Cannon Design

Global Heart and Vascular Institute

Kaleida Health and the University at Buffalo

William McDevitt
Structural Option
AE 482 – Senior Thesis
Dr. Richard Behr

Cannon Design

Cannon Design

Presentation Outline

- Introduction
- Existing Structural System
- Thesis Proposal
- Structural Depth
- Construction Management Breadth
- Conclusion

Cannon Design

Presentation Outline

- Introduction
  - Building Information
  - Primary Project Team
- Existing Structural System
- Thesis Proposal
- Structural Depth
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Introduction

Building Information

- 10-story medical facility
- Located in Buffalo, NY
- 476,500 sf
- $291 million
- Construction Dates: February 2008 – April 2011

Primary Project Team

- Owner(s): Kaleida Health & Buffalo 2020 Development Corporation
- Architect and Engineers: Cannon Design
- Construction Manager/General Contractor: Turner Construction

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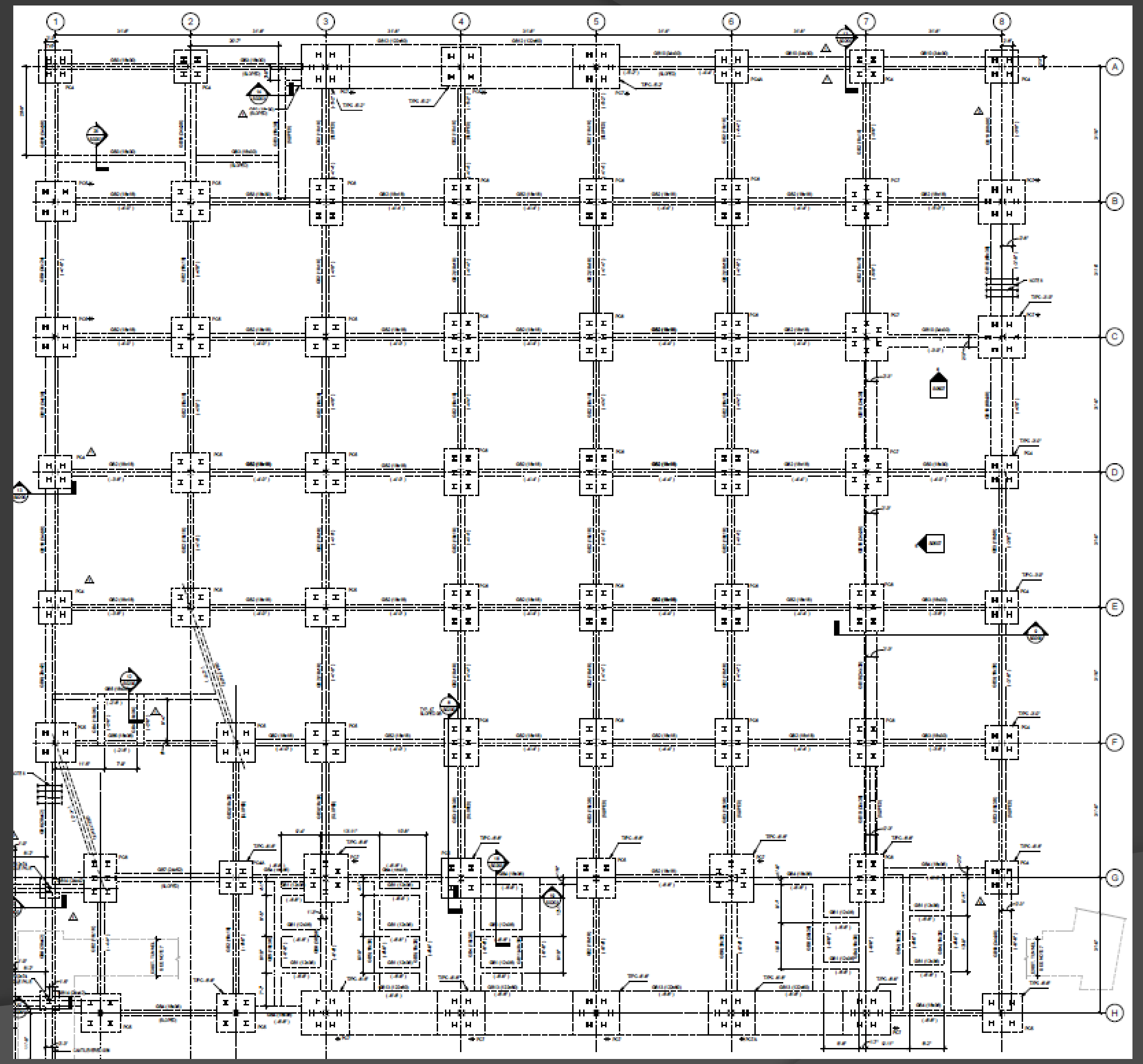
Existing Structural System

Foundation

- Grade beams and pile caps
  - 4000 psi concrete
- Steel helical piles
  - HP12x74 sections
  - Allowable axial capacity of 342 kips
  - Driven to refusal on limestone bedrock
- 5″ Slab on grade



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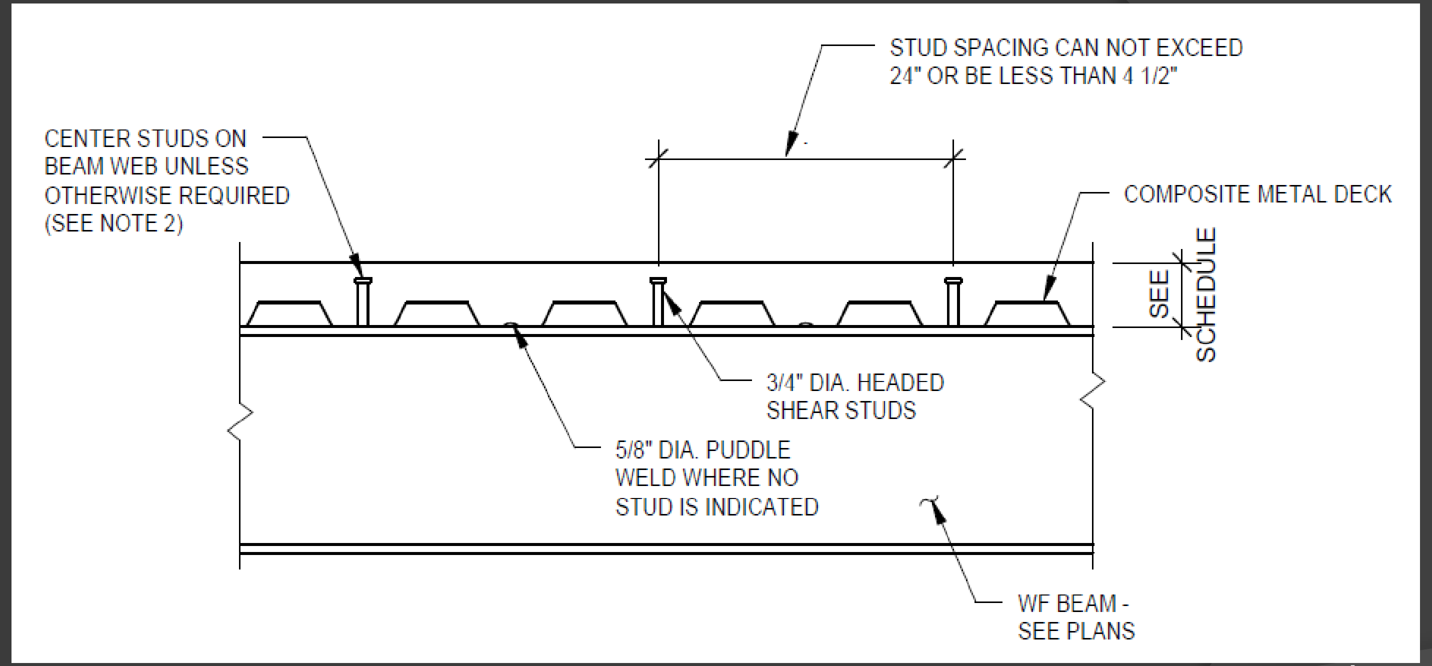
Existing Structural System

Gravity System

- Floor System
  - 3″ Composite Metal Deck
  - Total slab thickness ranging from 4″ to 7 ½″
  - 18-gage galvanized steel sheets
- Columns
  - W14 shapes, ranging from 68 to 370 lb/ft
  - Spliced every 36′
  - Provides 18′ floor-to-floor height
- Universal Grid Layout
  - Bay size of 31′-6″ by 31′-6″
  - Beams spaced at 10′-6″



