Architectural Engineering: Structural Option Thesis Presentation

Best Buy Main Corporate Campus: Building D
Richfield, MN

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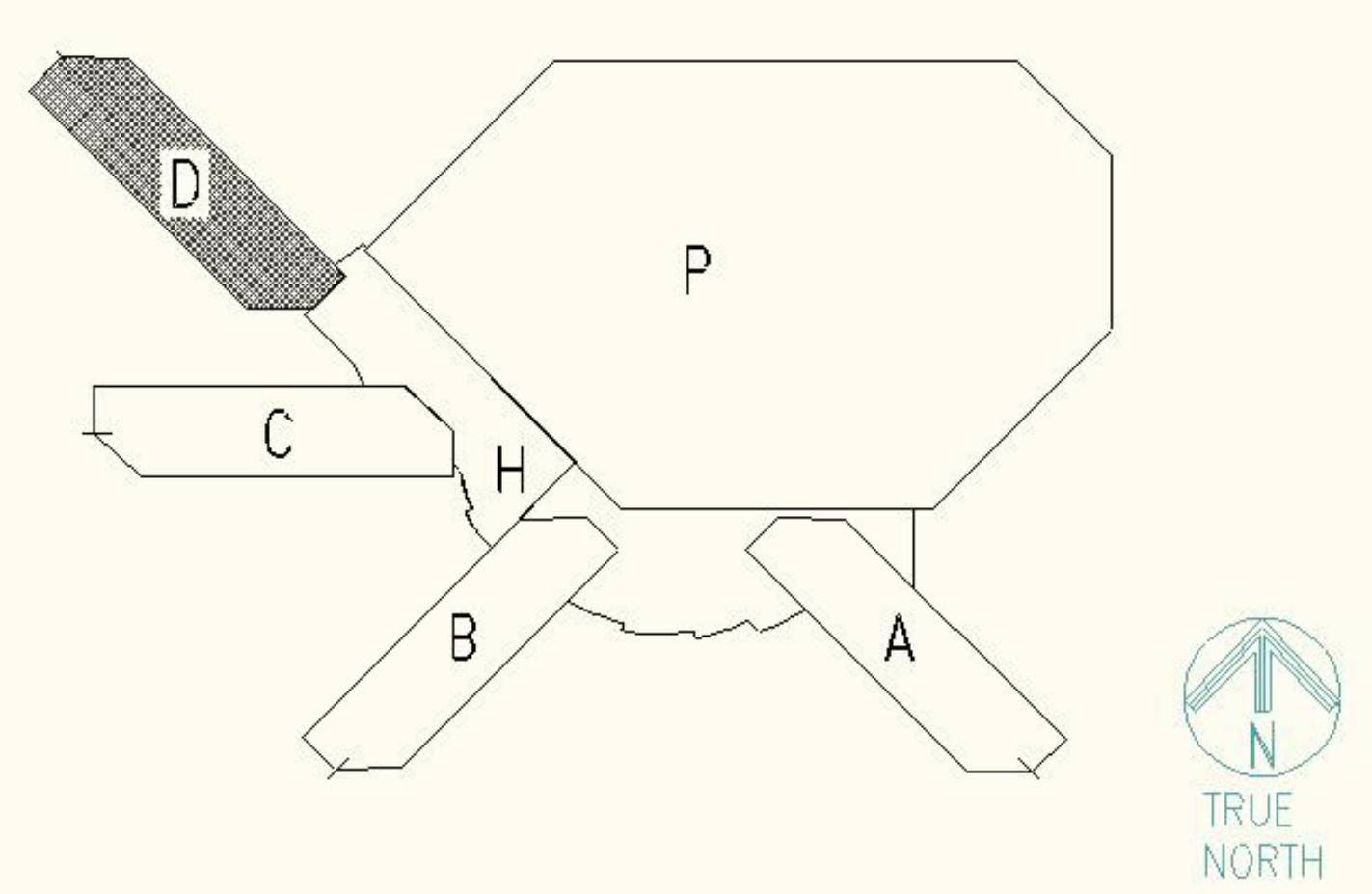
Presentation Outline

- Introduction
  - Building description
  - Existing structural conditions
- Project Proposal
- Building Redesign
  - Columns
  - PT floor system
  - Lateral system
  - Foundation
- Cost Comparison
- Architectural Comparison
- Conclusions

Introduction

- **Building Name:** Best Buy Main Corporate Building
- **Location:** Richfield, MN
- **Function:** Office building
- **Occupants:** Best Buy corporate employees
- **Architects:** Perkins & Will (www.perkinswill.com)
  - Minneapolis, MN
- **Engineers:** Opus Northwest (www.opuscorp.com)
  - Minnetonka, MN
- **CM:** Opus Northwest
  - Chris Johnson

Introduction



Building Description

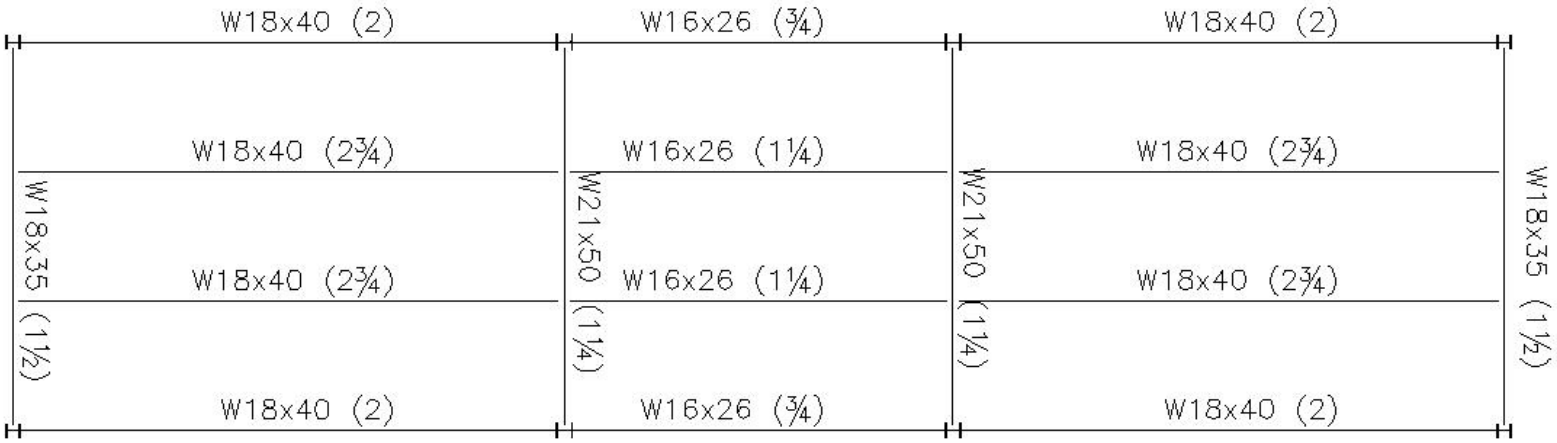
Architecture

- Precast curtain wall
- Ribbon windows
- Curtain wall consists of 6” architectural precast panels tied into the steel structure
- Prefinished aluminum closure panel holds the ribbon of windows on each floor

