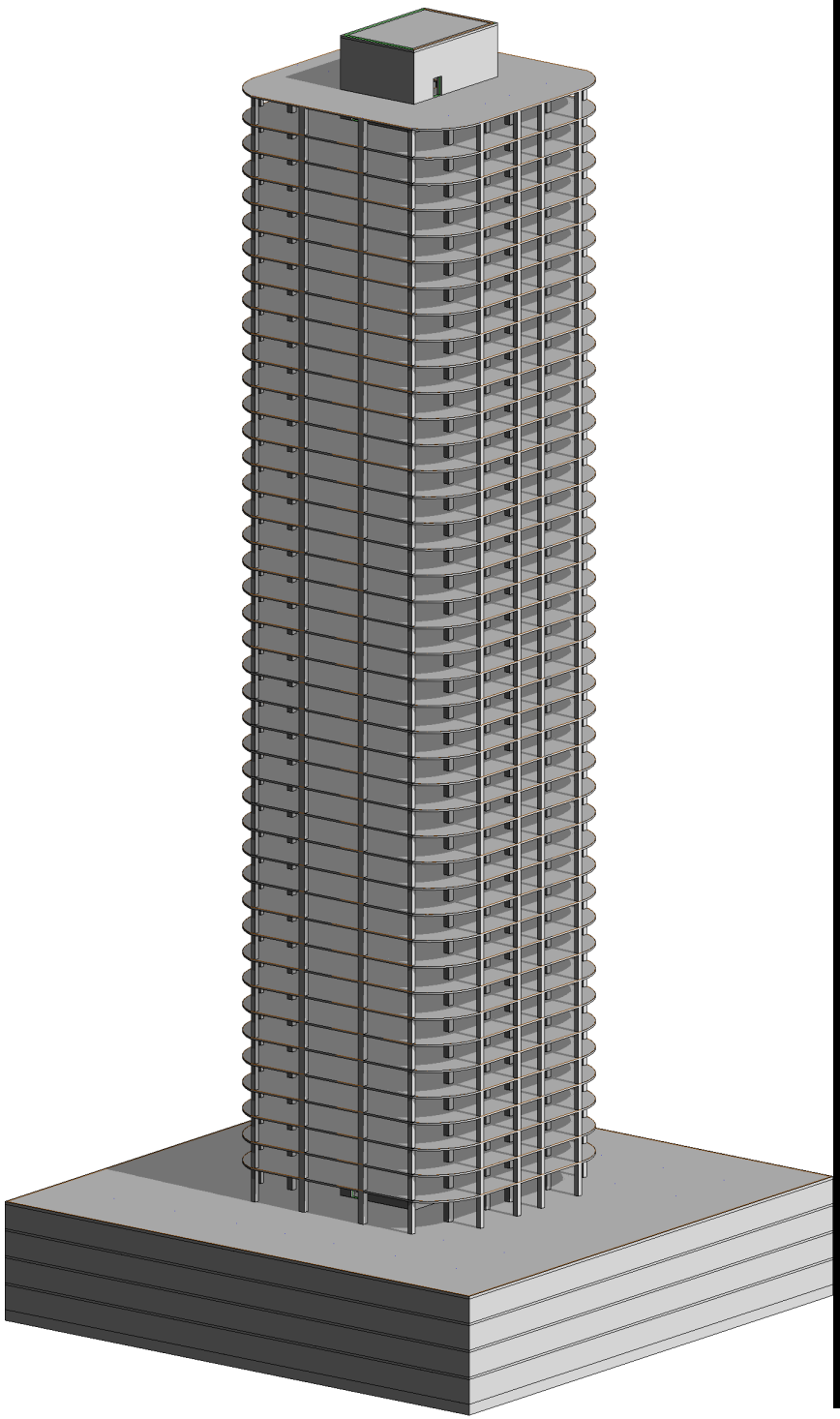


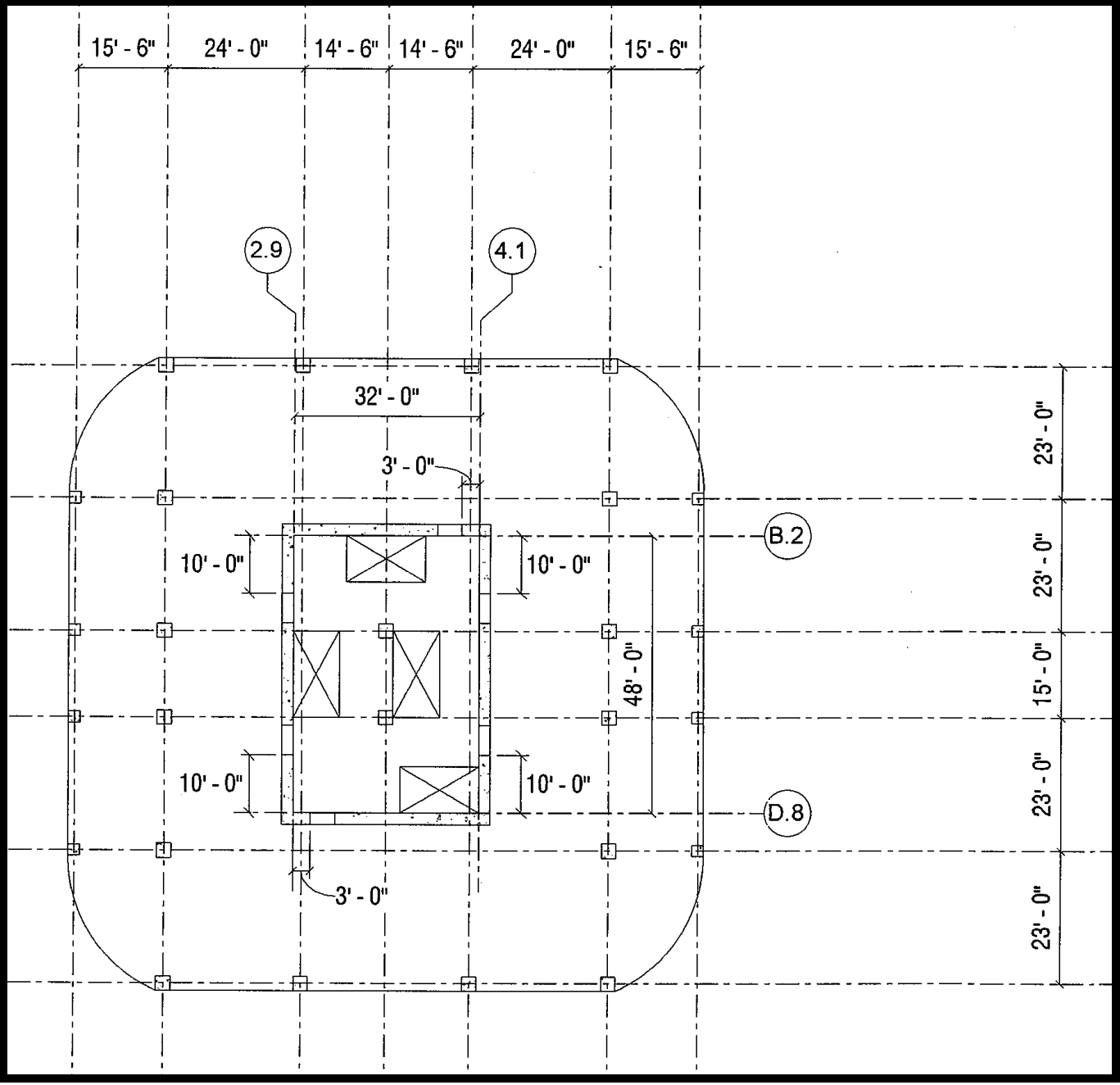
PEER Annual Meeting
CSSC Tall Building Design Case Study Building #1

J. Andrew Fry
John Hooper
Ron Klemencic
Magnusson Klemencic Associates

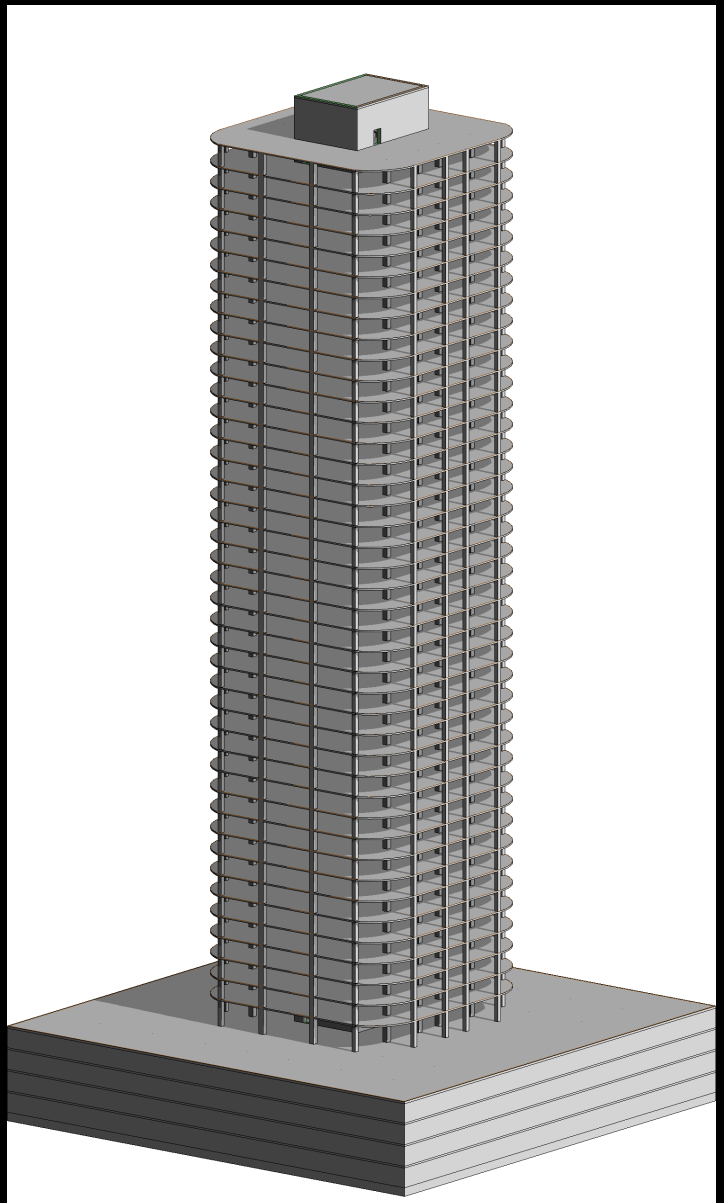
Building Information

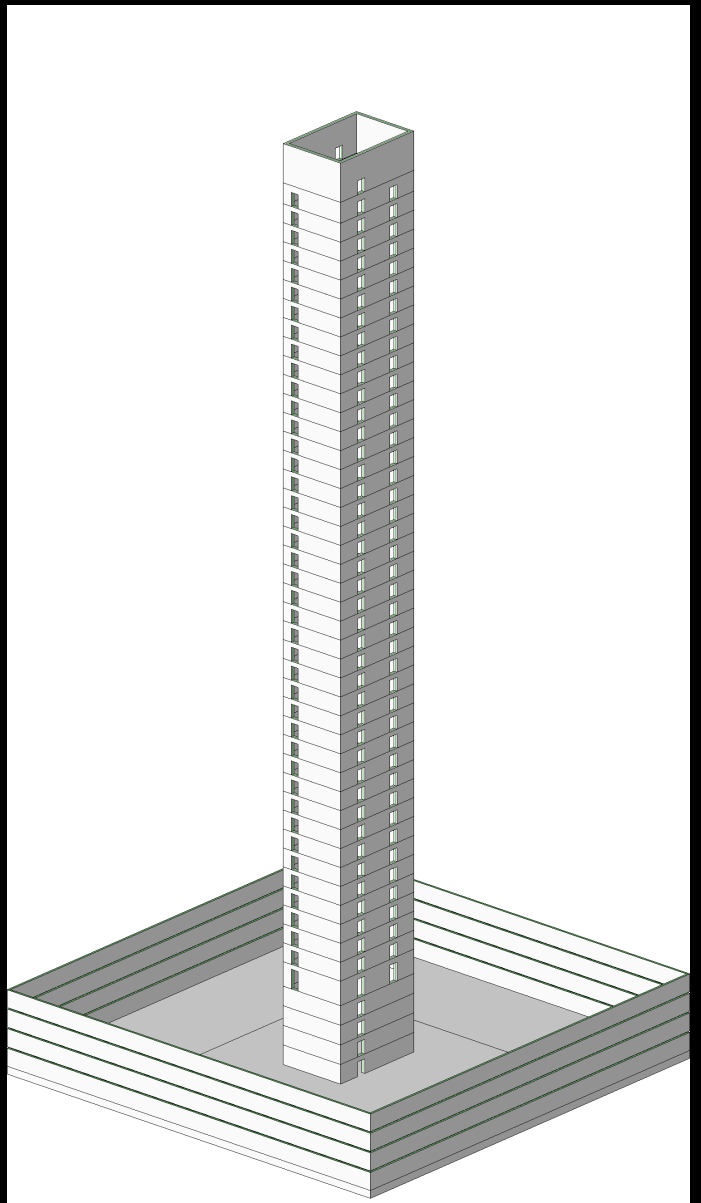
- Located in Los Angeles
- 42-Story Residential Building
- 410 ft Tall
- 108 ft X 107 ft Plan Dimensions
- Core Wall System
- Approximate Period: 5 Sec

Tower Plan


15' - 6"
24' - 0"
14' - 6"
14' - 6"
24' - 0"
15' - 6"
2.9
4.1
32' - 0"
3' - 0"
B.2
10' - 0"
10' - 0"
48' - 0"
10' - 0"
10' - 0"
D.8
3' - 0"
23' - 0"
23' - 0"
15' - 0"
23' - 0"
23' - 0"

Tower and Core Wall Isometric





Code Design

- Prescriptive provisions of the 2006 IBC
- All prescriptive provisions observed except height limit
- Capacity design principles were not employed

LATBC Design

- **Performance-Based Seismic Design conforming to the 2008 LATBC Seismic Design Criteria, with two exceptions:**
  - **25-year EQ used in Serviceability Analysis**
    - 2.5% viscous damping
    - 20% of elements allowed to reach 150% of their capacity
  - **The minimum base shear waived**
    - Minimum strength provided by 25-year EQ and Wind

