State of Practice in Performance-Based Wind Design

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Senior Principal, Magnusson Klemencic Associates

Prestandard for Performance-Based **Wind** Design

V1.1

American Society of Civil Engineers

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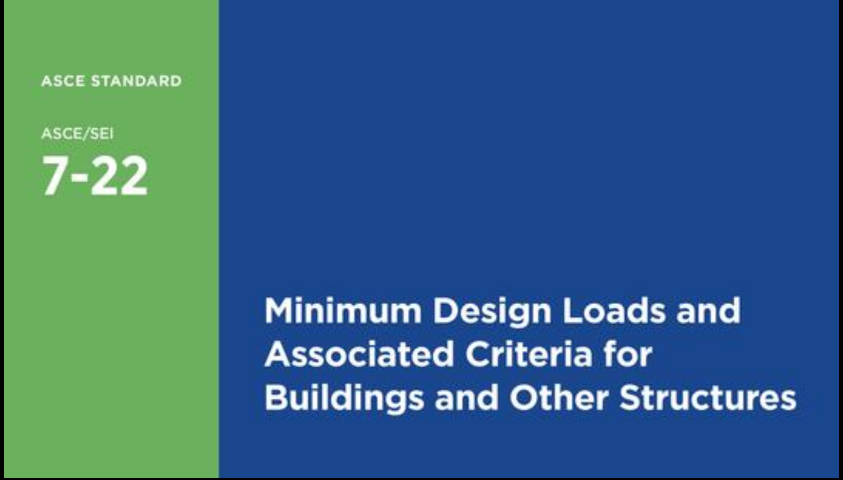
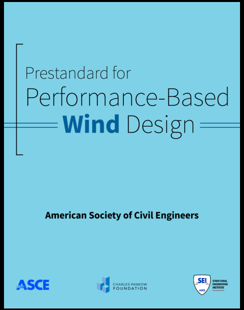
SEI STRUCTURAL ENGINEERING INSTITUTE



CHAPTER 26

WIND LOADS: GENERAL REQUIREMENTS

26.1.3 Performance-Based Procedures Wind design of buildings and other structures using performance-based procedures shall be permitted subject to the approval of the Authority Having Jurisdiction. The performance-based wind design procedures used shall, at a minimum, conform to Section 1.3.1.3.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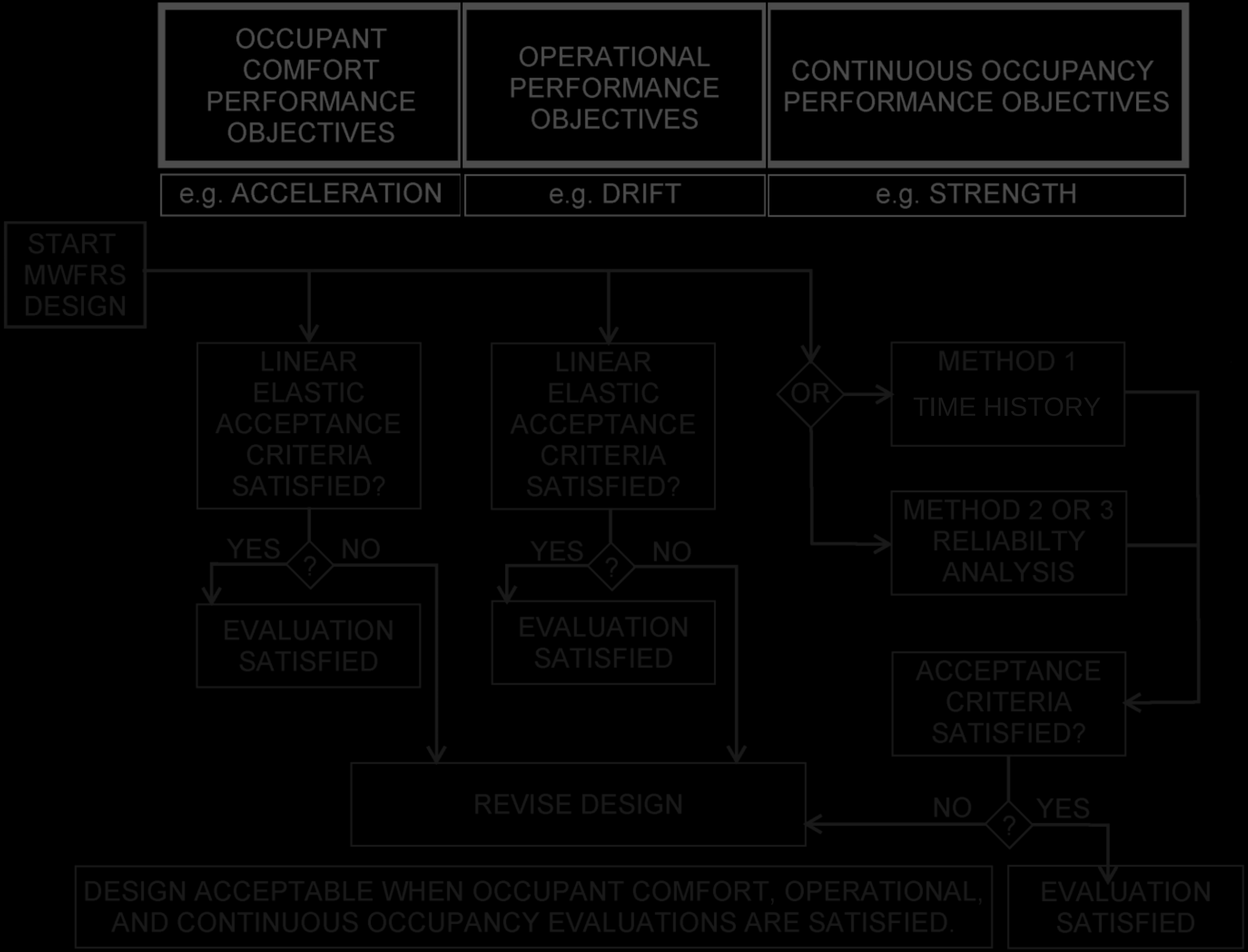
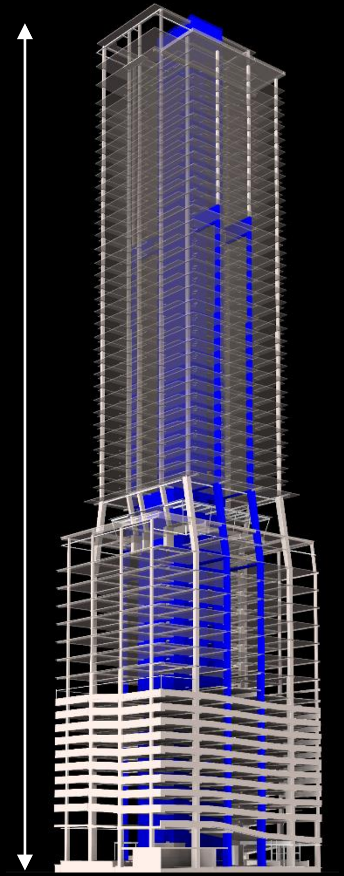
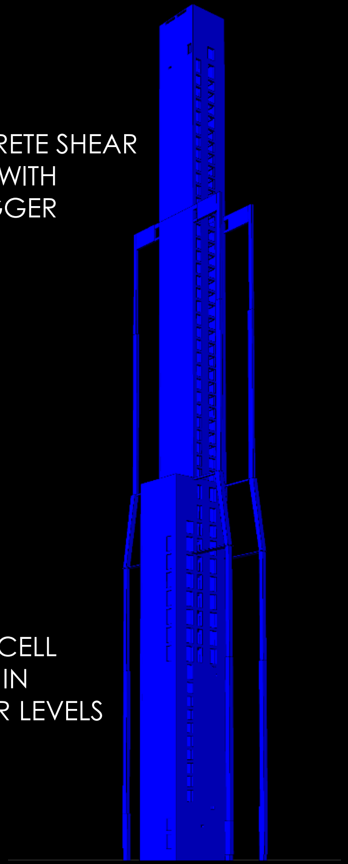

OCCUPANT COMFORT PERFORMANCE OBJECTIVES
OPERATIONAL PERFORMANCE OBJECTIVES
CONTINUOUS OCCUPANCY PERFORMANCE OBJECTIVES
e.g. ACCELERATION
e.g. DRIFT
e.g. STRENGTH
START MWFRS DESIGN
LINEAR ELASTIC ACCEPTANCE CRITERIA SATISFIED?
LINEAR ELASTIC ACCEPTANCE CRITERIA SATISFIED?
OR
METHOD 1
TIME HISTORY
METHOD 2 OR 3
RELIABILTY ANALYSIS
YES
?
NO
YES
?
NO
EVALUATION SATISFIED
EVALUATION SATISFIED
ACCEPTANCE CRITERIA SATISFIED?
REVISE DESIGN
NO
?
YES
DESIGN ACCEPTABLE WHEN OCCUPANT COMFORT, OPERATIONAL, AND CONTINUOUS OCCUPANCY EVALUATIONS ARE SATISFIED.
EVALUATION SATISFIED