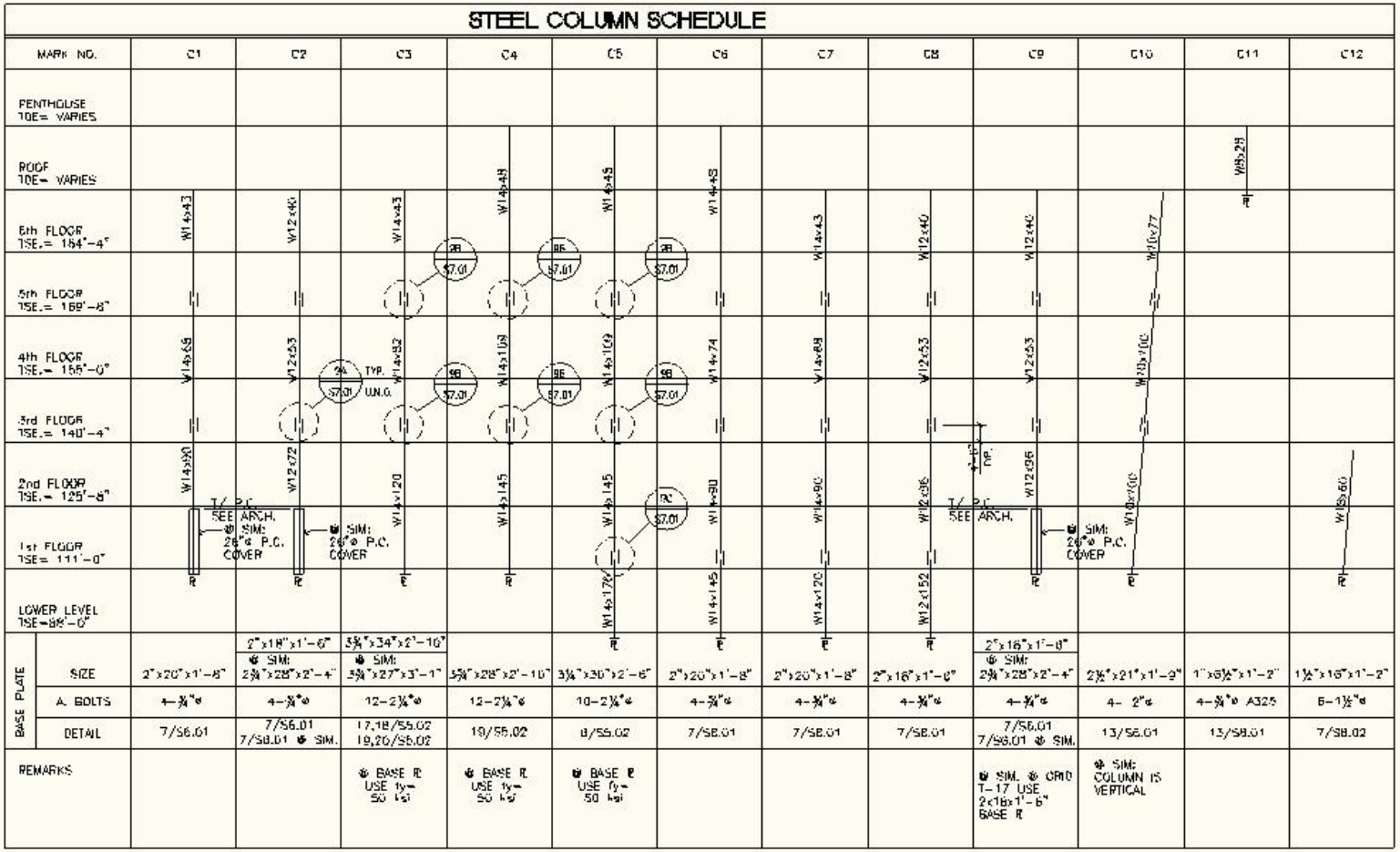
Structural System

Floor System

- Composite beam framing system
- 6¼” slab, 3” 20 gauge deck and 3¼” lightweight concrete
- Spray on fireproofing



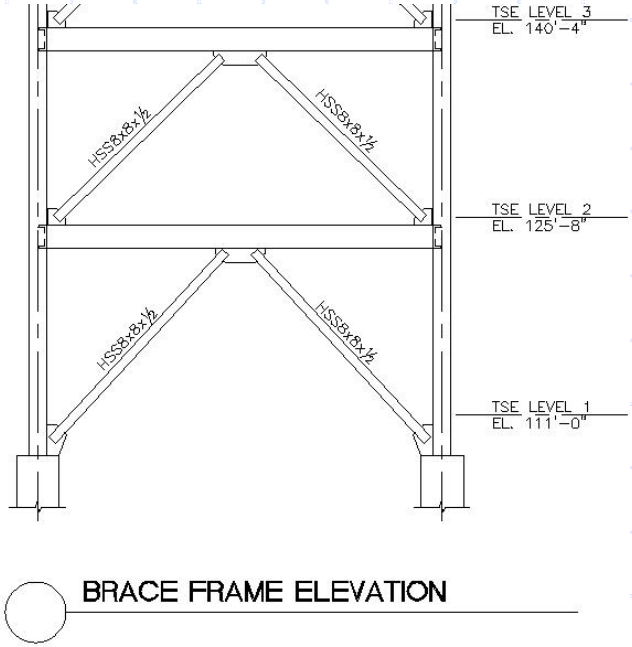
Structural System



Structural System

Lateral System

- Braced frame consist of 3 - W14 columns spliced together at the 3rd and 5th floors
- Heavier beams, W16x57



BRACE FRAME ELEVATION

Project Proposal

Proposed Solution:

- Redesign Best Buy Corporate Building D as a full concrete system
- Floor system will be redesigned post-tensioned slab with beams
- Columns will also be redesigned into concrete
- Lateral bracing system will be shear walls
- Goal is to allow for a larger bay size in the short direction of the building
- Cost Comparison of structural system
- The impact of the change in architecture on the tenant and rentable area

Project Proposal

Solution Method:

- Utilize ACI 318-05 Building Code Requirements for Structural Concrete
- Utilize ADAPT-PT to design beams and slab
- Utilize PCA Column and ETABS to design columns and shear walls
- Utilize RS Means Building Construction Cost Data for a structural cost analysis
- Compare and contrast new vs. old architecture

