

Experimental Assessment of Large-Scale FRP-Strengthened RC Shear Controlled Walls Subjected to Cyclic Loads

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- Motivation
- Experimental Program
- Experimental Results
- Preliminary Findings
- Recommendations and Future Work



- Shear-controlled reinforced concrete (RC) walls are common lateral force systems in older structures.
- Are existing models are based on realistic wall specimens?
- Are published strength models accurate for common applications?
- How to characterize load-deformation performance of FRP strengthened walls?
- What is the most effective anchor and fabric seismic detailing for deformation capacity?
- What is the effectiveness of a 1-sided retrofit?

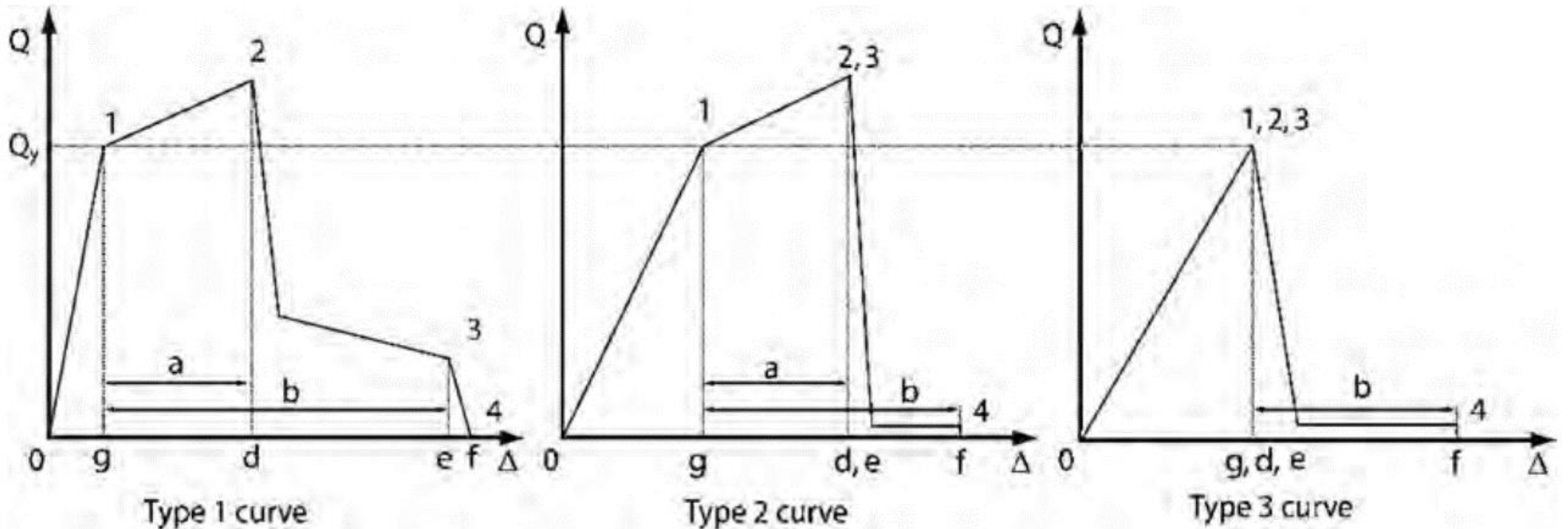
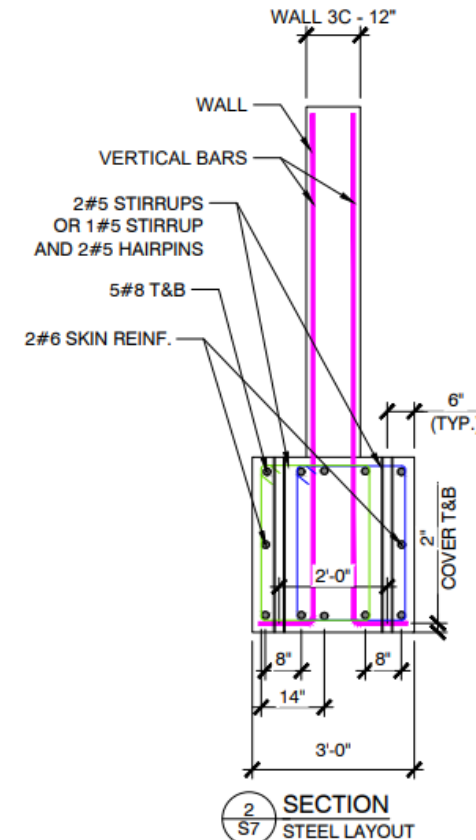


Figure 7-4. Component Force Versus Deformation Curves

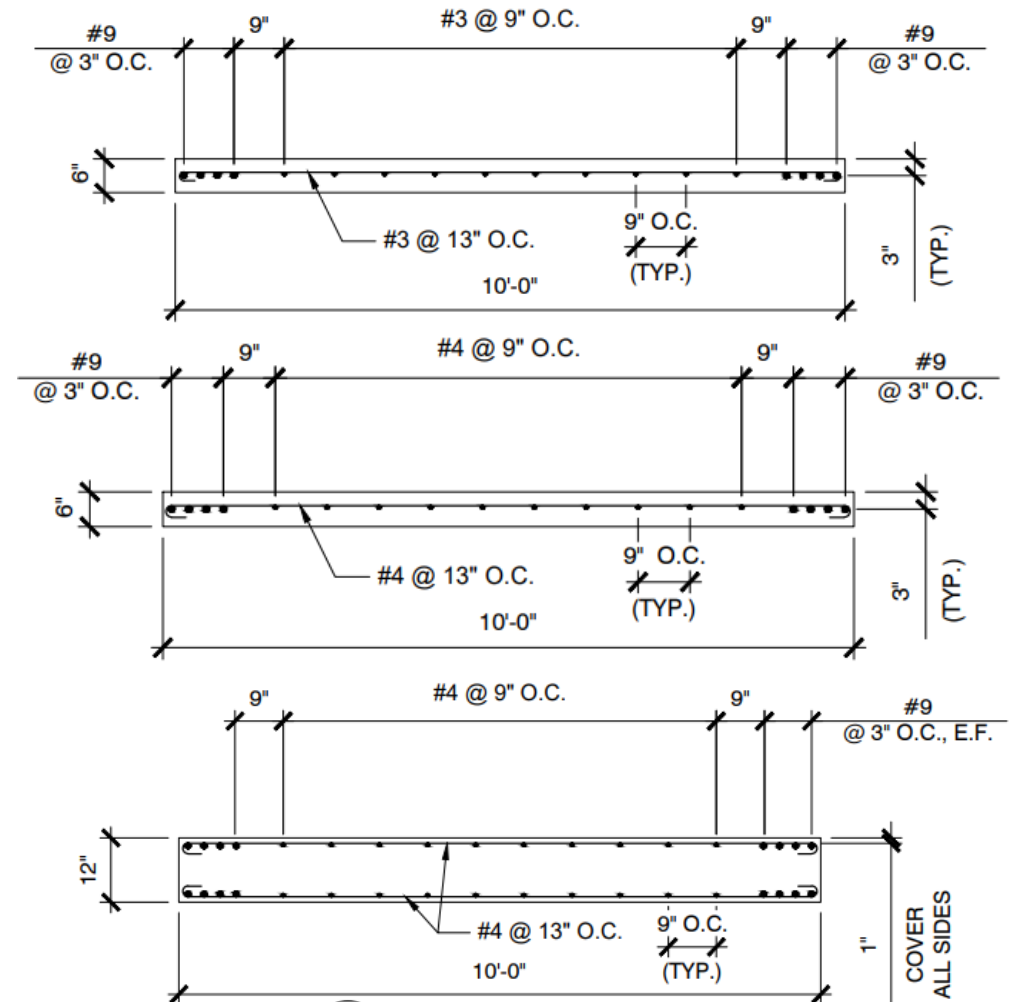
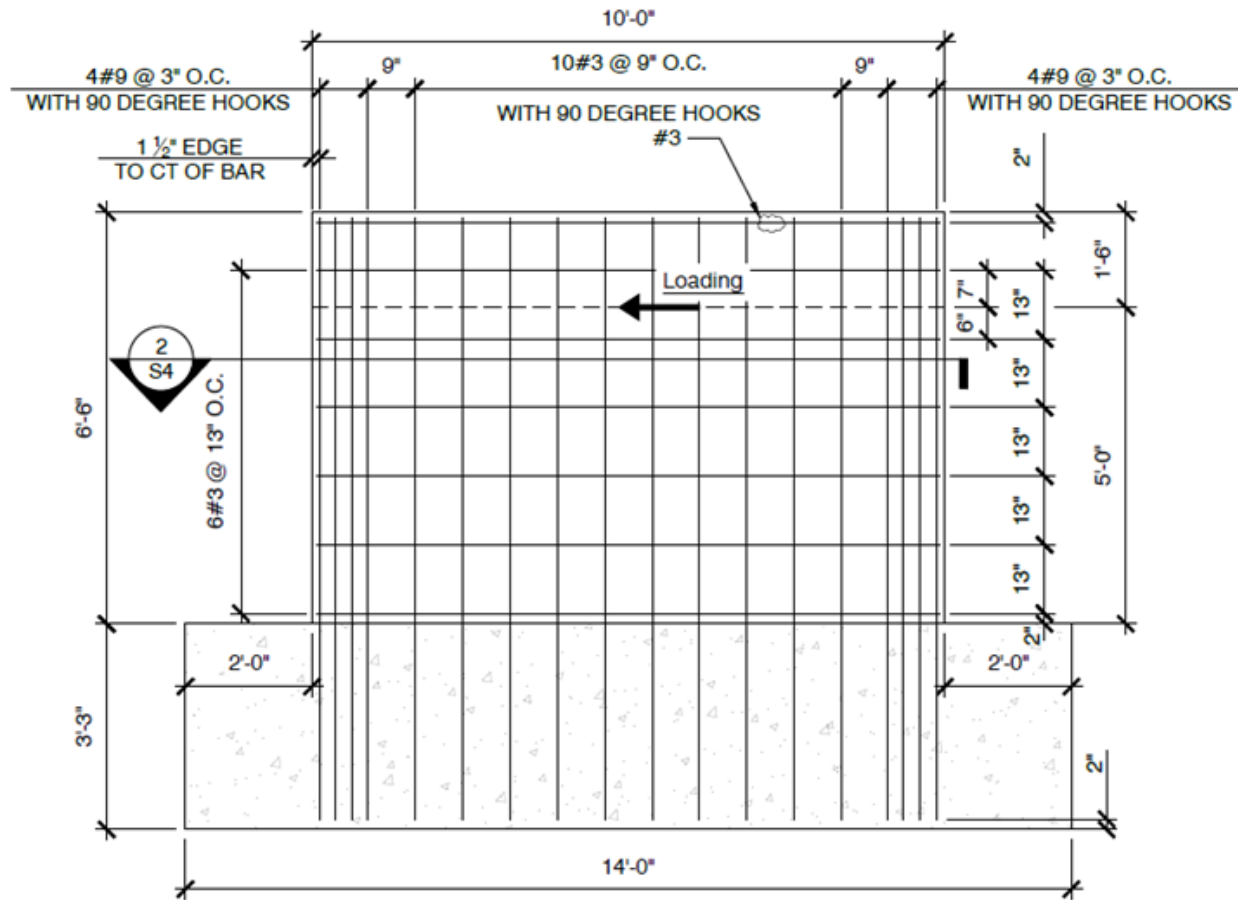
Testing Parameters