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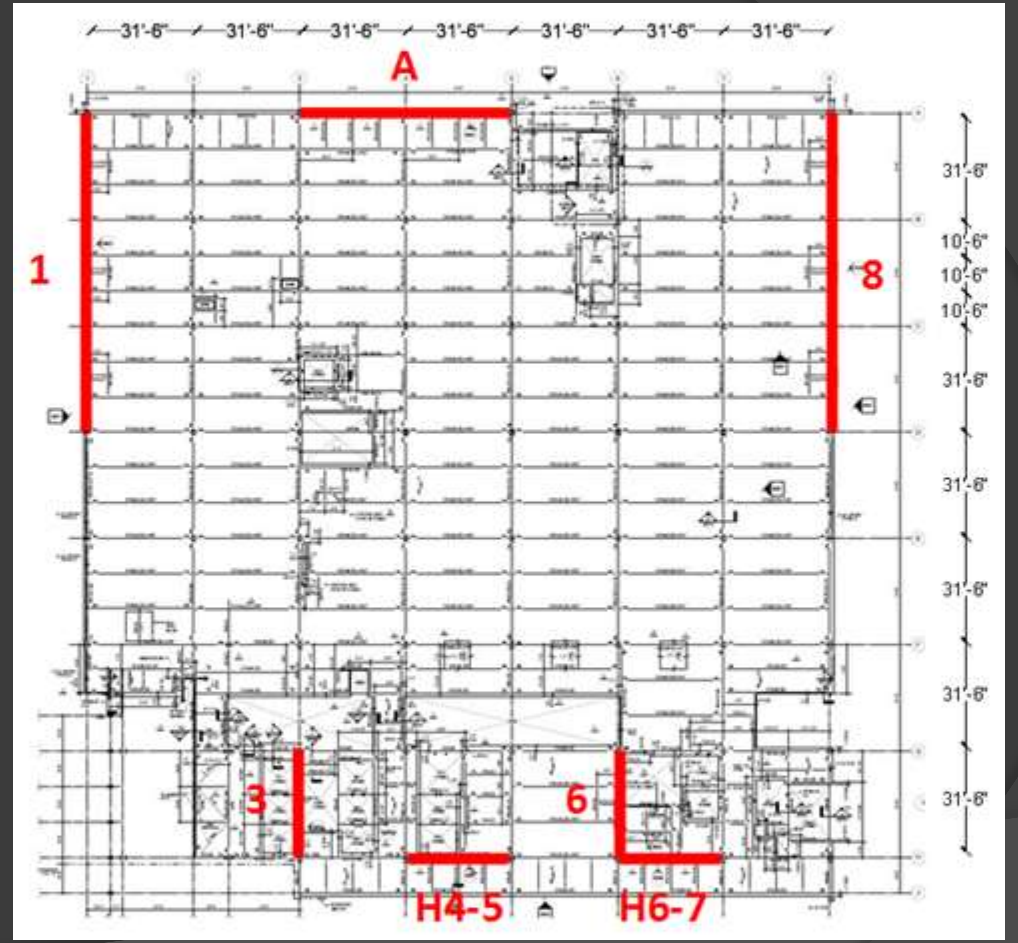
Existing Structural System

Lateral System

- Concentrically braced frames around the perimeter
- All HSS sections
- Low cost compared to moment frames



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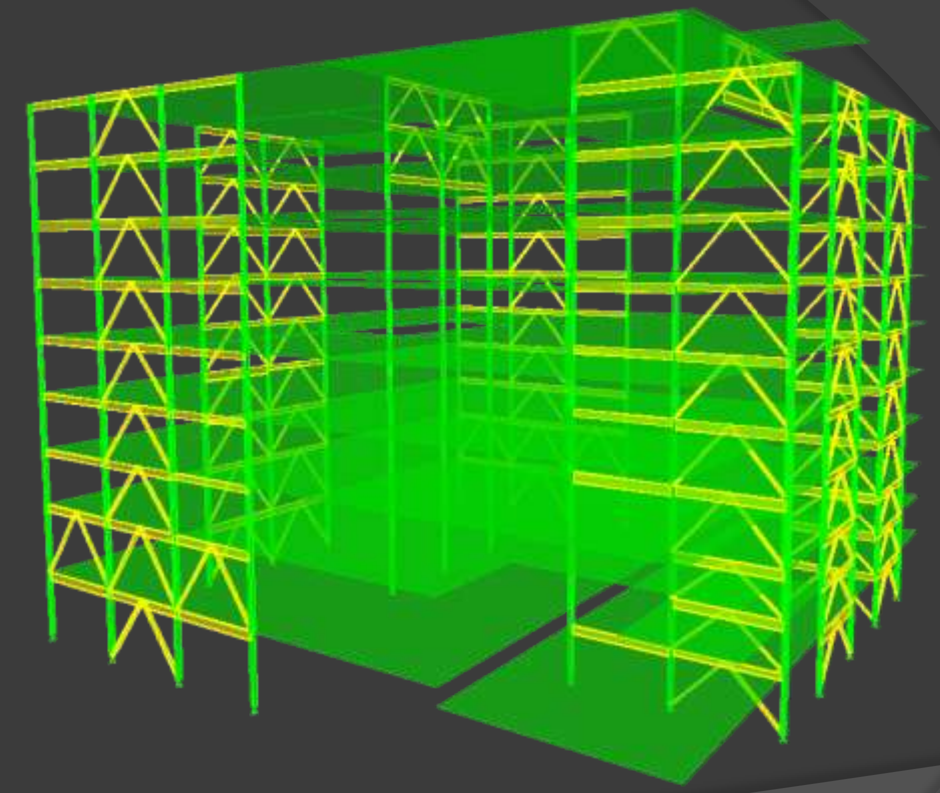

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- Introduction
- Existing Structural System
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  - Structural Depth
  - Construction Management Breadth
  - Mechanical Breadth
  - MAE Requirements
- Structural Depth
- Construction Management Breadth
- Conclusion

Thesis Proposal

Structural Depth

- Concrete system could be less expensive
- Explore three alternatives discussed in Tech 2
  - Flat slab with drop panels
  - One-way joist and beam
  - Pre-cast hollow core plank
- Redesign gravity and lateral systems
- Perform vibration analysis
- Goal is to design a more cost effective solution

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  - MAE Requirements
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Thesis Proposal

Construction Management Breadth

- Detailed Cost Analysis
  - Current steel structure
  - Redesigned concrete structure
- Schedule Analysis
  - Current steel structure
  - Redesigned concrete structure
- Determine if redesign is more cost effective

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  - Mechanical Breadth
  - MAE Requirements
- Structural Depth
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Thesis Proposal

Mechanical Breadth

- Building envelope and façade study
  - Obtain current curtain walls designs
  - Research more efficient glazing system
  - Perform thermal calculations using Trace 700
  - Compare various alternatives

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Thesis Proposal

Mechanical Breadth

- Building envelope and façade study
  - Obtain current curtain walls designs
  - Research more efficient glazing system
  - Perform thermal calculations using Trace 700
  - Compare various alternatives

MAE Requirements

- RAM Structural System, ETABS, and SAP2000 models will utilize information learned in AE 597A, Computer Modeling of Building Structures
- Mechanical Breadth will reference content from AE 542, Building Enclosure Science and Design
- Vibration analysis will constitute MAE level work

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Structural Depth

Gravity System Redesign

- Explored three alternative systems
  - Flat slab with drop panels
  - One-way joist and beam
  - Pre-cast hollow core plank
- Flat slab with drop panel system chosen
  - Lowest cost
  - Utilize current bay size
  - Relatively flat ceiling
- Designed gravity columns

Gravity Loads

- Floor System Dead Loads
  - Concrete self-weight
  - Superimposed Dead Load = 25 psf
- Floor System Live Loads
  - Conservatively assumed 125 psf for all floors
- Snow Load
  - Ground snow load determined from a case study to be 50 psf by Cannon Design
  - Calculated flat roof snow load of 42 psf

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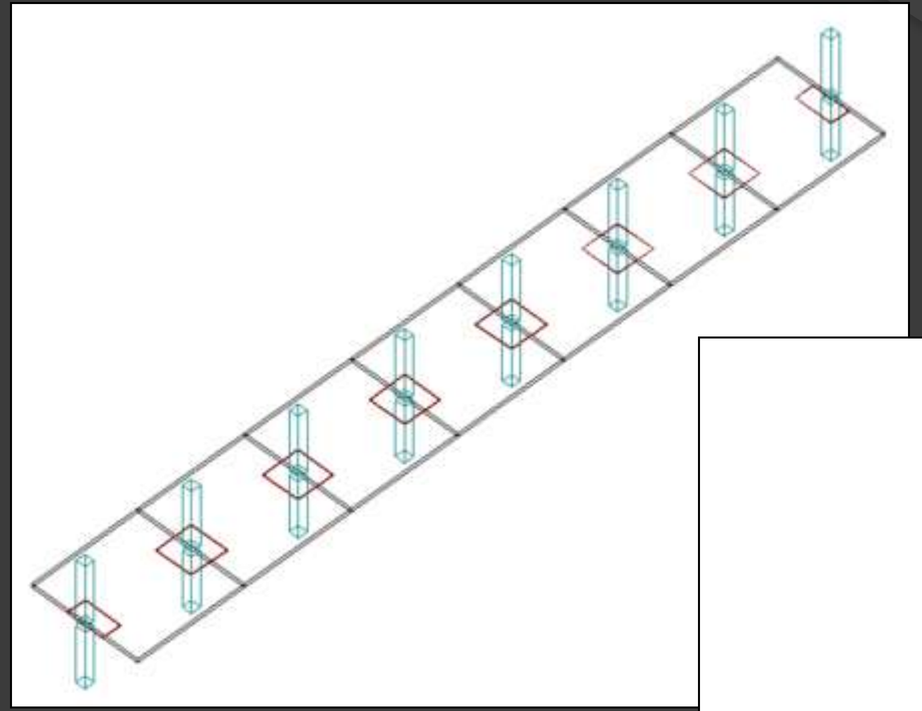
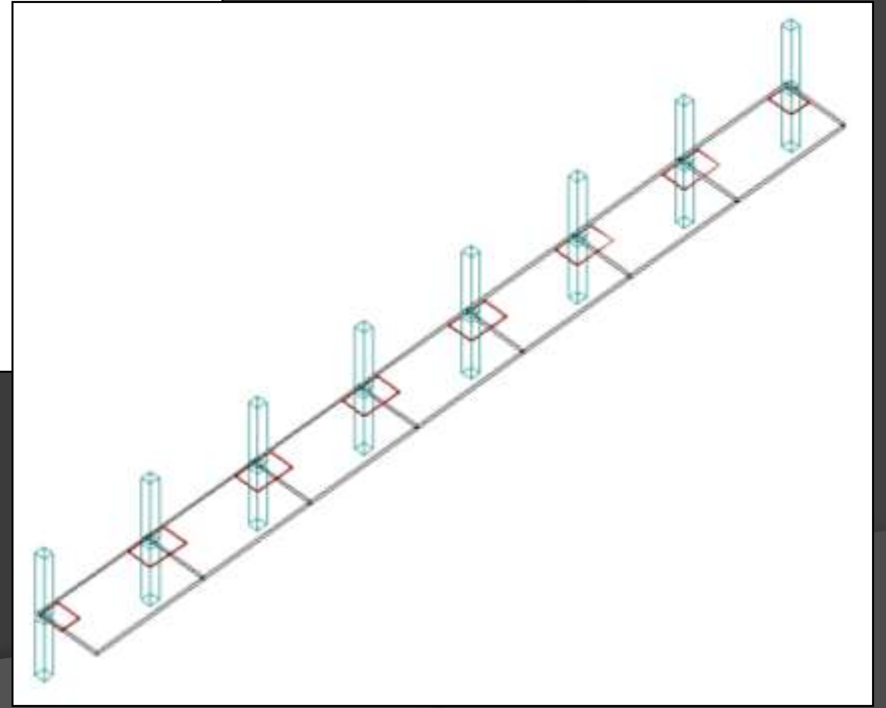
Structural Depth

