

FINITE ELEMENT MODELING AND VALIDATION OF STEEL SHEATHED COLD-FORMED STEEL FRAMED SHEAR WALLS

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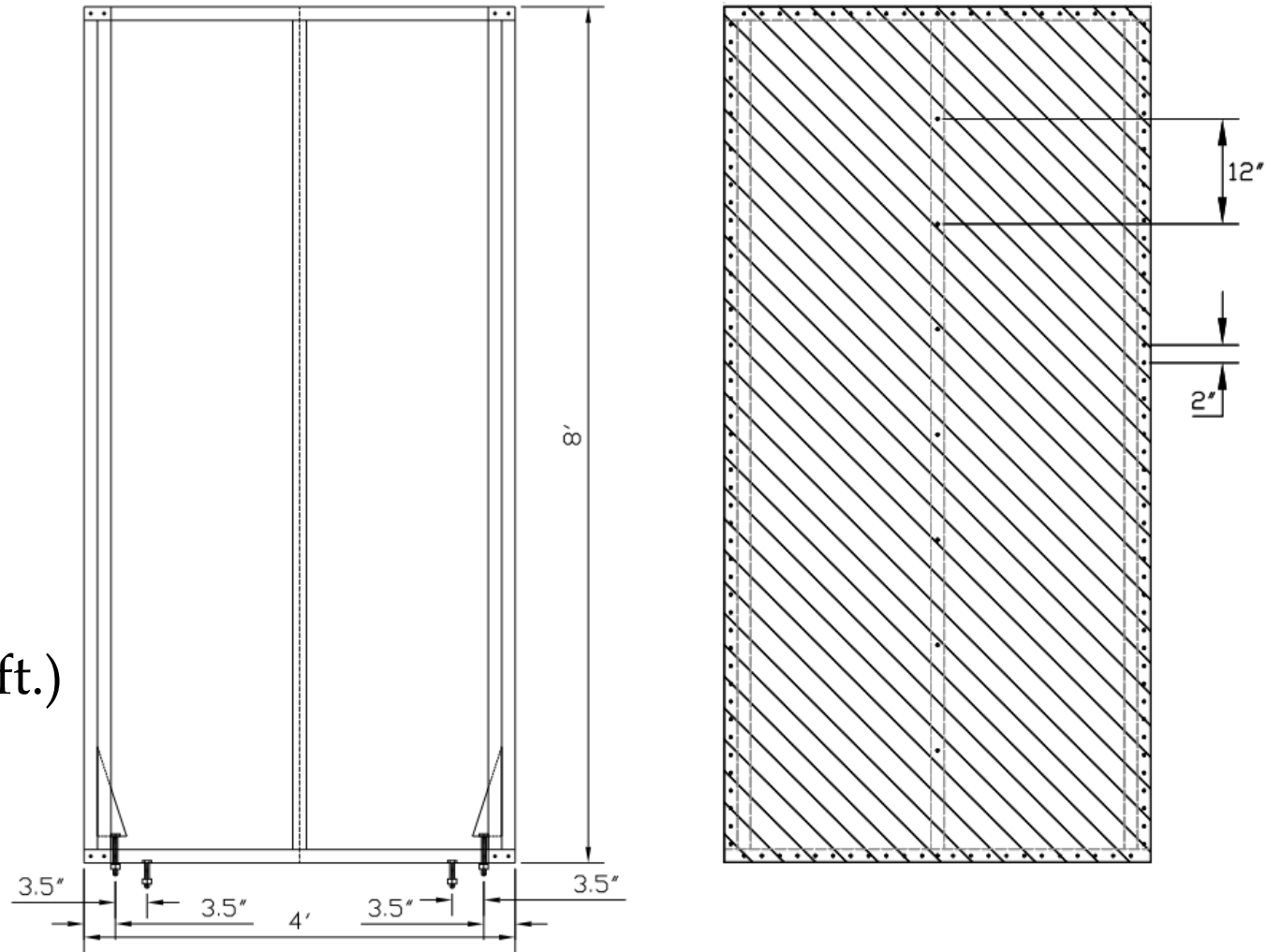
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Steel Sheathed Shear Wall Configuration

- Fifteen wall sets subjected to monotonic and cyclic loading in experimental program
- Nine wall specimens were modeled in OpenSees subjected to lateral cyclic displacement history
 - Aspect ratio
 - 2:1 (4 ft. × 8 ft.) and 4:1 (2 ft. × 8 ft.)
 - Single side steel sheet thickness
 - 0.033 in. and 0.030 in.
 - Edge fastener spacing
 - 6 in., 4 in., and 2 in.