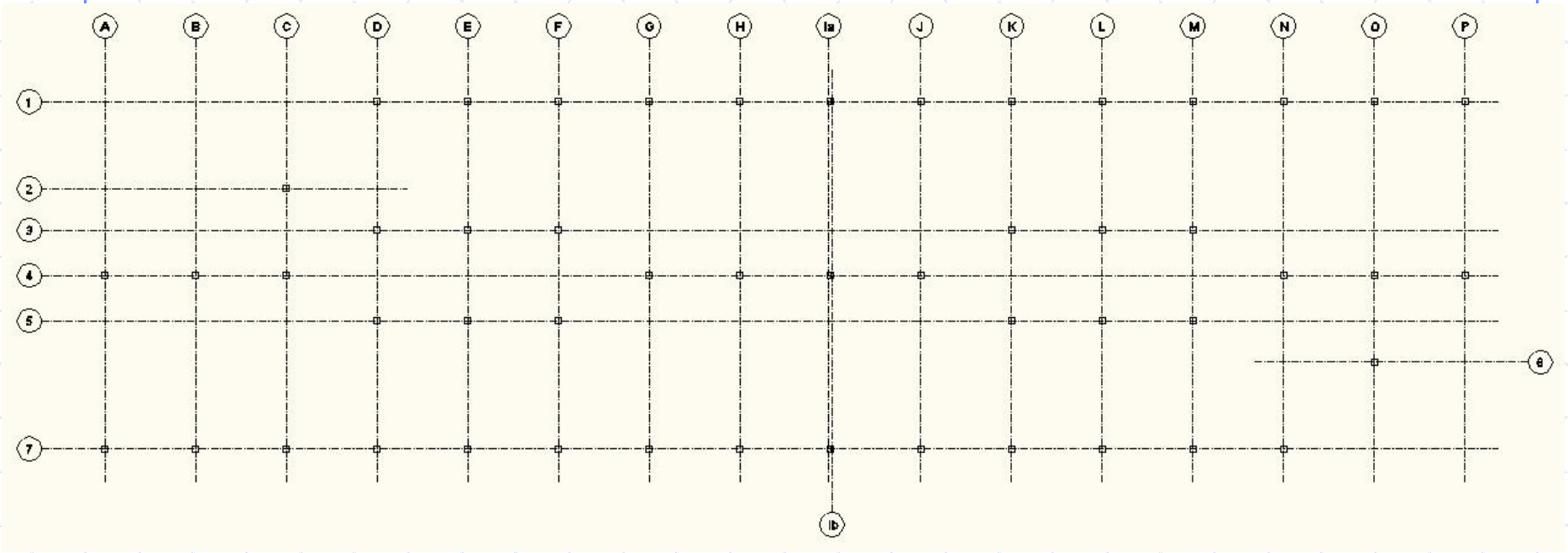
Building Redesign

- Columns
- PT floor system
- PT beams
- Shear Walls
- Foundation

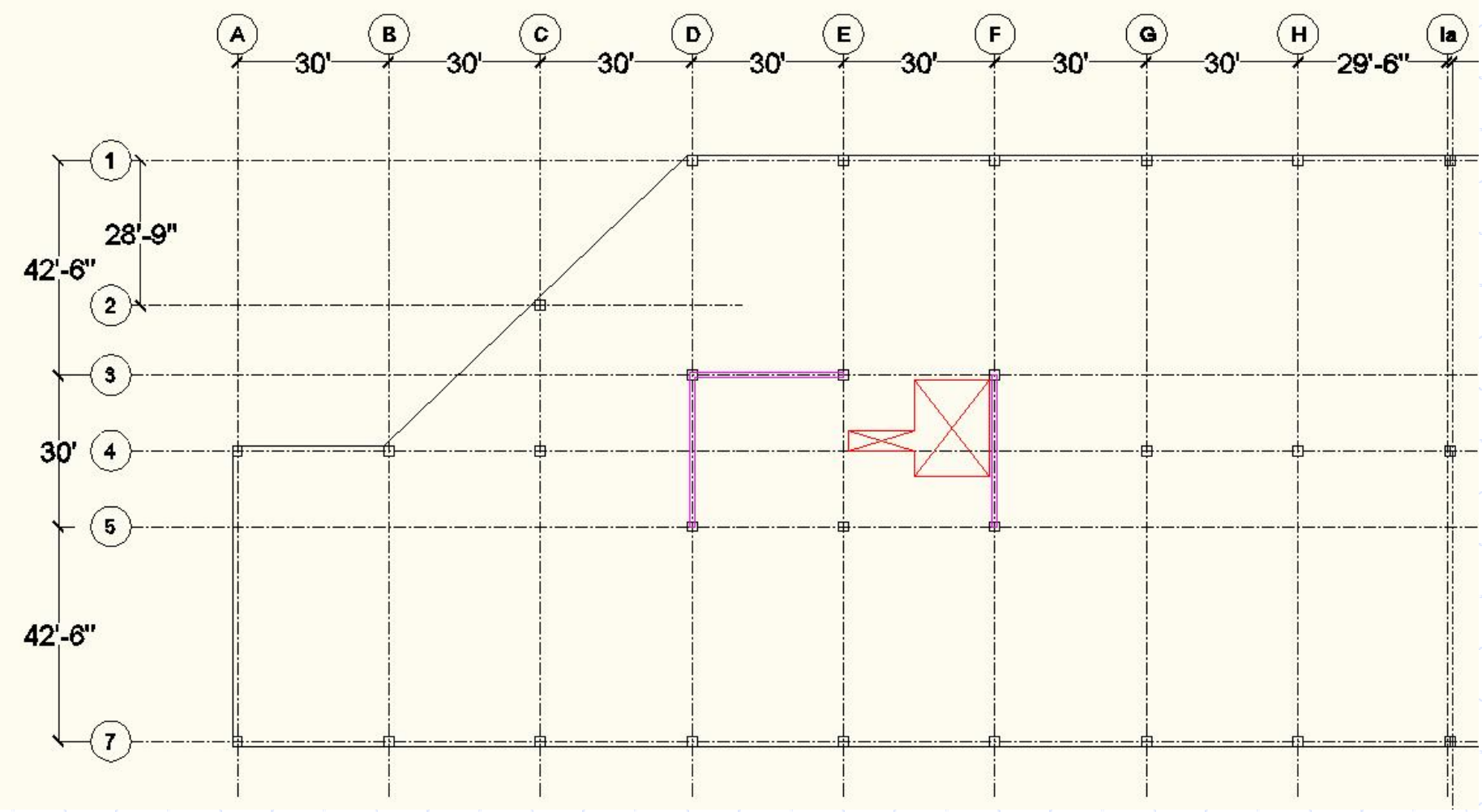
Columns

- Design floor layout to support larger bays with fewer columns
- PCA Columns aided in design of reinforcement
- ETABS used to verify column sizing

