



Residence Inn by Marriott
Now Featuring Executive Office Suites

DEVELOPING A PROTOTYPE

Presented by
Katie Ritter

Faculty Advisor:
Dr. Jill Mumford

The Pennsylvania State University
April 14, 2009

Residence Inn by Marriott

DEVELOPING A PROTOTYPE

- Introduction
- Proposal & Goals
- Original Structural Design
- Architectural Design
- Gravity System Site Design
- Lateral System Site Design
- Summary & Next Steps
- Conclusions

Residence Inn by Marriott

- All-suite hotel for extended-stay guests / design
- Fully-equipped kitchens in each suite
- Downtown Harrisburg, PA
- Ground floor amenities
- 9 stories, 120,000 sq. ft. for guests
- 100,000 sq. ft. for fitness

"A Home away from home"

Katie Ritter
Faculty Advisor:
Dr. Jill Mumford

The Pennsylvania State University
April 14, 2009

Residence Inn by Marriott

DEVELOPING A PROTOTYPE

- Introduction
- Proposal & Goals
- Original Structural Design
- Architectural Design
- Gravity System Site Design
- Lateral System Site Design
- Summary & Next Steps
- Conclusions

Proposal & Goals

- 1 Create a new signature brand for Marriott specifically for the business traveler, adding an *office suite dimension* to hotel-style living.
- 2 Engineer a *prototype structure* that is suitable for numerous locations across the U.S.

ARCHITECTURAL BREADTH

- Design team of architects, interior designers, and engineers
- Embrace open-plan design
- Provide professional quality for residents

STRUCTURAL DESIGN

- Develop loading criteria for prototype
- Develop structural analysis and design
- Develop construction details
- Develop construction schedule
- Develop construction cost estimate
- Develop construction risk assessment
- Develop construction safety plan
- Develop construction quality control plan
- Develop construction communication plan
- Develop construction close-out plan

STRUCTURAL DESIGN

- Check for lateral drift design per typical methods
- Run through design team
- Run through number of iterations

Katie Ritter
Faculty Advisor:
Dr. Jill Mumford

The Pennsylvania State University
April 14, 2009

Residence Inn by Marriott

DEVELOPING A PROTOTYPE

- Introduction
- Proposal & Goals
- Original Structural Design
- Architectural Design
- Gravity System Site Design
- Lateral System Site Design
- Summary & Next Steps
- Conclusions

Original Structural Design

Floor System

- 8" slab, typical
- 22" max bay size
- Most economical

Two-Way Flat Plate

Katie Ritter
Faculty Advisor:
Dr. Jill Mumford

The Pennsylvania State University
April 14, 2009



Residence Inn

Original Structural Design

DEVELOPING A PROTOTYPE

- Proposed & Clash
- Original Structure
- Architectural Design
- Gravity System Rev. Design
- Lateral System Rev. Design
- Summary & Next Steps
- Conclusions

Lateral System

- (14) cast-in-place reinforced concrete shear walls
- 12" thick, typical

Gravity System

- cast-in-place reinforced concrete columns
- 14" x 30", typical

Katie Ritter
Faculty Advisor
Dr. Ali M. Mostafa
The Pennsylvania State University
April 14, 2009

Residence Inn

...a new Executive Residence Inn

DEVELOPING A PROTOTYPE

- Proposed & Clash
- Original Structure
- Architectural Design
- Gravity System Rev. Design
- Lateral System Rev. Design
- Summary & Next Steps
- Conclusions

Office Suite

Hotel Suite

South Elevation

Katie Ritter
Faculty Advisor
Dr. Ali M. Mostafa
The Pennsylvania State University
April 14, 2009

Residence Inn

Office Level Floor Plans

DEVELOPING A PROTOTYPE

- Proposed & Clash
- Original Structure
- Architectural Design
- Gravity System Rev. Design
- Lateral System Rev. Design
- Summary & Next Steps
- Conclusions

Katie Ritter
Faculty Advisor
Dr. Ali M. Mostafa
The Pennsylvania State University
April 14, 2009

Residence Inn

Gravity Loads

DEVELOPING A PROTOTYPE

- Proposed & Clash
- Original Structure
- Architectural Design
- Gravity System Rev. Design
- Lateral System Rev. Design
- Summary & Next Steps
- Conclusions

Revised Gravity Loads kN

Location	Original	Revised	Original	Revised
Office	120	120	10	10
Hotel	120	120	10	10
Roof	120	120	10	10
Wind	120	120	10	10
Seismic	120	120	10	10
Other	120	120	10	10
Total	120	120	10	10

10' odd required

100 psf
50 psf
100 psf

10th Floor

Gravity Loads

- Modular system
- Light weight
- Accessible
- Flexibility

Katie Ritter
Faculty Advisor
Dr. Ali M. Mostafa
The Pennsylvania State University
April 14, 2009



Residence Hall

Gravity Column Re-Design

Katie Ritter
Faculty Advisor
Dr. Ali M. Masoud
The Pennsylvania State University
April 14, 2009