321 West 6th Street, Austin, Texas

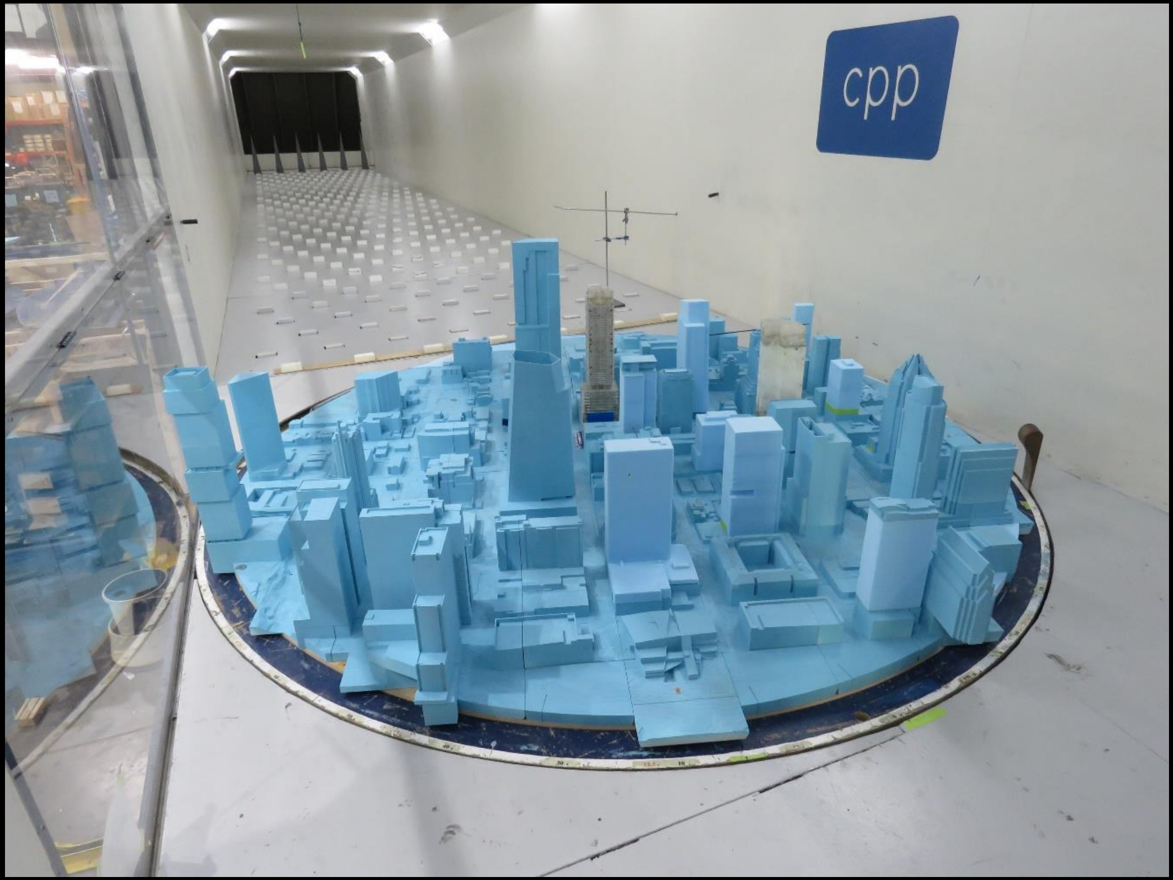
58
STORIES
670'/
204-m



CONCRETE SHEAR WALLS WITH OUTRIGGER



DUAL CELL CORE IN LOWER LEVELS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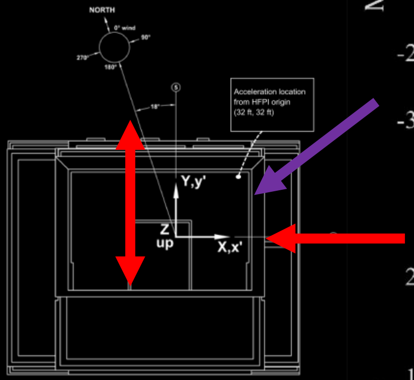
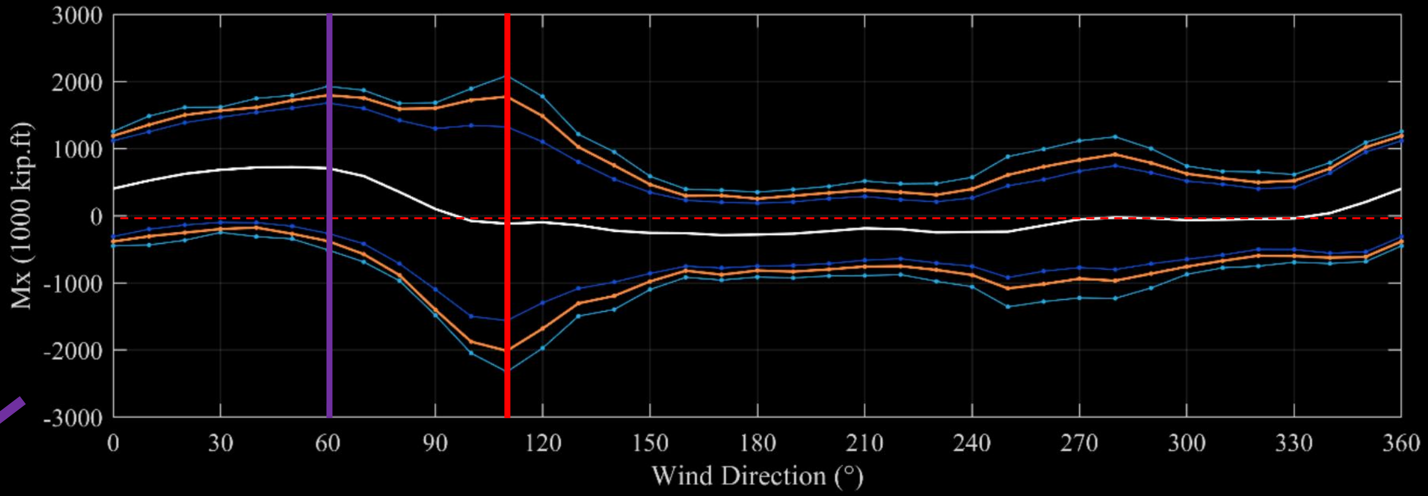
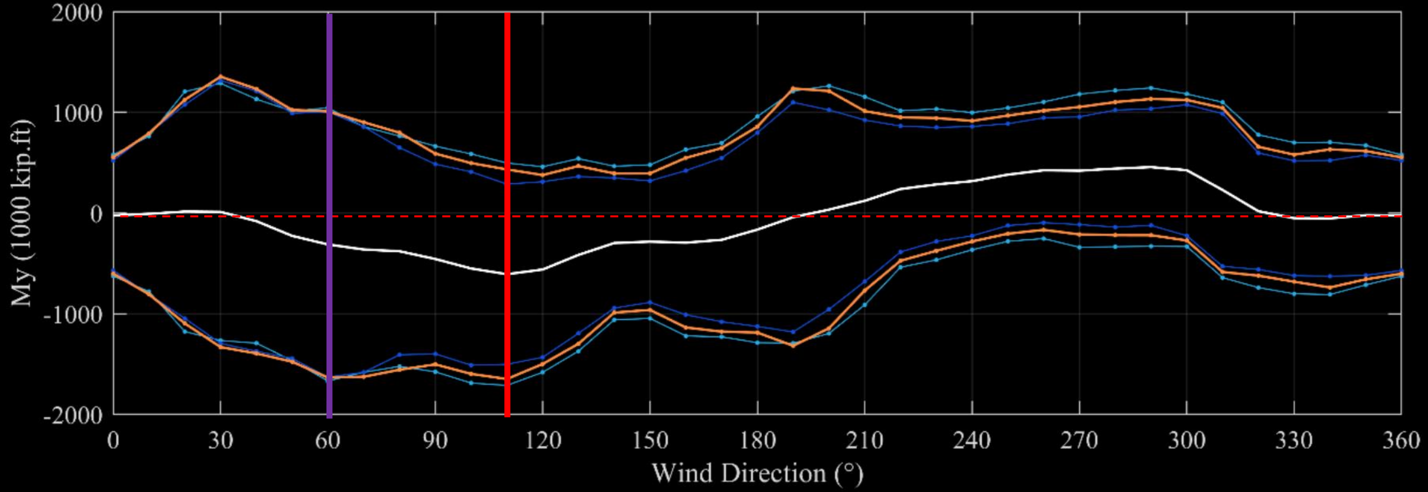
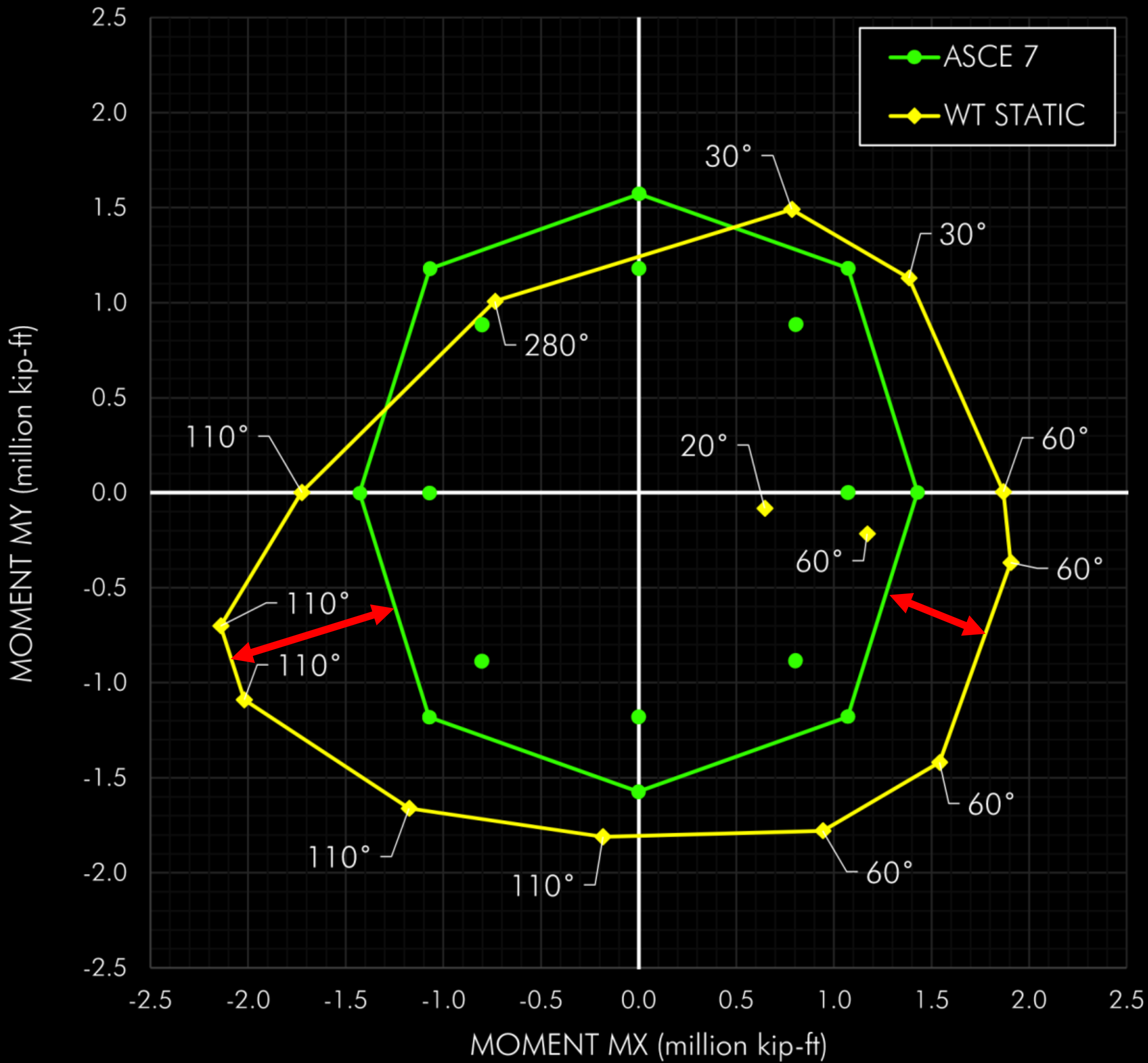