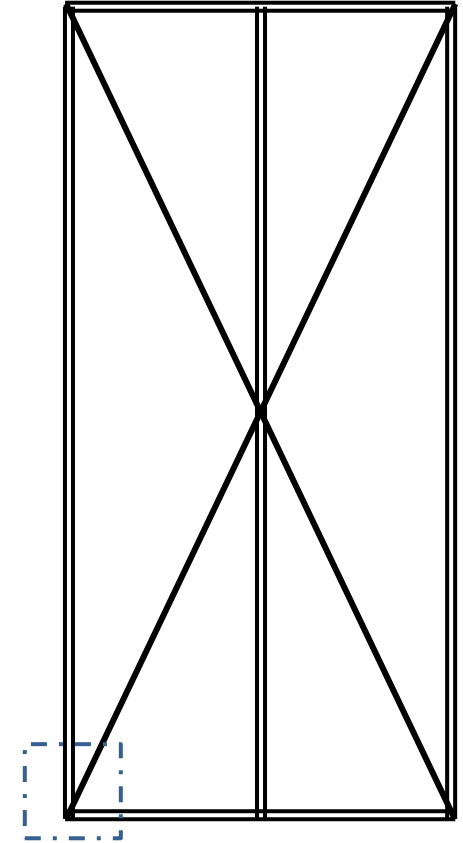
Configuration details of shear wall
Yu et al. (2007)

Modeled Wall Specimens

Wall No.	Test Label	Wall dimensions (width × height)	Steel sheet thickness	Fastener spacing (Perimeter/Field)
1	4×8×43×33-6/12-C1/C2	4 ft. × 8 ft.	33 mil	6 in./12 in.
2	4×8×43×33-4/12-C1/C2	4 ft. × 8 ft.	33 mil	4 in./12 in.
3	4×8×43×33-2/12-C1/C2	4 ft. × 8 ft.	33 mil	2 in./12 in.
4	4×8×43×30-6/12-C1/C2	4 ft. × 8 ft.	30 mil	6 in./12 in.
5	4×8×43×30-4/12-C1/C2	4 ft. × 8 ft.	30 mil	4 in./12 in.
6	4×8×43×30-2/12-C1/C2	4 ft. × 8 ft.	30 mil	2 in./12 in.
7	2×8×43×33-6/12-C1/C2	2 ft. × 8 ft.	33 mil	6 in./12 in.
8	2×8×43×33-4/12-C1/C2	2 ft. × 8 ft.	33 mil	4 in./12 in.
9	2×8×43×33-2/12-C1/C2	2 ft. × 8 ft.	33 mil	2 in./12 in.

Modeling Strategy

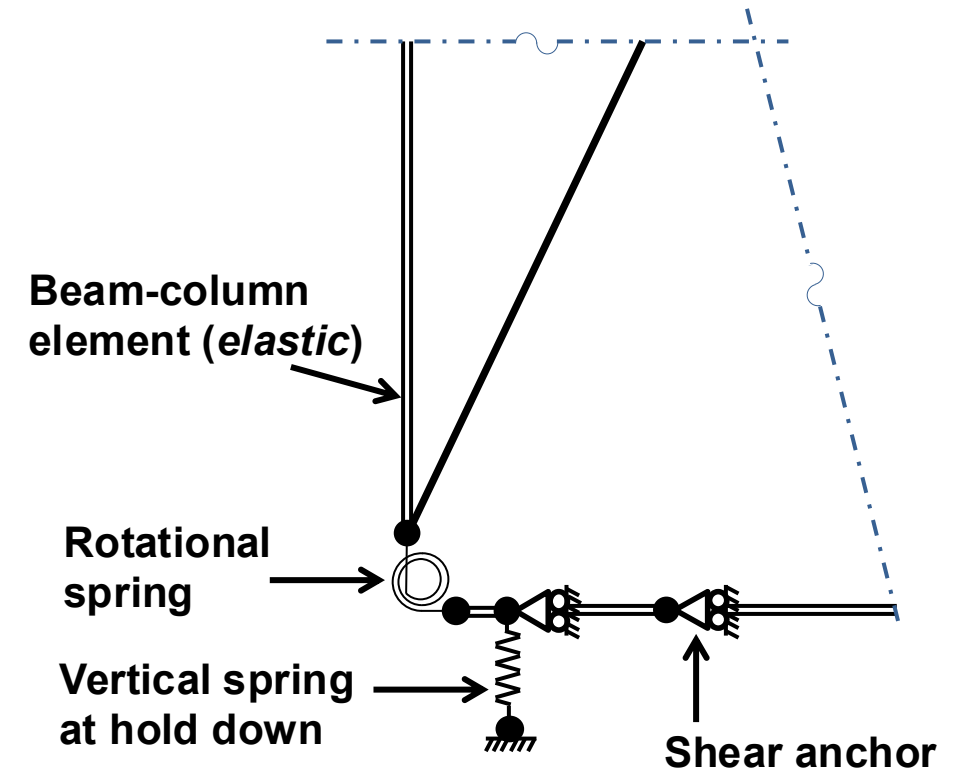
- Linear elastic displacement beam-column elements for framing members
- Rotational springs for stud-to-track connections
 - Rotational stiffness = 100 kip-in./rad (Buonopane et al. 2014)
- Vertical springs for hold-downs
 - Elastic stiffness = 99.3 kips/in. in tension (Simpson 2017)
 - 1000 times larger stiffness in compression (Leng et al. 2013)
- Pinned connection for shear anchors



