



NATIONAL HARBOR BUILDING M

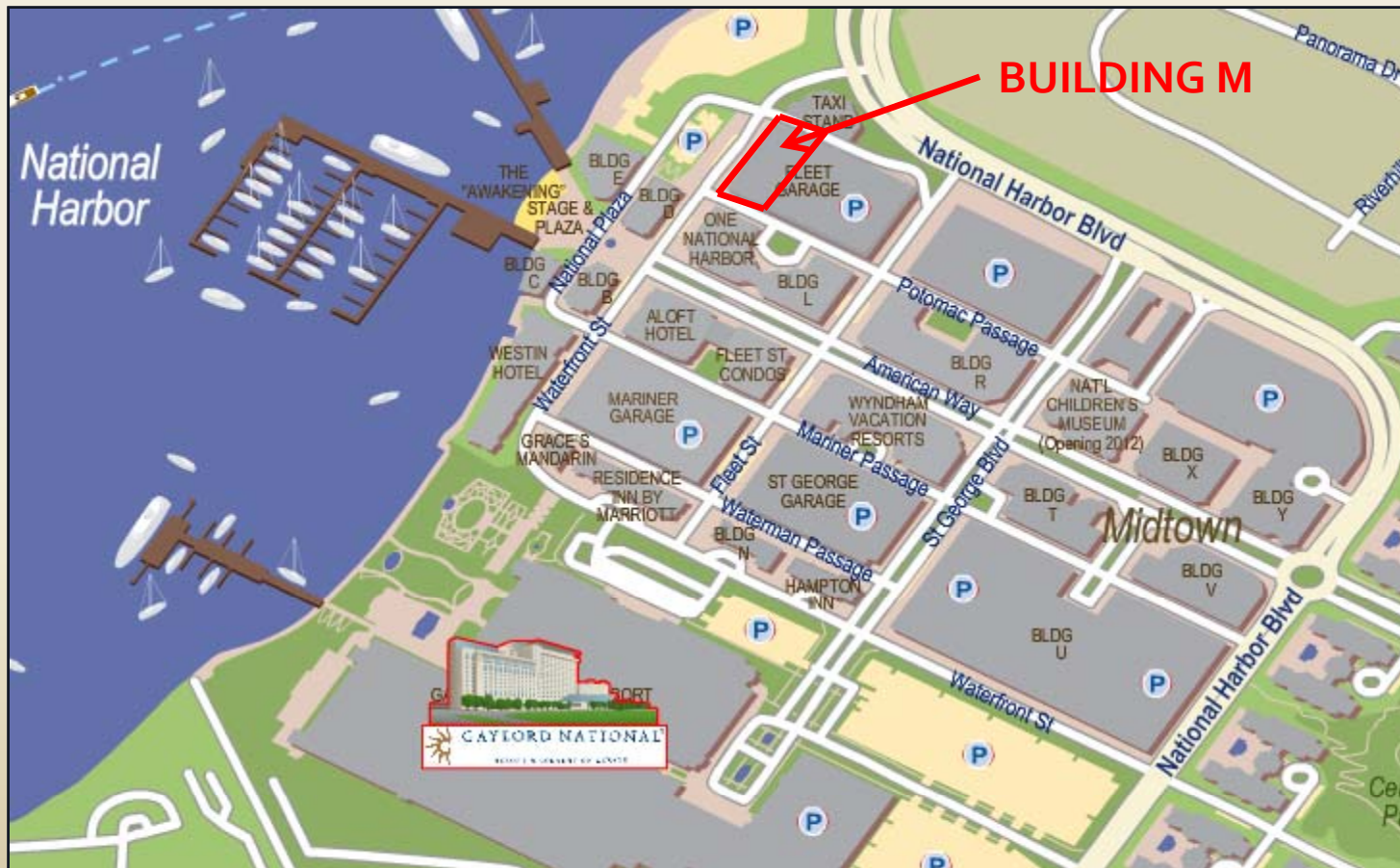
120 Waterfront St. Oxon Hill, Maryland

Ryan Sarazen – Structural Option

Senior Thesis Presentation – Spring 2008

Faculty Consultant – Dr. Lepage

BUILDING LOCATION



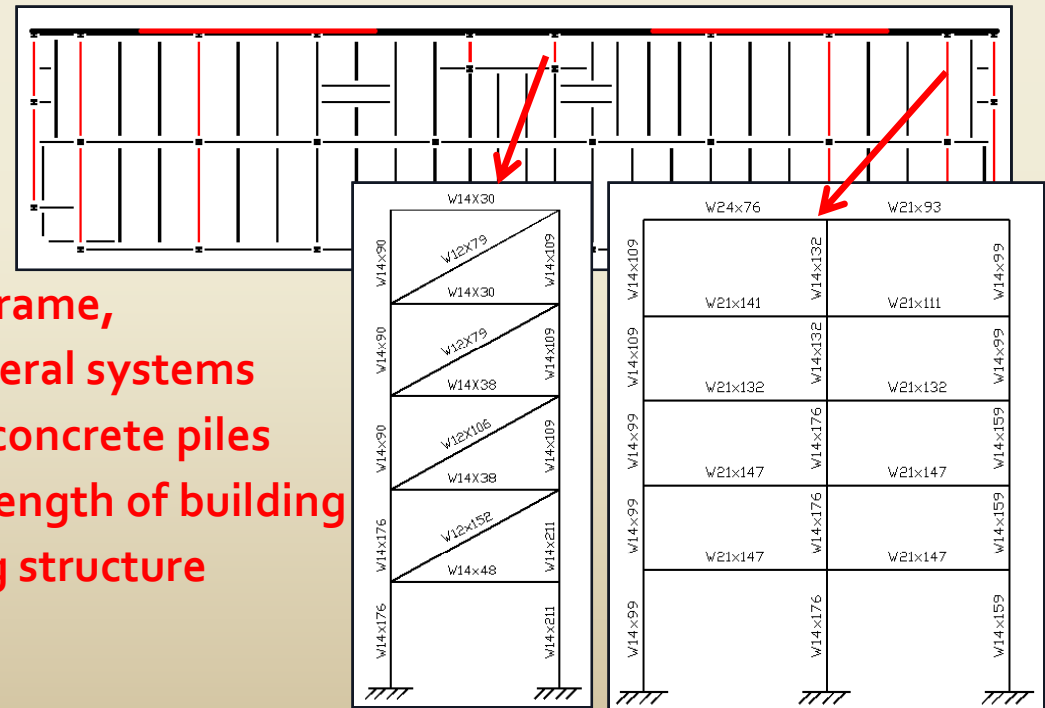
SITE PLAN FROM WWW.NATIONALHARBOR.COM

RYAN SARAZEN - STRUCTURAL OPTION

EXISTING BUILDING DATA



- **General Data:**
 - **Size:** 81,801 SF (14,688 Retail, 67,133 Office)
 - **Height:** 5 stories – 73'-4" tall
 - **Cost:** 9.5 Million Dollars
- **Structural:**
 - 6-1/4" LWC composite slab
 - Steel Braced and Moment Frame, and Masonry Shear Wall Lateral systems
 - 14" sq. precast prestressed concrete piles
 - 4" expansion joint running length of building separating adjacent parking structure



