CFSRC summer symposium

# Finite Element Modeling and Validation of the CFS-HUD 6-story Test Building

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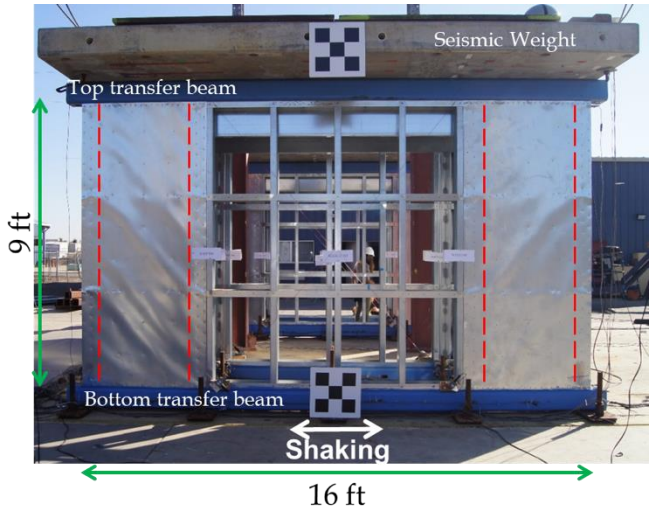
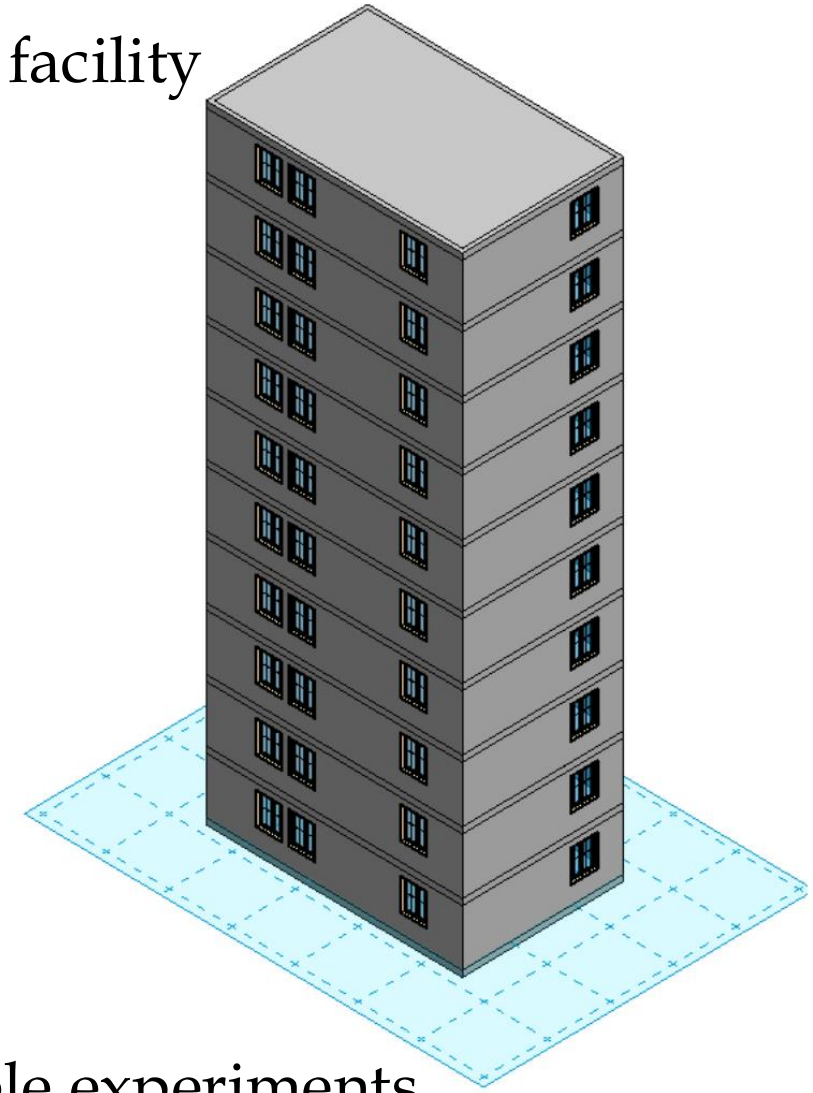
*CFSRC Summer Symposium, May 23, 2022*