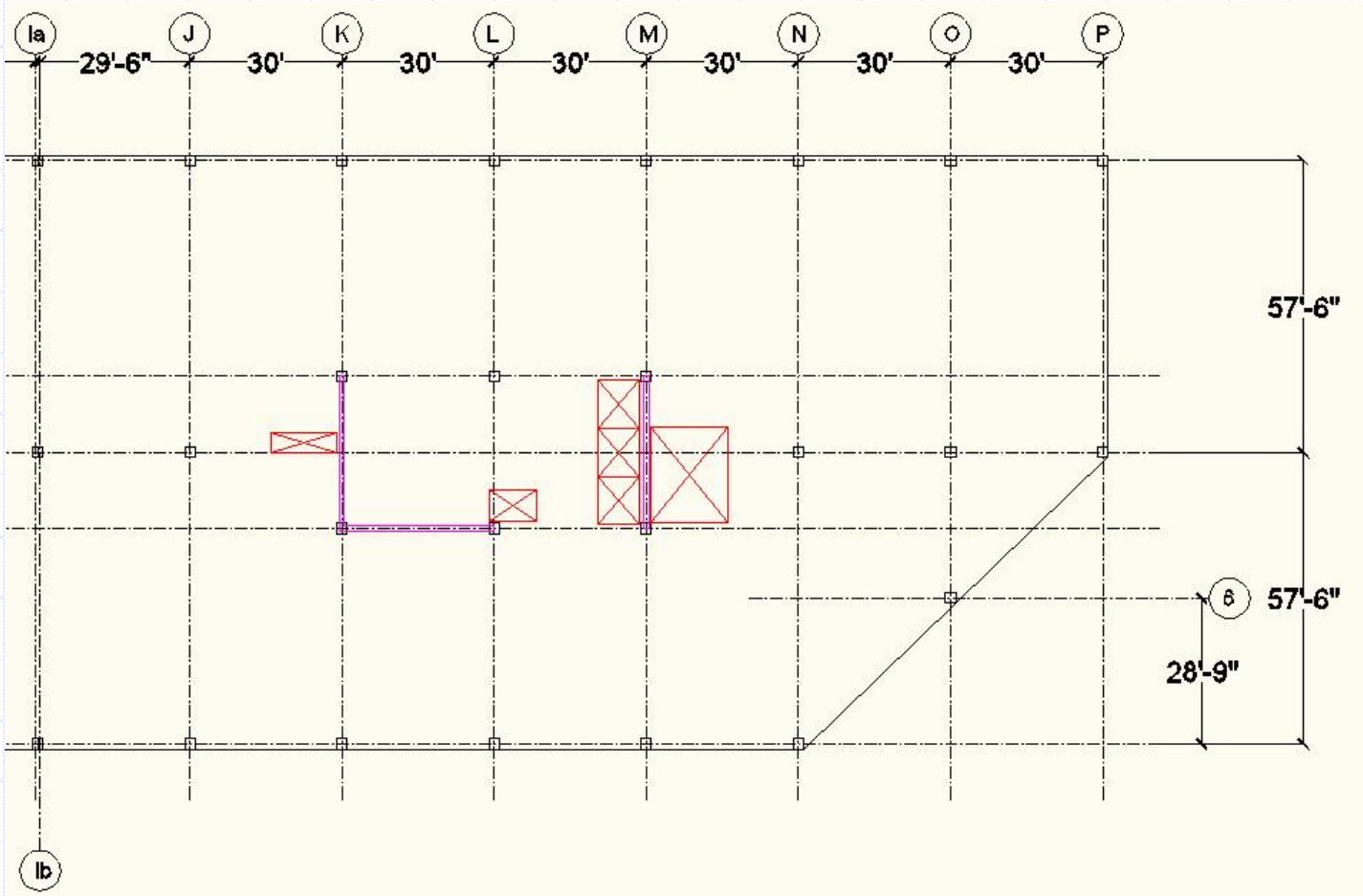
Columns



Columns

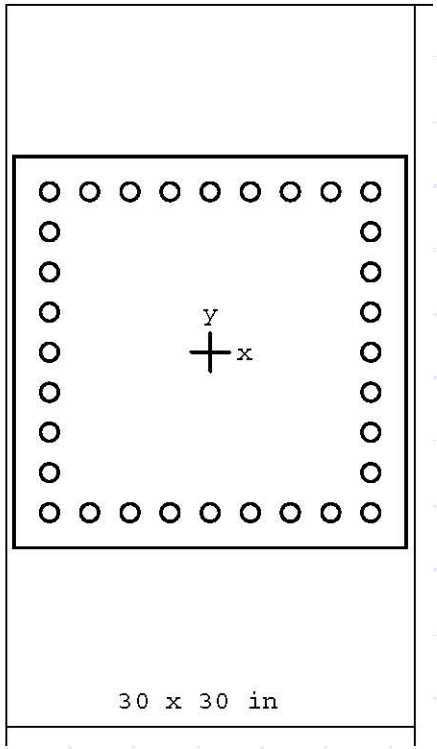


Columns



Columns

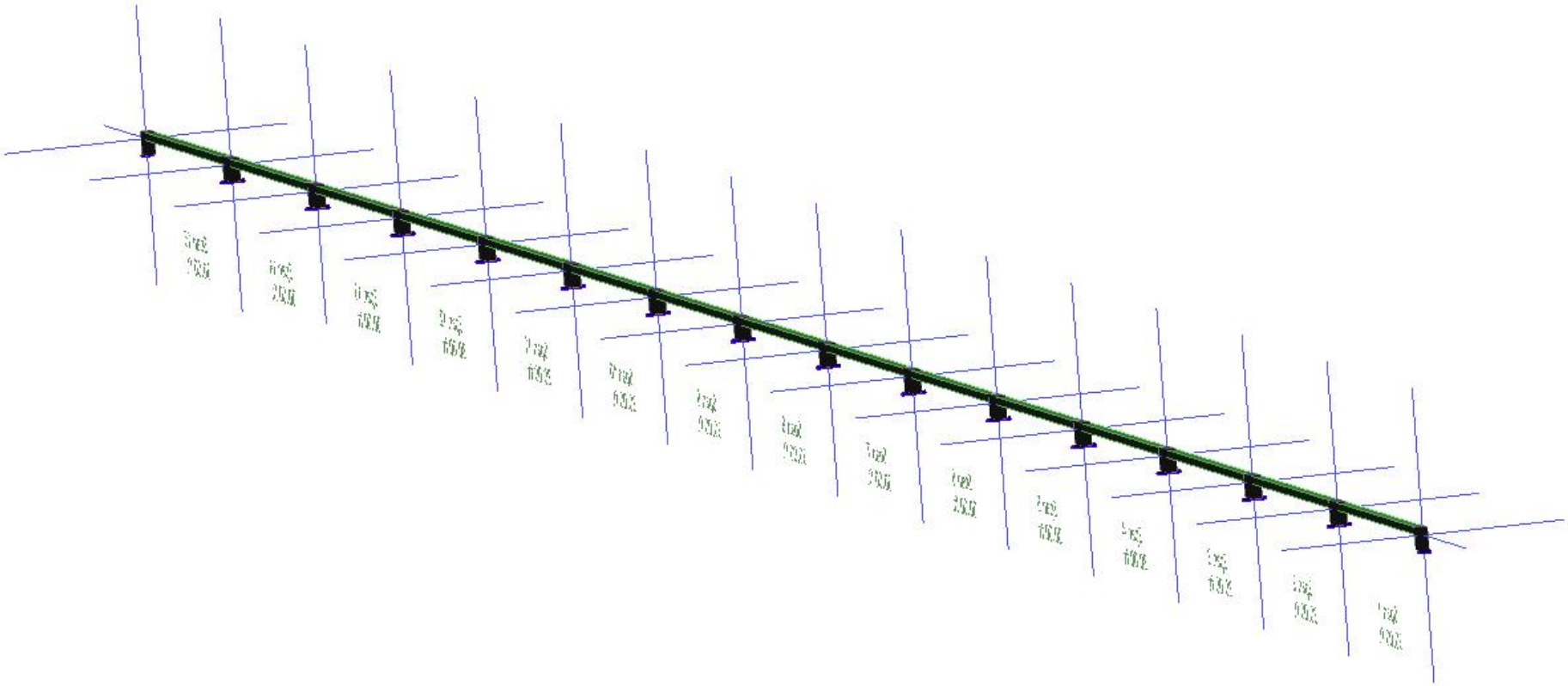
- 30”x30” columns requiring 32-#11 vertical reinforcing
- 24”x24” columns requiring 28-#11 vertical reinforcing



Post-tensioned Slab

- Design post-tensioned slab using ADAPT-PT as an aid
- Keep slab thickness close to 8” as recommended by span/depth ratio