THESIS OBJECTIVES- INTRODUCTION



- **STRUCTURAL DEPTH -** achieve efficiency of the steel design using a concrete-based structure
- **ARCHITECTURAL FAÇADE - STUDY BREADTH** determine and design the most efficient wall system for the rear façade
- **CONSTRUCTION INVESTIGATION- BREADTH** determine effects of the concrete redesign in terms of cost, schedule, and site layout

STRUCTURAL DEPTH - Post-Tension Concrete Redesign



STRUCTURAL DEPTH- GOALS

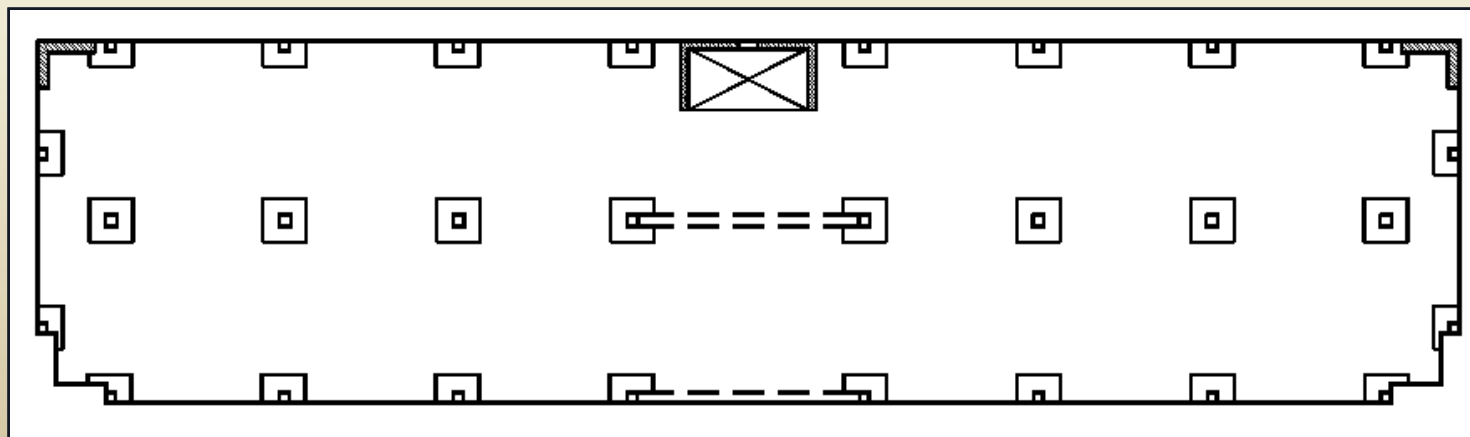


- **FLOOR SYSTEM-** design concrete floor system capable of spanning 30' bays without excessive structural depth
- **COLUMN GRID-** attempt to maintain existing column grid
- **LATERAL SYSTEM-** replace steel moment/braced frames and CMU shear walls with concrete lateral elements
- **FOUNDATION SYSTEM-** modify existing system to support concrete system

STRUCTURAL DEPTH- PT FLOOR SYSTEM



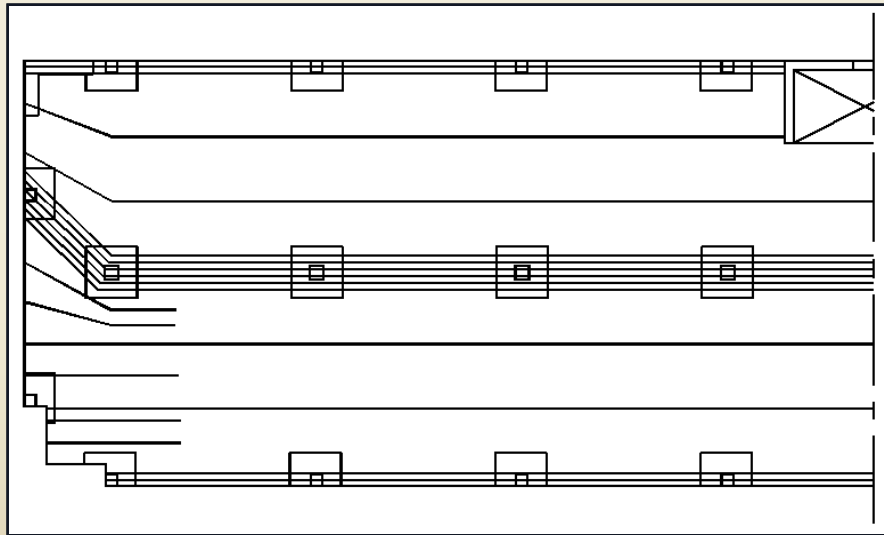
- 30'-0" x 30'- 5 1/2" typical bay
- 8" thick slab
- $f'_c = 5,000$ psi
- 0.6" diameter unbonded tendons
- 7.5'x7.5'x4" Column Caps for shear reinforcement
- Concrete Beams at 40' span location



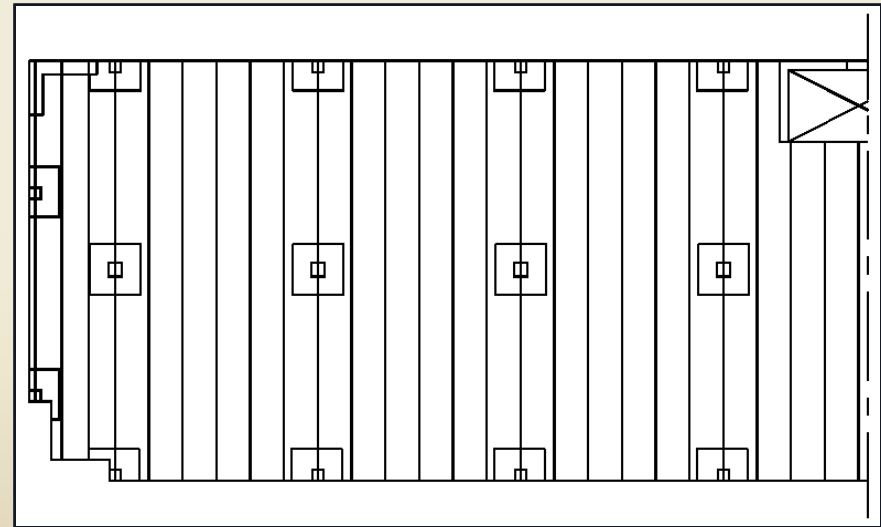
STRUCTURAL DEPTH- PT FLOOR SYSTEM



- TYPICAL TENDON LAYOUTS:



