

Lateral Response of Cold-Formed Steel Framed Steel Sheathed In-line Wall Systems Detailed for Mid-Rise Buildings

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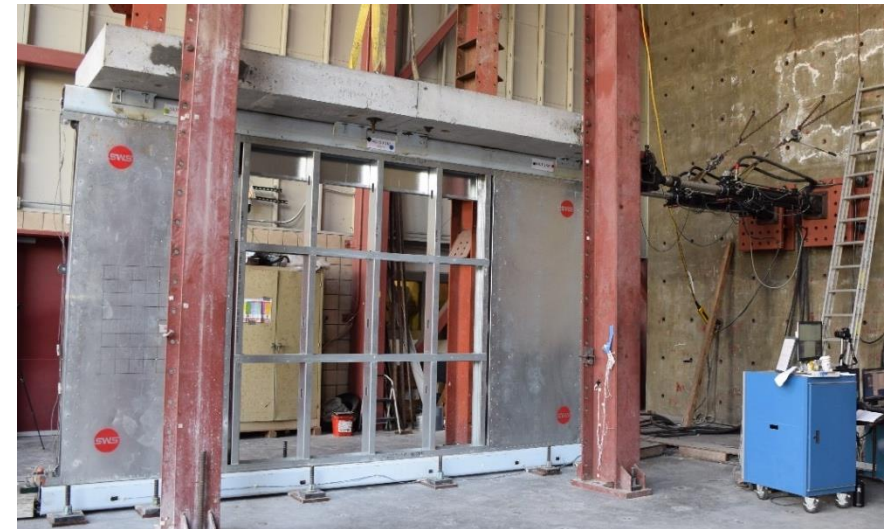


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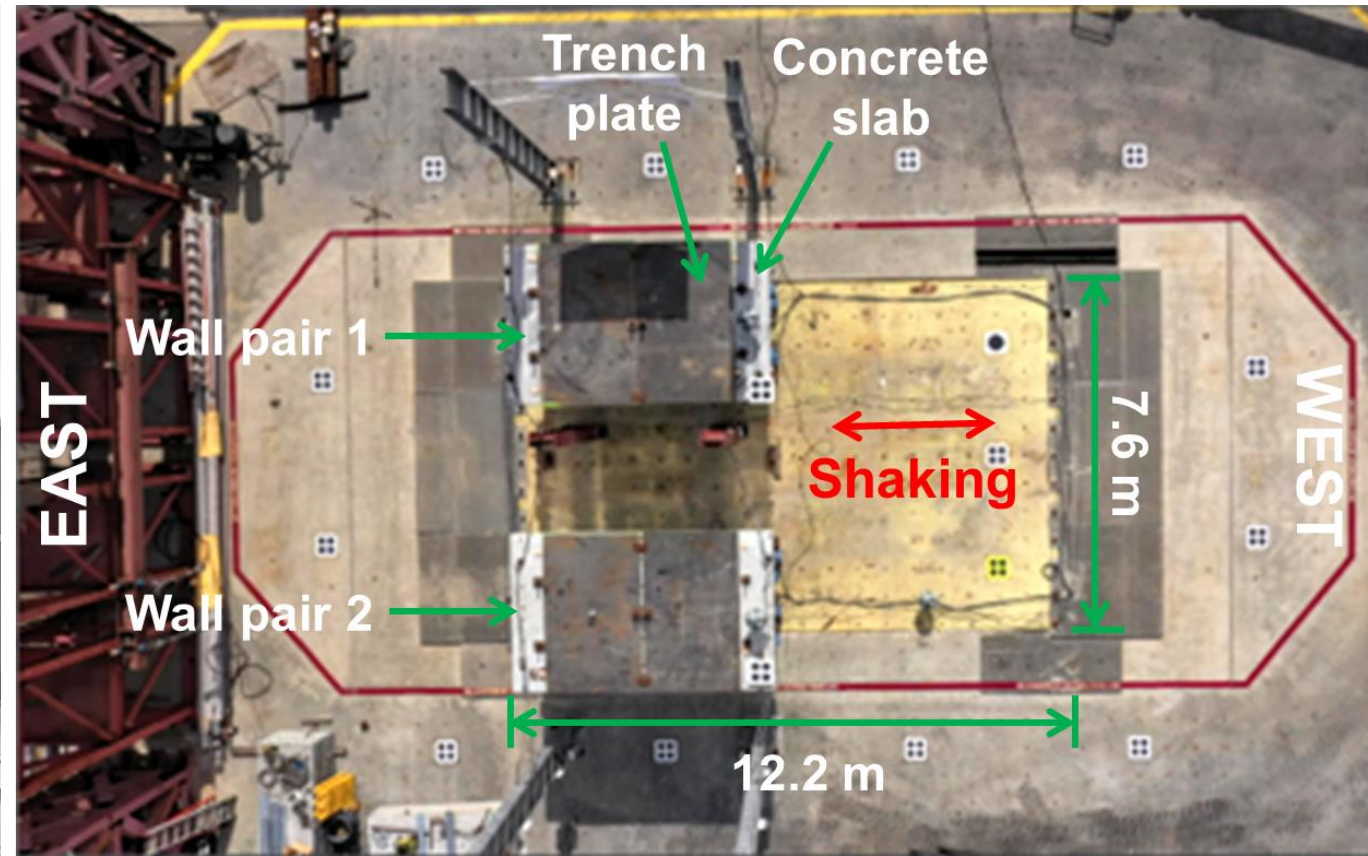
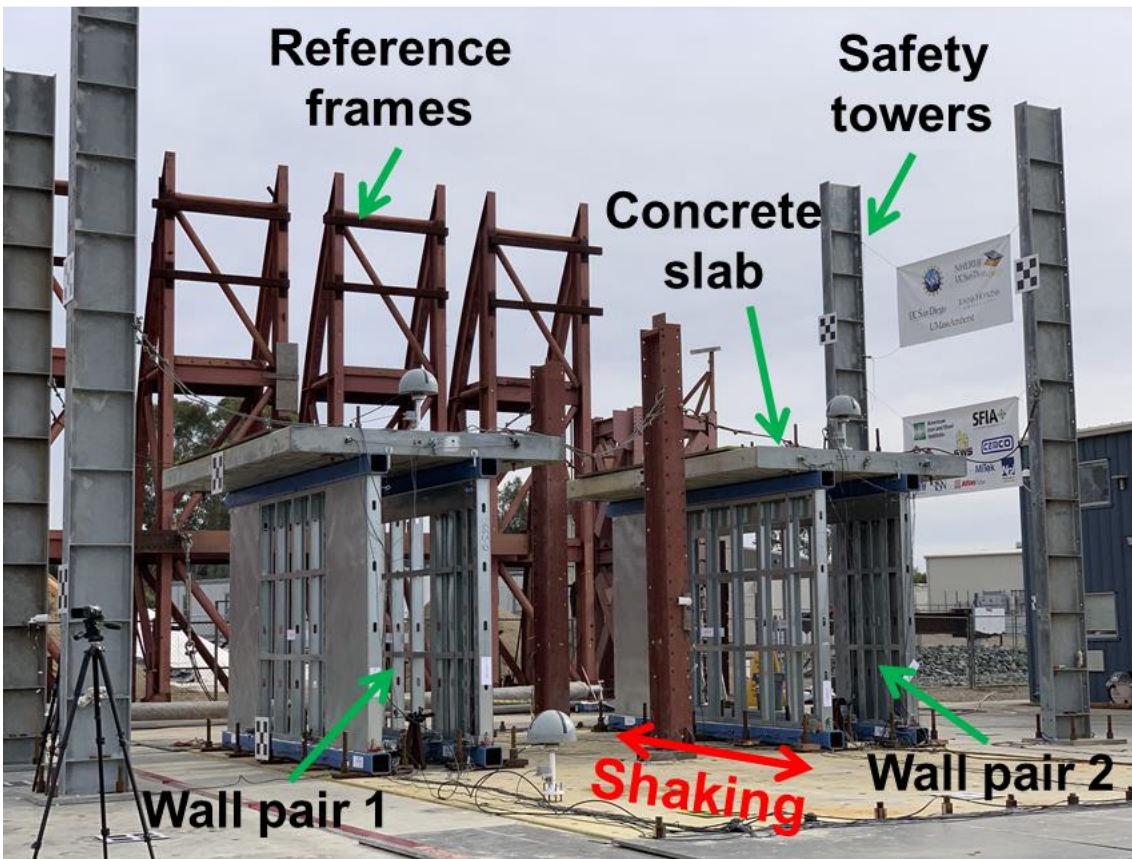


