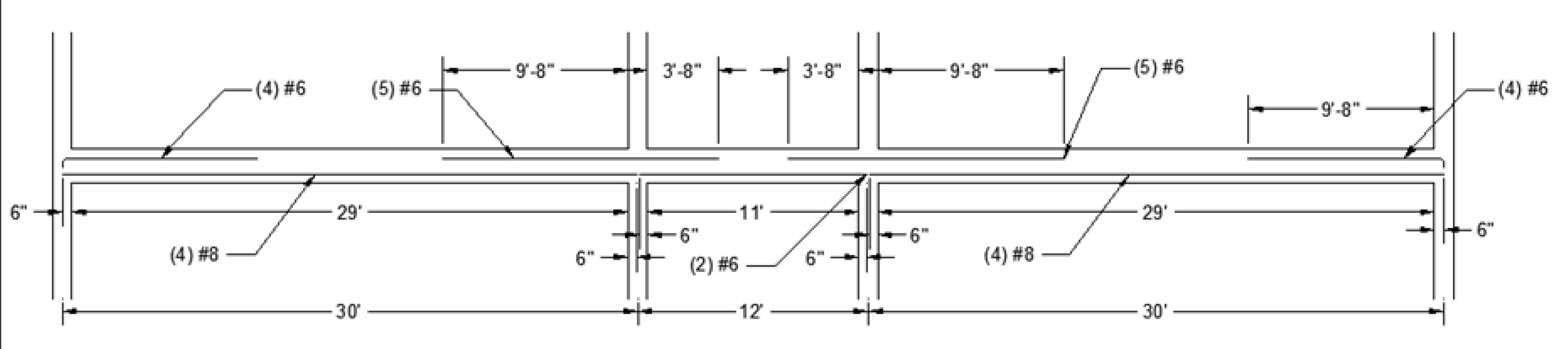
Floor Dead Loads above Ground Floor	
7½” slab on 2VLI18 Deck (NWC)	82 psf
Equipment Pads (NWC)	50 psf
Steel Framing	18 psf
MEP	20 psf
Partitions	10 psf
Total	180 psf
Roof Dead Load	
6” slab on 2VLI18 Deck (NWC)	63 psf
Equipment Pads (NWC)	50 psf
Steel Framing	18 psf
MEP	20 psf
Roofing	4 psf
Misc Dead	5 psf
Total	160 psf

Live Loads	
Floor Live Load	200 psf
Roof Live Load	100 psf

Gravity Design

- Loads
- Gravity Beams

- 6" slab based on worst beam spacing
- All beams are 12x22 for constructability
- Gravity beams use only #6 and #8 bars
- Controlling load case: 1.2D + 1.6L



