The Franklin Square Hospital Center Patient Tower

9000 Franklin Square Drive, Baltimore MD

Thomas Weaver – Structural Option – B.A.E./M.A.E. Candidate
Faculty Advisor – Professor M. Kevin Parfitt

The Franklin Square Hospital Center Patient Tower

Presentation Outline

- Existing Conditions
- Thesis Proposal
- Lateral System Study
- Floor System Study
- Architectural Breadth
- Construction Cost and Scheduling
- Conclusions
- Acknowledgements
- Questions and Answers

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Building Statistics

- Location: **9000 Franklin Square Drive, Baltimore MD**
- Function: **Medical**
- Size: **356,000 SF**
- Height: **105 ft, 7 stories + mechanical penthouse**
- Construction Dates: **November 2007 to October 2010**
- Overall Project Cost: **$176 million**
- Project Delivery Method: **Design-Bid-Build**

Fun Facts

- 291 private inpatient rooms
- Expanded emergency department with expanded lab to run more tests in less time
- Easier access to CAT scan and diagnostic services
- Dedicated pediatric emergency department
- Four new medical and surgical units
- Expanded 50 bed critical car unit

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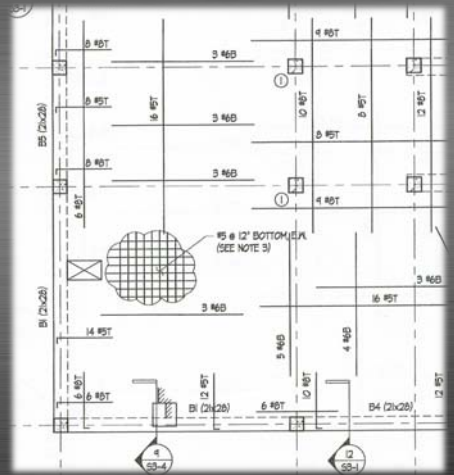
Existing Floor System

- 10” Reinforced Concrete Two-Way Flat Plate
- Typical Span: 30’x30’ bay
- Bottom Reinforcing: Continuous bottom mat of #5 bars at 12” each way with additional #6 bars in places for added strength
- Top Reinforcing: #5 bars in middle strips and #8 bars in column strips



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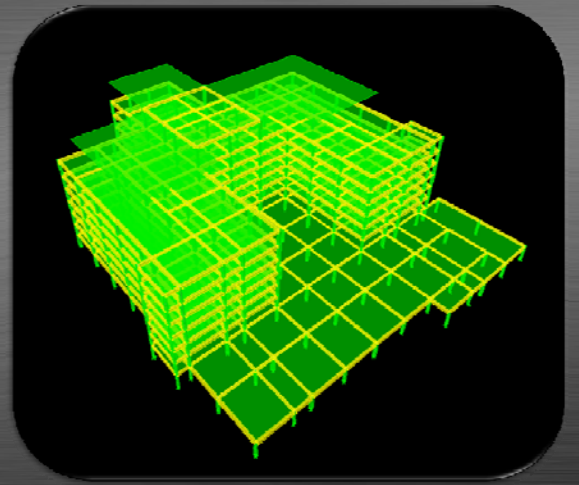
Existing Lateral System

- Ordinary Reinforced Concrete Moment Frame
- Perimeter Beams: 21”x28” with typical (3) #9 bottom and top
- Interior Beams: 10” Flat Plate floor system
- Perimeter Columns: 21”x21” with typical (8) #9
- Interior Columns: 22”x22” with typical (8) #9