Wall-Line Tests: *Experiment Objectives*

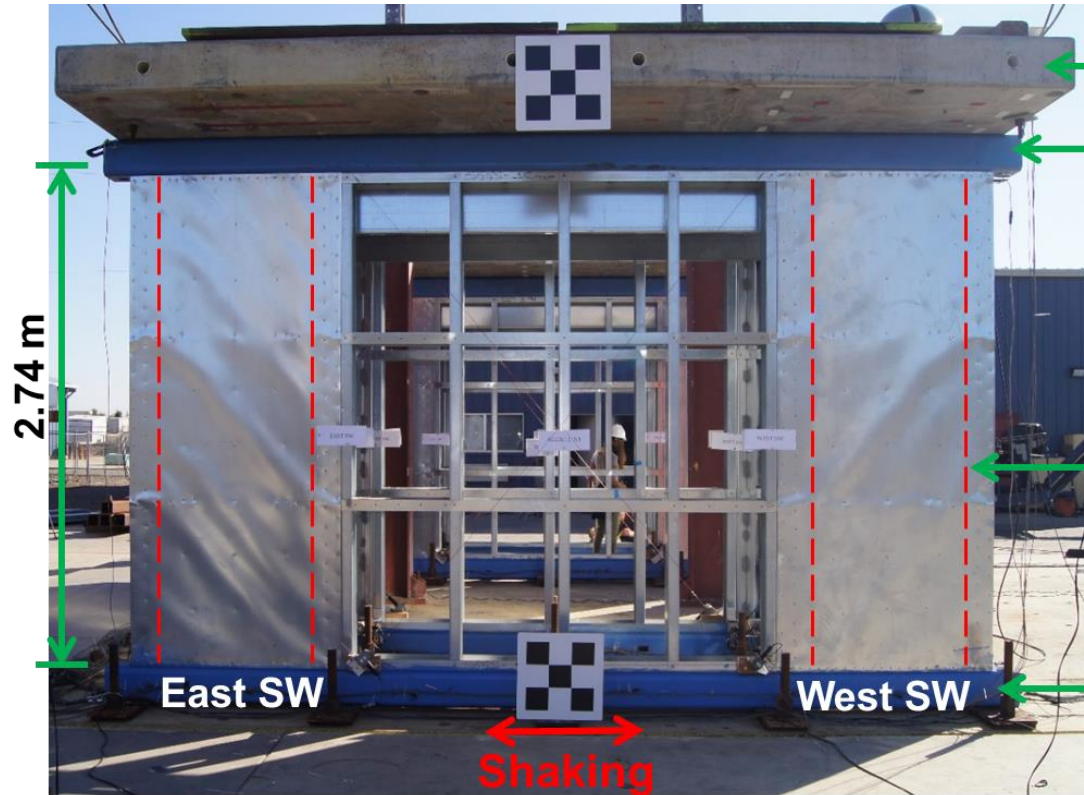
- Characterize dynamic performance of CFS framed walls subjected to in-line earthquake motions
- Effect of finishes and effects of openings on wall behavior
- Comparison of Type I and Type II walls
- Compare symmetrical and unsymmetrical walls
- Compare steel tension tie-rods assembly versus holdown systems
- Examine lateral load sharing between shear walls placed in-line with gravity walls
- In total, **16 unique configurations**; blend of **dynamic** (shake table) and **quasi-static reversed cyclic** (displacement control) testing regimes



