THE COMMONWEALTH MEDICAL COLLEGE (TCMC)

SCRANTON, PA

SENIOR THESIS 2013 ADVISOR: HEATHER SUSTERSIC

XIAO YE ZHENG | STRUCTURAL OPTION

THE COMMONWEALTH MEDICAL COLLEGE

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

BUILDING INTRODUCTION

- 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

SITE MAP

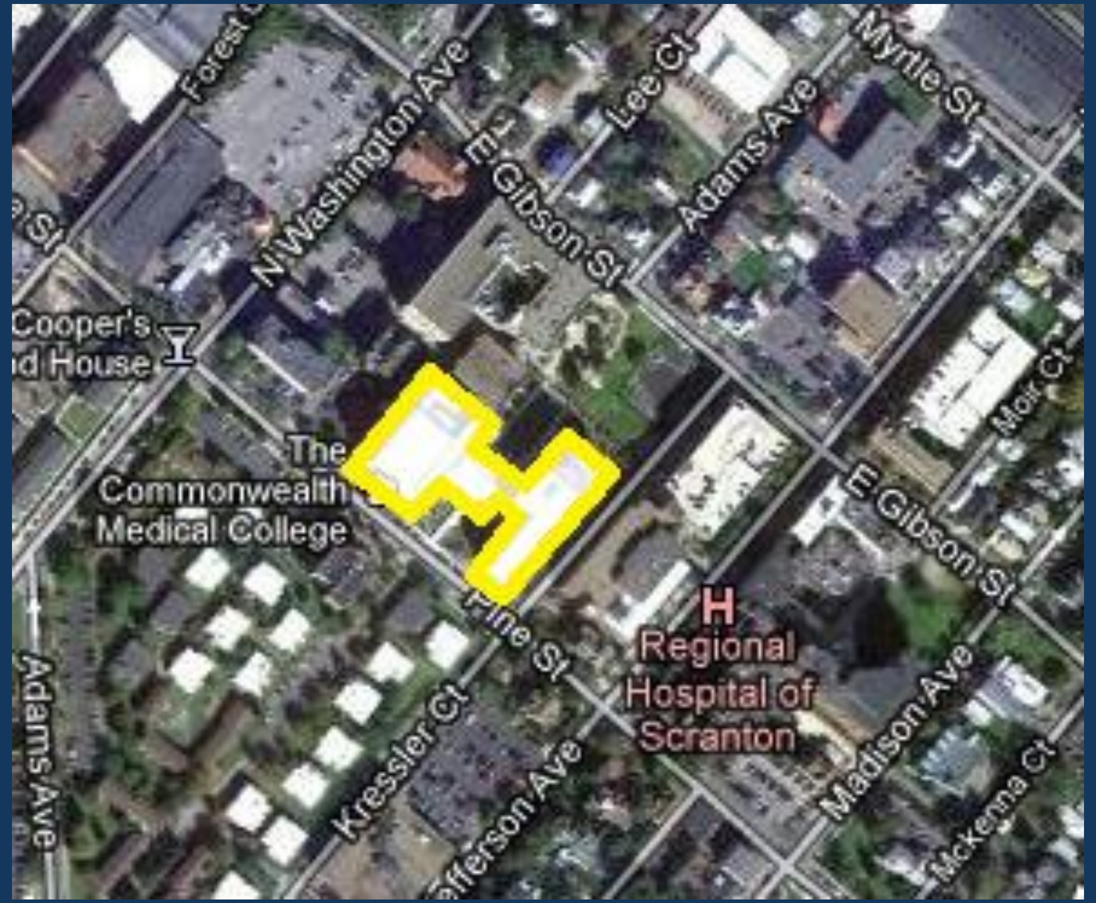


Image from Google Map, edited by Xiao

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

EXISTING STRUCTURAL SYSTEM

BAY SIZES

- 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

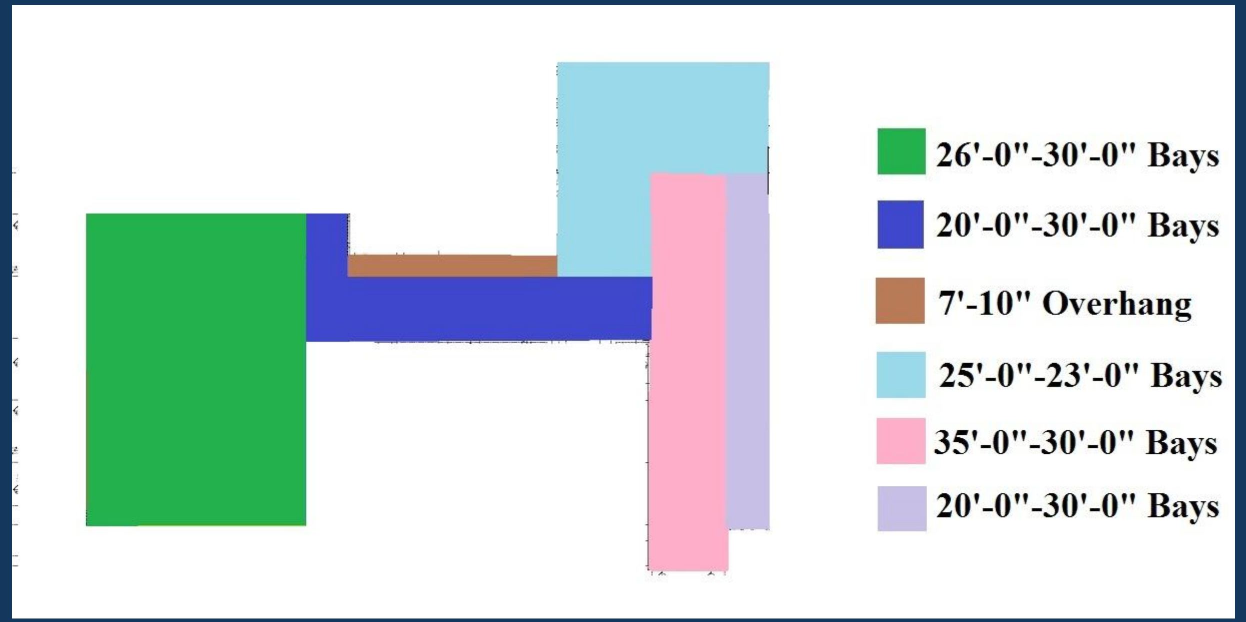
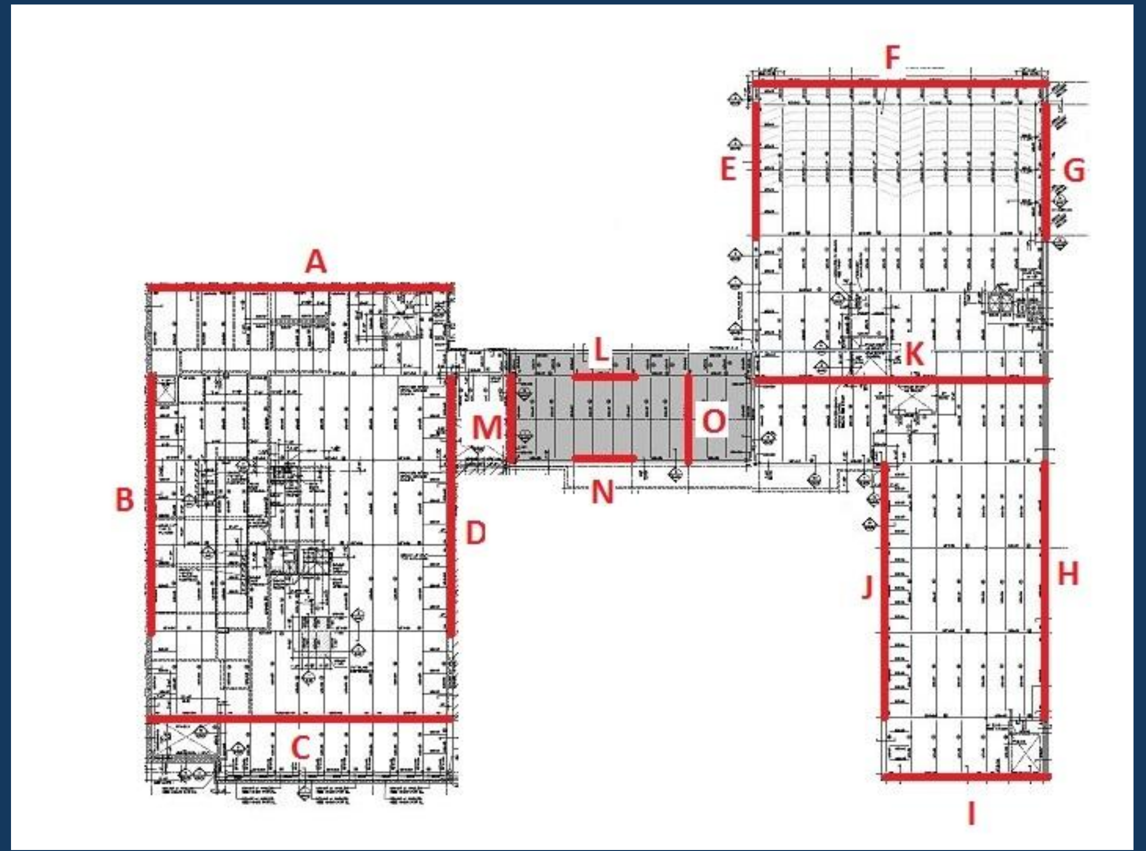


Image from Highland Associates, edited by Xiao

- Framing System
  - Composite steel frame
  - W8x24 to W14x257, lightest to heaviest
- Lateral System
  - 15 moment frames (not including penthouse)



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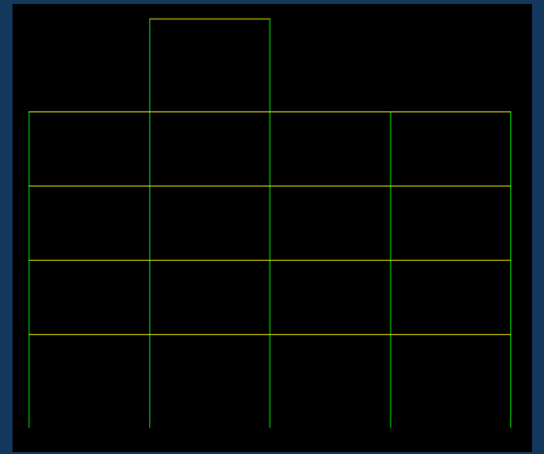
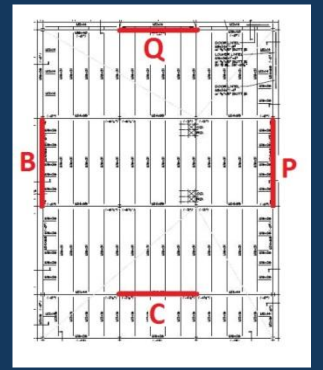


