THE COMMONWEALTH MEDICAL COLLEGE

BUILDING INTRODUCTION

- Building Introduction
- Existing Structural System
- Problem Statement
- Proposed Solution
- New Lateral Loads
- Lateral Frame Designs
- Façade Design Breadth
- Acknowledgements

- Medical College
- 185,000 SF
- 4 Story Building plus a Penthouse
- Maximum Height at 102'
- Cost $120 Million
- May 2009 to Oct 2011
- Design-Bid-Build
- Seeking LEED Silver

Photos From TCMC

Image from Google Map, edited by Xiao
THE COMMONWEALTH MEDICAL COLLEGE

PROJECT TEAM

- Owner: TCMC
- Architects: Highland Associates & HOK
- Structural/M.E.P. Engineers: Highland Associates
- Construction Management: Quandel Construction Group
- Landscape Architecture: McLane Associates
- Interior Architecture: Highland Associates & HOK

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**THE COMMONWEALTH MEDICAL COLLEGE**

- **EXISTING STRUCTURAL SYSTEM**
  - **West Wing**
    - Foundation: mat slab, 4'-0" thick, 3000 psf bearing pressure
    - Floor: composite steel deck, normal weight concrete topping, 7.5" thick
  - **East Wing**
    - Foundation: drilled caissons, 36" to 60" in diameters, carry loads to bedrock.
    - Floor: composite steel deck, lightweight concrete topping, 5.25" thick

---

**BAY SIZES**

- 20'-0" 30'-0" Bays
- 20'-0" 20'-0" Bays
- 10'-0" 20'-0" Bays
- 20'-0" 30'-0" Bays
- 20'-0" 26'-0" Bays

*Image from Highland Associates, edited by Xian*
THE COMMONWEALTH MEDICAL COLLEGE

EXISTING STRUCTURAL SYSTEM

• Framing System
  • Composite steel frame
    • W8x24 to W14x257, lightest to heaviest

• Lateral System
  • 15 moment frames (not including penthouse)

MOMENT FRAMES

Building Introduction
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ROOF HEIGHTS

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ROOF HEIGHTS PLAN

Image from Highland Associates, edited by Xiao
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PROBLEM STATEMENT

MIAMI, FL SITE

- Building Introduction
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- Interest in Wind Design
- Interest in Steel Design
- Scenario Created for Thesis
  - TCMC is to be designed on a site in Miami, FL
  - Hurricane Prone region, with wind speed up to 150 mph in building code.
  - Geotechnical report obtained from site in Miami-Dade County, Florida

Image from Google Map, edited by Xiao
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PROPOSED SOLUTION

PROJECT GOALS

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- Two Lateral Systems Proposed
  - Code Minimum Steel Moment Frames
  - Code Minimum Chevron Braced Frames
- Foundation
  - MAT Foundation

- Comparison Between Designs
  - Moment Frames to Braced Frames
  - New Systems to the Original System
  - A Typical Braced Connection
## Comparison of Seismic and Wind Forces

<table>
<thead>
<tr>
<th>Location</th>
<th>Wind, N-S</th>
<th>Wind, E-W</th>
<th>Seismic, N-S</th>
<th>Seismic, E-W</th>
<th>Seismic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miami, FL</td>
<td>560</td>
<td>730</td>
<td>136</td>
<td>300</td>
<td>970</td>
</tr>
<tr>
<td>Scranton, PA</td>
<td>200</td>
<td>270</td>
<td>130</td>
<td>110</td>
<td>350</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Base Shear (k)</th>
<th>200</th>
<th>270</th>
<th>130</th>
<th>110</th>
<th>350</th>
<th>120</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overturning Moment (k-ft)</td>
<td>10,000</td>
<td>12,900</td>
<td>7,600</td>
<td>5,230</td>
<td>17,100</td>
<td>7,000</td>
</tr>
</tbody>
</table>

### Summary: Wind Loads on TCMC

<table>
<thead>
<tr>
<th></th>
<th>West Wing</th>
<th>East Wing</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS Base Shear</td>
<td>560.0 k</td>
<td>296 k</td>
</tr>
<tr>
<td>NS Overturning Moment</td>
<td>27,500.0 k-ft</td>
<td>14,500 k-ft</td>
</tr>
<tr>
<td>EW Base Shear</td>
<td>731.0 k</td>
<td>960 k</td>
</tr>
<tr>
<td>EW Overturning Moment</td>
<td>35,800.0 k-ft</td>
<td>47,220 k-ft</td>
</tr>
</tbody>
</table>

### Wind Pressure and Wind Force acting on West Wing, EW Direction

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LATERAL FRAME LAYOUTS

- Building Introduction
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Moment Frame Layout

Braced Frame Layout

- Moment Frame
- Braced Frame
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MOMENT FRAME DESIGN

- Building Introduction
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STAAD Model for Frame A

1.2D + 1.6W + L + 0.5Lr

ETABS Model

AE 530

Computer Modeling

Etabs Models
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MOMENT FRAME DESIGN