# 10-story CFS-NHERI Building Test: *Planned for 2023*

- 10-story CFS framed building test at upgraded LHPOST6 facility
- Build upon knowledge gained in wall-line, diaphragm, and connection level tests within CFS-NHERI project



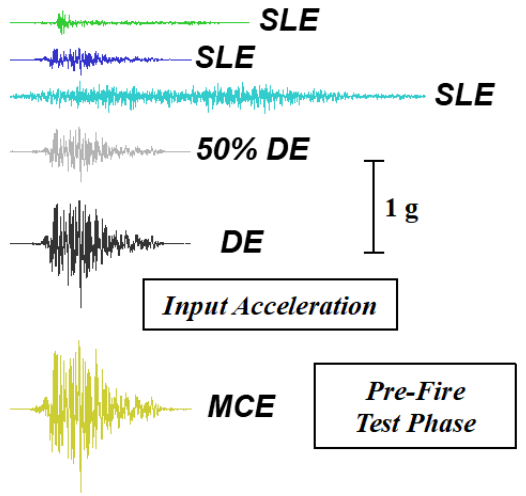


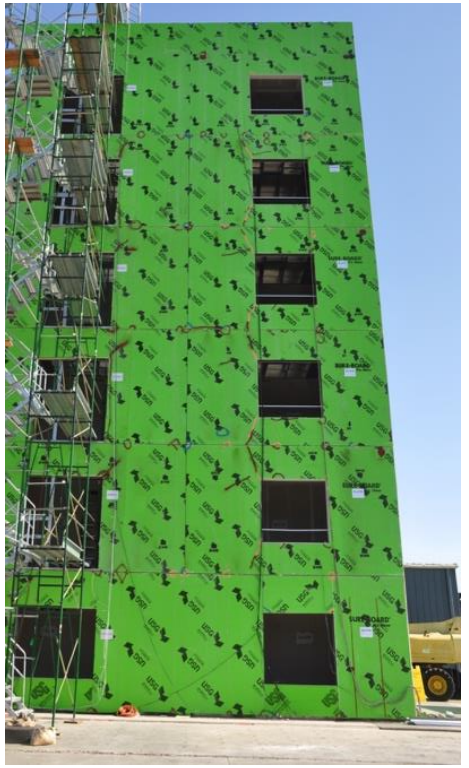


- Numerical modeling for seismic response predictions of 10-story building
- Model validation against available system-level shake table experiments

# Numerical Modeling: *Validation & Application*

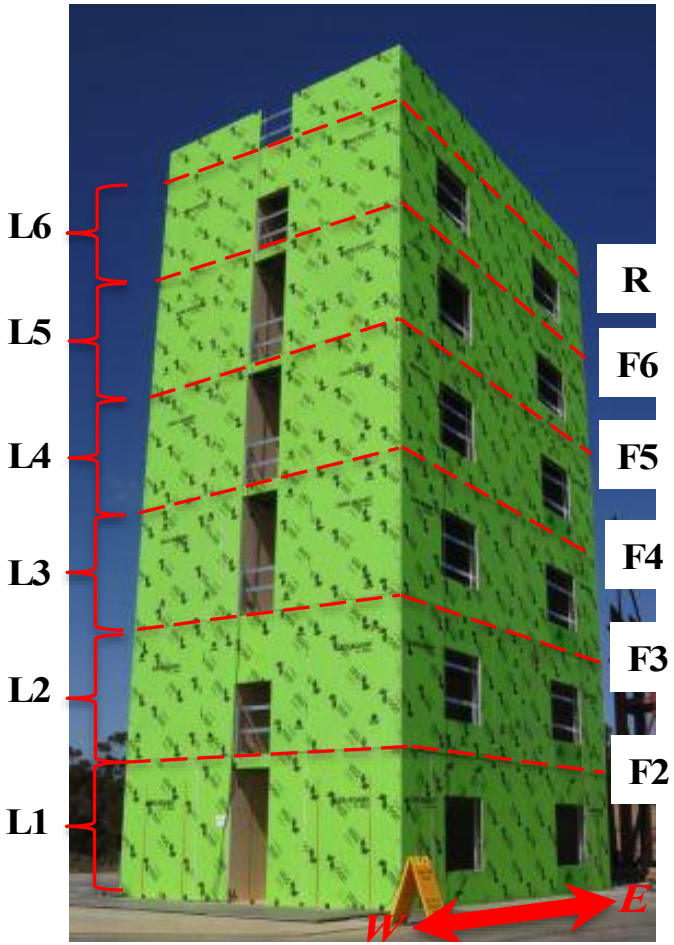
- Model validation at system-level
  - CFS-HUD (6-story) : Documented complete building response
  - Extend to 10-story CFS-NHERI test building
- Benchmark predictions for 10 story CFS-building response
- Guide ground motion scaling for shake table experiments
  - Choice of motions
  - Scale factors
  - Test protocol

