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NEW YORK, NY

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Jonathan R. Torch - Structural Option

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- EXISTING LATERAL
- LATERAL REDESIGN
- BUILDING ENCLOSURE
- ARCHITECTURE
- CONCLUSION

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Columbia University Northwest Science Building

New York, NY

Jonathan R. Torch
Structural Option
B.A.E/M.A.E Candidate
Faculty Advisor: Dr. Ali Memari

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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.

Upper Manhattan

Columbia University Campus

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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

Role	Location
General Contractor: Turner Construction	*375 Hudson Street New York, NY 10014*
Structural/MEP/Fire Engineers: Ove Arup & Partners Consulting Engineers	*155 Avenue of the Americas New York, NY 10012*

Thesis Abstract

- ***Located in Engr. Unit A (across from Room 104)***
- ***Copies Also Upfront***

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Northwest Science Building – Structure

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

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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

***Relocation of Building** – New York, NY to Miami, FL*

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Thesis – Goals

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.

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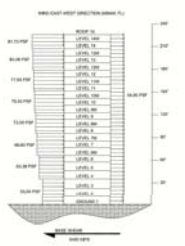
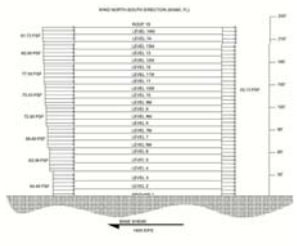
Determination of Wind Forces for Miami, FL

Wind East-West Direction
Miami, FL

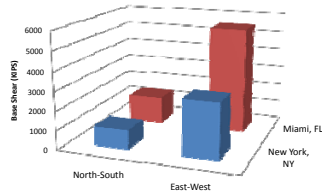


Wind North-South Direction
Miami, FL



- 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)



	North-South	East-West
New York, NY	982	2860
Miami, FL	1400	5490

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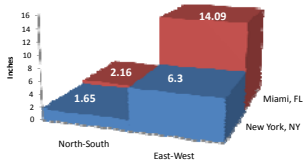
Existing Lateral Analysis for Miami, FL

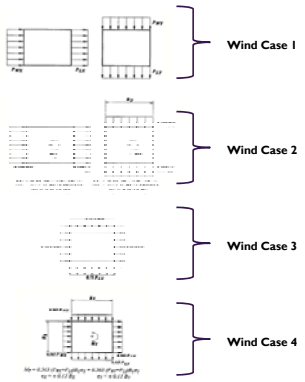
- Main Wind Force Resisting System – Method 2 – Design Wind Load Cases Used
- Governing Wind Case Determined for Each Frame

Comparison of Max Wind Drifts - NYC vs. Miami



*Allowable Drift H/400 = **6.78 in.***

- *Existing Lateral System **Failed** Most Drift, Story Drift, & Strength Checks*
- *System **Acceptable** for Overturning Moment Calculations*



Wind Case 1

Wind Case 2

Wind Case 3

Wind Case 4

Wind Case Forces Calculated & Inputted into ETABS Software – Analyzed

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My Lateral Redesign for Miami, FL

Strength Requirements Checked for Bracing & Columns:

- Available Compressive Strength ($\Phi_c P_n$)
- Local Buckling
- Effective Length and Bracing Slenderness
- Available Strength in Axial Tension ($\Phi_t P_n$)

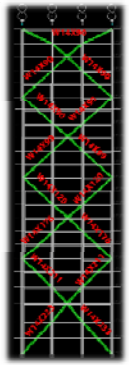
Strength Requirements Checked for Participating Beam Members:

- Available Compressive Strength ($\Phi_c P_n$)
- Available Strength in Axial Tension ($\Phi_t P_n$)
- Shear Capacity/Transfer at Joints

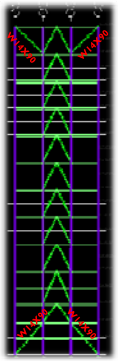
Load Combinations Critical for Design of Members:

- 1.2(Dead) + 1.6(Wind) + 1.0(Live)
- 0.9(Dead) + 1.6(Wind)

East-West Direction Lateral Redesign - Critical



Preliminary Exterior Braced Frame Design
Grids 1 & 10



Chevron Bracing

W14X53

W14X61

W14X74

W14X90

Interior Grid 4
Chevron Bracing

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My Lateral Redesign for Miami, FL

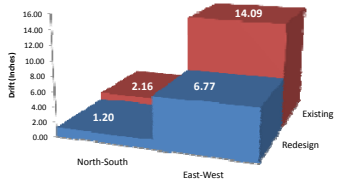
- Existing Building Drift (Miami, FL) – **14.09 Inches** *(East-West Direction)*
- Redesigned Building Drift (Miami, FL) – **6.77 Inches** *(East-West Direction)*

- 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***

Max Wind Drift - Existing vs. Redesign (Miami, FL)



Allowable Drift
*H/400 = **6.78 in.***

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My Lateral Redesign for Miami, FL

Lateral Steel Tonage:

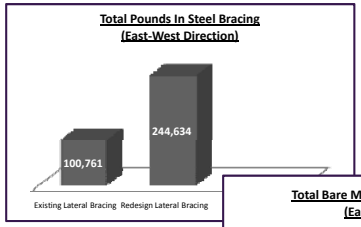
- Existing Lateral Bracing – **50.38 Tons** *(East-West Direction)*
- Redesigned Lateral Bracing– **122.32 Tons** *(East-West Direction)*

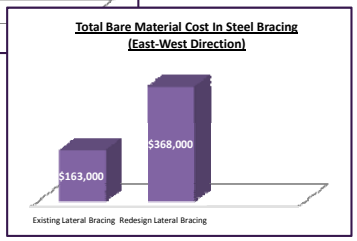
*Increase of **72 Tons***

Bare Material Costs:

- Existing Lateral Bracing – **$163,000** *(East-West Direction)*
- Redesigned Lateral Bracing– **$368,000** *(East-West Direction)*

*Increase of **$205,000***





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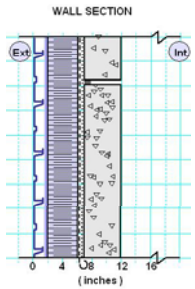
Building Enclosure Breadth

Building Enclosure Breadth Goals

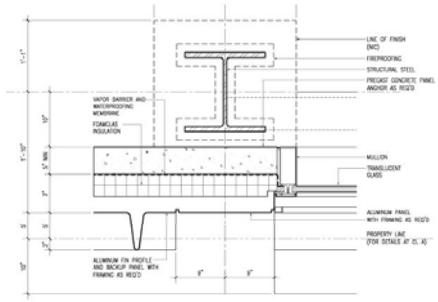
- Perform R-value, condensation, and air leakage analyses of curtain wall system for Miami, FL.
- Design for ASHRAE climate recommendations.
- Perform bare material cost analysis

Wall Section

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



Existing Building Enclosure System - Detail



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Building Enclosure Breadth

R-Value Analysis

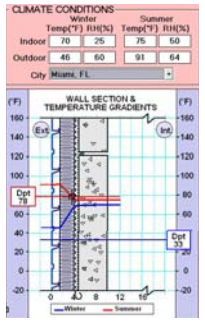
- Decrease in insulation layer (due to Miami's warmer climate)
- R-Value of Existing Wall System (**21.23**)
- R-Value of Redesign Wall System (**13.53**)

Condensation Analysis

- Decrease in insulation layer checked for condensation concerns.
- Dew points occur on outside of water vapor barrier – ***ACCEPTABLE***

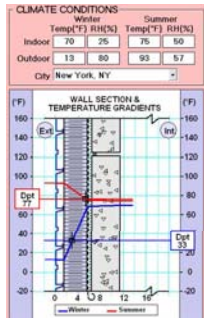
Redesign Wall Section

2.5" Rigid Insulation



Existing Wall Section

4" Rigid Insulation



Building Enclosure Analysis and Images above made possible with H.A.M. Toolbox Software

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Building Enclosure Breadth

ASHRAE R-Value Recommendations

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

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

Climate Zone 4 Recommendation Table

ASHRAE Climate Zone 4
New York, NY

Item	Component	Recommendation
Roof	Insulation entirely above deck	R-20 c.i.
	Metal building	R-13 + R-19
	Attic and other	R-38
	Single rafter	R-38
	Surface reflectance/emittance	No recommendation
Walls	Mass (HC > 7 Btu/ft²)	R-11.4 c.i.
	Metal building	R-13
	Steel framed	R-13 + R-7.5 c.i.
	Wood framed and other	R-13
	Below-grade walls	No recommendation

Climate Zone 1 Recommendation Table

ASHRAE Climate Zone 1
Miami, FL

Item	Component	Recommendation
Roof	Insulation entirely above deck	R-15 c.i.
	Metal building	R-19
	Attic and other	R-30
	Single rafter	R-30
	Surface reflectance/emittance	0.65 initial/0.86
Walls	Mass (HC > 7 Btu/ft²)	No recommendation
	Metal building	R-13
	Steel framed	R-13
	Wood framed and other	R-13
	Below-grade walls	No recommendation

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Building Enclosure Breadth

Air Leakage Analysis – *(New York, NY versus Miami, FL)*

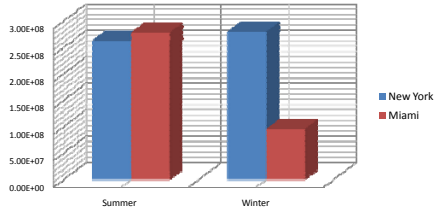
- Large difference in energy loss due to air leakage during the winter.
- 184,000,000 BTUs/Year Difference (New York, NY Greater Energy Loss)
- Equivalent too burning approximately 200,000 gallons of natural gas.
- Analysis supports reduction in insulation layer for Miami, FL.

Bare Material Cost Analysis – *(RS Means)*

- **$185,900** bare material cost **savings** due to reduction in insulation layer.