NORTH
0° wind
90°
270°
180°
18°
5
Acceleration location
from HFPI origin
(32 ft, 32 ft)
Y,y'
Z
up
X,x'


Mx (1000 kip.ft)
3000
2000
1000
0
-1000
-2000
-3000
0
30
60
90
120
150
180
210
240
270
300
330
360
Wind Direction (°)


My (1000 kip.ft)
2000
1000
0
-1000
-2000
0
30
60
90
120
150
180
210
240
270
300
330
360
Wind Direction (°)


ASCE 7
WT STATIC
30°
30°
280°
20°
60°
110°
60°
60°
110°
110°
60°
110°
110°
60°
MOMENT MY (million kip-ft)
MOMENT MX (million kip-ft)
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-2.5
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
2.5

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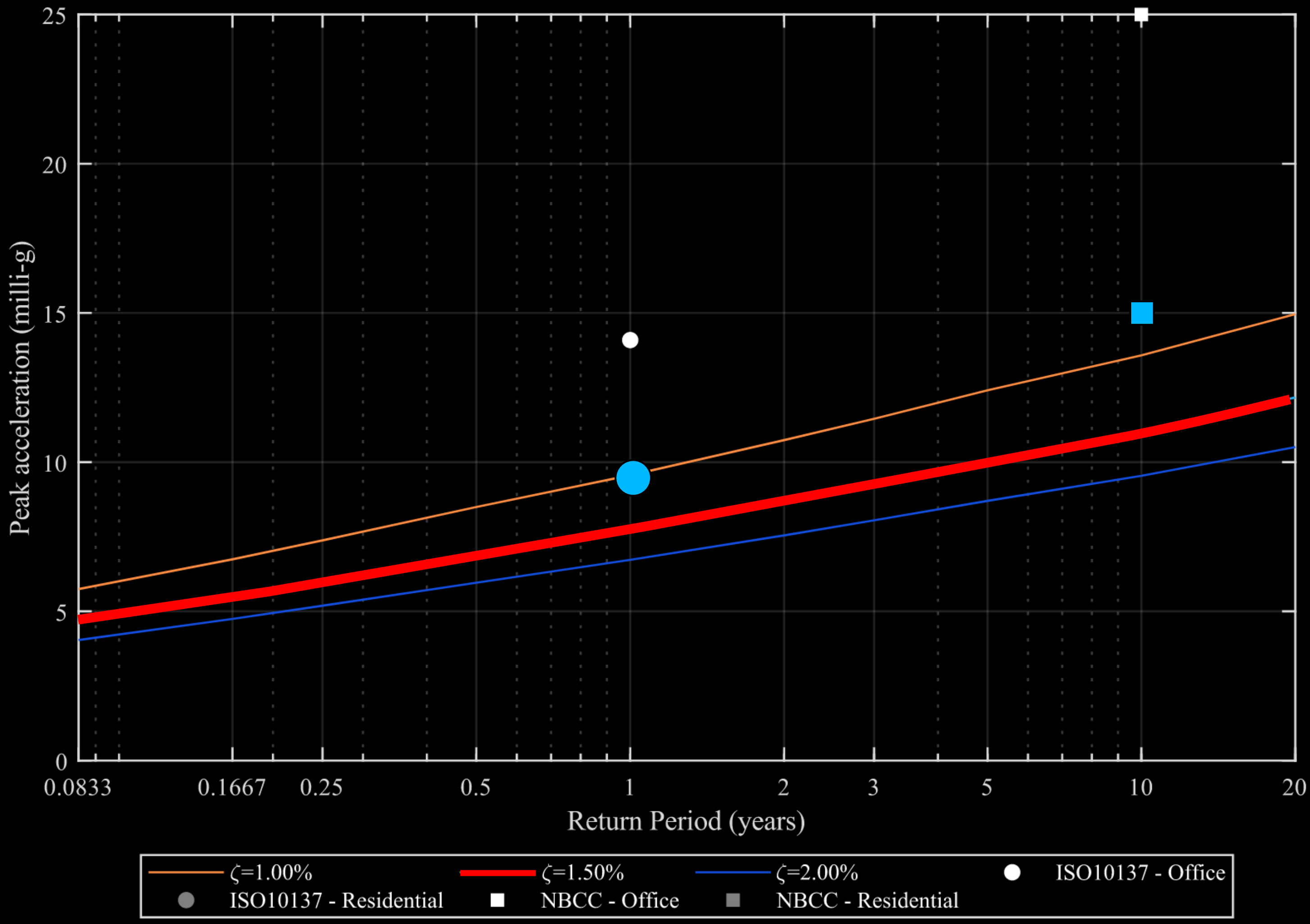
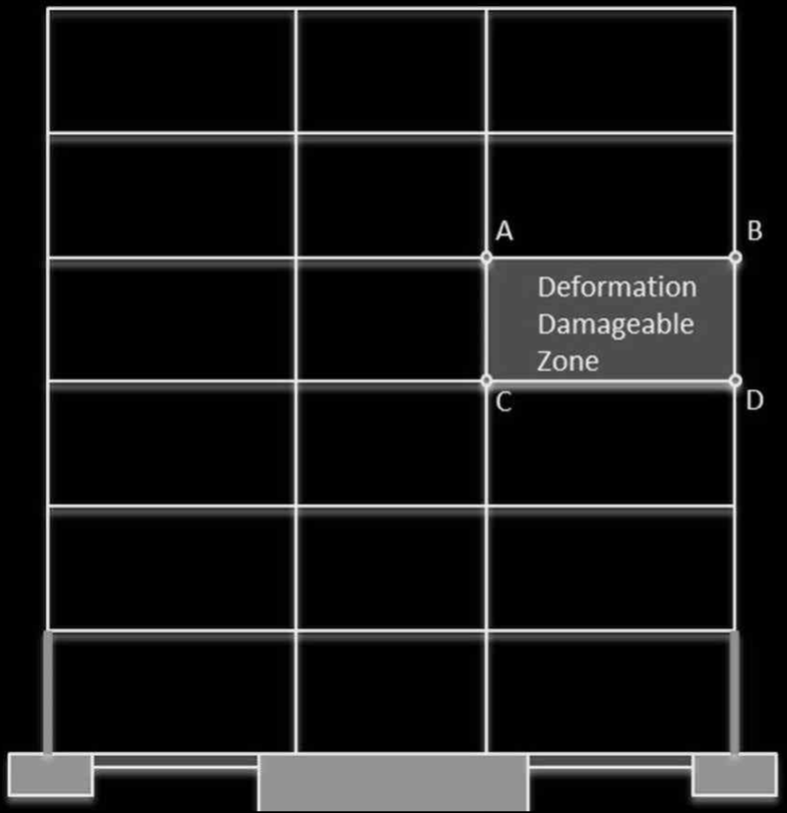
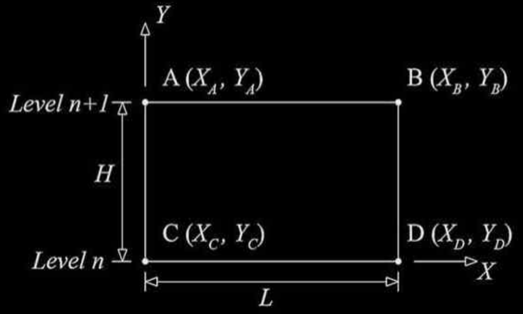
OCCUPANT COMFORT PERFORMANCE OBJECTIVES	OPERATIONAL PERFORMANCE OBJECTIVES	CONTINUOUS OCCUPANCY PERFORMANCE OBJECTIVES
e.g. ACCELERATION	e.g. DRIFT	e.g. STRENGTH