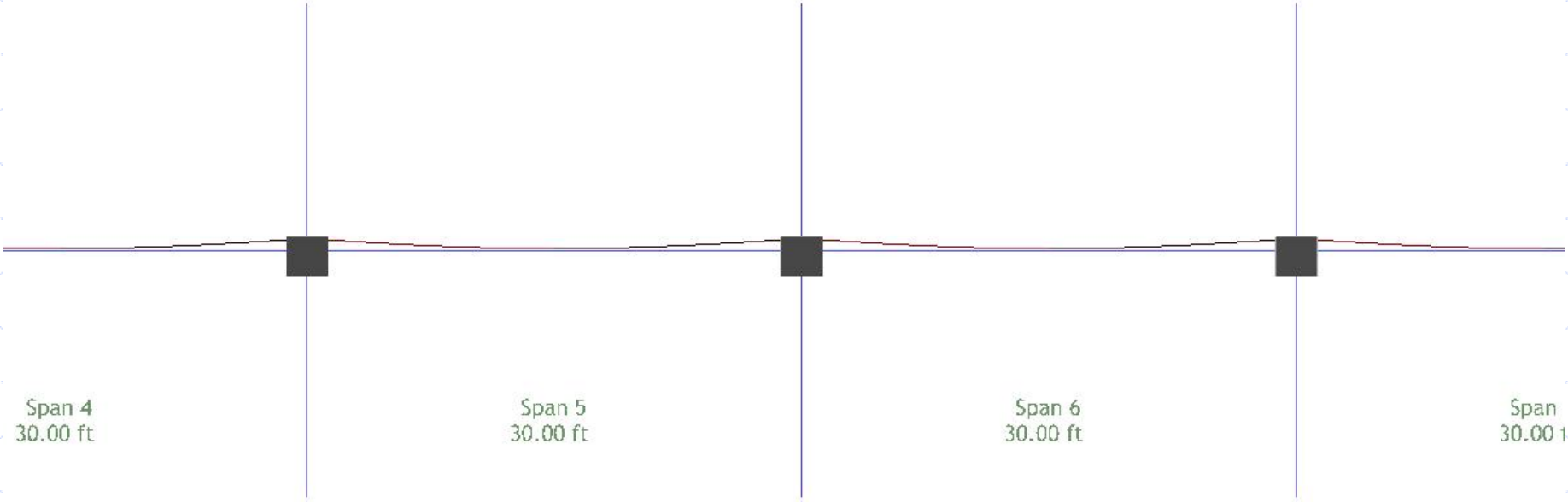
Post-tensioned Slab



Post-tensioned Slab

- Unit strip method
- Determined a 9.5” slab was required
- 2 tendons required for first and last 2 spans
- 1 tendon for the remaining spans

Post-tensioned Slab



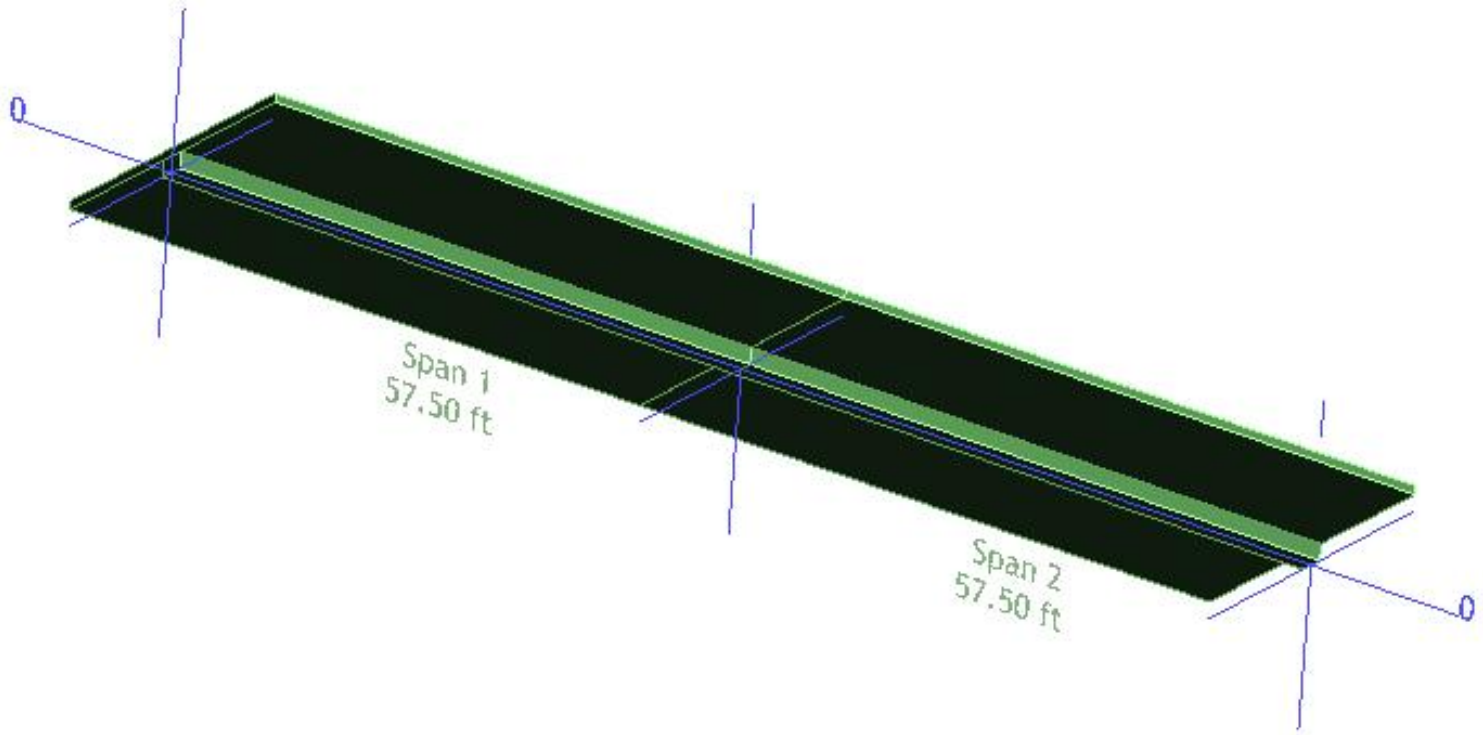
Post-tensioned Slab

	Number of strands	PT Force per unit	PT Force	P/A	%DL balanced	Left	Center	Right	Total strands	Total PT force per unit width	Total PT force	Left	Center	Right	Total P/A	Total %DL
1	2	30.0	30.0	263	43	4.75	1.75	8.50	2	30.0	30.0	19	27	27	263	43
2	2	30.0	30.0	263	69	8.50	1.00	8.50	2	30.0	30.0	30	17	17	263	69
3	1	25.0	25.0	219	57	8.50	1.00	8.50	1	25.0	25.0	17	17	19	219	57
4	1	25.0	25.0	219	57	8.50	1.00	8.50	1	25.0	25.0	19	17	18	219	57
5	1	25.0	25.0	219	57	8.50	1.00	8.50	1	25.0	25.0	18	17	18	219	57
6	1	25.0	25.0	219	57	8.50	1.00	8.50	1	25.0	25.0	18	17	18	219	57
7	1	25.0	25.0	219	57	8.50	1.00	8.50	1	25.0	25.0	18	17	18	219	57
8	1	25.0	25.0	219	57	8.50	1.00	8.50	1	25.0	25.0	18	17	18	219	57
9	1	25.0	25.0	219	57	8.50	1.00	8.50	1	25.0	25.0	18	17	18	219	57
10	1	25.0	25.0	219	57	8.50	1.00	8.50	1	25.0	25.0	18	17	18	219	57

Post-tensioned Beams

- Design post-tensioned beam using ADAPT-PT as an aid
- Keep beam thickness close to 27” as recommended by span/depth ratio

