Presentation Outline

1. Project Background
2. Scope of Work
3. Structural Depth Study
   i. Foundation System
   ii. Gravity System
   iii. Lateral Force Resisting System
4. Mechanical Breadth
5. Construction Management Breadth
6. Summary of Conclusions
7. Acknowledgments
Project Background

Building Statistics:

- **Location**: 462 Grider St, Buffalo, NY 14215
- **Occupant**: Erie County Medical Center
- **Occupancy Type**: Medical
- **Size**: 296,000 SF
- **Number of Stories**: 6
- **Maximum Height**: 90' - 0"
- **Completion Date**: July 2012
- **Project Cost**: $95 Million
- **Delivery Method**: Design-Bid-Build

Project Team:

- **Owner**: ECMC Corporation
- **Architect**: Cannon Design
- **Construction Manager**: LP Ciminelli
- **Structural Engineer**: Cannon Design
- **Civil Engineer**: Watts Architecture & Engineering
- **MEP Engineer**: M/E Engineering
Project Background

Existing Structural System

Foundation System:
- 5" Slab on Grade
- 12" Concrete Mat beneath elevator core
- Square Spread Footings
  - Sizes range from 3'-6" to 7'
  - Depths range from 1'-8" to 2'-8"
  - 3000 psi Normal Weight concrete
  - Soil Bearing Capacity of 16,000 psf
1. Project Background

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**Project Background**

**Existing Structural System**

**Gravity System:**
- Composite Metal Decking
  - 5½" LWC Floor Slab on 2” 20 Gage Metal Decking
  - Blended Fiber Reinforcement
- Composite Steel Framing
  - Column Sizes of W10
  - Beam Sizes of W12 to W16
  - Girder sizes ranged from W14 to W24
  - Column Splices at 2nd and 4th floors
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**Project Background**

**Existing Structural System**

Lateral Force Resisting System:
- Concentrically Braced Frame system
  - HSS Cross Bracing range in size from 6x6x3/8 to 7x7x1/2
- Lateral system located at the end of each and surrounding the building core
- Layout consists of a Radial Geometry
Scope of Work

Problem Statement:
- Existing Structural System currently the most efficient and economical
- Design Similar Structural System for Downtown Los Angeles, CA
- High Seismic activity in this new location

Problem Solution:
- Design Adequate Foundations
- Design Lighter Floor System
- Design Sufficient Lateral System:
  - Base Isolation
  - Concentric Braced Frame System
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Scope of Work

Project Goals:

Structural Depth Study
- Reduce Floor System Weight
- Maintain Architectural Layout
- Design Adequate Foundation and Lateral Systems for new location

Mechanical Breadth Study
- Verify Existing mechanical AHU’s are adequate for new location’s climate

Construction management Breadth Study
- Impact on construction schedule & cost
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Buffalo, NY:
- Wind Loads primarily dominated Lateral System Design
- Snow Loads contributed to Gravity System

Los Angeles, CA:
- Highly Active Seismic Region
- Frequent Earthquakes
- Possibility of Soil Liquefaction
- Bedrock is located around 80' depth
- Densely Populated Area
Structural Depth Study

The following systems will be evaluated:

- Foundation System
- Gravity System
- Lateral Force Resisting System
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**Foundation System**

Los Angeles, CA:
- 2,000 to 5,000 psi bearing strength
- Large Vertical/Lateral Loads on foundation
- 80’ depth to Limestone Bedrock
- Possibility of Liquefaction

Solution: Deep Foundation
- Driven piles provide adequate bearing strength
- Use of Bodine Resonant Pile Driver
  - Relatively Quiet Vs. Impact Hammer
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**Foundation System**

Deep Foundation Design Results:
- Pile Shape Size: HP12x84
- Pile Capacity: 597 Kips / Pile
- Safety Factor: 3.5
- Pile Length: 80’ (bearing on bedrock)
- Largest Footing: 9’ x 6’ w/ 12 Piles
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**Gravity System**

Framing Plan:
- Bays vary in size / largest = 29'-2" x 26'-0"
- Columns match wall partitions in plan
- Composite Decking spans parallel to wing
- Beams span perpendicular to wing
- Girders span parallel to wing
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**Gravity System**