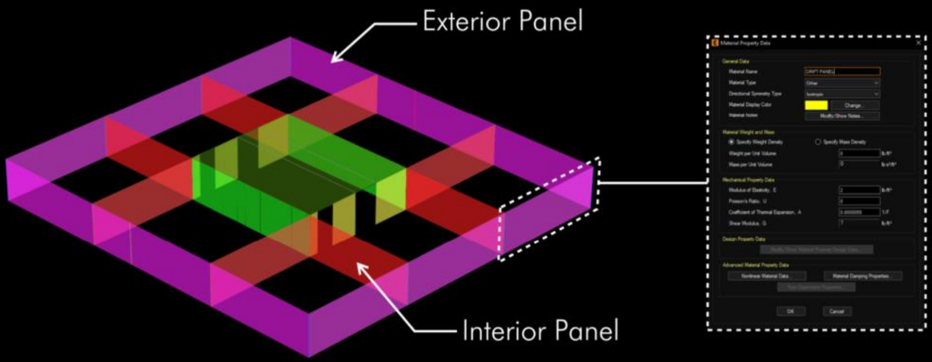


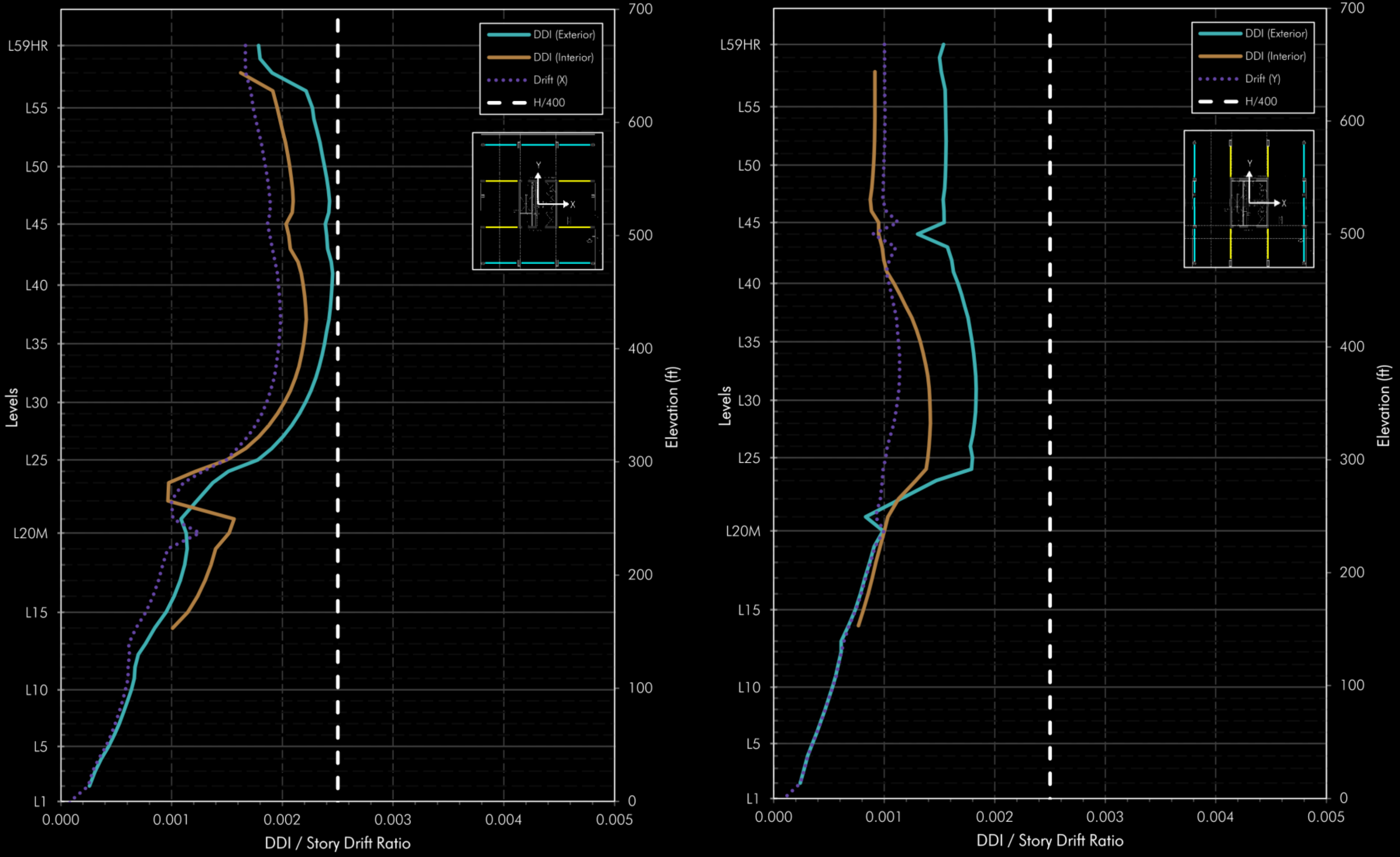
Peak acceleration (milli-g)
0
5
10
15
20
25
0.0833
0.1667
0.25
0.5
1
2
3
5
10
20
Return Period (years)
ζ=1.00%
ζ=1.50%
ζ=2.00%
ISO10137 - Office
ISO10137 - Residential
NBCC - Office
NBCC - Residential

$$DDI = 0.5\left[\frac{X_A - X_C}{H} + \frac{X_B - X_D}{H} + \frac{Y_D - Y_C}{L} + \frac{Y_B - Y_A}{L}\right]$$

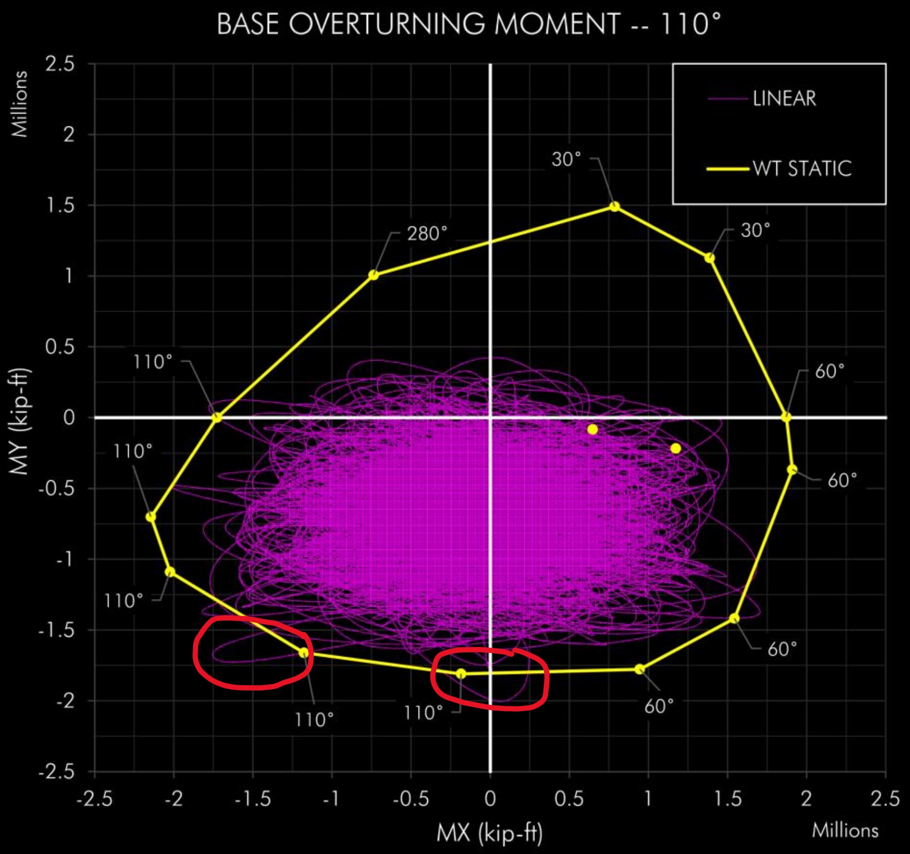


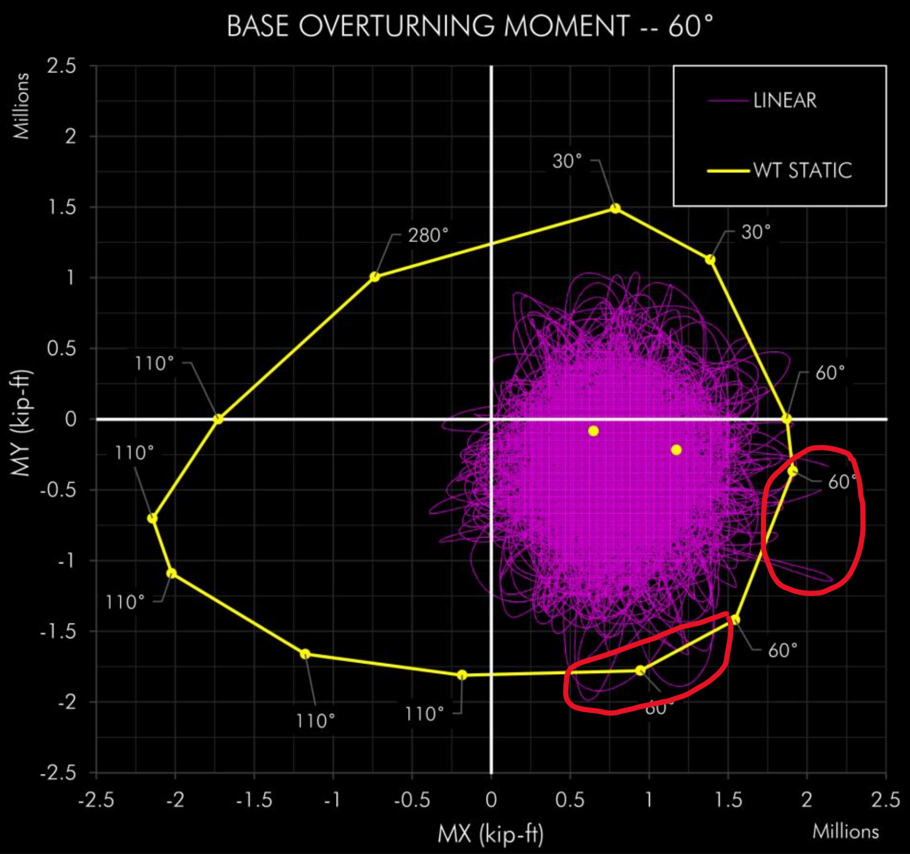


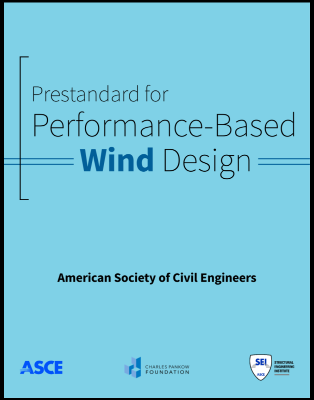




DDI (Exterior)
DDI (Interior)
Drift (X)
H/400
L59HR
L55
L50
L45
L40
L35
L30
L25
L20M
L15
L10
L5
L1
Levels
Elevation (ft)
700
600
500
400
300
200
100
0
0.000
0.001
0.002
0.003
0.004
0.005
DDI / Story Drift Ratio
DDI (Exterior)
DDI (Interior)
Drift (Y)
H/400
Levels
Elevation (ft)
DDI / Story Drift Ratio