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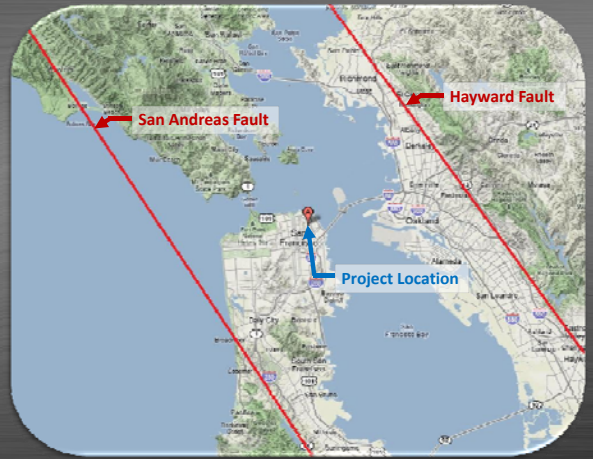
Structural Depth Topics

- Building relocation to 845 Jackson Street, San Francisco, CA
  - Close proximity to San Andreas and Hayward Faults
  - Hayward Fault considered by some to be the most dangerous fault in America at this time with a 63% chance of a magnitude 6.7 of greater earthquake within the next 30 years
- Study of concrete moment frame vs. concrete shear wall lateral systems
- Post-Tensioned floor system to reduce building self-weight



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Architectural Breadth Topics

- Floor Plan Study of existing architectural space layout vs. modified layout to accommodate structural shear walls and new elevator core placement
  - Redesign of support spaces, nurse's stations, hallways and elevator lobbies to provide flow and efficiency needed in hospital design

Construction Breadth Topics

- Cost and Schedule Analysis for change in floor system
  - Original Flat Plate floor system vs. PT Flat Slab floor system
  - Length of Construction Differences
  - Bare Material and Labor costs in addition to General Condition Costs

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Goals of Lateral System Study

- Using the Equivalent Lateral Force Procedure, investigate higher seismic loading than required in Baltimore
- Investigate lateral system design for seismic response
- Quantify and compare the applicability of Moment Frame and Shear Wall lateral systems for use in the Franklin Square Hospital Center Patient Tower

Site Seismic Parameters

- Spectral Response Coeff. S_s: 1.500
- Spectral Response Coeff. S_1: 0.620
- Soil Site Class: B
- Seismic Design Category: D
- Importance Factor: 1.5

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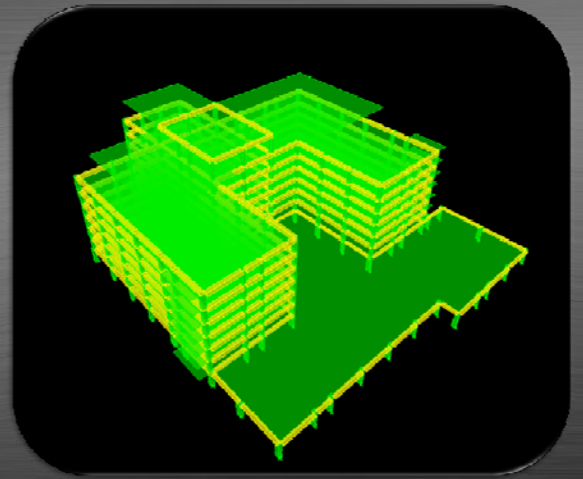
Moment Frame Lateral System

- 1st mode period of vibration = 1.402s < $3.5T_s$=1.446s
- Column size: 34”x 34”
- Column f'_c: Level G-4: 7000 psi
  Level 5-8: 5000 psi
- Beam size: 34”x 36”
- Beam f'_c: 5000 psi
- Response Modification Factor, R: 8
- Seismic Response Coeff. C_s: 0.0581
- Total Building Weight: 58,279 k
- Design Base Shear: 3,386 k



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Moment Frame Lateral System

Critical Design Forces	Maximum Shear (kips)	Maximum Moment (ft-kips)
Columns	195 kips	977 ft-kips
Beams	190 kips	1460 ft-kips

Controlling Load Case: 1.2D + 1.0E + L

Column Factored Loads: Axial = 830 k

Moment = 977 ft-k

Beam Factored Loads: Shear = 190 k

Moment = 1460 ft-k

Column Design:

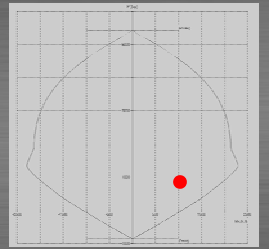
(12) #9 bars (ρ=1.04%)

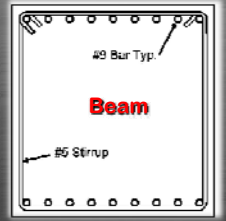
#5 Spiral Ties

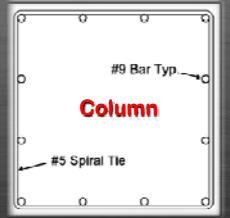
Beam Design:

(9) #9 bars Top and Bottom

#5 Stirrups @ 12”







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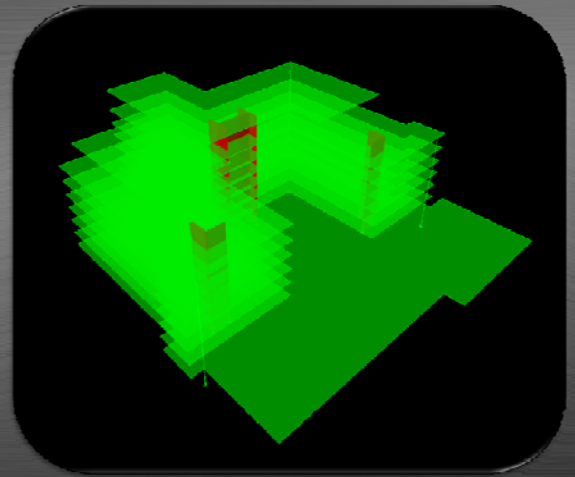
Shear Wall Lateral System

- 1st mode period of vibration = 1.3101s < $3.5T_s$=1.446s
- H-Shaped Core Walls (22”): (1) @ 30’, (2) @ 20’
- L-Shaped Walls (22”): 15’
- L-Shaped Walls (12”): 15’
- f'_c: 7000 psi
- Response Modification Factor, R: 6
- Seismic Response Coeff. C_s: 0.0775
- Total Building Weight: 51,209k
- Design Base Shear: 3,969k



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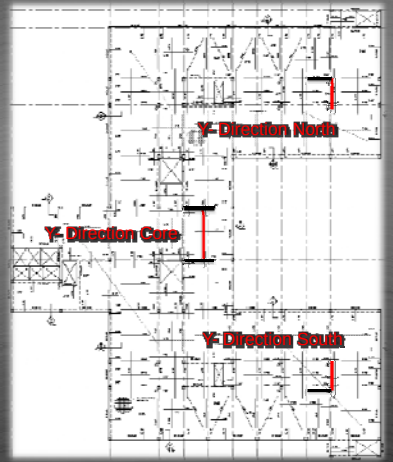
Shear Wall Lateral System

	Y- Direction Core	Y-Direction South	Y-Direction North
Level 4-7			
Max Shear	2,788 kips	454 kips	447 kips
Max Moment	19,168 ft-k	1,198 ft-k	1,194 ft-k
Level G-3			
Max Shear	3,717 kips	536 kips	522 kips
Max Moment	56,791 ft-k	7,002 ft-k	7,002 ft-k



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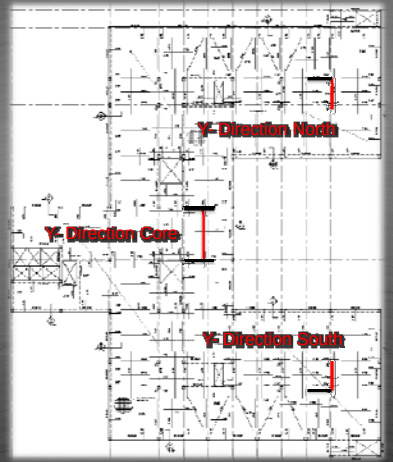
Shear Wall Lateral System