Test Setup: *Shake table tests*



Test Setup: *SGGS-1 specimen (baseline)*

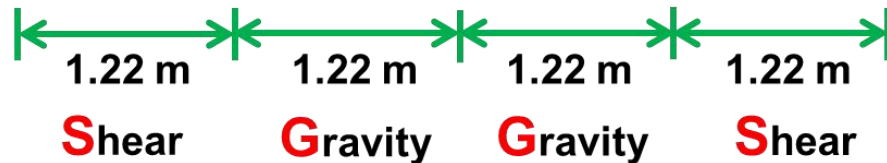


Seismic Weight (14.6 kN/m)
Concrete slab + trench plates
Top transfer HSS beam

Locations of
tension tie rods

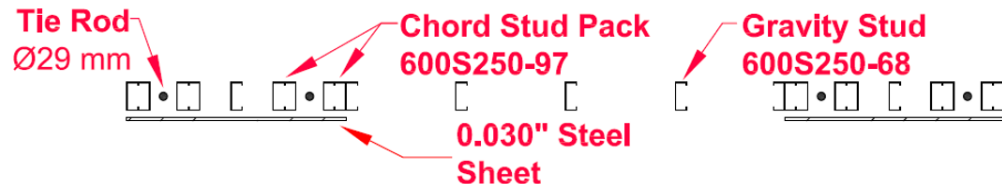
Bottom transfer HSS beam

- Framing thickness: 2.46 mm
- Sheet thickness: 0.76 mm
- #12 screws @ 51/305 mm o.c.



-1 (Type I)

Naming convention



Test Protocol: *Shake table tests*

- Scaled ground motions (increasing intensity)

- 1. Elastic Level

- 1994 Northridge – Canoga Park
 - 2010 Maule, Chile – Curico

- 2. Quasi-elastic Level

- 1994 Northridge – Canoga Park

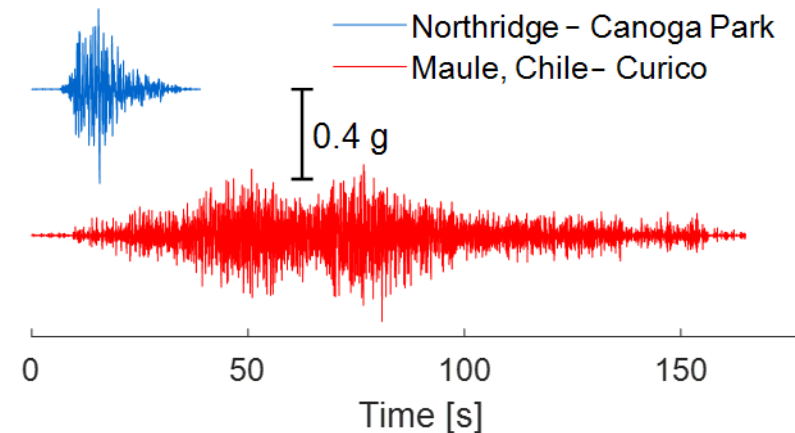
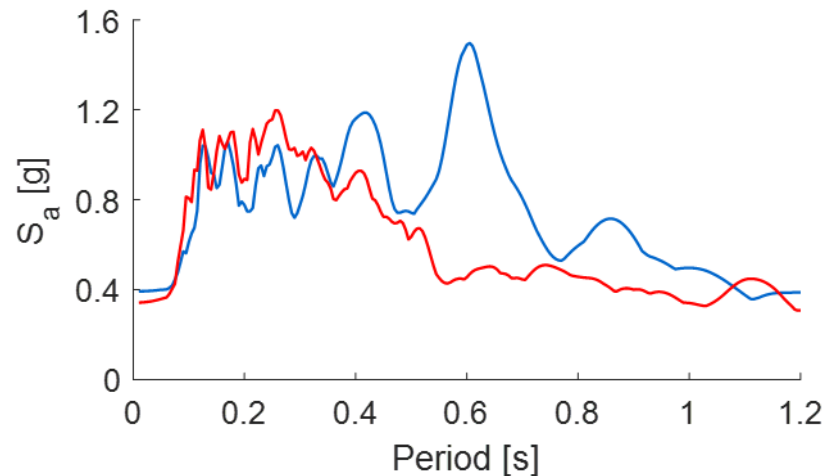
- 3. Design Level

- 1994 Northridge – Canoga Park

- 4. Above Design Level (optional)

- 1994 Northridge – Canoga Park

Seed Motions

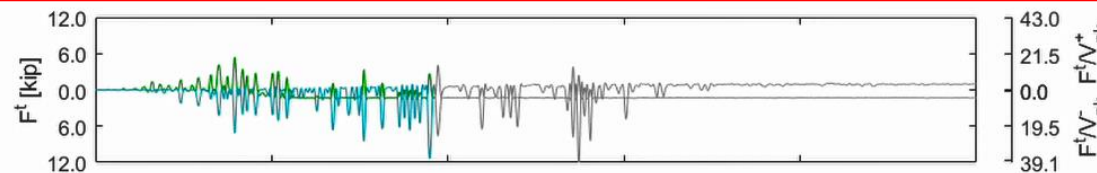
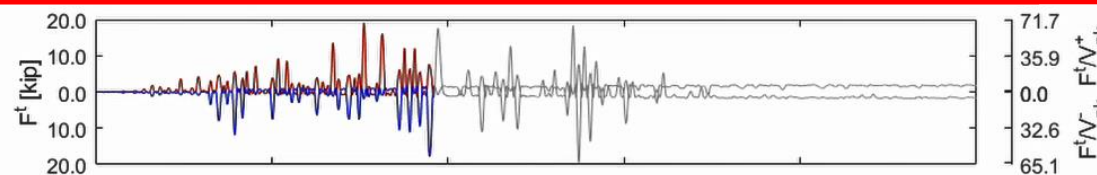
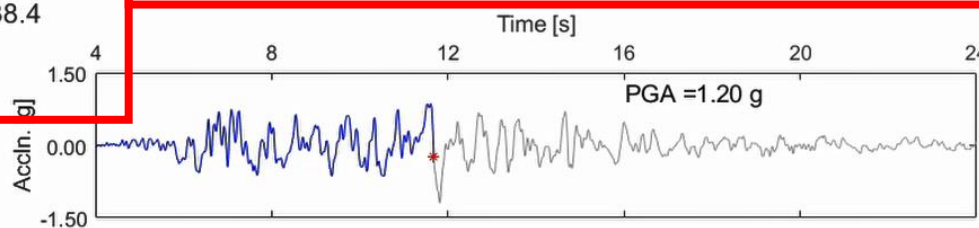
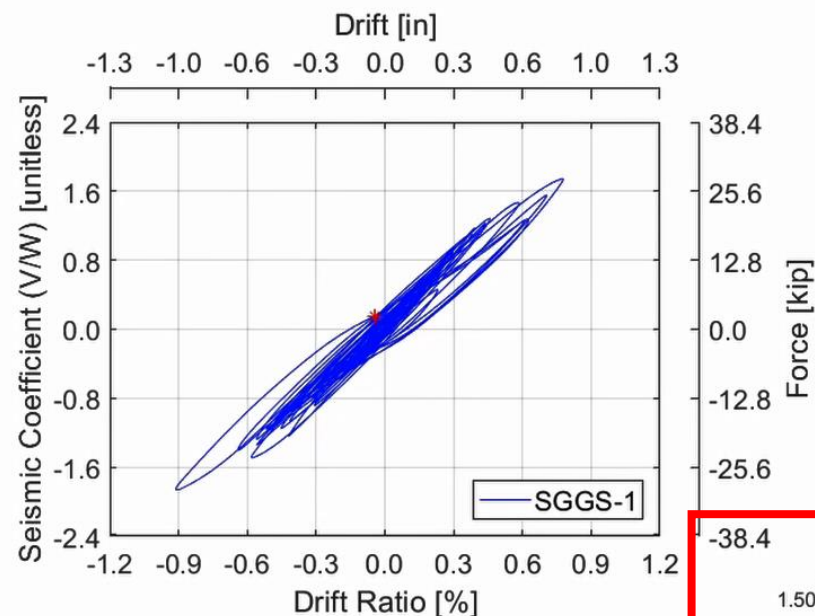