Numerical model of shear wall in OpenSees

Modeling Strategy

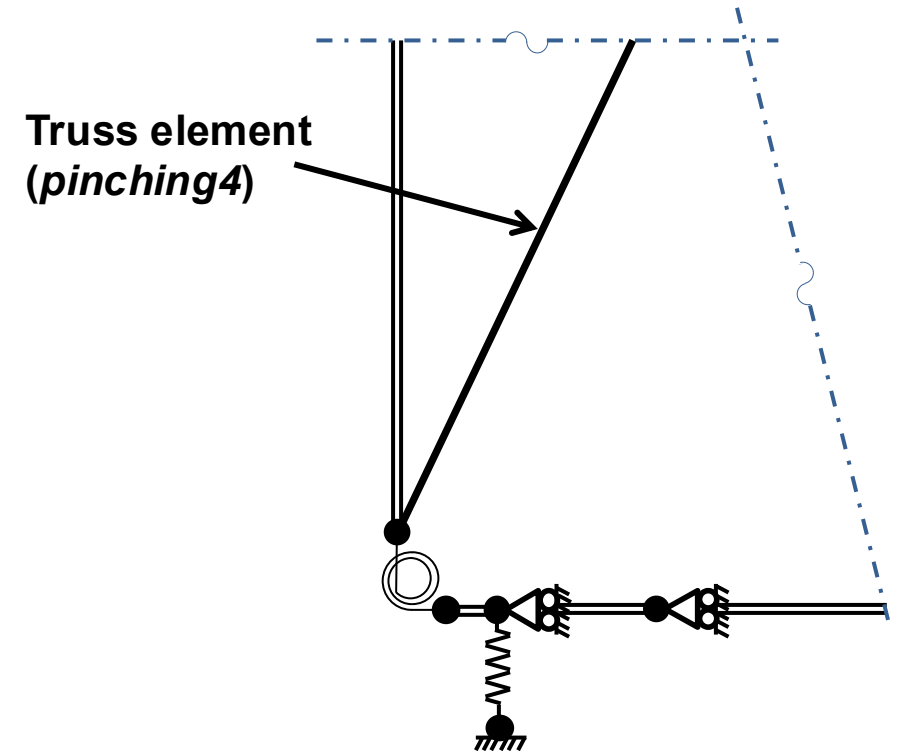
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Numerical model of shear wall in OpenSees

Modeling Strategy (Continued)

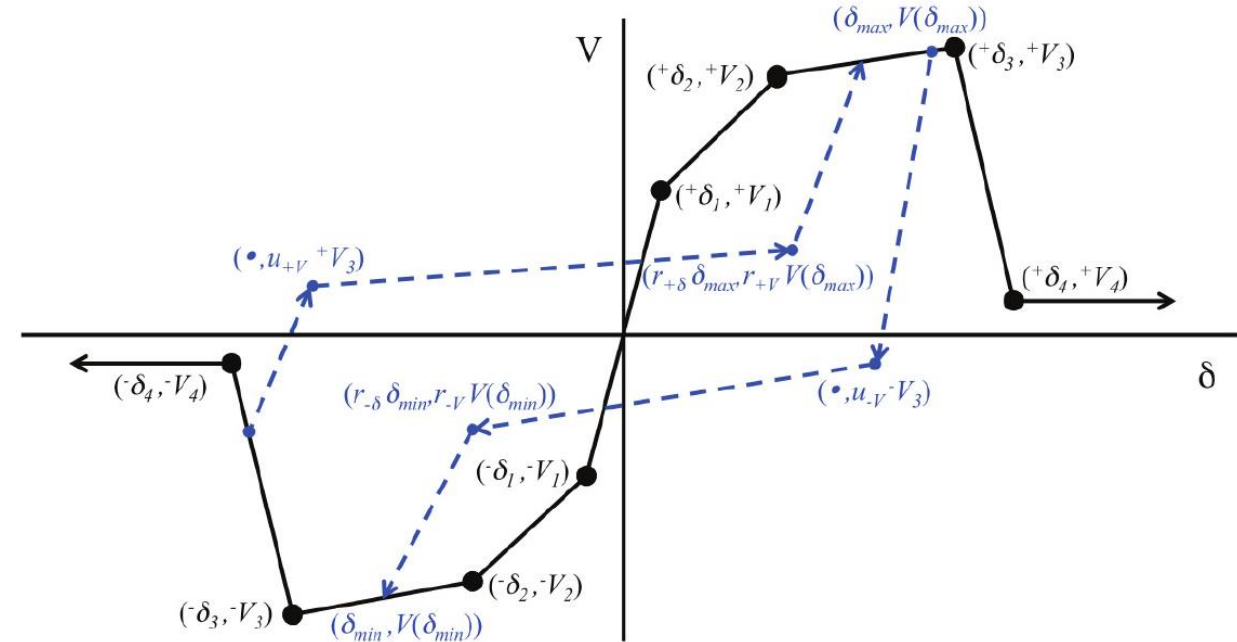
- Truss elements with nonlinear hysteretic material behavior for steel sheathing and fasteners
 - Symmetric *Pinching4* material behavior
 - Material parameter calibration based on experimental results from Yu (2007)
 - Strength and stiffness degradation parameters from Shamin (2013)



Numerical model of shear wall in OpenSees

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Pinching4 uniaxial material model