Frame C



ROOF HEIGHTS

ROOF HEIGHTS PLAN

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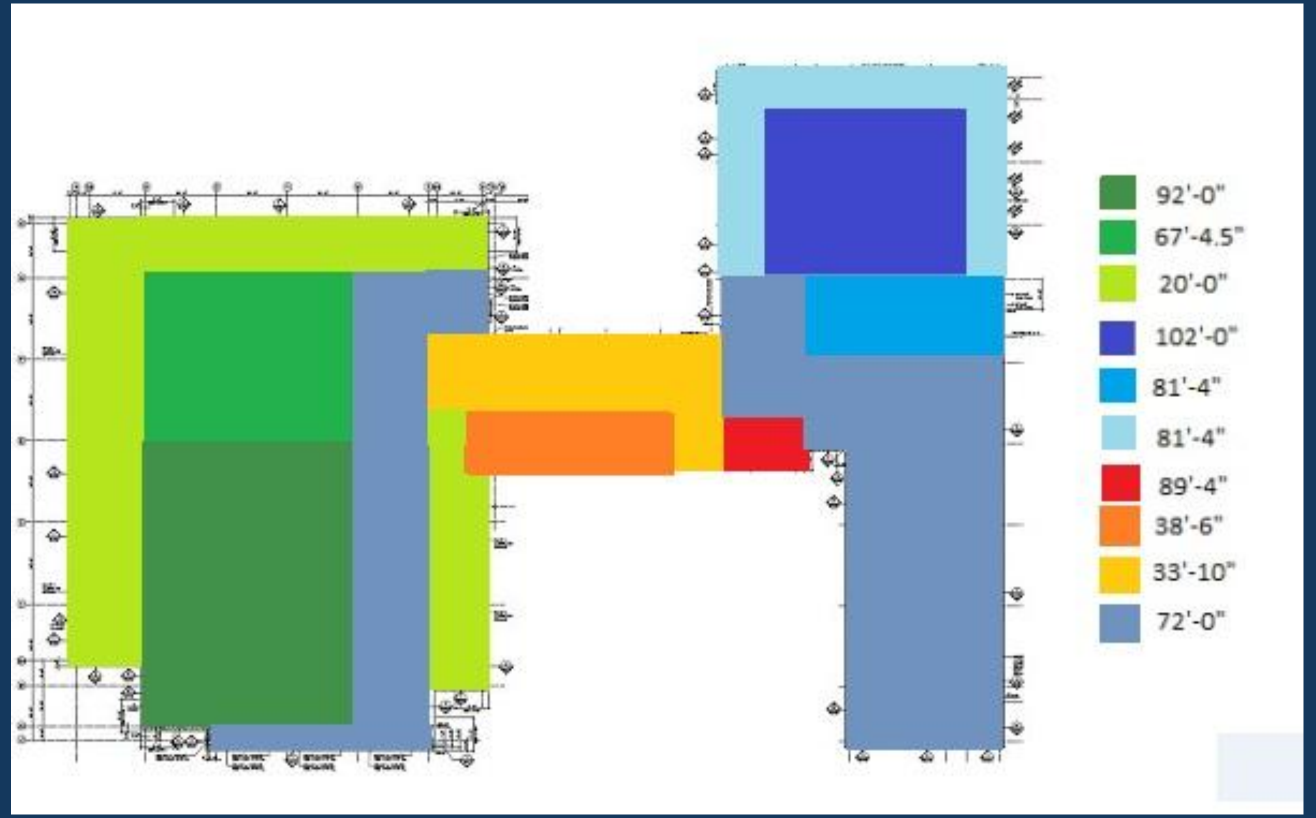
Image from Google Map



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PROBLEM STATEMENT

- 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

MIAMI, FL SITE

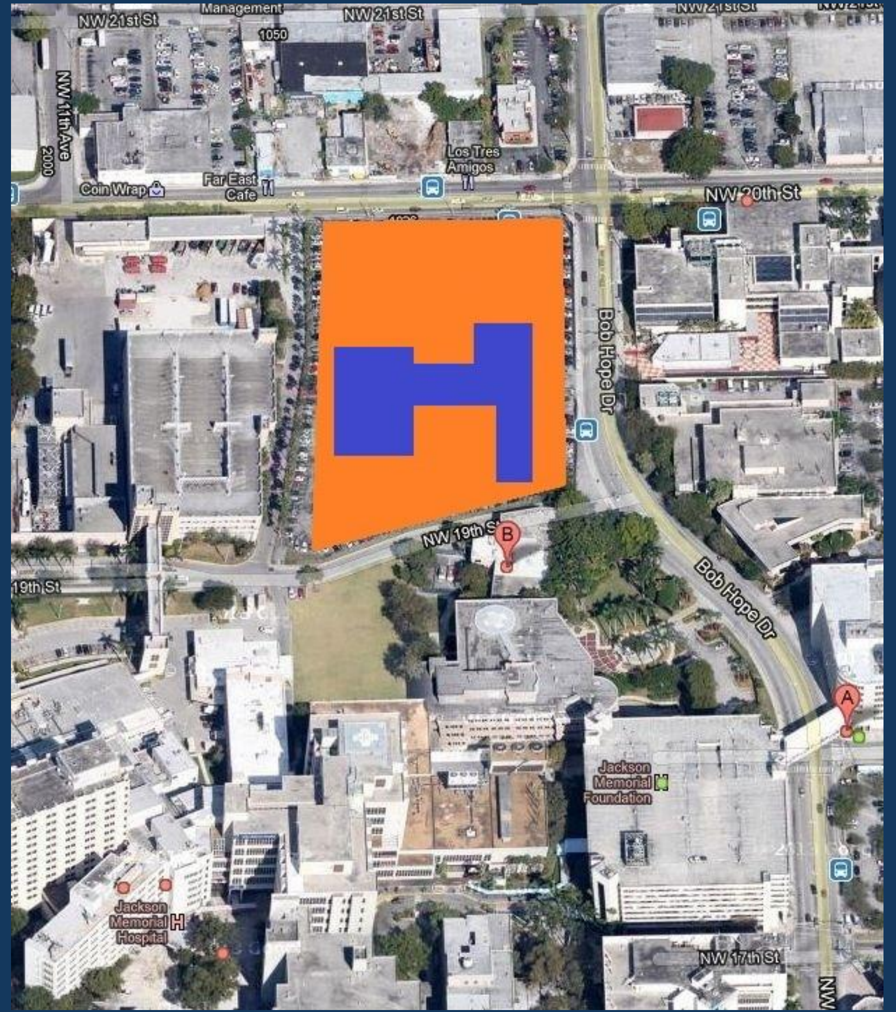

Image from Google Map, edited by Xiao

PROPOSED SOLUTION

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

PROJECT GOALS

- Comparison Between Designs
  - Moment Frames to Braced Frames
  - New Systems to the Original System
  - A Typical Braced Connection

THE COMMONWEALTH MEDICAL COLLEGE

NEW LOADS

COMPARISON

- Building Introduction
- Existing Structural System
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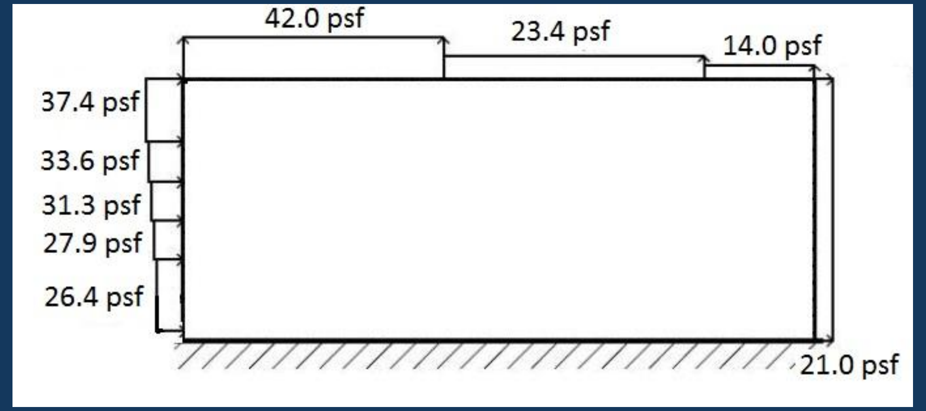
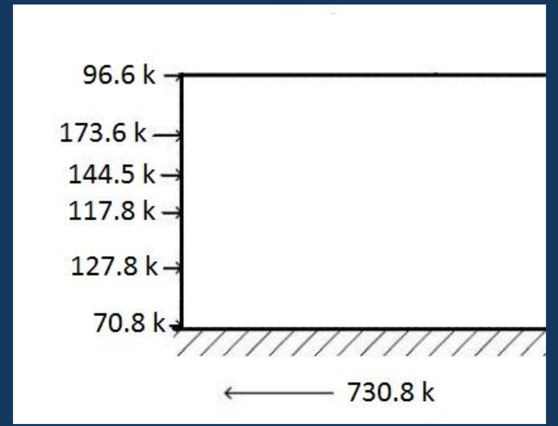
Summary: Wind Loads on TCMC

	West Wing		East Wing	
NS Base Shear	560.0	k	296	k
NS Overturning Moment	27,500.0	k-ft	14,500	k-ft
EW Base Shear	731.0	k	960	k
EW Overturning Moment	35,800.0	k-ft	47,220	k-ft





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

Comparison of Seismic and Wind Forces

	West Wing			East Wing		
Miami, FL	Wind, N-S	Wind, E-W	Seismic	Wind, N-S	Wind, E-W	Seismic
Base Shear (k)	560	730	136	300	970	126
Overturning Moment (k-ft)	27,500	35,800	7,950	14,500	47,300	7,350
Scranton, PA	Wind, N-S	Wind, E-W		Wind, N-S	Wind, E-W	Seismic
Base Shear (k)	200	270	130	110	350	120
Overturning Moment (k-ft)	10,000	12,900	7,600	5,230	17,100	7,000

LATERAL FRAME LAYOUTS

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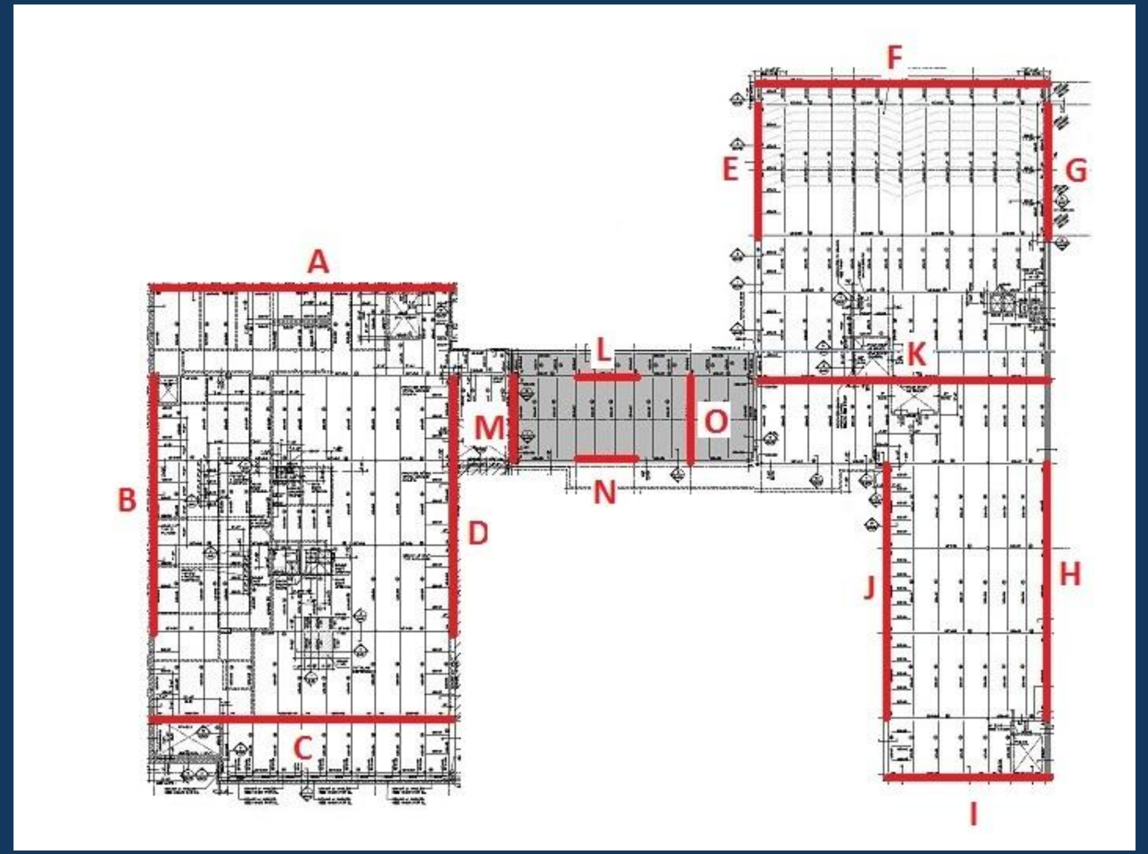
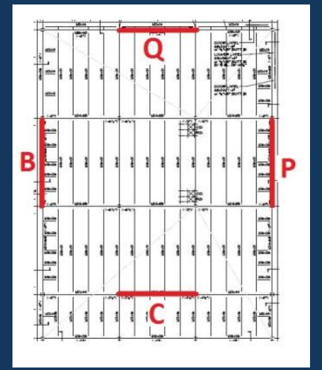
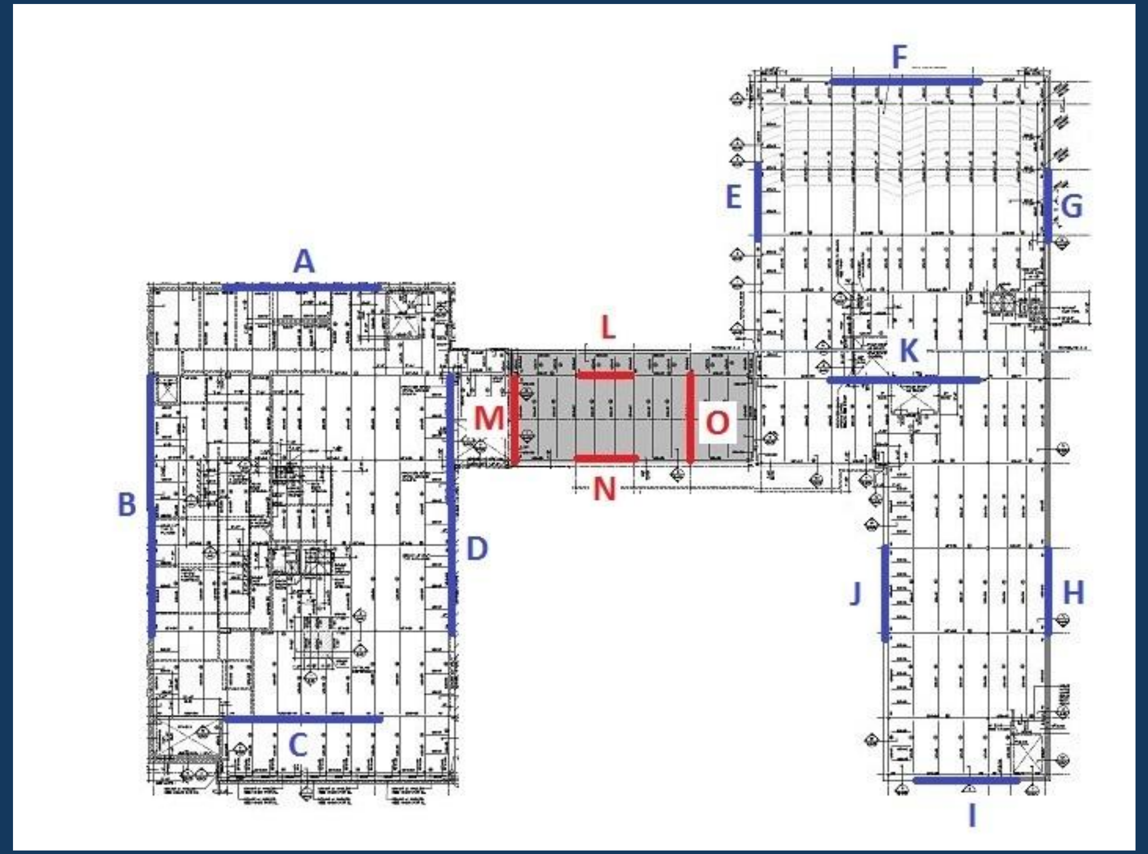
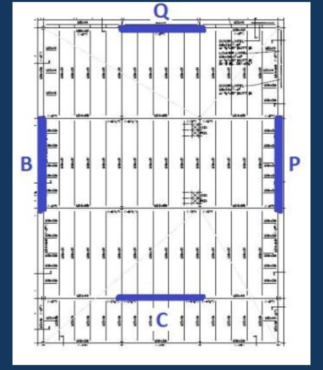
Moment Frame Layout