Flat Slab Design

- Performed hand calculations
  - Minimum slab thickness of 11" per ACI 9.5.3.2
  - 10 ½' by 10 ½' drop panels
  - 3 ½" depth
- Modeled in spSlab
  - Three alternatives for drop panel depth
  - Chose 3 ½" depth with 6000 psi concrete
- Determined column and middle strip reinforcement
  - Used #7 bars for top and bottom reinforcement



Interior Bays



Exterior Bays

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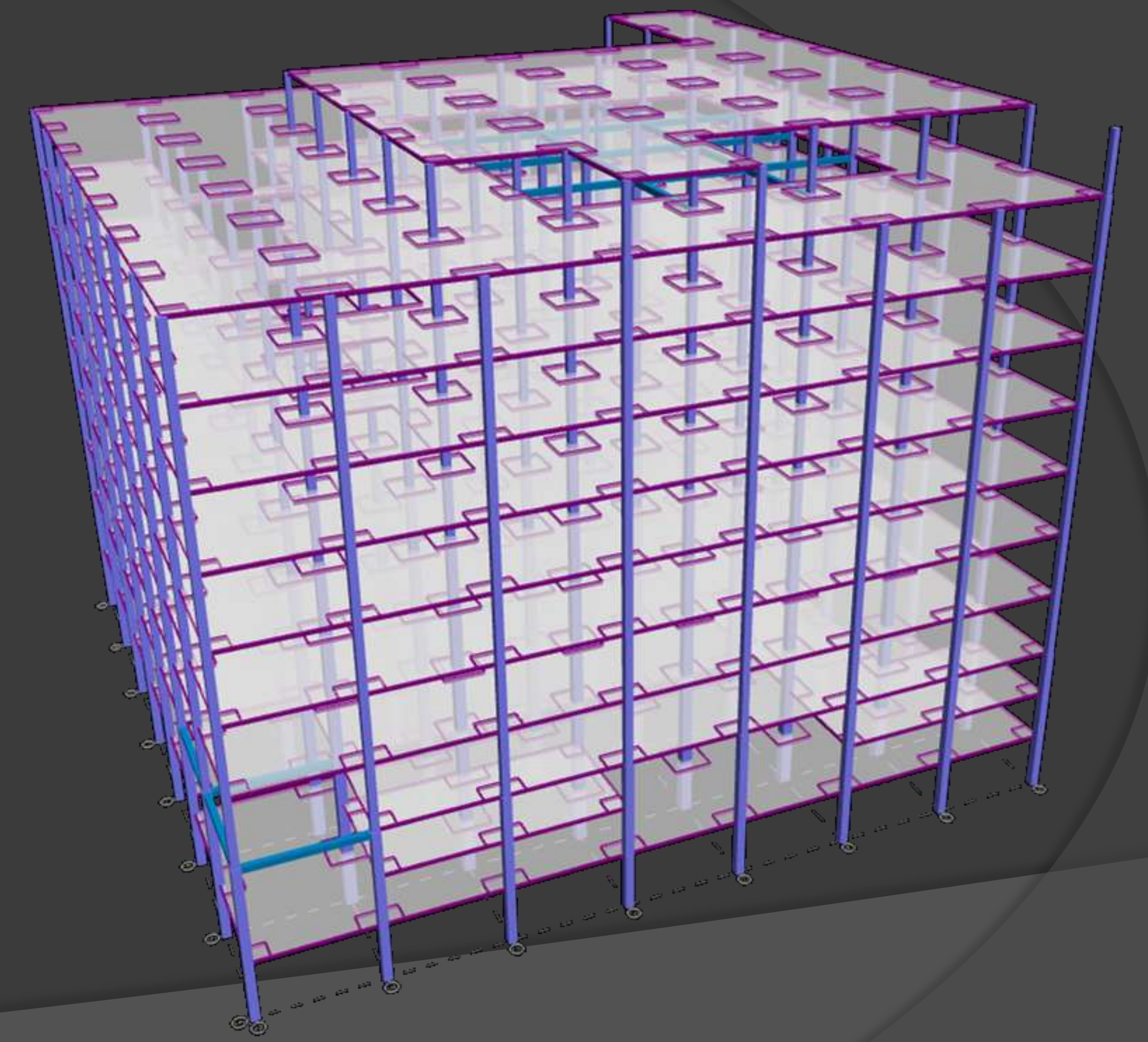
Structural Depth

Column Design

- Approximated sizes using RAM Structural System
    - Ranged from 20" by 20" to 36" by 36"
    - Unbraced length controlled the column size
- Summed axial loads on a corner, exterior, and interior column
- Determined column was part of a nonsway frame
- Checked slenderness
- Designed sub-basement, interior column by hand
- Checked hand design using spColumn
- Proceeded with design using spColumn



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Interior Column Design			
Level	Size (in x in)	A_s (in^2)	Long. Reinforcing
Roof	20 x 20	6.32	8 #8
9	24 x 24	6.32	8 #8
8	24 x 24	6.32	8 #8
7	24 x 24	6.32	8 #8
6	24 x 24	8.00	8 #9
5	28 x 28	8.00	8 #9
4	32 x 32	12.00	12 #9
3	32 x 32	12.00	12 #9
2	32 x 32	20.32	16 #10
1	32 x 32	20.32	16 #10
Mech	36 x 36	15.24	12 #10
Base	36 x 36	15.24	12 #10
SB	36 x 36	25.40	20 #10

Exterior Column Design			
Level	Size (in x in)	A_s (in^2)	Long. Reinforcing
Roof	20 x 20	6.32	8 #8
9	24 x 24	6.32	8 #8
8	24 x 24	6.32	8 #8
7	24 x 24	6.32	8 #8
6	24 x 24	6.32	8 #8
5	24 x 24	6.32	8 #8
4	24 x 24	6.32	8 #8
3	24 x 24	6.32	8 #8
2	28 x 28	8.00	8 #9
1	28 x 28	8.00	8 #9
Mech	28 x 28	8.00	8 #9
Base	28 x 28	8.00	8 #9
SB	28 x 28	8.00	8 #9

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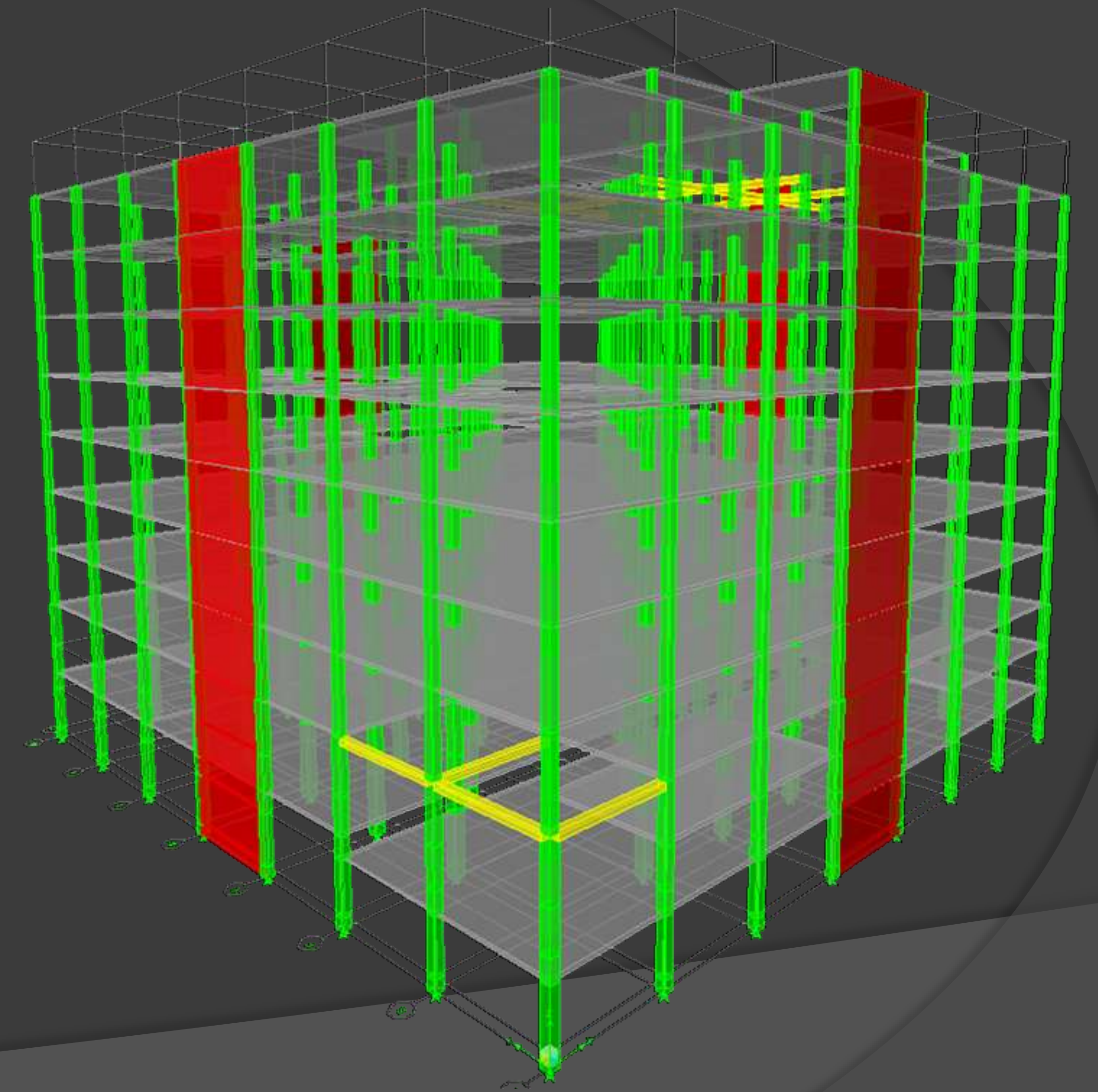
Lateral System Redesign