	Y- Direction Core	Y-Direction South	Y-Direction North
Level 4-7			
Horiz. Reinf.	(2) #10 @14"	(2) #6 @ 18"	
Vert. Reinf.	(2) #8 @ 16"	(2) #4 @ 12"	
Flex. Reinf.	(8) #11	(1) #11	
Boundry. Size	-	-	
Level G-3			
Horiz. Reinf.	(2) #11 @ 12"	(2) #6 @ 14"	
Vert. Reinf.	(2) #8 @ 12"	(2) #4 @ 12"	
Flex. Reinf.	(24) #11	(6) #11	
Boundry. Size	-	-	



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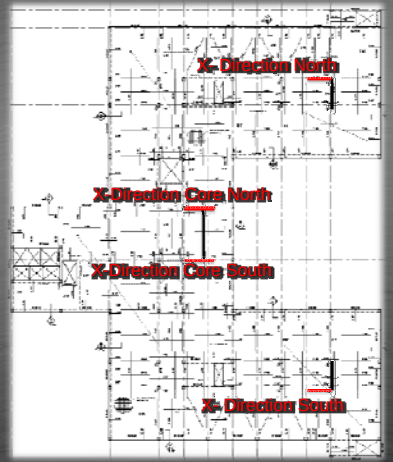
Shear Wall Lateral System

	X- Direction Core South	X-Direction Core North	X-Direction South	X-Direction North
Level 4-7				
Max Shear	739 kips	695 kips	749 kips	768 kips
Max Moment	22,032 ft-k	22,084 ft-k	12,168 ft-k	15,424 ft-k
Level G-3				
Max Shear	1,193 kips	1,191 kips	1,031 kips	1,009 kips
Max Moment	73,859 ft-k	74,074 ft-k	35,711 ft-k	35,987 ft-k



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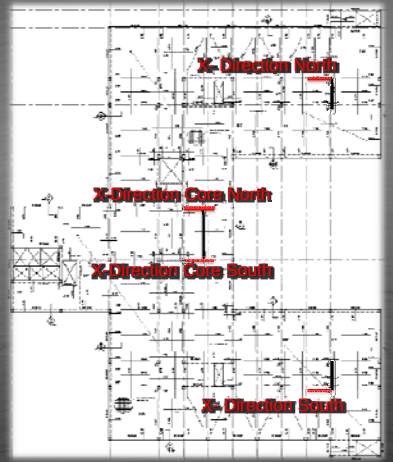
Shear Wall Lateral System

	X- Direction Core South	X-Direction Core North	X-Direction South	X-Direction North
Level 4-7				
Horiz. Reinf.	(2) #8 @ 18"		(2) #6 @ 12"	
Vert. Reinf.	(2) #6 @ 16"			
Flex. Reinf.	(14) #11			
Boundry. Size	-		26" x 32"	
Level G-3				
Horiz. Reinf.	(2) #8 @ 12"			
Vert. Reinf.	(2) #6 @ 16"			
Flex. Reinf.	(52) #11		(34) #11	
Boundry. Size	36" x 60"		30" x 44"	



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COMPARISON OF LATERAL SYSTEMS

	Eccentricity		Story Drift	
Lateral System	Δ X	Δ Y	Δ_i	Δ_a
Moment Frame	9.2 ft	1.3 ft	1.841	1.44
Shear Wall	7.3 ft	1.5 ft	1.154	1.44

LATERAL SYSTEM STUDY CONCLUSIONS

- Moment Frame system **Inadequate**
  - Column and Beam sizes far too large
  - Allowable story drift values too large
- Shear Wall system **Satisfactory**
  - Wall thickness just as thin as existing columns
  - Story drift values under allowable limit