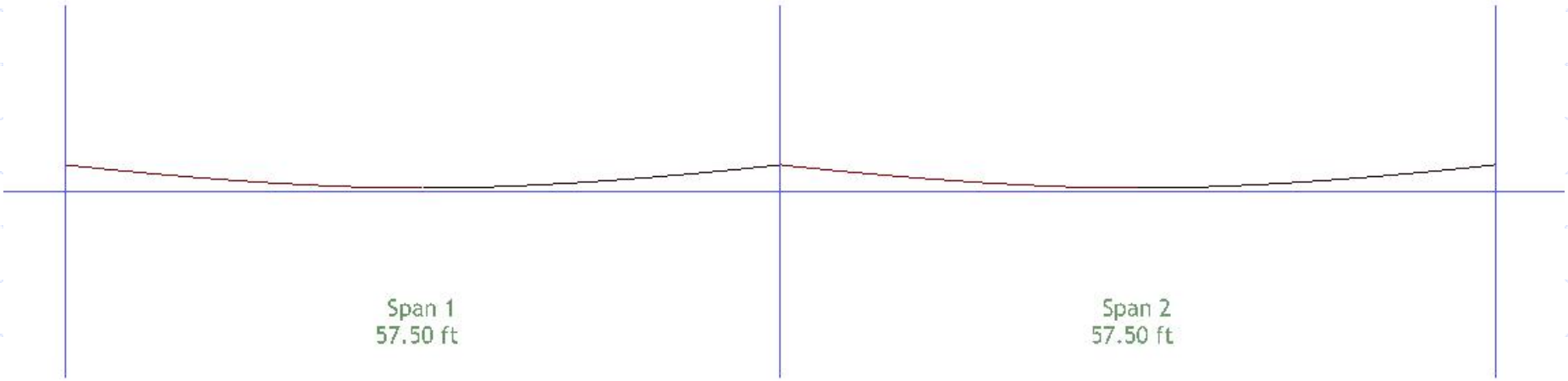
Post-tensioned Beams



Post-tensioned Beams

- 2 different beams had to be designed
  - 2 span (57’6”,57’6”)
  - 3 span (42’6”,30’,42’6”)
- Designed 28” deep for both spans
- 27 tendons needed for 2 span and 19 tendons for 3 span

Post-tensioned Beams



Post-tensioned Beams

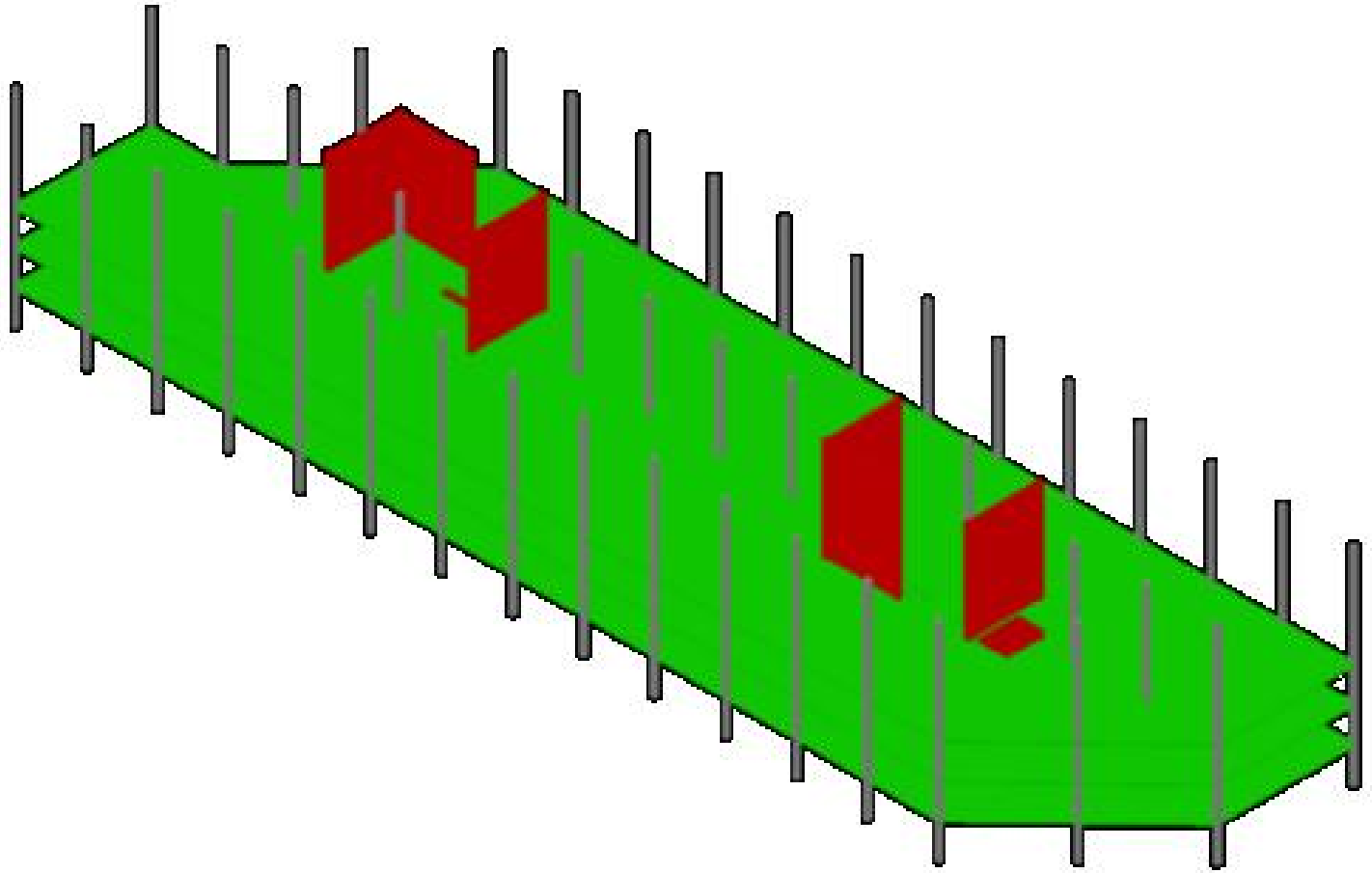
	Number of strands	PT Force per unit	PT Force	P/A	%DL balanced	Left	Center	Right	Total strands	Total PT force per unit width	Total PT force	Left	Center	Right	Total P/A	Total %DL
1	27	49.8	716.1	180	59	21.30	3.25	25.75	27	49.8	716.1	497	716	547	180	59
2	27	49.8	716.1	180	59	25.75	3.25	21.30	27	49.8	716.1	548	716	497	180	59

	Number of strands	PT Force per unit	PT Force	P/A	%DL balanced	Left	Center	Right	Total strands	Total PT force per unit width	Total PT force	Left	Center	Right	Total P/A	Total %DL
1	19	47.0	499.6	126	62	21.30	3.25	25.75	19	47.0	499.6	497	500	497	126	62
2	19	66.6	499.6	126	138	25.75	3.25	25.75	19	66.6	499.6	497	497	497	126	138
3	19	47.0	499.6	126	62	25.75	3.25	21.30	19	47.0	499.6	497	500	497	126	62