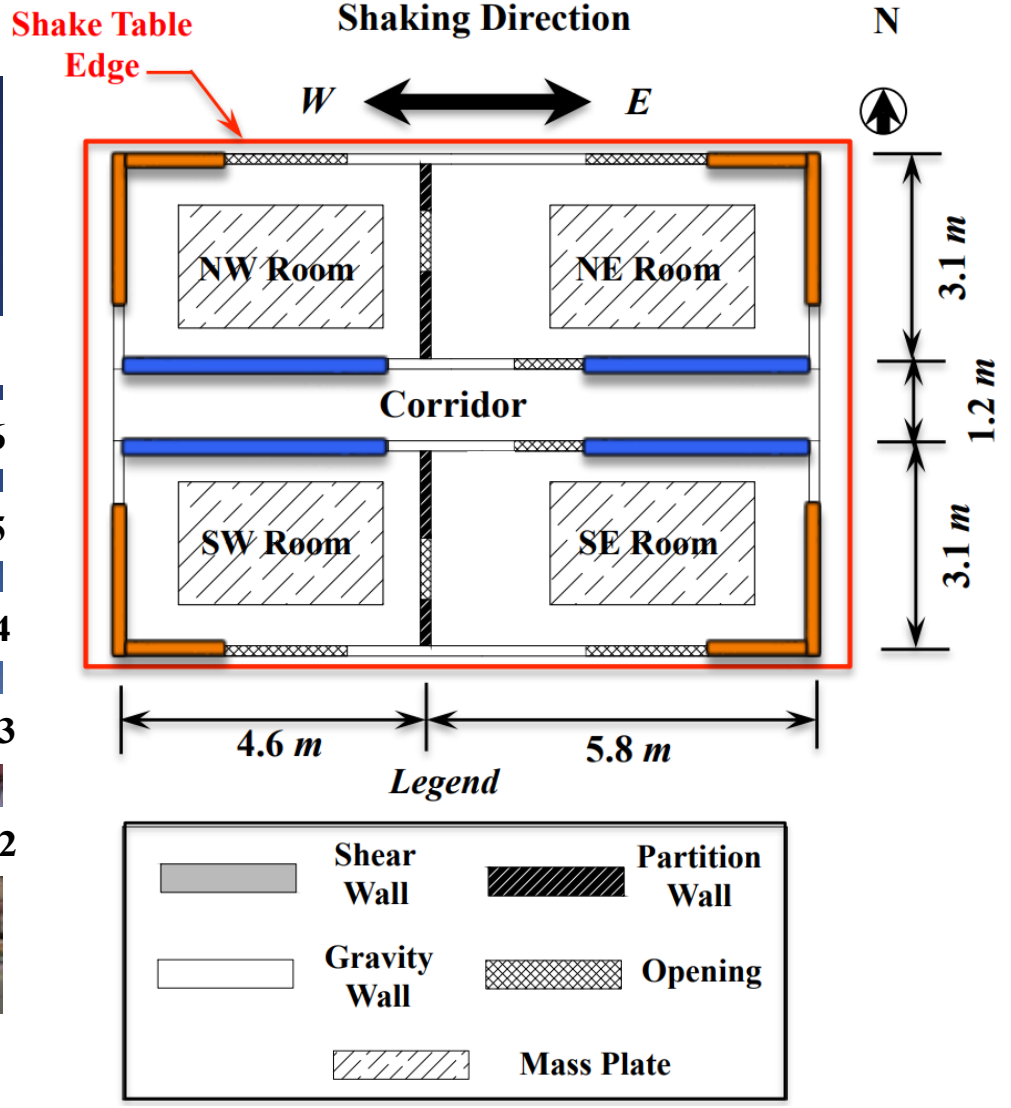


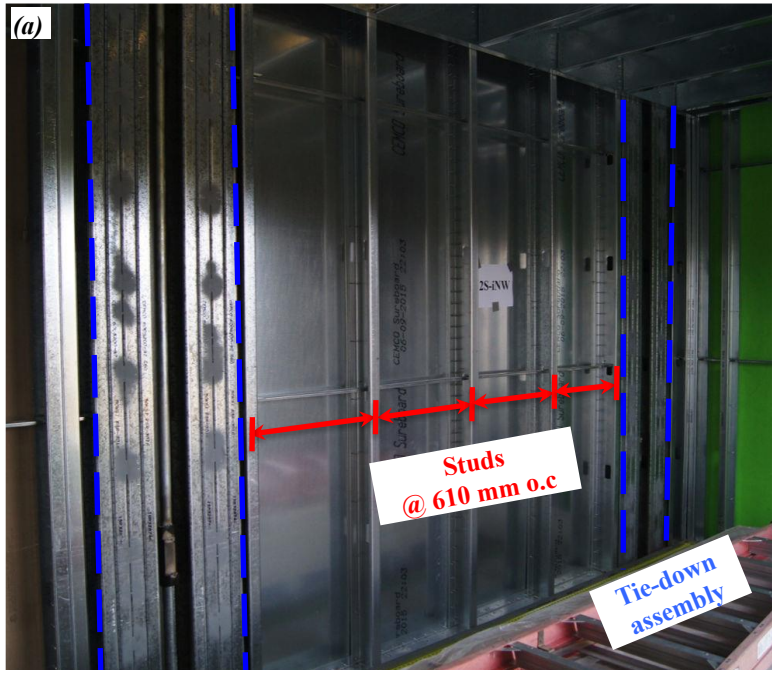
# CFS-HUD 6-story Test Building: *Overview*

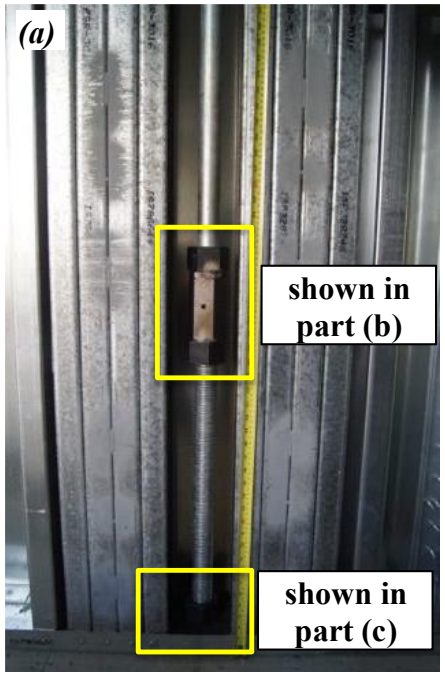
- Building height = 64ft, Story height = 10ft
- Plan area = 34ft x 24ft
- Building design location = Downtown Los Angeles
- $S_{DS} = 1.53g$, $S_{D1} = 0.81g$
- $R = 6.5$, $\Omega_o = 3.0$, $C_d = 4.0$