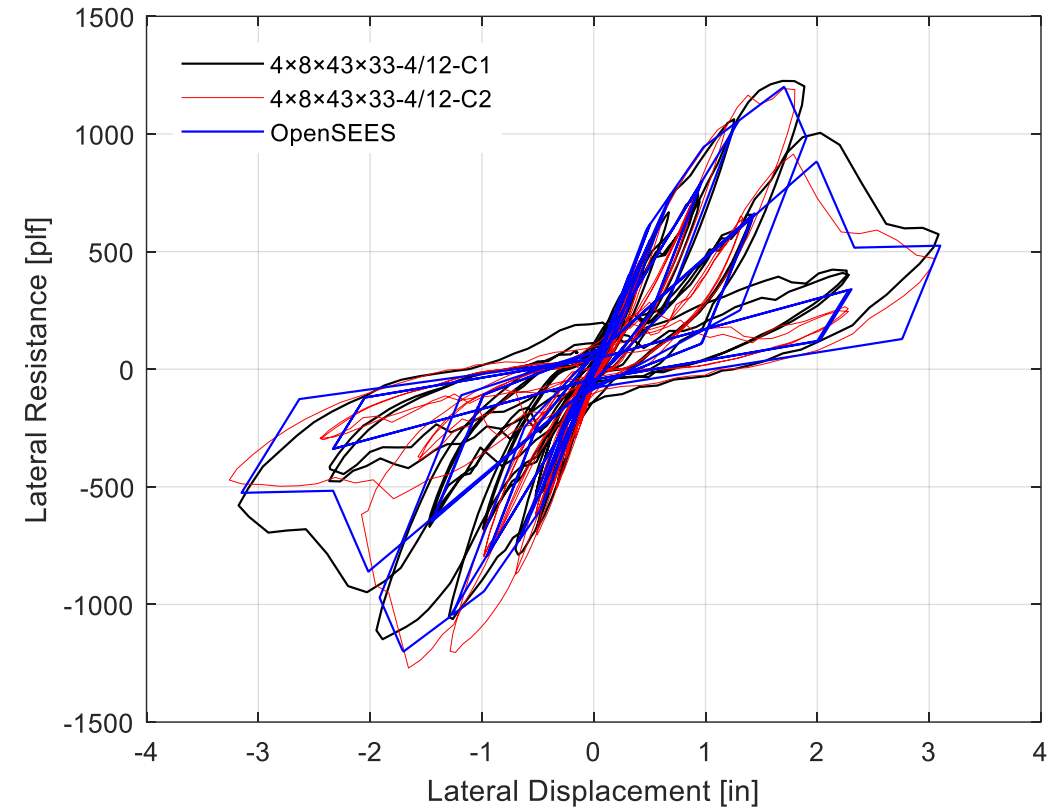
Hysteretic Response Comparison – Wall 2

Calibrated backbone (symmetric) parameters

$+\delta_1$ (mm)	$+\delta_2$ (mm)	$+\delta_3$ (mm)	$+\delta_4$ (mm)
7.5×10^{-3}	3.5×10^{-2}	9.0×10^{-2}	19.8×10^{-2}
$+V_1$ (kN)	$+V_2$ (kN)	$+V_3$ (kN)	$+V_4$ (kN)
38.5	61.0	77.3	32.1

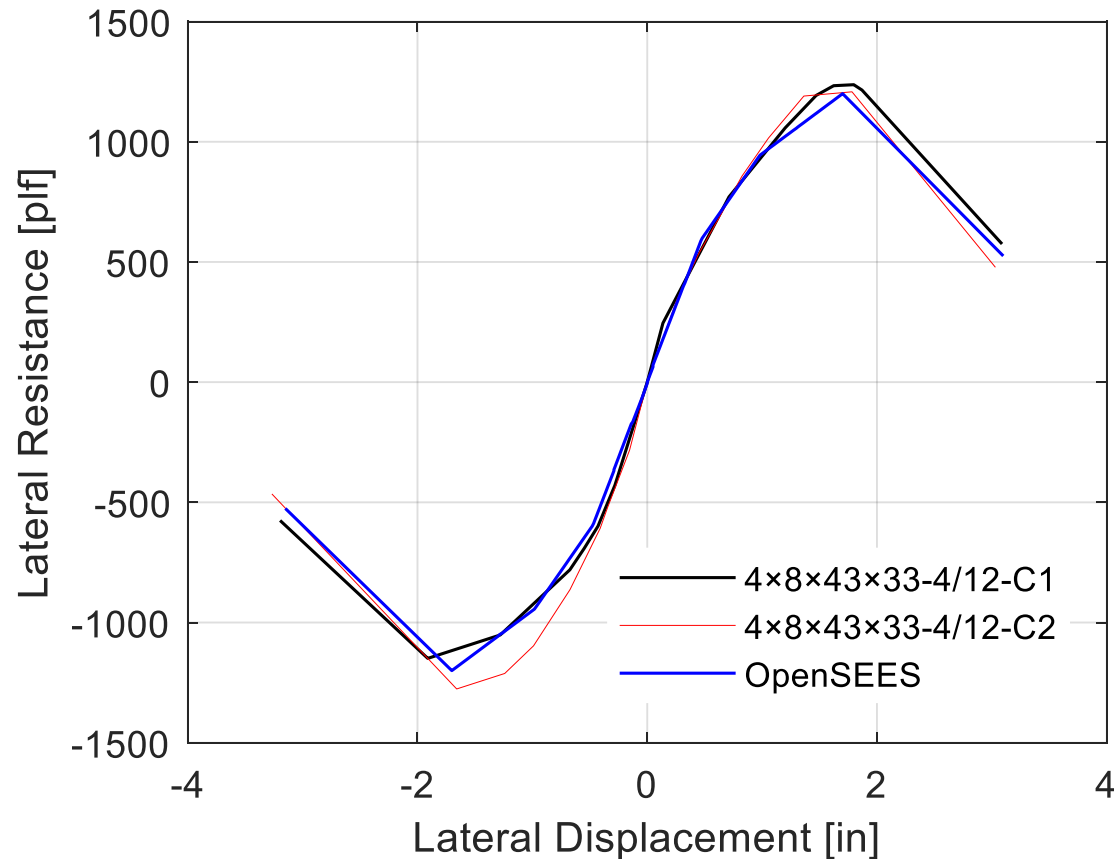
Calibrated unloading and reloading parameters