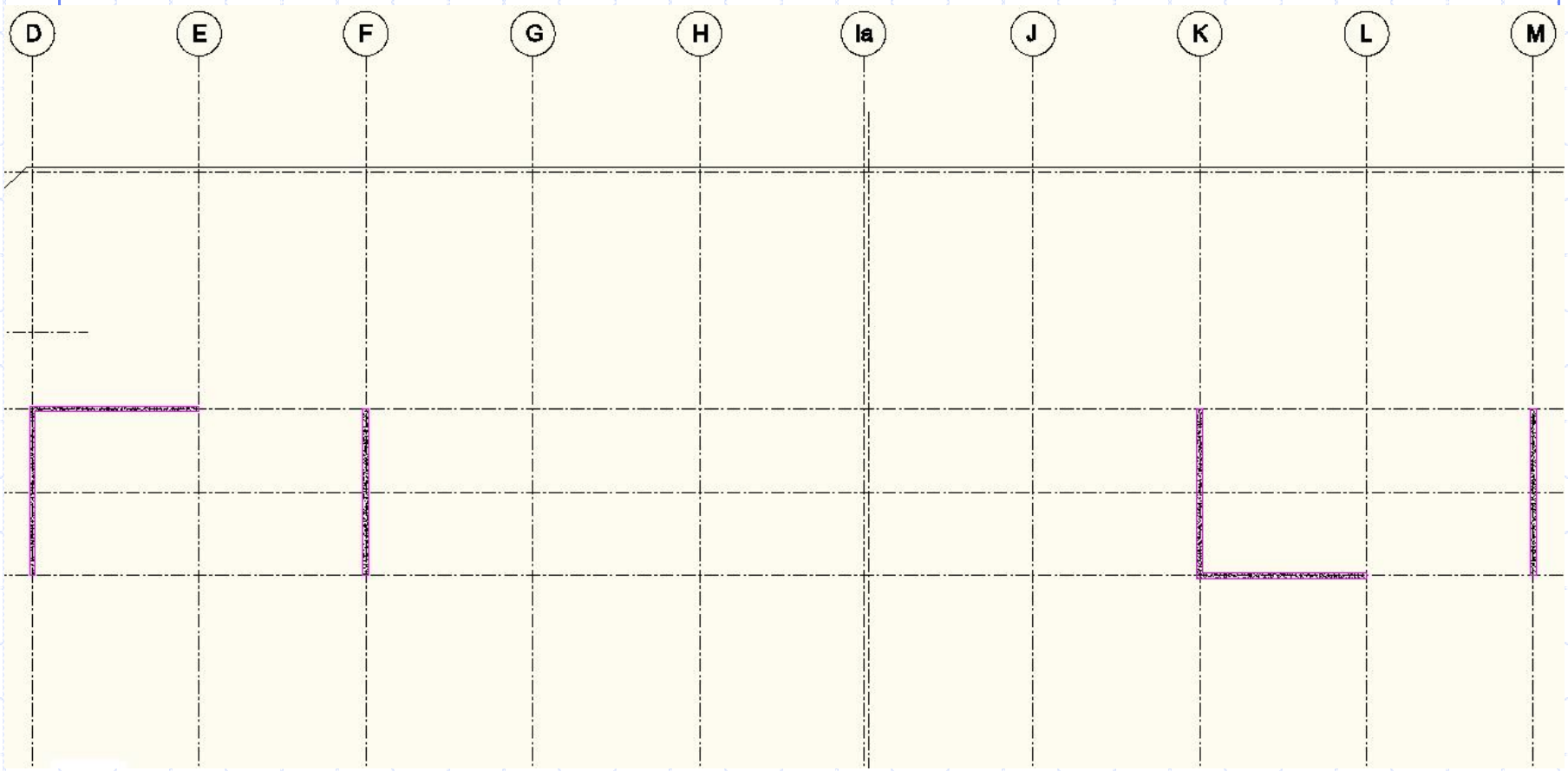
Lateral System

- Redesign braced frames into shear walls while maintaining current location

Lateral System



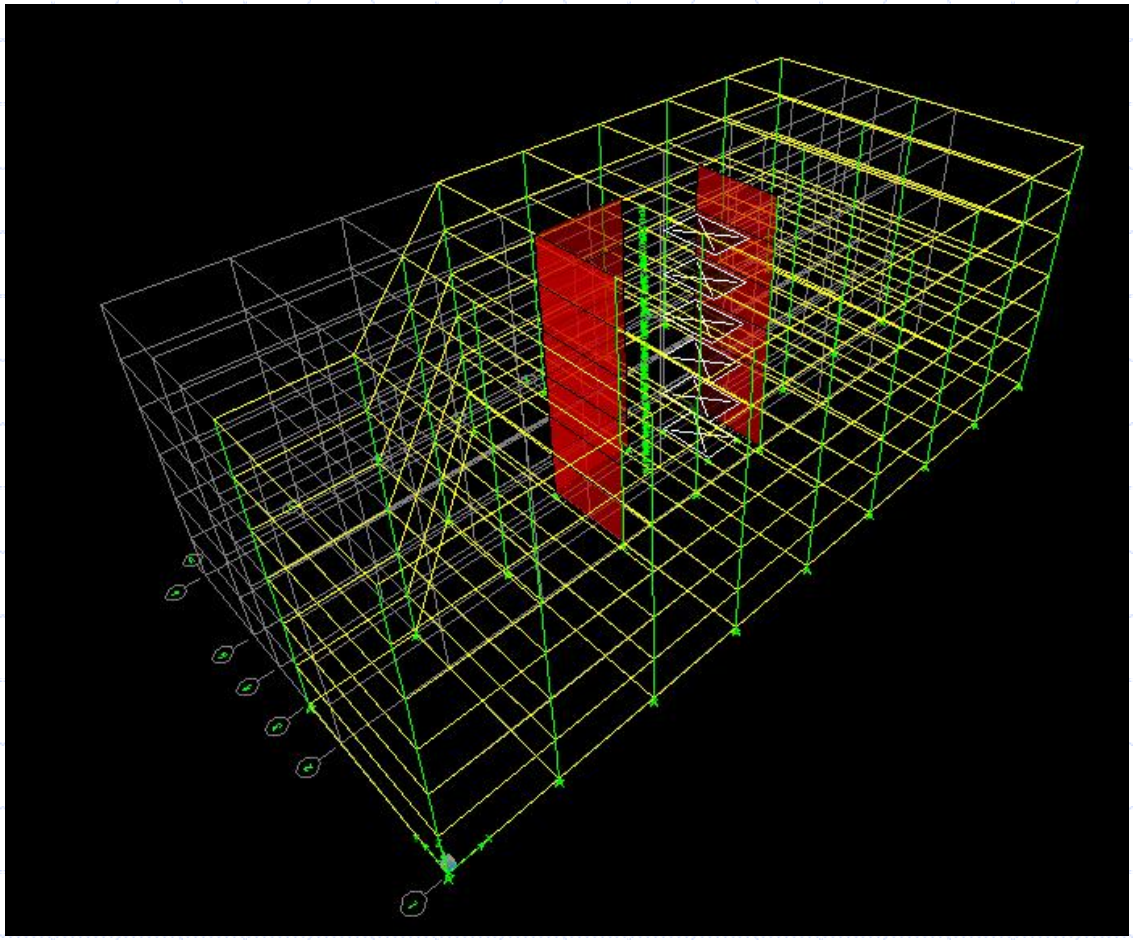
Lateral System



Lateral System

- ETABS assisted in the design
- Found that a 12” wall was a sufficient thickness
- Boundary elements were designed to fit inside the 12” wall