- 6 full-scale shear-controlled wall specimens
- Wall thickness:
 - 6 in. and 12 in.
- Shear reinforcement ratio:
 - 0.14% and 0.26%
- Concrete strength
 - 2200 – 3300 psi
- Zero axial load on the wall specimen
- Cyclic loading – ACI 374.2
- 1-sided FRP retrofit

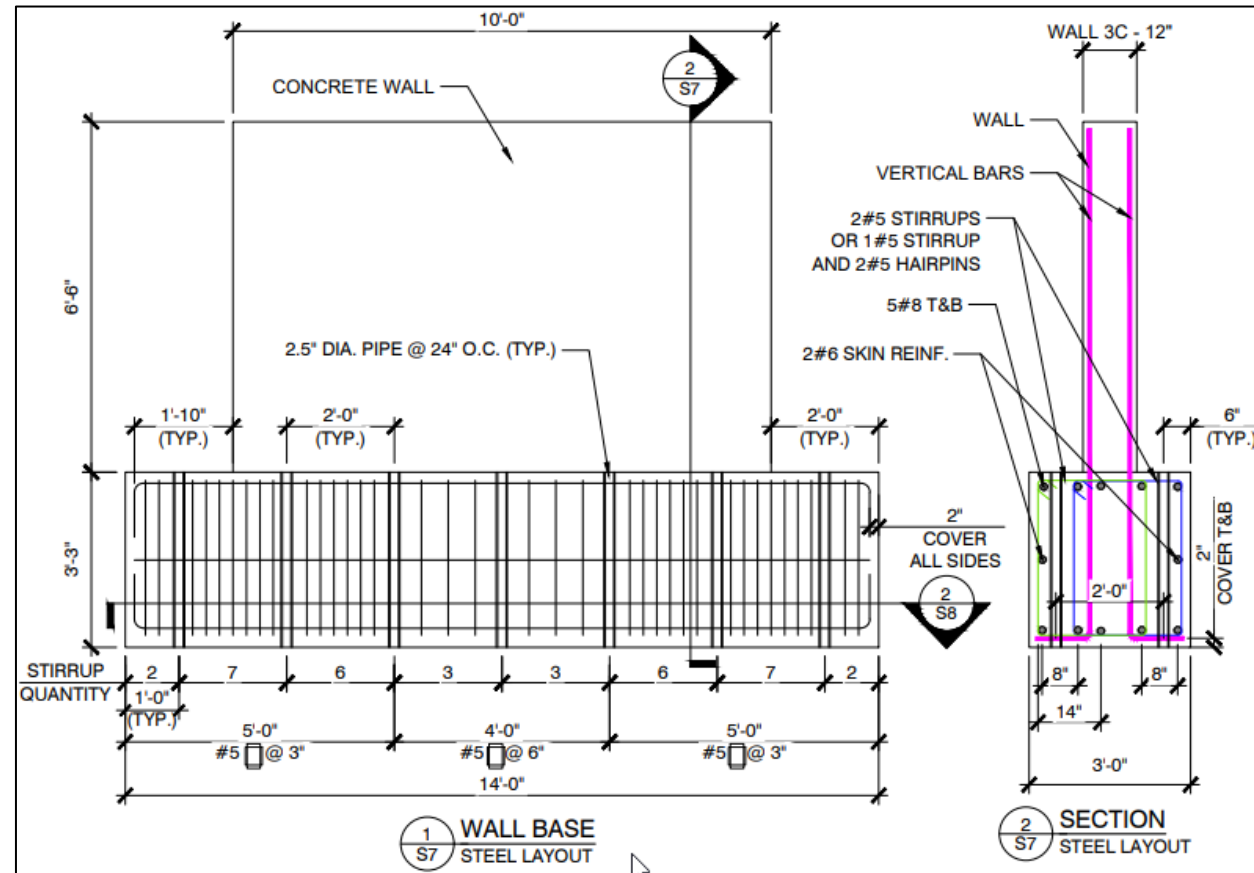
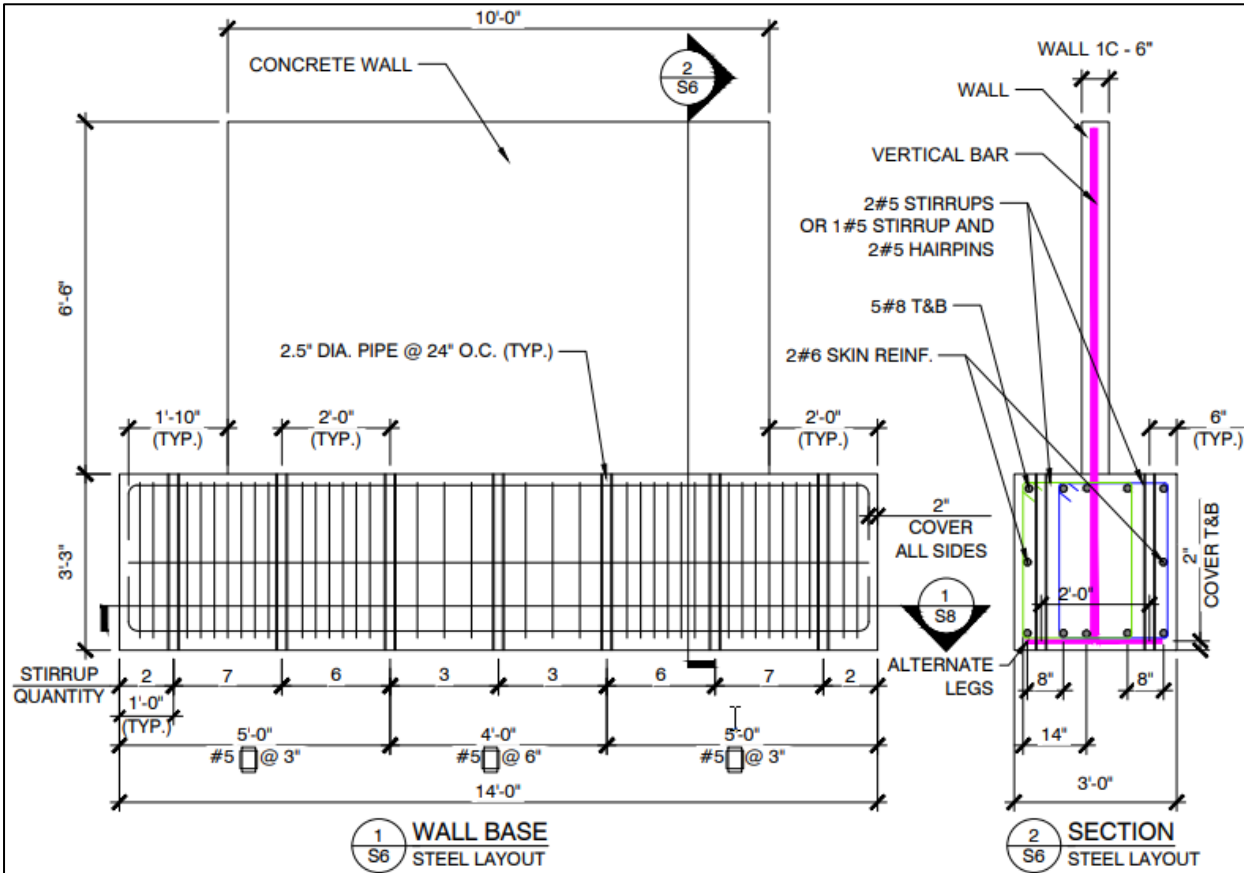