- Determined wind and seismic loads
- Found controlling load combination
- Designed shear walls
- Checked drift limitations
- Checked relative stiffness assumption
- Examined overturning and foundation impact



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Structural Depth

Wind Loads

- Chapters 26 and 27 of ASCE 7-10
- Occupancy category – IV
  - 120 mph basic wind speed
- Explored four wind cases
  - Case 1 controls
- Total base shear
  - East-West direction = 1581.7 kips
  - North-South direction = 1535.5 kips

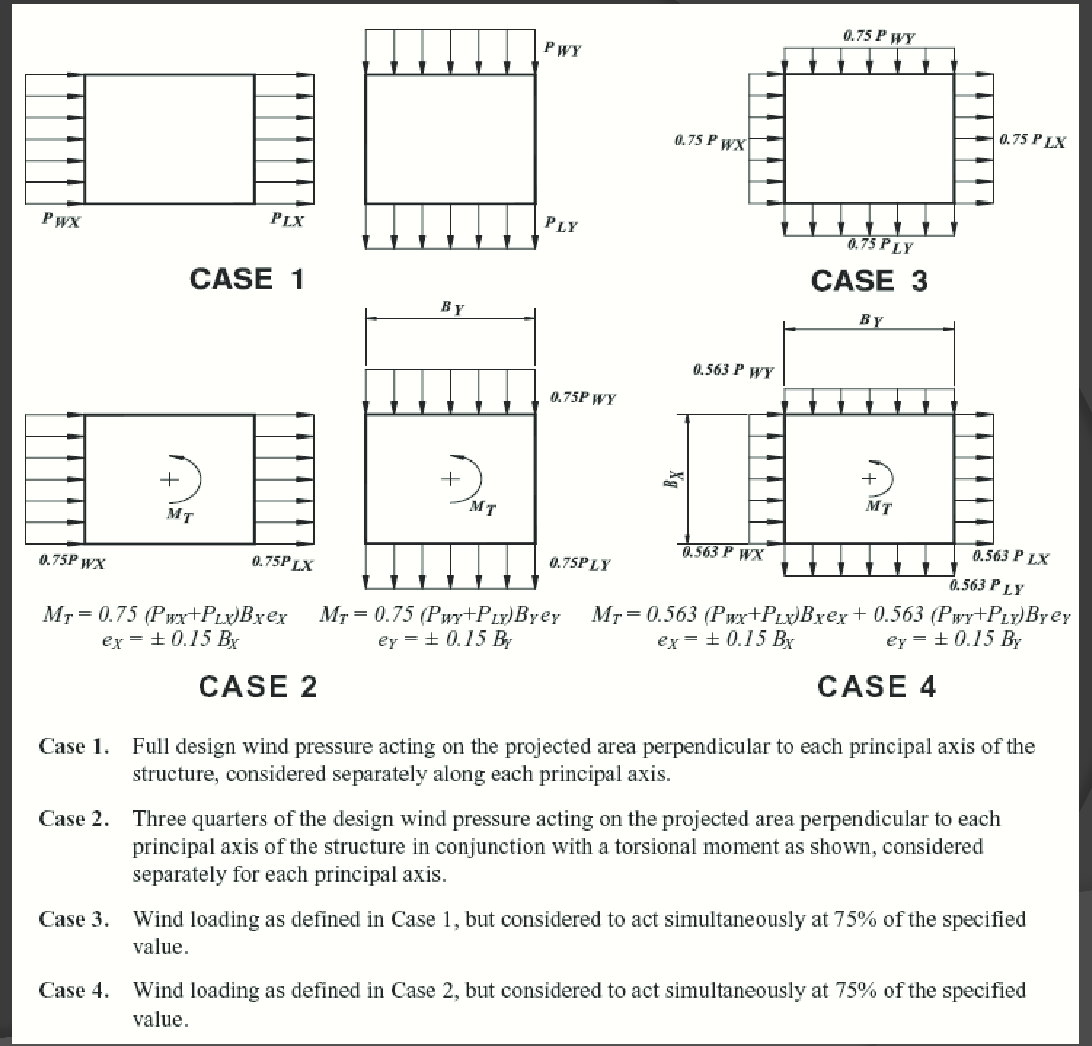

Figure 27.4-8 from ASCE 7-10

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Load Case	Direction	Shear in Wall (k)			
		A	H	1	8
1	W_x	730.0	784.4	11.0	4.0
	W_y	104.1	106.2	788.0	612.8
2	W_x	541.1	606.7	13.2	7.8
	W_y	84.4	86.3	597.3	464.3
3	W_{xy}	475.2	668.0	593.9	668.0
4	W_{xy}	342.9	511.3	434.5	354.2

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Wind Story Forces

		Load (kips)		Shear (kips)		Moment (ft-kips)	
Level	**Height (ft)**	**N-S**	**E-W**	**N-S**	**E-W**	**N-S**	**E-W**
Roof	185	57.3	80.4	0.0	0.0	10599.02	14872.28
9	169	146.3	169.4	57.3	80.4	24730.99	28634.67
8	151	176.4	176.4	203.6	249.8	26634.72	26634.72
7	133	172.8	172.8	380.0	426.2	22985.1	22985.1
6	115	168.8	168.8	552.8	599.0	19415.03	19415.03
5	97	164.5	164.5	721.7	767.9	15956.65	15956.65
4	79	159.7	159.7	886.2	932.4	12616.63	12616.63
3	61	153.7	153.7	1045.9	1092.1	9375.787	9375.787
2	43	126.2	126.2	1199.6	1245.8	5427.234	5427.234
1	30	85.0	85.0	1325.8	1372.0	2550.022	2550.022
Mechanical	21	51.9	51.9	1410.8	1457.0	1089.248	1089.248
Basement	16	72.8	72.8	1462.7	1508.9	1164.818	1164.818
	Total	1535.5	1581.7	1535.5	1581.7	152545.3	160722.2

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Seismic Loads

- Chapters 11 and 12 of ASCE 7-10
- Assumed both directions would be the same
- Estimated total building weight of 86240 kips
- Equivalent Lateral Force Procedure
  - Seismic design category C
  - R = 5.0
  - Base shear of 1380 kips

Level	h_i (ft)	h (ft)	w (k)	$w*h^k$	C_{VX}	f_i (k)	V_i (k)	M_i (ft-k)
Roof	16	185	4030	5038548	0.105	145	145	26907
9	18	169	7441	8220803	0.172	237	383	40104
8	18	151	8787	8323951	0.174	240	623	36282
7	18	133	8787	6998877	0.146	202	825	26870
6	18	115	8787	5737996	0.120	166	991	19048
5	18	97	9203	4762621	0.100	137	1128	13335
4	18	79	9630	3765258	0.079	109	1237	8586
3	18	61	9711	2667069	0.056	77	1314	4696
2	13	43	9303	1584711	0.033	46	1360	1967
1	9	30	2167	225691	0.005	7	1366	195
Mechanical	5	21	5617	359437	0.008	10	1376	218
Basement	16	16	2777	122592	0.003	4	1380	57
		Σ =	86240.43	47807553	1.000	1380		178264

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Load Combinations

1) 1.4D
2) 1.2D + 1.6L + 0.5(Lr or S or R)
3) 1.2D + 1.6(Lr or S or R) + L
4) 1.2D + 1.6(Lr or S or R) + 0.5Wx
5) 1.2D + 1.6(Lr or S or R) + 0.5Wy
6) 1.2D + 1.0Wx + L + 0.5(Lr or S or R)
7) 1.2D + 1.0Wy + L + 0.5(Lr or S or R)
8) 1.2D + 1.0Ex + L + 0.2S
9) 1.2D + 1.0Ey + L + 0.2S
10) 0.9D + 1.0Wx
11) 0.9D + 1.0Wy
12) 0.9D + 1.0Ex
13) 0.9D + 1.0Ey