$r_{+\delta}$	r_{+V}	u_{+V}
0.01	0.1	-0.2
$r_{-\delta}$	r_{-V}	u_{-V}
0.01	0.1	-0.2

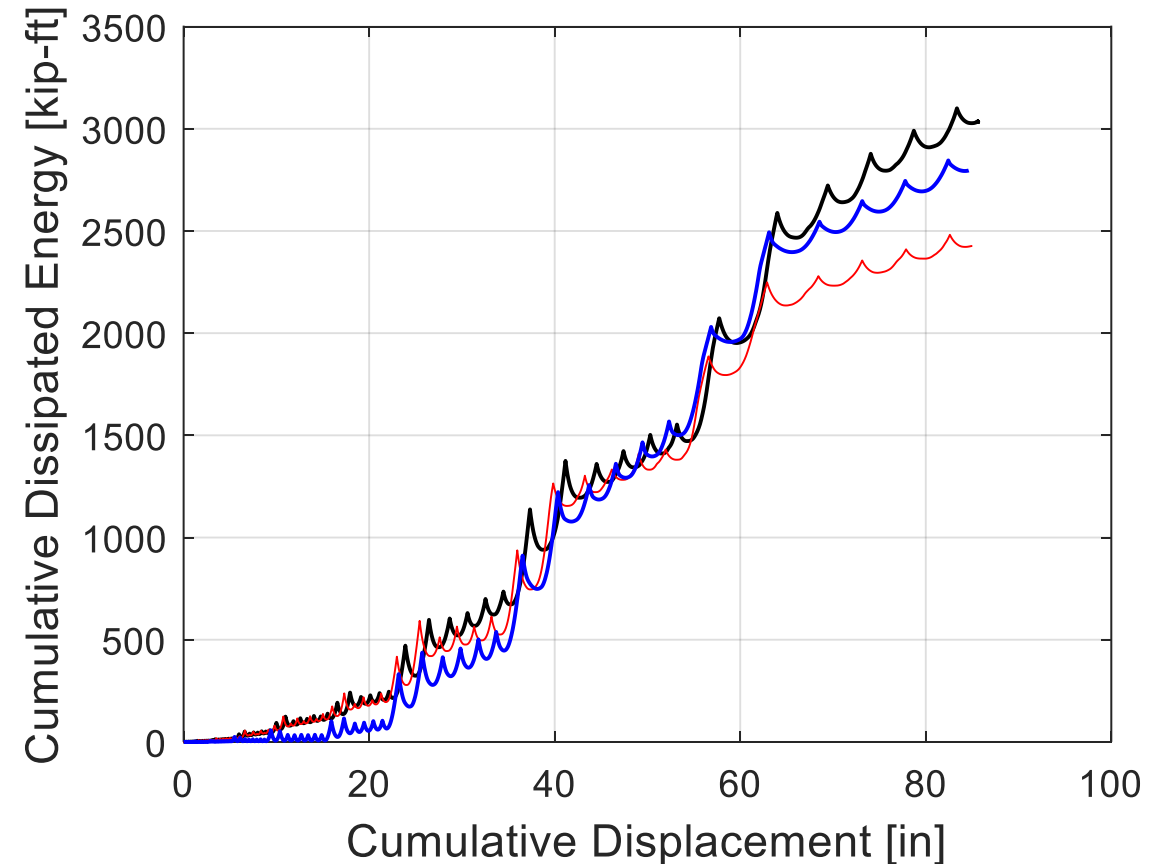


Experimental – **1187 plf @ 1.79 in**
 1232 plf @ 1.67 in
 Numerical – **1200 plf @ 1.70 in**