DEVELOPING A PROTOTYPE

- Introduction
- Proposed & Goals
- Original Structure
- Assessment of Original Structure
- Gravity System Re-Design
- Lateral System Re-Design
- Summary & Next Steps
- Conclusions

STRUCTURAL OPTION

Upper Office Floors - Column Layout

Residence Hall

Gravity Column Re-Design

Katie Ritter
Faculty Advisor
Dr. Ali M. Masoud
The Pennsylvania State University
April 14, 2009

DEVELOPING A PROTOTYPE

- Introduction
- Proposed & Goals
- Original Structure
- Assessment of Original Structure
- Gravity System Re-Design
- Lateral System Re-Design
- Summary & Next Steps
- Conclusions

STRUCTURAL OPTION

Original Design: 14' x 30' (4.27m x 9.14m)

Re-Design: 14' x 20' (4.27m x 6.10m)

20' x 30' (6.10m x 9.14m)

20' x 30' (6.10m x 9.14m)

4.5m

5.4m

✓ Horizontal Shear Control: Member required

✓ Slab Edge Tripping: Member required

Residence Hall

Loading Criteria for Prototype

Katie Ritter
Faculty Advisor
Dr. Ali M. Masoud
The Pennsylvania State University
April 14, 2009

DEVELOPING A PROTOTYPE

- Introduction
- Proposed & Goals
- Original Structure
- Assessment of Original Structure
- Gravity System Re-Design
- Lateral System Re-Design
- Summary & Next Steps
- Conclusions

STRUCTURAL OPTION

Basic Wind Speed (10-min, 3-sec)

V ≤ 120 mph

Other Assumptions:

- Exposure Category B
- Urban & suburban areas with closely spaced structures
- Not located on a hill
- Topographic factor, $K_z = 1$

Residence Hall

Loading Criteria for Prototype

Katie Ritter
Faculty Advisor
Dr. Ali M. Masoud
The Pennsylvania State University
April 14, 2009

DEVELOPING A PROTOTYPE

- Introduction
- Proposed & Goals
- Original Structure
- Assessment of Original Structure
- Gravity System Re-Design
- Lateral System Re-Design
- Summary & Next Steps
- Conclusions

STRUCTURAL OPTION

Seismic Parameters:
Spectral Response Acceleration

Short Period, $S_s \leq 50$

Long Period, $S_l \leq 15$

Other Assumptions:

- Site Class D - Stiff Soil
- Seismic Design Category D
- Ordinary reinforced concrete shear walls not permitted per ACI 318-05
- Max height for special reinforced concrete shear walls = 140'
- System overstrength factor = 2.5
- Redundancy factor = 1.3



Residence Inn

Structural Computer Model

DEVELOPING A PROTOTYPE

- Predefined & Custom
- Original Structure
- Architectural Changes
- Concrete System (in Design)
- Lateral System (in Design)
- Summary & Next Steps
- Questions

Number of Periods:
 $T_1 = 1.021$ sec
 $T_2 = 1.021$ sec
 $T_3 = 0.607$ sec

Katie Ritter
Faculty Advisor
Dr. Ali M. Masoud
The Pennsylvania State University
April 14, 2009

ETABS
Modeling Assumptions:

- Shear Walls
 - Cast-in-place
 - Maximum mesh of 2'4"
 - Critical sections considered: 50% of sillness
 - P-Delta effects included
- Floor Diaphragms
 - Rigid
 - Rest areas with assigned area masses

Residence Inn

Structural Irregularities

DEVELOPING A PROTOTYPE

- Predefined & Custom
- Original Structure
- Architectural Changes
- Concrete System (in Design)
- Lateral System (in Design)
- Summary & Next Steps
- Questions

- (1a) Torsion in X-Direction
- (1b) Extreme Torsion in Y-Direction
- (2) Reentrant Corner @ Upper Critical Floors

Katie Ritter
Faculty Advisor
Dr. Ali M. Masoud
The Pennsylvania State University
April 14, 2009

Modal Response Spectrum Analysis Required

- Equivalent Lateral Force procedure leads to distate seismic loads for preliminary design

Diaphragm Considerations:

- Connections to Shear Walls
- Model as semi-rigid

Residence Inn

Relative Stiffness of Shear Walls

DEVELOPING A PROTOTYPE

- Predefined & Custom
- Original Structure
- Architectural Changes
- Concrete System (in Design)
- Lateral System (in Design)
- Summary & Next Steps
- Questions

X-Direction Shear Walls

Wall	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17	W18	W19	W20	W21	W22	W23	W24	
Relative Stiffness (%)	9	9	52	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	24

Katie Ritter
Faculty Advisor
Dr. Ali M. Masoud
The Pennsylvania State University
April 14, 2009

Residence Inn

Controlling Lateral Loads

DEVELOPING A PROTOTYPE

- Predefined & Custom
- Original Structure
- Architectural Changes
- Concrete System (in Design)
- Lateral System (in Design)
- Summary & Next Steps
- Questions

