Residence Inn by Marriott

Stamford, Connecticut

David Walenga -Structural Option

AE Senior Thesis – April 14, 2004

Residence Inn by Marriott

Stamford, Connecticut

Topics

- Project Background
- Structural Design Depth Study
- Breadth Study 1 : Construction Management
- Breadth Study 2 : Mechanical Design
- Final Comments
- Questions?

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Project Team

Owner/Developer - F.D. Rich Company

Architect – BBGM Architects and Interiors

General Contractor – Haynes Construction

Structural Engineer – Holbert Apple Associates, Inc.

M.E.P. – Collective Design Associates, LLC

Civil Engineer – Redniss & Mead, Inc.

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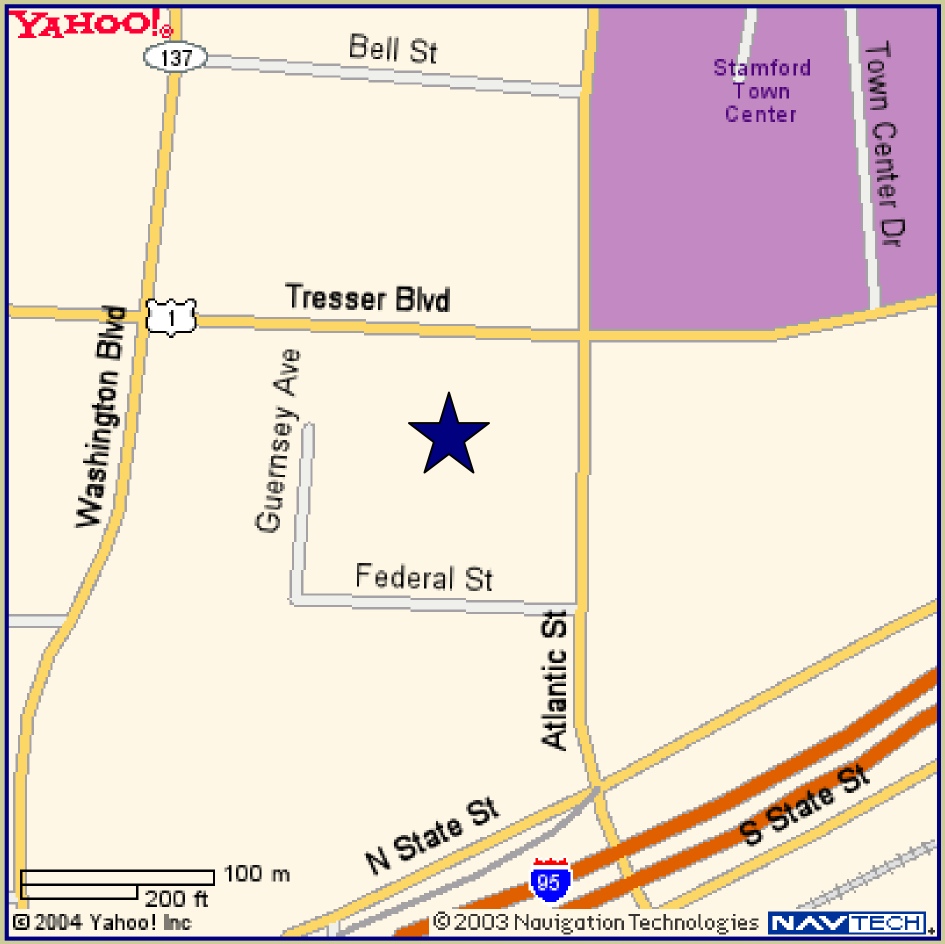
Building Location



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Building Site and Use

Building Site

Structure replaces a small one story commercial building and is built on the former site of a YMCA.

Building Use

The Residence Inn by Marriott is a hotel offering one and two bedroom suites complete with kitchenettes and private baths.

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Building Cost

Hotel: $24,947,000

Precast parking garage: $2,631,000

Total: $27,578,000

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Building Size

- 130,000 square feet
- 164 guest suites
- 13 occupied floors
- 2 mechanical penthouse levels
- 1 basement level with pool
- 404 space precast parking garage

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Architecture

- -Slender-wall cladding system
- -Cantilevered balconies on floors 9 through 13
- -Suspended mezzanine level above ground floor
- -L-shaped plan design, levels on short leg end at 5th floor.

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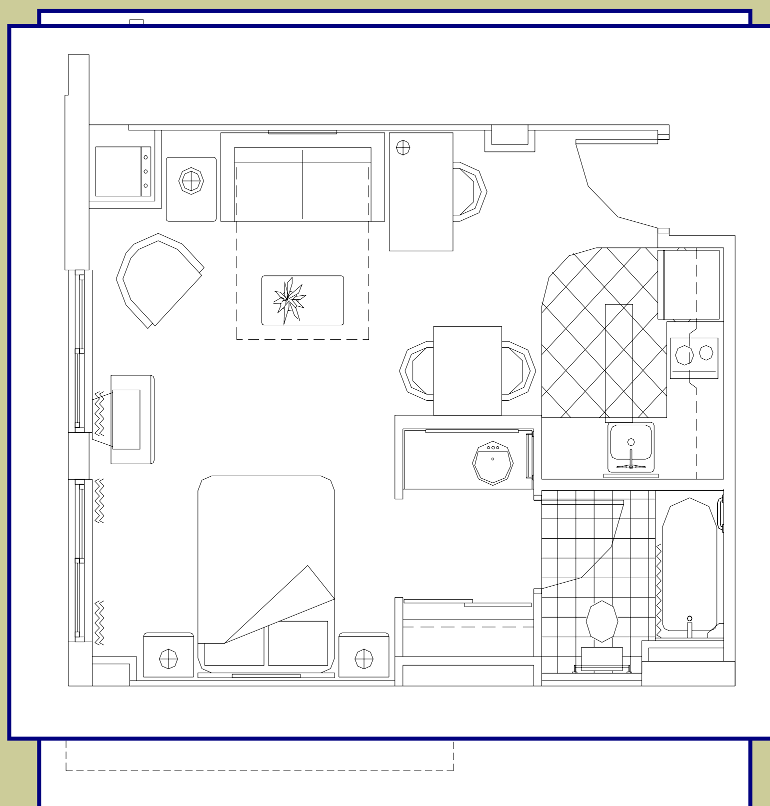
Architecture