Response Comparison– Wall 2



Comparison of backbone curves



Comparison of cumulative dissipated energy

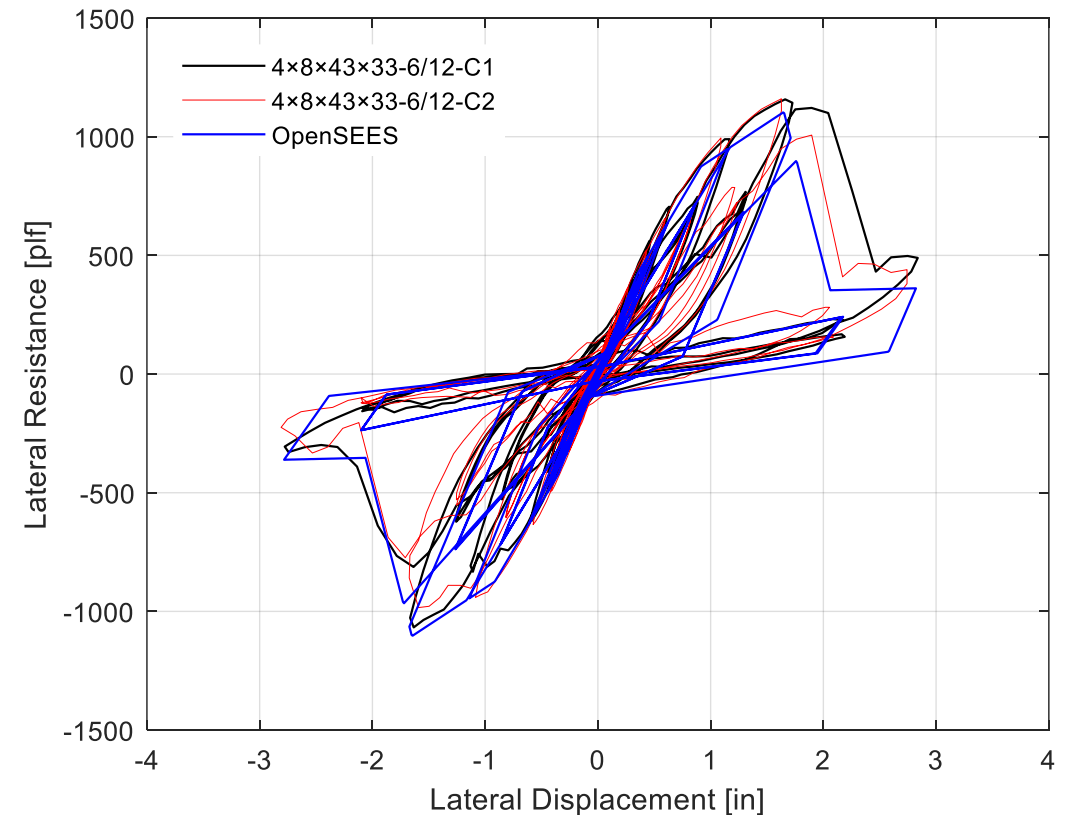
Hysteretic Response Comparison – Wall 1

Calibrated backbone (symmetric) parameters

$+\delta_1$ (mm)	$+\delta_2$ (mm)	$+\delta_3$ (mm)	$+\delta_4$ (mm)
6.9×10^{-3}	3.3×10^{-2}	9.1×10^{-2}	18.2×10^{-2}
$+V_1$ (kN)	$+V_2$ (kN)	$+V_3$ (kN)	$+V_4$ (kN)
27.3	56.5	71.0	21.6

Calibrated unloading and reloading parameters

$r_{+\delta}$	r_{+V}	u_{+V}
0.01	0.1	-0.2
$r_{-\delta}$	r_{-V}	u_{-V}
0.01	0.1	-0.2



Experimental – **1072 plf @ 1.61 in**
 1113 plf @ 1.65 in
 Numerical – **1102 plf @ 1.64 in**

Calibrated *Pinching4* Parameters

Wall No.	$+V_1$ kN	$+V_2$ kN	$+V_3$ kN	$+V_4$ kN	$+\delta_1$ ($\times 10^{-3}$) mm	$+\delta_2$ ($\times 10^{-2}$) mm	$+\delta_3$ ($\times 10^{-2}$) mm	$+\delta_4$ ($\times 10^{-2}$) mm
1	27.3	56.5	71.0	21.6	6.9	3.3	9.1	18.2
2	38.5	61.0	77.3	32.1	7.5	3.5	9.0	19.8
3	59.2	79.2	88.3	40.2	1.5	0.20	8.4	20.0
4	18.5	43.0	55.5	19.0	11.0	6.0	14.1	28.0
5	25.5	50.8	64.9	26.0	14.0	5.5	13.2	30.0
6	33.0	58.5	69.0	31.0	17.0	5.0	10.1	31.0
7	23.5	57.0	69.9	22.0	0.40	2.8	8.8	22.0
8	31.0	55.0	79.9	26.0	0.65	2.0	6.4	24.0
9	33.0	50.0	89.1	26.0	1.0	1.5	5.6	24.0