- Low-amplitude white-noise base excitation tests

- Before & after each EQ tests (duration: 4 minutes)
 - Amplitude: 1.5% g & 3% g RMS

- Static monotonic pull over for post-peak behavior (for select specimens)

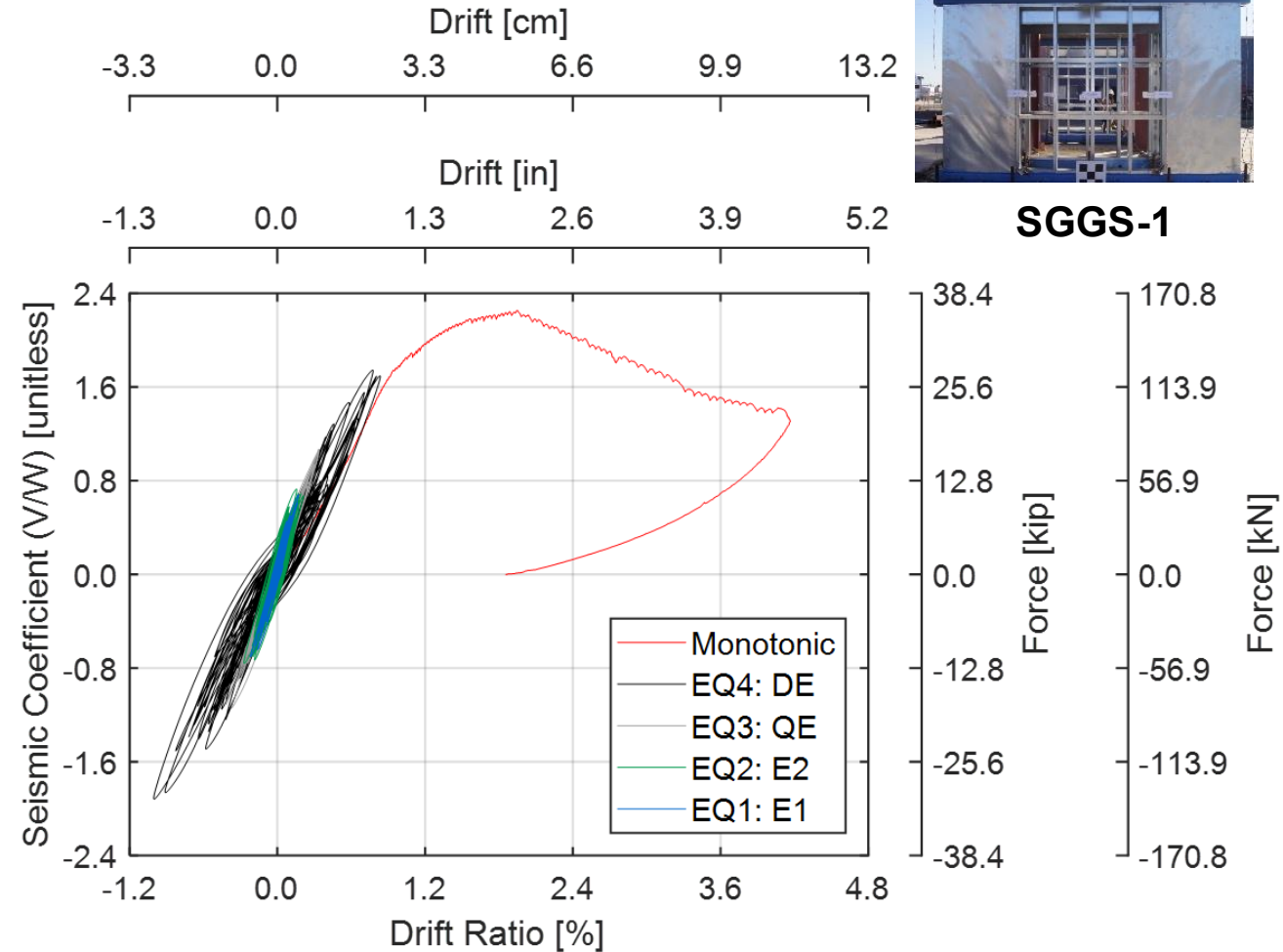
SGGS-1 (Baseline Specimen) – Design EQ



Force-Displacement Response: *SGGS-1*

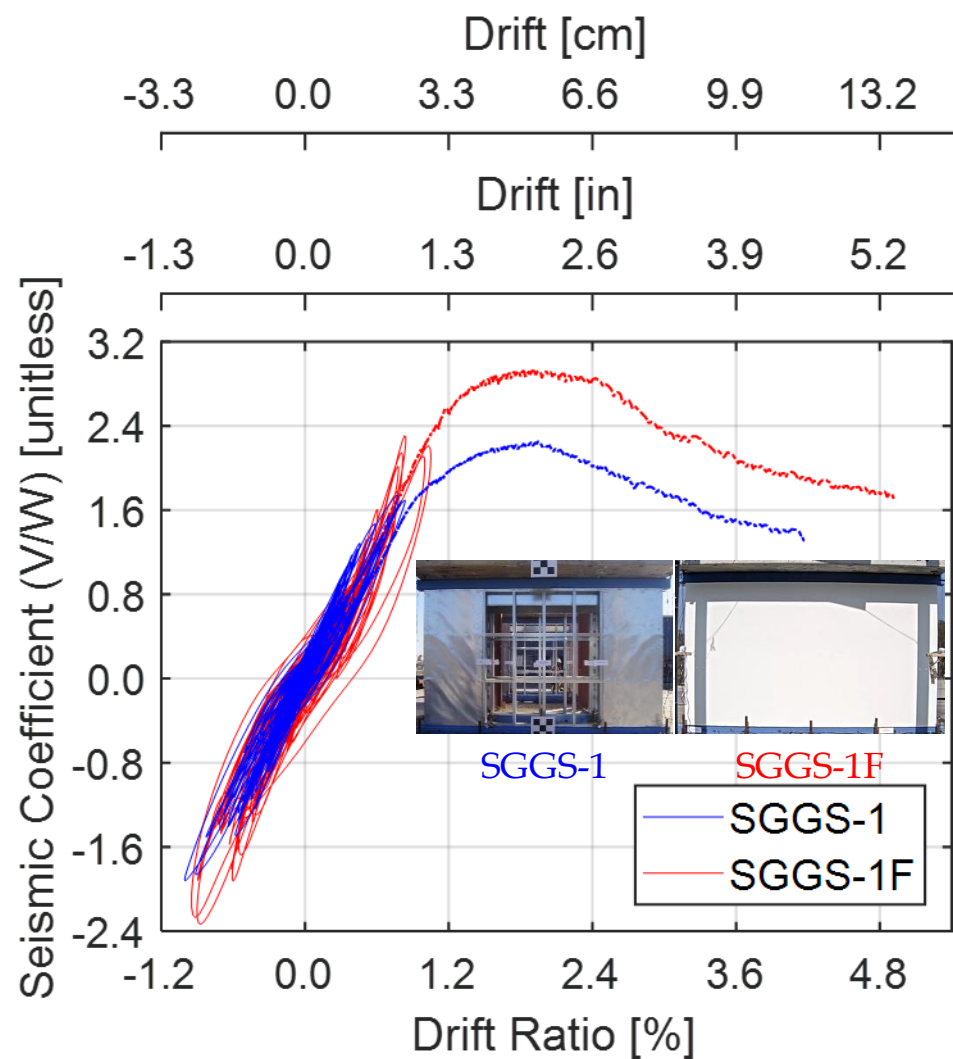


SGGS-1

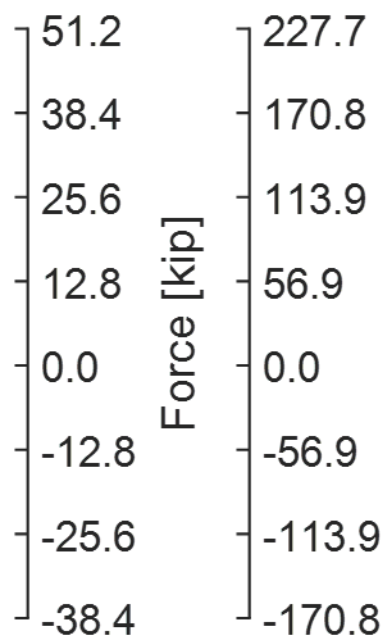


Specimen	Strength, V_{max} [kN]	Drift, $\delta_{V_{max}}$ [%]	Elastic Stiffness, k_e [kN/cm]
SGGS-1	160.2	1.95%	83.0