- Lateral force resisting system: CFS shear walls
  - *Corridor walls*: primary lateral resisting elements
  - *Exterior walls*: resist transverse & torsional loads



# CFS-HUD 6-story Test Building: *LFRS Details*



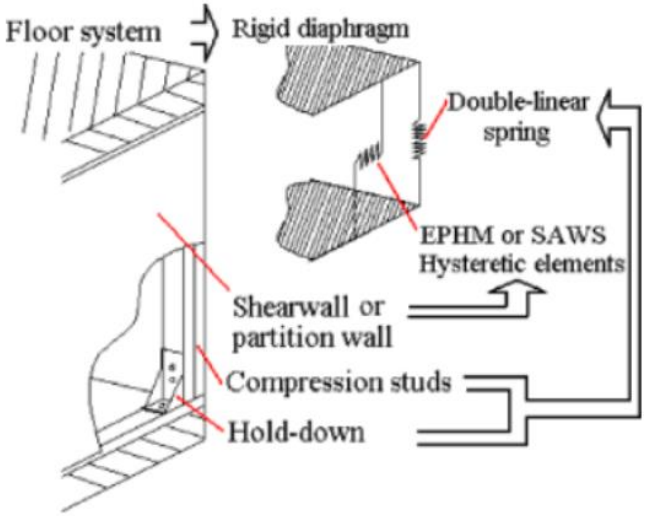



Corridor shear wall with compression stud packs and tension tie-rods (Level 2)