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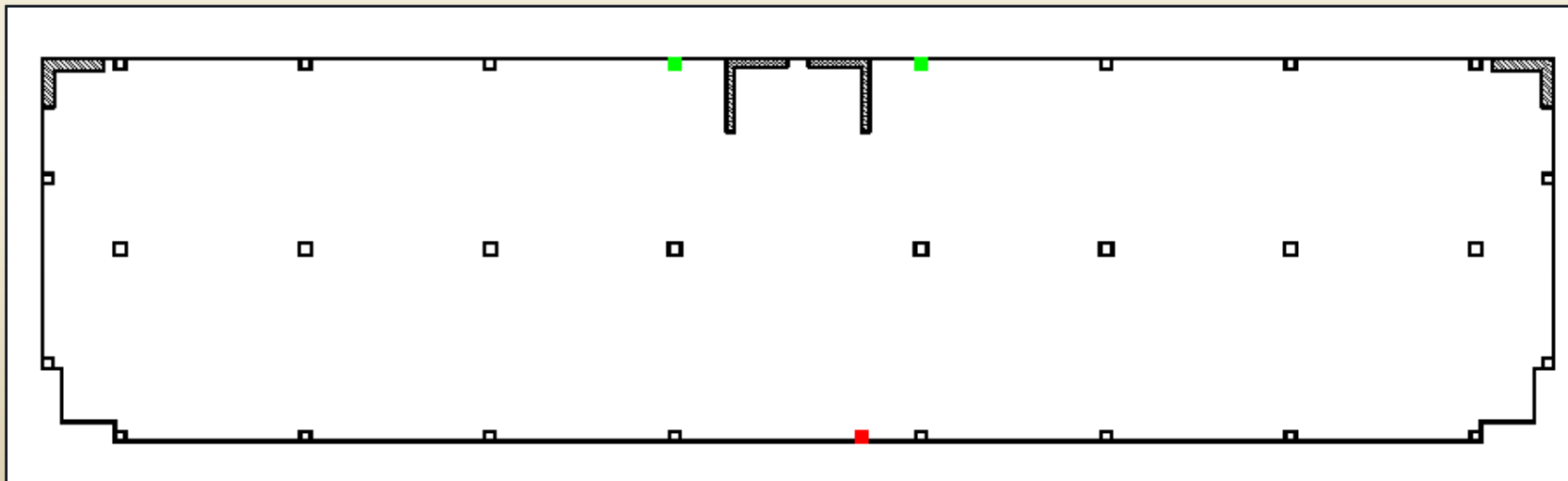


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STRUCTURAL DEPTH- COLUMN DESIGN



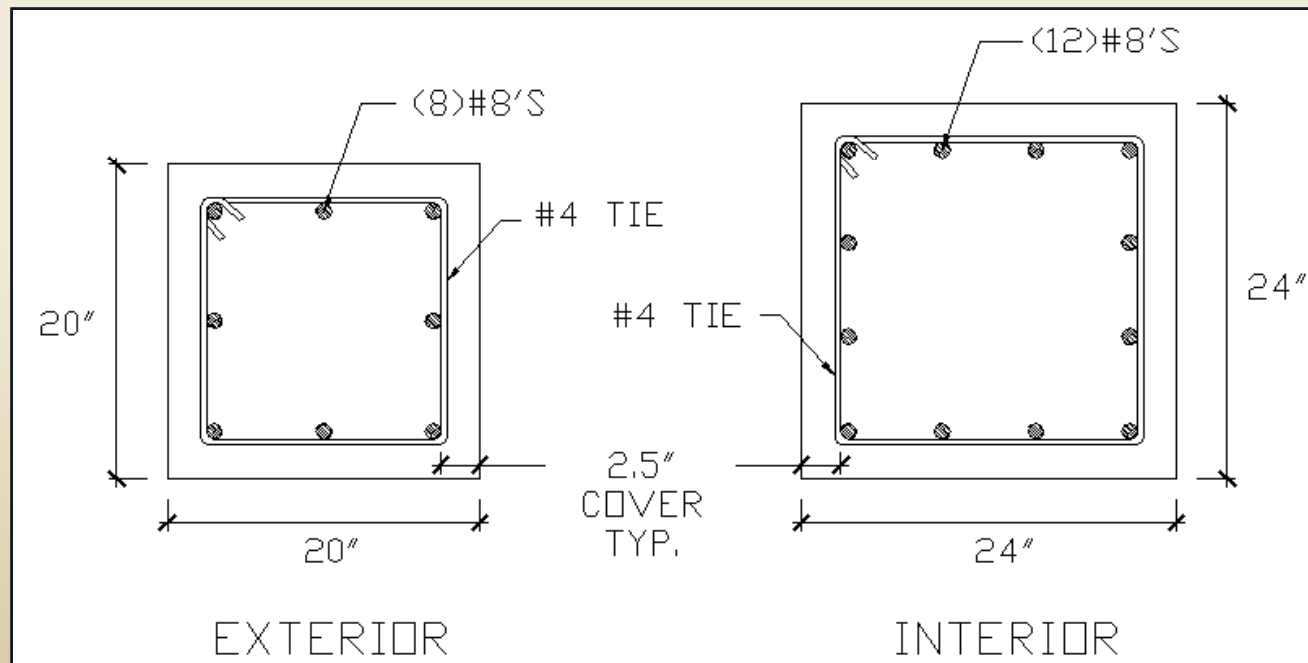
- Attempted to maintain existing column grid which provides open floor plan that is beneficial to office/ retail buildings
- Minor changes: **Red Column** Removed, **Green Columns** Added



STRUCTURAL DEPTH- COLUMN DESIGN



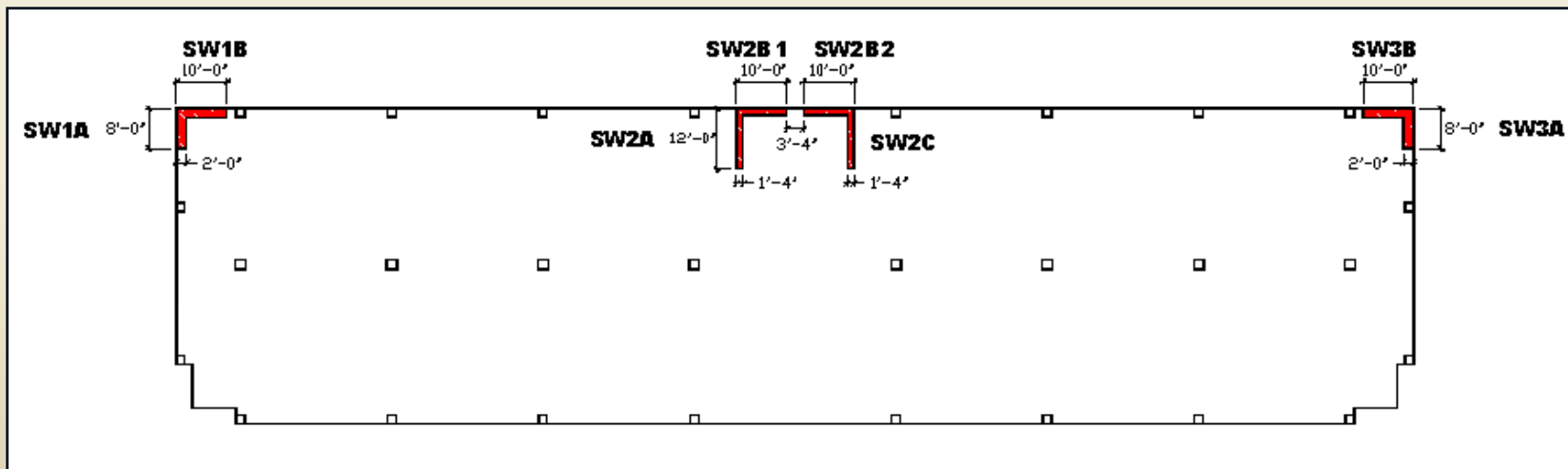
- Columns broken into 2 groups (Exterior and Interior) and designed for the worst case loads of each group.