Lateral Design

- Lateral Loads / Recalculation of earthquake loads

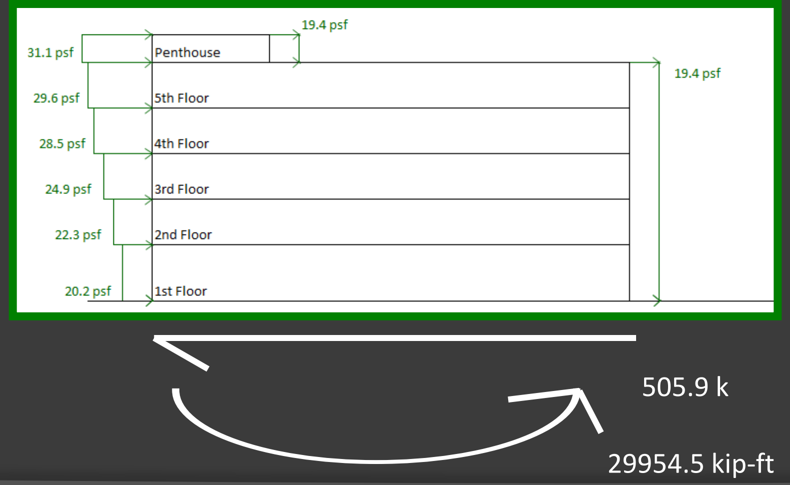
East-West Wind Loads

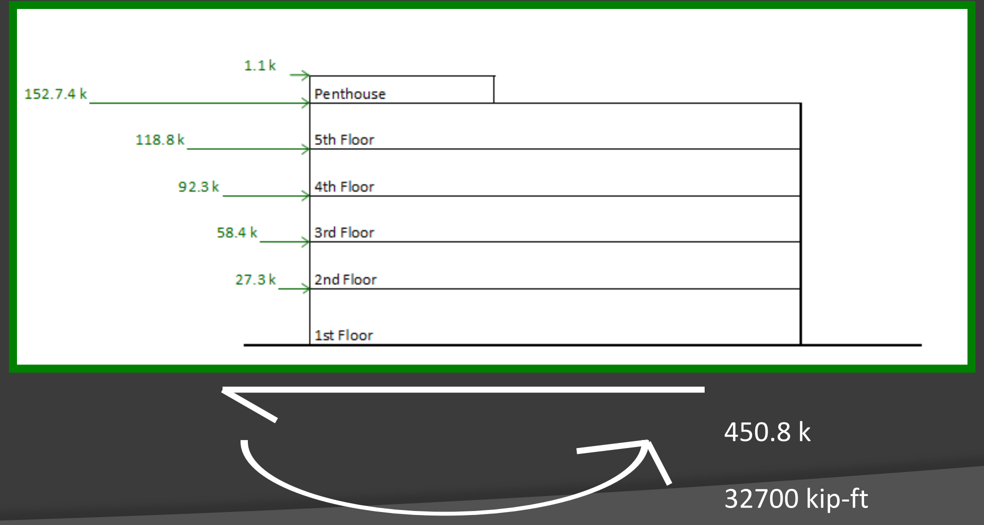
New Earthquake Loads

Floor	Total Weight (k)
1	3076
2	3025
3	3144
4	3134
5	2876
ROOF	2828
Penthouse	18.6

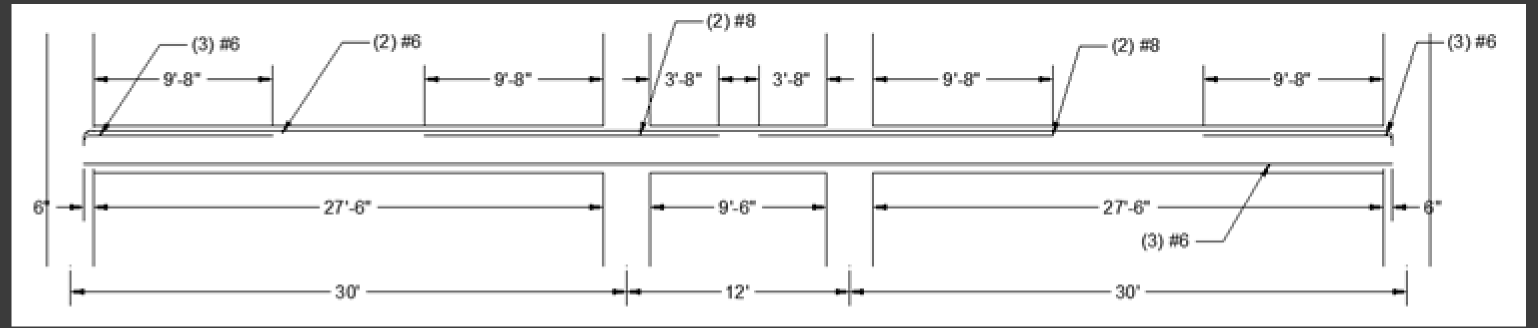
- Design Category C
- Must use at least Intermediate Moment Frame
- R value of 5