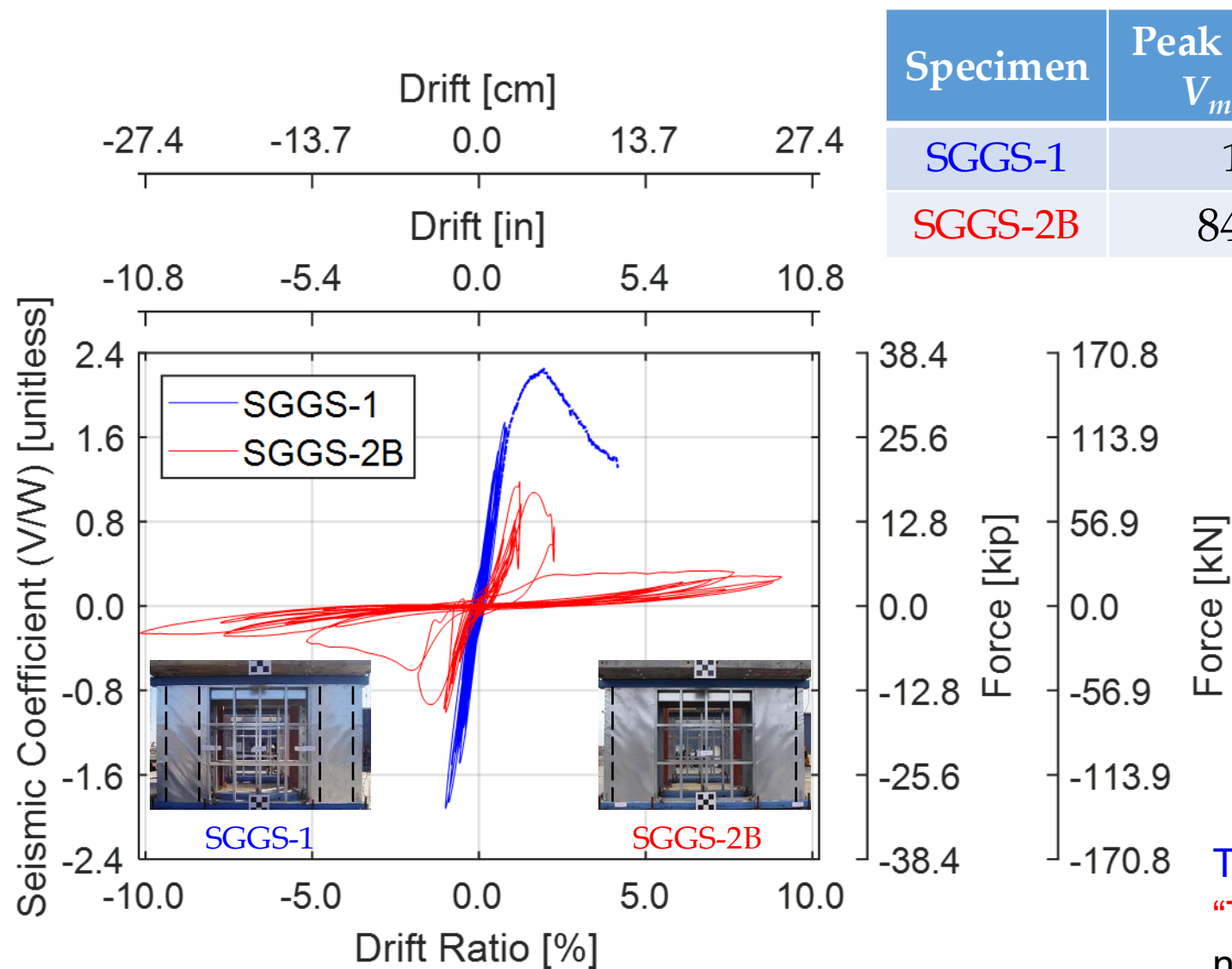
Finished vs Unfinished Wall Behavior



Specimen	Peak Strength, V_{max} [kN]	Drift, $\delta_{V_{max}}$ [%]	Elastic Stiffness, k_e [kN/cm]
SGGS-1	160.2	1.95%	83.0
SGGS-1F	208.2 ($\uparrow 30\%$)	1.90%	204.5 ($\uparrow 150\%$)



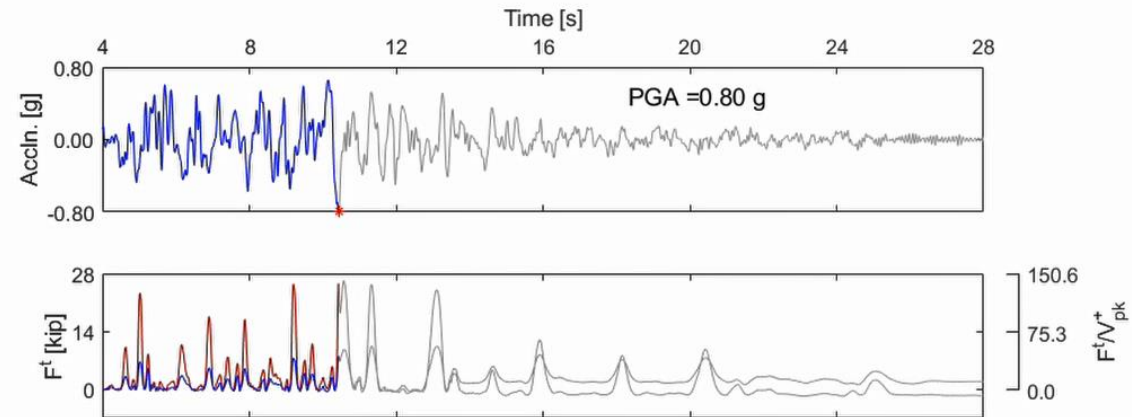
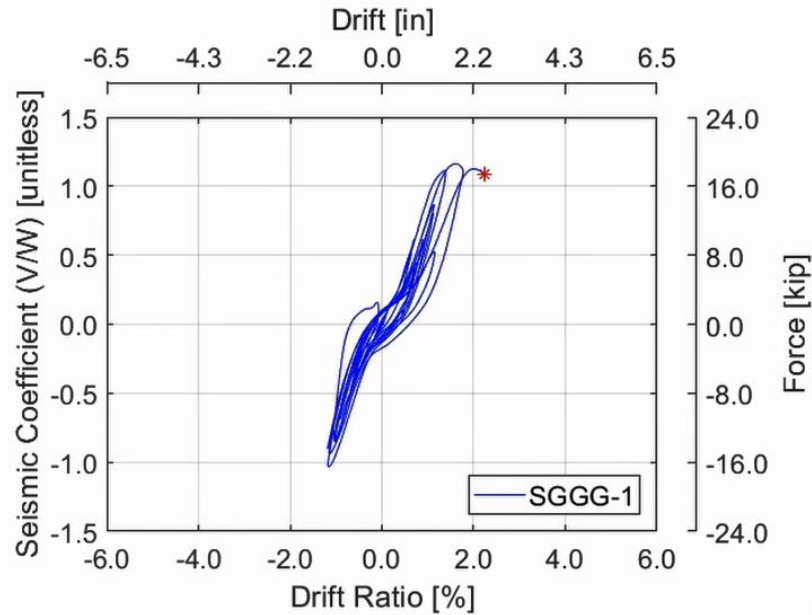
Type I vs “Type II” Wall Behavior