STRUCTURAL DEPTH- LATERAL SYSTEM



- REINFORCED CONCRETE SHEAR WALLS

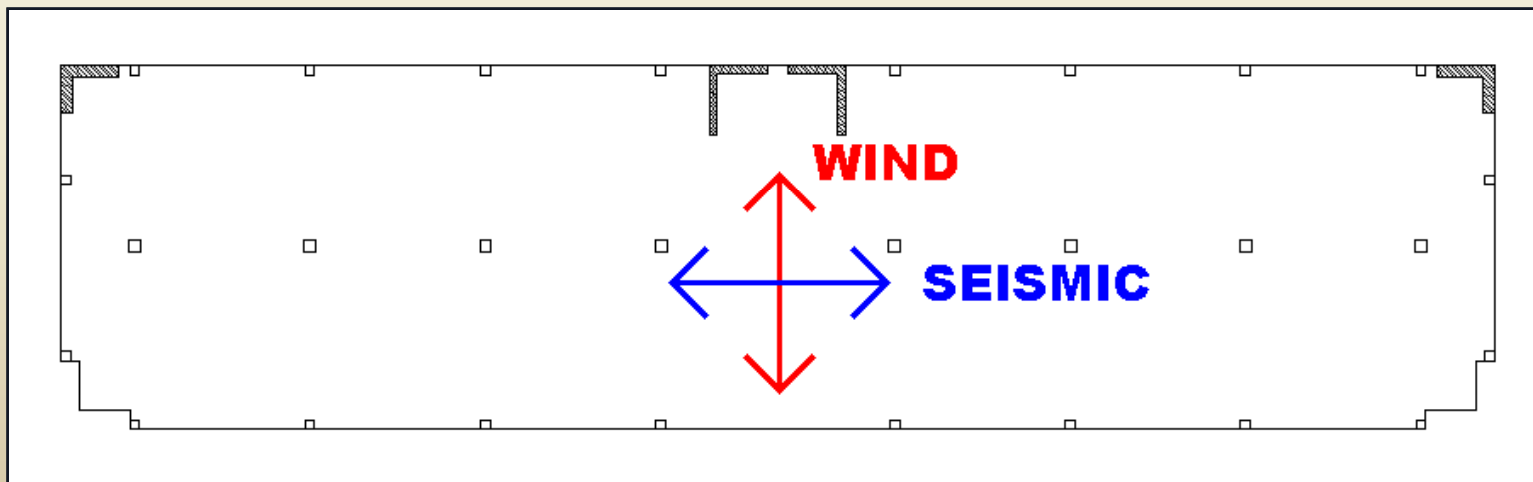


STRUCTURAL DEPTH- LATERAL SYSTEM



- CONTROLLING LOADS

Item	Longitudinal (N-S)	Transverse (E-W)
1.6 Wind	141 K	730 K
1.0 Seismic	369 K	369 K

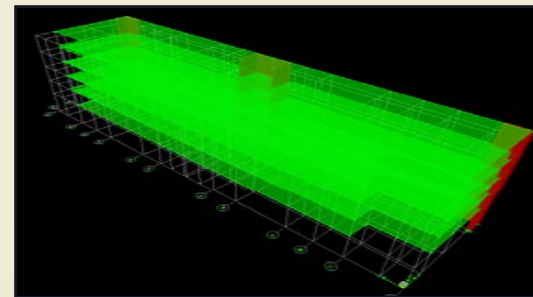


STRUCTURAL DEPTH- LATERAL SYSTEM



- ETABS MODEL CREATED FOR LATERAL ANALYSIS
 - **Modal Analysis Run to Determine Building Period**

Mode	Period T (seconds)
1	1.7340
2	1.0149
3	0.6678



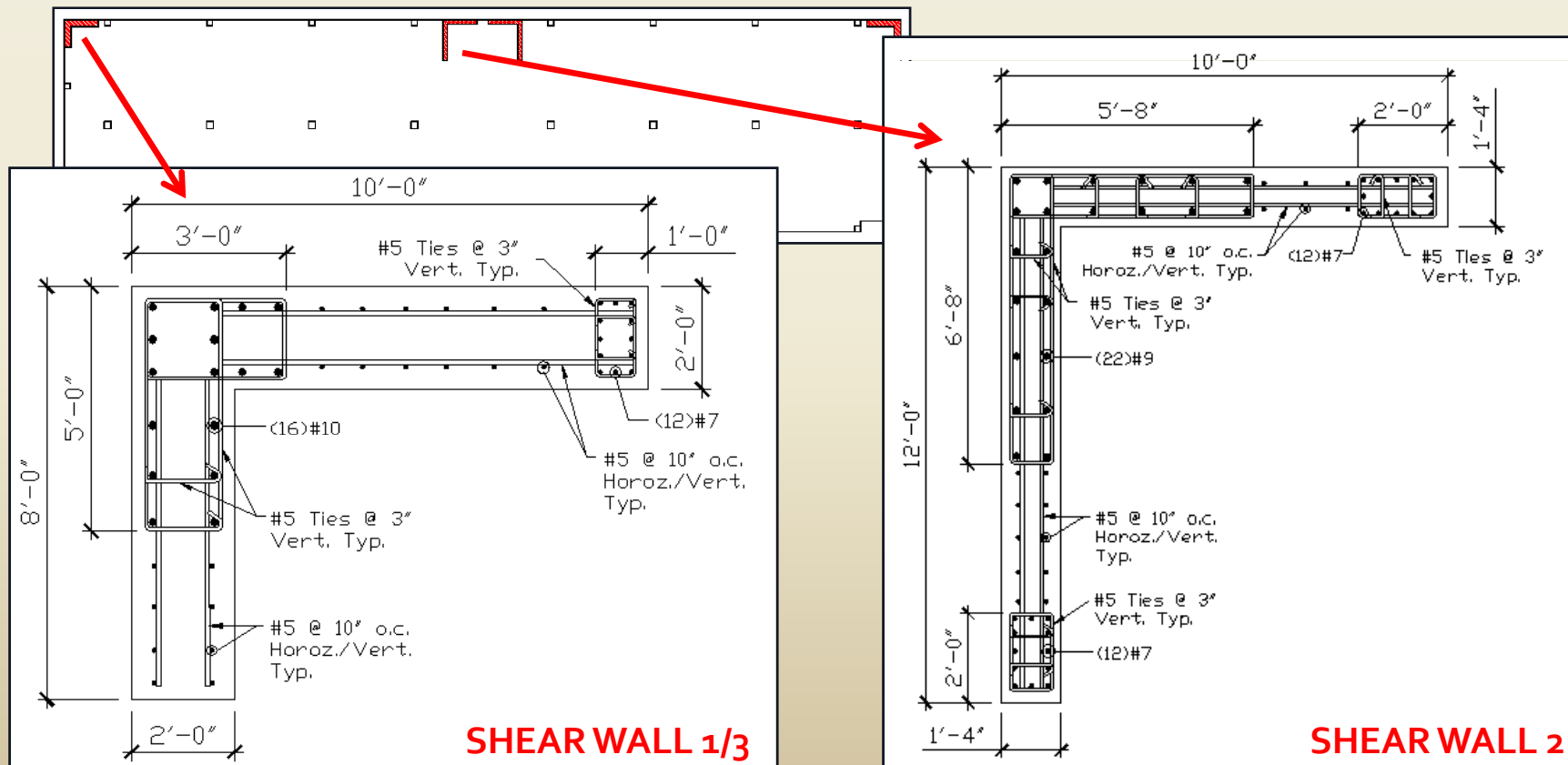
- **Model Used to Distribute Lateral Loads Based on Relative Stiffness**