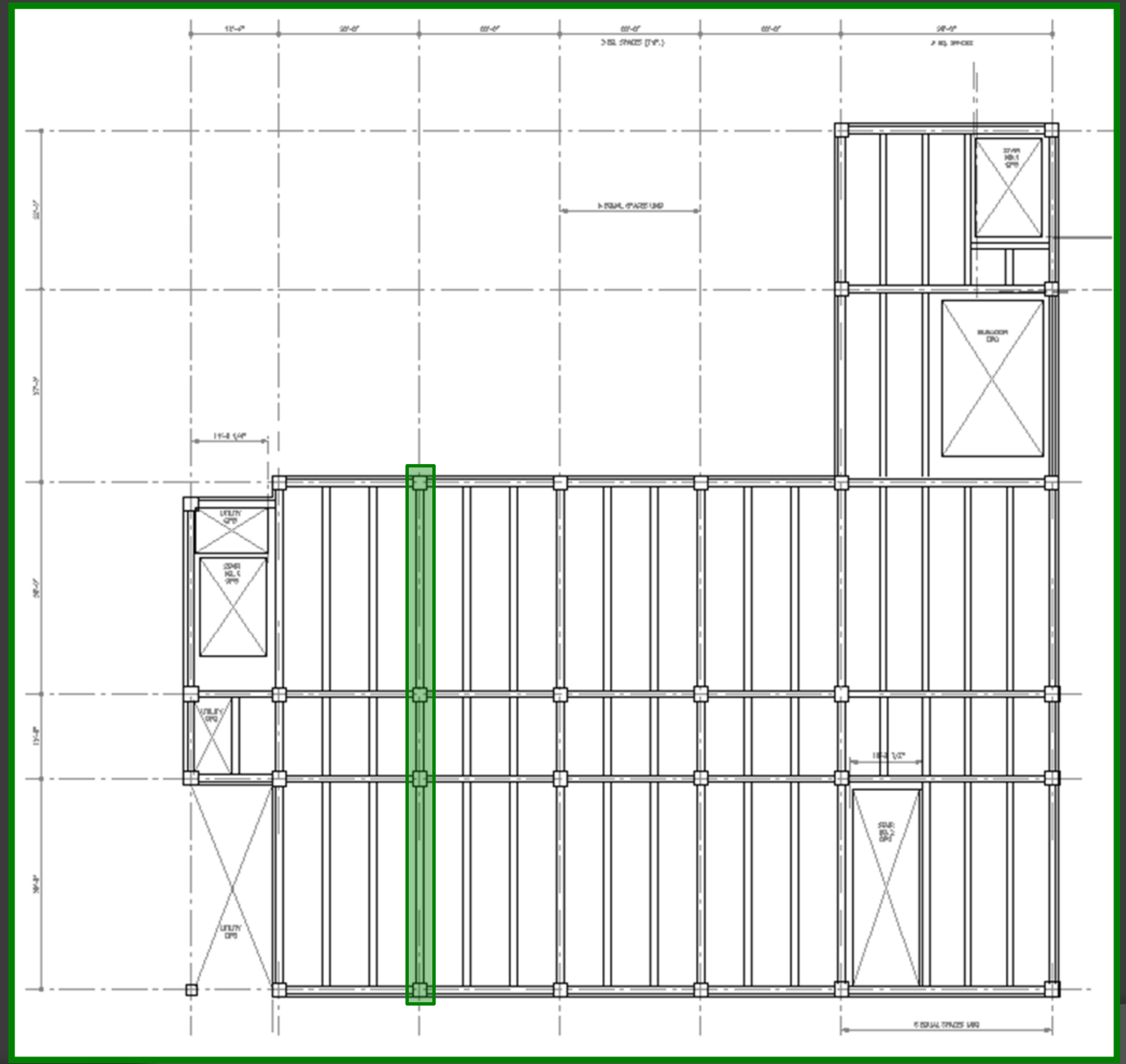
North-South Wind Loads





BEAMS 2/3/4/5									
Trib Width=	6.7 ft.		b = 12		h = 30		d = 27.5		
	Beam 1			Beam 2			Beam 3		
	ext. support	midspan	int. support	int. support	midspan	int. support	int. support	midspan	int. support
Span	30 -	-		12 -	-		30 -	-	
l_n (ft) =	27.5	27.5	18.5	18.5	9.5	18.5	18.5	27.5	27.5
w_u (klf) =	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
$w_u l_n^2$ =	2218	2218	1004	1004	265	1004	1004	2218	2218
C_m =	-0.0417	0.0714	-0.100	-0.0909	0.0625	-0.0909	-0.1000	0.0714286	-0.0417
$M_{ud} = C_m W_u L_n^2$ =	-92.4	158.5	-100.4	-91.3	16.5	-91.3	-100.4	158.5	-92.4
M_{ue} =	-150.6	0.0	-144.5	-282.3	0.0	-282.3	-144.5	0.0	-150.6
M_{utot} =	-243.0	158.5	-244.9	-373.6	16.5	-373.6	-244.9	158.5	-243.0
b_{eff} (in) =	39.5	12	55.5	55.5	12	55.5	55.5	12	40
$A_{s(req'd)}$ (in.) =	2.060865167	1.311277	2.107409095	3.2146967	0.136925	3.2146967	2.10740909	1.3112769	2.06086517
a =	2.588235294	1.294118	3.352941176	3.35294118	1.294118	3.35294118	3.35294118	1.2941176	2.58823529
t-beam?	NO	NO	NO	NO	NO	NO	NO	NO	NO
$A_{s(prov'd)}$ (in.) =	2.2 (5) #6	1.32 (3) #6	2.46 (2)#6, (2)#8	2.46 (2)#6, (2)#8	1.32 (3) #6	2.46 (2)#6, (2)#8	2.46 (2)#6, (2)#8	1.32 (3) #6	2.2 (5) #6
A_s' (in.) =	1.32 (3) #6	0.88 (2) #6	1.32 (3) #6	1.32 (3) #6	0.88 (2) #6	1.32 (3) #6	1.32 (3) #6	0.88 (2) #6	1.32 (3) #6
Φ =	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
ΦMn =	356.1	205.3	413.4	413.4	205.3	413.4	413.4	205.3	356.1
OK?	OK	OK	OK	OK	OK	OK	OK	OK	OK
ρ =	0.0067	0.0040	0.0075	0.0075	0.0040	0.0075	0.0075	0.0040	0.0067
OK?	OK	OK	OK	OK	OK	OK	OK	OK	OK
capacity ratio:	0.683	0.772	0.592	0.904	0.081	0.904	0.592	0.772	0.683