PEER TBI Design

- 43-year EQ used in Serviceability Analysis
  - 2.5% viscous damping
  - Ductile elements allowed to reach 150% of their capacity
    - Coupling beams for core wall building
    - Wall piers with axial stress < 0.3f'c
- Minimum strength provided by 43-year EQ and Wind Demands

Code Design—Seismic Design Criteria

- Occupancy Category II: $I_e = 1.0$
- Mapped Spectral Accelerations:
  - $S_s = 2.147$; $S_1 = 0.720$
- Spectral Response Coefficients:
  - $S_{DS} = 1.145$; $S_{D1} = 0.521$
- Seismic Design Category: D
- Building Frame, Special Reinforced Concrete Shear Walls, $R = 6$

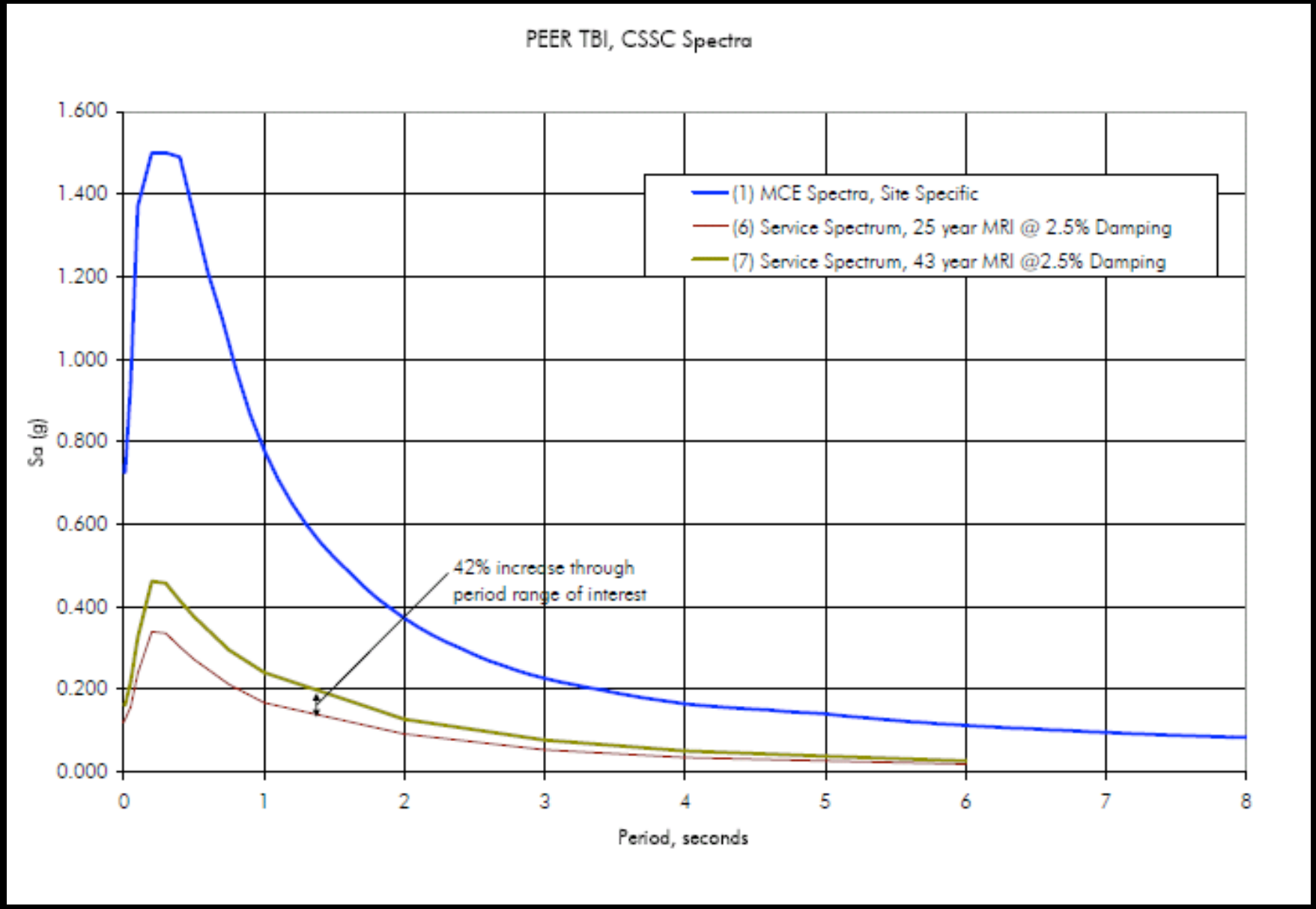
Code Design—Results

- Core Wall Thickness
  - Grade – Level 25 = 24 inches
  - Level 25 – Roof = 21 inches
- Building Modes:
  - Mode 1—T_X = 6.7 Sec
  - Mode 2—T_Y = 4.8 Sec
  - Mode 3—T_Z = 2.6 Sec

Code Design—Results

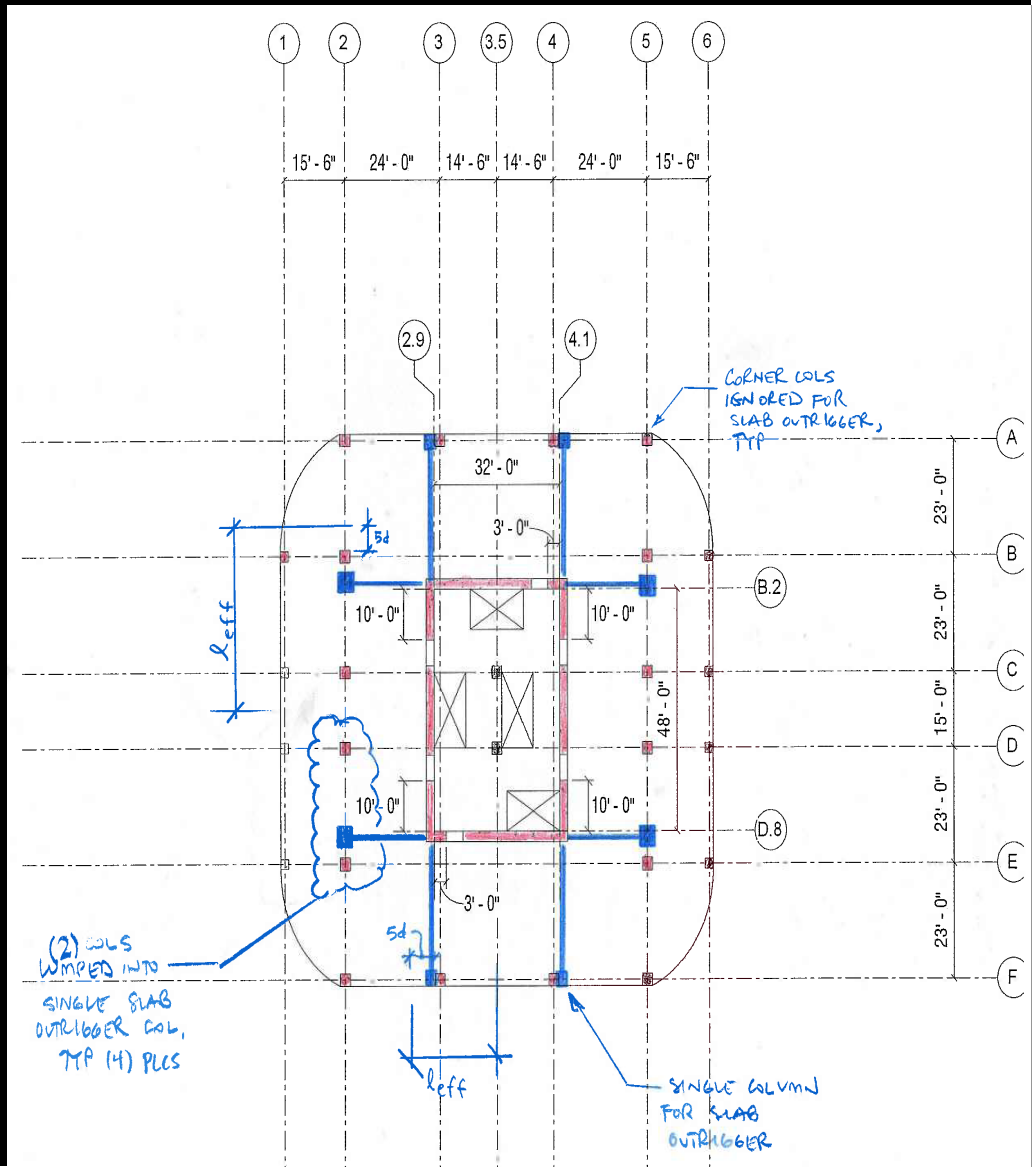
- Shears at Grade:
  - Seismic V_X = 4,581k V_Y = 4,581k
  - Wind V_X = 2,080k V_Y = 2,080k
- Overturning Moment at Grade
  - Seismic M_Y = 587,000 k-ft M_X = 697,000 k-ft
  - Wind M_Y = 540,000 k-ft M_X = 513,000 k-ft
- Maximum Story Drifts:
  - Δ_X = 1.1%
  - Δ_Y = 0.8%

LATBC & PEER TBI Seismic Hazard Spectra



LATBC & PEER TBI—Serviceability Model

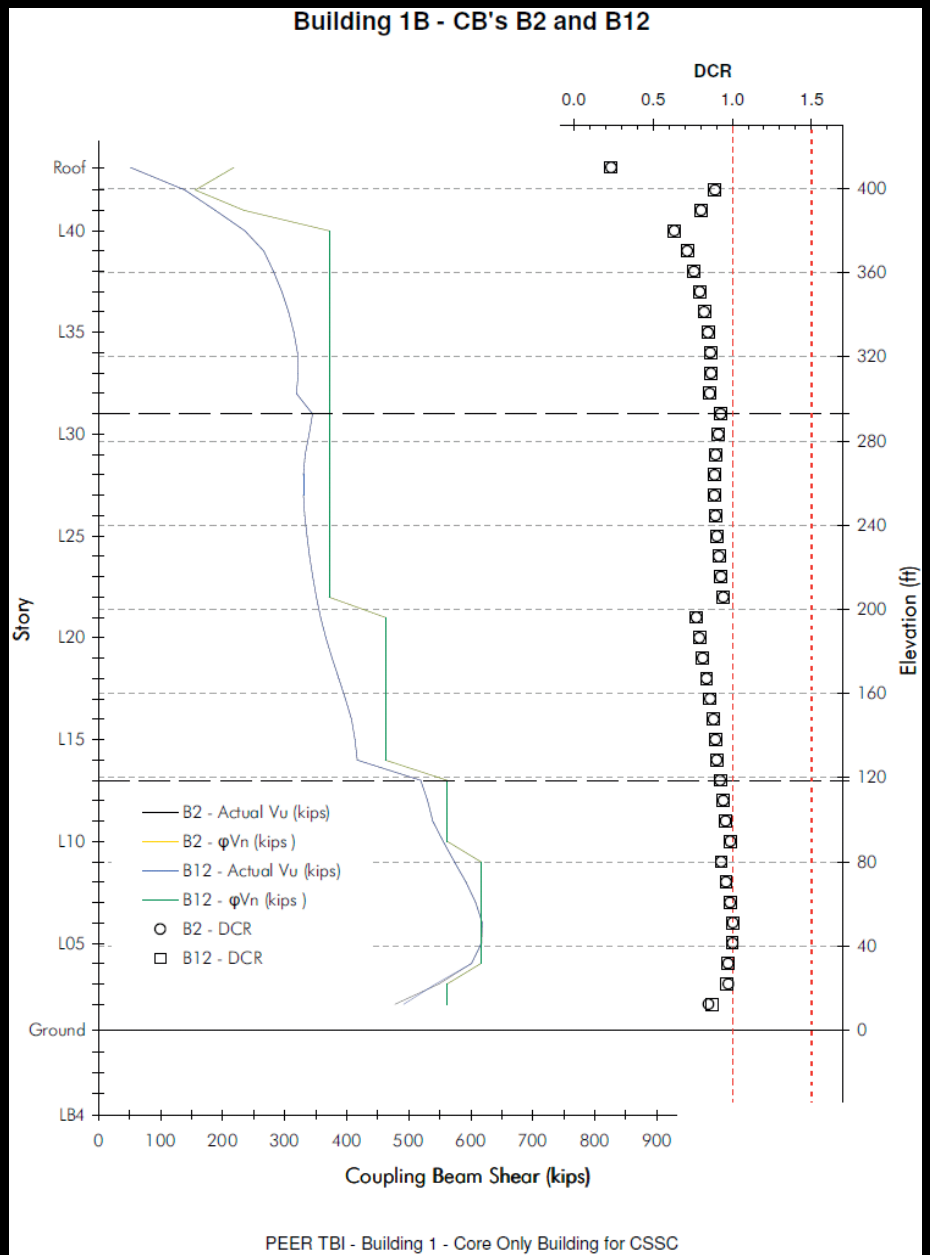
- 3-D Model using ETABS
- Elastic RSA
- Model Included Slab Outriggers