Member	Trans. Load (K)	% of Trans Load	Long. Load (K)	% of Long. Load
SW 1A/1B	77.3	19.15%	88.8	22.39%
SW 2A1/2B1	124.5	30.85%	96.0	24.21%
SW 2A2/2B2	124.5	30.85%	96.0	24.21%
SW 3A/3B	77.3	19.15%	88.8	22.39%

STRUCTURAL DEPTH- LATERAL SYSTEM



- TYPICAL SHEAR WALL REINFORCING DESIGNS

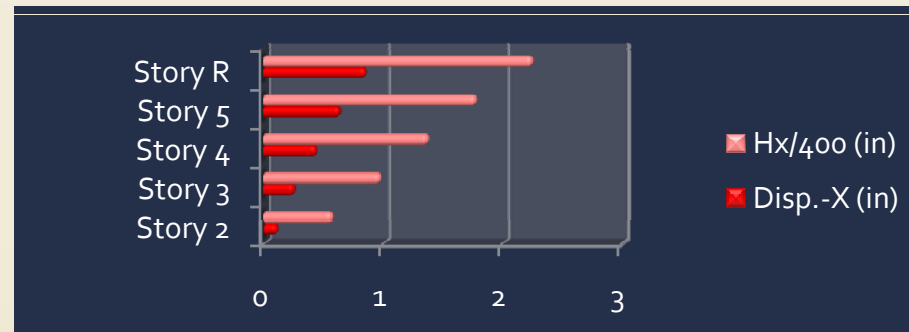


STRUCTURAL DEPTH- LATERAL SYSTEM



- STRUCTURE DRIFT AND DISPLACEMENT LIMITS

- TRANSVERSE DIRECTION – 1.6 WIND



- LONGITUDINAL DIRECTION – 1.0 SEISMIC



STRUCTURAL DEPTH- FOUNDATION



- FOUNDATION SYSTEM CONSISTS OF 14" SQ. PRECAST PRESTRESSED CONCRETE PILES

PILE TYPE	AXIAL CAPACITY (K)	UPLIFT CAPACITY (K)	LATERAL CAPACITY (K)
STANDARD	220	--	15
UPLIFT	110	110	15

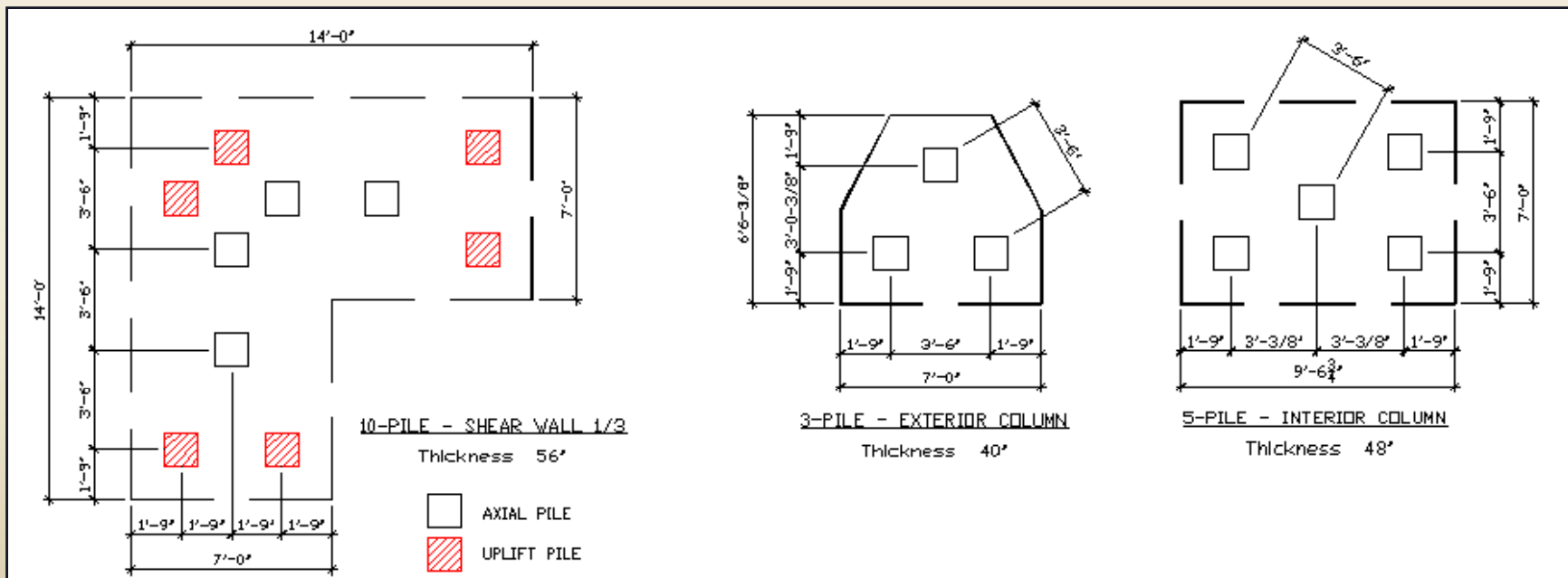
- LOAD ACCUMULATION AT TYPICAL FOUNDATION LOCATIONS

LOCATION	AXIAL LOAD (K)	UPLIFT LOAD (K)	LATERAL LOAD (K)	ORIGINAL PILES REQUIRED	REDESGN PILES REQUIRED
INT. COL	1035	--	--	4	5
EXT. COL	538	--	--	3	3
SW 1/3	842	539	124	--	10
SW 2	1995	1110	400	43	43

STRUCTURAL DEPTH- FOUNDATION



- FOUNDATION MODIFICATIONS



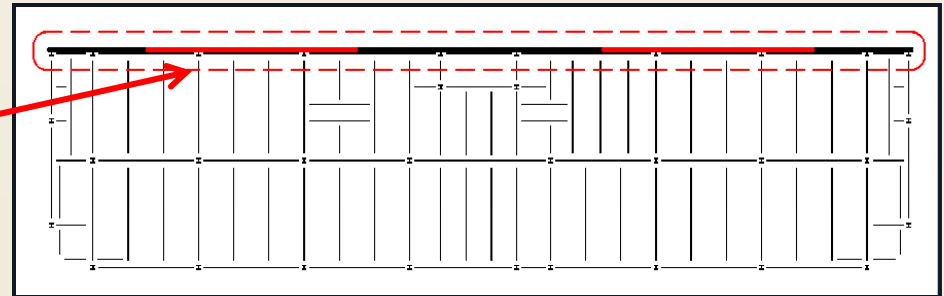


ARCHITECTURAL FAÇADE STUDY - Precast Wall Design

FAÇADE STUDY- GOALS



- REPLACE REAR FAÇADE OF BUILDING, PREVIOUSLY MASONRY SHEAR WALLS



- DETERMINE MOST APPROPRIATE WALL SYSTEM
 - CMU Wall System
 - Poured Concrete Wall System
 - Precast Concrete Wall System
- DESIGN WALL SYSTEM CONSIDERING ARCHITECTURAL ISSUES
 - Fire Wall Rating – 2 Hour Required
 - Moisture Penetration
 - Aesthetics
 - Cost/Construction