Design Loads:
- ASCE 7-10
- Live loads
- Superimposed Dead Loads

Serviceability Criteria: Deflection
- Live Load = L/360
- Total Load = L/240

Controlling Load Combination:
- 1.2D + 1.6L + 0.5L
Gravity System Design Results:

- Composite Steel Slab
  - 3VL122 steel decking
  - 5" total thickness
  - Reduced floor weight from 42 psf to 35 psf

- Composite W-Flange Steel Columns
  - W10 shapes used for easy spliced connections
  - Sizes range from W10x33 to W10x60
  - Design relatively similar to Existing

- Composite W-Flange Steel Beam
  - W14x26 (w/16 shear studs)
  - Redesign lighter than Existing (by 5 lb)

- Composite W-Flange Steel Girder
  - W18x35 (w/20 shear studs)
  - Same weight as existing, less studs

Seismic Weight Comparison (Los Angeles, CA):

<table>
<thead>
<tr>
<th></th>
<th>Existing Building Design</th>
<th>New Building Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Weight</td>
<td>26,045 kips</td>
<td>21,527 kips</td>
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<tr>
<td>Base Shear</td>
<td>7918 kips</td>
<td>6550 kips</td>
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<tr>
<td>Total Moment</td>
<td>423,858 ft-l</td>
<td>350,654 ft-l</td>
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</tbody>
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Lateral Force Resisting System

Lead-Core Rubber Base Isolation:
- Increases building period
- Reduces building lateral drift
- Incorporation of lead core dampens seismic forces and re-aligns building after quake

<table>
<thead>
<tr>
<th>Seismic Base Isolation Comparison (Los Angeles, CA)</th>
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<tbody>
<tr>
<td>Building Period</td>
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<tr>
<td>1.4754 sec</td>
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<tr>
<td>Base Shear</td>
</tr>
<tr>
<td>Total Moment</td>
</tr>
<tr>
<td>Displacement (@ 90')</td>
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<tr>
<td>Drift (@ 90')</td>
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<tr>
<td>Member Size</td>
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Lateral Force Resisting System

Wind Variables

| Basic Wind Speed | V | Tab. 26.4-1 |
| Directional Factor | Kd | Tab. 26.4-1 |
| Exposure Category | Ex | Tab. 26.4-1 |
| Exposure Classification | E | Tab. 26.4-1 |
| Building Height | Z | Tab. 26.4-1 |
| Topographic Factor | Kt | Tab. 26.4-1 |
| Velocity Pressure Exposure Coefficient at Height 2 | qZ | Tab. 26.4-1 |
| Velocity Pressure at Mean Roof Height | qh | Tab. 26.4-1 |

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Seismic Design Variables

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<tr>
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<th>ASCE Reference</th>
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<tr>
<td>Structural System</td>
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<tr>
<td>MCE Spectral Response Acceleration, Short</td>
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<tr>
<td>Calculated Period Upper Limit Coefficient</td>
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<td>Calculated Period Upper Limit Coefficient</td>
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Wind Variables

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| Topographic Factor | Kt | Tab. 26.4-1 |
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Seismic Design Variables

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<td>Approximate Fundamental Period</td>
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</tr>
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<td>Seismic Design Variables</td>
</tr>
</tbody>
</table>
**Lateral Force Resisting System**

**Design Loads:**
- ASCE 7-10
  - Wind Loads (Directional Method)
  - Seismic Loads (Equiv. Lat. Force Method)

**Serviceability Criteria: Drift Criteria**
- $\Delta_{\text{Wind}} = \frac{H}{400}$
- $\Delta_{\text{Seismic}} = 0.02H_{sx}$

**Controlling Load Combination:**
- $1.2D + 1.0E + 1.0L$
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Lateral Force Resisting System

Frame Stiffness:
- Equally about 12% contribution
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### Lateral Force Resisting System

#### Controlling Seismic Drift (x-direction)

<table>
<thead>
<tr>
<th>Floor</th>
<th>Story Drift (in)</th>
<th>Allowable Story Drift (in)</th>
<th>Is this OK?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof</td>
<td>0.0184</td>
<td>0.400</td>
<td>yes</td>
</tr>
<tr>
<td>3rd Floor</td>
<td>0.0156</td>
<td>0.267</td>
<td>yes</td>
</tr>
<tr>
<td>2nd Floor</td>
<td>0.0123</td>
<td>0.267</td>
<td>yes</td>
</tr>
<tr>
<td>1st Floor</td>
<td>0.0073</td>
<td>0.320</td>
<td>yes</td>
</tr>
</tbody>
</table>