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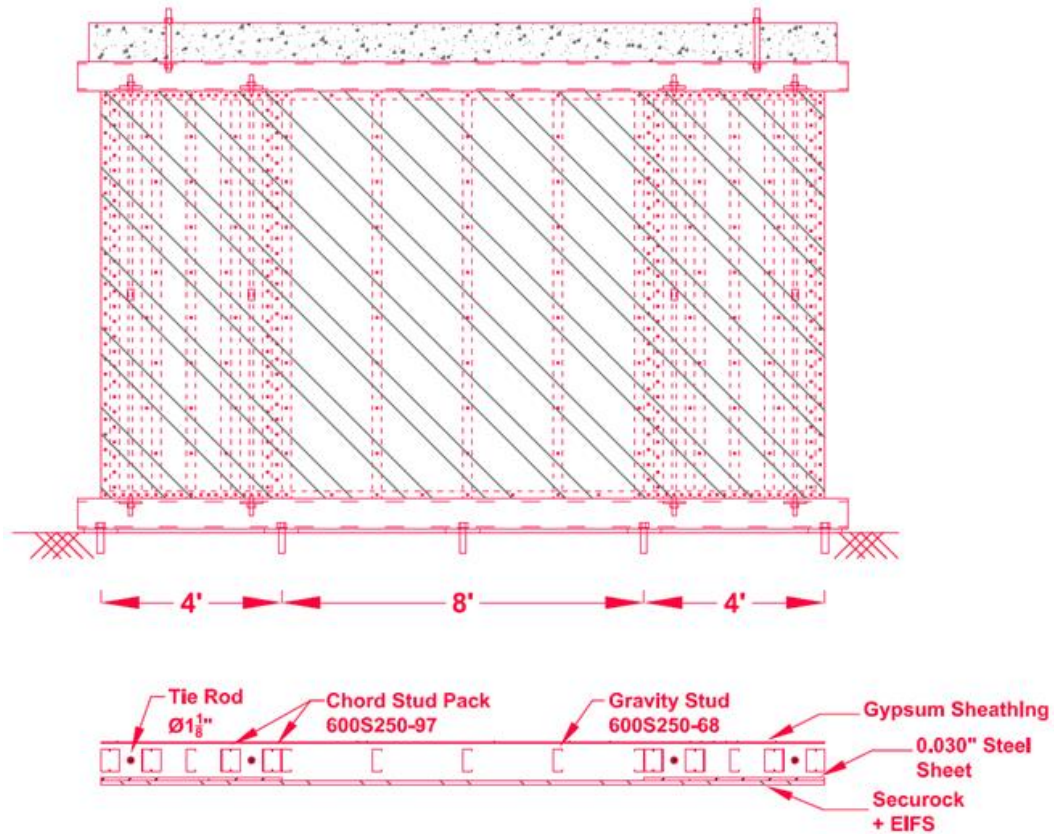
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Conclusions

- Wall configurations modeled using a low degree of freedom truss-element based finite element model in OpenSees
- Parameters for *Pinching4* material model calibrated using experimental data
- Extensions of modeling strategy
 - Different steel sheet thickness, framing member size
 - Inelastic beam column elements for framing member behavior
- X-brace type numerical models capable of capturing steel sheathed shear wall response
- Building block for models intended to capture system-level behavior