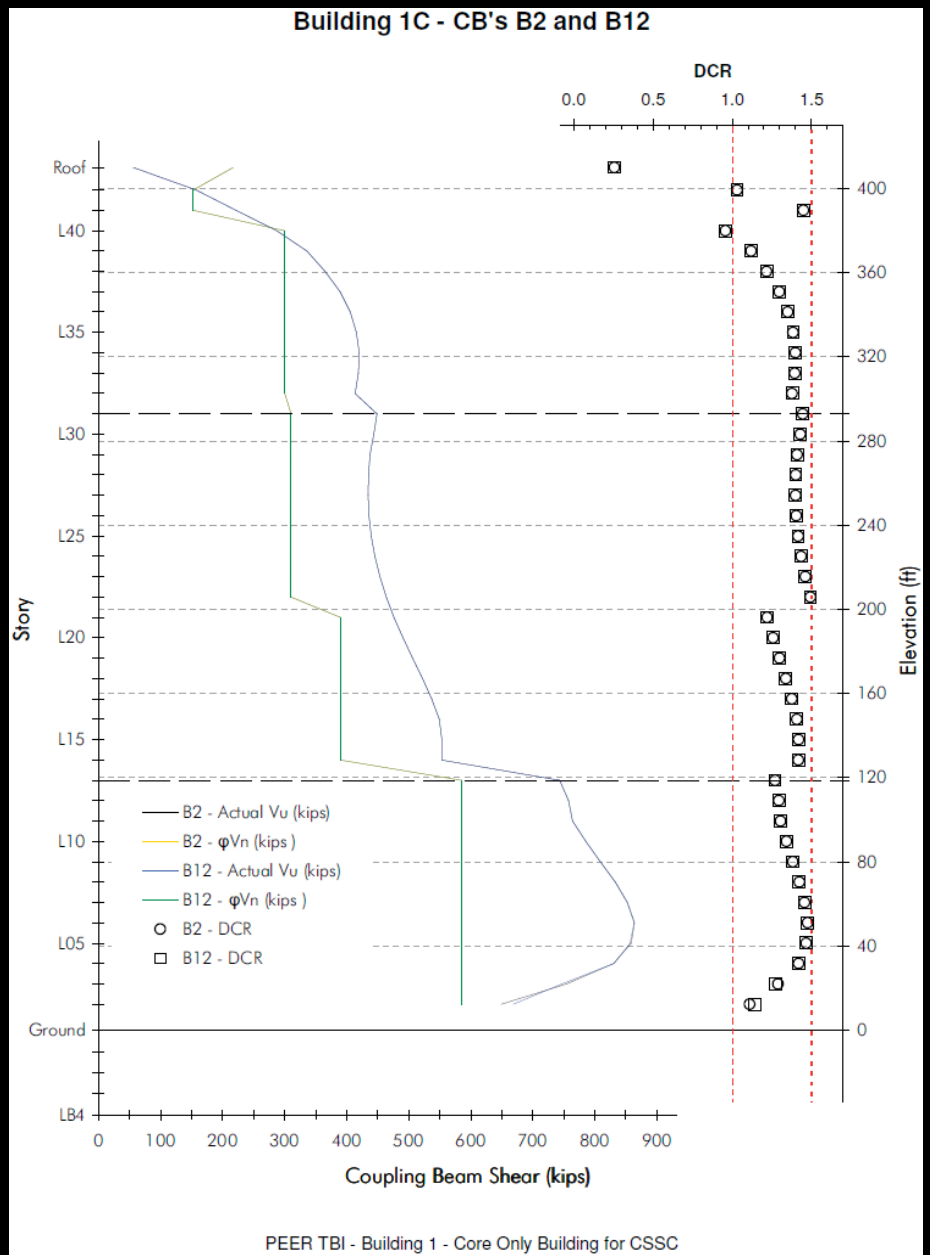
Summary of Results—Code & Serviceability

	CODE Building 1A	LATBC Building 1B	PEER TBI Building 1C
Code/Service EQ Base Shear (kips)	Vx = 4,581 Vy = 4,581	Vx = 5,013 Vy = 6,018	Vx = 6,686 Vy = 8,151
Service EQ Overturning Moment (kip-ft)	My = 587,000 Mx = 697,000	My = 591,000 Mx =921,000	My = 892,000 Mx =1,371,000
Wall thicknesses	Grade – Lvl 25 = 24 in Lvl 25 – Roof = 21 in	Grade – Lvl 13 = 28 in (E-W) and 32 in (N-S) Lvl 13 – Lvl 31 = 24 in Lvl 31 – Roof = 21 in	Grade – Lvl 13 = 32 in (E-W) and 36 in (N-S) Lvl 13 – Lvl 31 = 24 in Lvl 31 – Roof = 21 in
Periods (sec)	6.7 4.8 2.6 (ETABS)	4.2 3.4 2.3 (PERFORM)	4.0 3.2 2.2 (PERFORM)