BASE OVERTURNING MOMENT -- 110°
LINEAR
WT STATIC
30°
280°
30°
110°
60°
110°
60°
110°
60°
110°
110°
60°
MY (kip-ft)
Millions
MX (kip-ft)
Millions


BASE OVERTURNING MOMENT -- 60°
LINEAR
WT STATIC
30°
280°
30°
110°
60°
110°
60°
110°
60°
110°
110°
60°
MY (kip-ft)
Millions
MX (kip-ft)
Millions



7.4.3.2 Deformation-controlled elements and actions

Calculated demand to capacity ratios for deformation-controlled elements shall not exceed 1.25, where demand is calculated per provisions in Chapter 6, and the capacity is calculated as follows:

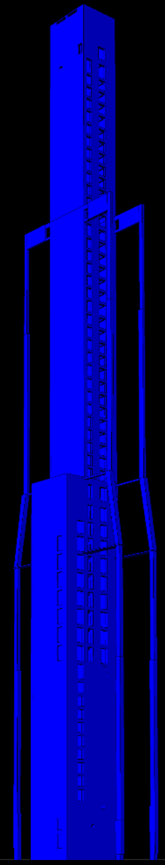
1. For reinforced concrete elements, the capacity is the expected strength in accordance with ACI 318, with the phi-factor taken as 1.0.

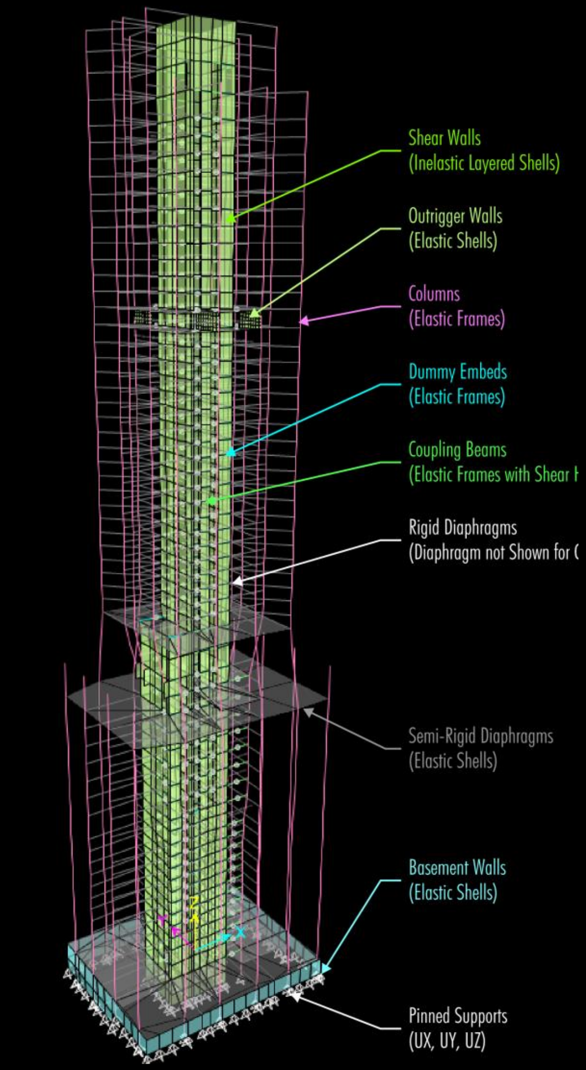
7.4.3.4 Minimum strength for Method 1 design

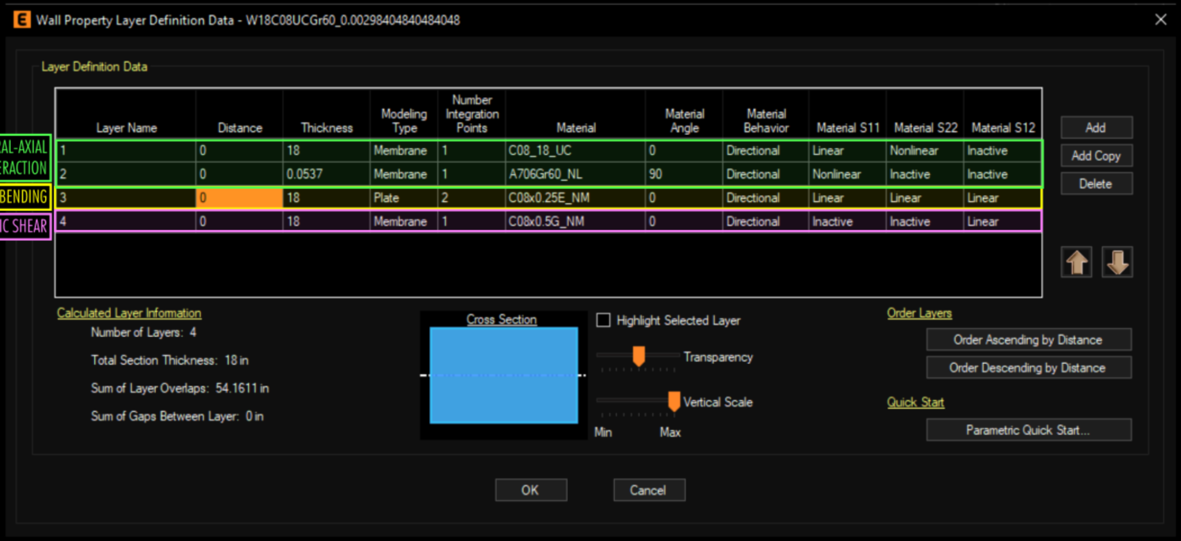
The MWFRS shall be designed so that the calculated demand to capacity ratio for deformation controlled elements shall not exceed 1.25, where demand is calculated per the static wind loads prescribed in ASCE7-16 Directional Procedure, and the capacity is calculated as follows:

1. For reinforced concrete elements, the capacity is the expected strength in accordance with ACI 318 with the phi-factor according to ACI 318.

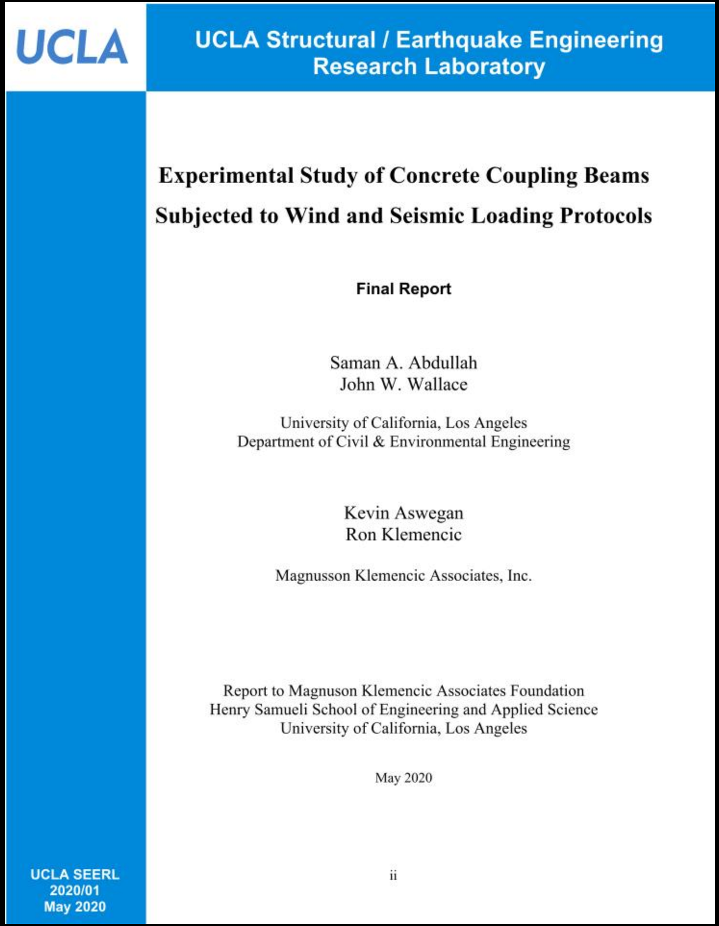
Member Action	Category: Deformation-Controlled	Category: Force-Controlled
Shear wall shear		x
Shear wall flexural-axial interaction	x	
Coupling beam flexure	x	
Coupling beam shear		x







Layer Name	Distance	Thickness	Modeling Type	Number Integration Points	Material	Material Angle	Material Behavior	Material S11	Material S22	Material S12
1	0	18	Membrane	1	C08_18_UC	0	Directional	Linear	Nonlinear	Inactive
2	0	0.0537	Membrane	1	A706Gr60_NL	90	Directional	Nonlinear	Inactive	Inactive
3	0	18	Plate	2	C08x0.25E_NM	0	Directional	Linear	Linear	Linear
4	0	18	Membrane	1	C08x0.5G_NM	0	Directional	Inactive	Inactive	Linear



UCLA

UCLA Structural / Earthquake Engineering Research Laboratory

Experimental Study of Concrete Coupling Beams Subjected to Wind and Seismic Loading Protocols

Final Report

Saman A. Abdullah
John W. Wallace

University of California, Los Angeles
Department of Civil & Environmental Engineering

Kevin Aswegan
Ron Klemencic

Magnusson Klemencic Associates, Inc.