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1) 1.4D
2) 1.2D + 1.6L + 0.5(Lr or S or R)
3) 1.2D + 1.6(Lr or S or R) + L
4) 1.2D + 1.6(Lr or S or R) + 0.5Wx
5) 1.2D + 1.6(Lr or S or R) + 0.5Wy
6) 1.2D + 1.0Wx + L + 0.5(Lr or S or R)
7) 1.2D + 1.0Wy + L + 0.5(Lr or S or R)
8) 1.2D + 1.0Ex + L + 0.2S
9) 1.2D + 1.0Ey + L + 0.2S
10) 0.9D + 1.0Wx
11) 0.9D + 1.0Wy
12) 0.9D + 1.0Ex
13) 0.9D + 1.0Ey

Load Combo	Shear in Wall (k)			
	A	H	1	8
1	3.3	4.3	1.5	0.9
2	2.9	2.7	5.0	3.8
3	2.1	1.7	3.7	2.6
4	371.7	399.5	7.8	1.3
5	52.8	56.8	395.4	305.6
6	727.9	786.1	7.5	1.6
7	106.1	107.8	804.9	623.8
8	647.7	675.6	7.6	0.1
9	93.2	94.4	711.4	575.6
10	739.9	784.2	10.1	0.5
11	104.5	108.8	799.1	622.6
12	647.1	673.7	2.2	1.8
13	92.2	92.5	708.8	583.3
QUAKE	628.5	718.6	206.6	182.2

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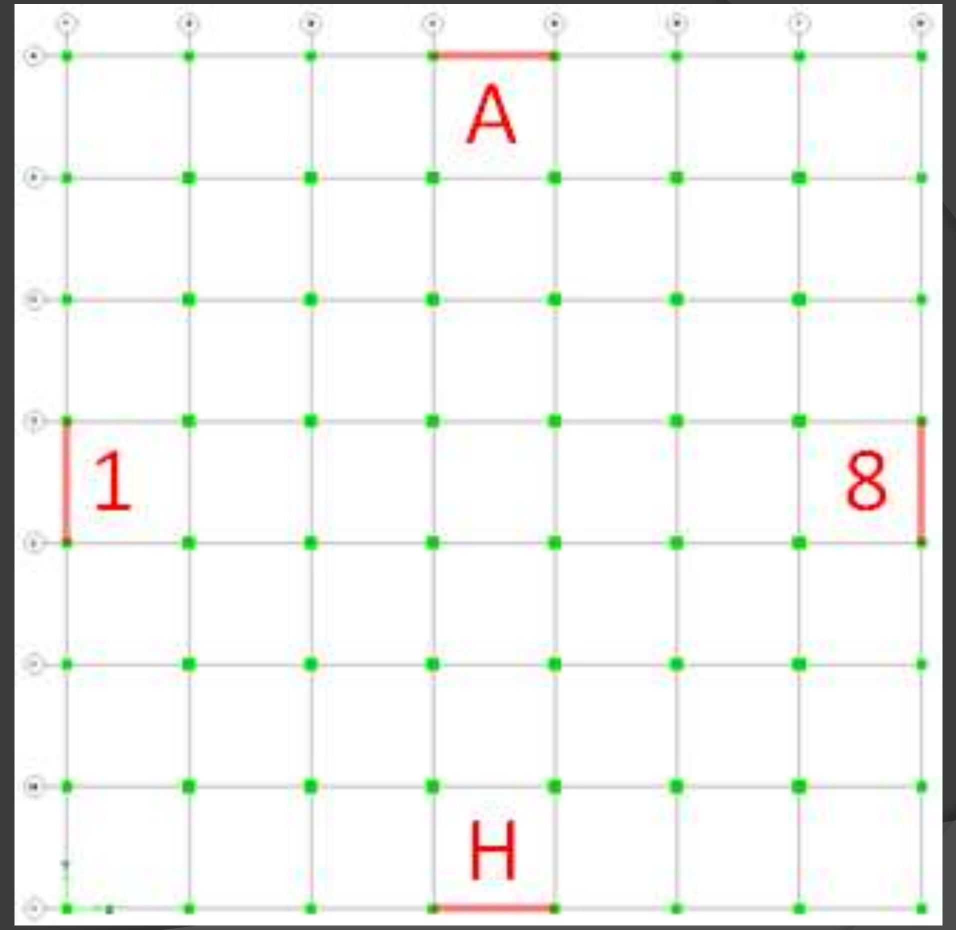
Shear Wall Design

- Placed two 16" thick shear walls in each direction
- Located on the perimeter
- Assumed each would take 50% of the load applied in that direction
- Used ETABS to determine the wall with the largest base shear
- Designed all four walls , by hand, for this controlling shear value
    - 16" thick wall
    - #4 bars at 10" for horizontal reinforcement
    - #4 bars at 10" for vertical reinforcement
    - (10) #9 bars at 2" for flexural reinforcement



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Drift Analysis

- Checked controlling seismic load combination for story drift
  - $0.010h_{sx}$ (Table 12.12-1 in ASCE 7-10)
- Checked controlling wind load combination for total building drift
  - H/400
- All drift values were acceptable

Controlling Seismic Drift: East-West				
Level	Height (ft)	Story Drift (in)	Allowable Story Drift (in)	
Roof	185	0.467310	1.92	Acceptable
9	169	0.429936	2.16	Acceptable
8	151	0.396828	2.16	Acceptable
7	133	0.352317	2.16	Acceptable
6	115	0.301185	2.16	Acceptable
5	97	0.238329	2.16	Acceptable
4	79	0.174195	2.16	Acceptable
3	61	0.114924	2.16	Acceptable
2	43	0.062178	1.56	Acceptable
1	30	0.036000	1.08	Acceptable
Mechanical	21	0.021861	0.60	Acceptable
Basement	16	0.010368	1.92	Acceptable
SB	3	0.001791	0.36	Acceptable

Wind Deflection: East-West				
Level	Height (ft)	Total Deflection(in)	Allowable Total Deflection (in)	
Roof	185	1.280716	5.55	Acceptable
9	169	1.157314	5.07	Acceptable
8	151	1.015849	4.53	Acceptable
7	133	0.868758	3.99	Acceptable
6	115	0.718702	3.45	Acceptable
5	97	0.567508	2.91	Acceptable
4	79	0.422255	2.37	Acceptable
3	61	0.288135	1.83	Acceptable
2	43	0.169761	1.29	Acceptable
1	30	0.101421	0.90	Acceptable
Mechanical	21	0.061281	0.63	Acceptable
Basement	16	0.041924	0.48	Acceptable
SB	3	0.007381	0.09	Acceptable

Controlling Seismic Drift: North-South				
Level	Height (ft)	Story Drift (in)	Allowable Story Drift (in)	
Roof	185	0.478410	1.92	Acceptable
9	169	0.438555	2.16	Acceptable
8	151	0.404982	2.16	Acceptable
7	133	0.359499	2.16	Acceptable
6	115	0.307395	2.16	Acceptable
5	97	0.243276	2.16	Acceptable
4	79	0.178224	2.16	Acceptable
3	61	0.116937	2.16	Acceptable
2	43	0.055857	1.56	Acceptable
1	30	0.032490	1.08	Acceptable
Mechanical	21	0.017829	0.6	Acceptable
Basement	16	0.015552	1.92	Acceptable
SB	3	0.003078	0.36	Acceptable

Wind Deflection: North-South				
Level	Height (ft)	Total Deflection (in)	Allowable Total Deflection (in)	
Roof	185	1.215410	5.55	Acceptable
9	169	1.099820	5.07	Acceptable
8	151	0.968110	4.53	Acceptable
7	133	0.830436	3.99	Acceptable
6	115	0.689243	3.45	Acceptable
5	97	0.546207	2.91	Acceptable
4	79	0.408127	2.37	Acceptable
3	61	0.279683	1.83	Acceptable
2	43	0.166710	1.29	Acceptable
1	30	0.114844	0.90	Acceptable
Mechanical	21	0.083211	0.63	Acceptable
Basement	16	0.067298	0.48	Acceptable
SB	3	0.013594	0.09	Acceptable

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Structural Depth

Relative Stiffness Check

- Reasonable method for checking the assumed distribution of lateral load
- Placed 100 kip load at the top of each wall
- Measured lateral displacement in inches
- Calculated relative stiffness of both shear walls in either direction

East-West Direction Relative Stiffness					
Frame	Height (ft)	Load (k)	Displacement (in)	Stiffness (k/in)	Relative Stiffness
A	169	100	0.6659	150.1695	0.5666
H	185	100	0.8707	114.8510	0.4334
			Σ =	265.0206	1.0000

North-South Direction Relative Stiffness					
Frame	Height (ft)	Load (k)	Displacement (in)	Stiffness (k/in)	Relative Stiffness
1	169	100	0.6659	150.1695	0.5666
8	185	100	0.8707	114.8510	0.4334
			Σ =	265.0206	1.0000