Air Leakage Analysis Comparison - Miami, FL vs. New York, NY		
All Values in BTUs per Year		
	Summer	Winter
New York	2.63E+08	2.80E+08
Miami	2.78E+08	9.56E+07
Difference	1.50E+07	1.84E+08

Air Leakage Analysis Comparison
Miami, FL vs. New York, NY (BTUs/Year)



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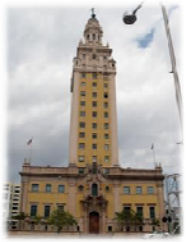
Architectural Breadth

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



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

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

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

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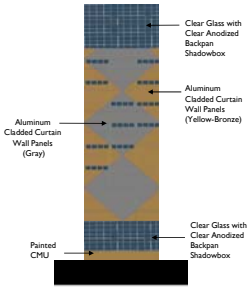
Architectural Breadth

Proposed Architecture – North Façade

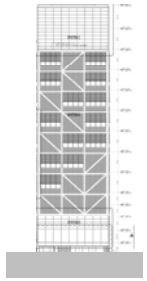
- Aluminum Cladding Coloring (Yellow-Bronze & Gray)
  - o Diamond Color Pattern Exemplifies Lateral Exterior Frame
  - o Color Cladding Represents Art Deco Style Architecture

Park Central Hotel – Miami, FL
Art Deco Style

North Façade Redesign



Existing North Facade



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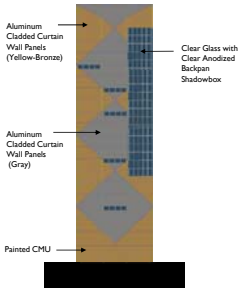
Proposed Architecture – South Façade

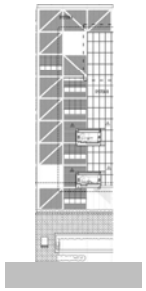
- Aluminum Cladding Coloring (Yellow-Bronze & Gray)
  - o Diamond Color Pattern Exemplifies Lateral Exterior Frame
  - o Color Cladding Represents Art Deco Style Architecture

Park Central Hotel – Miami, FL
Art Deco Style

South Façade Redesign



Existing South Facade



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Special Thanks To:
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- ✓ GOALS
- ✓ EXISTING LATERAL
- ✓ LATERAL REDESIGN
- ✓ BUILDING ENCLOSURE
- • **ARCHITECTURE**
- • CONCLUSION

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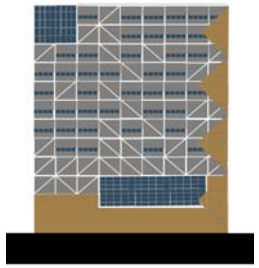
Architectural Breadth

Proposed Architecture – West Façade

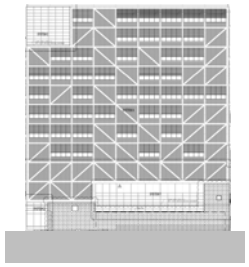
- Aluminum Cladding (Yellow-Bronze) Wrapped at Corner
- Façade Design Inspired by Sailboat (Miami Culture)

Sailboat
Miami Culture

West Façade Redesign



Existing West Facade



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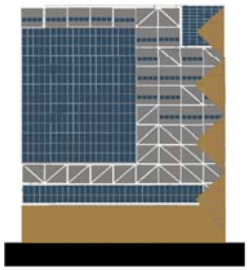
Architectural Breadth

Proposed Architecture – East Façade

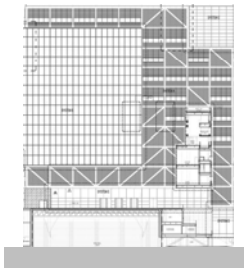
- Aluminum Cladding (Yellow-Bronze) Wrapped at Corner
- Façade Design Inspired by Sailboat (Miami Culture)

Sailboat
Miami Culture

East Façade Redesign



Existing East Facade



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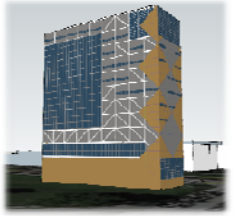
Architectural Breadth

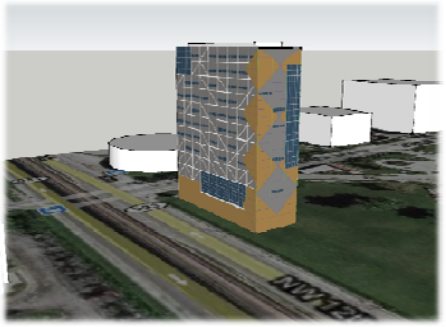
Architectural Breadth Conclusions

- Design Incorporates Mix of Miami Modern Architectural Styles
  - o Mediterranean Revival
  - o Art Deco
  - o Streamline Modern



3D North-East Image

3D South-West Image



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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.

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Thank You

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AE Advisor
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ARUP
Joshua Yacknowitz
AE Faculty
AE Classmates
Family & Friends

Columbia University Northwest Science Building

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