Report to Magnuson Klemencic Associates Foundation
Henry Samueli School of Engineering and Applied Science
University of California, Los Angeles

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ii

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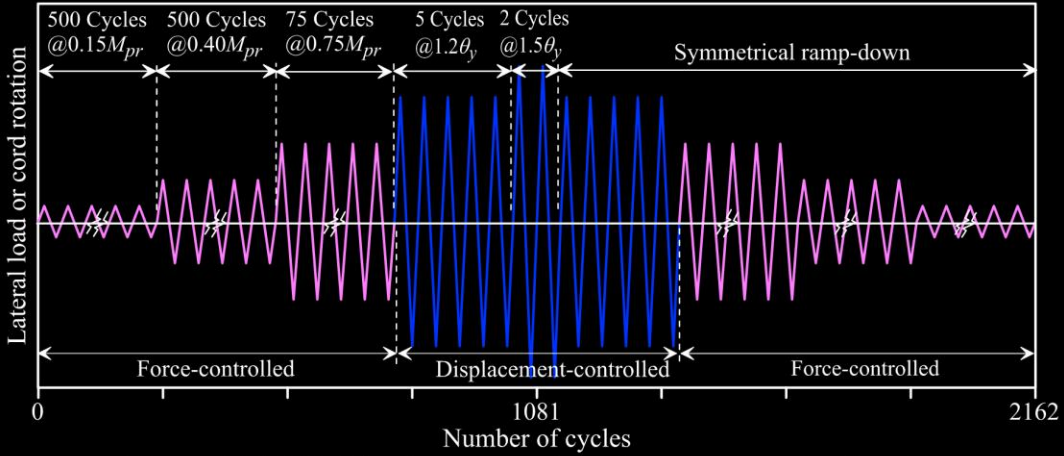
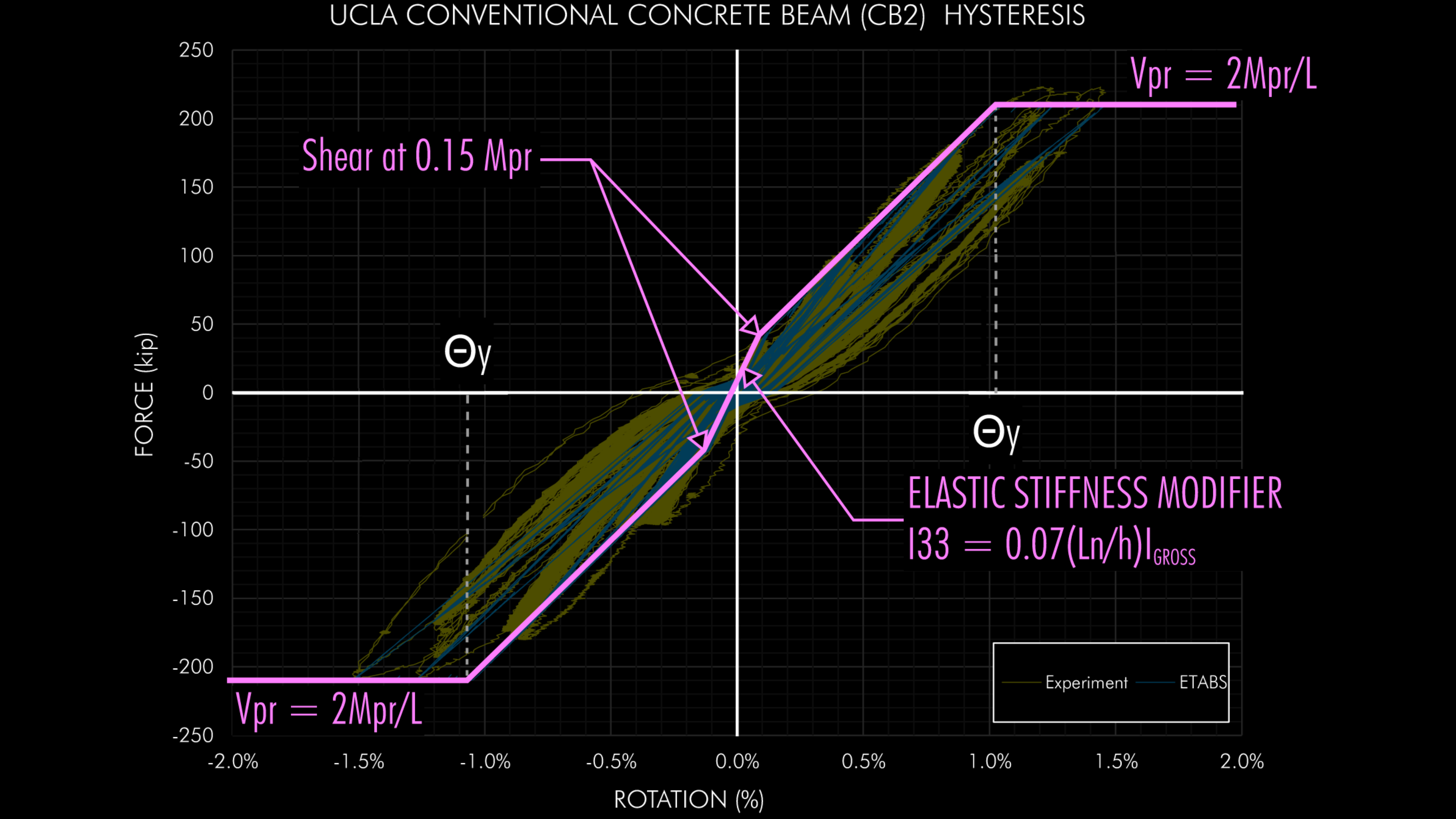
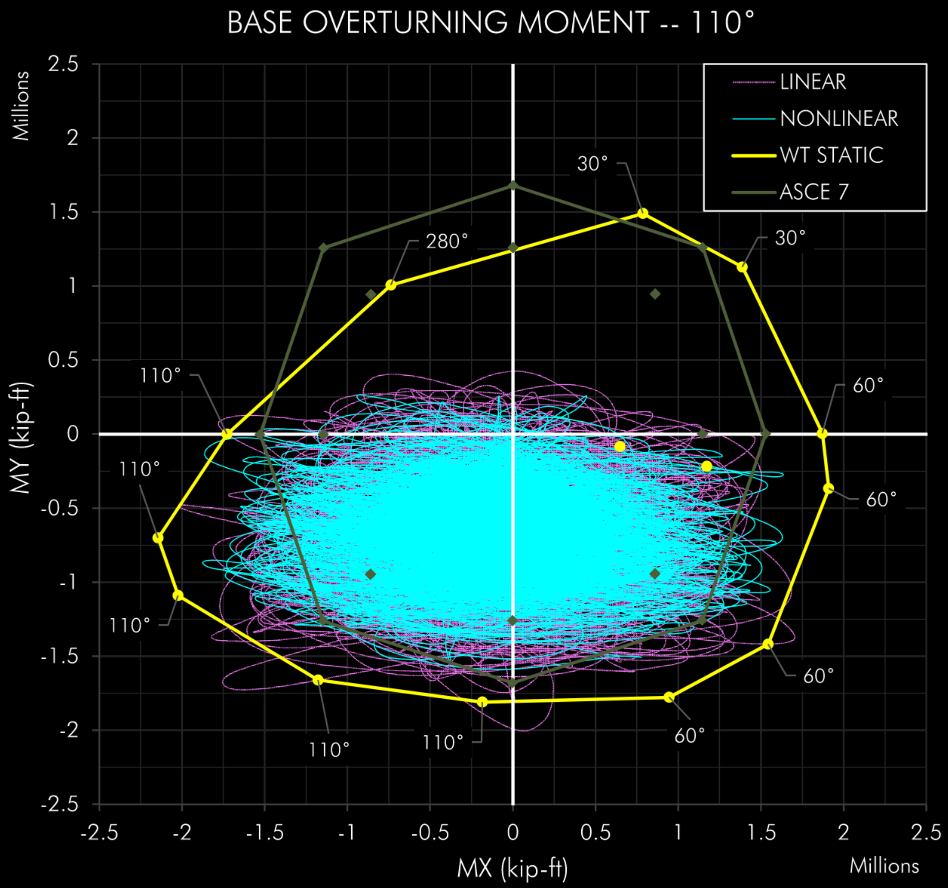
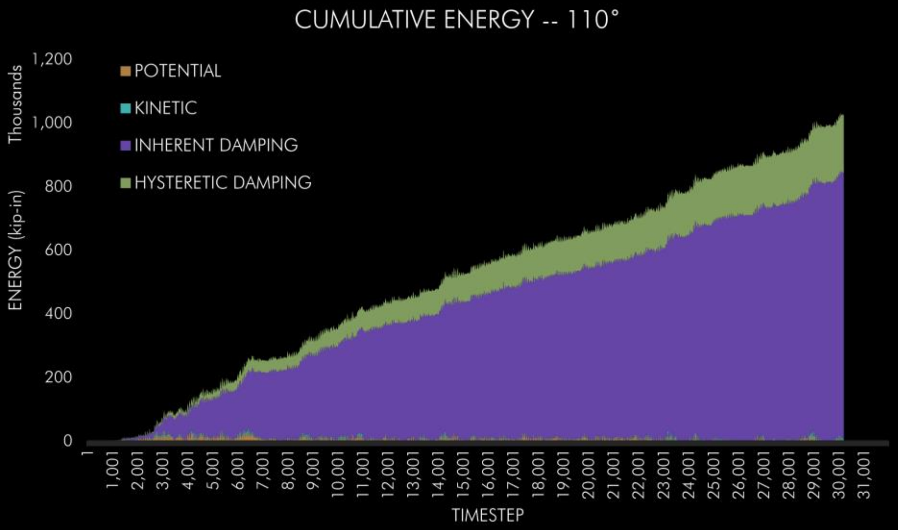


Figure 2-21. Wind loading protocol used to test beams in Phase I.