Typical One Bedroom Suite

Typical Two Bedroom Suite



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Project Situation

-Original start date: January 2004

-Original completion date: June 2005

-Due to budgetary concerns, project construction has been delayed 5 months to redesign certain building components in order to lower the overall cost of construction.

-Updated start date: June 2004

-Updated completion date: November 2005

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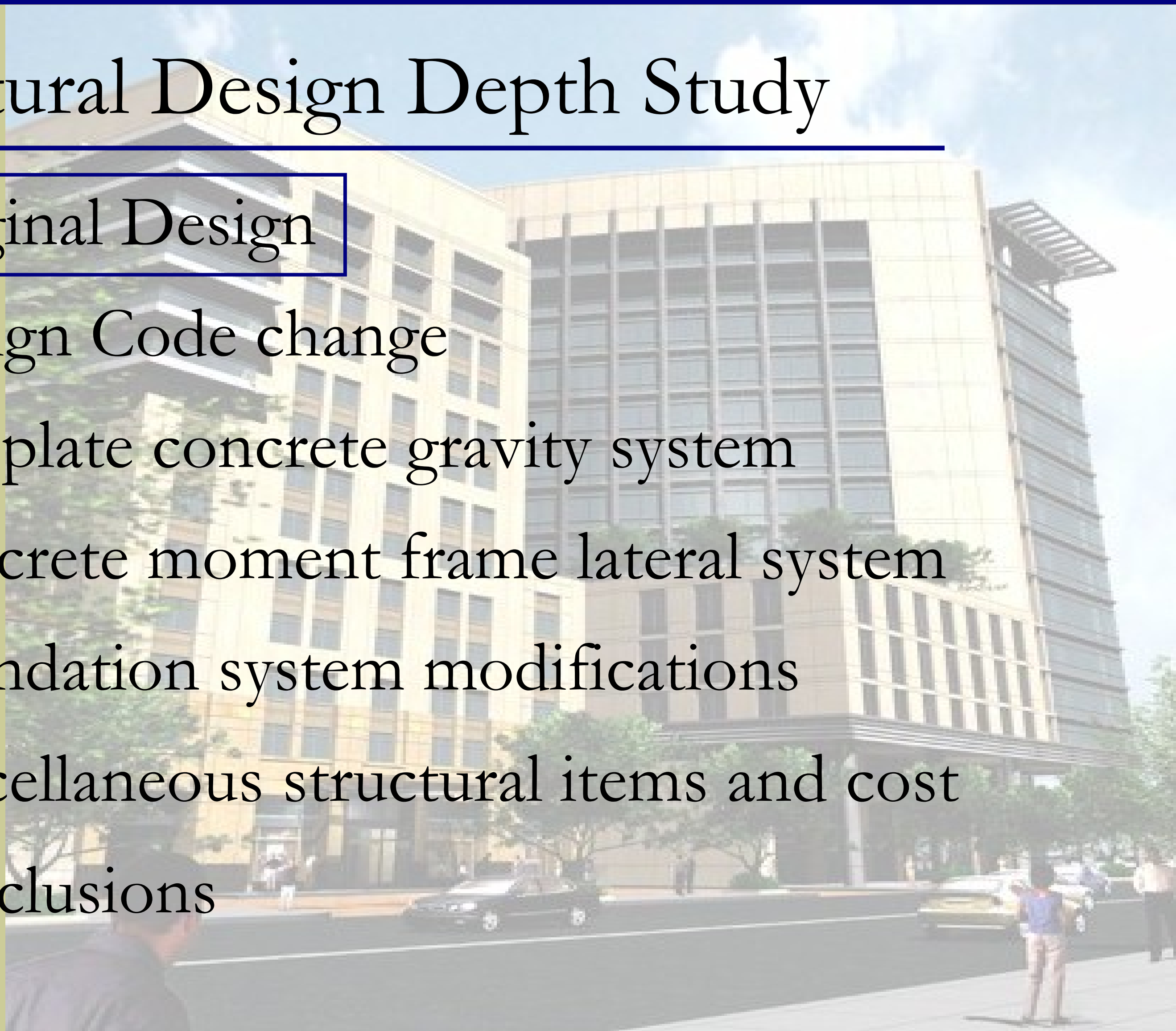

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Original Design

-Gravity System:

- -Steel framed superstructure
- -8" precast concrete hollow-core plank slab with gypcrete topping
- -Composite steel construction on mezzanine level

