



NHERI@UC San Diego: Design of a Shared-Use Modular Testbed Building (MTB²)

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In collaboration with CoreBrace, DuraFuse & SME Steel*

Joint Researcher Workshop, UC San Diego & RAPID

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University of California at San Diego



Natural Hazards Engineering Research Infrastructure



Natural Hazards Reconnaissance



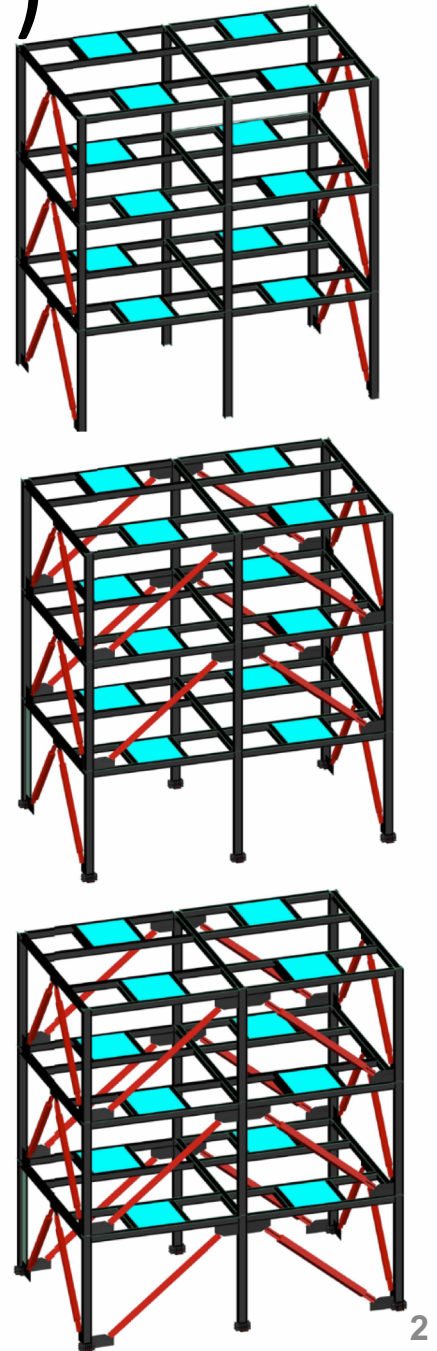
SME STEEL



THE RESILIENT SEISMIC SOLUTION

Modular Testbed Building (MTB²)