Specimen Design

Composite Strengthening Systems

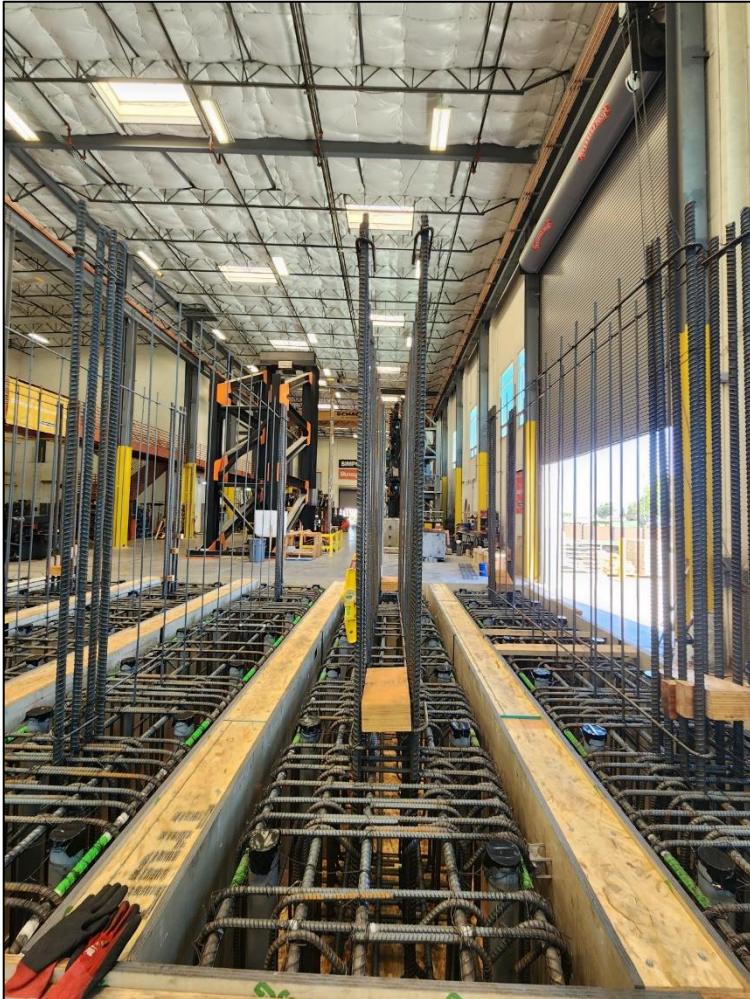


Specimen Design – Inverted-T – Bases



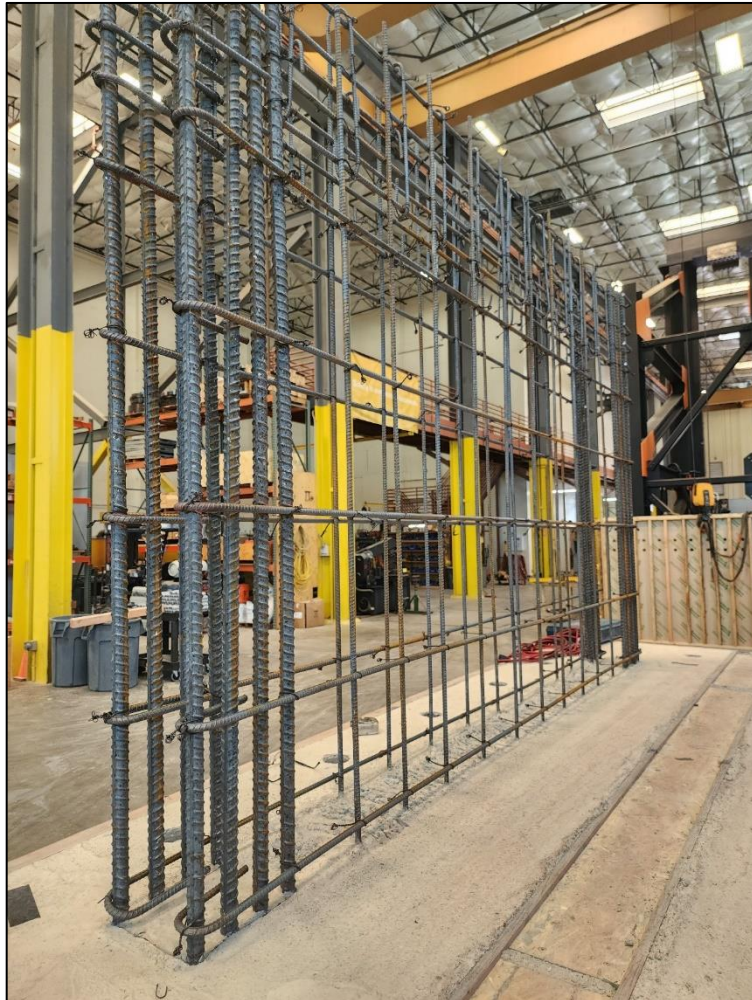
Specimen Construction - Bases

Composite Strengthening Systems