| SW location | SW dimensions | Fastener detailing | Tension tie-rod diameter |
|---|---|---|---|
| Corridor (West) | 13’ x 10’ | #8 screws @ 3”/16” (Levels 1-3)<br>#8 screws @ 4”/16” (Level 4)<br>#8 screws @ 6”/16” (Levels 5-6) | 1-3/4” (Level 1), 1-5/8” (Level 2),<br>1-3/8” (Level 3), 1-1/4” (Levels 4-5),<br>5/8” (Level 6) |
| Corridor (East) | 11’ x 10’ | | |
| Corner (Longitudinal) | 5’-4” x 10’ | #8 screws @ 6”/16” (Levels 1-6) | 1-3/4” (Level 1), 1-1/4” (Level 2),<br>1” (Level 3), 3/4” (Level 4),<br>5/8” (Levels 5-6) |
| Corner (Transverse) | 7’ x 10’ | | |

# Numerical Modeling: *Simplified Pancake Model*

- Simplified model for multi-story building dynamic analysis
  - Nonlinear hysteretic springs for shear wall elements
  - Nonsymmetric linear springs for each uplift restraints
    - ✓ Important for tall buildings
  - Rigid diaphragms for the roof and floors



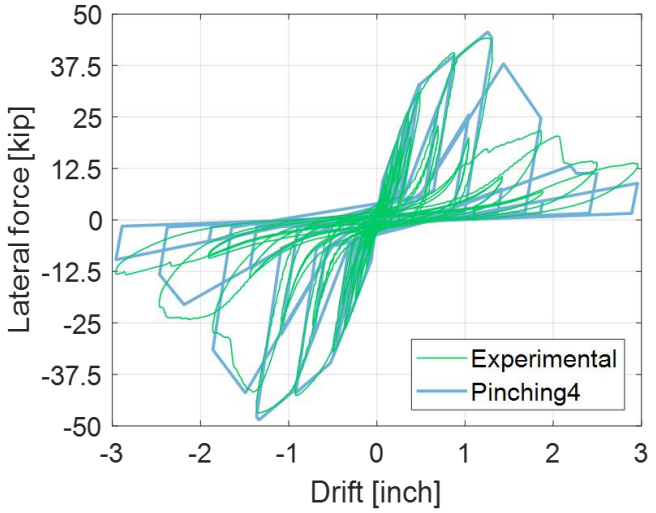

Modeling elements in SAPWood (Pei et al. 2010)

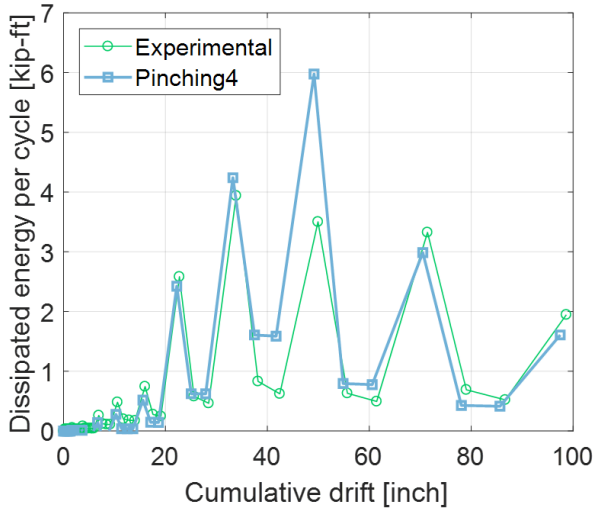
- OpenSeesPy for numerical modeling of structural components for benchmark predictions of building response
- Use non-linear spring elements validated against component-level experiments

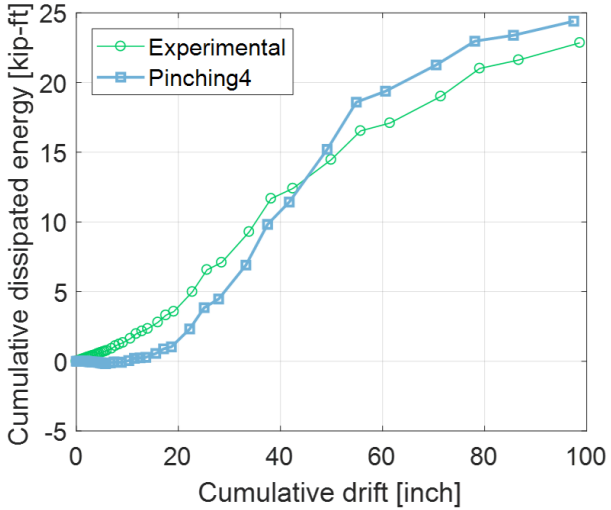
# Numerical Modeling: *Component-Level Validation*