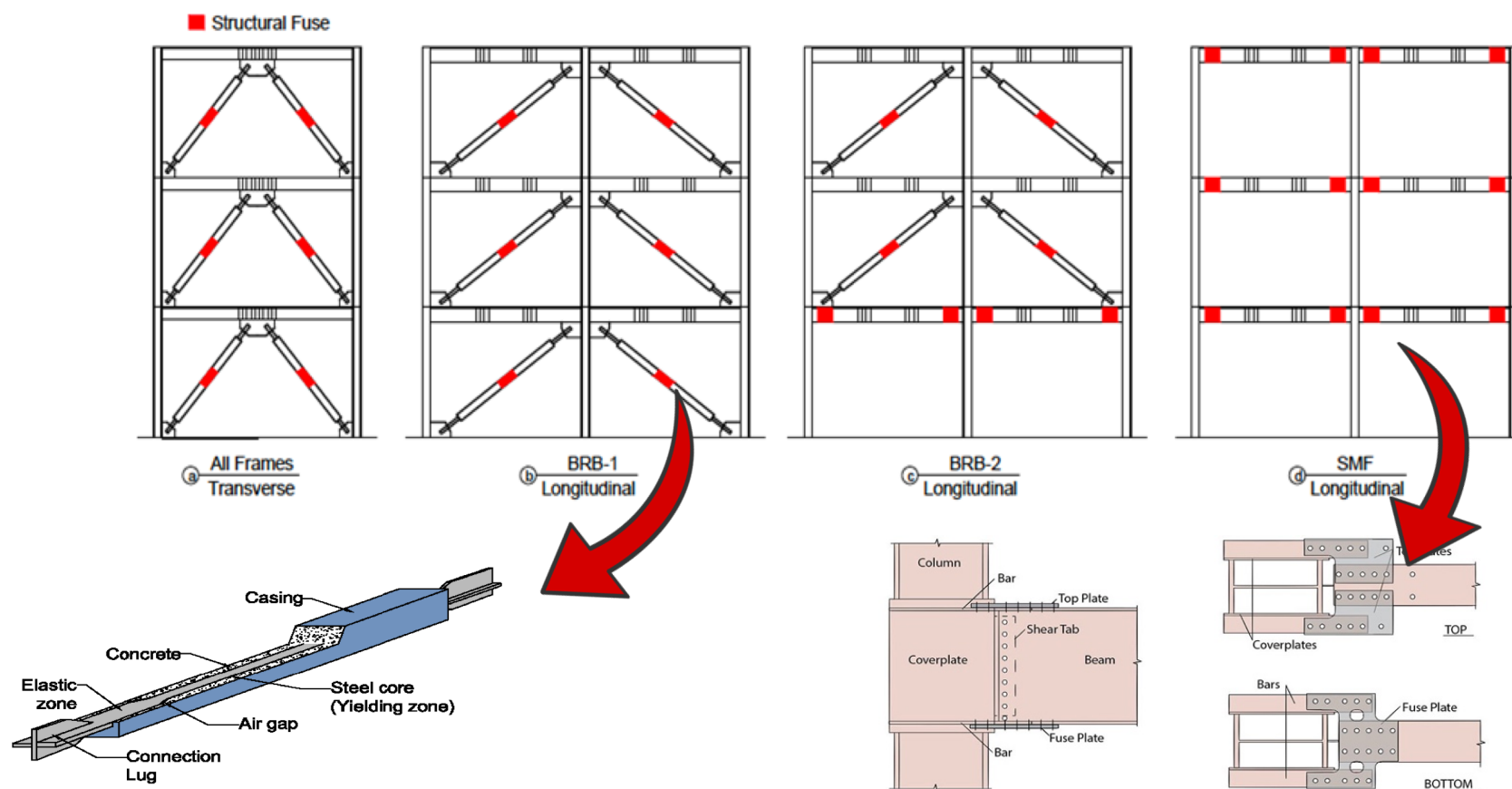
- Community-available building for NHERI users
 - Presently in design phase; materials procured
 - First structure to be tested on newly upgraded LHPOST6
- **Evolution:**
 - Multi-university collaboration (University of Utah & UCSD)
 - Close collaboration with industry partners (SMS steel, BRB manufacturer CoreBrace & MF designer DuraFuse)
 - Community input (via NHERI workshops)
- **Unique features:** Designed to be **reconfigurable** & **reusable** enabling low-cost testing of components and systems under simulated dynamic 3D loading



Design Features

Reconfigurable 3-D full-scale three-story steel building designed to accommodate wide range of seismic behavior of buildings:

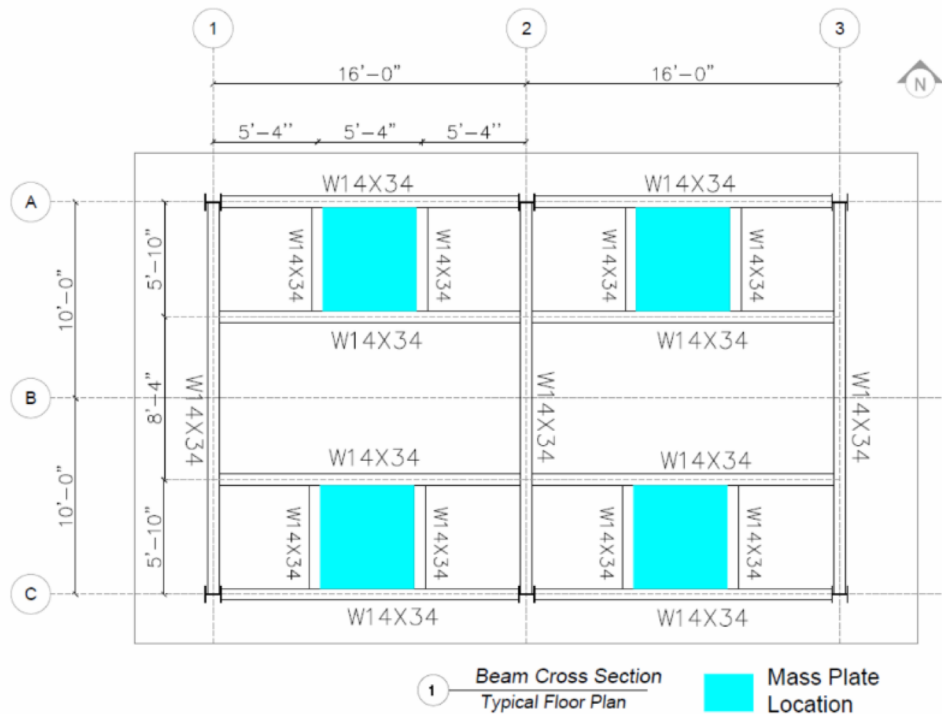
- i) Moment frame behavior with **shear fuse** type plastic hinge
- ii) Braced frame behavior with **buckling restrained braces** (BRBs) at the built-in gusset plates at joints