FAÇADE STUDY- SYSTEM COMPARISON



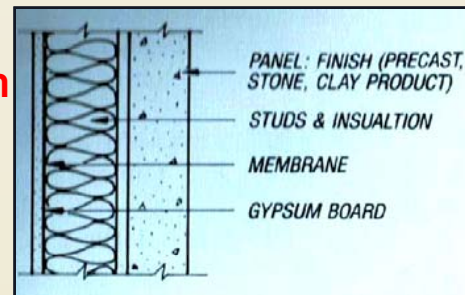
WALL SYSTEM	DESIGN FLEXIBILITY	FORMWORK REQUIRED	REQUIRED FIRE WALL THICKNESS	MOISTURE LEAK RESISTANCE
CMU	--	--	8"	--
POURED CONCRETE	--	X	4"	X
PRECAST CONCRETE	X	--	4"	X

FAÇADE STUDY- PRECAST DESIGN



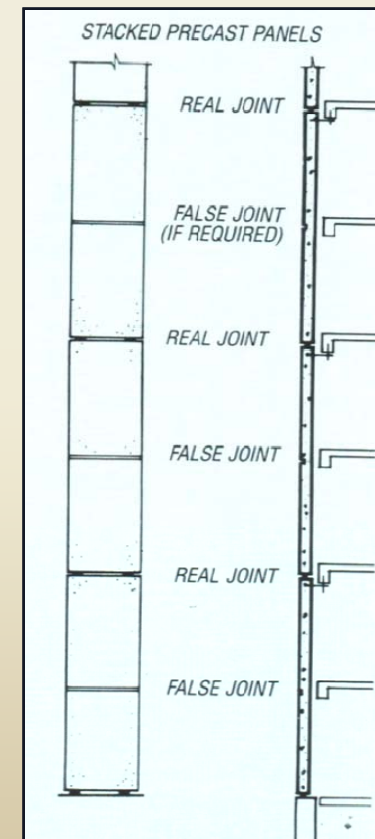
- **CONVENTIONAL WALL SYSTEM SELECTED**

- Only 1 Wythe of precast required
- Simple manufacturing/ installation



- **STACKED PANEL SUPPORT SYSTEM SELECTED**

- Panels bear on panels below
- Eliminate additional gravity load on slab
- Only transfer lateral loads to structure



FAÇADE STUDY- PRECAST DESIGN



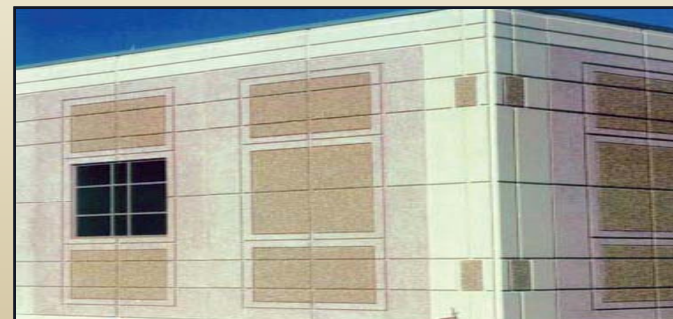
- **PANEL SELECTION**

- Repetitive panel layout selected
- 30'-8 1/8" x 13'-8" panel typical (1 Bay x 1 Story)



- **AESTHETIC CONSIDERATIONS**

- Not high priority for this application
- Aesthetic enhancements can account for large percent of total cost
 - Aggregate 5-20%
 - Cement 4-8%

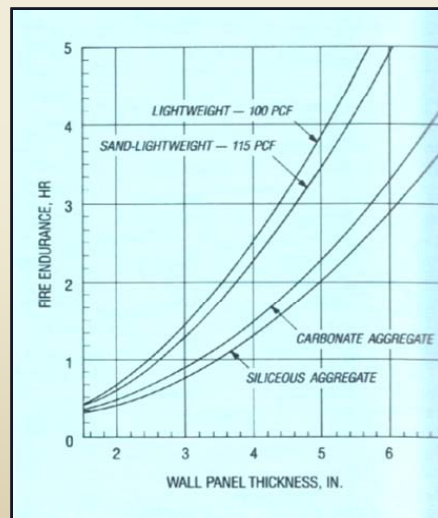


FAÇADE STUDY- PRECAST DESIGN



- FIRE RESISTANCE

- Used to determine panel thickness
- Sand-Lightweight Concrete
- Original design called for façade to act as two-hour fire barrier



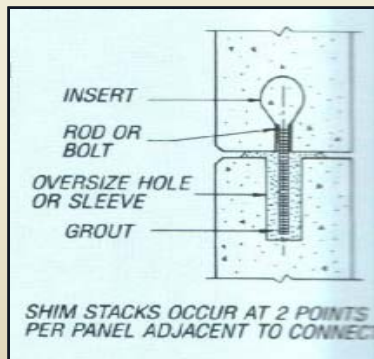
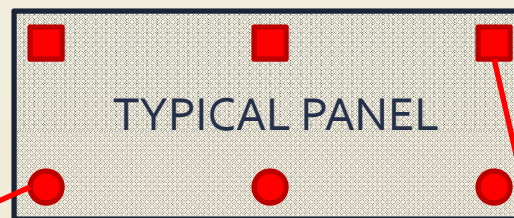
Aggregate	Thickness in inches for fire endurance of			
	1 hr	2 hr	3 hr	4 hr
All lightweight	2.47	3.56	4.35	5.10
Sand-lightweight	2.63	3.76	4.62	5.37
Carbonate	3.25	4.67	5.75	6.63
Siliceous	3.48	5.00	6.15	7.05