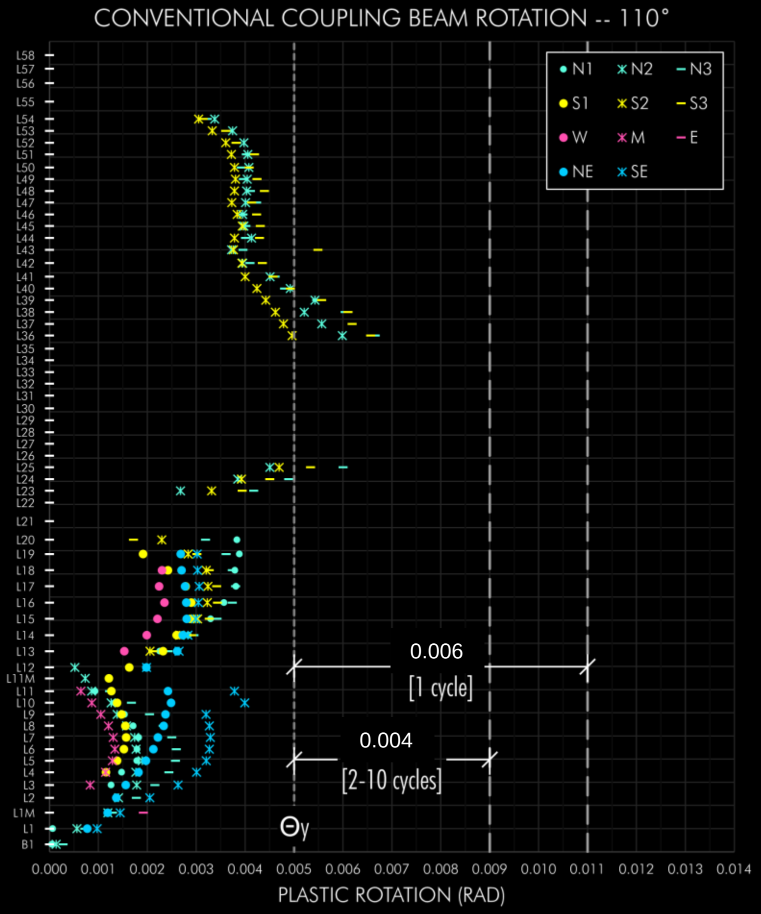

UCLA CONVENTIONAL CONCRETE BEAM (CB2) HYSTERESIS
Vpr = 2Mpr/L
Shear at 0.15 Mpr
Θy
Θy
ELASTIC STIFFNESS MODIFIER
I33 = 0.07(Ln/h)I GROSS
Vpr = 2Mpr/L
Experiment
ETABS
FORCE (kip)
ROTATION (%)
250
200
150
100
50
0
-50
-100
-150
-200
-250
-2.0%
-1.5%
-1.0%
-0.5%
0.0%
0.5%
1.0%
1.5%
2.0%

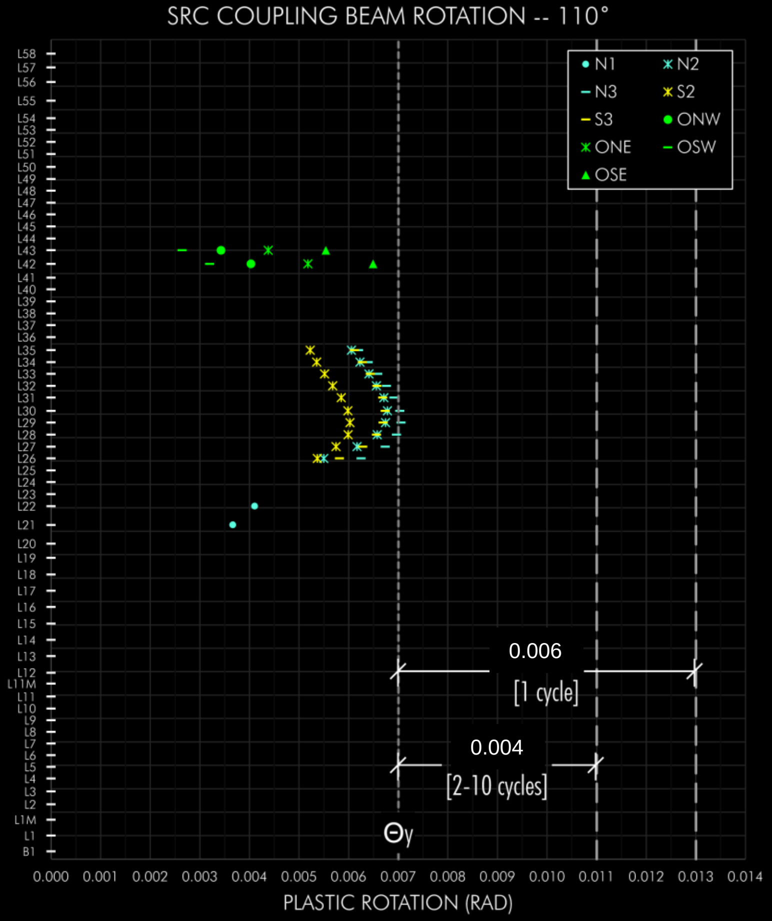


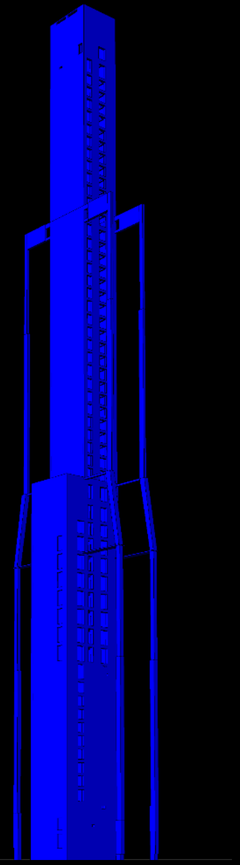
BASE OVERTURNING MOMENT -- 110°
LINEAR
NONLINEAR
WT STATIC
ASCE 7
Millions
MY (kip-ft)
MX (kip-ft)
Millions
30°
30°
280°
110°
110°
110°
110°
110°
60°
60°
60°
60°
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5



CUMULATIVE ENERGY -- 110°
POTENTIAL
KINETIC
INHERENT DAMPING
HYSTERETIC DAMPING
Thousands
ENERGY (kip-in)
1,200
1,000
800
600
400
200
0
TIMESTEP

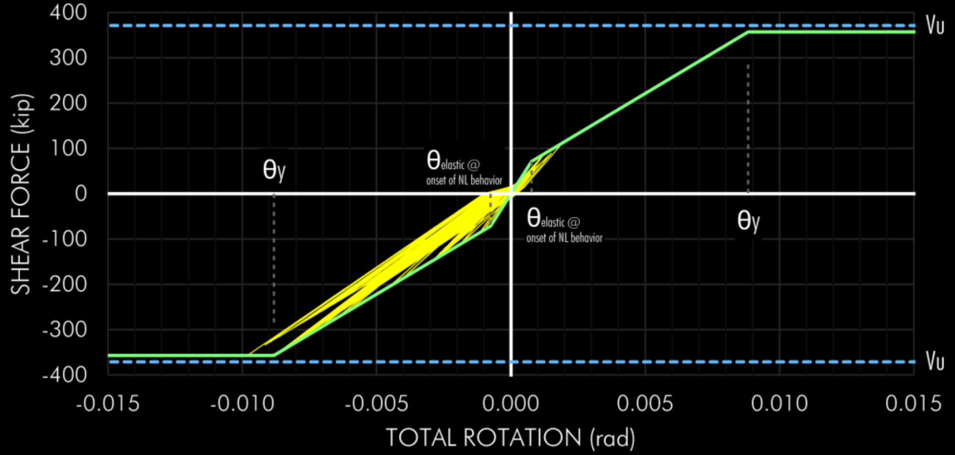

CONVENTIONAL COUPLING BEAM ROTATION -- 110°
N1
N2
N3
S1
S2
S3
W
M
E
NE
SE
0.006
[1 cycle]
0.004
[2-10 cycles]
Θy
PLASTIC ROTATION (RAD)

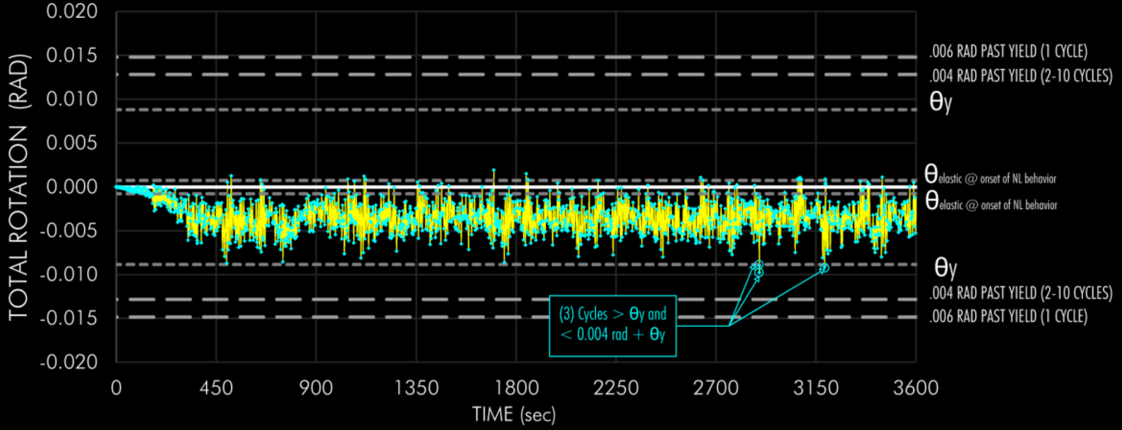

SRC COUPLING BEAM ROTATION -- 110°
N1
N2
N3
S2
S3
ONW
ONE
OSW
OSE
0.006
[1 cycle]
0.004
[2-10 cycles]
Θy
PLASTIC ROTATION (RAD)