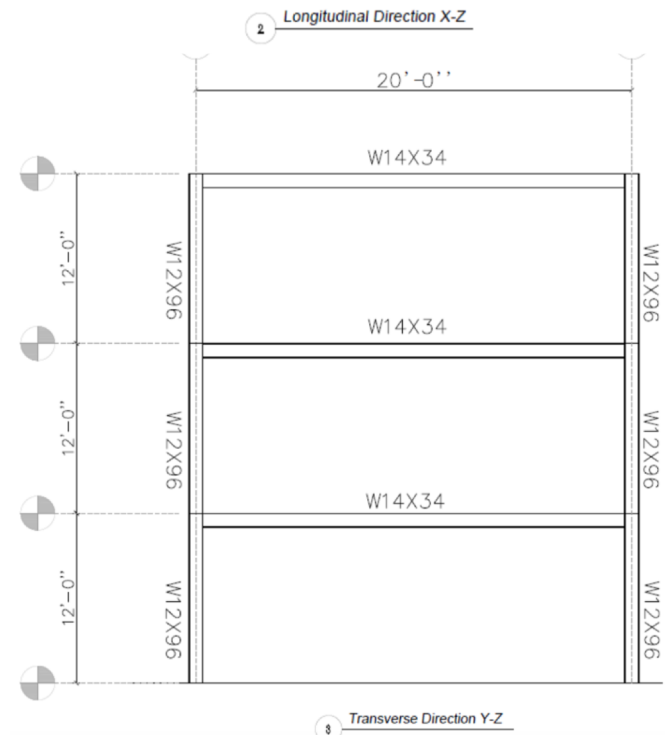
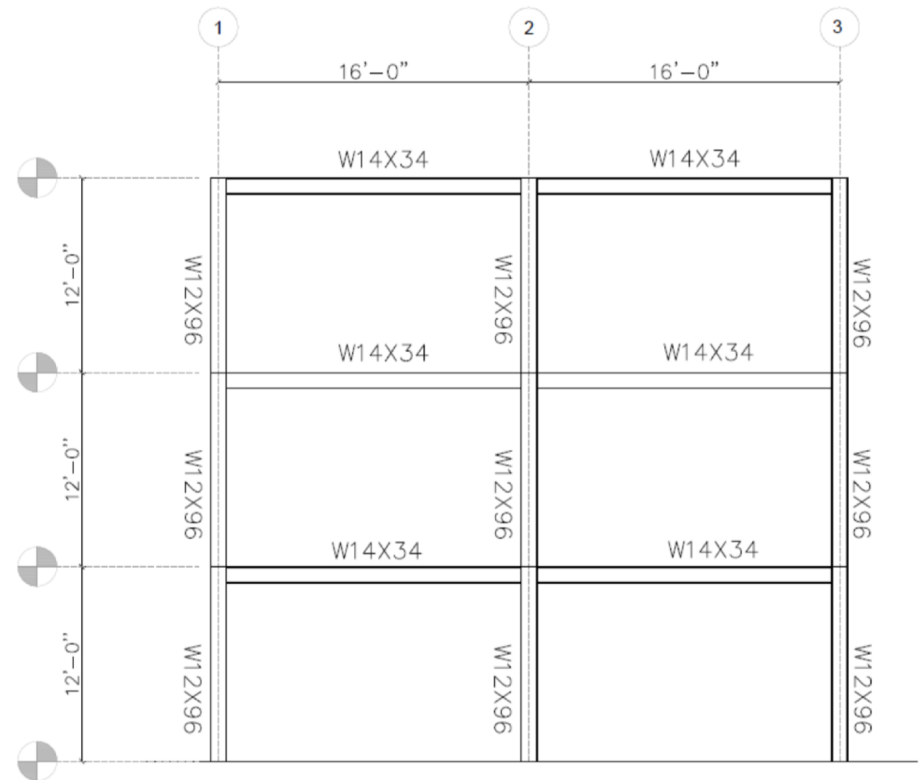
Buckling restrained braces