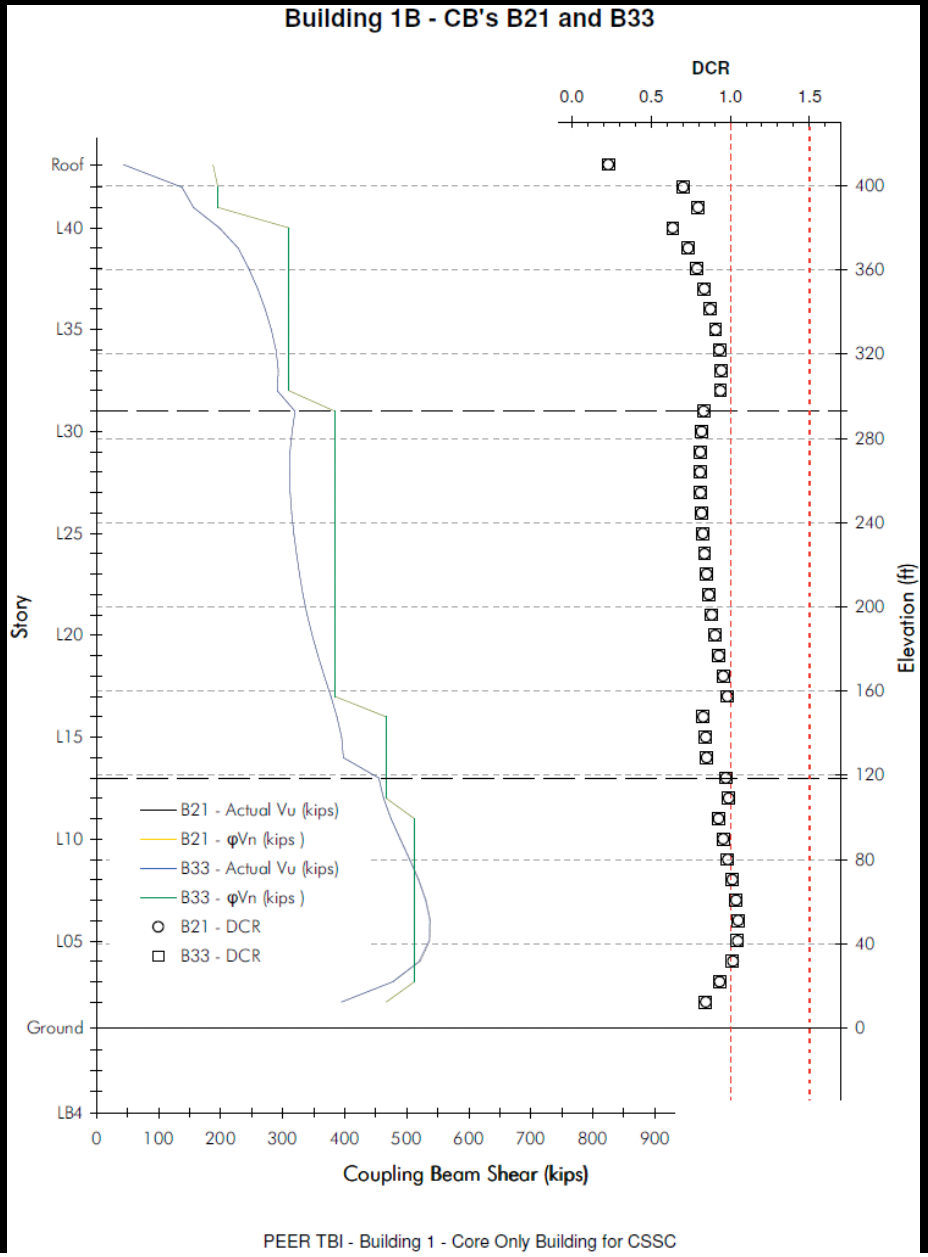
LATBC



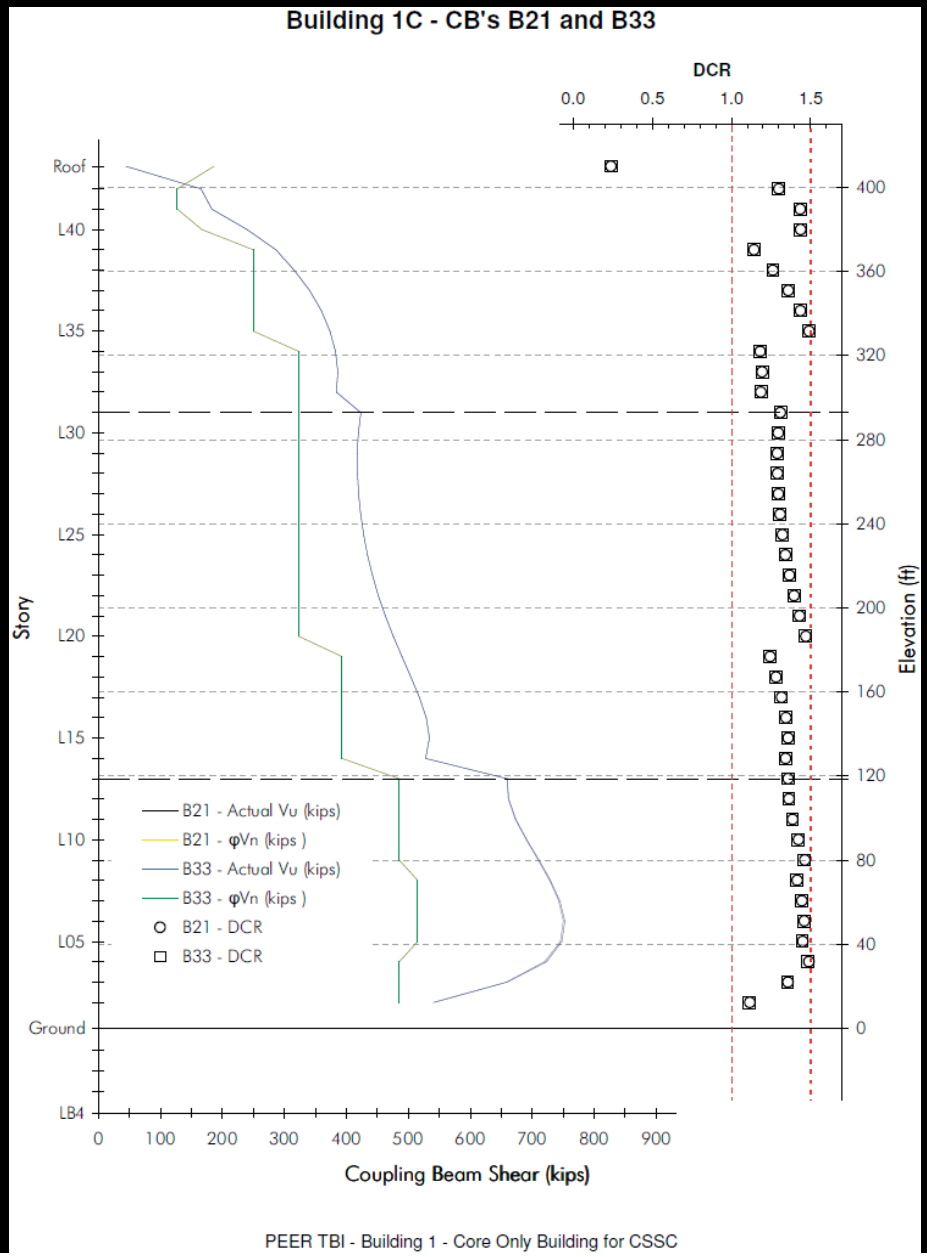
PEER TBI



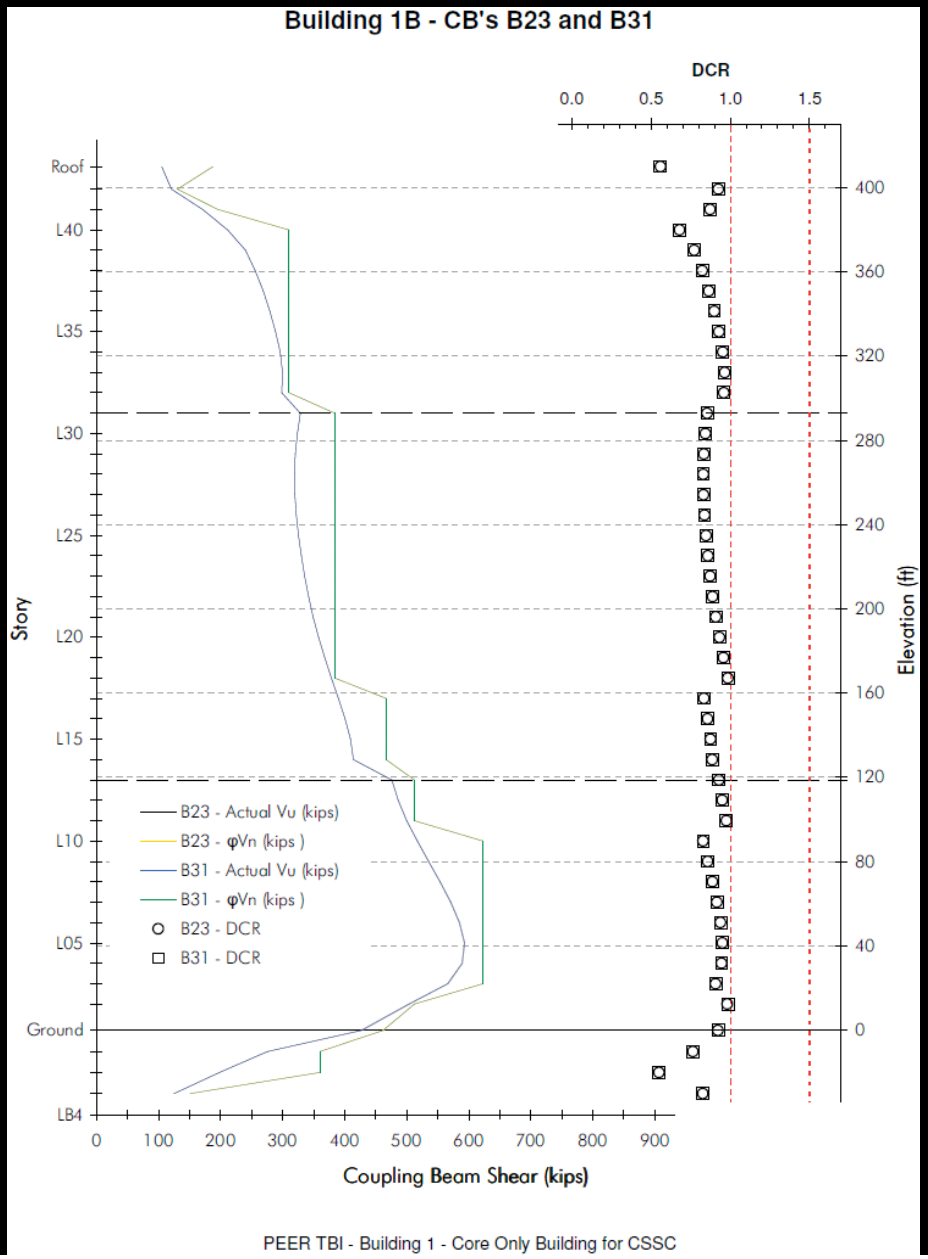
LATBC



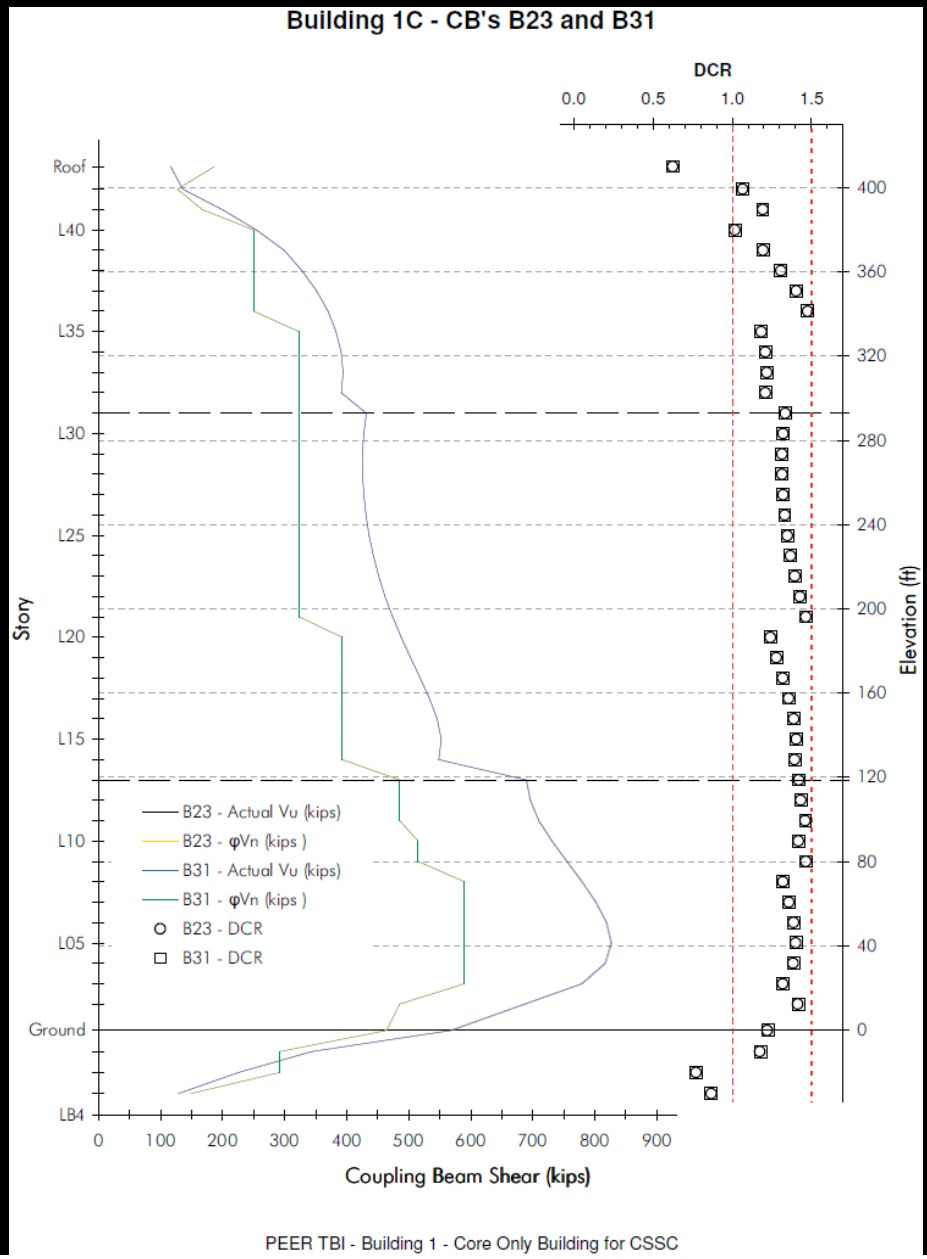
PEER TBI



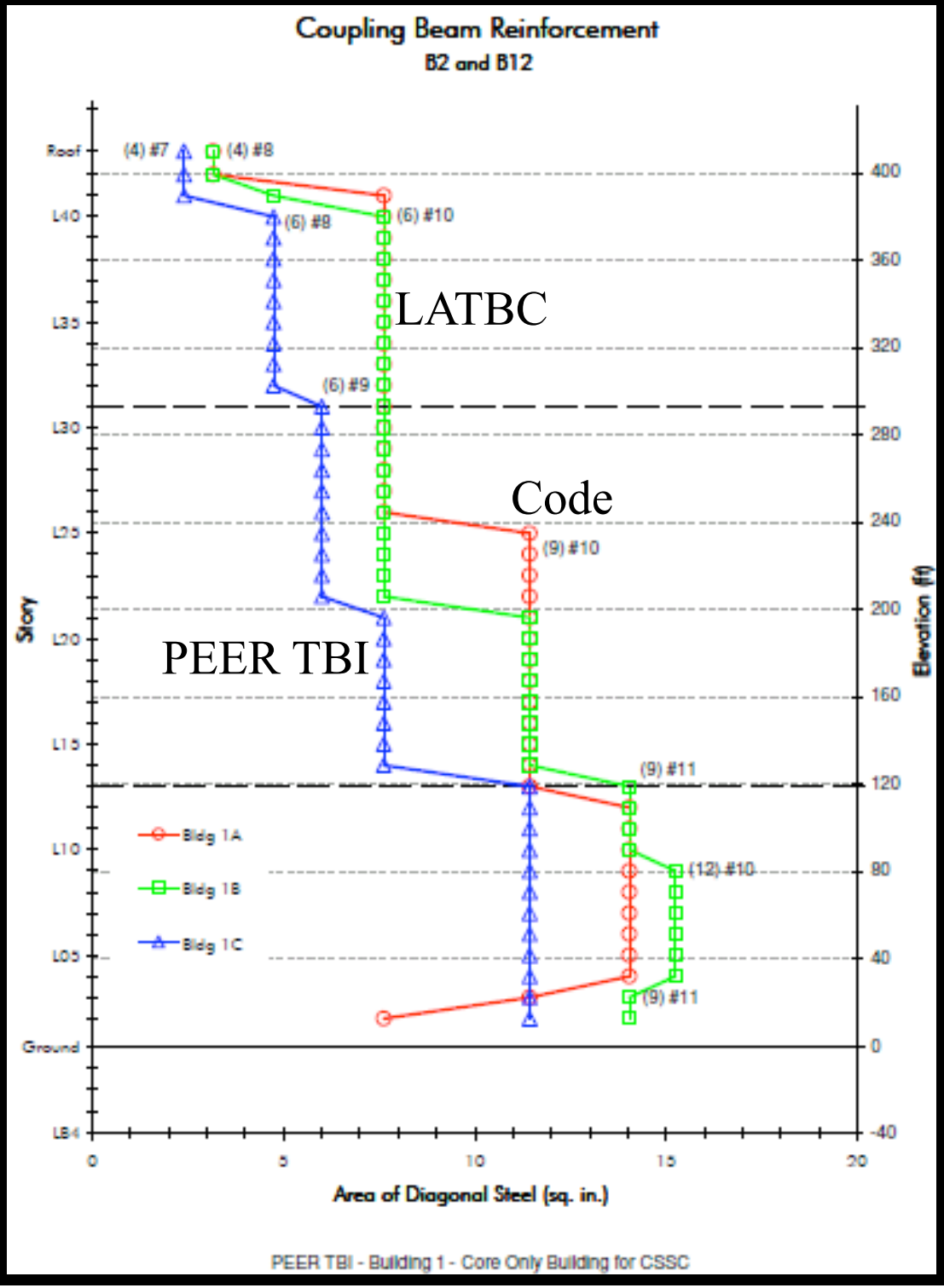
LATBC



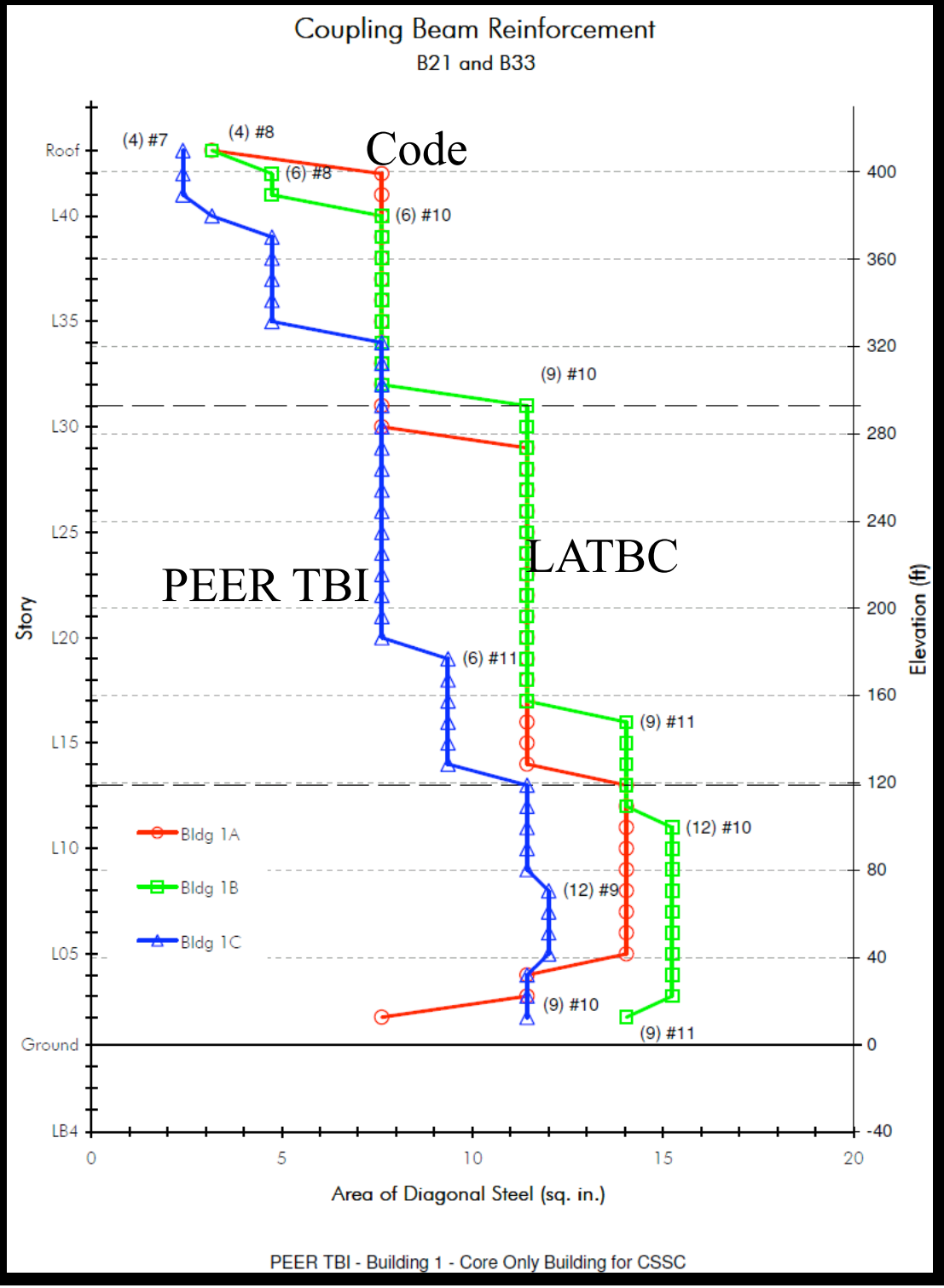
PEER TBI



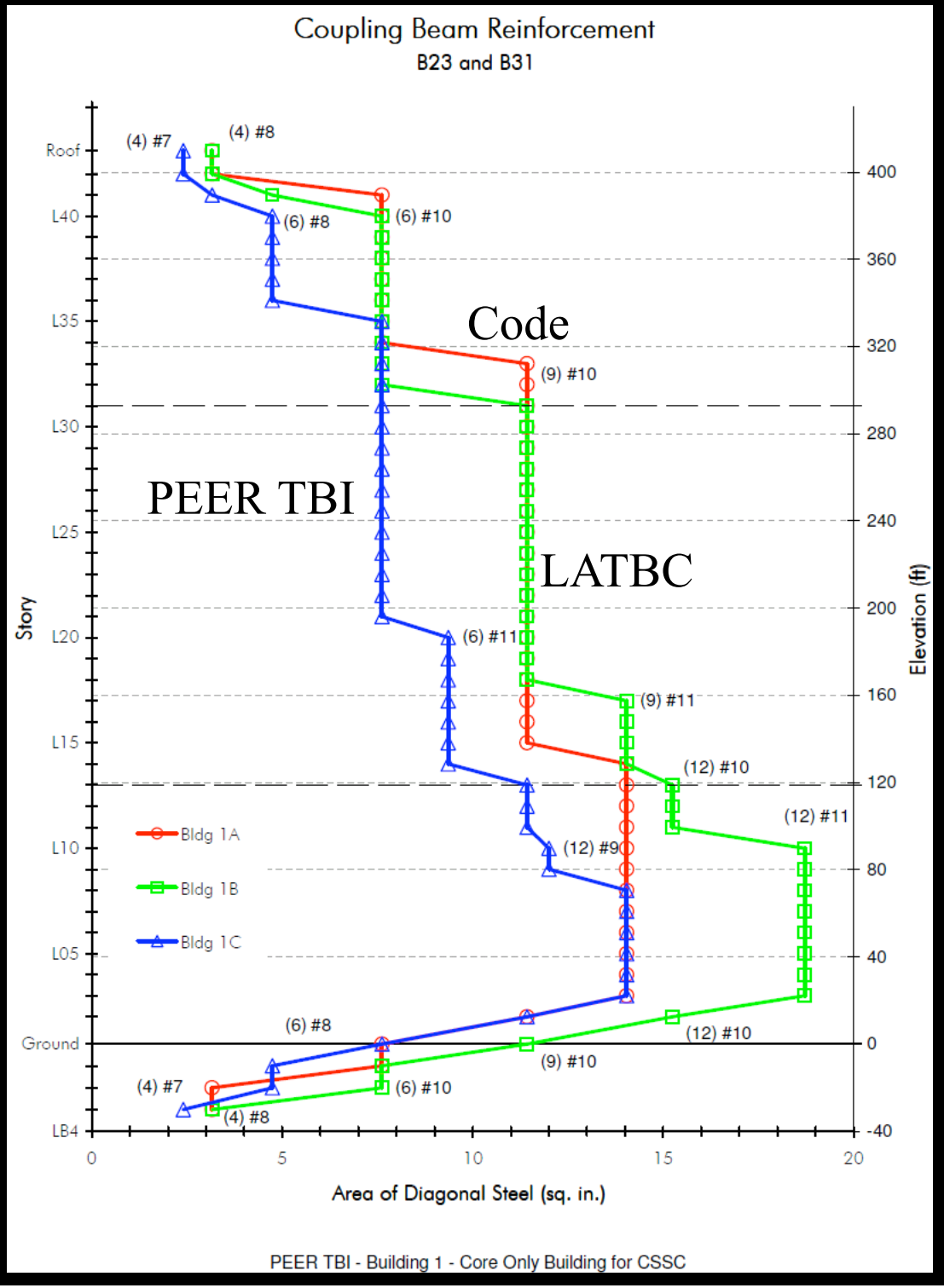
Coupling Beam Reinforcement



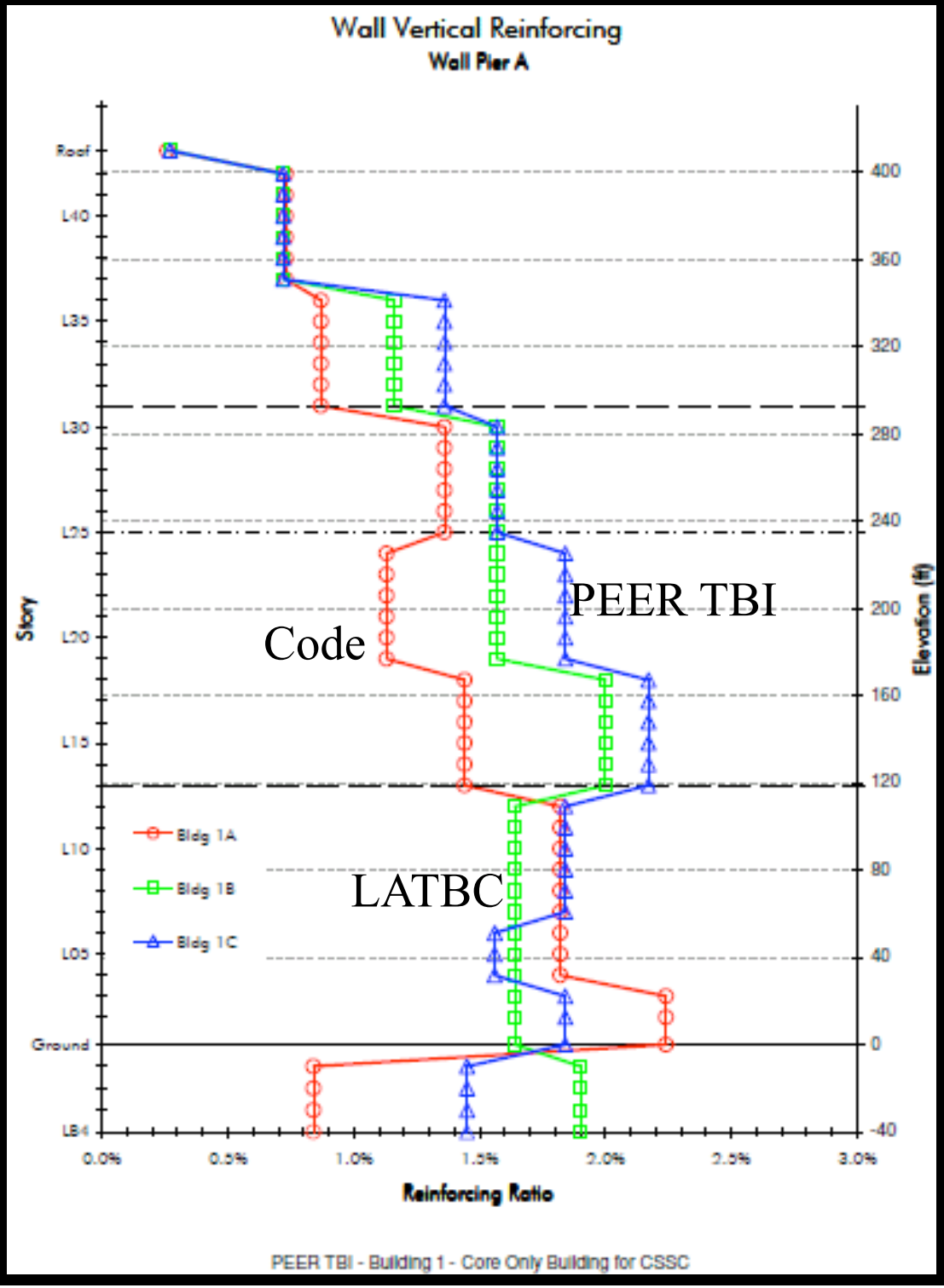
Coupling Beam Reinforcement