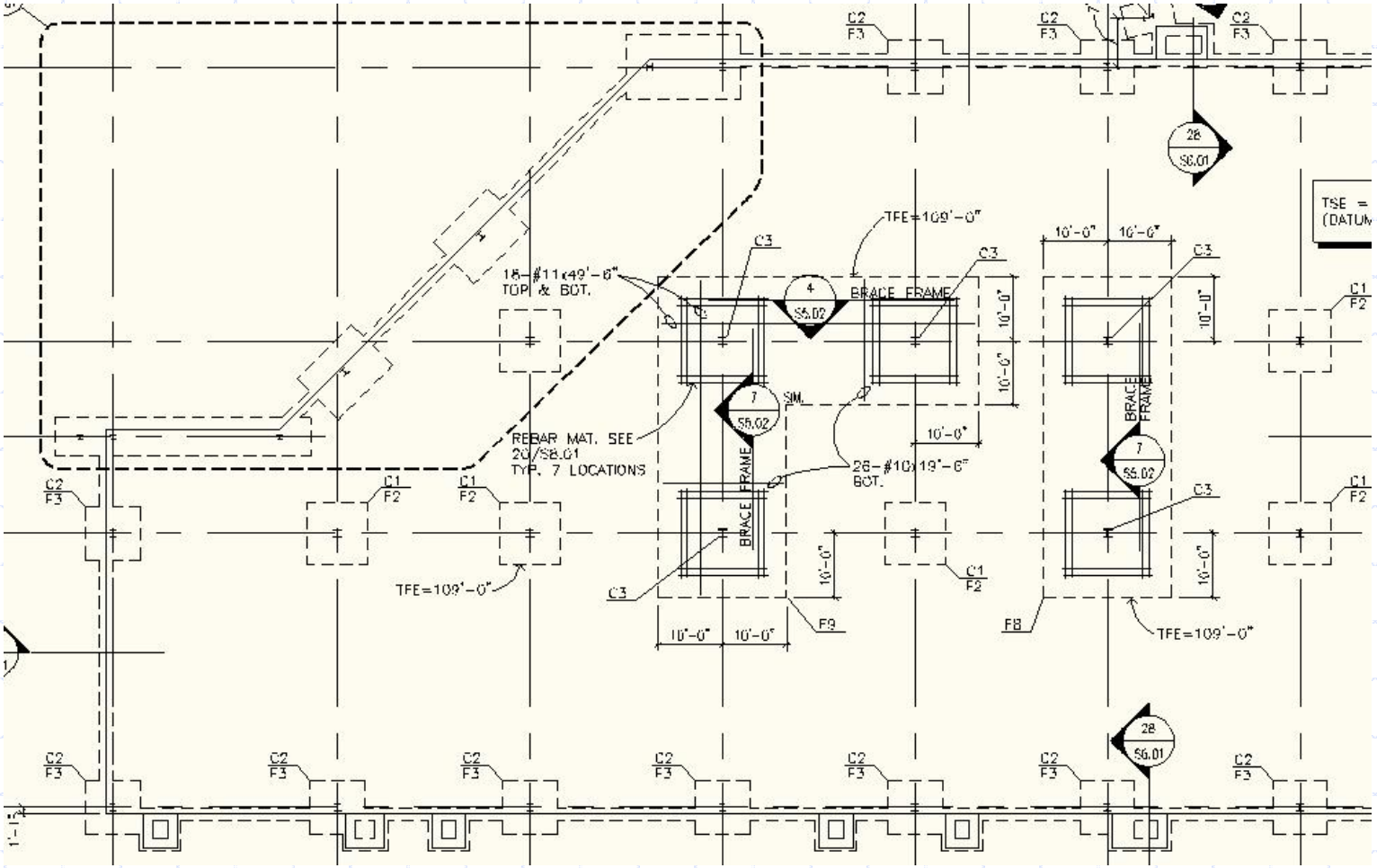
Lateral System



Foundation

- Considered, however, not redesigned
- Heavier concrete columns and shear walls
  - Larger piers and slabs
  - Stronger concrete

Foundation


C2 F3
C1 F2
C3
TFE=109'-0"
18-#11x49'-0" TOP & BOT.
REBAR MAT. SEE 20/S6.01 TYP. 7 LOCATIONS
BRACE FRAME
4 S6.02
7 S6.02
SIM.
26-#10x19'-6" BOT.
10'-0"
F8
F9
28 S6.01
TSE = (DATUM

Cost Analysis

Beams and Girders				
Size	Quantity	Average Length	Cost per ft	Cost per Floor
W8x15	3	10	$37.00	$1,110.00
W12x14	8	10	$36.00	$2,880.00
W12x19	5	15	$36.00	$2,700.00
W14x22	2	13	$47.00	$1,222.00
W16x26	42	30	$53.00	$66,780.00
W16x31	1	30	$63.50	$1,905.00
W16x57	4	30	$98.50	$11,820.00
W18x35	25	30	$81.00	$60,750.00
W18x40	81	42.5	$72.00	$247,860.00
W21x44	1	34	$87.50	$2,975.00
W21x50	27	30	$98.50	$79,785.00
W24x55	3	33.2	$107.00	$10,657.20
W24x62	1	30	$121.00	$3,630.00
		Total Cost per Floor		$494,074.20
		Total Building Cost		$2,964,445.20

Cost Analysis

Slab		Columns			Beams		
Depth	Area	# of	Height	Area	# of	Length	Area
0.83	46575	51	11.84	6.25	16	115	4.72
Total (c.y.)		Total (c.y.)			Total (c.y.)		
1431.75		139.78			321.66		

Cast-in-Place Concrete		
Cost per c.y.	Cost per c.y.	Cost per c.y.
610	1375	1200
Cost per Floor	Cost per Floor	Cost per Floor
$873,367.50	$192,194.44	$385,991.11
CIP Costs per Floor		
$1,451,553.06		
Total Building CIP Costs		
$8,709,318.33		

Cost Comparisons

- A considerable increase in costs of materials and erection

	Beam	Columns	Floor System	Total
Steel	$2,964,445.20	$909,422.64	$2,443,540.96	$6,317,408.80
Concrete	$2,315,946.67	$1,153,166.67	$5,240,205.00	$8,709,318.33

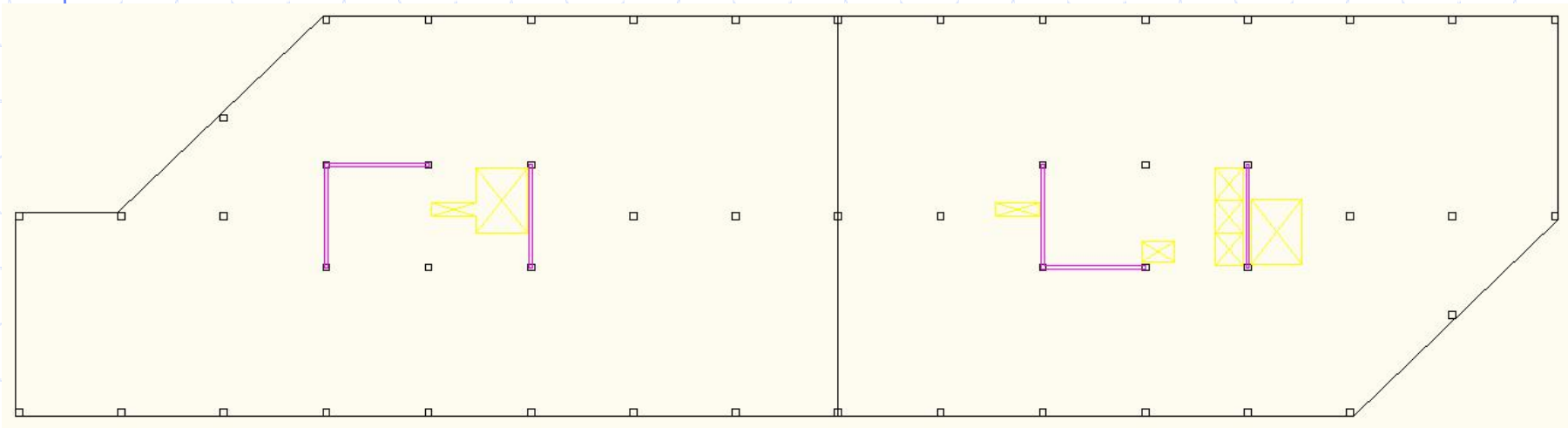
- 38%

Architecture Comparisons

- Increased open space bays from 42’6” to 57’6”
- No fireproofing
- Fewer columns for partitioned rooms to work around

Architecture Comparisons

Architecture Comparisons



Conclusions

- New floor system increased bay sizes without sacrificing ceiling/floor height
- Cost of new system far exceeds cost of existing system

Acknowledgements

- **Thesis Advisors:**
  - Dr. Thomas E. Boothby
- **Industry Contacts:**
  - Gary R. Strand, P.E. - Simpson Gumpertz & Heger
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  - Richard Apple, P.E. - Holbert Apple Associates
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  - Professor Moses Ling

Questions