Braced Frame Layout





- Moment Frame
- Braced Frame

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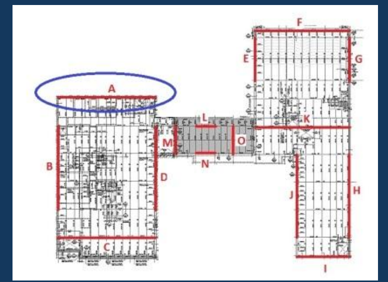
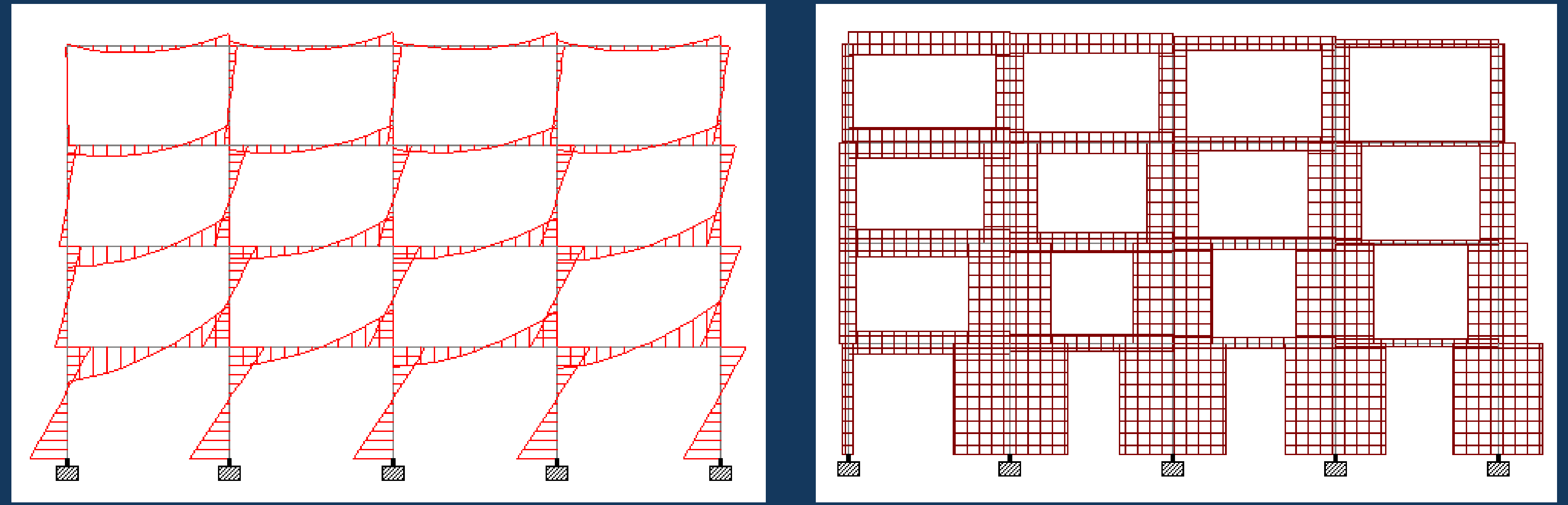
ETABS Model