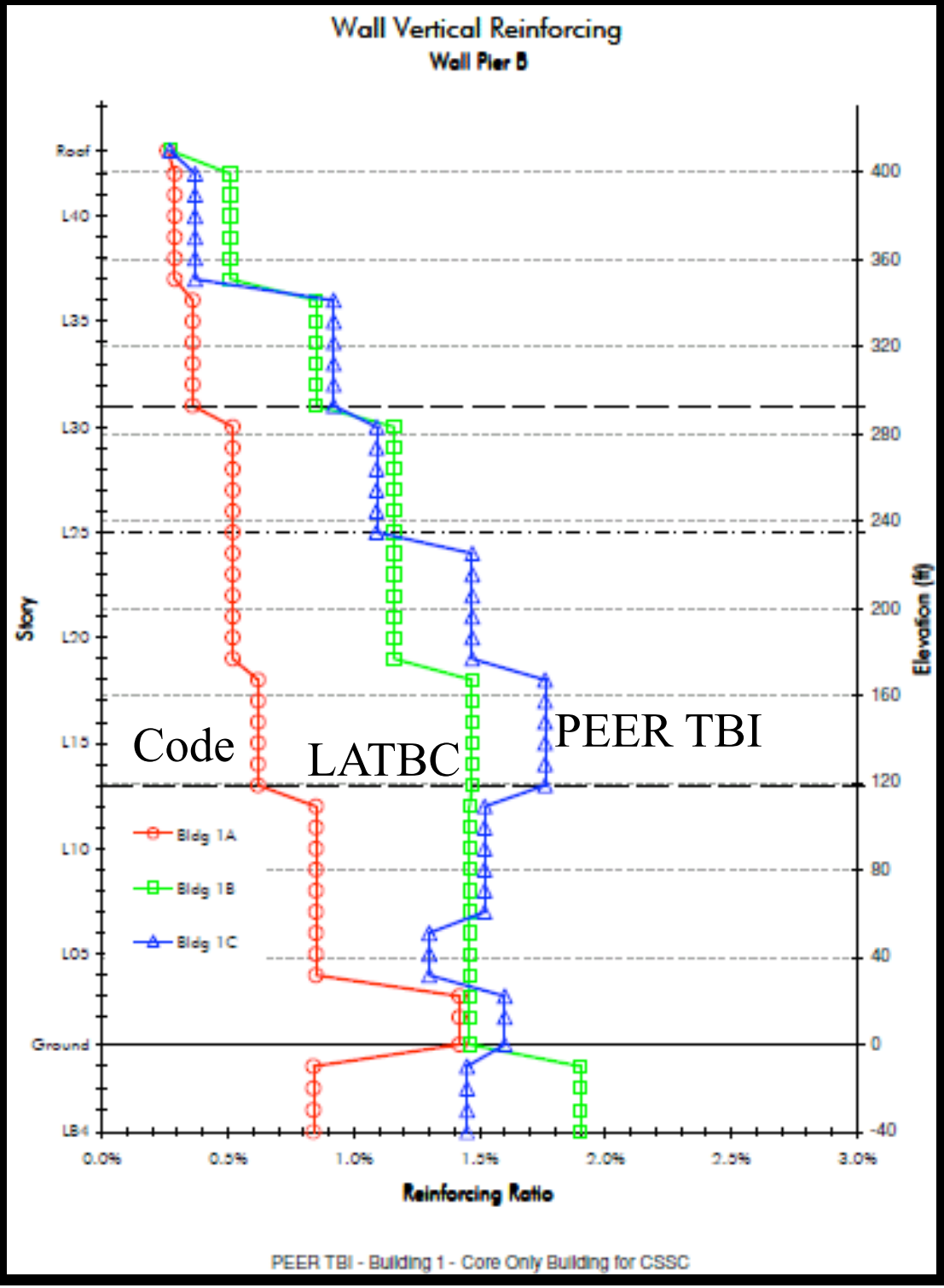
Coupling Beam Reinforcement



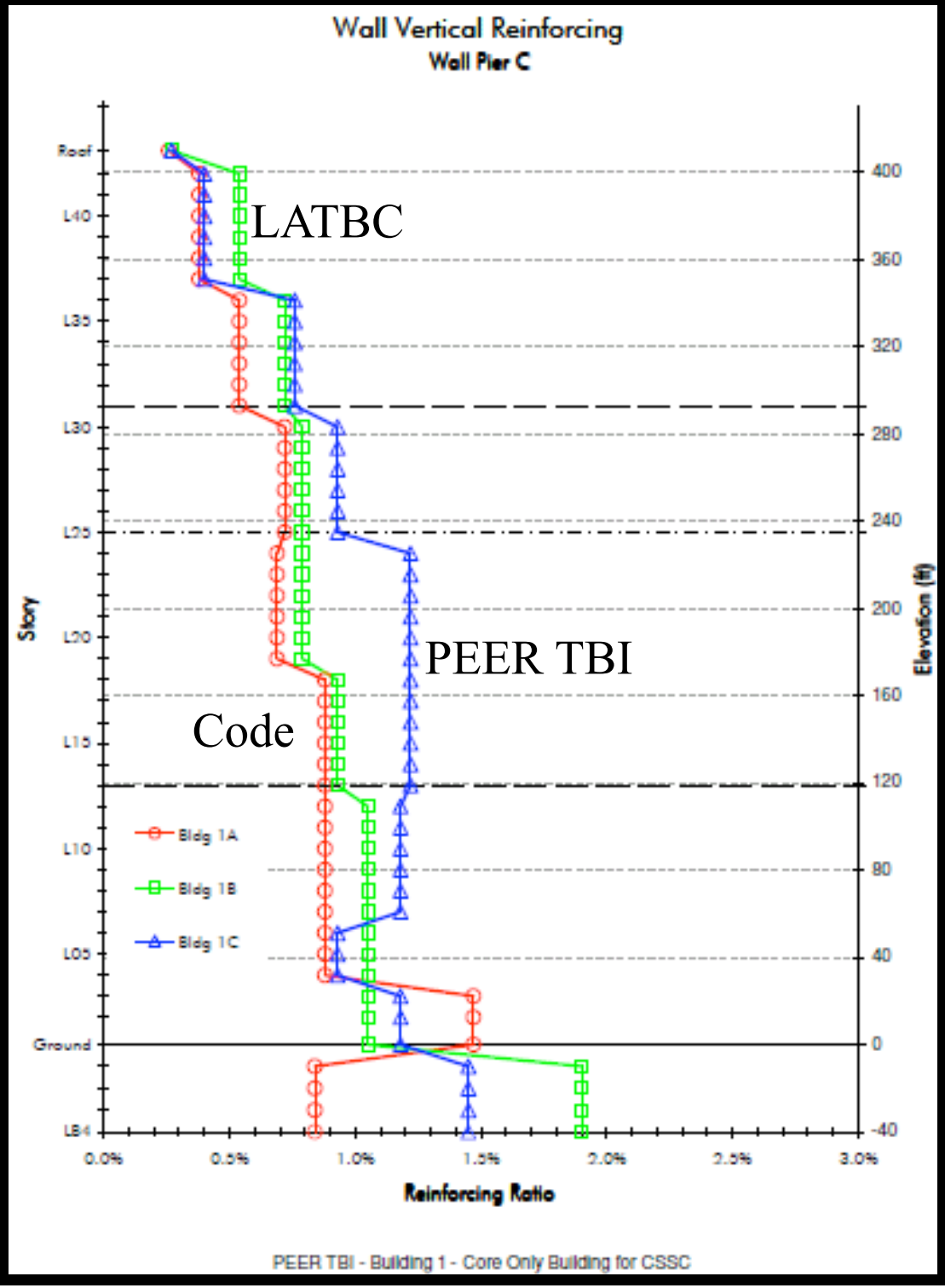
Vertical Wall Reinforcement



Vertical Wall Reinforcement



Vertical Wall Reinforcement



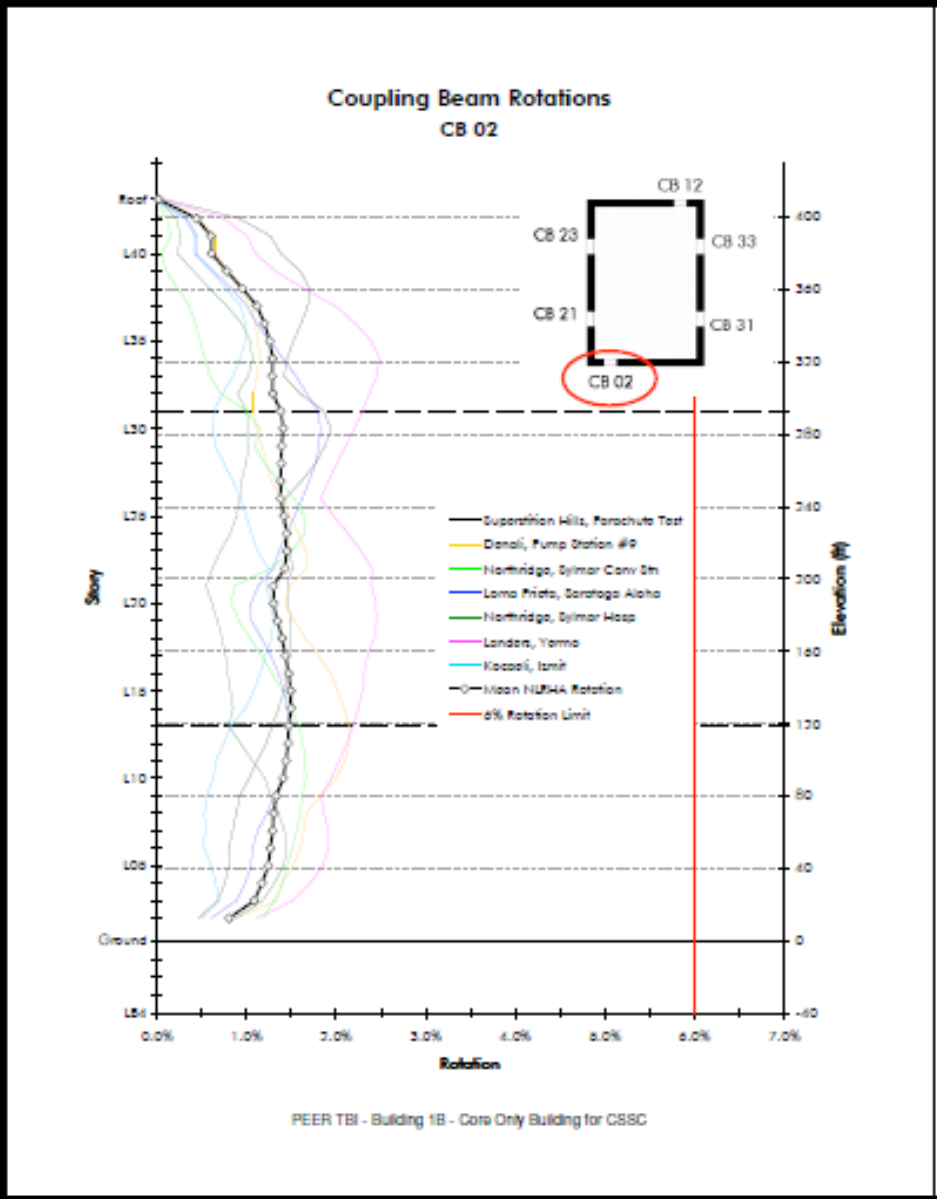
LATBC & PEER TBI—MCE Model

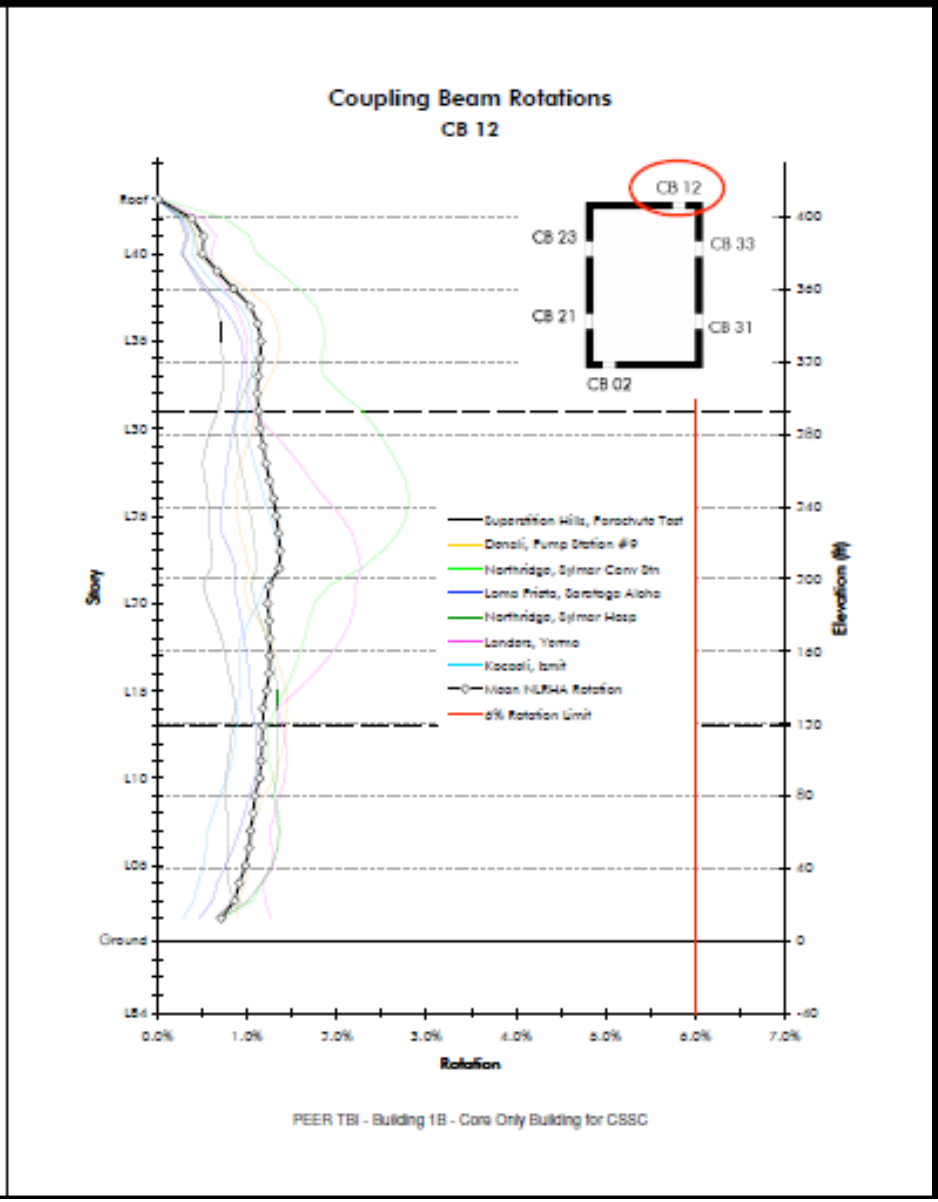
- 3-D model using CSI Perform-3D
- Modeled as inelastic:
  - Coupling beams
  - Core wall flexural behavior
  - “Slab-beams“
- Modeled as elastic:
  - Core wall shear behavior