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### Building Introduction

### Existing Structural System

### Problem Statement

### Proposed Solution

### New Lateral Loads

### Lateral Frame Designs

### Façade Design Breadth

### Acknowledgements
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ETABS Model

AE 530

Computer Modeling

BRACED FRAME DESIGN

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STAAD Model for Frame A

0.9D + 1.6W

1.2D + 1.6L + 0.5Lr

1.2D + 1.6W + L + 0.5Lr

0.9D + 1.6W

Etabs Models
Building Introduction

Existing Structural System

Problem Statement

Proposed Solution

New Lateral Loads

Lateral Frame Designs

Façade Design Breadth

Acknowledgements
Comparisons

Estimated Cost Analysis For Frame A

<table>
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<tr>
<th></th>
<th>Original</th>
<th>Moment</th>
<th>Braced</th>
</tr>
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<tbody>
<tr>
<td>Cost</td>
<td>$186,281.00</td>
<td>$567,043.00</td>
<td>$202,572.00</td>
</tr>
<tr>
<td>Percent</td>
<td>100%</td>
<td>304%</td>
<td>109%</td>
</tr>
</tbody>
</table>

Building Height Change

<table>
<thead>
<tr>
<th></th>
<th>Original</th>
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<tbody>
<tr>
<td>Height</td>
<td>93'</td>
<td>98'</td>
<td>92'</td>
</tr>
<tr>
<td>Difference</td>
<td>N/A</td>
<td>5'</td>
<td>-1'</td>
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Comparisons

Typical Member Size between 1st and 2nd Floor on Frame A

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<tr>
<td>Beam in NS</td>
<td>W24x68</td>
<td>W36x256</td>
<td>W21x68</td>
</tr>
<tr>
<td>Beam in EW</td>
<td>W30x99</td>
<td>W40x372</td>
<td>W24x76</td>
</tr>
<tr>
<td>Column</td>
<td>W14x257</td>
<td>W14x605</td>
<td>W14x176</td>
</tr>
<tr>
<td>Bracing</td>
<td>N/A</td>
<td>N/A</td>
<td>W14x90</td>
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Weight Comparison

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<tr>
<td>Lateral Resisting Members</td>
<td>330 k</td>
<td>1220 k</td>
<td>256 k</td>
</tr>
<tr>
<td>Total Building Weight</td>
<td>18400 k</td>
<td>19290 k</td>
<td>18600 k</td>
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<tr>
<td>Percentage</td>
<td>100%</td>
<td>105%</td>
<td>101%</td>
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New Lateral Loads

Lateral Frame Designs

Facade Design Breadth

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Moment Frames have more Architectural Freedom
MAT Foundation Design

- Great for Soil with Low Bearing Capacity
- Great for Large Column Loads
- Soil Bearing Capacity of 2500 psf
- Design is Very Complex

<table>
<thead>
<tr>
<th>Foundation Summary</th>
<th>Original</th>
<th>Moment</th>
<th>Braced</th>
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</thead>
<tbody>
<tr>
<td>F.S. Bearing</td>
<td>N/A</td>
<td>2.8</td>
<td>2.8</td>
</tr>
<tr>
<td>F.S. Uplift</td>
<td>N/A</td>
<td>Not an issue</td>
<td>4.4</td>
</tr>
<tr>
<td>F.S. Strength</td>
<td>N/A</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Depth into Earth</td>
<td>8'-8&quot;</td>
<td>10'</td>
<td>11'-6&quot;</td>
</tr>
<tr>
<td>Thickness of MAT</td>
<td>4'</td>
<td>6'</td>
<td>7'-6&quot;</td>
</tr>
</tbody>
</table>
THE COMMONWEALTH MEDICAL COLLEGE

MAE REQUIREMENT

ETABS Model
- AE 530, Computer Modeling

Typical 2nd Floor Brace Connection
- AE 534, Steel Connections

FAÇADE BREADTH

- AE 542, Building Enclosures
FAÇADE DESIGN

Rain Screen Wall Cladding System

- TerraClad Rain Screen manufactured by Boston Valley Terra Cotta
  - Simple to Install
  - Shield from wind driven rain
  - LEED credit opportunities
  - Abundant colors and sizes, match original
  - 6” additional thickness to exterior wall

TerraClad RAIN SCREEN

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Windows/Glazing

- LGUs with the concept of Sacrificial Ply

<table>
<thead>
<tr>
<th>Width x Height</th>
<th>Outer Ply Thickness</th>
<th>Inner Ply Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>2’x4’</td>
<td>1/8”</td>
<td>3/16”</td>
</tr>
<tr>
<td>6’x10’</td>
<td>1/8”</td>
<td>5/8”</td>
</tr>
</tbody>
</table>
Penn State Architectural Engineering Faculty
  • Heather Sustersic
Highland Associates
  • Eric McAndrew
TCMC
Family and Friends
Appendix
The Bechtler Museum of Modern Arts

HIT Power 220A Photovoltaic Module, by Panasonic
- Withstand 60 psf
- Top Energy Producer
- Highest Output on Cloudy Days

Estimated Life-Cycle Cost for 20 years = $279,086
Estimated Total Savings = $10,000
Estimated Payback Period = 27 years
Reduced in Number of Steam Boilers
Number of McQuay Chillers for Cooling stayed the same
Main Problem – High Humidity
  ▪ RLNL-G Dehumidifier by Rheem
    • Money – Saving Efficiency
    • Quiet Operation
    • Quality
    • Remote Monitoring and Control

Grid-Tied System
  ▪ Net-metering
High-Velocity Hurricane Zones

The High-Velocity Hurricane Zones (HVHZ) are specifically defined as Miami-Dade and Broward Counties. As in previous editions of the FBCB, a single wind speed is used for the HVHZ for each Risk Category Map. The design wind speeds in the HVHZ are as follows:

**Miami-Dade County**
- Risk Category I Buildings and Structures: 165 mph
- Risk Category II Buildings and Structures: 175 mph
- Risk Category III and IV Buildings & Structures: 185 mph

Did not check for Compression Force