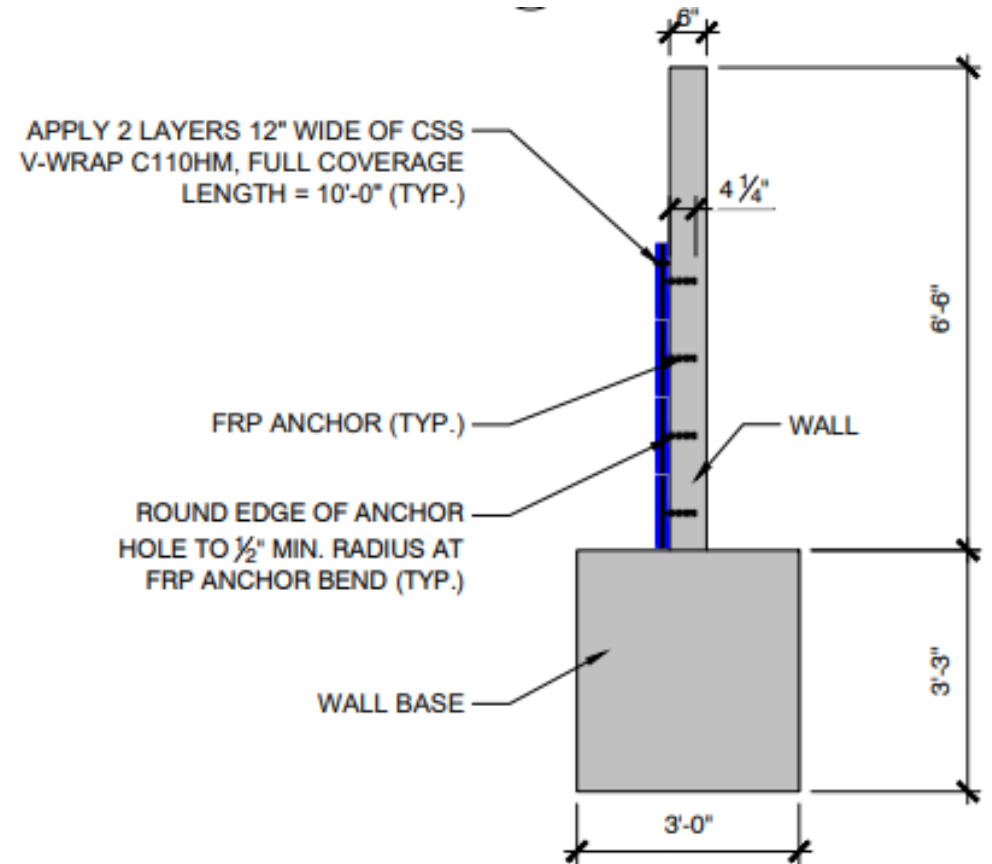
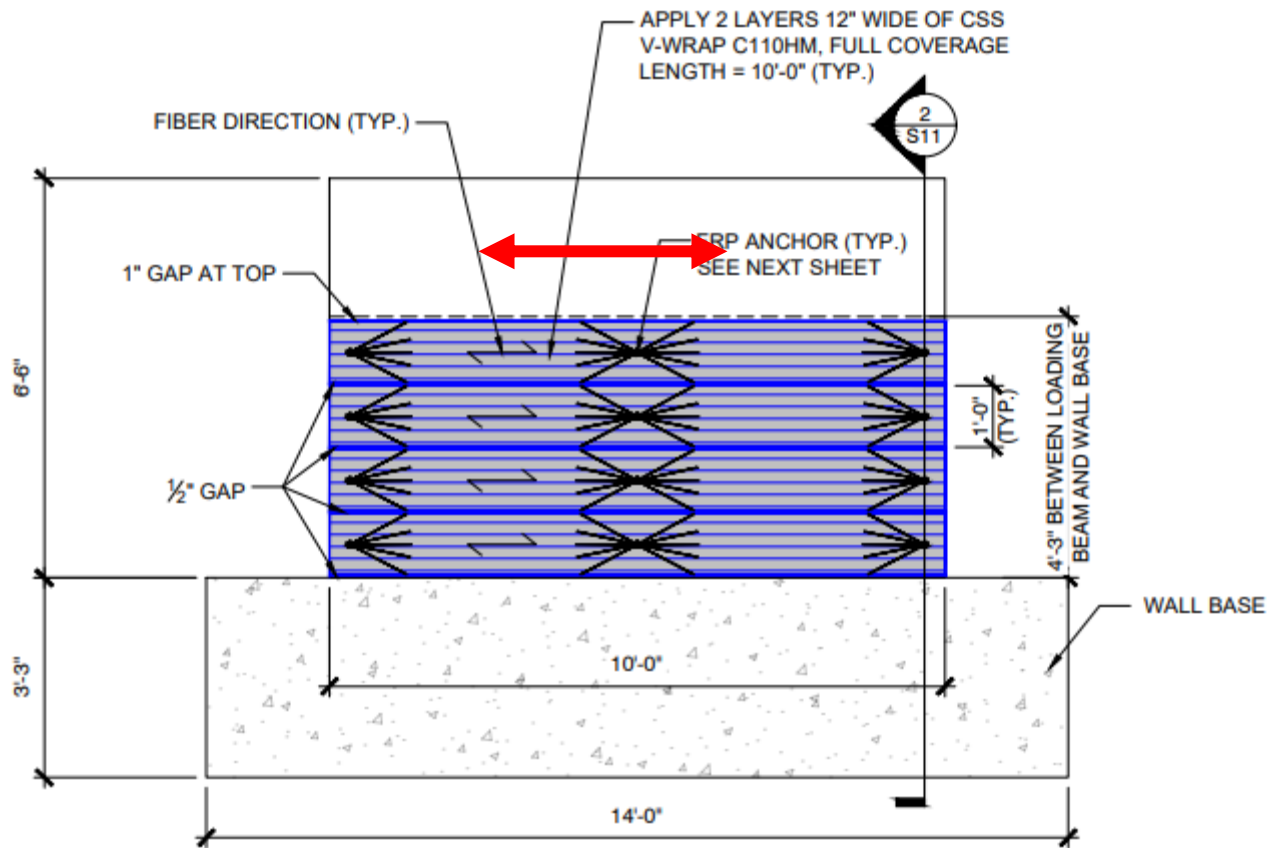


Specimen Construction - Walls

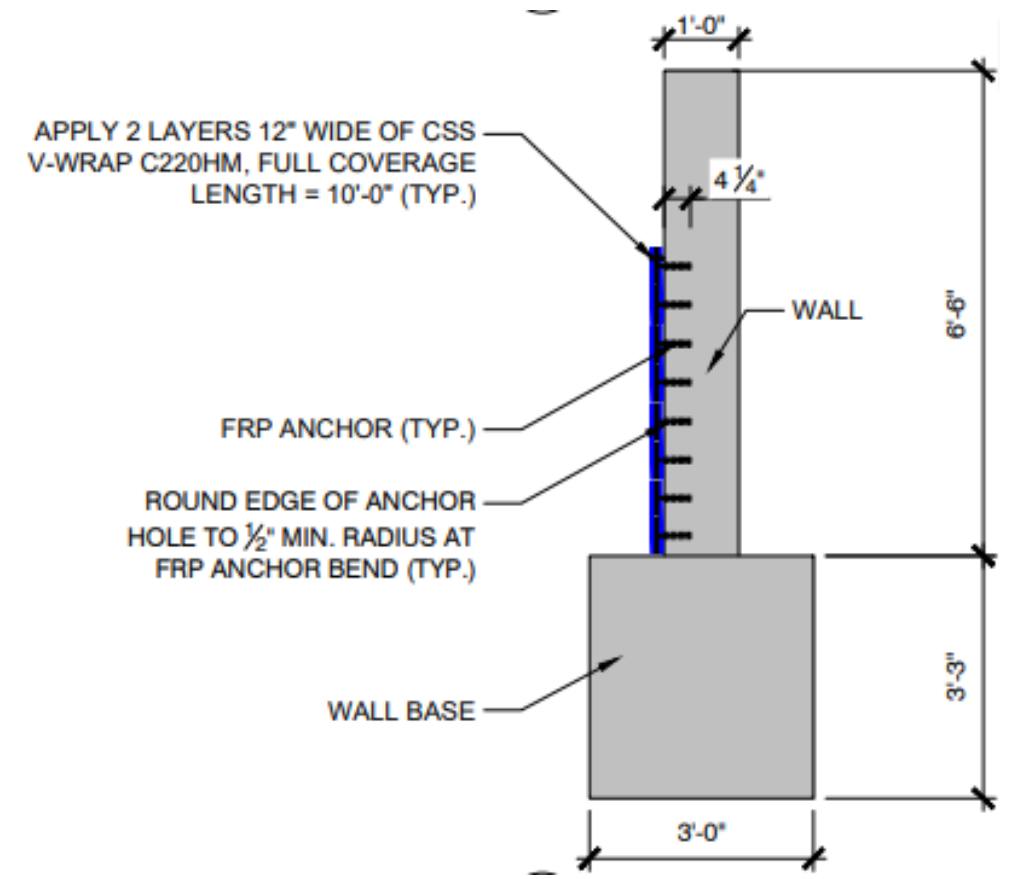
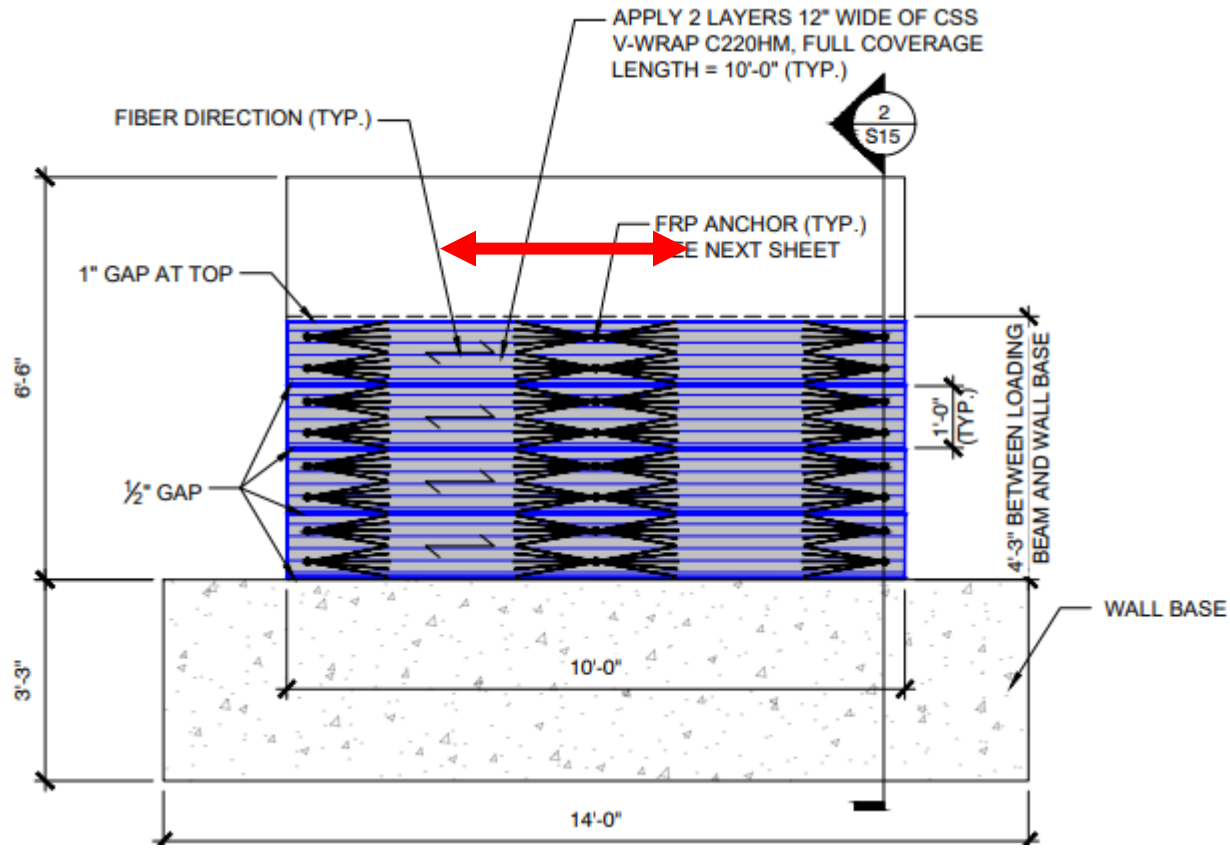
Composite Strengthening Systems