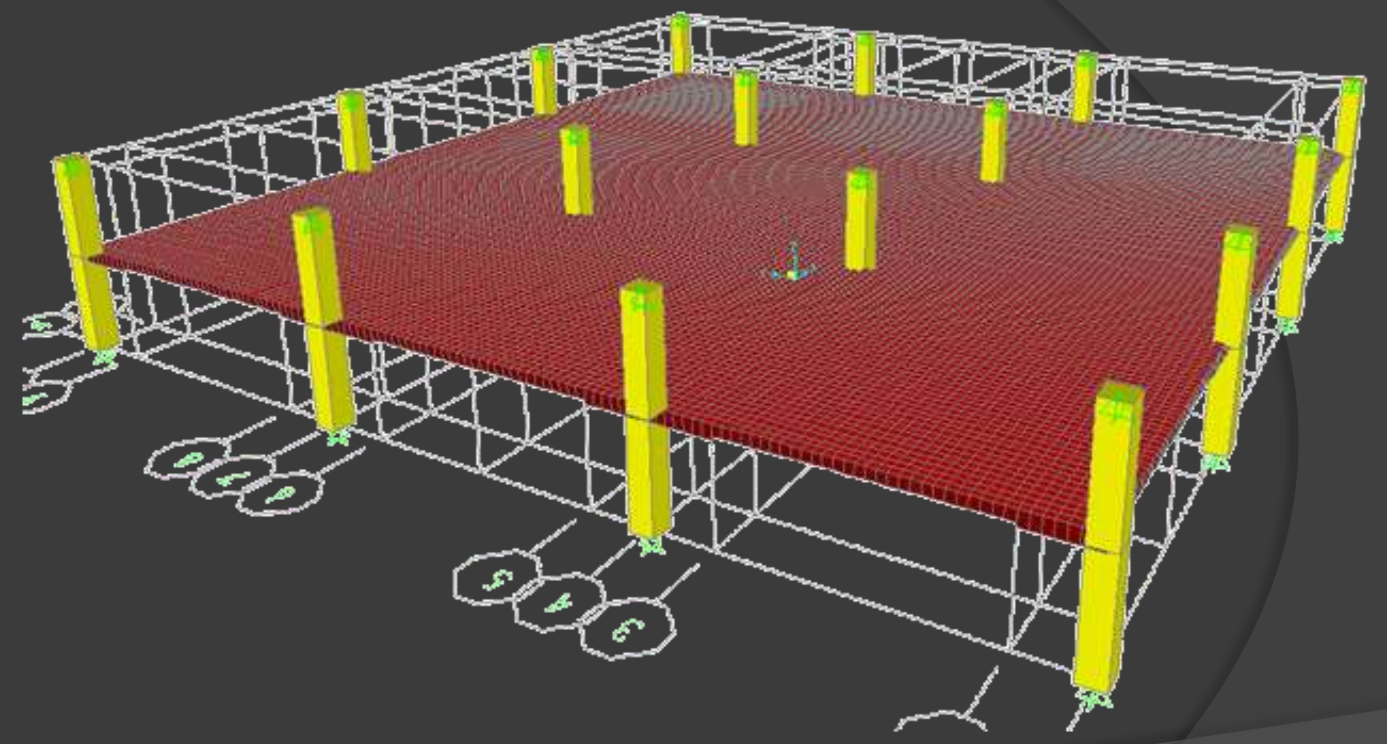
Presentation Outline

- Introduction
- Existing Structural System
- Thesis Proposal
- Structural Depth
  - Gravity System Redesign
  - Lateral System Redesign
  - Vibration Analysis
- Construction Management Breadth
- Conclusion

Structural Depth

Vibration Analysis

- Current Design
  - Moderate walking pace of 75 steps/minute
  - Velocities ranging from 4000 – 500 μ in/sec
- Checked redesign to determine if criteria was met
- Built 3-bay by 3-bay SAP2000 model
  - Slab modeled as 11″ shell element
  - Drop panels modeled as 14 ½″ shell elements
  - Discretized each into 9″ by 9″ squares
  - Columns modeled halfway above and below
  - Assumptions: $E = 1.2E_c$
    $I = 0.7I_g$ for columns
    $I = 0.25I_g$ for slab and drops



Presentation Outline

- Introduction
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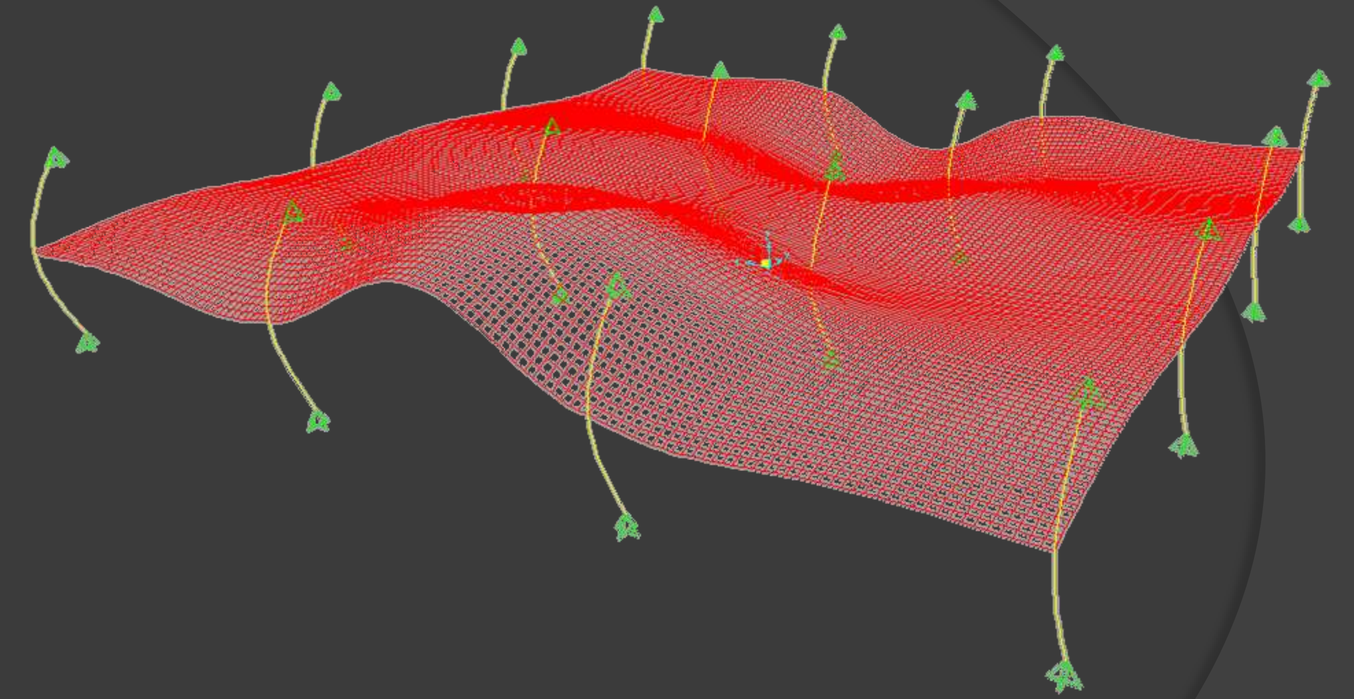
Structural Depth

Vibration Analysis

- Separately placed 1 kip load at the center of interior and exterior bay
- Measures deflection in inches
- Determined fundamental period and natural frequency

Bay	Mode	Δ_p (in)	T (s)	f_n (Hz)
Exterior	7	0.00472	0.15133	6.60793
Interior	11	0.00420	0.12631	7.91720



Mode 7 Shape for Exterior Bay

Presentation Outline

- Introduction
- Existing Structural System
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- Structural Depth
  - Gravity System Redesign
  - Lateral System Redesign
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Structural Depth

Vibration Analysis

- Separately placed 1 kip load at the center of interior and exterior bay
- Measures deflection in inches
- Determined fundamental period and natural frequency

Bay	Mode	Δ_p (in)	T (s)	f_n (Hz)
Exterior	7	0.00472	0.15133	6.60793
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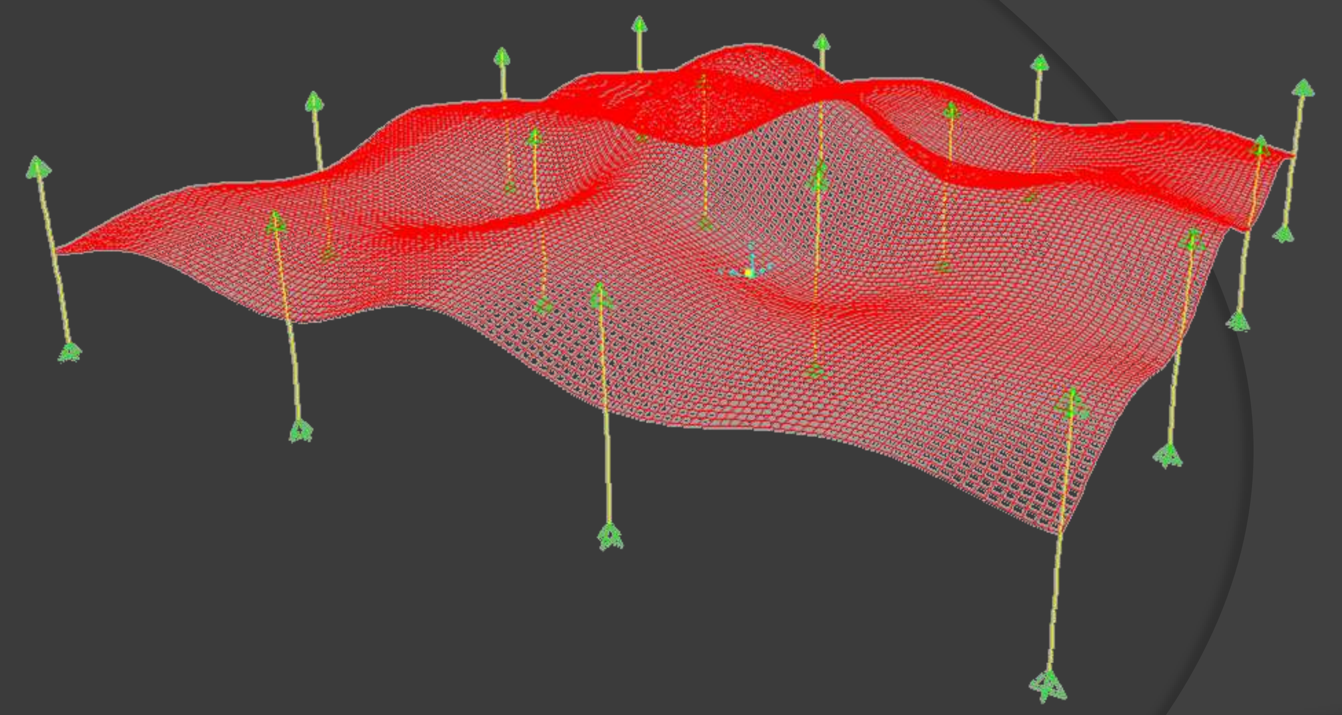