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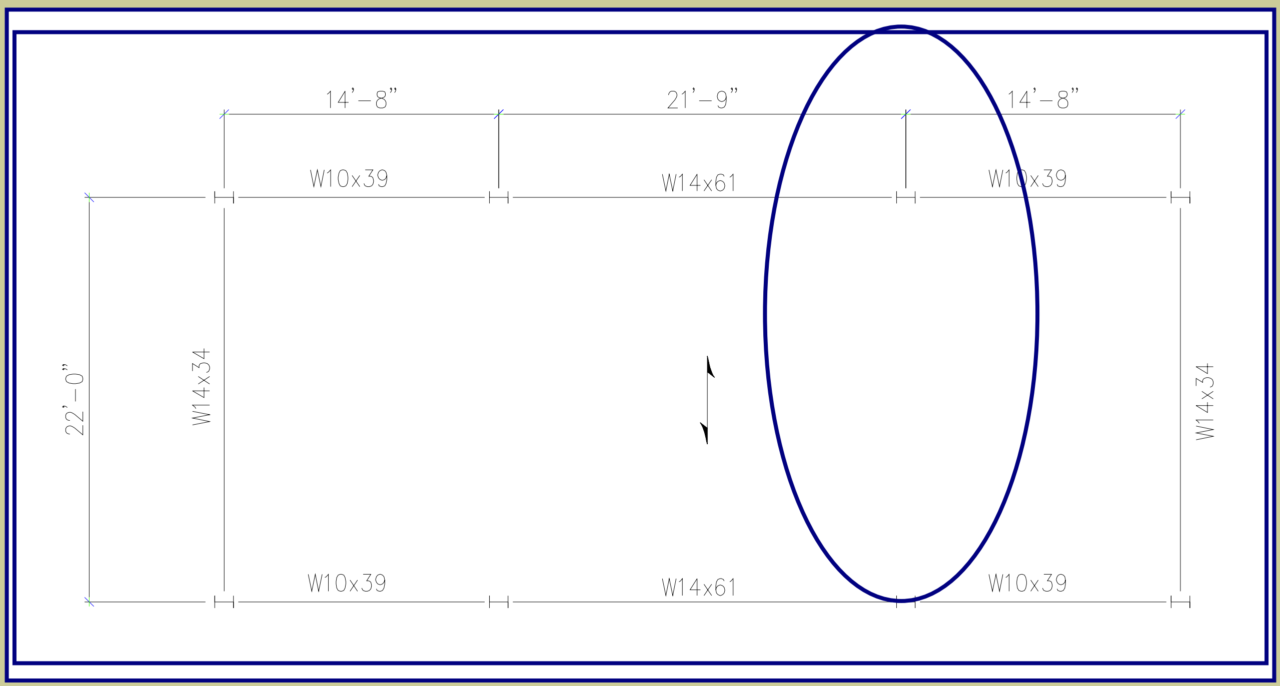
Original Design

-Gravity System: Typical Bay Plan



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Original Design

-Foundation System:

- Spread and mat footing foundation system
- Mat footings located at laterally braced frames, spread footings everywhere else.
- Typical exterior footing size: 10’ x 10’ x 3’
- Typical interior footing size: 11’ x 11’ x 3’

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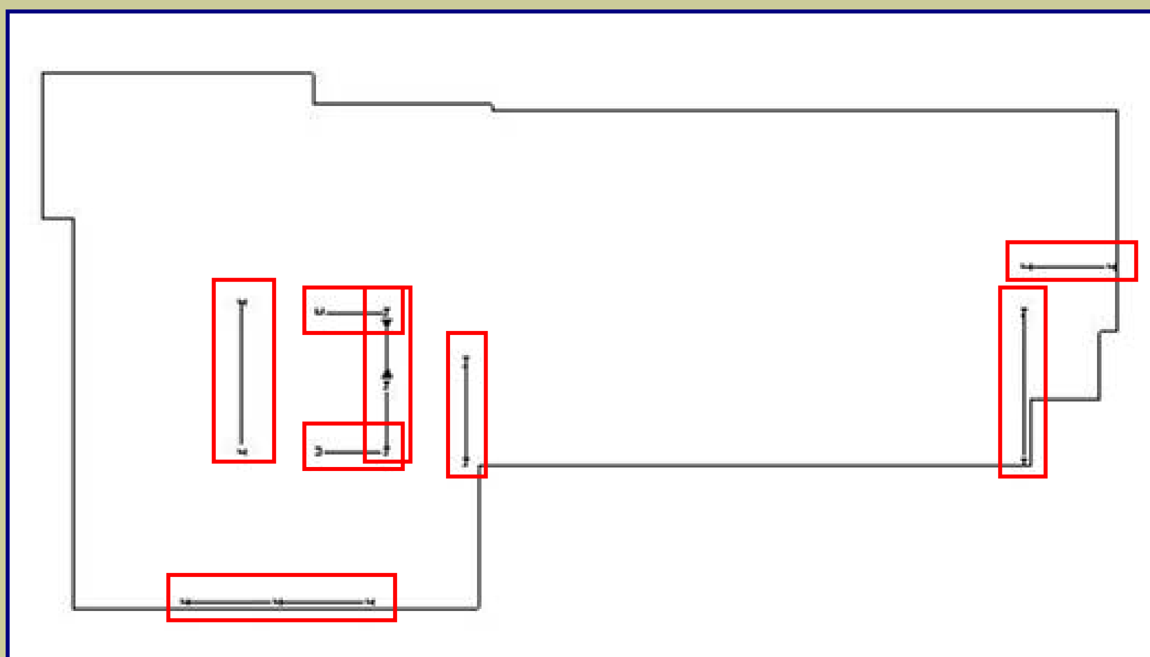
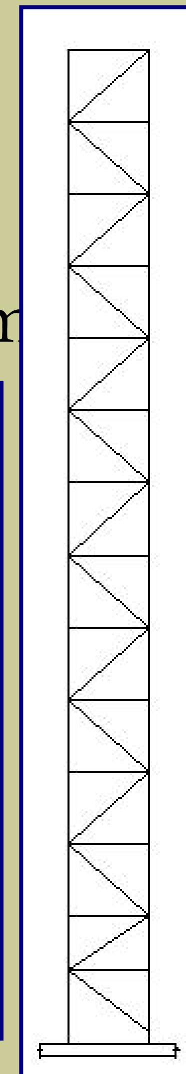
Original Design