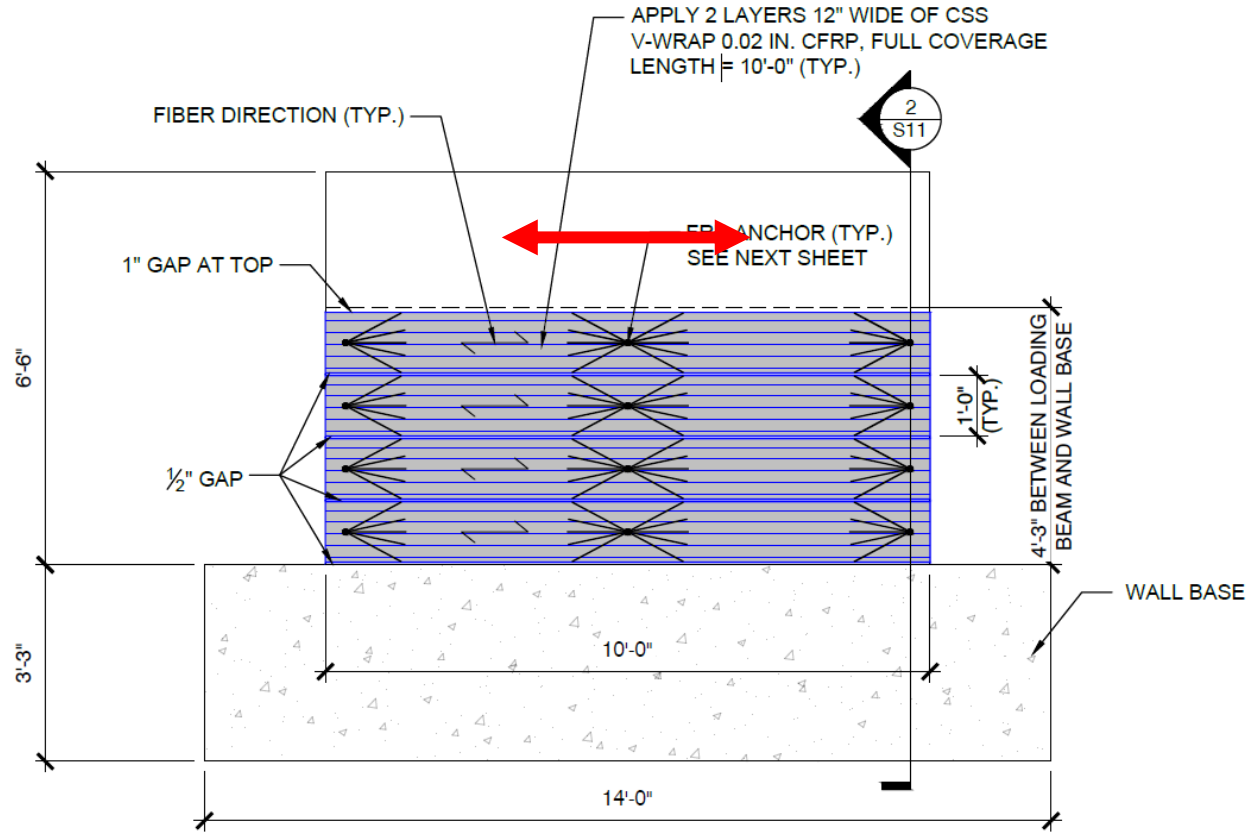
FRP Design – 6" wall



FRP Design – 12" wall



FRP Installation



Test Setup – Simpson Strong-Tie – Tye Gilb Lab

Composite Strengthening Systems



Control Specimen 6" wide (1C & 2C) – At Failure

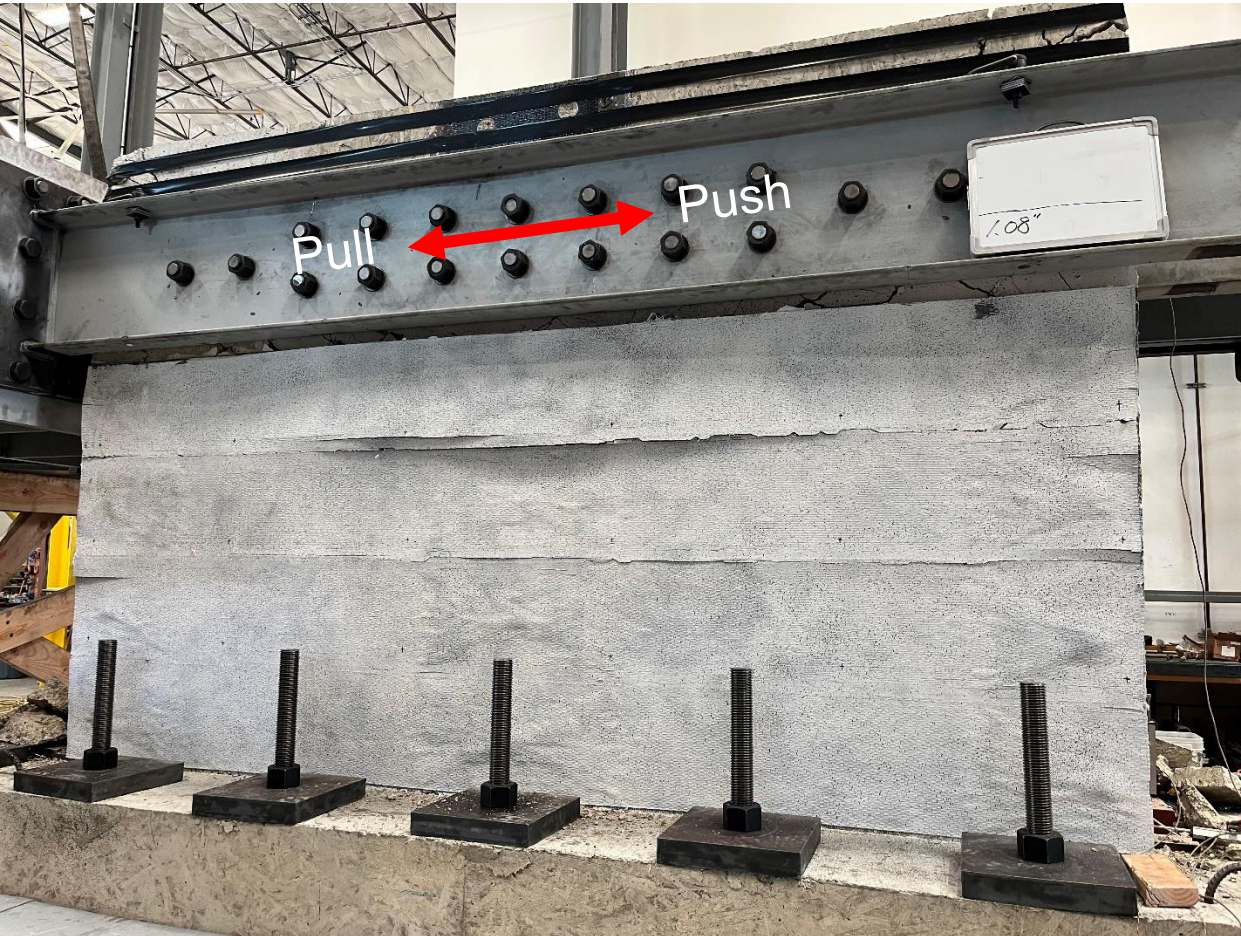


6" wall with 0.14% shear reinforcement ratio (Type 1)