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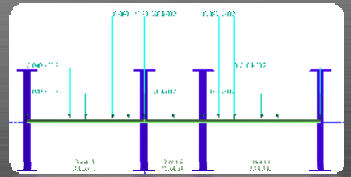
Goals of Floor System Study

- Reduce building self weight benefiting lateral system design
  - Original 10” flat plate consumes over 56% of the original building self weight
  - 8” PT flat slab has possibility to reduce building self weight by 15%, thereby reducing seismic base shear by 15%



PT Floor system Design Using ADAPT-PT

- ½” 7-wire un-grouted tendons
  - Uniform spacing @ 12” in the North-South direction
    - Stressed to 390 kips balancing ~ 60 to 96% DL
    - P/A = 270 psi
  - Banded tendons in column strips in East-West direction
    - Groups of 11 to 33, stressed from 293 to 864 kips
    - Balance 66 to 93% DL
    - P/A = 300 psi
  - Deflections limited to 0.4” in exterior spans and 0.25” in interior spans
- 4’x4’x2” drop panels provided to resist punching shear

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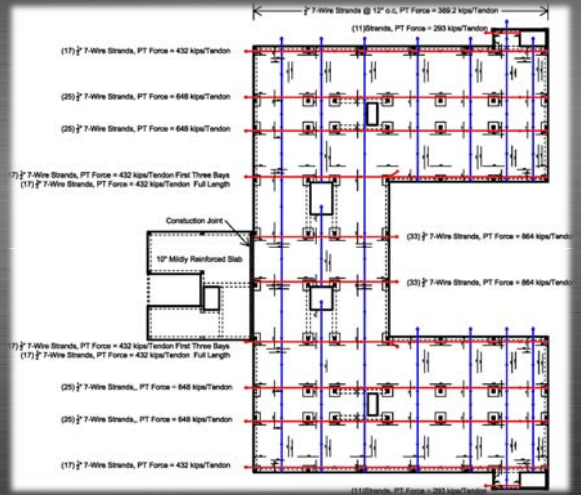
PT Slab Design for Moment Frame Configuration

- West wing of plan problematic for 8” PT slab
  - Area required 11” PT slab to meet stress limits
  - With goal of reducing slab weight, original 10” Flat Plate system kept for this area
  - Construction joint provided between 10” Flat Plate and 8” PT Flat Slab that can be filled solid after PT Tendons stressed.



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PT Slab Design for Shear Wall Configuration

- 8” PT Slab functional in west wing
- Arrangement of tendons around elevator/stairs problematic
  - One group of banded tendons required to snake around stair opening
  - One section of uniform tendons required to snake around elevator opening

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FLOOR SYSTEM STUDY CONCLUSIONS

- 8” PT Flat Slab system Satisfactory
  - Weight loss of 5,800 kips from 10” Flat Plate
  - Weight loss of 10% in total building weight
  - Decrease in seismic base shear of 10%

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GOALS OF ARCHITECTURAL BREADTH

- Provide logical floor plan arrangements to accommodate addition of structural shear walls and relocation of elevator core
- Retain easy access to vertical transportation routes
- Keep patient rooms close to nurse's stations
- Group similar task spaces close to each other
- Locate mechanical support spaces close to vertical mechanical transportation routes