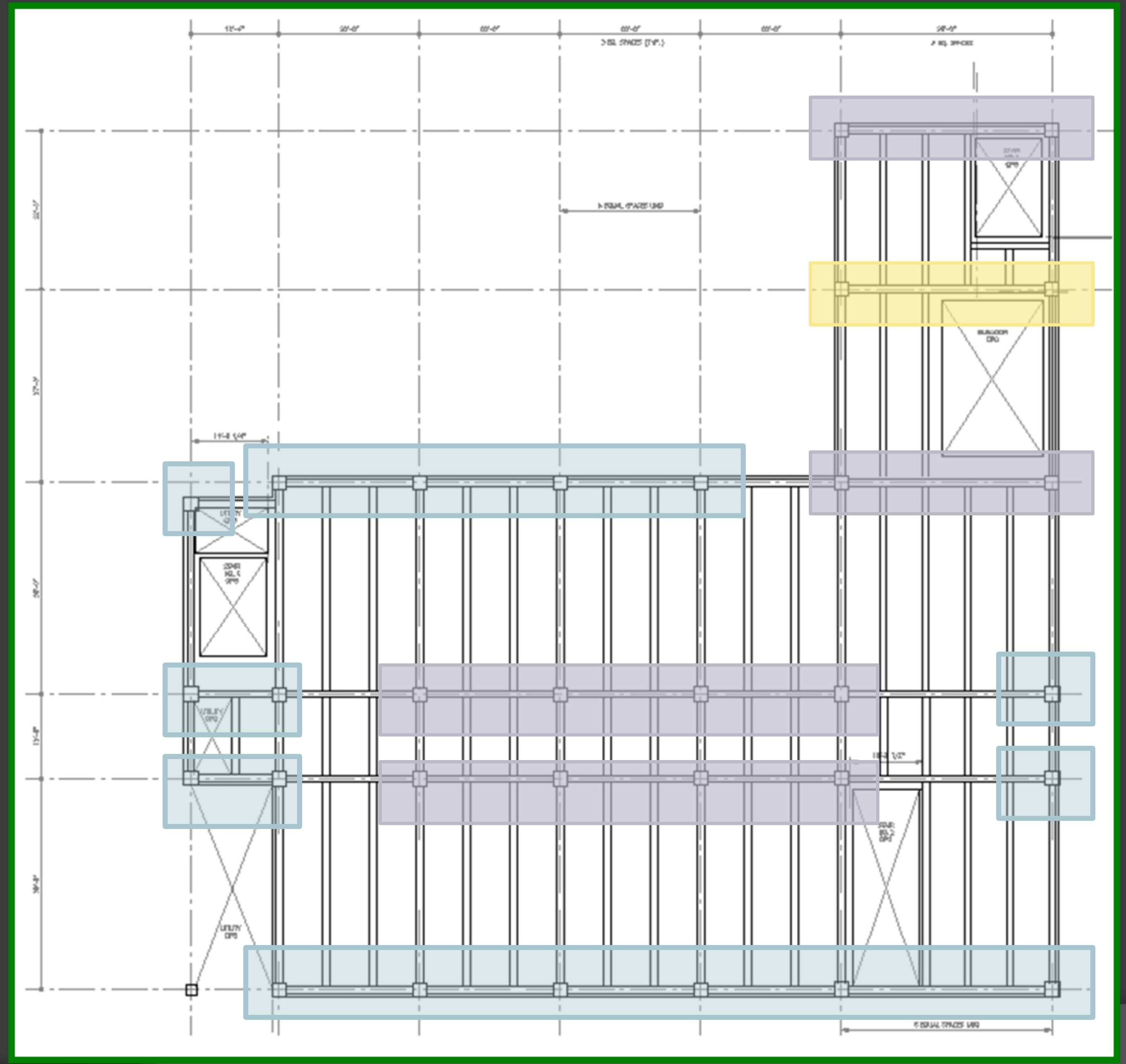


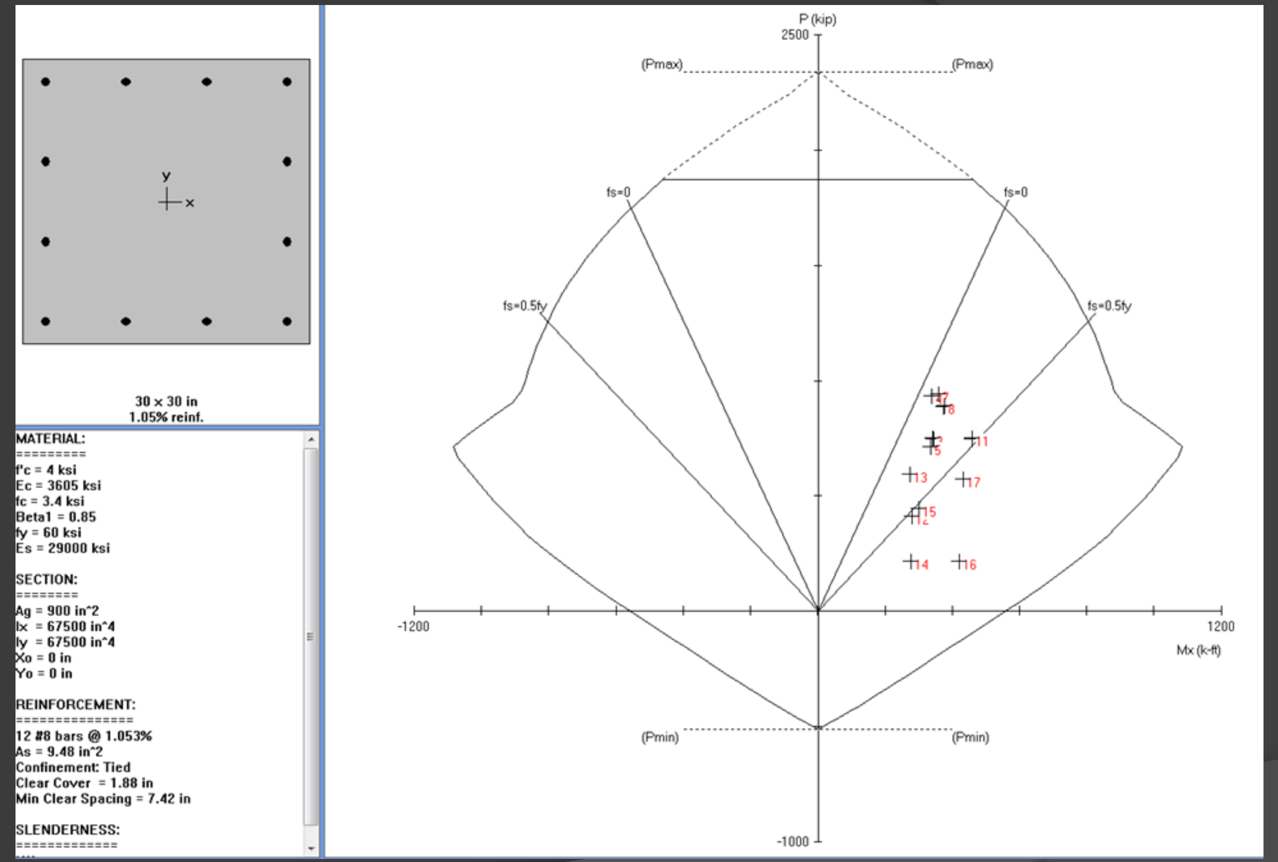
Lateral Design

- Lateral Loads / Recalculation of earthquake loads
- ETABS model
- Lateral design

Column Design

- All columns are 30x30 for ease of construction
- Controlling Load Case: 1.2D+1.0W+L+.5S
- Three rebar configurations:
  - (12) #8
  - (12) #10
  - (16) #10


Concrete framing plan



spColumn Output for the columns shaded in purple

Drift Checks

- Wind loads were checked against h/400
- Earthquake loads were checked against .015 for category III buildings
- All drifts acceptable