6" wall with 0.26% shear reinforcement ratio (Type 2)

Strengthened Specimen 6" wide (1S) – At Failure



FRP Side



No FRP Side

Strengthened Specimen 6" wide (2S) – At Failure

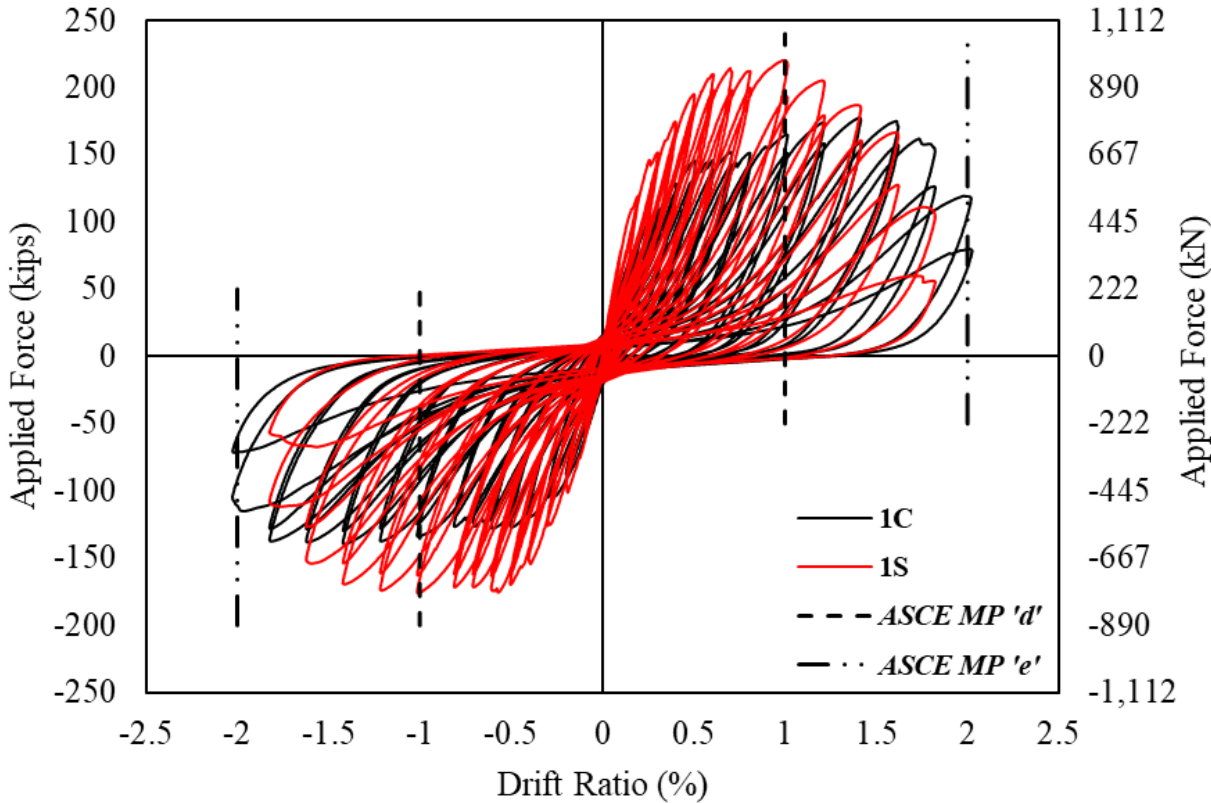


FRP Side

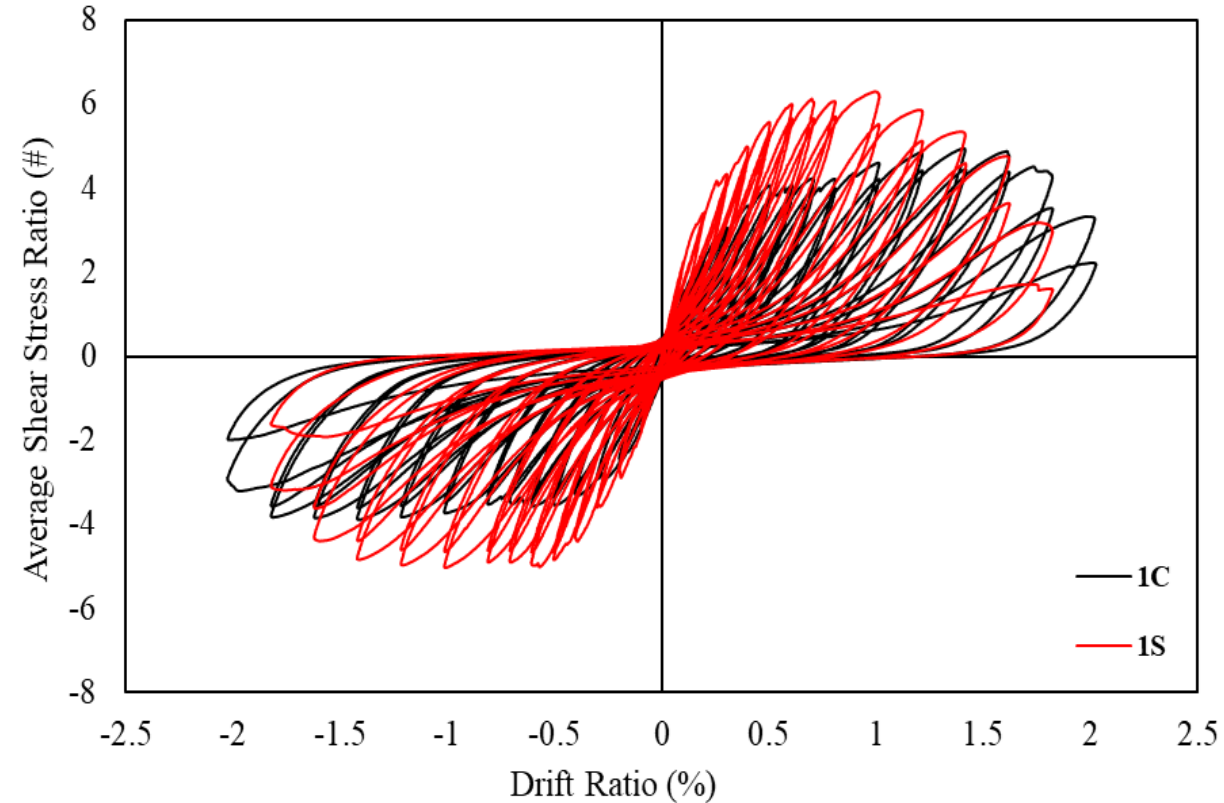


No FRP Side

Hysteresis loops – 6” Wall – (1C & 1S)