- *Pinching4* material model for shear wall elements
  - Validated against NIST wall lateral & fire testing
    - 12′ x 9′ shear walls
    - Steel sheathed composite sheathing (SureBoard) panels using #8 screws @ 3″/12″
      - ✓ Similar to corridor SW at levels 1-3
    - CUREE protocol

Hoehler, M. S., Smith, C. M., Hutchinson, T. C., Wang, X., Meacham, B. J., & Kamath, P. (2017). Behavior of steel-sheathed shear walls subjected to seismic and fire loads. *Fire safety journal*, *91*, 524-531.

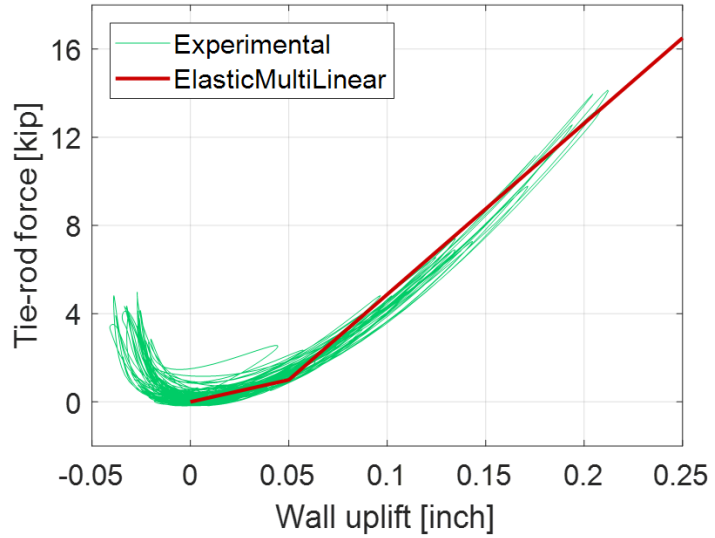


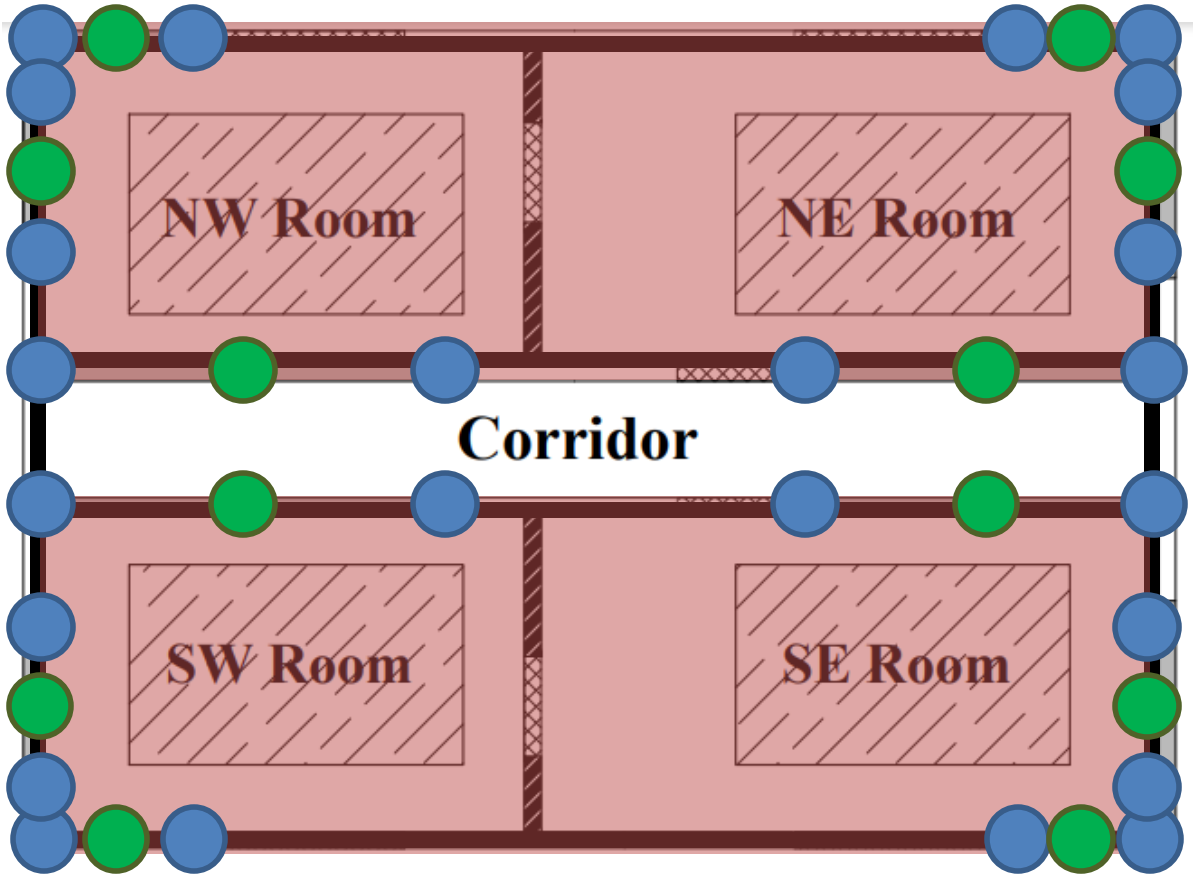
# Numerical Modeling: *Component-Level Validation (continued)*