Drift (in.)							
Floor	Height (ft)	WIND ANALYSIS				Allow	Pass?
		WIND - E/W		WIND - N/S			
		x-dir	y-dir	x-dir	y-dir		
Penthouse	15	0.07	0.04	0.12	0.09	0.45	YES
Story 5	18	0.19	0.08	0.10	0.20	0.54	YES
Story 4	18	0.30	0.13	0.14	0.32	0.54	YES
Story 3	18	0.40	0.16	0.20	0.43	0.54	YES
Story 2	18	0.46	0.18	0.24	0.51	0.54	YES
Story 1	24	0.44	0.12	0.23	0.66	0.72	YES

Drift (in.)							
Floor	Height (ft)	EARTHQUAKE ANALYSIS				Allow	Pass?
		EQ - E/W		EQ - N/S			
		x-dir	y-dir	x-dir	y-dir		
Penthouse	15	0.19	0.05	0.06	0.06	2.7	YES
Story 5	18	0.59	0.10	0.14	0.61	3.24	YES
Story 4	18	0.93	0.17	0.26	0.95	3.24	YES
Story 3	18	1.19	0.21	0.30	1.17	3.24	YES
Story 2	18	1.27	0.22	0.33	1.27	3.24	YES
Story 1	24	0.85	0.13	0.22	0.87	4.32	YES

Lateral Design

- Lateral Loads / Recalculation of earthquake loads
- ETABS model
- Lateral design
- Drift checks

Foundation Impact

- Each pile has a 100-ton capacity

Column	P D+.75(.6W)+.75L+.75S	P D+L	Existing Cassions in Steel Design	Needed Cassions in Conc Design
A.2	345.5	356.3	3	3
A.3	657.5	712.5	4	4
A.4	658.1	712.5	4	4
A.5	659.1	712.5	4	4
A.6	820.6	890.7	4	5
A.7	507.3	534.4	4	4
B.1	137.2	89.1	3	3
B.2	584.8	587.8	4	4
B.3	954.0	997.5	4	5
B.4	950.3	997.5	4	5
B.5	954.0	997.5	4	5
B.6	1183.8	1246.9	6	7
B.7	736.2	748.2	6	6
C.1	340.6	311.8	3	3
C.2	788.2	810.6	4	5
C.3	954.0	997.5	4	5
C.4	950.3	997.5	4	5
C.5	954.0	997.5	4	5
C.6	1184.7	1246.9	6	7
C.7	737.2	748.2	6	6
C9.1	184.4	193.1	3	3
D.2	498.6	534.4	4	4
D.3	657.5	712.5	4	4
D.4	658.1	712.5	4	4
D.5	658.9	712.5	4	4
D.6	1185.5	1291.6	6	7
D.7	865.0	935.2	6	6
E.6	829.1	890.7	4	5
E.7	829.1	890.7	4	5
F.6	385.8	400.9	4	4
F.7	385.8	400.9	4	4
		Σ =	132	145

A simplified approach to the number of piles needed for each column.

Lateral Design

- Lateral Loads / Recalculation of earthquake loads
- ETABS model
- Lateral design
- Drift checks
- Foundation Impact

Cost Analysis

Original Cost Estimate provided by project engineer

S0004	Structural Steel - Fabricate and Erect	$	6,000,000	$	$\boxed{4,599,899}$	41,381
S0005	Underground Piping and Utilities	$	430,000	$	534,211	5,108
S0006	Concrete Slabs	$	900,000	$	$\boxed{597,530}$	6,226
S0007	Siding					