Drift Ratio – Applied Force

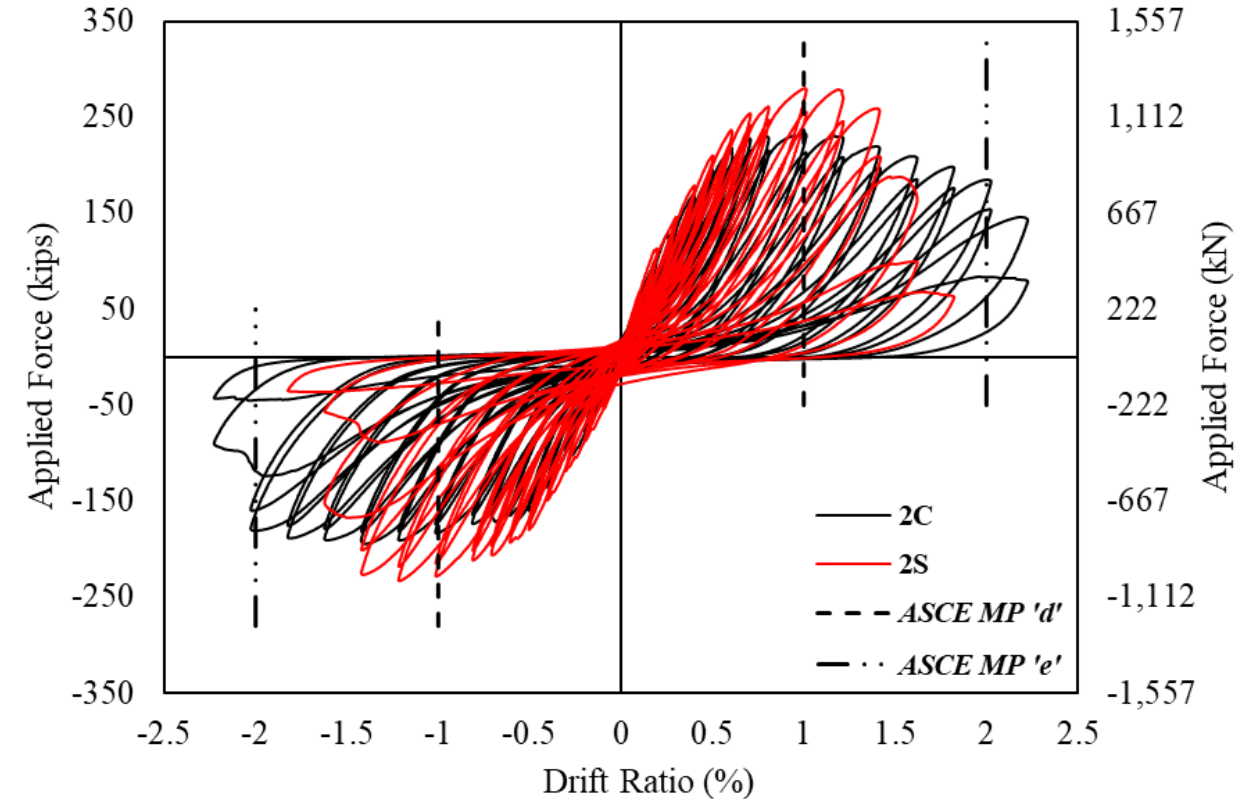


Drift Ratio – Average Shear Stress

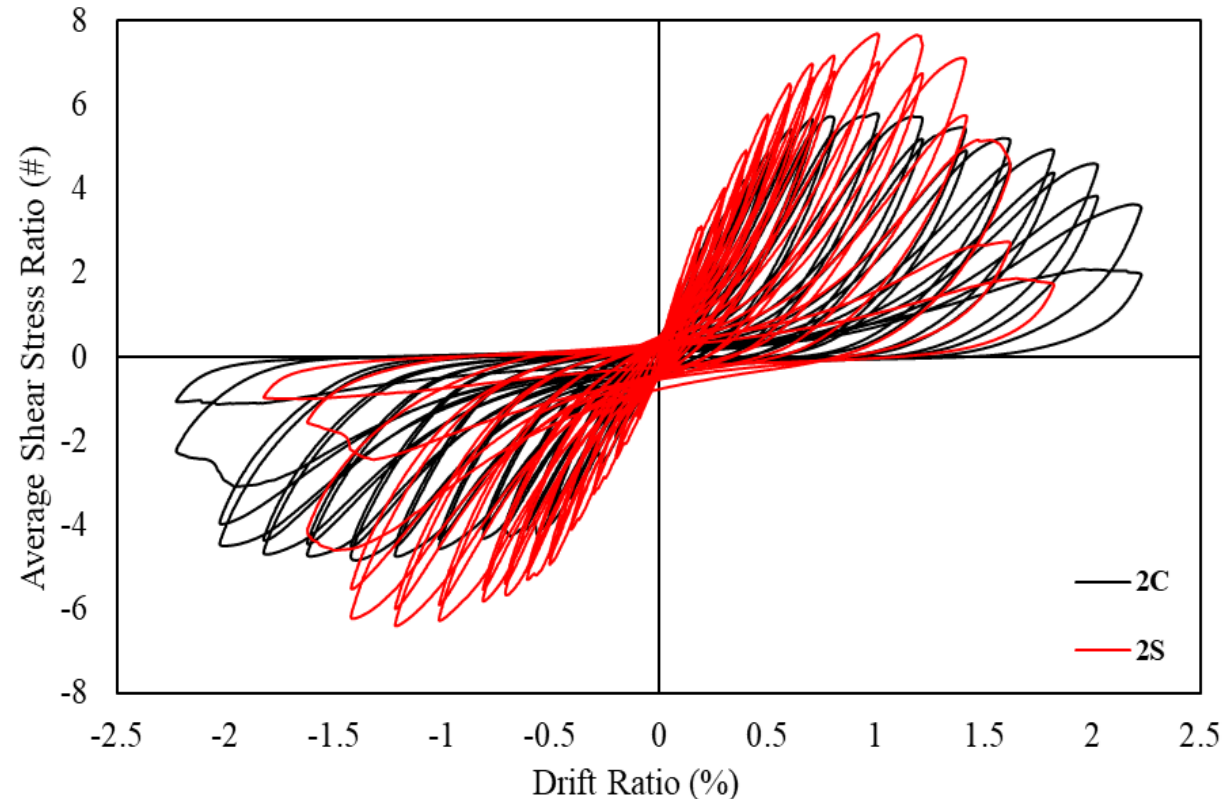
$$\text{Average Shear Stress Ratio} = \frac{F_{\text{applied}}}{\sqrt{f'_c} b_w d}$$



Hysteresis loops – 6” Wall – (2C & 2S)