  - Diaphragm slabs
  - Columns
  - Basement walls
- Model extended to mat

LATBC and PEER TBI—MCE Acceptance Criteria

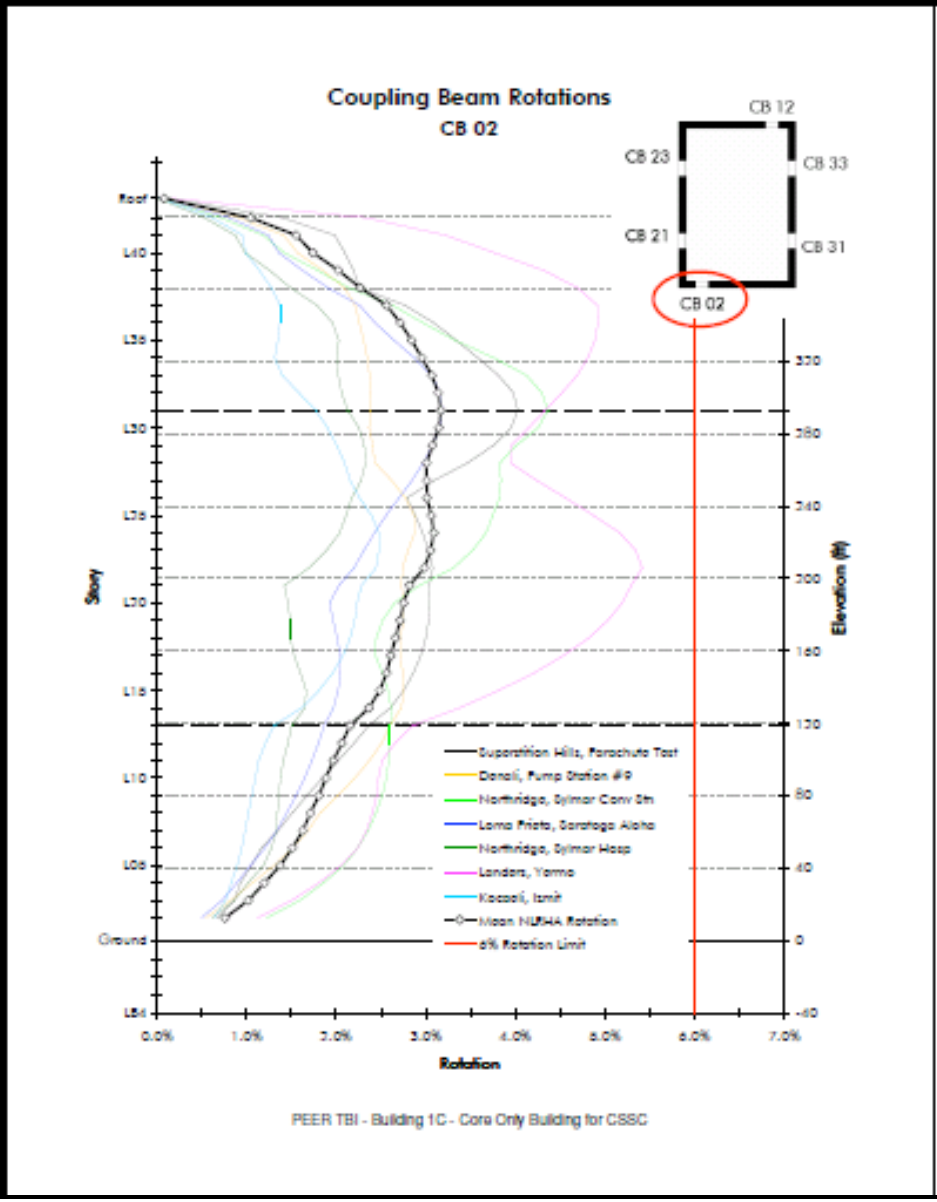
- Story Drift: 3 %
- Coupling Beam Rotation: 0.06 radian limit
- Core Wall Reinforcement Axial Strain:
  - Tensile strain = 0.05
  - Compression strain = 0.02
- Core Wall Concrete Axial Strain: Fully Confined Concrete Compression Strain = 0.015
- Core Wall Shear: Post-Analysis Verification Performed