Sum = $5,197,429

Estimated Cost of Concrete Structure

Concrete Structual Element	Total-O&P	Total Price
Concrete	$ 1,810,613.96	$ 2,161,293.70
Finish	$ 3,612.00	$ 5,882.40
Formwork	$ 493,028.65	$ 748,430.13
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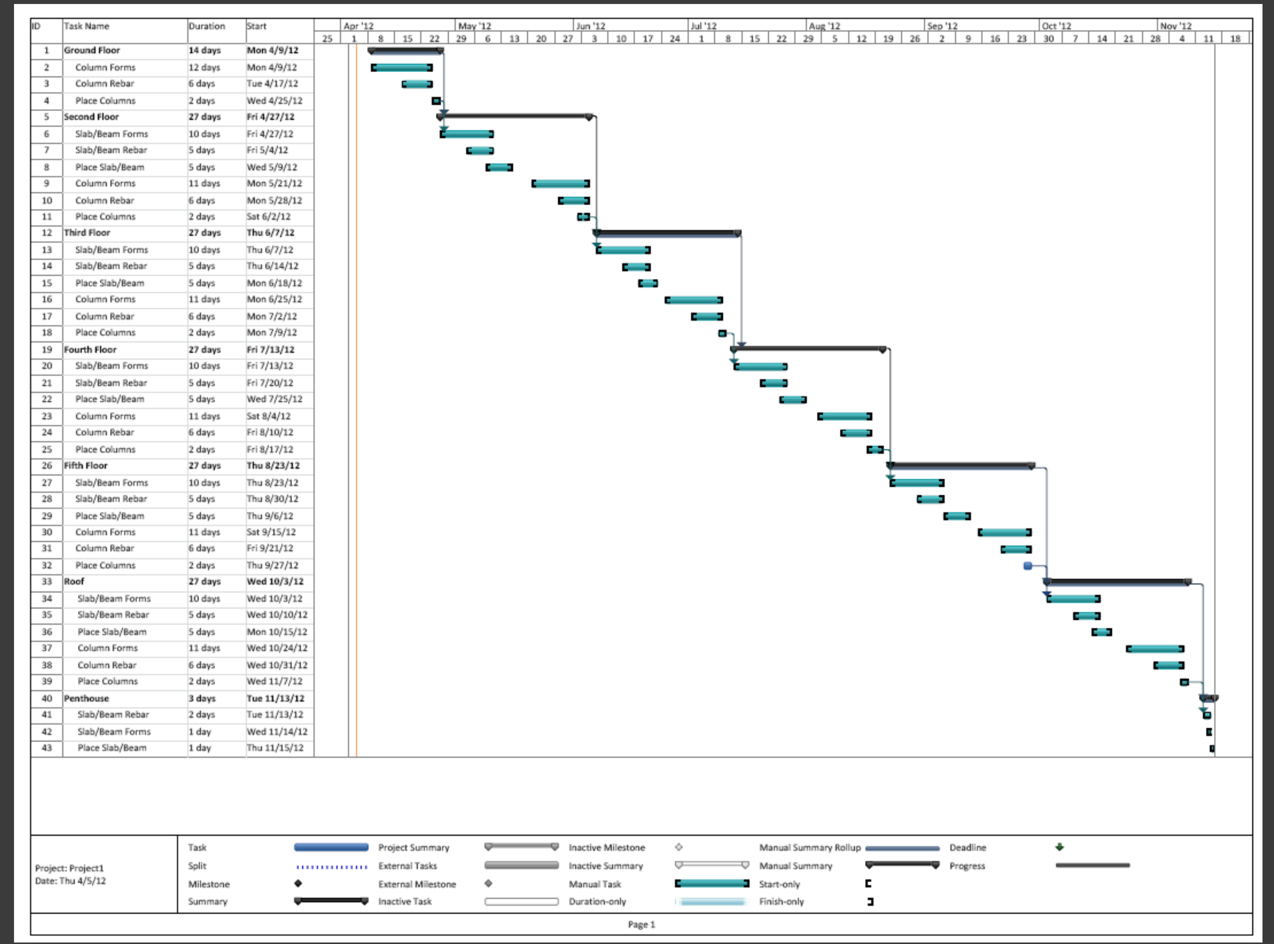
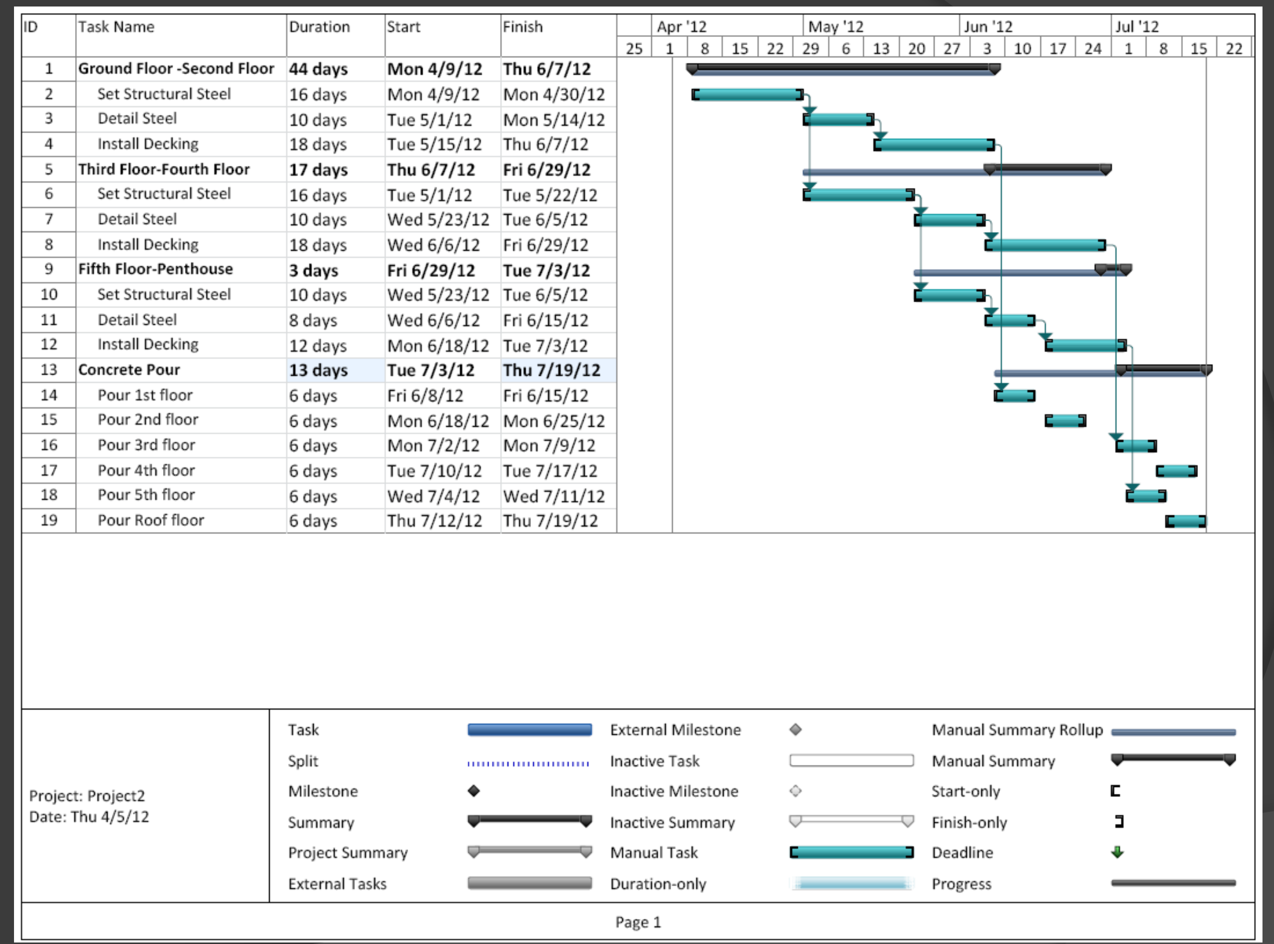