3.76 " → 4" THICK PANEL

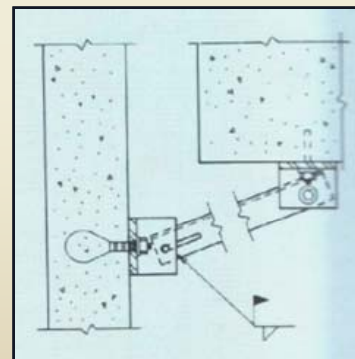
FAÇADE STUDY- PRECAST DESIGN



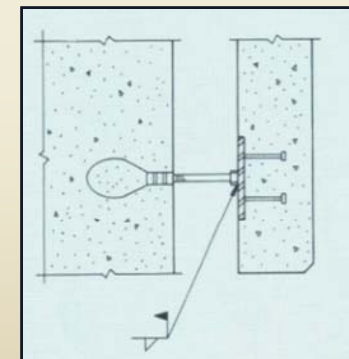
- CONNECTIONS



DIRECT BEARING CONNECTION

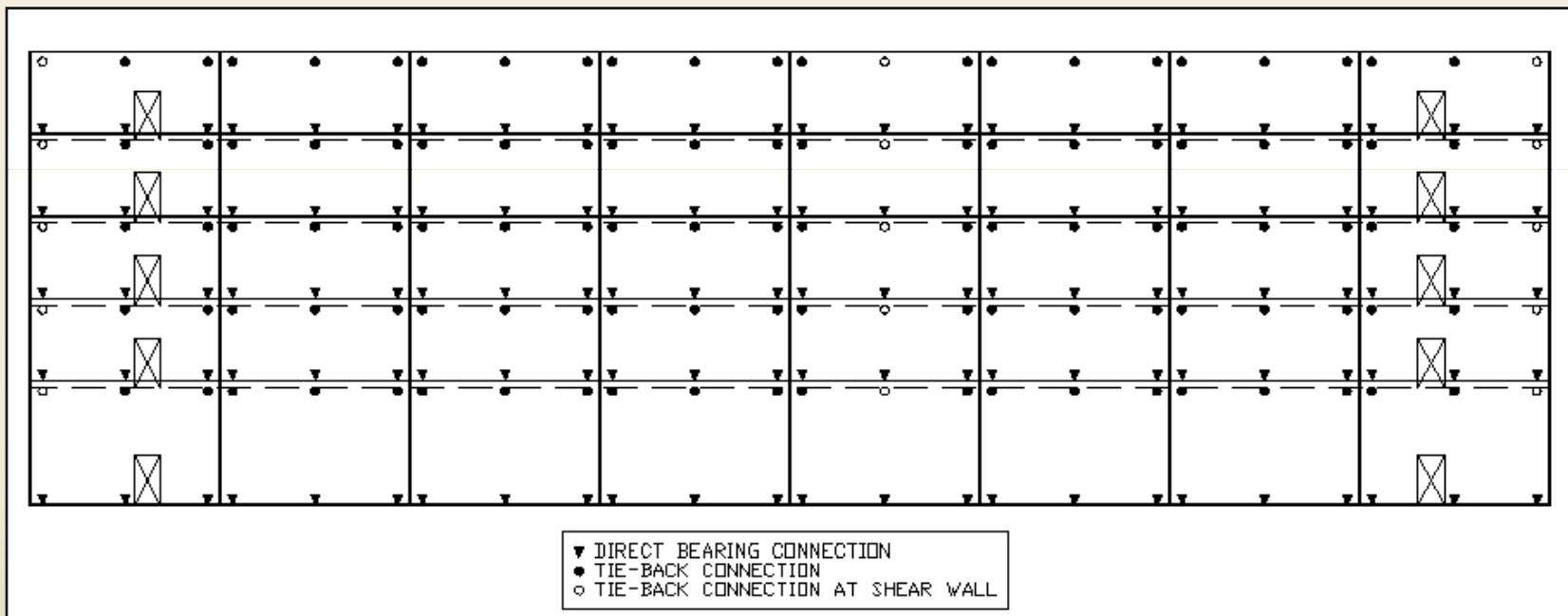


LATERAL TIE-BACK CONNECTION



LATERAL TIE-BACK CONNECTION @ SHEAR WALL

FAÇADE STUDY- PRECAST DESIGN

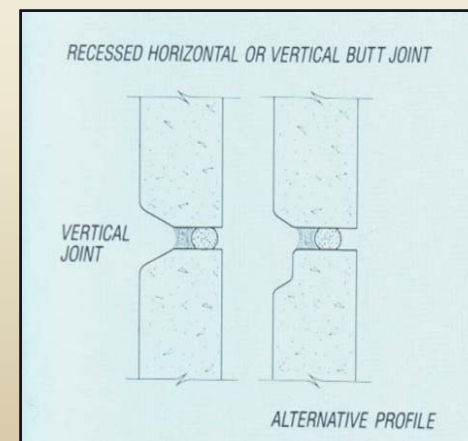
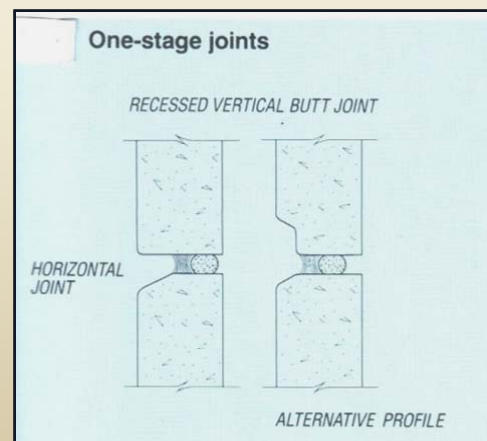


PANEL AND CONNECTION LAYOUT

FAÇADE STUDY- PRECAST DESIGN



- JOINT CALCULATION AND SEALANT SELECTION
 - One-stage recessed joints selected
 - Thermal expansion requires 1" wide joints
 - Two-Component Polyurethane sealant selected
 - 25% Extensibility
 - Very good weather resistance





CONSTRUCTION INVESTIGATION-

Cost, Schedule, and Site Layout

CONSTRUCTION INVESTIGATION- COST



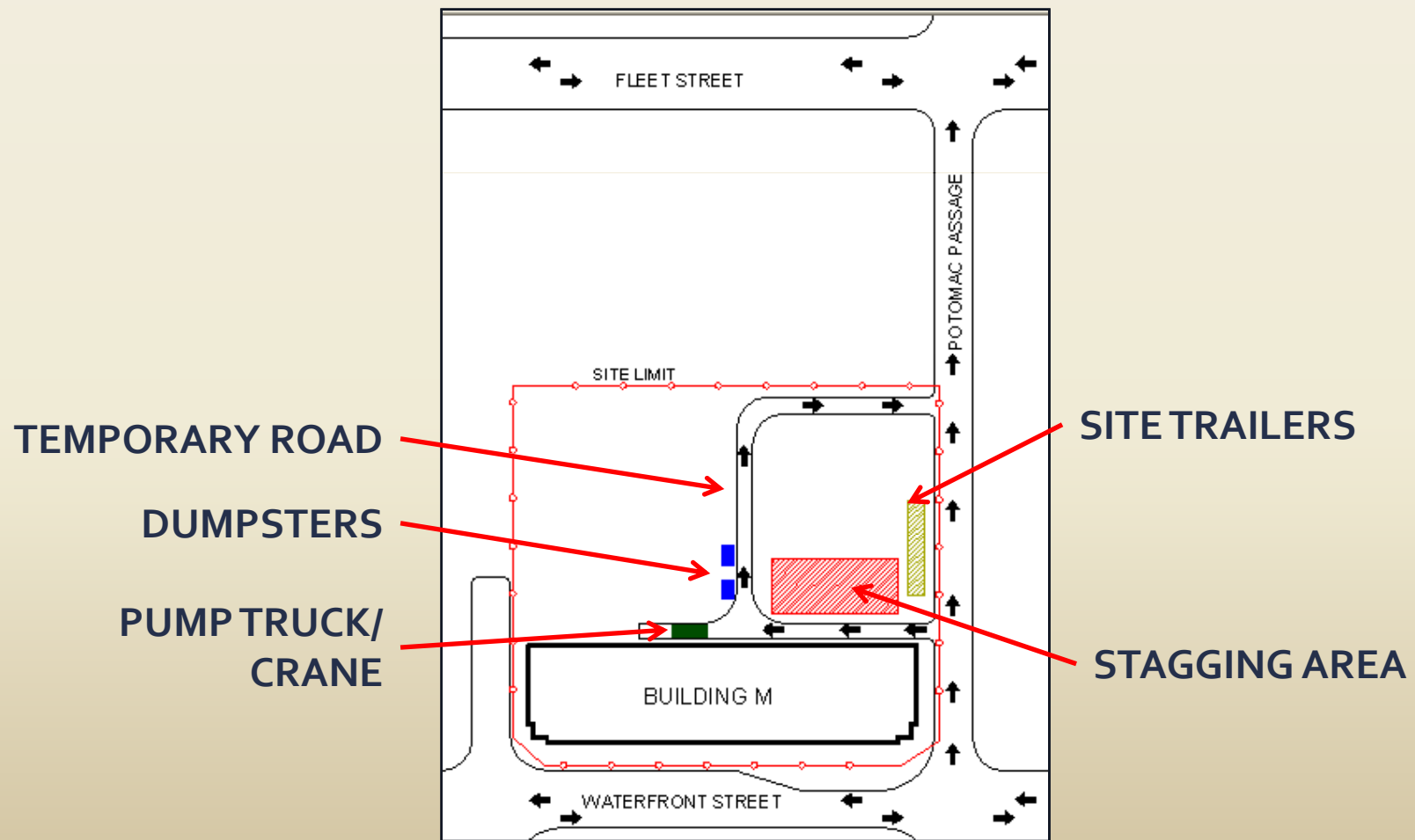
COMPONENT	EXISTING STEEL STRUCTURE	REDESIGNED CONCRETE STRUCTURE
GRAVITY/LATERAL SYSTEM	W-Shape Steel Columns	Reinf. Concrete Columns
	W-Shape Steel Beams	Reinf. Concrete Shear Walls
	W-Shape Steel Braces	Concrete Shear Caps
	Steel Studs	
FLOOR SYSTEM	Steel Decking	Normal Weight Concrete
	Lightweight Concrete	Post-Tensioning Cables
	WWM Reinforcing	
REAR FAÇADE	Reinforced 8" CMU Wall	Architectural Precast Wall
FOUNDATION MODIFICATION	N/A	Additional Piles

