Caitlin Behm
Structural Option
Senior Thesis
Advisor: Dr. Boothby

Nemours Children’s Hospital
as a part of
The Nemours Foundation
Orlando, Florida
Introduction
Existing Structural System
Problem Statement
Proposed Solution
Thesis Redesign
Daylighting Analysis
Conclusion
Introduction

Project Team

Owner: The Nemours Foundation
Construction Manager: Skanska USA Building
Architect: Stanley Beaman & Sears
Landscape Architect: AECOM
Structural Designer: Simpson, Gumpertz, & Heger
Civil Engineer: Harris Civil Engineers
MEP: TLC Engineering for Architecture
Introduction

Enhanced Hurricane Protection Area (EHPA)

"The EHPA shall provide emergency shelter and protection for people for a period of up to 8 hours during a hurricane" - Florida Building Code
Existing Structural System

Hospital
Clinic

Expansion Joint

Shear Wall Core

Hospital
Clinic

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Problem Statement

- Restricted floor plan flexibility
- Coordination with MEP systems
- Additional formwork required for drop panels
- Extremely high design wind speed
**Presentation Outline**

- Introduction
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**Proposed Solution**

**Design Goals**

- Analyze feasibility of concrete moment frames
- Increase amount of useable space per floor
- Eliminate drop panels
- Evaluate louvers for daylighting control and EHPA criteria

**Concrete Moment Frames**

**Flat Plate System**

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**Courtesy: SGH**
**Design Goals**

- Analyze feasibility of concrete moment frames
- Increase amount of useable space per floor
- Eliminate drop panels
- Evaluate louvers for daylighting control and EHPA criteria
Thesis Redesign

Moment Frame Research

- < 8-10 stories
- Flat plate study
- Recommended β-value

Table 13-7 Recommended \( \alpha \) and \( \beta \) values for the flexural stiffness of slab-beam elements

<table>
<thead>
<tr>
<th>Region of the slab</th>
<th>( \alpha )-value</th>
<th>( \beta )-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive bending regions</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Negative bending regions (interior columns)</td>
<td>0.5</td>
<td>0.33, for lateral-load analysis</td>
</tr>
<tr>
<td>Negative bending regions (exterior columns)</td>
<td>0.2 to 0.5</td>
<td>(function of edge beam stiffness)</td>
</tr>
</tbody>
</table>

Wight & MacGregor 2008

Courtesy: SGH
Max Wind Speed: 79 mph (based on 1 min avg)

Max Wind Speed: 102 mph (based on 3 s gust)
Portal Frame Method

- Lateral only analysis
- Moment transfer
- Shear solutions

Structure Point

- Moments from portal method
- Column & slab studies
- Gravity only analysis

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Wight & MacGregor 2008

Caitlin Behm | Structural Option | Slide 12
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Thesis Redesign

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Clinic Expansion Joint

SAP

- Column sizes from spColumn
- Link element
- Lateral and gravity analysis

ETABS

- Two models
- Lateral and gravity analysis
- Capacity checks
- Deflection check

Conclusion

Edge beams with flat plate slab
With 110 mph wind design speed
Daylighting Analysis

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Daylighting Analysis

Summer Solstice

9 AM  11 AM  1 PM  3 PM  5 PM
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Daylighting Analysis

Winter Solstice

9 AM
11 AM
1 PM
3 PM
5 PM

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Summary

- Concrete moment frames not feasible for 157 mph
- Shear studs or edge beams required for moment transfer
- Edge beams required to mitigate excessive deflection
- Louvers not adequate for winter solstice
- Instead, use interior sun shades, also meeting EHPA criteria
Acknowledgements

Nemours Foundation
Simpson Gumpertz & Heger
- Cynthia Staats
- Michael Bolduc
The Pennsylvania State University Architectural Engineering Department
- Advisor: Dr. Thomas Boothby
Family and friends
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Appendix

<table>
<thead>
<tr>
<th>ETABS</th>
<th>SAP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Material</strong></td>
<td>f'c</td>
</tr>
<tr>
<td>Column</td>
<td>6</td>
</tr>
<tr>
<td>Slab (72&quot; wide)</td>
<td>5</td>
</tr>
<tr>
<td><strong>pinned base</strong></td>
<td></td>
</tr>
<tr>
<td><strong>shell element</strong></td>
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</tbody>
</table>

Ordinary concrete shear wall: R=5
Ordinary concrete moment frame: R=3

<table>
<thead>
<tr>
<th>Deflection</th>
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<tbody>
<tr>
<td>Story 6</td>
</tr>
<tr>
<td>2.92</td>
</tr>
<tr>
<td>Story 5</td>
</tr>
<tr>
<td>Story 4</td>
</tr>
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<td>Story 3</td>
</tr>
<tr>
<td>Story 2</td>
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<tr>
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Code Limit

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<tr>
<th>SAP</th>
<th>Deflection</th>
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<td>2.93</td>
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