Mode 11 Shape for Interior Bay

Presentation Outline

- Introduction
- Existing Structural System
- Thesis Proposal
- Structural Depth
  - Gravity System Redesign
  - Lateral System Redesign
  - Vibration Analysis
- Construction Management Breadth
- Conclusion

Structural Depth

Vibration Analysis

- Calculated the vibrational velocity for each bay

$$V = \frac{U_v \Delta_p}{f_n}$$

U_v = 5500 lb Hz^2 (moderate walking)

- Interior Bay = 2918 μ in/sec
- Exterior Bay = 3929 μ in/sec
- Potential Improvements
  - Increase concrete strength
  - Increase slab thickness
  - Decrease span length

Required Vibrational Velocities

- 4000 μ in/sec
  - Typical lab and surgery areas
- 2000 μ in/sec
  - Laboratory areas near corridors
- 1000 μ in/sec
  - Central lab areas with sensitive photography equipment
- 500 μ in/sec
  - Extremely sensitive areas

Presentation Outline

- Introduction
- Existing Structural System
- Thesis Proposal
- Structural Depth
- Construction Management Breadth
  - Detailed Cost Analysis
  - Schedule Analysis
- Conclusion

Construction Management Breadth

Detailed Cost Analysis

- Estimated the current steel building cost to create a relevant baseline
  - Used RSMeans Building Construction Cost Data
  - About $11.9 million
- Estimated concrete structure
  - Used RSMeans Building Construction Cost Data
  - About $11.6 million
- About $300,000 savings, or 2.9% cost reduction

Category	Description	Cost ($)
Gravity Beam	Grade: 50	5771092.02
	Grade: Other	29273.21
	Fireproofing	499254.65
Gravity Column	I Section	1313676.83
	Fireproofing	69863.42
Structure Frame	Columns	823162.57
	Beams	349404.53
	Braces	129188.26
	Fireproofing	84842.30
Composite Deck	Metal Decking	1231183.80
	Shear Studs	89844.99
	Concrete Fill	993242.25
	Placing Concrete	197149.05
	Finishing Concrete	318710.70
	Total Cost ($)	11899888.58

Steel Construction Cost

Presentation Outline

- Introduction
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- Structural Depth
- Construction Management Breadth
    - Detailed Cost Analysis
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- Conclusion

Construction Management Breadth

Detailed Cost Analysis

- Estimated the current steel building cost to create a relevant baseline
  - Used RSMeans Building Construction Cost Data
  - About $11.9 million
- Estimated concrete structure
  - Used RSMeans Building Construction Cost Data
  - About $11.6 million
- About $300,000 savings, or 2.9% cost reduction

Category	Description	Cost ($)
Columns	6000 psi Concrete	292821.23
	Reinforcing Steel	736412.60
	Formwork	1133271.98
	Placing Concrete	60460.03
Slabs and Drops	6000 psi Concrete	1994706.97
	Reinforcing Steel	1816459.43
	Formwork	4076464.63
	Placing Concrete	261323.82
	Finishing Concrete	319072.69
Shear Walls	6000 psi Concrete	146862.80
	Reinforcing Steel	115049.84
	Formwork	575849.91
	Placing Concrete	26266.80
	Total Cost ($)	11555022.74

Concrete Construction Cost

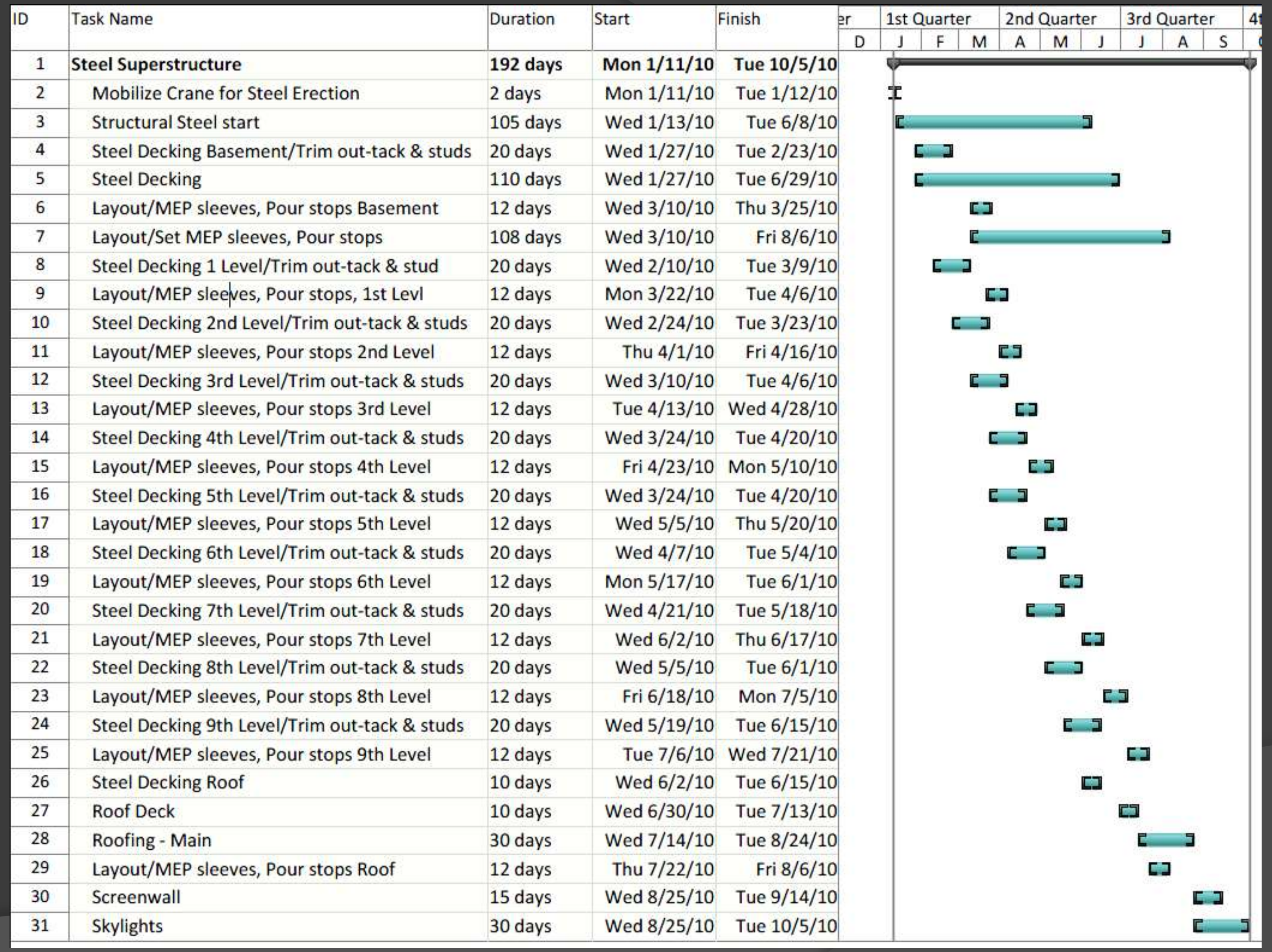
Presentation Outline

- Introduction
- Existing Structural System
- Thesis Proposal
- Structural Depth
- Construction Management Breadth
    - Detailed Cost Analysis
    - Schedule Analysis
- Conclusion

Construction Management Breadth

Schedule Analysis

- Determine which system results in a longer construction time
- Examined schematic design schedule for steel building that was obtained from Cannon Design
    - 192 days, or about 9 months
- Assembled concrete structure schedule
    - RSMeans daily output values
    - Projects of comparable size
    - 242 days, or about 11 months