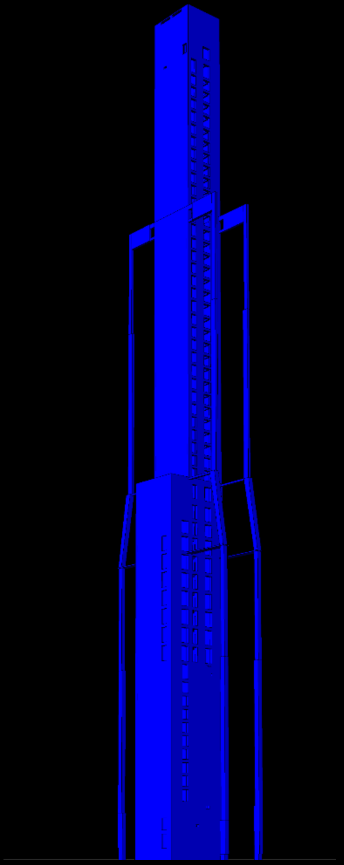


COUPLING BEAM ROTATION CYCLE COUNT EXAMPLES -- WIND ANGLE 110°

CONVENTIONAL COUPLING BEAM L36 N2

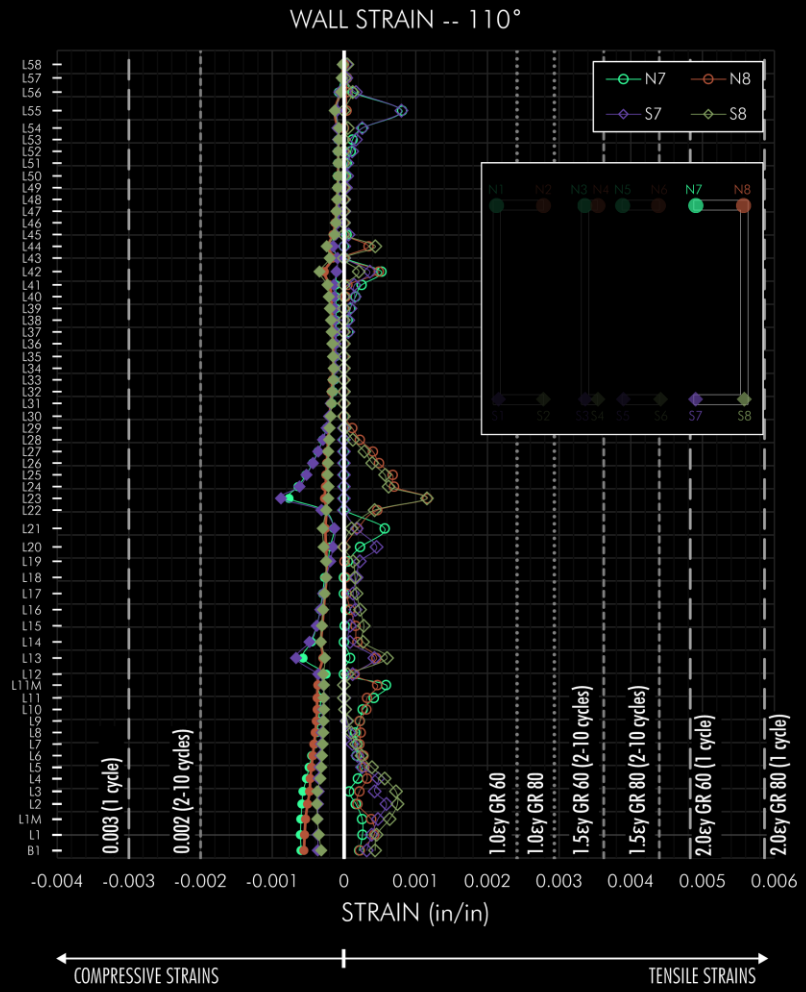


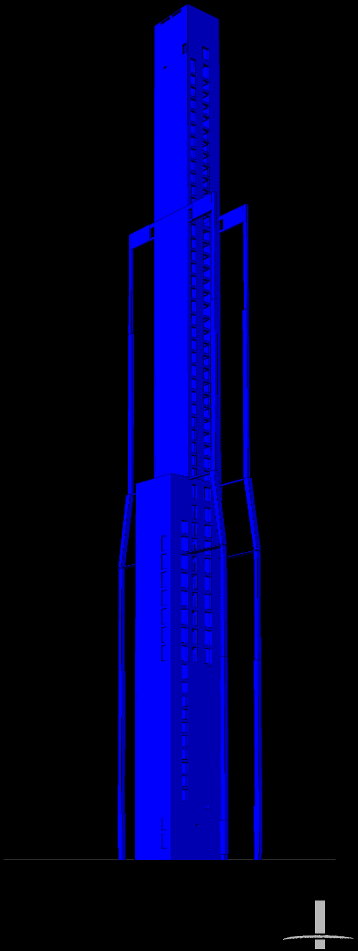




MAXIMUM TENSILE AND COMPRESSIVE WALL STRAINS

As shown below, all peak compressive strains are < 0.002 and all peak tensile strains are < yield. No cycles are required to be counted.





Material Savings

20 TRUCKS OF REBAR (350 TONS)

10 TRUCKS OF STEEL
(125 TONS)

200 CONCRETE TRUCKS (1,800
CUBIC YARDS)

5% STRUCTURAL COST REDUCTION


THE CONSTRUCTION RESOURCE
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THE TOP
PROFESSIONAL
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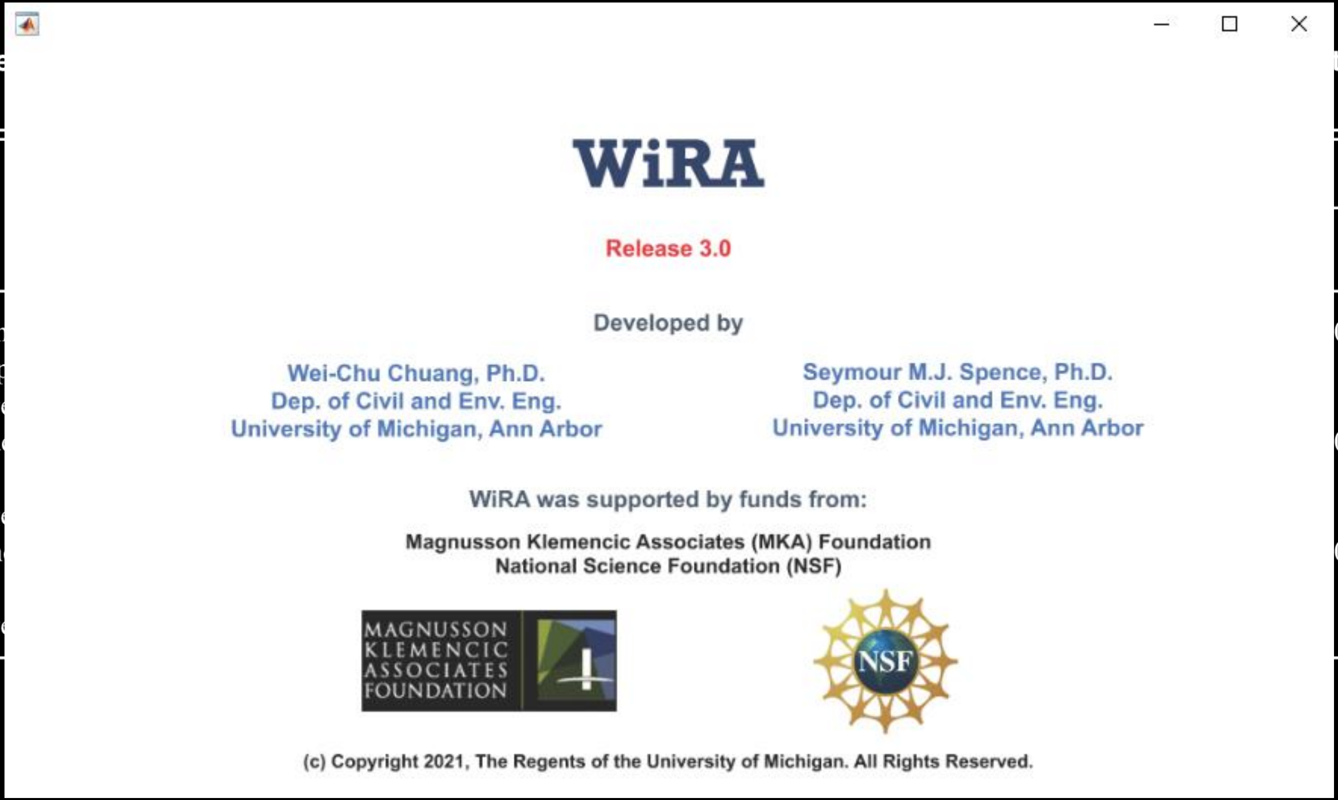
(P. 53)
WIND SIMULATION FOR
321 WEST 6TH STREET
AUSTIN
PART ONE OF A SERIES
BUILDING A LOWER CARBON FUTURE
WINDS OF CHANGE
TRAILBLAZERS LEAD THE WAY TOWARD A PARADIGM SHIFT IN SKYSCRAPER WIND DESIGN
THAT REDUCES MATERIALS, COST AND EMBODIED CARBON
(P. 20)
A bnp PUBLICATION


RYAN

Method 3

Table 1.3-1. Target Re ... tions That Do Not

Basis		IV
Failure that is not sudden ... does not lead to widesp... progression of damage...		0 × 10^{-6} per year $\beta = 3.5$
Failure that is either sudde... leads to widespread progression of damage...		0 × 10^{-7} per year $\beta = 4.0$
Failure that is sudden an... results in widespread progression of damage...		0 × 10^{-7} per year $\beta = 4.5$



RESEARCH

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WASHINGTON STATE UNIVERSITY

University at Buffalo

UNIVERSITY OF Cincinnati

PURDUE UNIVERSITY

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