Member-end Base Shear
Critical Loads at Base of Shear Walls

Member	X-Direction	Y-Direction	LC (3) 1200 + 0.5 + 0.5 + 1.5		LC (4) 1200 + 0.5 + 0.5 + 1.5	
			Shear	Moment	Shear	Moment
W1	115	13	507	11,114	507	11,114
W2	115	13	507	11,114	507	11,114
W3	115	13	507	11,114	507	11,114
W4	115	13	507	11,114	507	11,114
W5	115	13	507	11,114	507	11,114
W6	115	13	507	11,114	507	11,114
W7	115	13	507	11,114	507	11,114
W8	115	13	507	11,114	507	11,114
W9	115	13	507	11,114	507	11,114
W10	115	13	507	11,114	507	11,114
W11	115	13	507	11,114	507	11,114
W12	115	13	507	11,114	507	11,114
W13	115	13	507	11,114	507	11,114
W14	115	13	507	11,114	507	11,114
W15	115	13	507	11,114	507	11,114
W16	115	13	507	11,114	507	11,114
W17	115	13	507	11,114	507	11,114
W18	115	13	507	11,114	507	11,114
W19	115	13	507	11,114	507	11,114
W20	115	13	507	11,114	507	11,114
W21	115	13	507	11,114	507	11,114
W22	115	13	507	11,114	507	11,114
W23	115	13	507	11,114	507	11,114
W24	115	13	507	11,114	507	11,114

Katie Ritter
Faculty Advisor
Dr. Ali M. Masoud
The Pennsylvania State University
April 14, 2009

Residence Inn

DEVELOPING A PROTOTYPE

- Introduction
- Program & Goals
- Original Structure
- Architectural Changes
- Control System Re-Design
- Label System Re-Design
- Summary & Next Steps
- Questions

Shear Wall Re-Design

Boundary Element Design

12' EW

4' x 8' vertical opening

12' x 11.5'

12' x 11'

Katie Ritter

Faculty Advisor
Dr. Ali Momeni

STUCTURAL OPTION

The Pennsylvania State University

April 14, 2009

%Material Increase Required for S/W

14%
15%
52%

Control
Reinforcement

Prototype
#Norfolk, VA

Residence Inn

DEVELOPING A PROTOTYPE

- Introduction
- Program & Goals
- Original Structure
- Architectural Changes
- Control System Re-Design
- Label System Re-Design
- Summary & Next Steps
- Questions

Preliminary Prototype Feasibility

PROS

- Loading criteria meets demands of large geographic area
- Design capable of having minimal impact on architecture & interiors

↑

CONS

- Potentially significant increase in material COST to "overdesign"
- Impossible to pre-engineer completely due to multiple assumptions that must be made upfront

↓

Katie Ritter

Faculty Advisor
Dr. Ali Momeni

STUCTURAL OPTION

The Pennsylvania State University

April 14, 2009

Summary of Assumptions for Prototype

- Wind
 - V-L: 120 mph
 - Closely spaced obstructions nearby
- Seismic
 - Site Class D
 - SDC-D
- Snow
 - Ground snow load = 30 psf

Residence Inn

DEVELOPING A PROTOTYPE

- Introduction
- Program & Goals
- Original Structure
- Architectural Changes
- Control System Re-Design
- Label System Re-Design
- Summary & Next Steps
- Questions

Summary & Next Steps

Katie Ritter

Faculty Advisor
Dr. Ali Momeni

STUCTURAL OPTION

The Pennsylvania State University

April 14, 2009

ARCHITECTURAL HEADS

- Design new soffits/ceilings
- Interior upgrade design
- Provide ground space for residents
- Minimize all existing vertical transportation requirements/mechanical shaft penetrations

LIGHTING BREADTH

- Integrate conference room lighting design

STRUCTURAL DEPTH

- Check original floor design for increased loads
- Re-design grade columns
- Re-design transfer girders @ 2nd Floor
- Re-design bearing columns for prototype
- Apply loads to original structure & analyze
- Shear wall re-design
 - Design new structural solution that satisfies code requirements with new demands
 - Maintain original shear wall locations
- Evaluate feasibility of prototype structure
 - Flexibility to consider
 - Cost

NEXT STEPS

OC-conference room lighting design

DBA-design of transfer girders

DBA-Performance based response spectrum analysis & check if resulting loads are more critical than ELF

DBA-check column design with displacements

DBA-check detail @ openings

DBA-check column design with displacements

DBA-check analysis of prototype

Residence Inn

DEVELOPING A PROTOTYPE

- Introduction
- Program & Goals
- Original Structure
- Architectural Changes
- Control System Re-Design
- Label System Re-Design
- Summary & Next Steps
- Questions

QUESTIONS?

Katie Ritter

Faculty Advisor
Dr. Ali Momeni

STUCTURAL OPTION

The Pennsylvania State University

April 14, 2009

Special Thanks to:

- Advisor Dr. Ali Momeni
- Dr. Andros Lagaris
- Professor Kevin Parfitt
- Hubert Apple Assoc.
- STD Management Co.
- Re-A
- Clancy + Thoms Construction Co.
- AE Faculty & Staff
- Family & Friends