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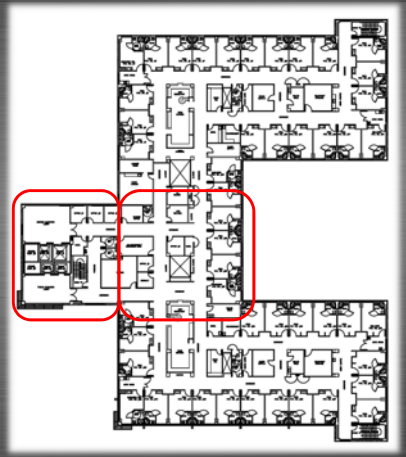
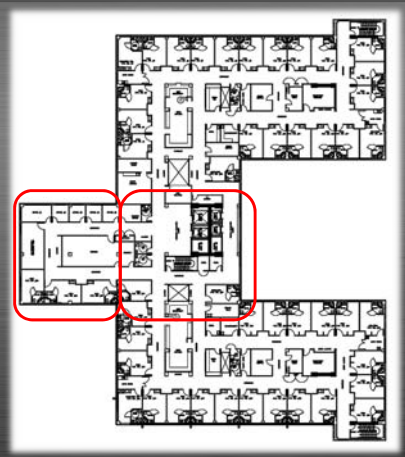
Existing Layout Overview



Proposed Layout Overview



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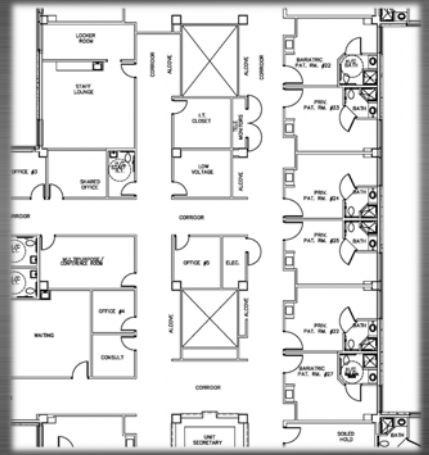
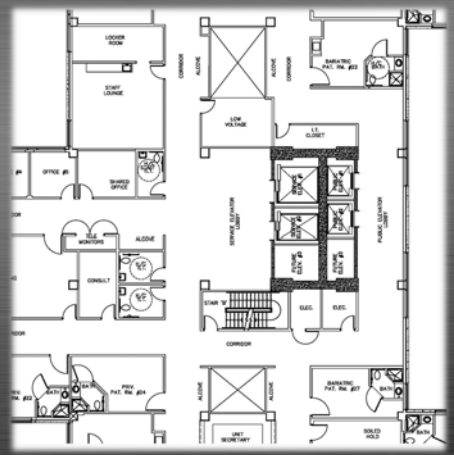
Existing Layout Enlarged Center Section



Proposed Layout enlarged Center Section



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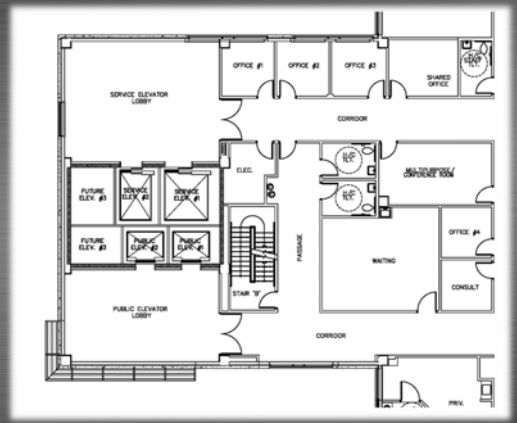
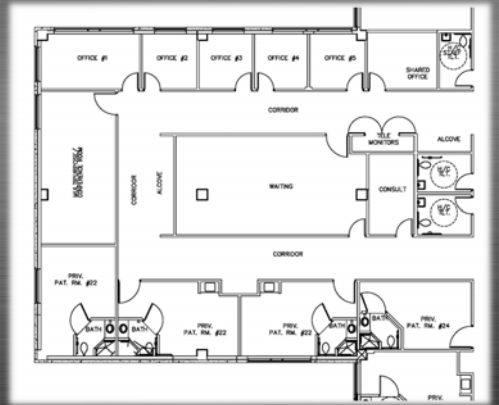
Existing Layout Enlarged Western Section



Proposed Layout Enlarged Western Section



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ARCHITECTURAL BREADTH CONCLUSIONS