LATBC Coupling Beam Rotations

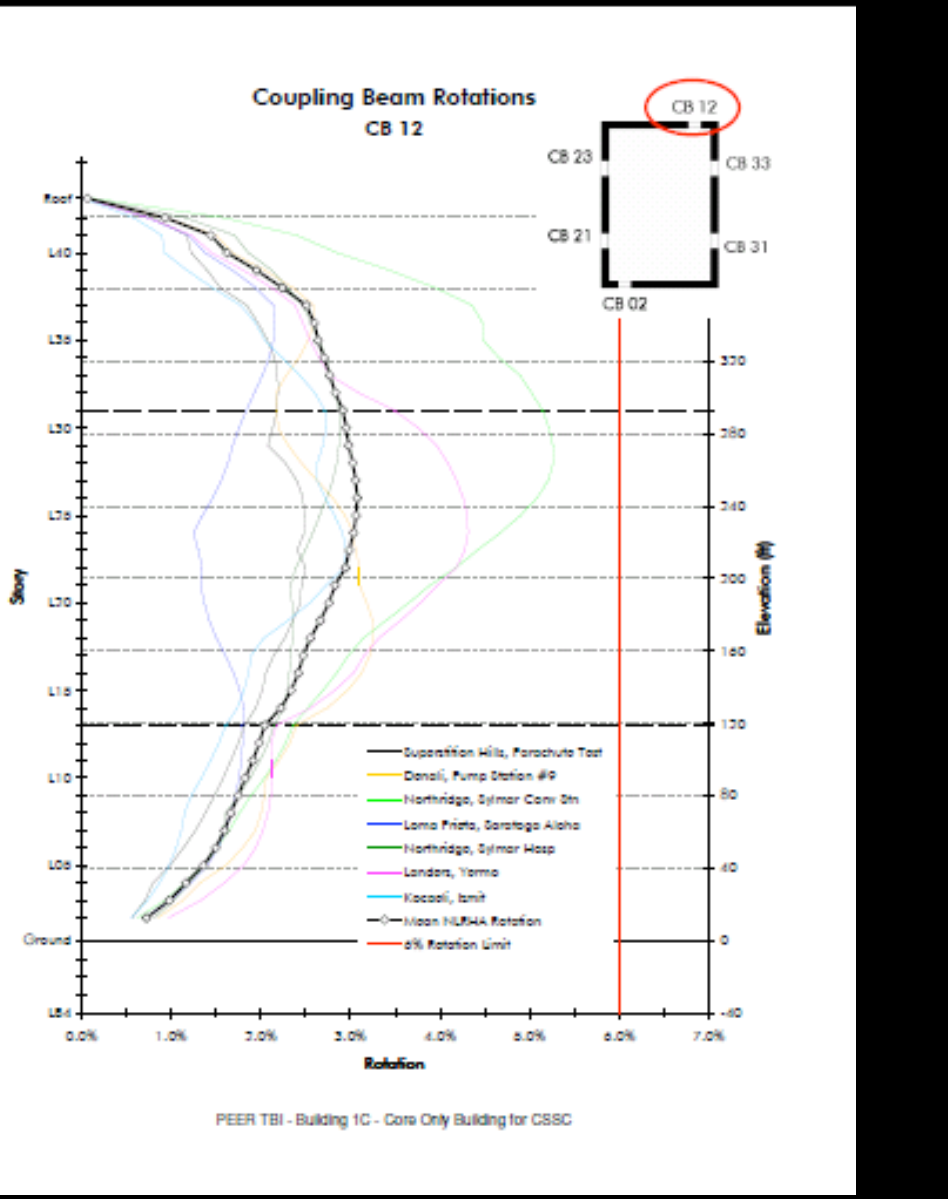




PEER TBI Coupling Beam Rotations

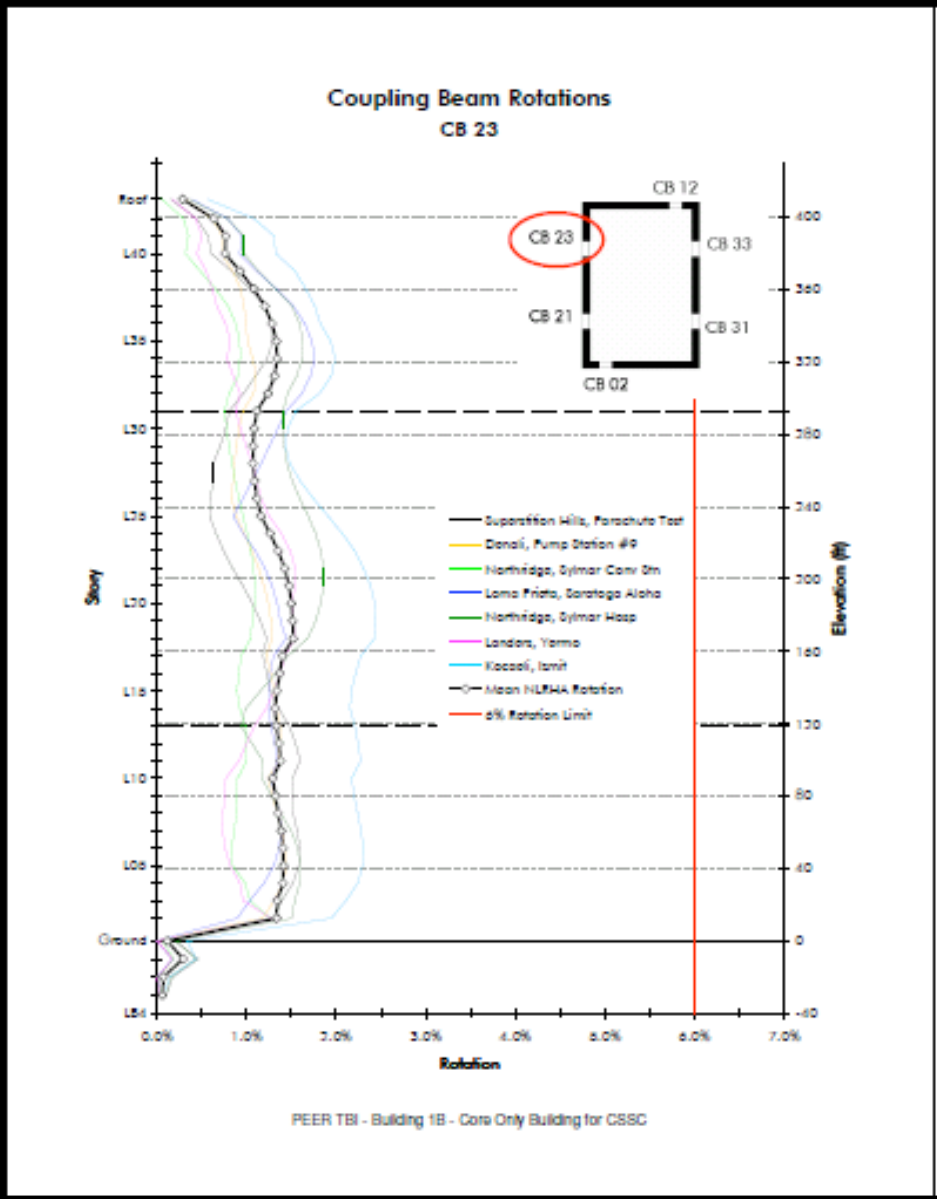


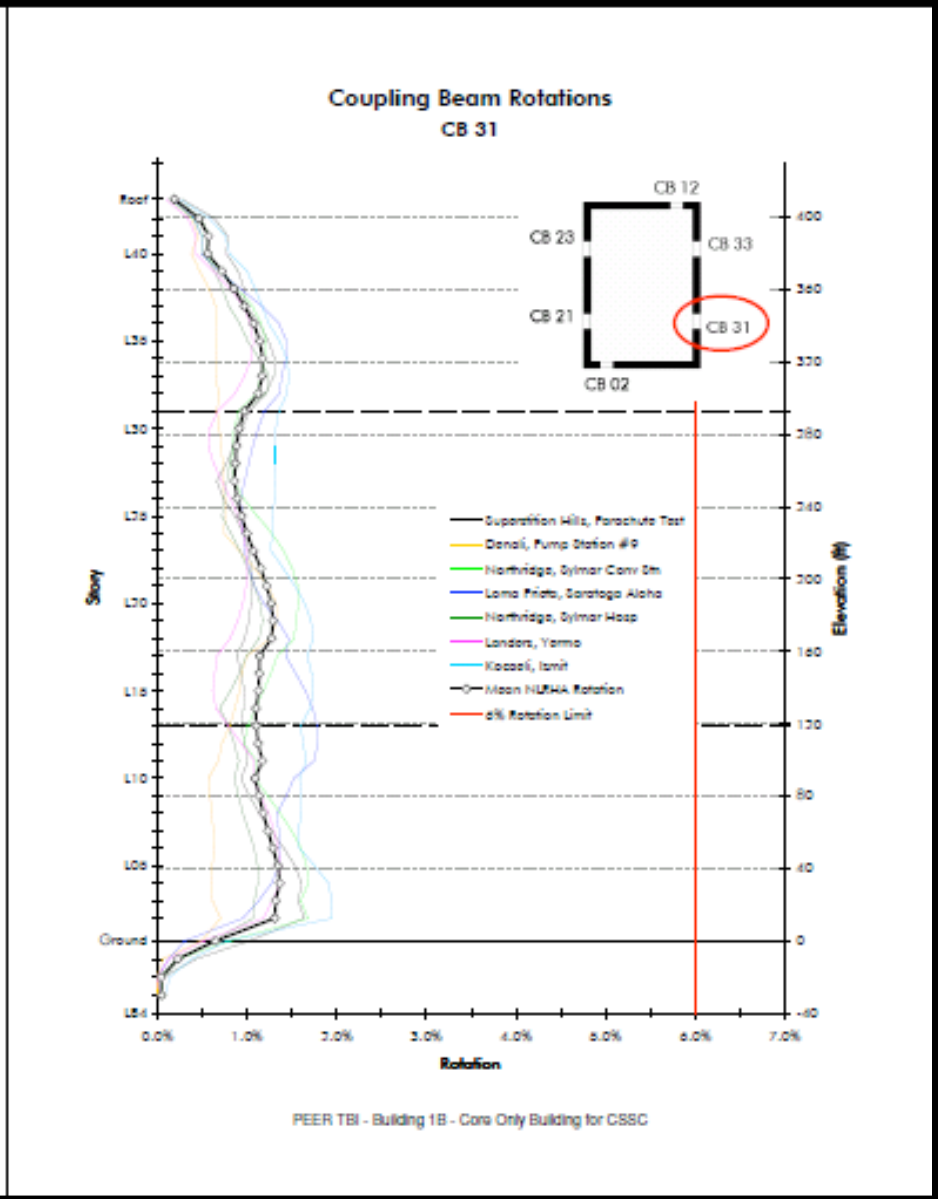
PEER TBI - Building 1C - Core Only Building for CSSC



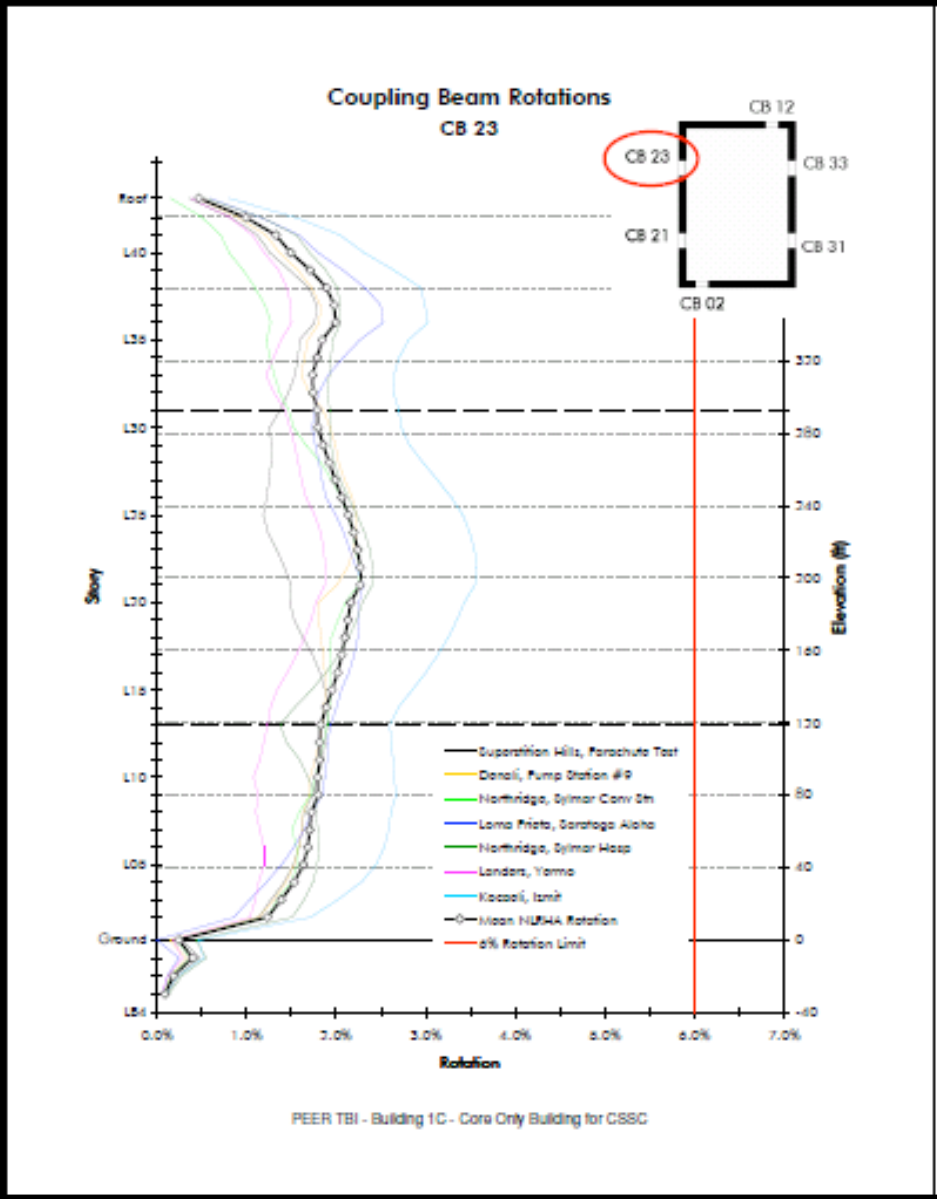
PEER TBI - Building 1C - Core Only Building for CSSC