Drift Ratio – Applied Force



Drift Ratio – Average Shear Stress

Control Specimen 12" wide (Type 3 – 3C) – At Failure



Strengthened Specimen 12" wide (3S) – At Failure

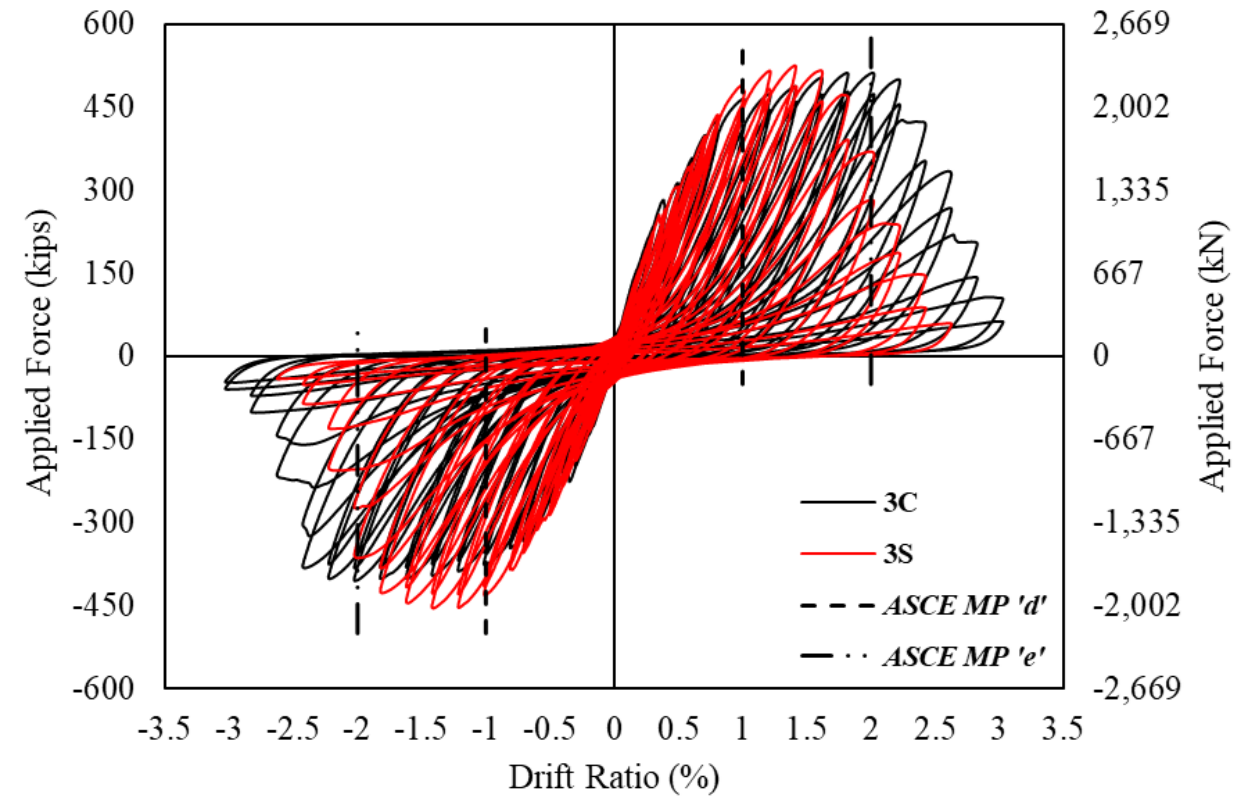


FRP Side

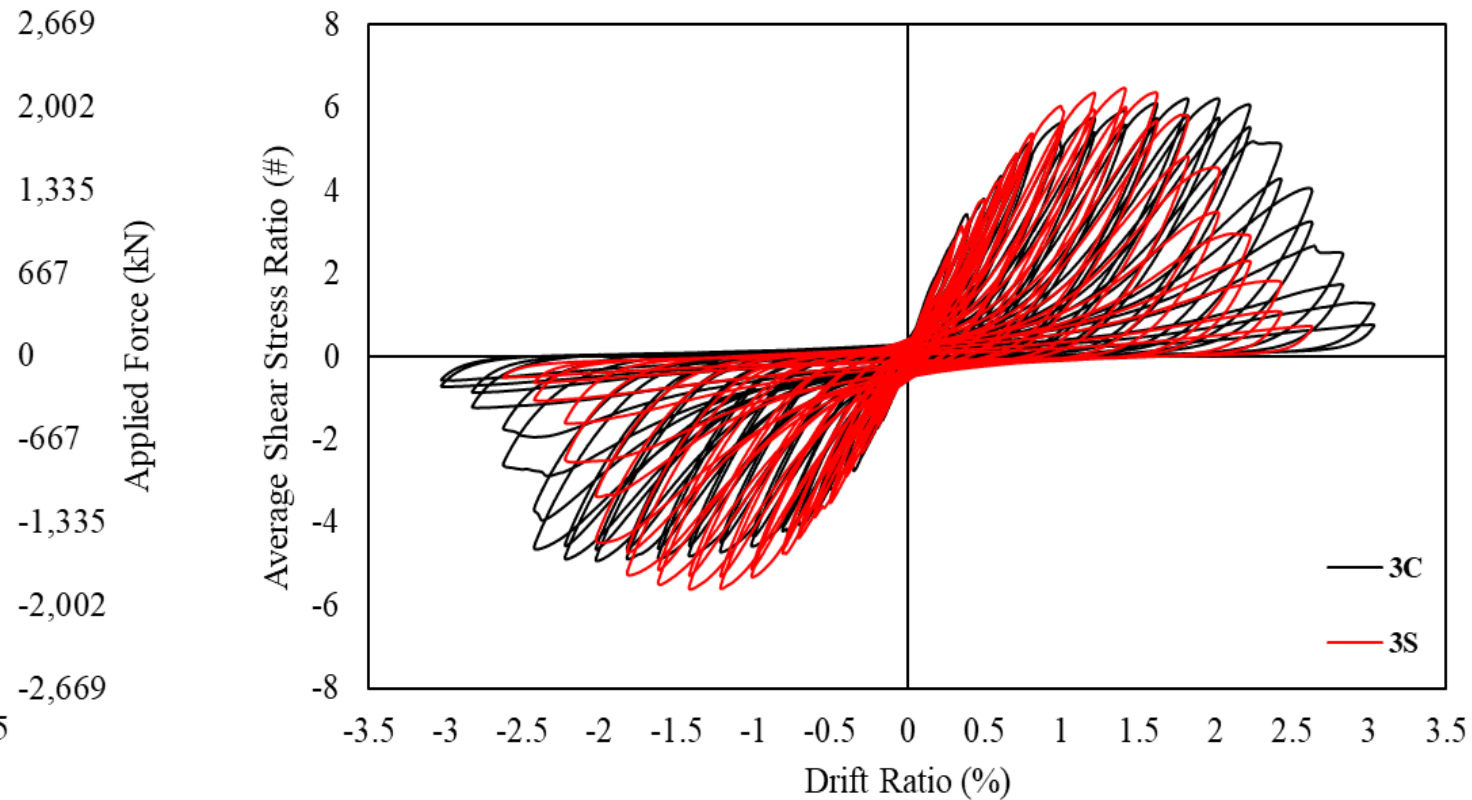


No FRP Side

Hysteresis loops – 12” Wall – (3C & 3S)

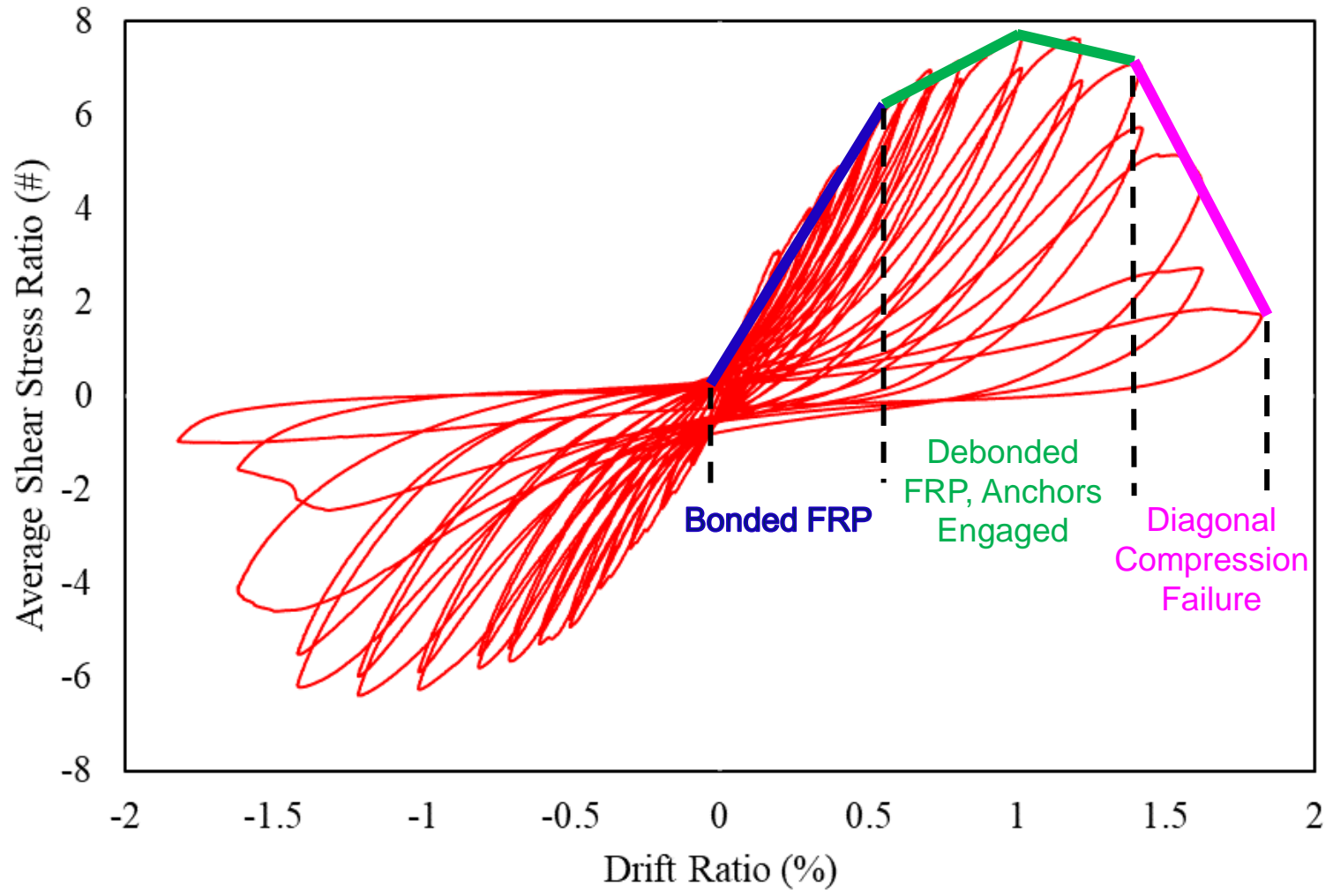


Drift Ratio – Applied Force



Drift Ratio – Average Shear Stress

Strengthened Specimen Hysteresis



- FRP strengthening wall tends to increase the shear capacity.
- The presence of FRP anchors can delay complete detachment of the FRP and allow the FRP to continue resisting load and deformation.
- ACI 440.2 Eq 13.7.2.2d strengthening limit ($10 \sqrt{f'_c}$) should be used for FRP strengthened walls.
- The testing results for 6" walls were in general conformance with ACI 440.2R design equations when the FRP was fully anchored.

- Redesign FRP configuration
 - More FRP anchors along the length of the FRP strip
 - Increase FRP anchor diameter
 - Increase FRP anchor embedment for 12" wall specimens
- Future Shearwall Testing
 - 12 more walls tested by SST as part of this program
 - FEA modeling of test specimens
 - Investigate strengthening of flexure-controlled walls

Thank you