AE 530

Computer Modeling

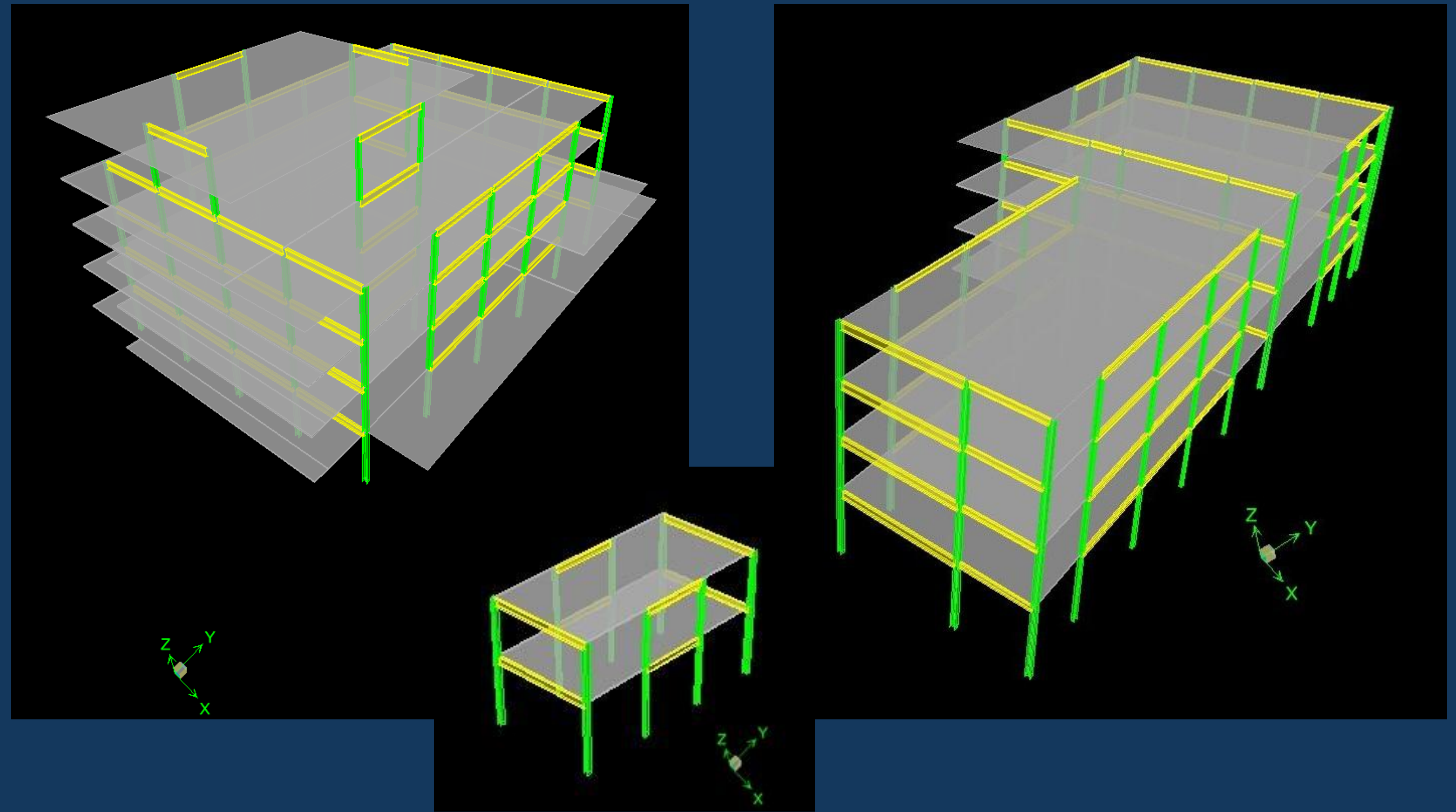


STAAD Model for Frame A



1.2D + 1.6W + L + 0.5Lr

Etabs Models



MOMENT FRAME DESIGN

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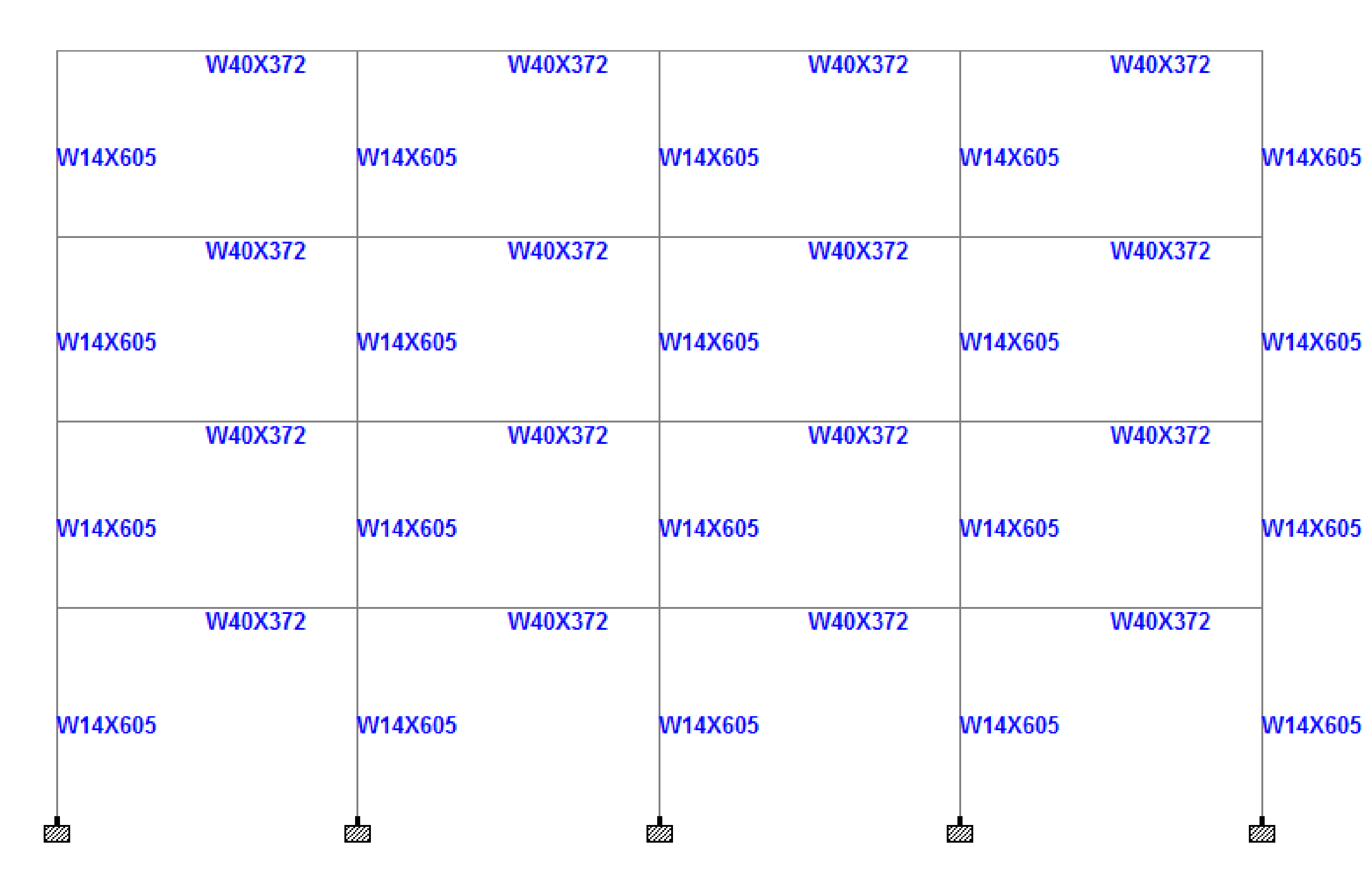
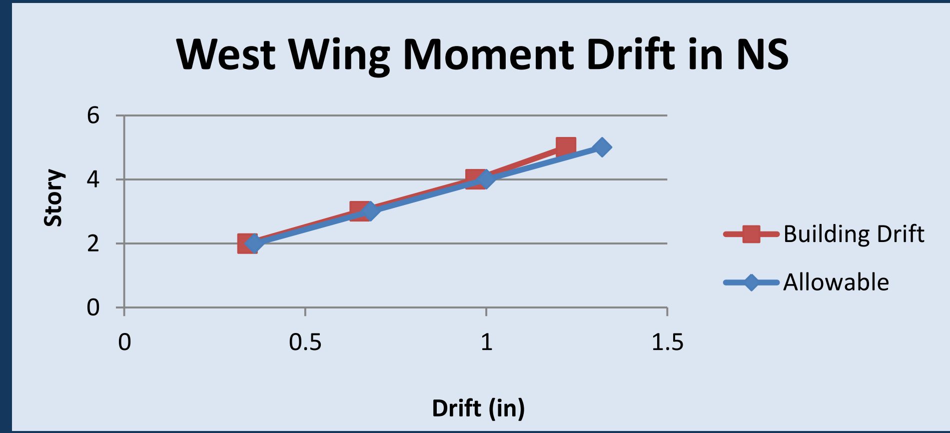
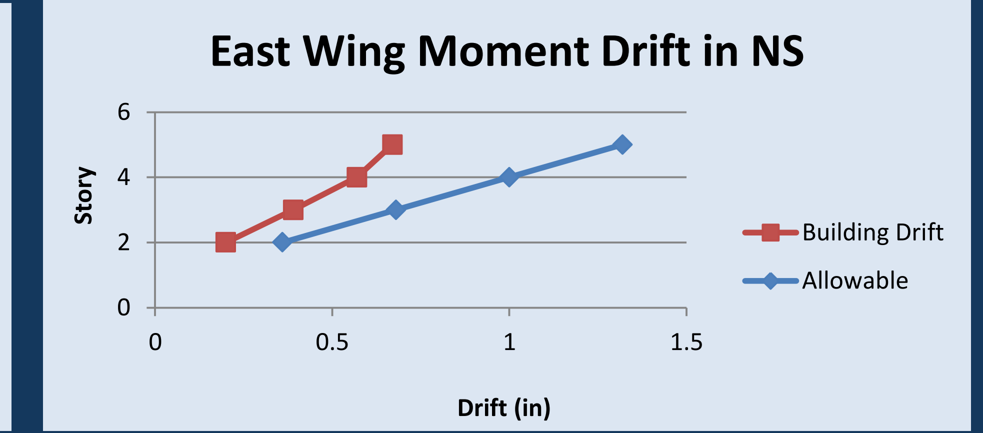
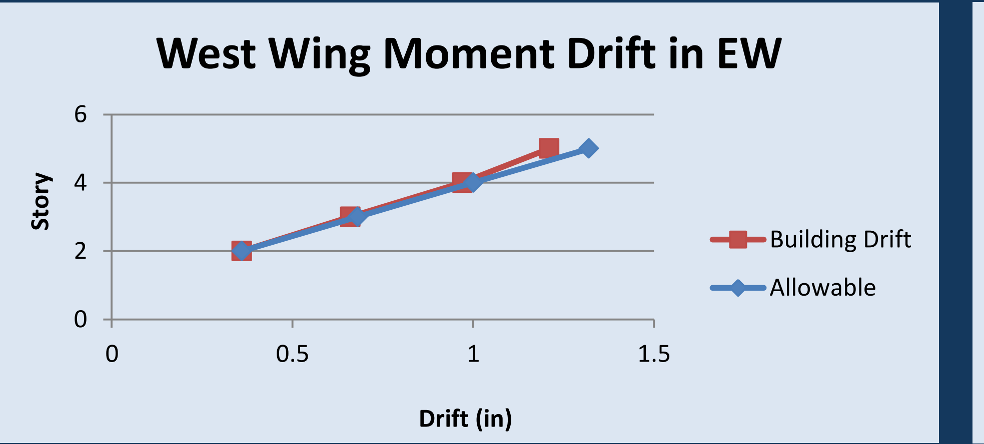
Frame A Sizes

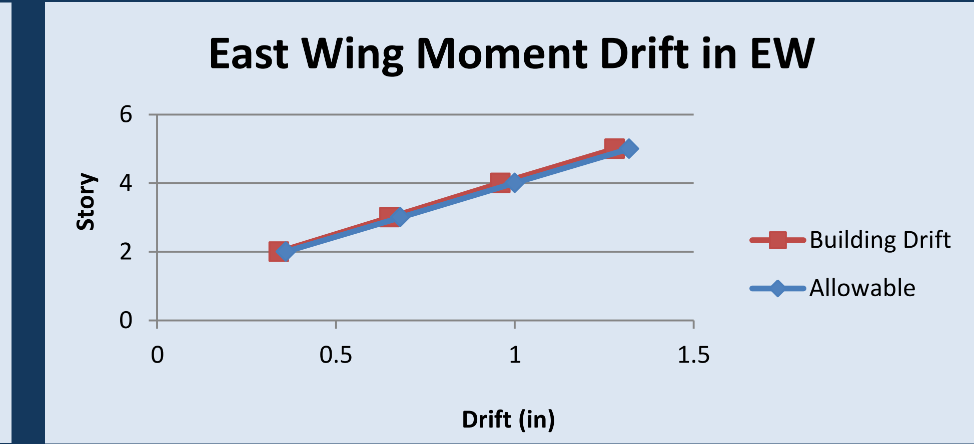


Moment Frame Drift









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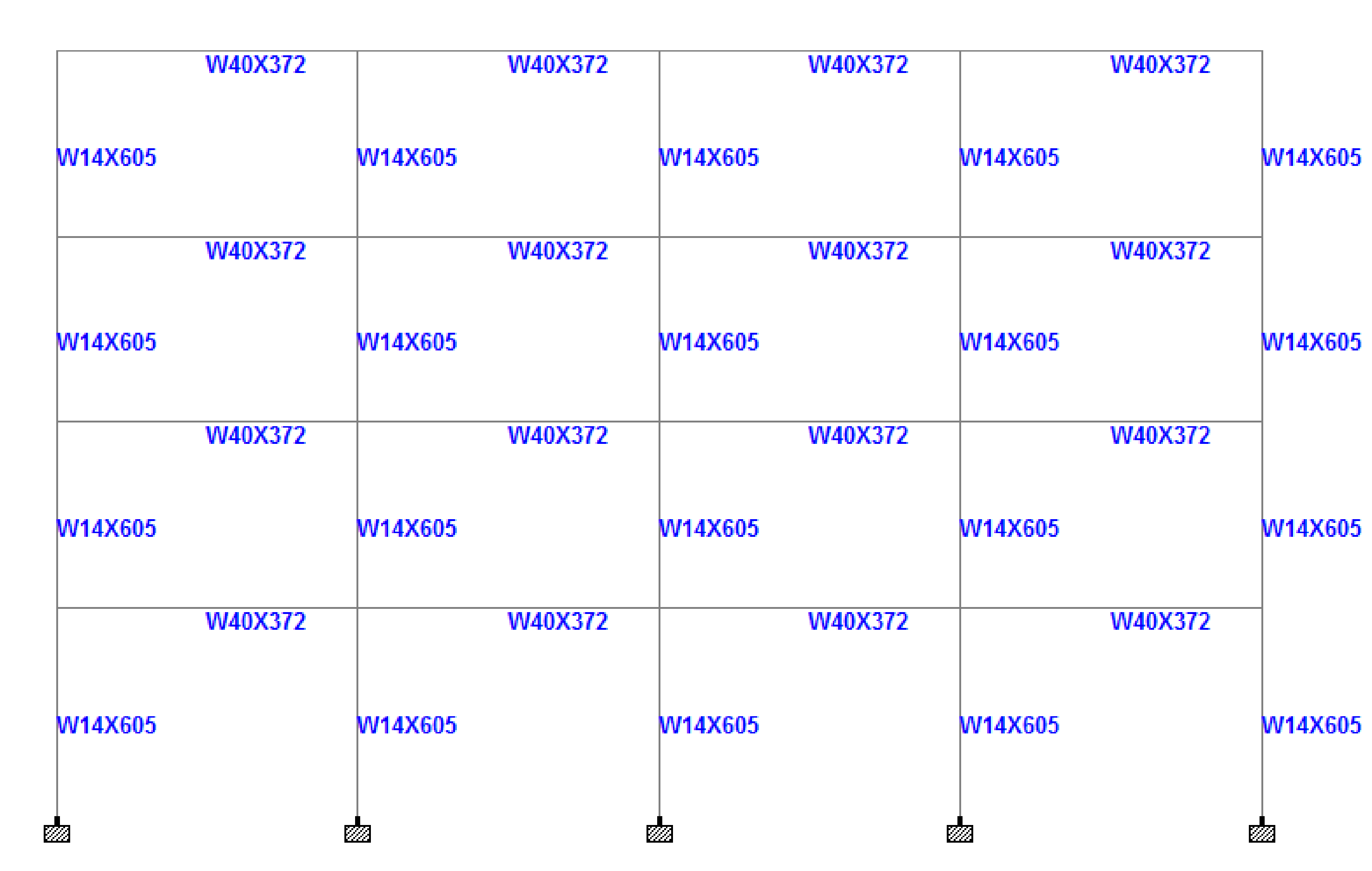
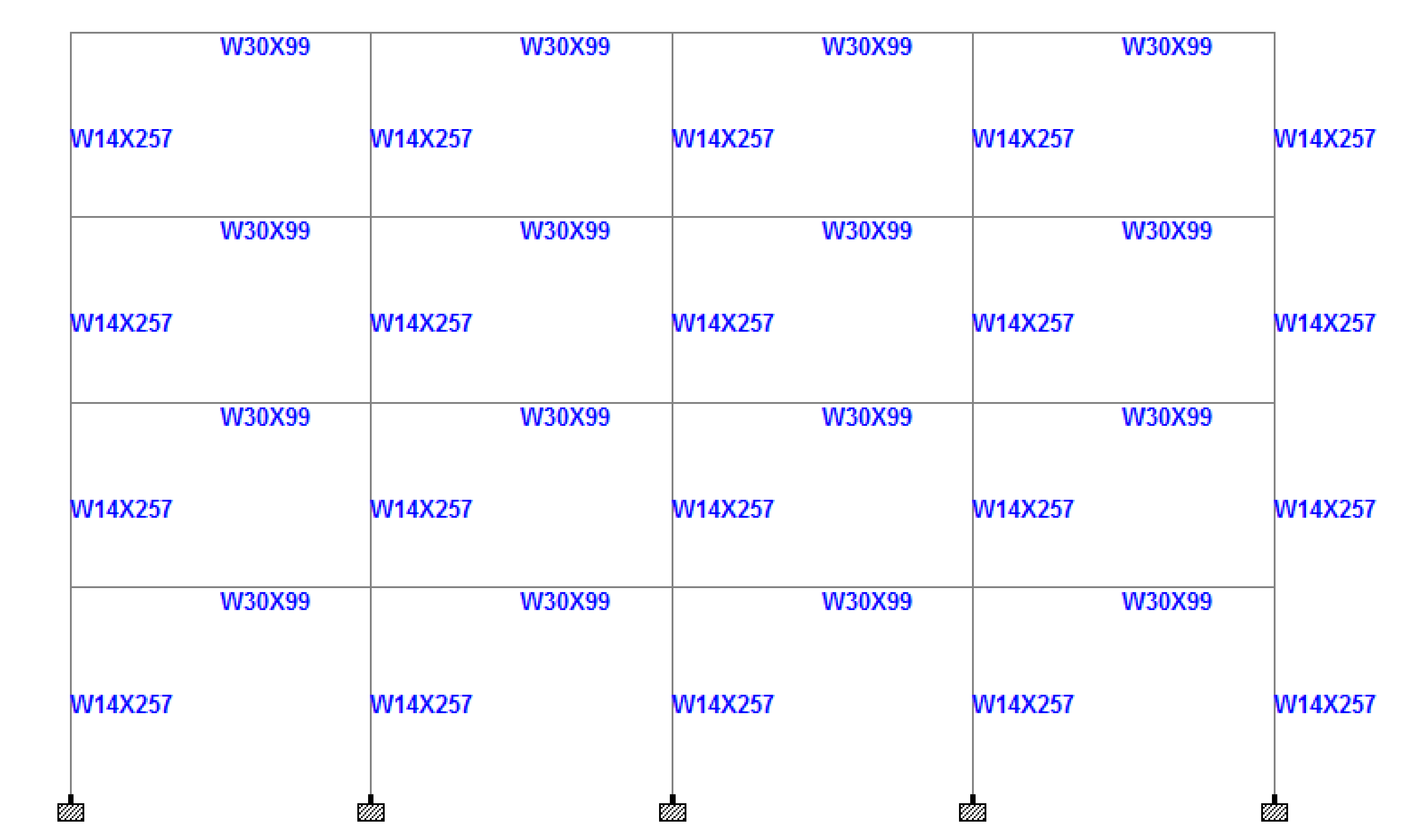