Concrete Schedule



ID	Task Name	Duration	Start	Finish
1	**Ground Floor -Second Floor**	**44 days**	**Mon 4/9/12**	**Thu 6/7/12**
2	Set Structural Steel	16 days	Mon 4/9/12	Mon 4/30/12
3	Detail Steel	10 days	Tue 5/1/12	Mon 5/14/12
4	Install Decking	18 days	Tue 5/15/12	Thu 6/7/12
5	**Third Floor-Fourth Floor**	**17 days**	**Thu 6/7/12**	**Fri 6/29/12**
6	Set Structural Steel	16 days	Tue 5/1/12	Tue 5/22/12
7	Detail Steel	10 days	Wed 5/23/12	Tue 6/5/12
8	Install Decking	18 days	Wed 6/6/12	Fri 6/29/12
9	**Fifth Floor-Penthouse**	**3 days**	**Fri 6/29/12**	**Tue 7/3/12**
10	Set Structural Steel	10 days	Wed 5/23/12	Tue 6/5/12
11	Detail Steel	8 days	Wed 6/6/12	Fri 6/15/12
12	Install Decking	12 days	Mon 6/18/12	Tue 7/3/12
13	**Concrete Pour**	**13 days**	**Tue 7/3/12**	**Thu 7/19/12**
14	Pour 1st floor	6 days	Fri 6/8/12	Fri 6/15/12
15	Pour 2nd floor	6 days	Mon 6/18/12	Mon 6/25/12
16	Pour 3rd floor	6 days	Mon 7/2/12	Mon 7/9/12
17	Pour 4th floor	6 days	Tue 7/10/12	Tue 7/17/12
18	Pour 5th floor	6 days	Wed 7/4/12	Wed 7/11/12
19	Pour Roof floor	6 days	Thu 7/12/12	Thu 7/19/12

Steel Schedule