-Lateral System:

- System of 8 concentrically braced fram

- Frame elevation:





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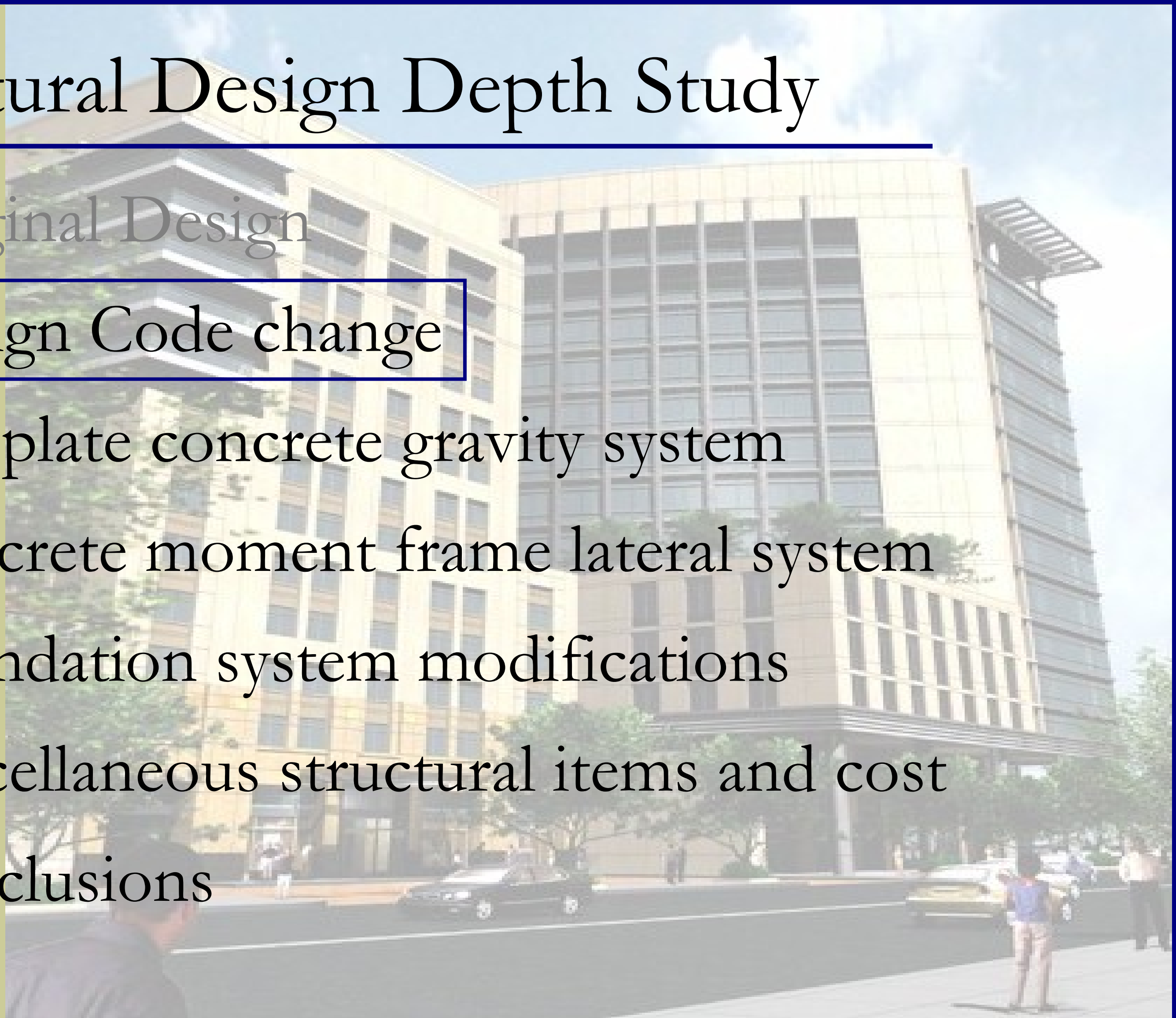
Structural Design Depth Study



- Original Design
- **Design Code change**
- Flat plate concrete gravity system
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Design Code Change

-Original Design Code: BOCA 1996

-Code for redesign: IBC 2000

-Connecticut plans to adopt IBC 2003 in 2005 as the state's governing code.

-IBC 2000 used in lieu of IBC 2003 since it is currently more common.