Original Frame A Sizes



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ETABS Model

AE 530

Computer Modeling

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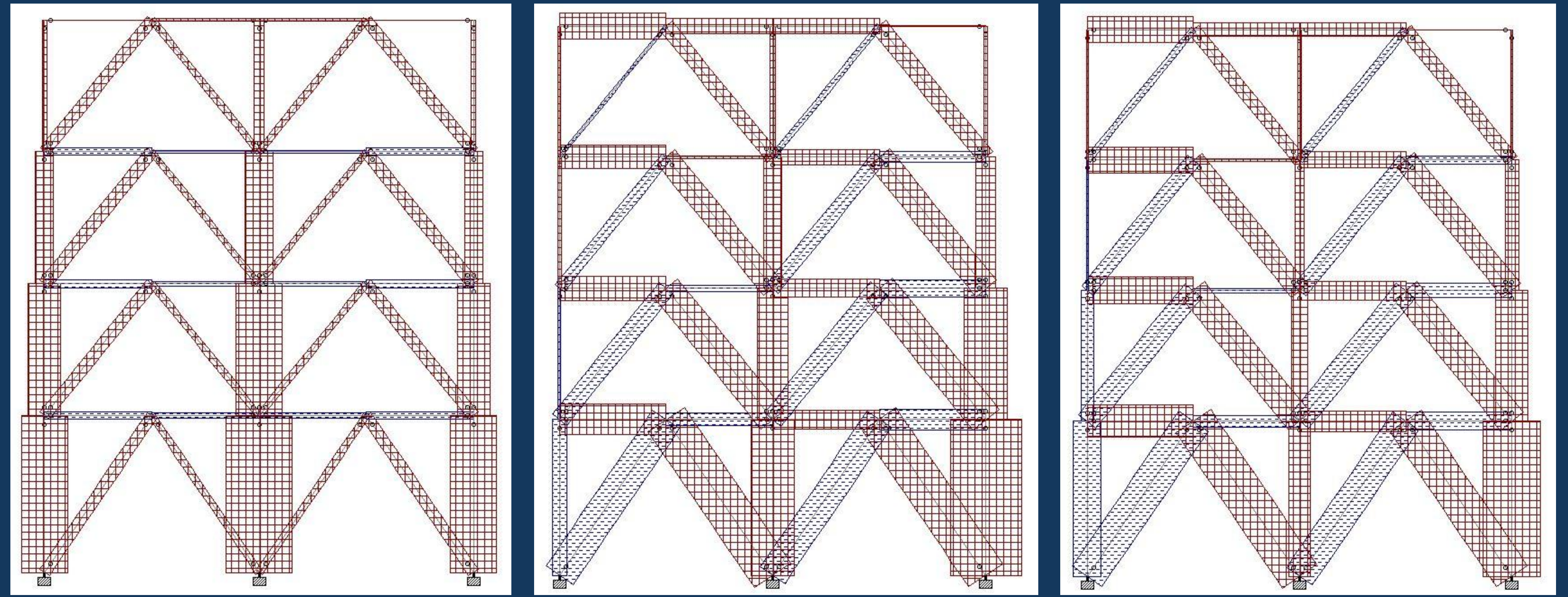
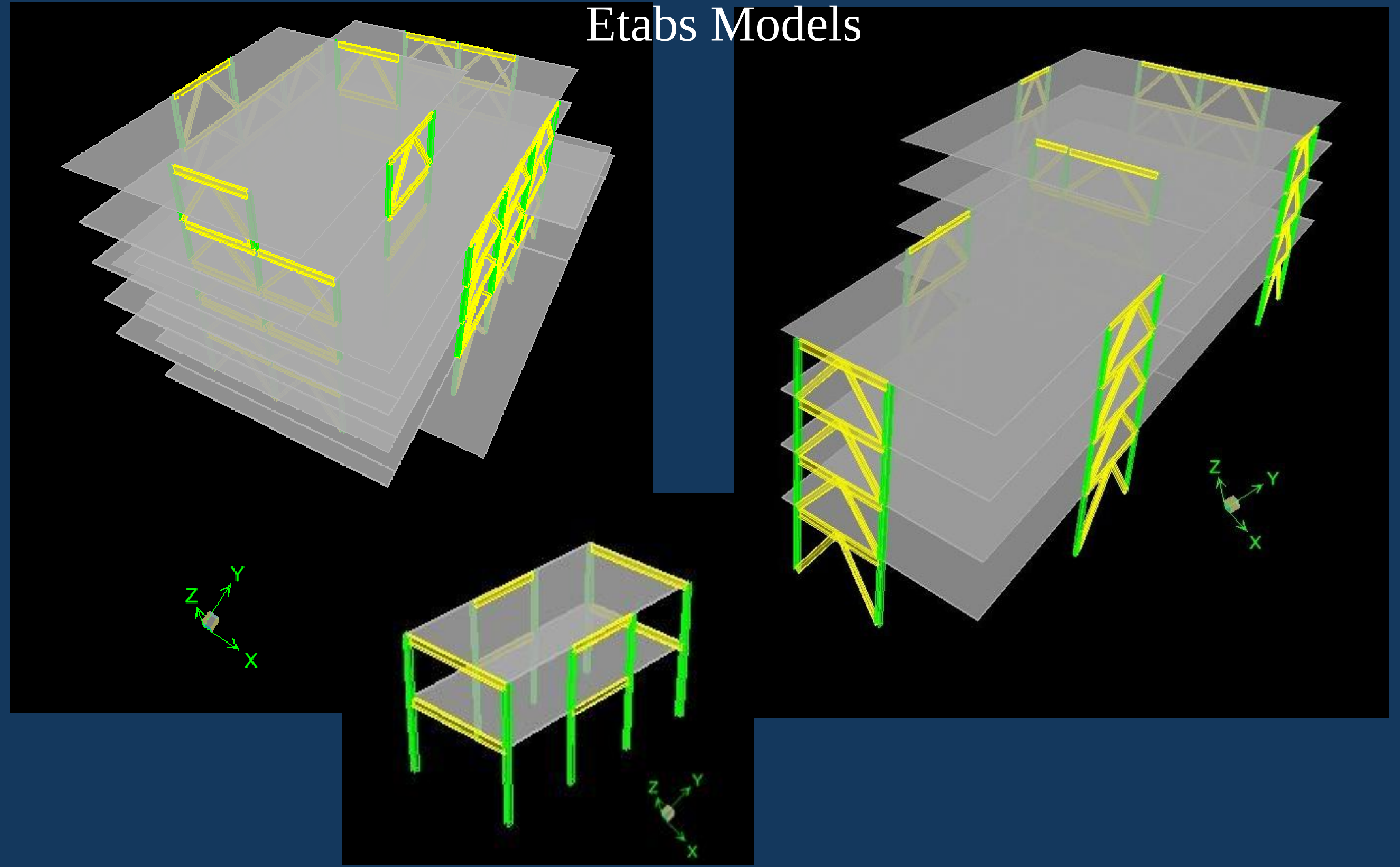