ID	Task Name	Duration	Start	Finish
1	**Steel Superstructure**	**192 days**	**Mon 1/11/10**	**Tue 10/5/10**
2	Mobilize Crane for Steel Erection	2 days	Mon 1/11/10	Tue 1/12/10
3	Structural Steel start	105 days	Wed 1/13/10	Tue 6/8/10
4	Steel Decking Basement/Trim out-tack & studs	20 days	Wed 1/27/10	Tue 2/23/10
5	Steel Decking	110 days	Wed 1/27/10	Tue 6/29/10
6	Layout/MEP sleeves, Pour stops Basement	12 days	Wed 3/10/10	Thu 3/25/10
7	Layout/Set MEP sleeves, Pour stops	108 days	Wed 3/10/10	Fri 8/6/10
8	Steel Decking 1 Level/Trim out-tack & stud	20 days	Wed 2/10/10	Tue 3/9/10
9	Layout/MEP sleeves, Pour stops, 1st Levl	12 days	Mon 3/22/10	Tue 4/6/10
10	Steel Decking 2nd Level/Trim out-tack & studs	20 days	Wed 2/24/10	Tue 3/23/10
11	Layout/MEP sleeves, Pour stops 2nd Level	12 days	Thu 4/1/10	Fri 4/16/10
12	Steel Decking 3rd Level/Trim out-tack & studs	20 days	Wed 3/10/10	Tue 4/6/10
13	Layout/MEP sleeves, Pour stops 3rd Level	12 days	Tue 4/13/10	Wed 4/28/10
14	Steel Decking 4th Level/Trim out-tack & studs	20 days	Wed 3/24/10	Tue 4/20/10
15	Layout/MEP sleeves, Pour stops 4th Level	12 days	Fri 4/23/10	Mon 5/10/10
16	Steel Decking 5th Level/Trim out-tack & studs	20 days	Wed 3/24/10	Tue 4/20/10
17	Layout/MEP sleeves, Pour stops 5th Level	12 days	Wed 5/5/10	Thu 5/20/10
18	Steel Decking 6th Level/Trim out-tack & studs	20 days	Wed 4/7/10	Tue 5/4/10
19	Layout/MEP sleeves, Pour stops 6th Level	12 days	Mon 5/17/10	Tue 6/1/10
20	Steel Decking 7th Level/Trim out-tack & studs	20 days	Wed 4/21/10	Tue 5/18/10
21	Layout/MEP sleeves, Pour stops 7th Level	12 days	Wed 6/2/10	Thu 6/17/10
22	Steel Decking 8th Level/Trim out-tack & studs	20 days	Wed 5/5/10	Tue 6/1/10
23	Layout/MEP sleeves, Pour stops 8th Level	12 days	Fri 6/18/10	Mon 7/5/10
24	Steel Decking 9th Level/Trim out-tack & studs	20 days	Wed 5/19/10	Tue 6/15/10
25	Layout/MEP sleeves, Pour stops 9th Level	12 days	Tue 7/6/10	Wed 7/21/10
26	Steel Decking Roof	10 days	Wed 6/2/10	Tue 6/15/10
27	Roof Deck	10 days	Wed 6/30/10	Tue 7/13/10
28	Roofing - Main	30 days	Wed 7/14/10	Tue 8/24/10
29	Layout/MEP sleeves, Pour stops Roof	12 days	Thu 7/22/10	Fri 8/6/10
30	Screenwall	15 days	Wed 8/25/10	Tue 9/14/10
31	Skylights	30 days	Wed 8/25/10	Tue 10/5/10

Steel Construction Schedule

Presentation Outline

- Introduction
- Existing Structural System
- Thesis Proposal
- Structural Depth
- Construction Management Breadth
  - Detailed Cost Analysis
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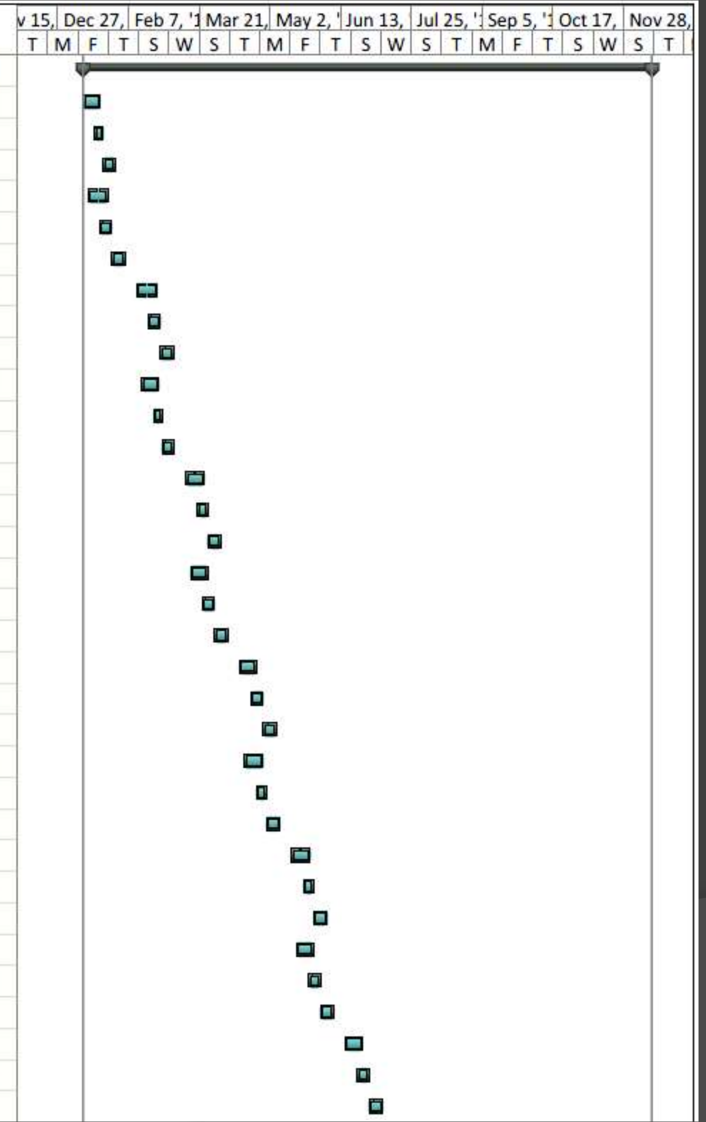
Construction Management Breadth

Schedule Analysis

- Determine which system results in a longer construction time
- Examined schematic design schedule for steel building that was obtained from Cannon Design
  - 192 days, or about 9 months
- Assembled concrete structure schedule
  - RSMeans daily output values
  - Projects of comparable size
  - 242 days, or about 11 months

ID	Task Name	Duration	Start	Finish
1	**Concrete Superstructure**	**242 days**	**Mon 1/11/10**	**Tue 12/14/10**
2	Frame Columns and Walls - Basement	8 days	Mon 1/11/10	Wed 1/20/10
3	Set Rebar Columns and Walls - Basement	5 days	Mon 1/18/10	Fri 1/22/10
4	Pour Columns and Walls - Basement	6 days	Sat 1/23/10	Fri 1/29/10
5	Frame Slab and Drops - Basement	8 days	Thu 1/14/10	Mon 1/25/10
6	Set Rebar Slabs and Drops - Basement	5 days	Thu 1/21/10	Wed 1/27/10
7	Pour Slabs and Drops - Basement	6 days	Thu 1/28/10	Thu 2/4/10
8	Frame Columns and Walls - Mechanical	8 days	Fri 2/12/10	Tue 2/23/10
9	Set Rebar Columns and Walls - Mechanical	5 days	Fri 2/19/10	Thu 2/25/10
10	Pour Columns and Walls - Mechanical	6 days	Fri 2/26/10	Fri 3/5/10
11	Frame Slab and Drops - Mechancial	8 days	Mon 2/15/10	Wed 2/24/10
12	Set Rebar Slabs and Drops - Mechanical	5 days	Mon 2/22/10	Fri 2/26/10
13	Pour Slabs and Drops - Mechanical	6 days	Sat 2/27/10	Fri 3/5/10
14	Frame Columns and Walls - Level 1	8 days	Sat 3/13/10	Tue 3/23/10
15	Set Rebar Columns and Walls - Level 1	5 days	Sat 3/20/10	Thu 3/25/10
16	Pour Columns and Walls - Level 1	6 days	Fri 3/26/10	Fri 4/2/10
17	Frame Slab and Drops - Level 1	8 days	Tue 3/16/10	Thu 3/25/10
18	Set Rebar Slabs and Drops - Level 1	5 days	Tue 3/23/10	Mon 3/29/10
19	Pour Slabs and Drops - Level 1	6 days	Tue 3/30/10	Tue 4/6/10
20	Frame Columns and Walls - Level 2	8 days	Wed 4/14/10	Fri 4/23/10
21	Set Rebar Columns and Walls - Level 2	5 days	Wed 4/21/10	Tue 4/27/10
22	Pour Columns and Walls - Level 2	6 days	Wed 4/28/10	Wed 5/5/10
23	Frame Slab and Drops - Level 2	8 days	Sat 4/17/10	Tue 4/27/10
24	Set Rebar Slabs and Drops - Level 2	5 days	Sat 4/24/10	Thu 4/29/10
25	Pour Slabs and Drops - Level 2	6 days	Fri 4/30/10	Fri 5/7/10
26	Frame Columns and Walls - Level 3	8 days	Sat 5/15/10	Tue 5/25/10
27	Set Rebar Columns and Walls - Level 3	5 days	Sat 5/22/10	Thu 5/27/10
28	Pour Columns and Walls - Level 3	6 days	Fri 5/28/10	Fri 6/4/10
29	Frame Slab and Drops - Level 3	8 days	Tue 5/18/10	Thu 5/27/10
30	Set Rebar Slabs and Drops - Level 3	5 days	Tue 5/25/10	Mon 5/31/10
31	Pour Slabs and Drops - Level 3	6 days	Tue 6/1/10	Tue 6/8/10
32	Frame Columns and Walls - Level 4	8 days	Wed 6/16/10	Fri 6/25/10
33	Set Rebar Columns and Walls - Level 4	5 days	Wed 6/23/10	Tue 6/29/10
34	Pour Columns and Walls - Level 4	6 days	Wed 6/30/10	Wed 7/7/10



Concrete Construction Schedule

Presentation Outline

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Conclusion

- The main goal of this thesis was to design a concrete building in the hope that it would be less expensive than its steel counterpart

- While the concrete building is currently about $300,000 less expensive, several factors should be considered
  - Inadequate vibration design
  - Foundation strengthening
  - Cold weather concreting in Buffalo, NY
  - Elongated schedule

- In the end, the current steel building is probably the more efficient and economical design

Presentation Outline

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Acknowledgements

Cannon Design

- Rachel Chicchi
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- Professor Kevin Parfitt
- Professor Robert Holland

My family and friends!

Cannon Design

Questions and Comments?

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