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Effects of Code Change: Wind

-BOCA 1996 Basic Wind Speed: 80 mph

-BOCA 96 Base Shears:

East – West	North - South
393 kips	485 kips

-IBC 2000 Basic Wind Speed: 110 mph

-Five second gust required by IBC 2000

-IBC 2000 Base Shears:

East – West	North - South
422 kips	633 kips

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Effects of Code Change: Seismic

-BOCA 96 Story Shears

Level	H (ft)	Fx (kip)
14	18	23.8
13	12.5	104.6
12	10.5	84.9
11	10.5	76.9
10	10.5	69.1
9	10.5	61.4
8	10.5	53.8
7	10.5	45.0
6	10.5	38.1
5	10.5	34.4
4	10.5	27.5
3	10.5	20.6
2	10.5	14.1
1	18	10.2

Base Shear: 665 kips

-IBC 2000 Story Shears

Level	H (ft)	Fx (kip)
14	18	26.8
13	12.5	113.3
12	9.75	109.4
11	9.75	99.3
10	9.75	89.4
9	9.75	79.7
8	9.75	70.2
7	9.75	59.3
6	9.75	50.4
5	9.75	45.0
4	9.75	38.5
3	9.75	29.2
2	9.75	20.4
1	18	14.9

Base Shear: 846 kips

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Flat Plate Concrete System: Slabs

-Design Loads:

Dead Load: 50 psf

Live Load: 40 psf in suites

100 psf in corridors

-Design Assumptions:

f'c = 3000 psi

Fy = 60 ksi

NW concrete = 150 pcf

ACI 318-02

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Flat Plate Concrete System: Slabs

-Results:

- 8” slab required in typical bays
- 9” slab required in larger non-typical bays
- 9” slab applied everywhere to simplify construction and to increase shear capacity

-Minimum steel controlled using 40 psf LL in suites for trial design.

-Redesigned using 100 psf LL in all areas, A_s increased slightly. Should building use change this provides versatility.

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Flat Plate Concrete System: Slabs

-19' Wide Bay

Span Location		M_u (ft-kips)	b (in)	d (in)	A_s (in^2)	Min. A_s (in^2)	Reinforcement
End Spans							
Column Strip	Ext. Neg	19	88	7.75	0.61	1.43	8 No. 5 @ 12"
	Positive	86	88	7.75	2.77	1.43	9 No. 5 @ 10"
	Int. Neg	143	88	7.75	4.61	1.43	8 No. 7 @ 10"
Middle Strip	Ext. Neg	0	140	7.75	0.00	2.27	12 No. 5
	Positive	60	140	7.75	1.94	2.27	12 No. 5
	Int. Neg	48	140	7.75	1.55	2.27	12 No. 5
Interior Span							
Column Strip	Positive	72	88	7.75	2.32	1.43	8 No. 5 @ 12"
Middle Strip	Positive	163	140	7.75	5.26	2.27	12 No. 5 @ 12"

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Flat Plate Concrete System: Columns

-Design Assumptions:

- f'c = 5 ksi

-Typical column sizes found on floors 13, 9, 5, and Ground to determine a general size distribution.

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Flat Plate Concrete System: Columns

-Results:

-Typical Exterior Column

Floor	Design
13th	14" x 14" 8 #5 w/ #3 T
9th	16" x 16" 8 #6 w/ #3 T
5th	18" x 18" 8 # 8 w/ #4 T
Ground	22" x 22" 8 #10 w/ #4 T

-Typical Interior Column

Floor	Design
13th	14" x 14" 8 #5 w/ #3 T
9th	18" x 18" 8 #6 w/ #3 T
5th	20" x 20" 8 #8 w/ #4 T
Ground	22" x 22" 12 #10 w/ #4 T

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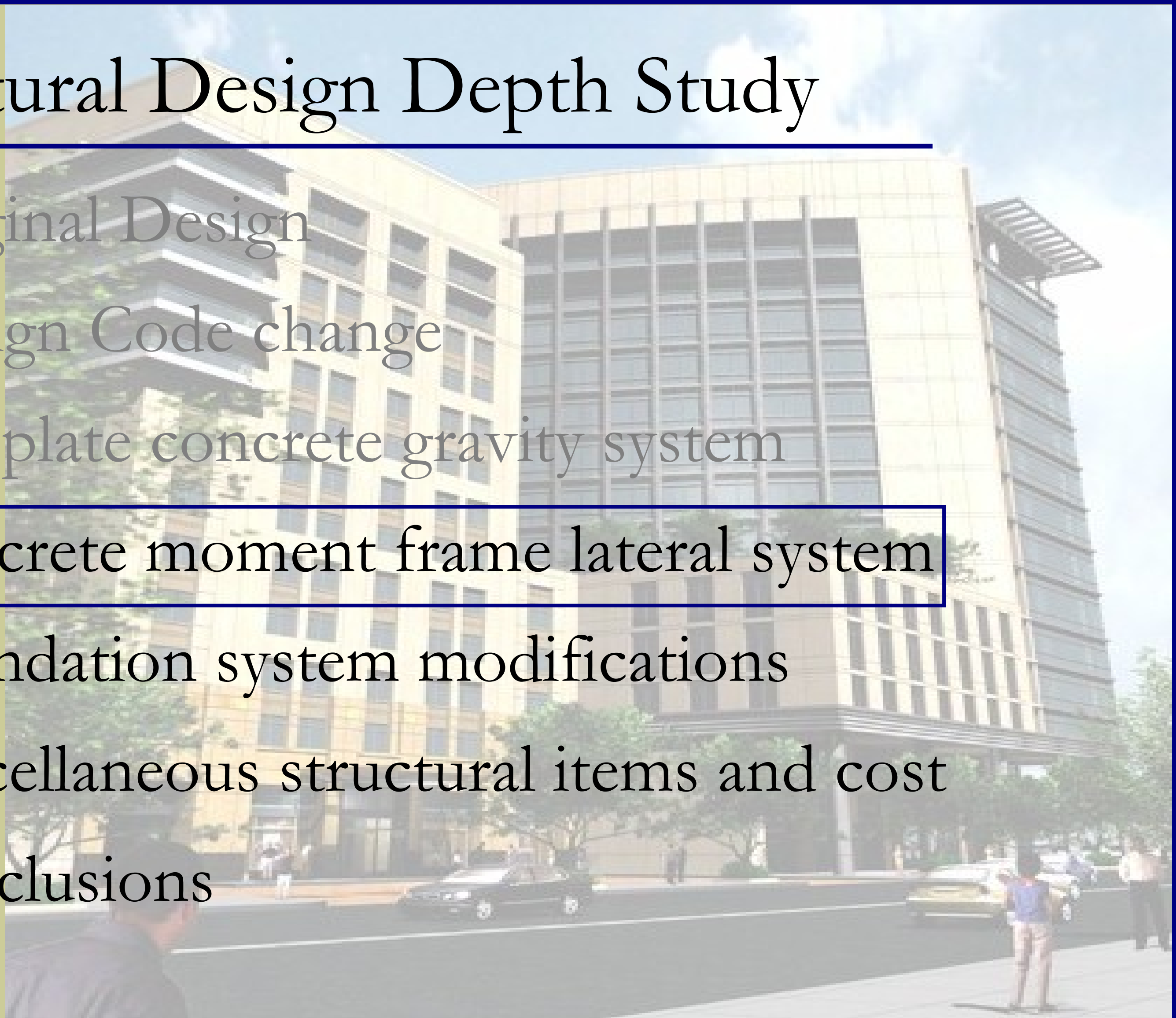
Structural Design Depth Study