#### Controlling Wind Displacement (x-direction)

<table>
<thead>
<tr>
<th>Floor</th>
<th>Height above Ground (ft)</th>
<th>Displacement (in)</th>
<th>Allowable Displacement (in)</th>
<th>Is this OK?</th>
</tr>
</thead>
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<tr>
<td>Roof</td>
<td>60</td>
<td>2.523</td>
<td>≥ 1.500</td>
<td>yes</td>
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<tr>
<td>3rd Floor</td>
<td>42.067</td>
<td>0.751</td>
<td>1.280</td>
<td>yes</td>
</tr>
<tr>
<td>2nd Floor</td>
<td>29.333</td>
<td>0.413</td>
<td>0.880</td>
<td>yes</td>
</tr>
<tr>
<td>1st Floor</td>
<td>16</td>
<td>0.553</td>
<td>0.440</td>
<td>yes</td>
</tr>
</tbody>
</table>
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**Mechanical Breadth**

Mechanical System:
- Variable Air Volume (VAV) system
- 12 separate AHU’s
- Energy Recovery Wheels used for resident rooms

Buffalo, NY:
- Summer: 86°F
- Winter: 1°F

Los Angeles, CA:
- Summer: 84°F
- Winter: 43°F
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**Mechanical Breadth**

Mechanical System Results:

- **Buffalo, NY:**
  - Max Summer $Q_s$: 8,189,038 BTU/hr
  - Max Winter $Q_s$: 38,411,170 BTU/hr
  - Possible condensation within wall cavity in summer season

- **Los Angeles, CA:**
  - Max Summer $Q_s$: 7,988,607 BTU/hr
  - Max Winter $Q_s$: 34,202,119 BTU/hr
  - No condensation
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Cost Analysis:
- Project Cost increased by roughly 6%
- Primarily due to addition of LRB Isolators

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
<th>Labor</th>
<th>Material</th>
<th>TOTALS</th>
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</thead>
<tbody>
<tr>
<td>M12 Lateral Steel Columns</td>
<td>144,183</td>
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<td>716,067</td>
<td>858,724</td>
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<tr>
<td>HSS Steel Beams</td>
<td>10.37</td>
<td>22.08</td>
<td>2,074,444</td>
<td>2,098,522</td>
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<tr>
<td>W10 Steel Flange</td>
<td>594</td>
<td>16.7</td>
<td>2,049,000</td>
<td>2,065,740</td>
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<td>LRB Steel Pipe</td>
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<td>2,168,700</td>
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<td>207</td>
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<td>20,000,000</td>
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</tbody>
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**Construction Management breadth**

Schedule Impact:
- Project Schedule increased by 170 days
- Primary Impact: installation of Pile Foundations
- 2 week setback due to installation of LRB isolators
Summary of Conclusions

Foundation Redesign:
- HP 12x84 Grouped Steel Pile Deep Foundation
  - Sufficiently designed for strength requirements
  - Increased project cost and schedule

Gravity System Redesign:
- Composite Floor System
  - Sufficiently designed for strength and Deflection requirements
  - Slightly Reduced Floor Weight
  - Maintained architectural floor layout

Lateral System Redesign:
- Concentrically Braced Frames
  - Sufficient Strength
  - Drift reduced due to LRB isolators
  - Limited displacements and drifts due to wind and seismic
  - LRB isolators increased project cost and schedule

Mechanical Breadth:
- VAV mechanical system is adequate for new location

Construction Management Breadth:
- Cost was only increased by roughly 6%
- Project schedule was increased by 170 days
Acknowledgements

Cannon Design:
- Rachel Chicchi
- Douglas Flynn
- Brenda Onnen

The Pennsylvania State University:
- Prof. M. Kevin Parfitt
- Prof. Robert Holland
- The entire AE faculty and staff

All my friends, family, and classmates for their continuous support and encouragement.
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