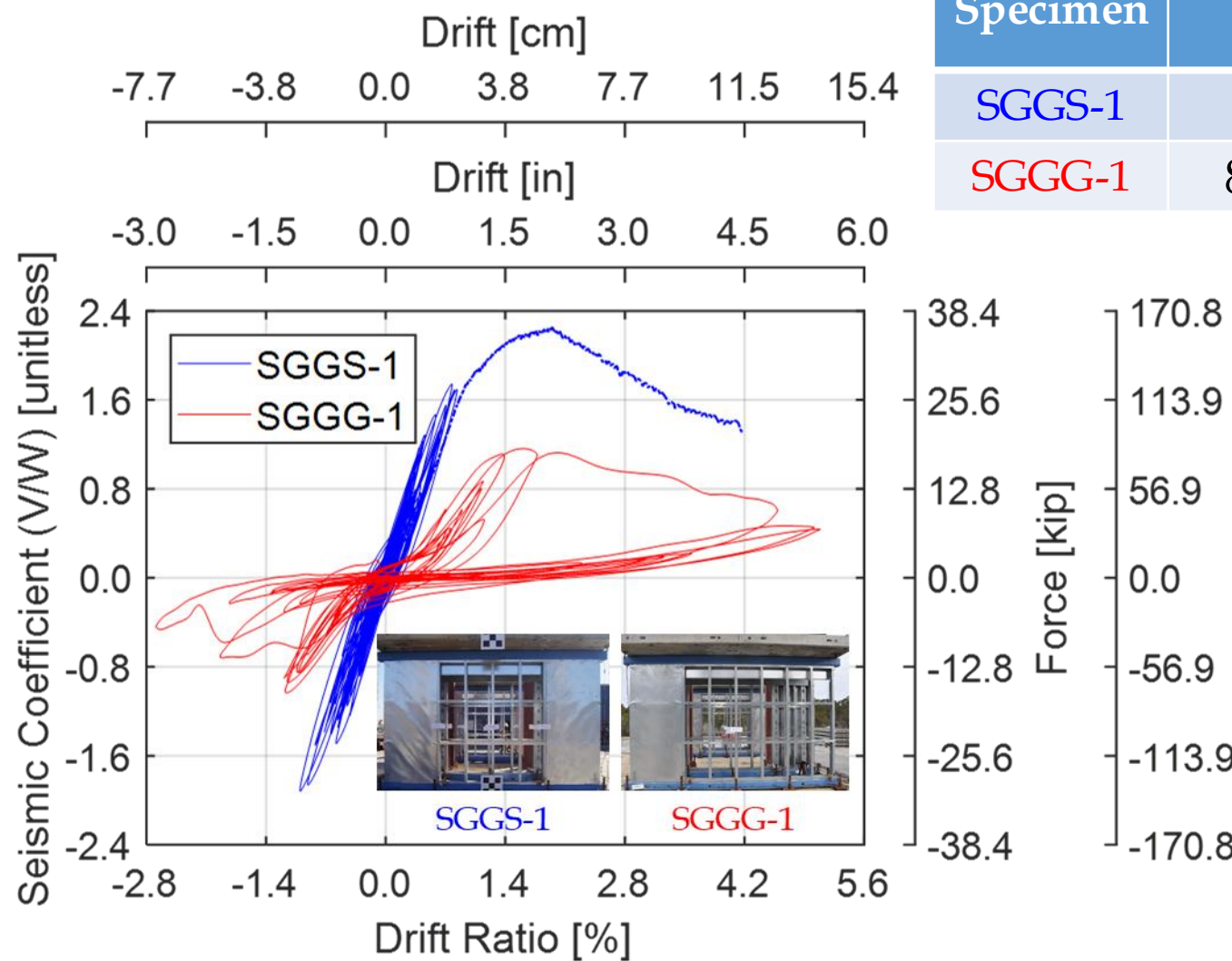
- **Strength** and **elastic stiffness** decrease
- **Drift at strength** lower

Type I = Tie-downs at each end of shear segment
“Type II” = Tie-downs only at ends of the wall, not detailed with any members collecting and carrying shear force to shear segments at the ends

