Columbia University Northwest Science Building

New York, NY

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Structural Option
B.A.E/M.A.E Candidate
Faculty Advisor: Dr. Ali Memari
Northwest Science Building – Location

- Located at the Corner of Broadway & West 120th Street, New York, NY
- 13,000 square feet lot size
- Adjacent to Columbia University’s Chandler Hall and Pupin Physics Laboratories.
- Building contains a 126-foot clear span over an existing structure, the Dodge Physical Fitness Center.
Northwest Science Building – Statistics

- **Location & Site:** Broadway & 120th Street, New York, NY
- **Building Occupant Name:** Columbia University
- **Function Type:** Educational
- **Size:** 188,000 Square Feet
- **Number of Stories:** 14 Stories Above Grade
- **Height:** 239' 4"
- **Construction Dates:** March 2007 – October 2010
- **Cost:** $250,000,000 (Total Construction Cost)
- **Project Delivery Method:** Design-Bid-Build

**Architect**
- **Role:** Structural/MEP/Fire Engineers
- **Location:** 155 Avenue of the Americas, New York, NY 10012

**General Contractor:**
- **Role:** Turner Construction
- **Location:** 375 Hudson Street, New York, NY 10014

**Conclusion**
- **Role:**
  - General Contractor
  - Structural/MEP/Fire Engineers
  - Associate Project Managers
  - Design-Bid-Build

**Thesis Abstract**
- **Location:** Engr. Unit A (across from Room 194)
- **Copies Also Upfront**
Northwest Science Building – Structure

- Composite Steel Frame Design
  - Concrete Slab & Metal Decking Sheared to Beam Members
- All Columns are W14's
- Lateral System Contains the following:
  - Horizontal HSS Shaped Girt Members
  - Concentric Braced Frames (Wide Flanges)

Thesis Abstract
- Located in Eng. Unit A
  - across from Room 104
- Copies Also Upfront
Thesis Proposal

Structural Depth
- Calculation of Wind Forces for Miami, FL
- Analyze Existing Lateral System for Miami, FL
- Redesign and Analyze Lateral System

Building Enclosure Breadth
- Perform R-value, Condensation, and Air Leakage Analyses
- Modify Curtain Wall for Miami, FL

Architectural Breadth
- Research Miami, FL Architecture
- Redesign Exterior Architecture for Miami, FL
Goals – Based on Relocation of Building to Miami, FL

- Redesign building's lateral system to meet code requirements.
- Provide analysis of lateral system through means of ETABS and hand calculations.
- Research, analyze, and modify building enclosure appropriately for water condensation and heat transmission concerns.
- Redesign exterior architecture of building.
Determination of Wind Forces for Miami, FL

- Determine Wind Forces using ASCE 7-05 Method 2 – Analytical Procedure.
- Base Shear Increased by 2600 kips (East-West Direction)
- Base Shear Increased by 418 kips (North-South Direction)

Comparison of Base Shears (NYC vs. Miami)

<table>
<thead>
<tr>
<th></th>
<th>Base Shear (kips)</th>
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<tbody>
<tr>
<td>Miami, FL</td>
<td>1400</td>
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<tr>
<td>New York, NY</td>
<td>982</td>
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-EXISTING
-THESIS PROPOSAL
-GOALS
-EXISTING LATERAL
-LATERAL REDESIGN
-BUILDING ENCLOSURE
-ARCHITECTURE
-CONCLUSION
Existing Lateral Analysis for Miami, FL

- Main Wind Force Resisting System – Method 2 – Design Wind Load Cases Used
- Governing Wind Case Determined for Each Frame

Comparison of Max Wind Drifts - NYC vs. Miami

Wind Case 1
Wind Case 2
Wind Case 3
Wind Case 4

Allowable Drift
H/400 = 6.78 in.

Existing Lateral System Failed Most Drift, Story Drift & Strength Checks
System Acceptable for Overturning Moment Calculations
My Lateral Redesign for Miami, FL

Strength Requirements Checked for Bracing & Columns:
- Available Compressive Strength ($\Phi_cP_n$)
- Local Buckling
- Effective Length and Bracing Slenderness
- Available Strength in Axial Tension ($\Phi_tP_n$)

Strength Requirements Checked for Participating Beam Members:
- Available Compressive Strength ($\Phi_cP_n$)
- Available Strength in Axial Tension ($\Phi_tP_n$)
- Shear Capacity/Transfer at Joints

Load Combinations Critical for Design of Members:
- $1.2(\text{Dead}) + 1.6(\text{Wind}) + 1.0(\text{Live})$
- $0.9(\text{Dead}) + 1.6(\text{Wind})$
My Lateral Redesign for Miami, FL

- Existing Building Drift (Miami, FL) – 14.09 Inches (East-West Direction)
- Redesigned Building Drift (Miami, FL) – 6.77 Inches (East-West Direction)

- Existing Building Drift (Miami, FL) – 2.16 Inches (North-South Direction)
- Redesigned Building Drift (Miami, FL) – 1.20 Inches (North-South Direction)

- North-South Direction Lateral System Redesign
  - Not as critical as East-West Direction
  - Larger member sections provided where needed. (small occurrence)

- Redesigned Lateral System Meets Drift, Story Drift, & Strength Requirements
- Redesign Acceptable for Overturning Moment Calculations

Allowable Drift
H/400 = 6.78 in.
My Lateral Redesign for Miami, FL

Lateral Steel Tonne:
- Existing Lateral Bracing – 50.38 Tons (East-West Direction)
- Redesigned Lateral Bracing – 122.32 Tons (East-West Direction)

Increase of 72 Tons

Bare Material Costs:
- Existing Lateral Bracing – $163,000 (East-West Direction)
- Redesigned Lateral Bracing – $368,000 (East-West Direction)

Increase of $205,000
Building Enclosure Breadth

Building Enclosure Breadth Goals

- Perform R-value, condensation, and air leakage analyses of curtain wall system for Miami, FL.
- Design for ASHRAE climate recommendations.
- Perform bare material cost analysis.