1.2D + 1.6L + 0.5 Lr

1.2D + 1.6W + L + 0.5Lr

0.9D + 1.6W

Etabs Models



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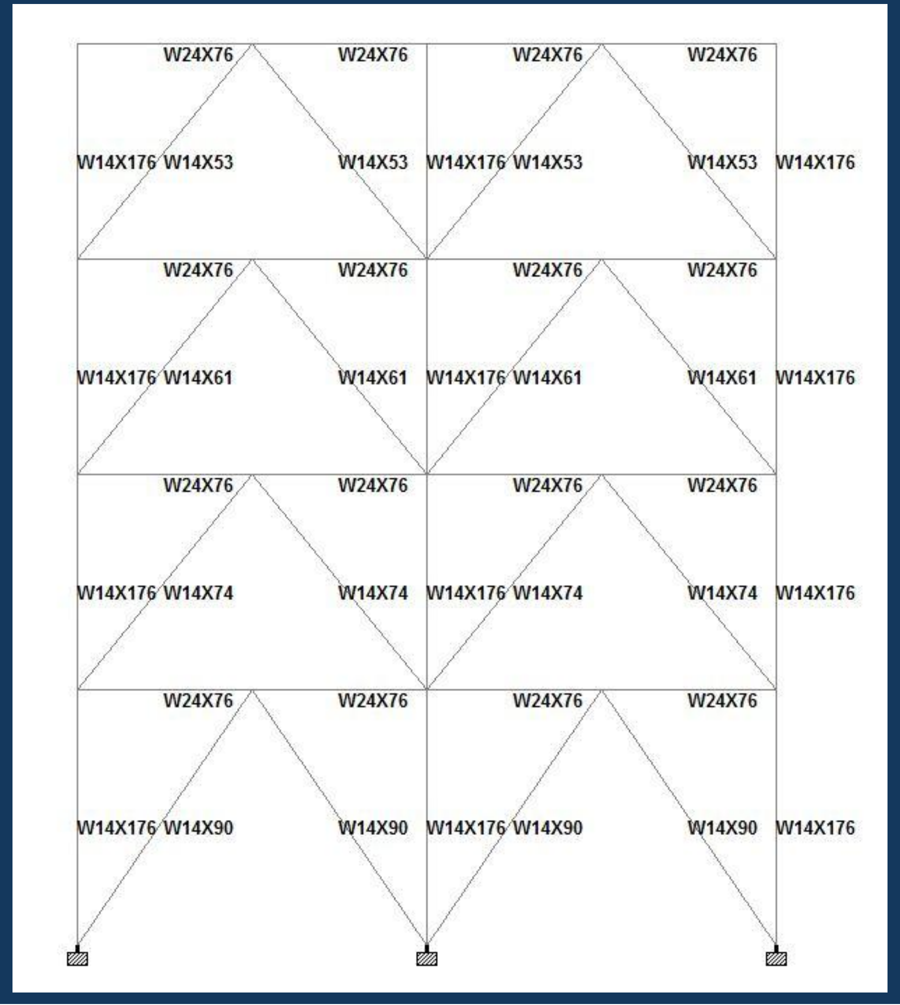
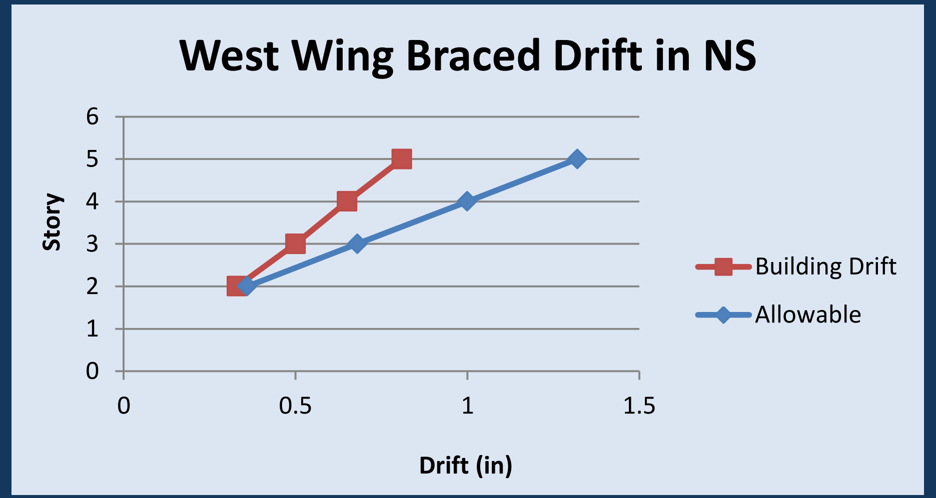
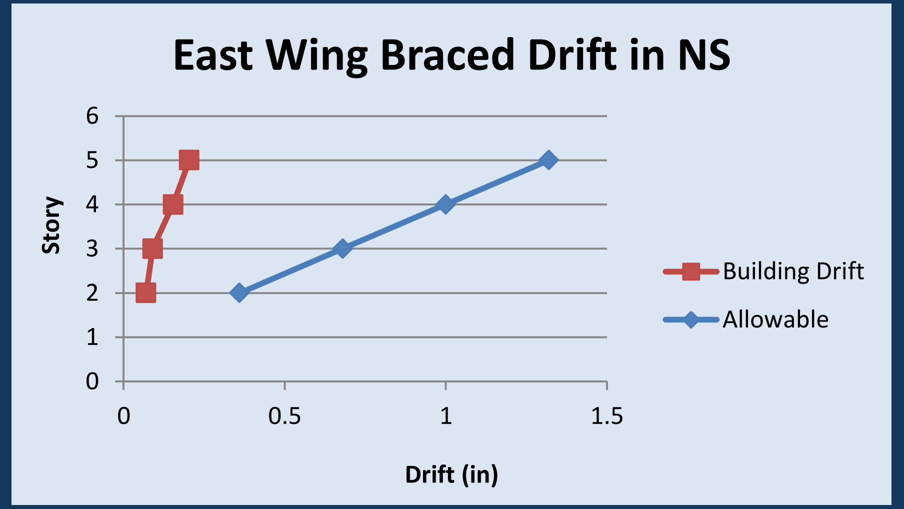
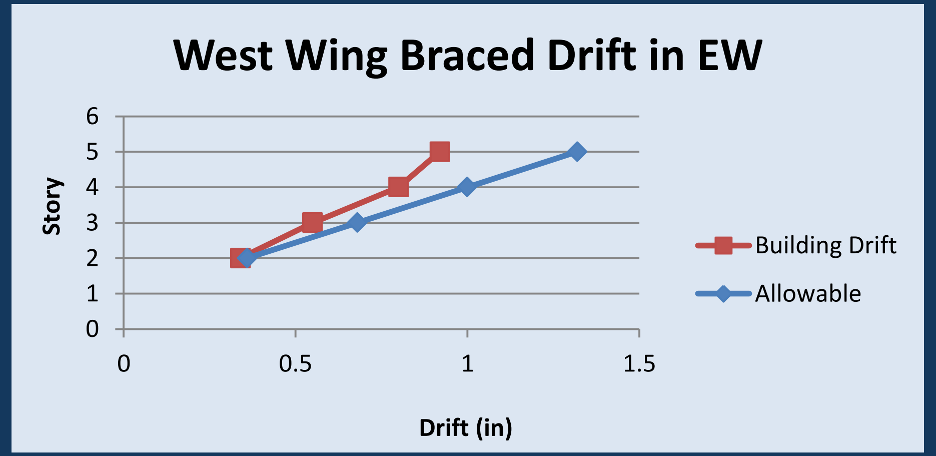
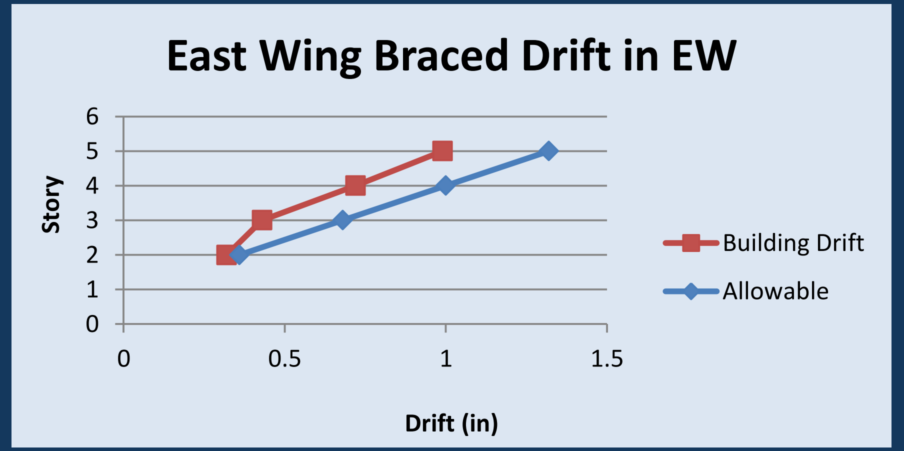


Braced Frame Drift









COMPARISONS

Estimated Cost Analysis For Frame A

	Original	Moment	Braced
Cost	$ 186,281.00	$ 567,043.00	$ 202,572.00
Percent	100%	304%	109%

Building Height Change

	Original	Moment	Braced
Height	93'	98'	92'
Difference	N/A	5'	-1'

COMPARISONS

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

	Original	Moment	Braced
Beam in NS	W24x68	W36x256	W21x68
Beam in EW	W30x99	W40x372	W24x76
Column	W14x257	W14x605	W14x176
Bracing	N/A	N/A	W14x90

Building Height Change

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Weight Comparison

	Original	Moment	Braced
Lateral Resisting Members	330 k	1220 k	256 k
Total Building Weight	18400 k	19290 k	18600 k
Percentage	100%	105%	101%

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Moment Frames have more Architectural Freedom

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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

Foundation Summary

	Original	Moment	Braced
F.S. Bearing	N/A	2.8	2.8
F.S. Uplift	N/A	Not an issue	4.4
F.S. Strength	N/A	2.5	2.5
Depth into Earth	8'-8"	10'	11'-6"
Thickness of MAT	4'	6'	7'-6"

ETABS Model

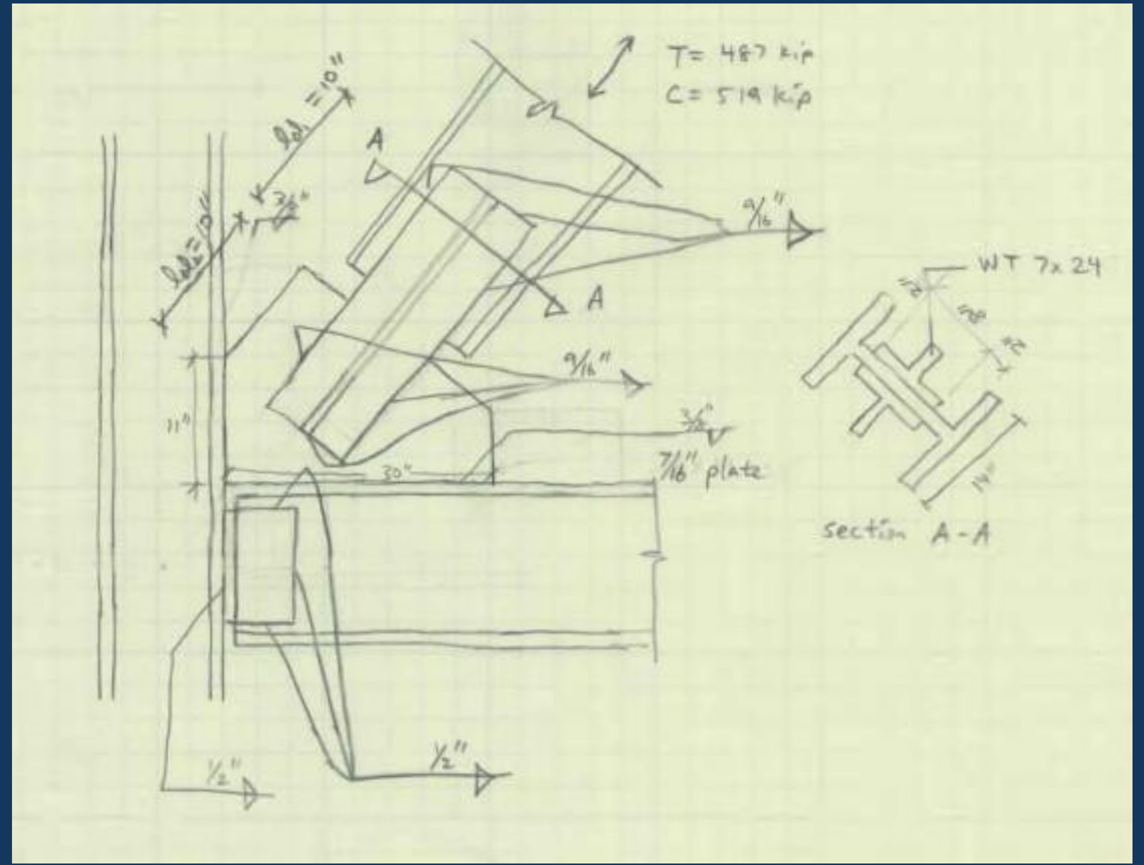
- AE 530, Computer Modeling

Typical 2nd Floor Brace Connection

- AE 534, Steel Connections

Façade Breadth

- AE 542, Building Enclosures



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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

Florida Building Code - High Velocity Hurricane Zone Testing, Miami-Dade County NOA08-1014.03

TAS 201-94

Impact Test Procedures - Large Missile Impact

TAS 202-94

Criteria for Testing Products Subject to Cyclic Wind Pressure Loading

TAS 203-94

Criteria for Testing Impact & Non Impact Resistant Building Envelope Components Using Uniform Static Air Pressure

http://www.bostonvalley.com/terraclad/product-testing.html

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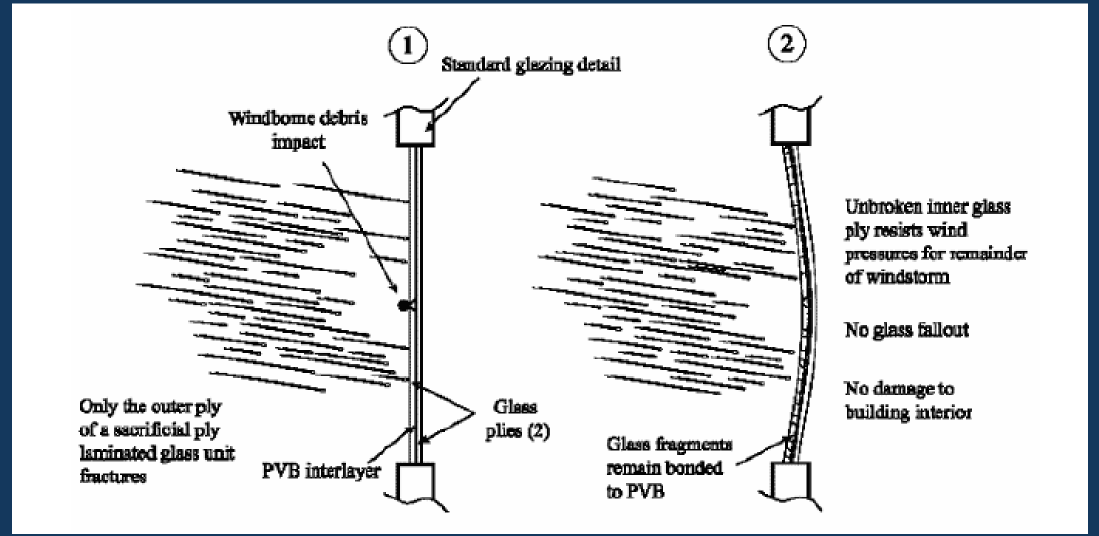
The Bechtler Museum of Modern Arts

http://www.bostonvalley.com

The Colburn School of Performing Arts

Windows/Glazing

- LGUs with the concept of Sacrificial Ply



Typical Window Design				
	Width	Height	Outer Ply Thickness	Inner Ply Thickness
2'x4'	2'	4'	1/8"	3/16"
6'x10'	6'	10'	1/8"	5/8"