SGGG-1 (Unsymmetrical) – Above Design EQ



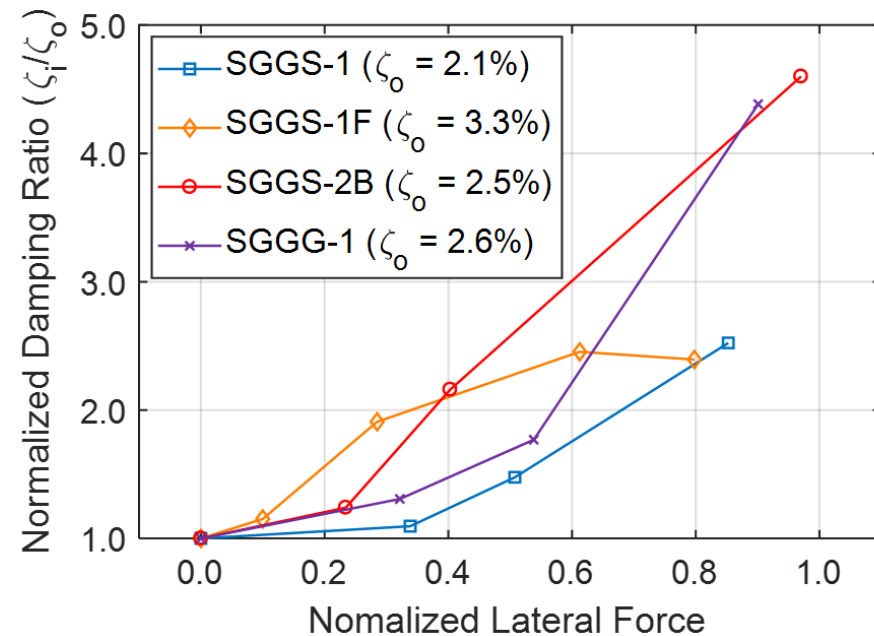
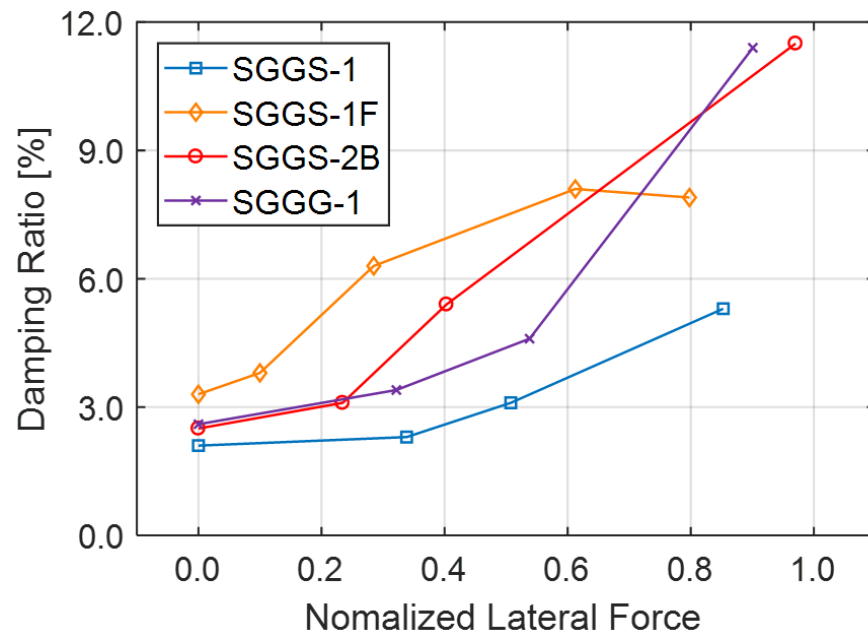
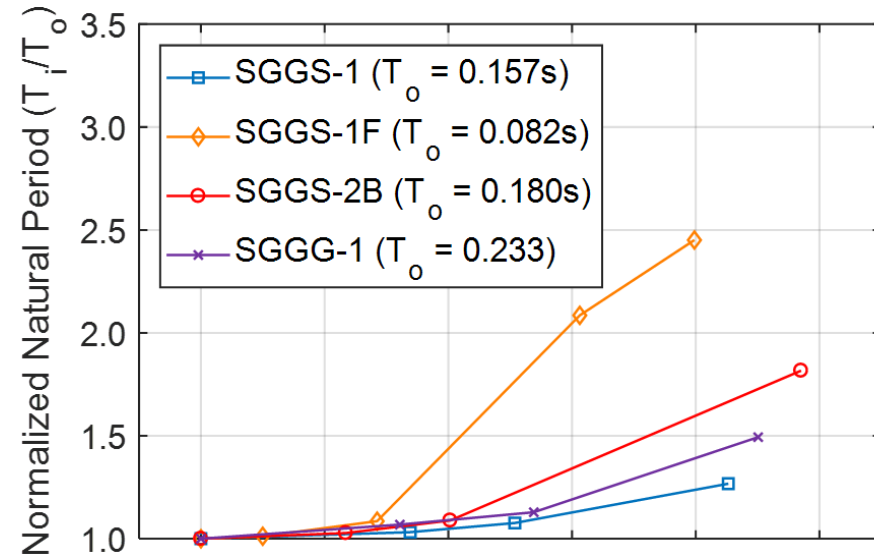
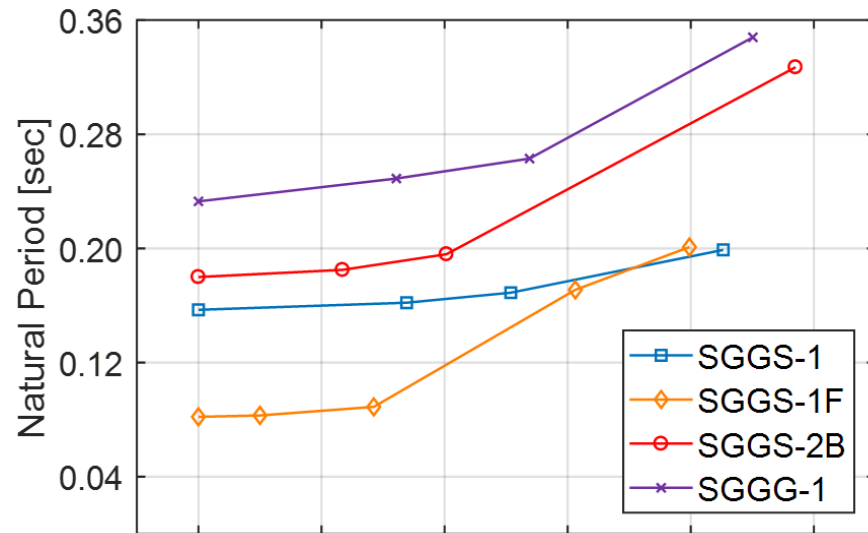
Symmetrical vs Unsymmetrical Wall Behavior



Specimen	Peak Strength, V_{max} [kN]	Drift, $\delta_{V_{max}}$ [%]	Elastic Stiffness, k_e [kN/cm]
SGGS-1	160.2	1.95%	83.0
SGGG-1	82.7 ($\downarrow 48\%$)	1.60%	39.1 ($\downarrow 53\%$)



Evolution of Dynamic Characteristics



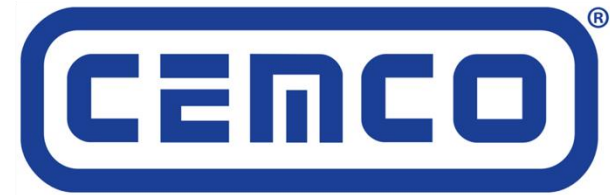
Concluding Remarks: Observations

- Baseline:
 - Low damping ratios: 2-3%
 - Higher shear wall strength (62 kN/m):
>2x current AISI S400-15 provisions
- Symmetry: wall with one shear wall segment
 - ~50%↓ in strength and stiffness
 - Lower drift at strength
 - Lateral strength contribution from gravity segment expected but not observed appreciably
- Finishes: EIFS and Gypsum boards
 - Strength: ↑30%
 - Elastic stiffness: ↑2.5x
 - Period elongation < 10% (QE)
 - Damping: ~↑50%
 - No derogatory effect on drift capacity
- Tie-down detailing: “Type II” wall with tie-rods at ends of wall
 - Strength and stiffness decrease
 - Lower drift at strength

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Questions/Comments?

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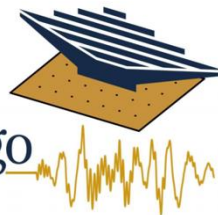
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