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Concrete Moment Frames

- Initial analysis showed that concrete moment frames as the best option for the hotel's lateral system.

- Further analysis concluded that concrete shear walls would be a more efficient alternative that moment frames in terms of cost and performance.

- The story drifts of from the moment frame system were checked using Bent-Action displacements and found to be below the allowable range.

- Significantly more analysis would have to be performed to obtain the design for the Residence Inn's lateral system.

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Foundation System

-Building weight increased by 27%

-Design Assumptions:

- f'c = 3 ksi
- Allowable soil pressure = 6 ksf

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Foundation System

-Interior Column Spread Footing

-Original

Size	11’ x 11’ x 3’
Reinforcement	(10) #9 each way

-Redesign

Size	12’ x 12’ x 3’
Reinforcement	(11) #9 each way

-Exterior Column Spread Footing

-Original

Size	10’ x 10’ x 3’
Reinforcement	(9) #9 each way

-Redesign

Size	11’ x 11’ x 3’
Reinforcement	(10) #9 each way

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Mezzanine

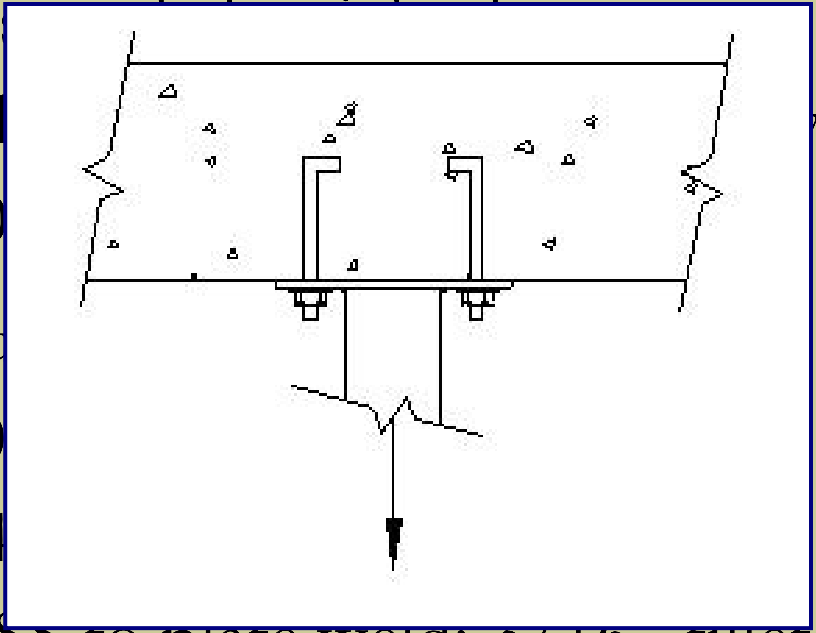
-Original design of composite steel retained

-Connection detail:

to keep su

-Cast-in-pl ving

ACI 318-0



-Design su

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- HSS to plate weld: 5/16" fillet

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Structural Systems Cost Comparison

-Steel System Cost

Original Total Structure Cost	$3,982,192
Original Plus 1% Inflation	$4,022,014
Steel Surcharge of $100/ton	$104,200
Total Original Cost	$4,126,214

-Flat Plate System Cost

Total Flat Plate Cost	$3,540,817

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Structural Systems Cost Comparison

-System Cost Difference

Cost Difference	$585,397

- Flat plate system saves almost $600,000 compared to steel with precast plank.

- The cost of fireproofing and steel surcharges account for 62% of savings.

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Conclusions

-Recommendation:

-Based on the assumptions and work performed here, it is concluded that the flat plate system is a better design alternative than the original steel system.

-Therefore, it is my recommendation that a flat plate concrete system be chosen as the structural system for the Stamford Residence Inn.

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Scheduling and Sequencing Analysis

Analysis Goals

-The purpose of this analysis is to determine which, if either, structural system analyzed here has an advantage over the other in terms of scheduling and project sequencing.

-Which structural system allows other trades to begin work first?

-Schedule assumption: Foundations complete in mid-July 2004.

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Scheduling and Sequencing Analysis

Steel System-

-Steel and concrete plank are lead time dependent. Can be prevented with proper scheduling.

-On-site coordination and site organization critical to steel construction. Large layout areas.

-Steel erection can continue in cold weather with plank grouting and plank topping delays possible.