ACKNOWLEDGEMENTS

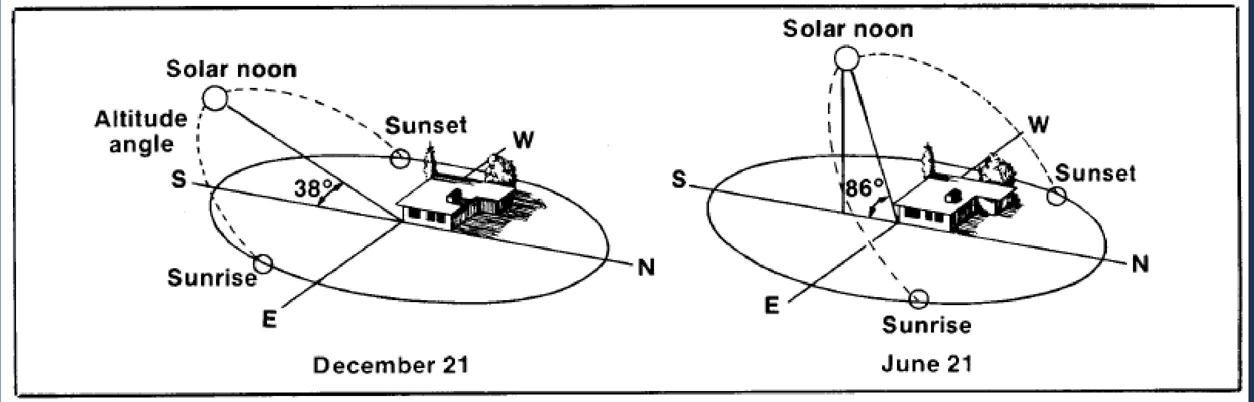
- Penn State Architectural Engineering Faculty
  - Heather Sustersic
- Highland Associates
  - Eric McAndrew
- TCMC
- Family and Friends

QUESTIONS?

Appendix

THE COMMONWEALTH MEDICAL COLLEGE

SOLAR PANEL DESIGN



http://www.kahnsolar.com/images/how_solar_works_pic.jpg

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

http://us.sanyo.com/Solar/Stone-Brewing-Company

The Bechtler Museum of Modern Arts

THE COMMONWEALTH MEDICAL COLLEGE

MECHANICAL AND ELECTRICAL

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 CONNECTION

Grid-Tied System

- Net-metering

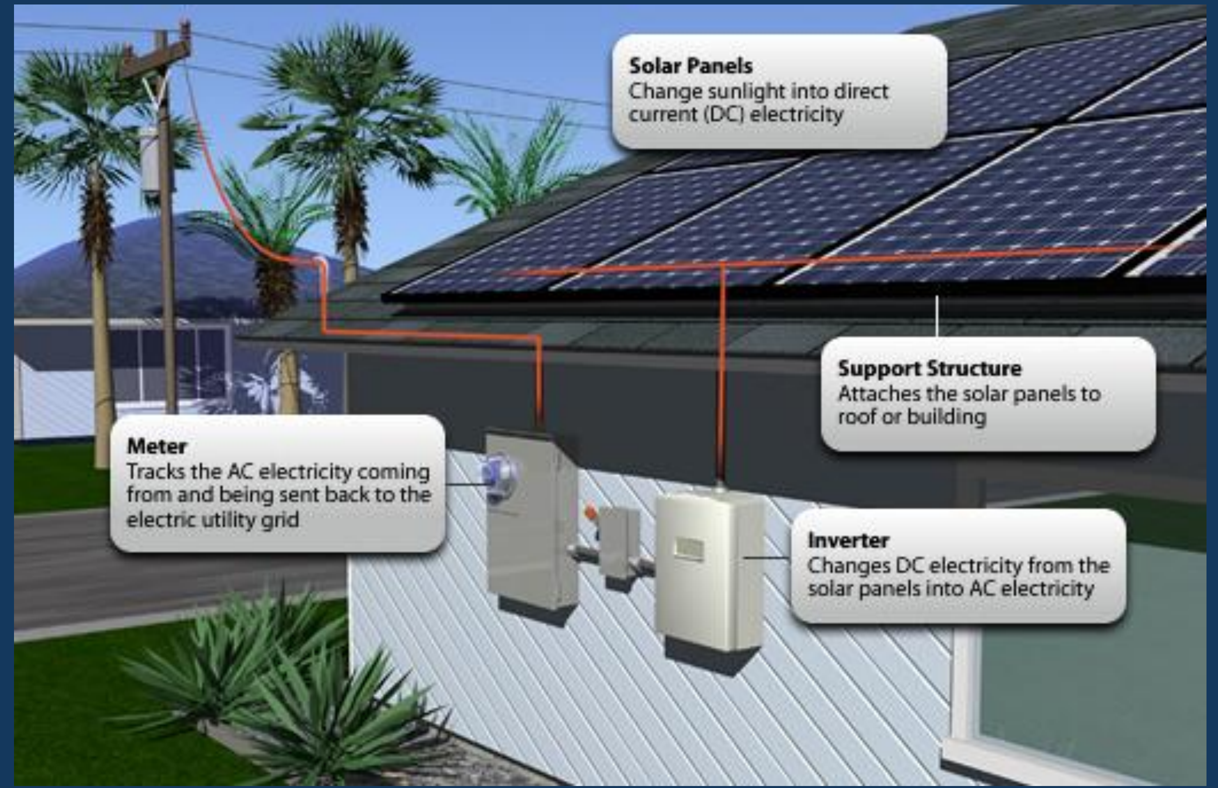
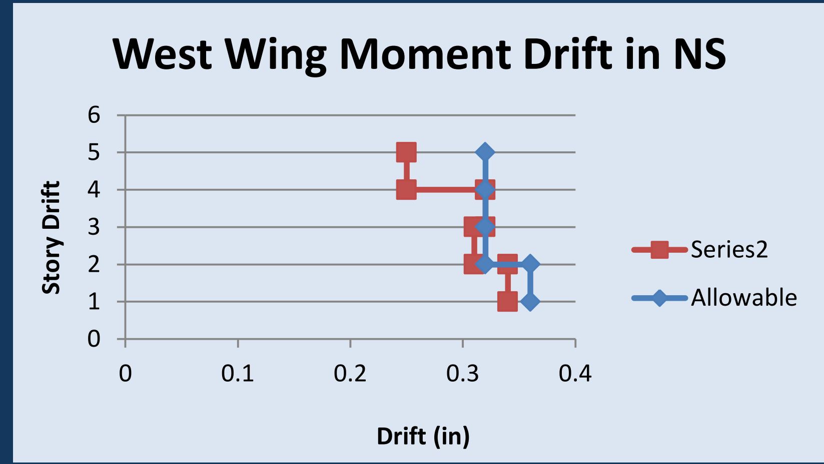