Wall Section

- Aluminum Cladding
- Cavity (1/2")
- Foamglass Insulation
- Vapor & Air Barriers
- 5 Inch Precast Face Seal
Building Enclosure Breadth

R-Value Analysis
- Decrease in insulation layer (due to Miami’s warmer climate)
- R-Value of Existing Wall System (21.23)
- R-Value of Redesign Wall System (13.53)

Condensation Analysis
- Decrease in insulation layer checked for condensation concerns.
- Dew points occur on outside of water vapor barrier — ACCEPTABLE
Building Enclosure Breadth

ASHRAE R-Value Recommendations

- Climate Zone 4 (New York, NY)
  - Walls R-Value of 22.5
- Climate Zone 1 (Miami, FL)
  - Walls R-Value of 13.5

- R-Value Provided in Wall Redesign is 13.53 - ACCEPTABLE

ASHRAE Climate Zone 4
New York, NY

ASHRAE Climate Zone 1
Miami, FL
Building Enclosure Breadth

Air Leakage Analysis – (New York, NY versus Miami, FL)
• Large difference in energy loss due to air leakage during the winter.
• 184,000,000 BTUs/Year Difference (New York, NY Greater Energy Loss)
• Equivalent to burning approximately 200,000 gallons of natural gas.
• Analysis supports reduction in insulation layer for Miami, FL.

Bare Material Cost Analysis – (RS Means)
• $185,900 bare material cost savings due to reduction in insulation layer.
Architectural Breadth

Architectural Breadth Goal

• Redesign building exterior appearance to be representative of Miami architectural culture.

  o Mediterranean Revival Style
  o Art Deco Style
  o Streamline Modern Style

US Bacardi Headquarters – Miami, FL
Streamline Modern Style
• Natural Forms
  • Pronounced Vertical Features

Freedom Tower – Miami, FL
Mediterranean Revival Style
• Stucco Color Wall

Park Central Hotel – Miami, FL
Art Deco Style
• Symmetrical Massing
  • Geometric Patterns

Miami architectural culture.

- Mediterranean Revival Style
- Art Deco Style
- Streamline Modern Style

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ARCHITECTURE
CONCLUSION

THE PENNSYLVANIA STATE UNIVERSITY
Architectural Breadth

Proposed Architecture – North Façade
- Aluminum Cladding Coloring (Yellow-Bronze & Gray)
  - Diamond Color Pattern Exemplifies Lateral Exterior Frame
  - Color Cladding Represents Art Deco Style Architecture

Existing North Façade
- Park Central Hotel – Miami, FL
  - Art Deco Style

North Façade Redesign
- Clear Glass with Clear Anodized Backpan Shadowbox
- Aluminum Clad Curtain Wall Panels (Gray)
- Painted CMU

Existing North Façade
- Clear Glass with Clear Anodized Backpan Shadowbox
- Aluminum Clad Curtain Wall Panels (Yellow-Bronze)
Proposed Architecture – South Façade
- Aluminum Cladding Coloring (Yellow-Bronze & Gray)
  - Diamond Color Pattern Exemplifies Lateral Exterior Frame
  - Color Cladding Represents Art Deco Style Architecture

Existing South Façade

Architectural Breadth

South Façade Redesign

Clear Glass with Clear Anodized Backpan

Aluminum Cladded Curtain Wall Panels (Yellow-Bronze)

Painted CMU

Park Central Hotel – Miami, FL
Art Deco Style
Architectural Breadth

Proposed Architecture – West Façade
- Aluminum Cladding (Yellow-Bronze) Wrapped at Corner
- Façade Design Inspired by Sailboat (Miami Culture)
Architectural Breadth

Proposed Architecture – East Façade

- Aluminum Cladding (Yellow-Bronze) Wrapped at Corner
- Façade Design Inspired by Sailboat (Miami Culture)
Architectural Breadth

Architectural Breadth Conclusions
- Design Incorporates Mix of Miami Modern Architectural Styles
  - Mediterranean Revival
  - Art Deco
  - Streamline Modern
Senior Thesis Conclusions

Lateral System Redesign for Miami, FL Winds
- Miami Wind Force Calculations
- ETABS Model Assistance
- Drift, Story Drift, Strength, and Overturning Moment Checks
- $205,000 Steel Bare Material Additional Cost

Building Enclosure Modified for Miami, FL Climate
- Reduction in Insulation Layer (4" to 2.5")
- $185,900 Bare Material Cost Savings

Exterior Architecture Redesign for Miami, FL
- Includes Elements of Mediterranean Revival, Art Deco, & Streamline Modern Architectural Styles

Proposed Goals:
- Redesign building's lateral system to meet code requirements.
- Provide analysis of lateral system through means of ETABS and hand calculations.
- Research, analyze, and modify building enclosure appropriately for water condensation and heat transmission concerns.
- Redesign exterior architecture of building.
Thank You

Thesis Advisor
Dr. Ali Memari

Thesis Course Administrators
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AE Faculty
AE Classmates
Family & Friends

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