-Days required for structural completion of 2nd Floor: 42

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Scheduling and Sequencing Analysis

Flat Plate System-

-Lead time not as critical with concrete. Important to have a concrete plant who can supply material when needed.

-Smaller layout and shakeout area required versus steel.

-Assuming a two-part 'pyramid' phasing:

-Eastern portion of 2nd Floor loadable after 28 days
-Western section after 39 days.

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Scheduling and Sequencing Analysis

Conclusion-

-For this project, flat plate concrete has an advantage over the steel with precast plank system in terms of scheduling and trade sequencing.

-Without delays, a flat plate concrete system will allow non-structural building trades to begin work before the original design will.

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Topics

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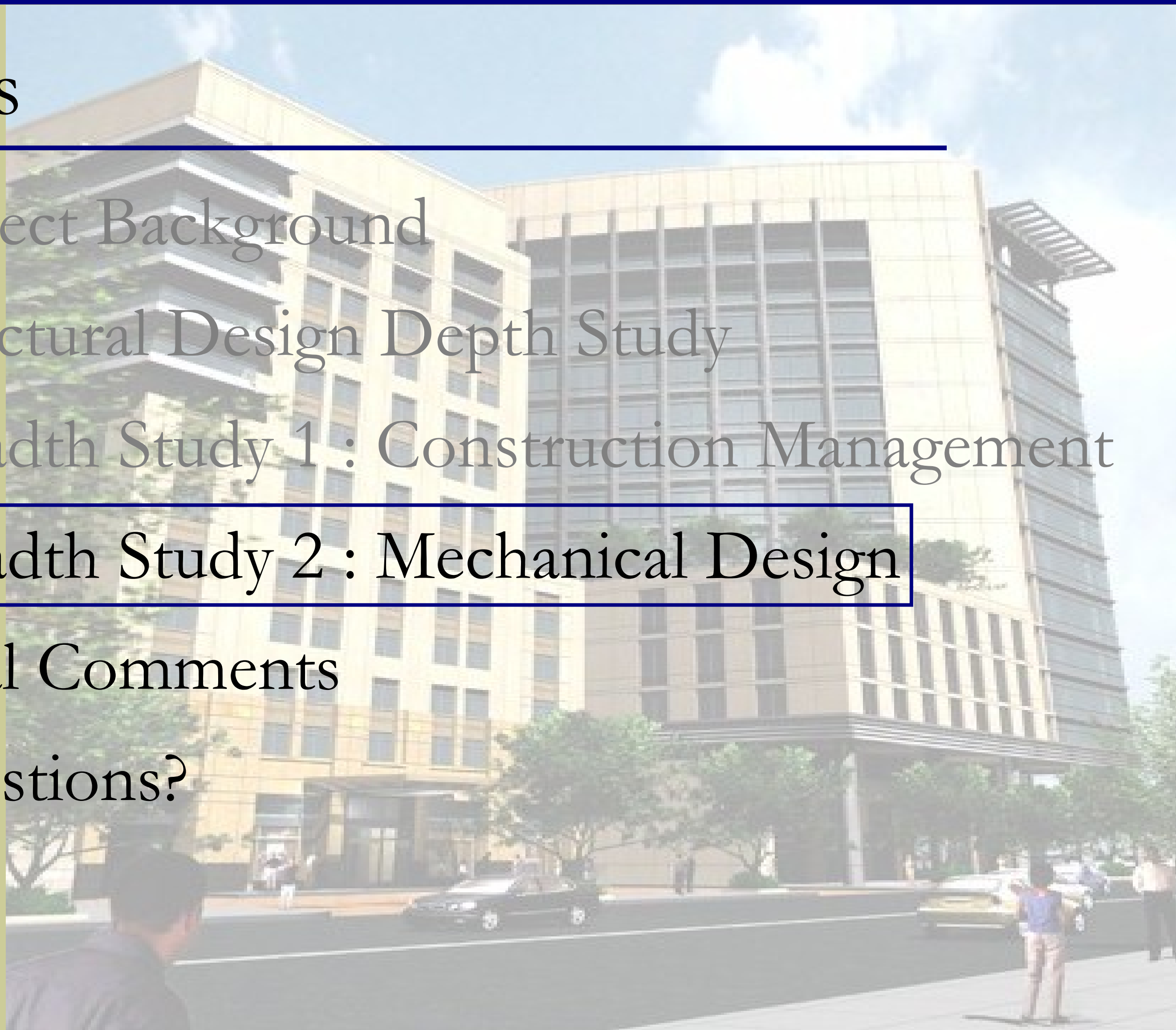

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Redesign Goals

-As previously discussed, the construction of the hotel has been delayed due to the cost of construction. Therefore, the goal of this redesign is to lower the first cost of the mechanical system without significantly cutting quality.

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Original Mechanical System

-Original system consists of two cooling towers and three boilers located in the penthouse.

-Roof top units supply air to the heat pumps located in each guest suite.