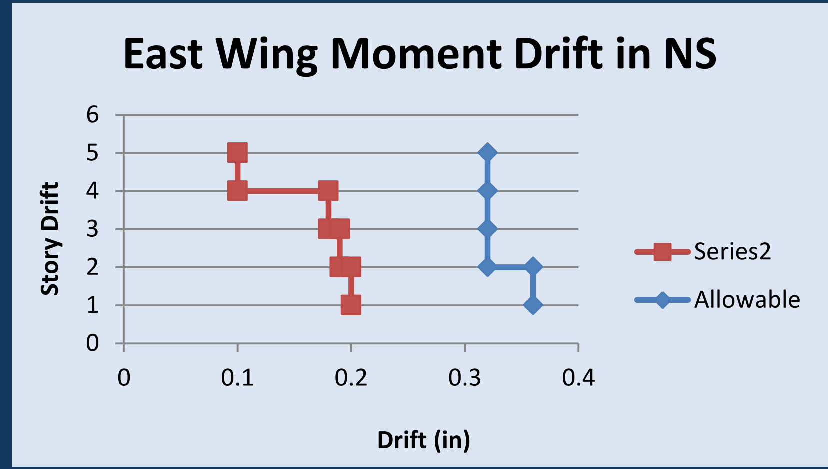
Image from Kahn Solar

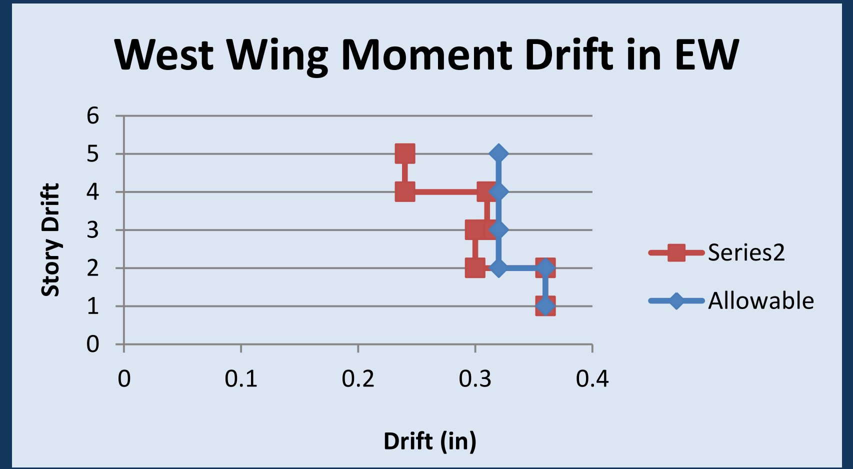
THE COMMONWEALTH MEDICAL COLLEGE

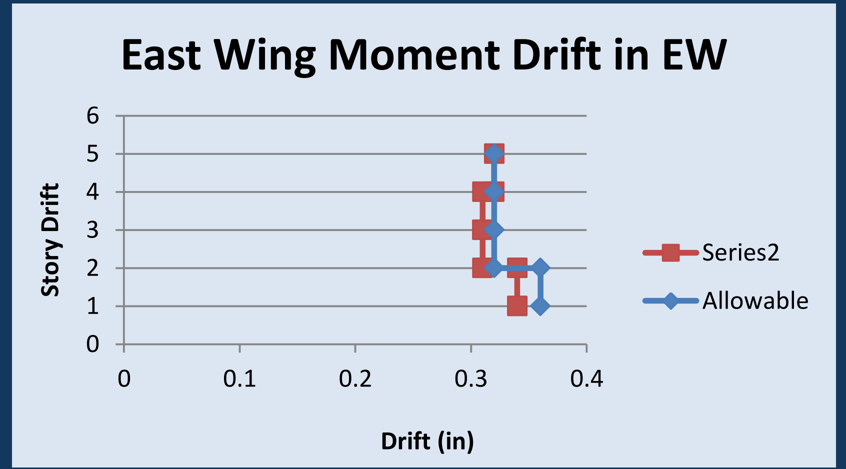
BUILDING DRIFT

Moment Frame Drift

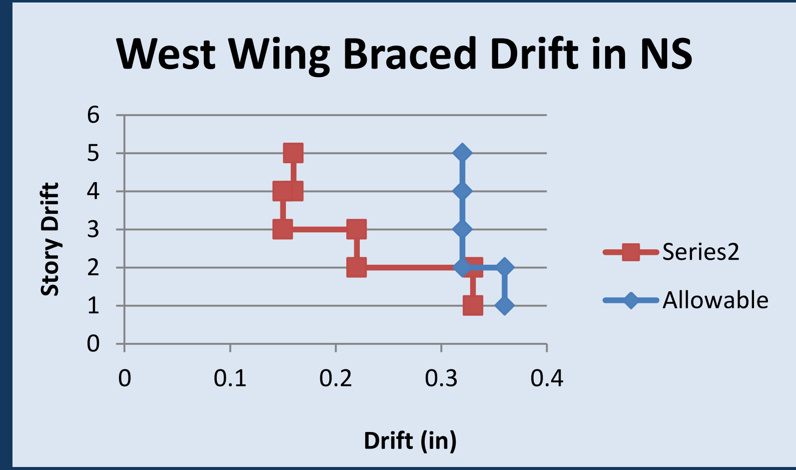


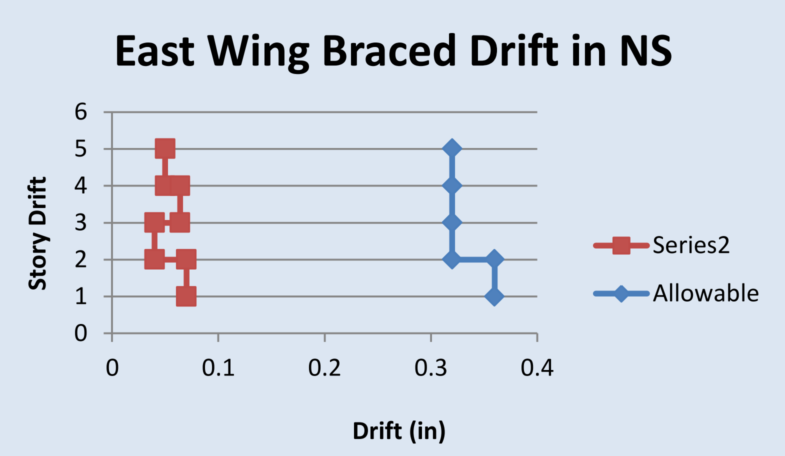


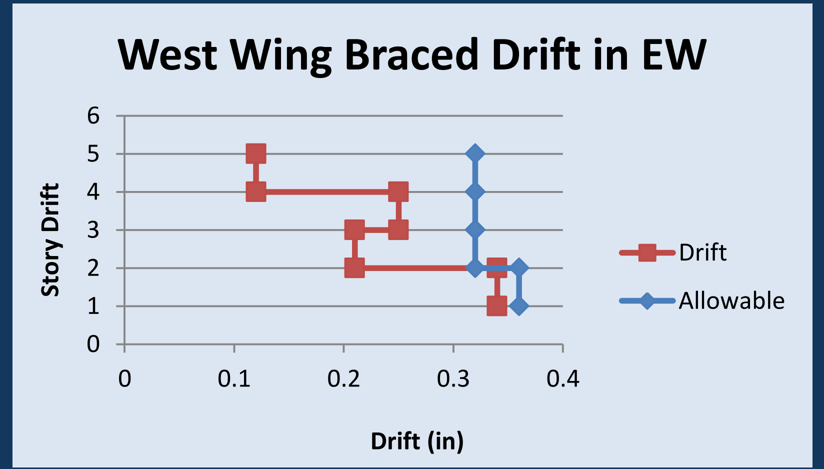


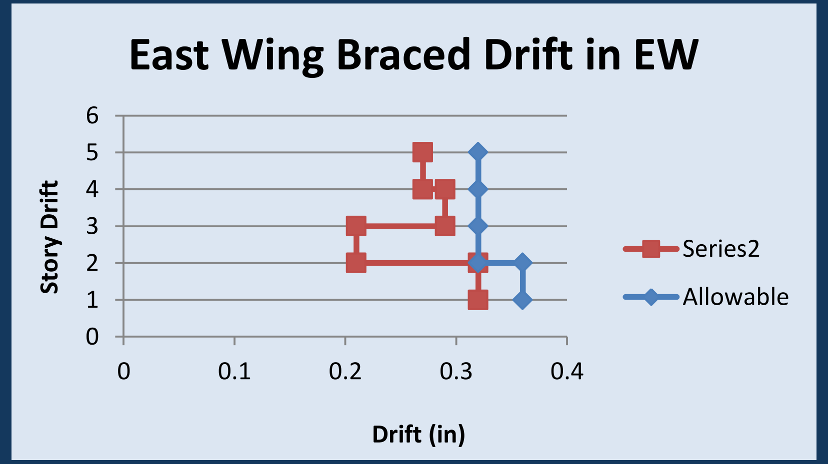


Braced Frame Drift









High-Velocity Hurricane Zones

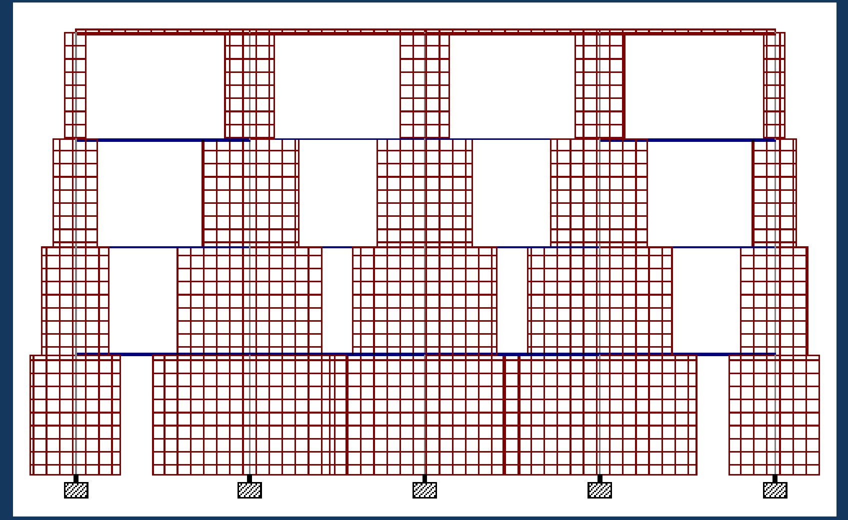
The High-Velocity Hurricane Zones (HVHZ) are specifically defined as Miami-Dade and Broward Counties. As in previous editions of the FBCB, a single wind speed is used for the HVHZ for each Risk Category Map. The design wind speeds in the HVHZ are as follows:

Miami-Dade County

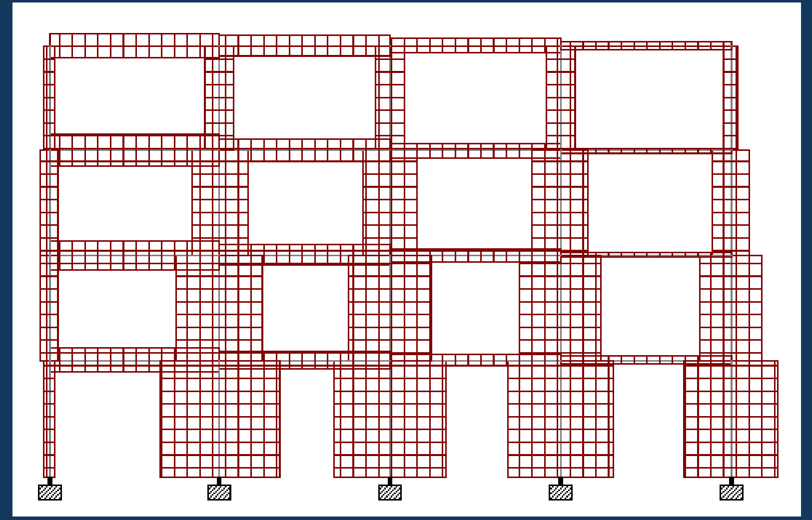
Risk Category I Buildings and Structures: 165 mph
Risk Category II Buildings and Structures: 175 mph
Risk Category III and IV Buildings & Structures: 185 mph

http://www.floridabuilding.org/fbc/Wind_2010/Flyer_Wind_January2012.pdf

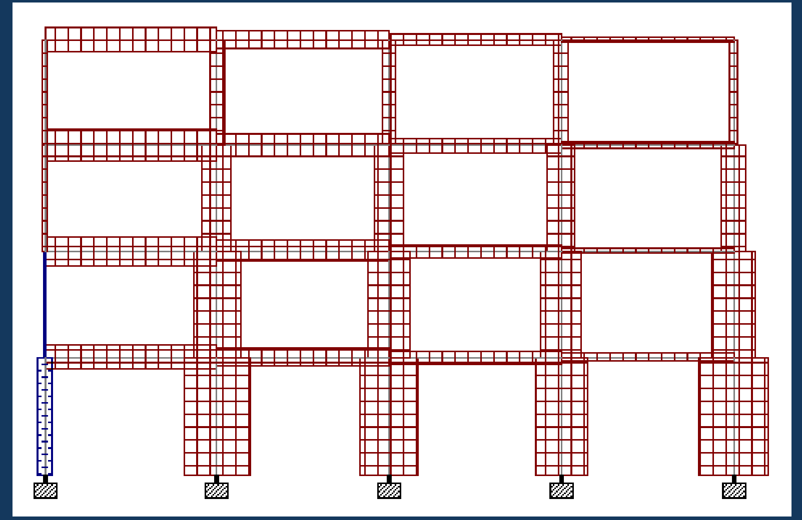
Frame A



1.2D + 1.6L + 0.5 Lr

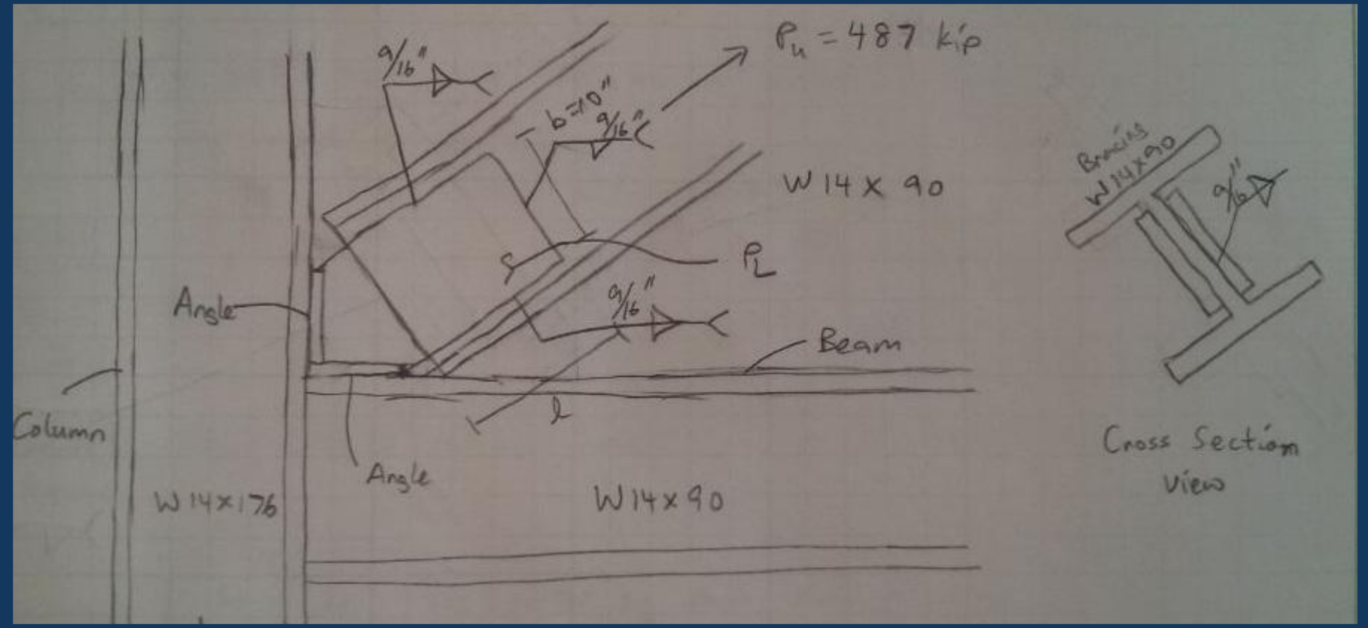


1.2D + 1.6W + L + 0.5Lr



0.9D + 1.6W

CONNECTIONS



Did not check for Compression Force