- Provide logical floor plan arrangements to accommodate addition of structural shear walls and relocation of elevator core ✓
- Retain easy access to vertical transportation routes ✓
- Keep patient rooms close to nurse's stations ✓
- Group similar task spaces close to each other ✓
- Locate mechanical support spaces close to vertical mechanical transportation routes ✓

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10" FLAT PLATE FLOOR SYSTEM

Item	Quantity	Total Cost
Elevated Slab Flat Plate Formwork	282,070 SF	$484,351.25
Mild Steel Reinforcing	295 Tons	$500,290.44
Concrete	9,221 CY	$1,301,671.65
Placing of Concrete	9,221 CY	$206,187.15
Total		**$2,492,500.49**

8" PT FLAT SLAB FLOOR SYSTEM

Item	Quantity	Total Cost
Elevated Slab Flat Plate Formwork	282,070 SF	$521,132.23
Mild Steel Reinforcing	58 Tons	$97,955.74
Post-Tension Tendons	324,268 Lb	$593,410.07
Concrete	7,222 CY	$1,019,457.52
Placing of Concrete	7,222 CY	$161,483.92
Total		**$2,393,439.48**

Post-Tension Floor System: $99,061 Less Expensive

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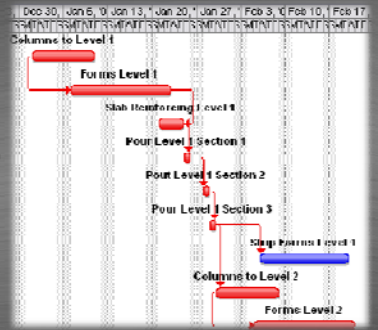
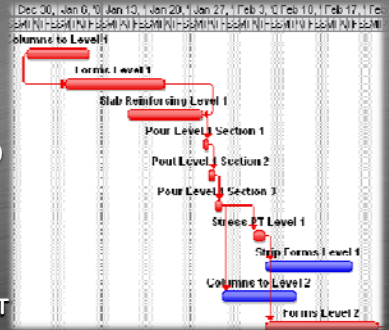
10" Flat Plate Floor System

Columns: 8 days
Forming of Slab: 12 days
Reinforcing: 4 days
Pouring: 3 days (300CY/day)
Stripping: 10 days, 7 days after cure time
Average Time/Floor: 22 days



8" PT Flat Slab Floor System

Columns: 8 days
Forming of Slab: 12 days
Reinforcing: 8 days
Pouring: 3 days (300CY/day)
Stress PT: 2 days, 3 days after last pour
Stripping: 10 days, 1 day after stressing PT
Average Time/Floor: 28 days



Average Schedule Increase: 6 Days/Floor Increase

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- Acknowledgements
- Questions and Answers

10" FLAT PLATE VS. 8" PT FLAT SLAB CONCLUSIONS

•Material & Labor Costs:	-$99,061
•General Condition:	$40,000/Week
•Cost of Increased Schedule (+4 Weeks):	+$160,000
•Total Price Difference:	+$60,939

Cost Increase per S.F. of Concrete: **+ 22¢ / S.F.**

The Franklin Square Hospital Center Patient Tower

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Thomas Weaver Structural Option April 12, 2010

Proposed Goals

- Investigate More Severe Seismic Loading through Relocation of the Franklin Square Hospital Center to San Francisco, CA ✓
- Successfully Design Lateral System to Resist Increased Lateral Loading ✓
- Successfully Reduce Building Self Weight through the use of a Post-Tensioned Floor system ✓
- Provide logical floor plan arrangements to accommodate addition of structural shear walls and relocation of elevator core ✓
- Assess Cost Increases with Change to PT Floor System ✓

Final Recommendations

If the Franklin Square Hospital Center Patient Tower were to be built in San Francisco, the ideal structure would contain a Special Reinforced Concrete Shear Wall Lateral System with a Post-Tensioned Concrete Flat Slab floor system.

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Questions and Answers