CFS-NHERI Inline Wall Tests



Typical wall details



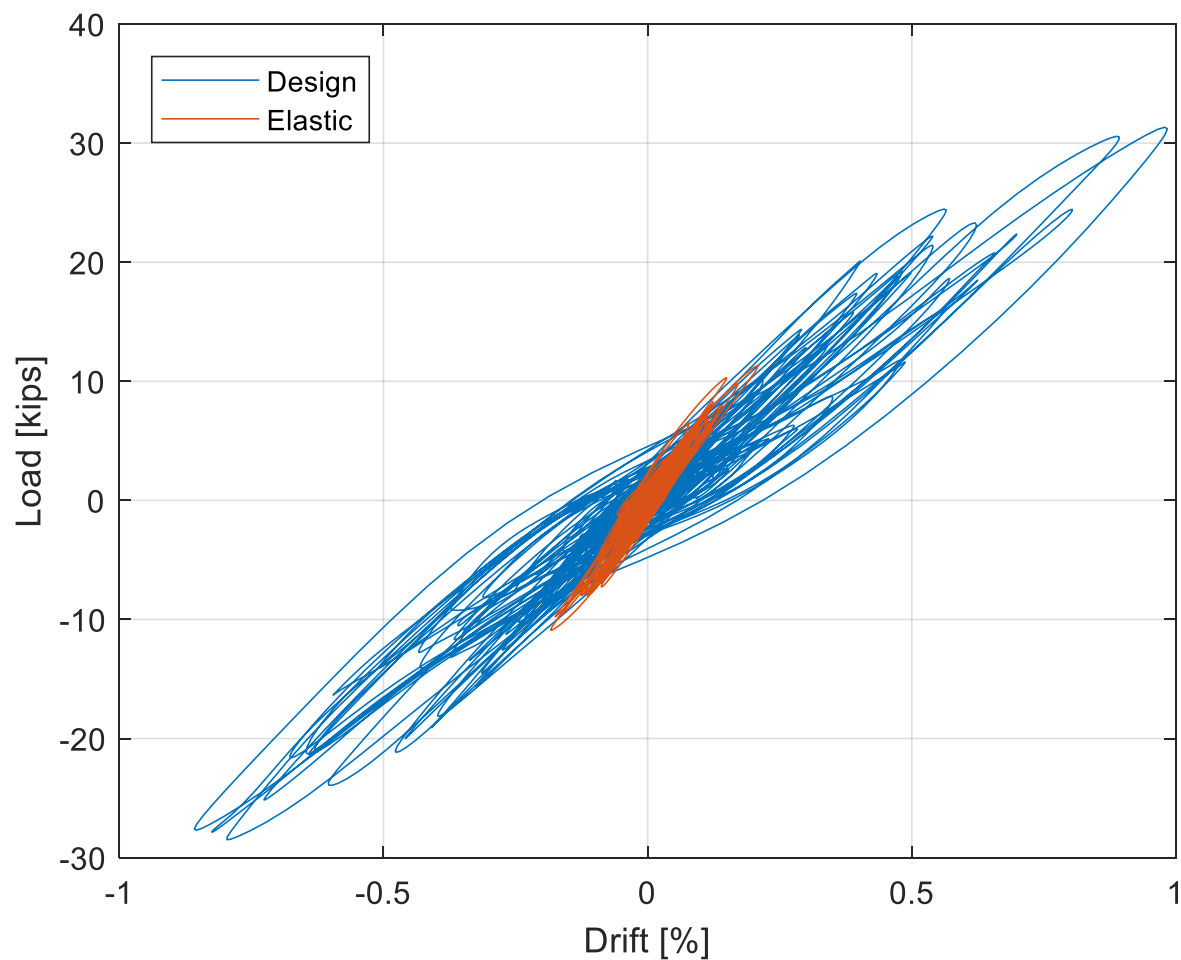
Test Setup

CFS-NHERI Inline Wall Tests (Design Level EQ)

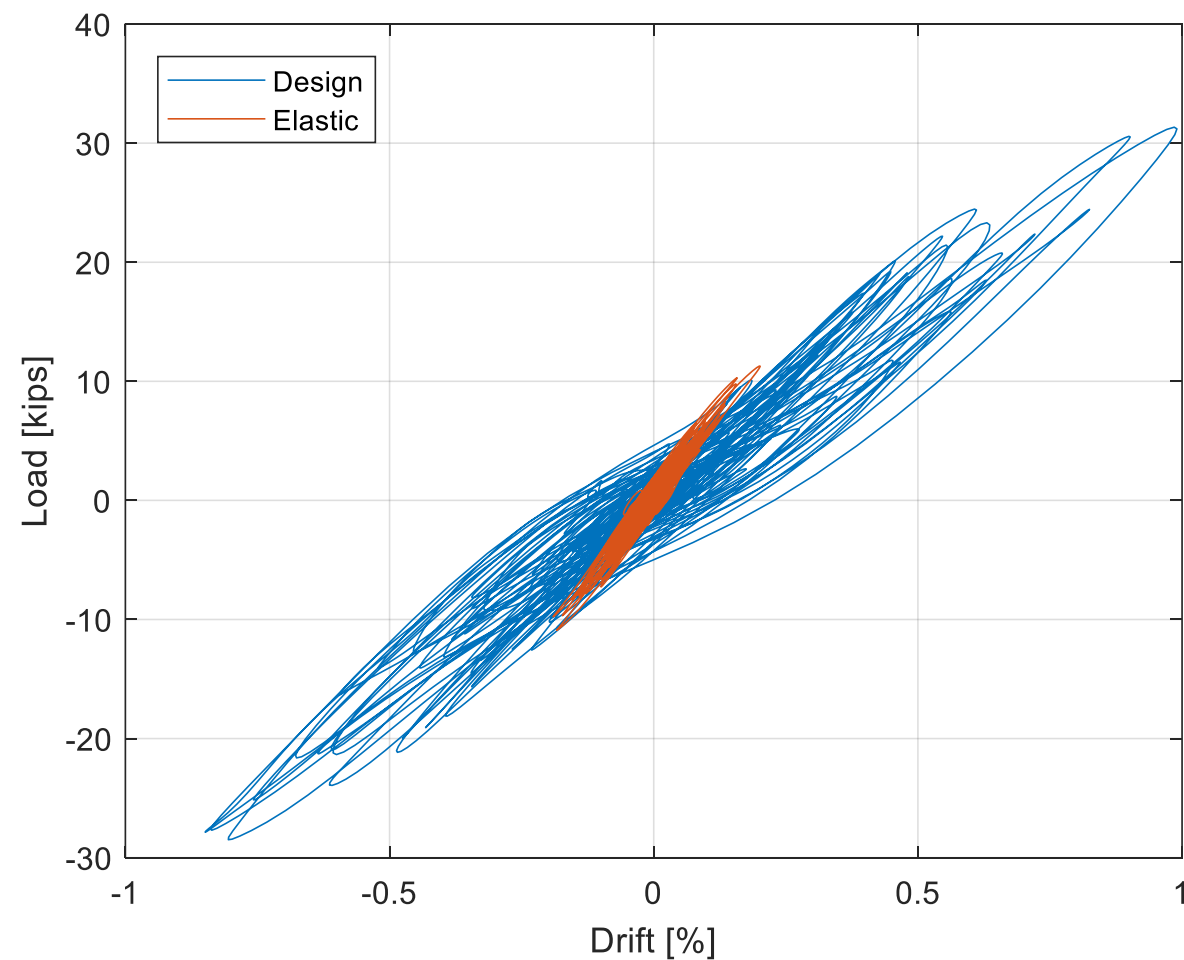


Northridge (1994)
Station: Canoga park
Scaled to 1.05g PGA

CFS-NHERI Inline Wall Tests (Preliminary Results)



Wall N1



Wall N2

Acknowledgments

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UNIVERSITY

UMassAmherst

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References

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Thank You



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