Guest Suite Mechanical Cost	$1,068,100

Advantages:
- High level of comfort control
- Quiet operation
- Low operating costs
- Durable system vs. PTAC's

Disadvantages:
- High first cost
- More equipment required
- More difficult to maintain

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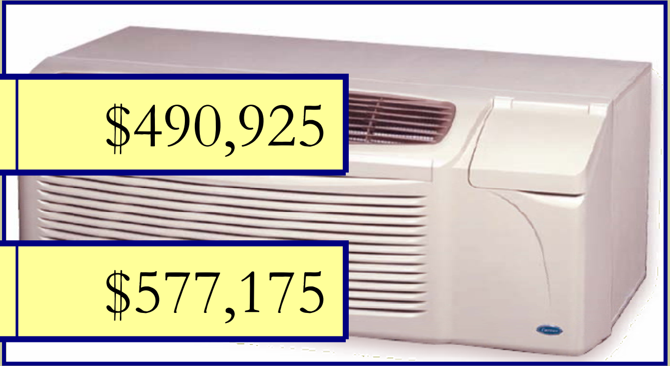
Redesigned Mechanical System

-A system of Carrier packaged
thermal
was selected as the design
alternati



Guest Suite Mechanical Cost	$490,925
First cost savings	$577,175

Advantages:
-More flexible/lower design cost
-Lower mechanical failure impacts
-Much less equipment required
-Lower upfront cost

Disadvantages:
-Lack of ducting lowers air distribution quality
-Impacts architectural design of exterior: louvers
-Higher operating costs
-High noise operation level

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Conclusions and Recommendation

Recommendation

➢By changing to PTAC's, the quality of the mechanical system would be lowered and the architecture of the building is negatively impacted.

➢Over the life cycle of the building, PTAC's will cost more than the original design.

➢It is recommended that the owner not change the mechanical system to PTAC's and in turn find another way to lower the first cost of the building.

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Final Conclusions

- A flat plate concrete system is a more economical structural design for the Residence Inn.
- Flat plate concrete construction impacts the progress of other trades less than steel with precast plank.
- Changing the in-suite mechanical system to PTAC’s is not suggested due to a lowering of quality.

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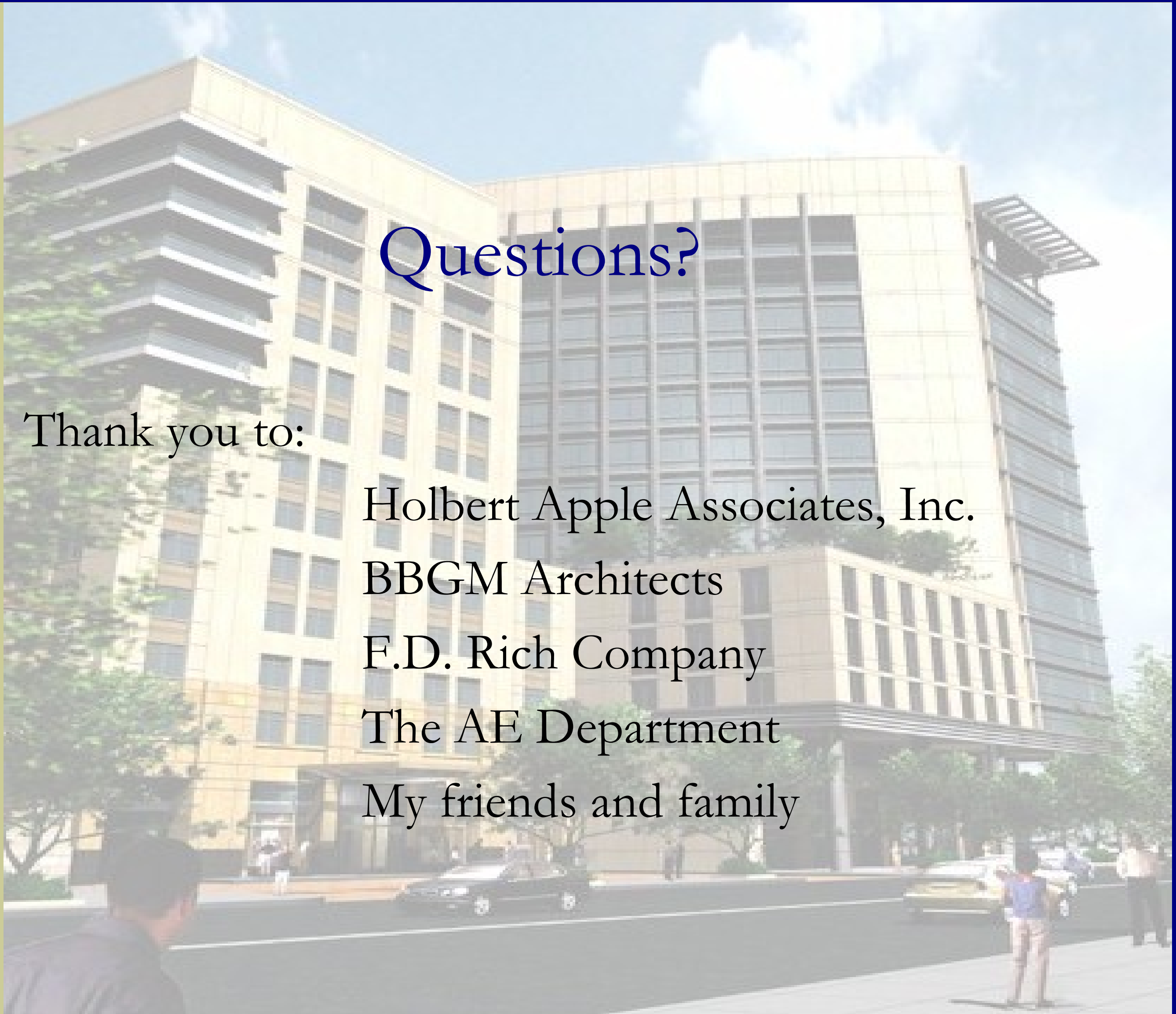

Questions?

Thank you to:

- Holbert Apple Associates, Inc.
- BBGM Architects
- F.D. Rich Company
- The AE Department
- My friends and family