- *ElasticMultiLinear* material model for tie-rod elements in tension
  - Validated against CFS-NHERI shake table wall-line testing (currently)
    - 16′ x 9′ wall-lines with f1-1/4″ tension tie-rods
      - ✓Similar to tie-rods in corridor SW at levels 4-5
    - Steel sheathed shear walls using #10 screws @ 2″/12″
  - Will be updated to CFS-HUD measured wall local response




Singh, A., Wang, X., Zhang, Z., Derveni, F., Castaneda, H., Peterman, K. D., Schafer, B. W., and Hutchinson, T. C. (2021). "Steel Sheet Sheathed Cold-Formed Steel Framed In-line Wall Systems. I: Impact of Structural Detailing" *ASCE Journal of Structural Engineering*. (accepted)

# Numerical Modeling: *Model Schematics (Under Development)*



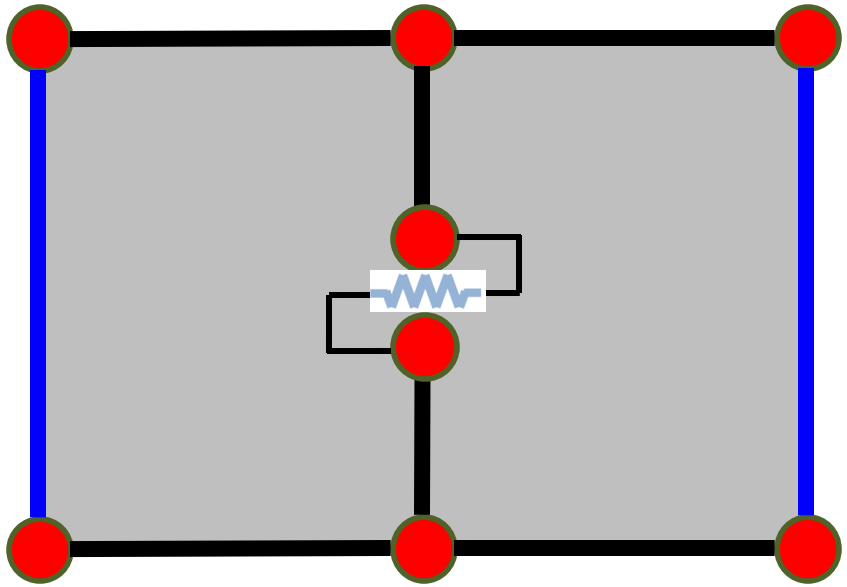

Tie-rods/compression posts as multi-linear elements

Shear walls as spring elements (*pinching4*)

Rigid link

Rigid diaphragm

Shear wall schematic



*zerolength* element (shear wall)

*truss* element (tie-rod)

Node

Rigid link

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