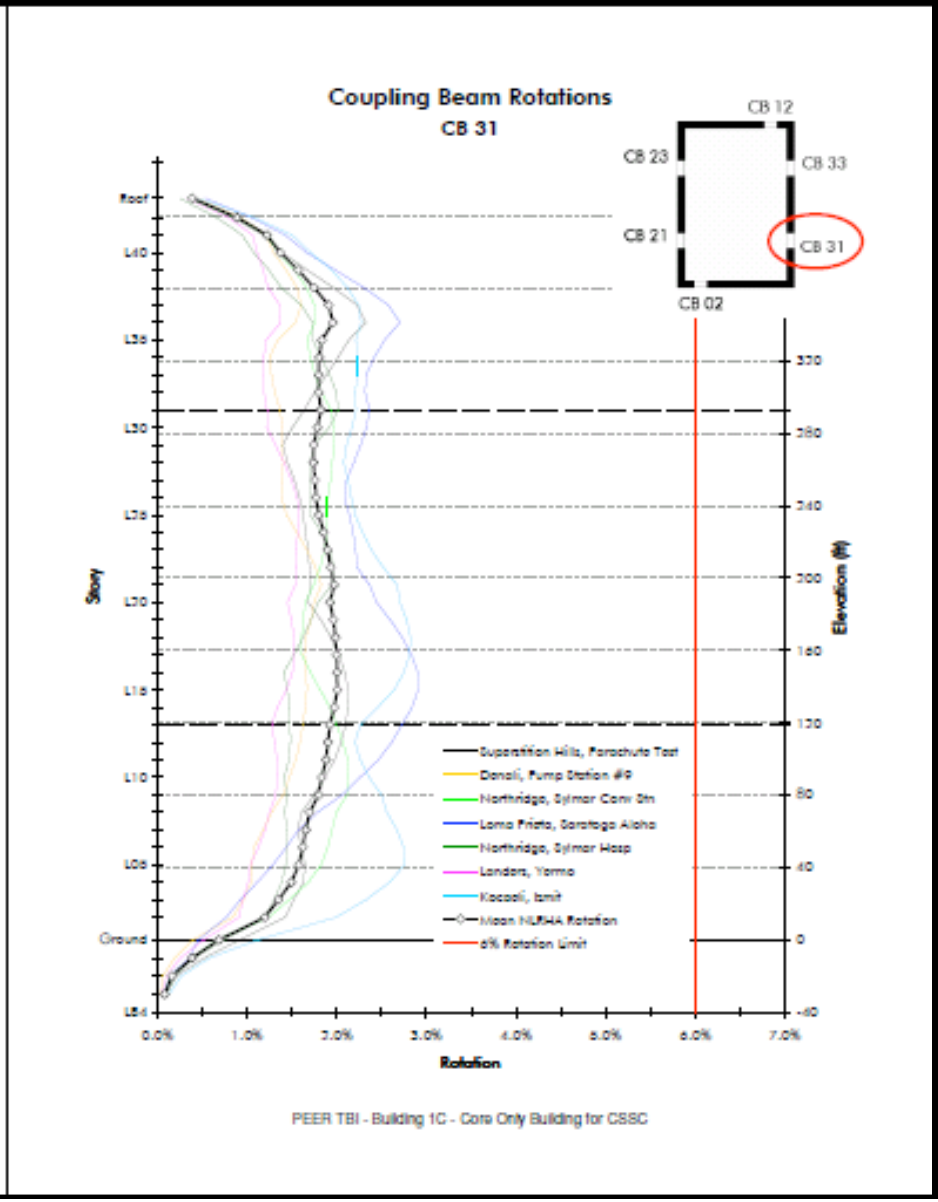
LATBC Coupling Beam Rotations



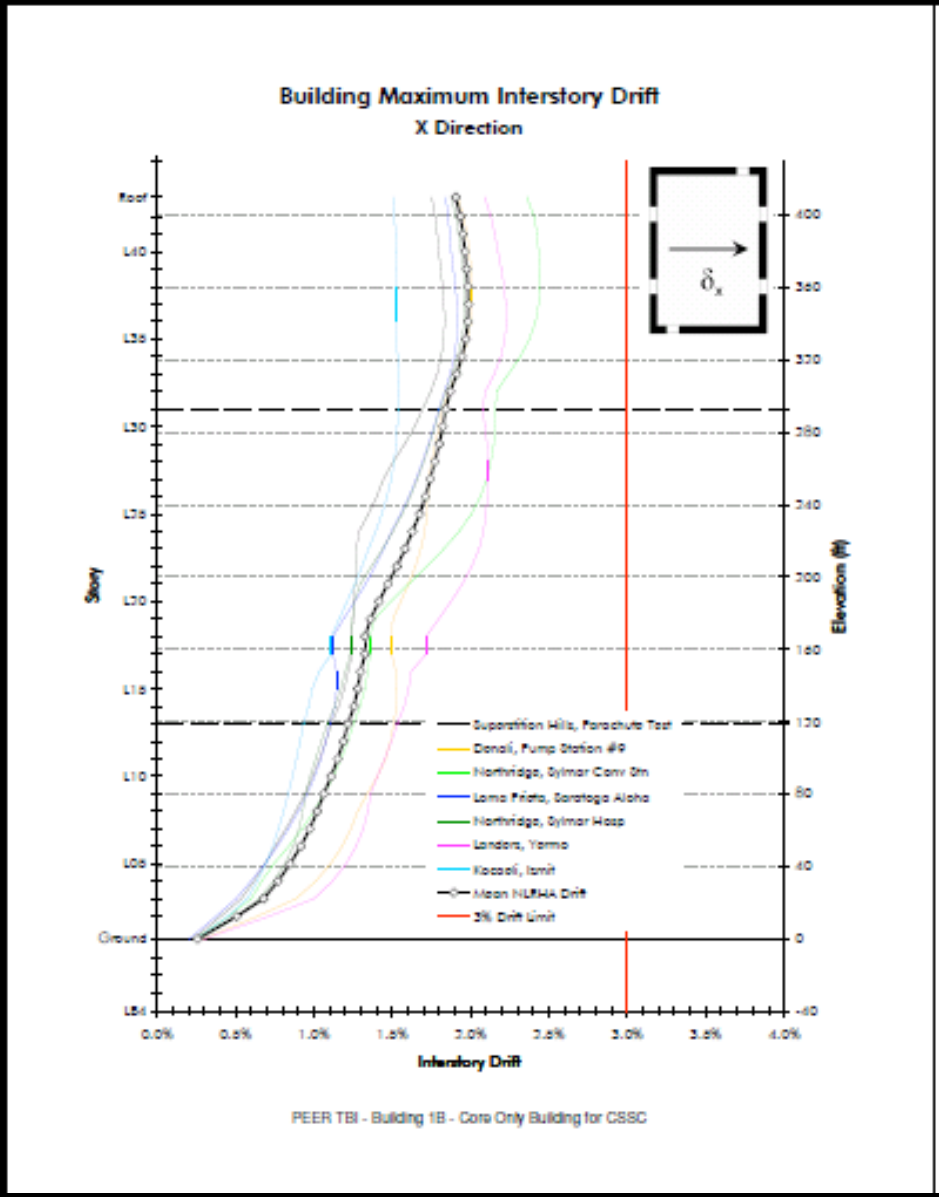


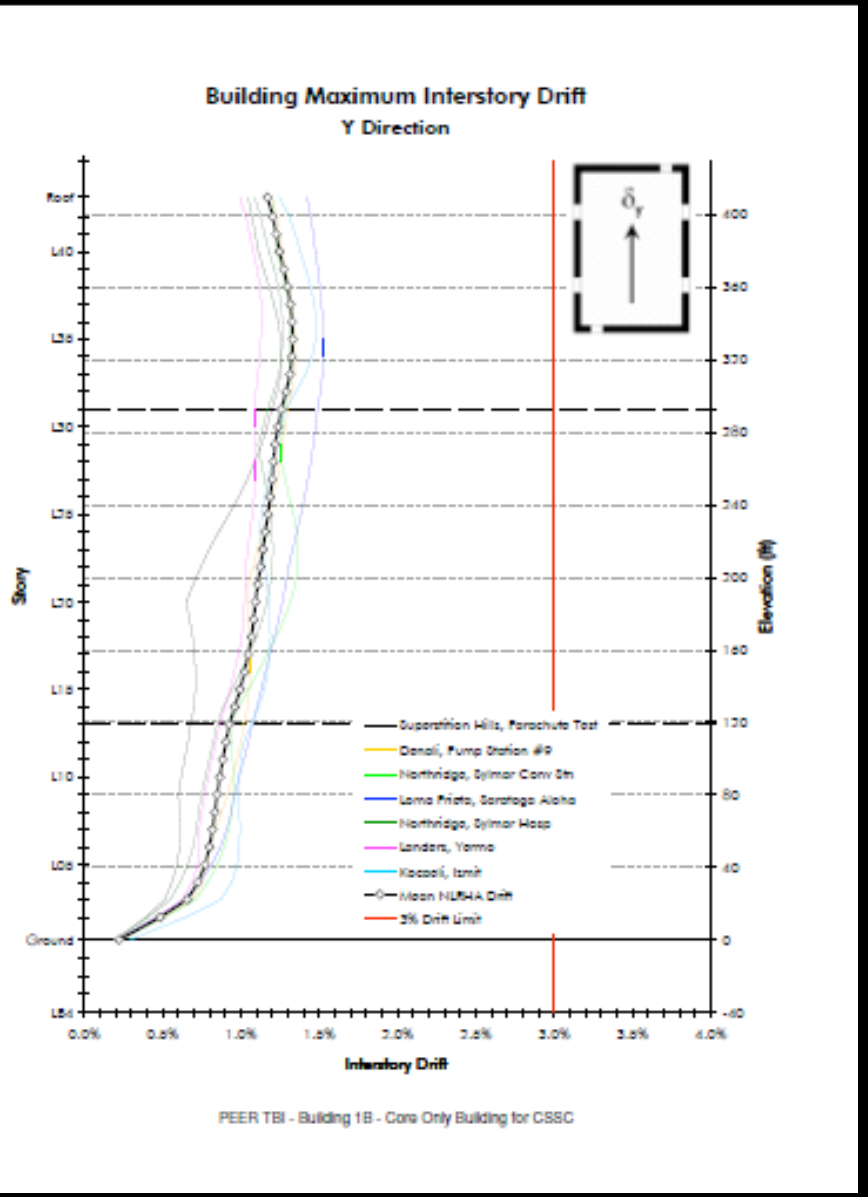
PEER TBI Coupling Beam Rotations



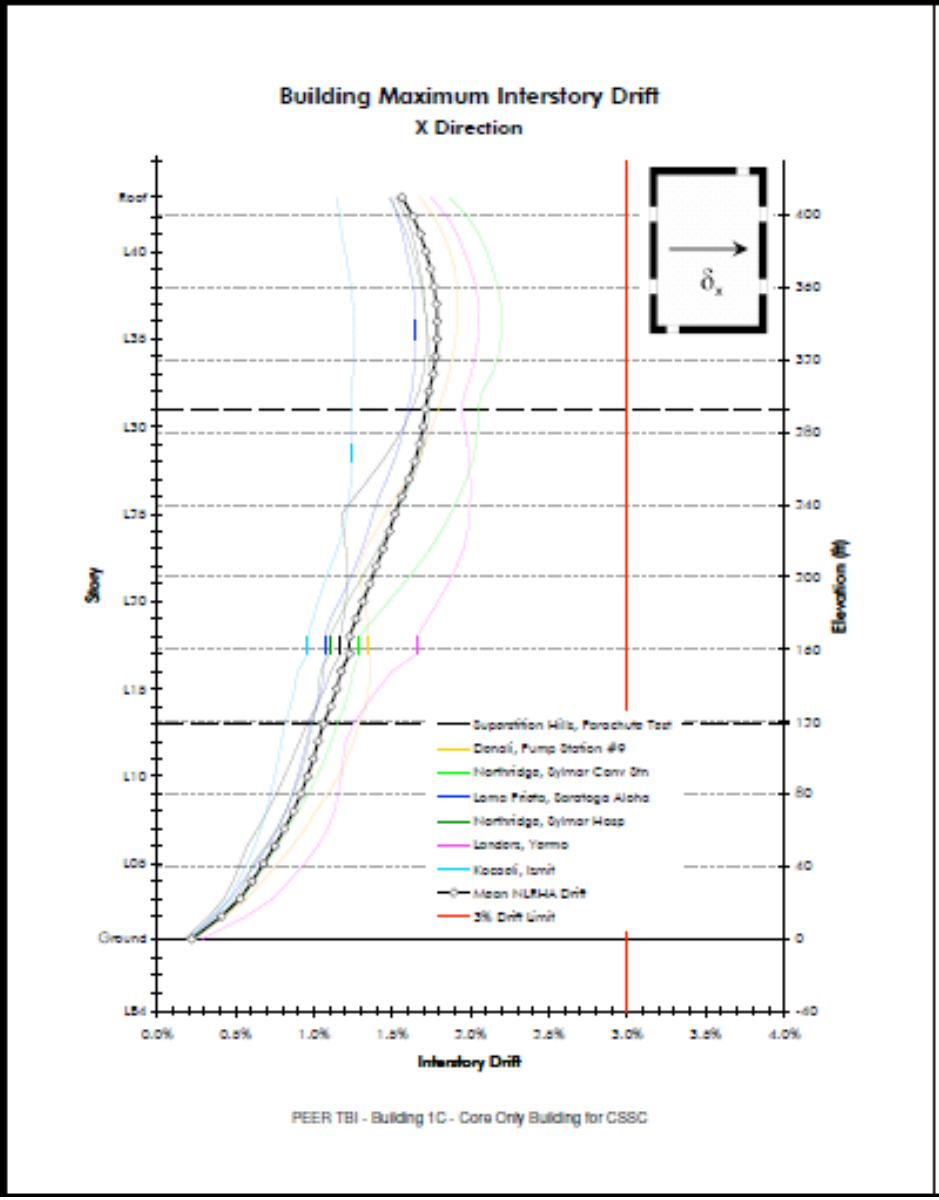


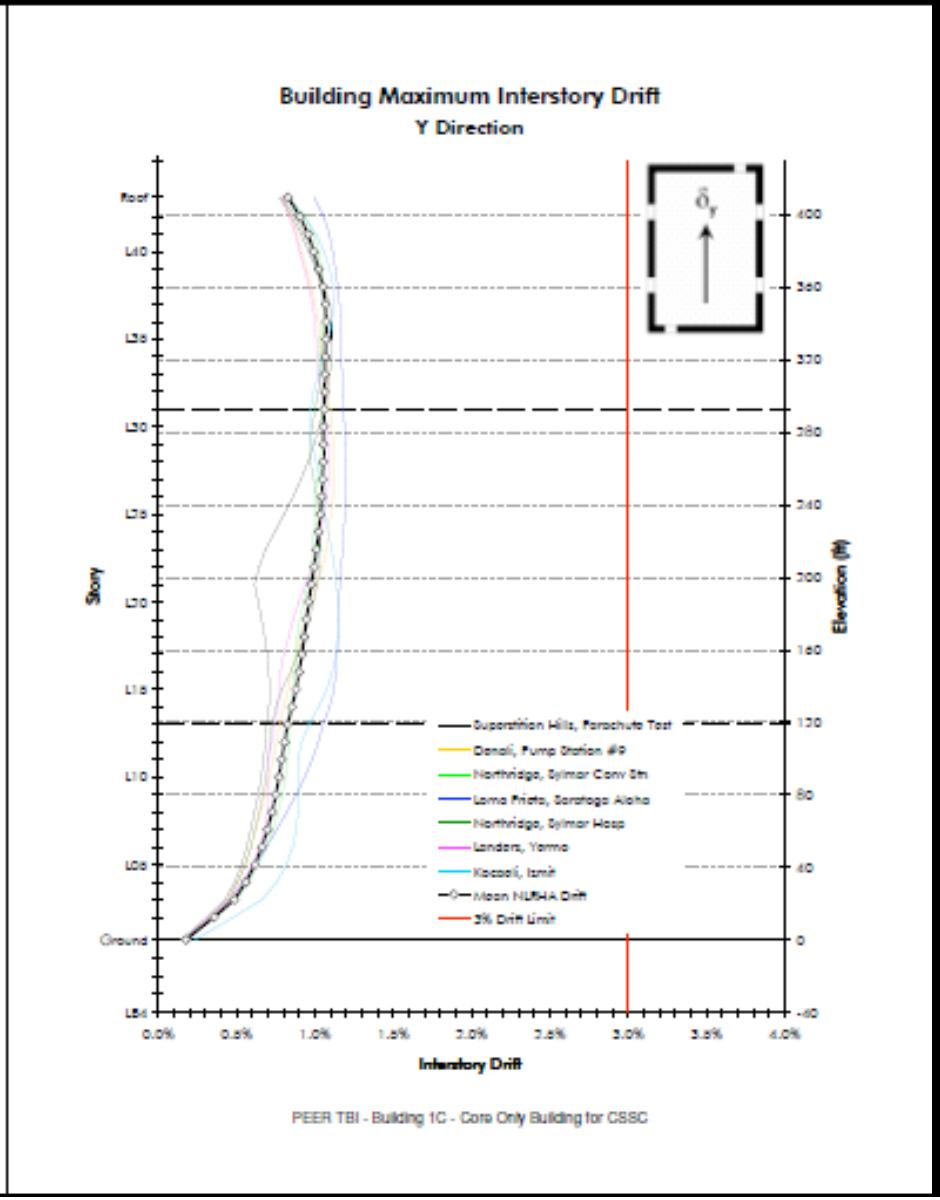
LATBC Story Drifts





PEER TBI Story Drifts





Case Study #1 Observations

- Core wall shear is the governing design parameter & governs wall thickness
- Serviceability Design governed over Wind Design for LATBC and PEER TBI
- Walls thicker for PEER TBI vs. LATBC vs. Code
- Serviceability Demands of PEER TBI > LATBC > Code

Case Study #1 Observations

- Coupling Beam Reinforcement for PEER TBI < LATBC ~ Code
- Vertical Wall Reinforcement for PEER TBI > LATBC > Code
- PEER TBI Results in Greater Strong Pier—Weak Coupling Beam Performance than LATBC & Code Designs