CONSTRUCTION INVESTIGATION- COST



COMPONENT	EXISTING STEEL STRUCTURE	REDESIGNED CONCRETE STRUCTURE
GRAVITY/LATERAL SYSTEM	Base	-204.32%
FLOOR SYSTEM	Base	+106.55%
REAR FAÇADE	Base	-33.50%
FOUNDATION MODIFICATION	Base	+\$36,000
TOTAL COMPARABLE COST	Base	-22.50%

CONSTRUCTION INVESTIGATION- SITE LAYOUT



RYAN SARAZEN - STRUCTURAL OPTION

CONSTRUCTION INVESTIGATION- SCHEDULE



COMPONENT	STAGE	PROCEDURE	DURATION (DAYS/FL)
Detailing/ Shop Drawings	--	Completion/ Approval	21 (total)
Columns/ Shear Walls	1	Formwork/ Reinforcing / Pouring	3
	2	Curing/ Stripping of Formwork	4
Slab	1	Formwork/ Reinforcing/ Pouring	5
	2	Curing	3
	3	Stressing Tendons/ Stripping of Formwork/ Re-shoring	2

- **17 days total per floor X 5 floors @ 3 days overlap = 73 days**
- **21 + 73 days = 94 total days or approximately 19 weeks**

THESIS OBJECTIVES- CONCLUSION



- STRUCTURAL DEPTH -



achieve efficiency of the steel design using a concrete-based structure

- ARCHITECTURAL FAÇADE -
STUDY BREADTH



determine and design the most efficient wall system for the rear façade

- CONSTRUCTION INVESTIGATION
BREADTH



determine effects of the concrete redesign in terms of cost, schedule, and site layout

QUESTIONS?

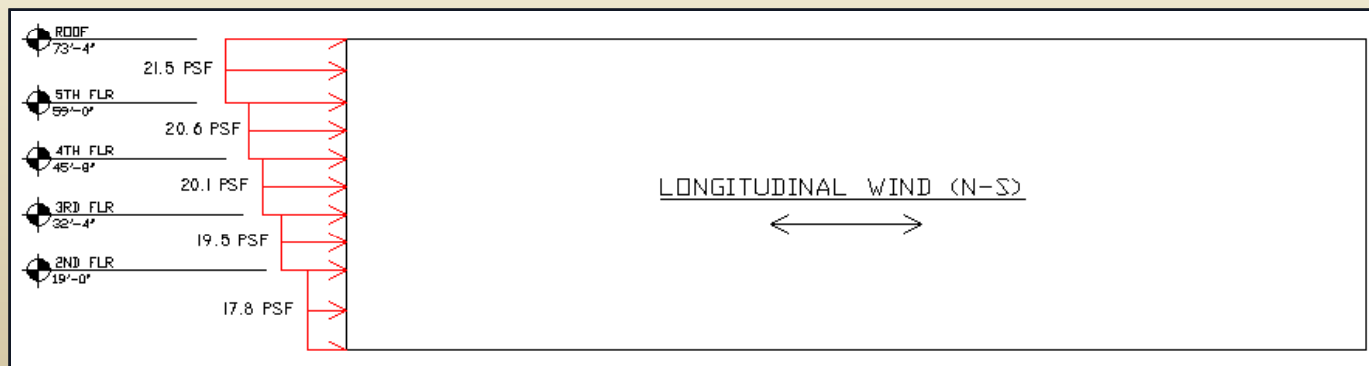
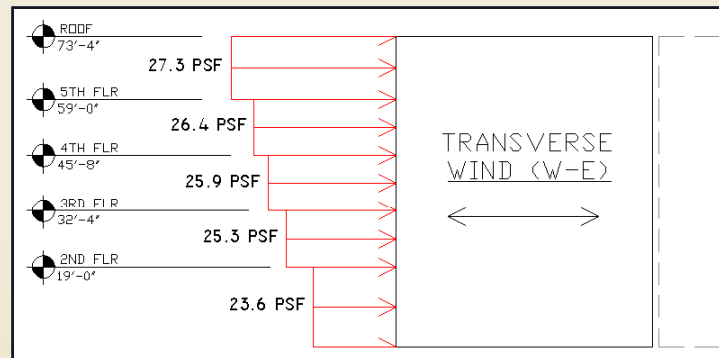


STRUCTURAL DEPTH- LATERAL SYSTEM



- WIND LOADING

- Rigid structure, Exposure D, Basic Wind Speed = 90 mph



STRUCTURAL DEPTH- LATERAL SYSTEM



- **SEISMIC LOADING**

- **Site Class – D**
- **Seismic Design Category – B**
- **Importance Factor (I) – 1.0**
- **Seismic Resisting System – Ordinary Reinforced Concrete Shear Walls**
- **Response Modification Factor (R) – 4.0**
- **Deflection Amplification Factor (Cd) – 4.0**
- **Building Period – 0.6678 seconds**
- **Seismic Response Coefficient – 0.0378**
- **Seismic Weight – 9,762 Kips**
- **Design Base Shear – 369 Kips**