Special moment frame joints (shear fuses)³

Dimensional Plans



Archetype building: (top) plan view and (right) elevations



Design Process

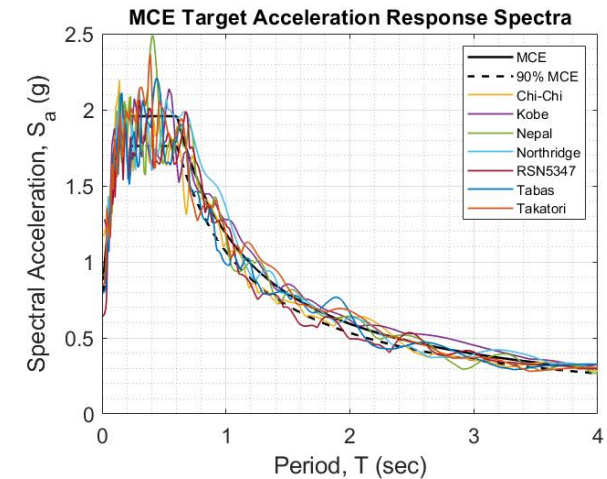
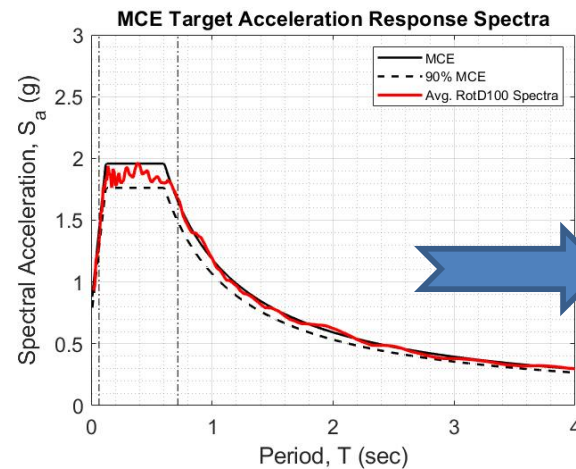
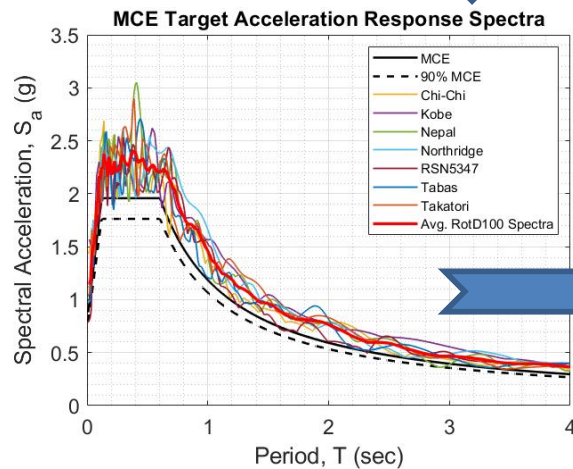
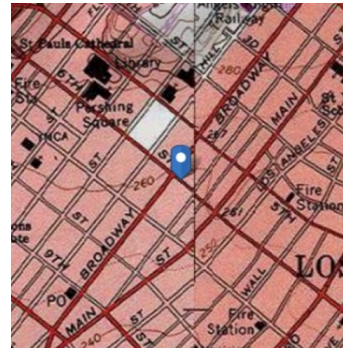
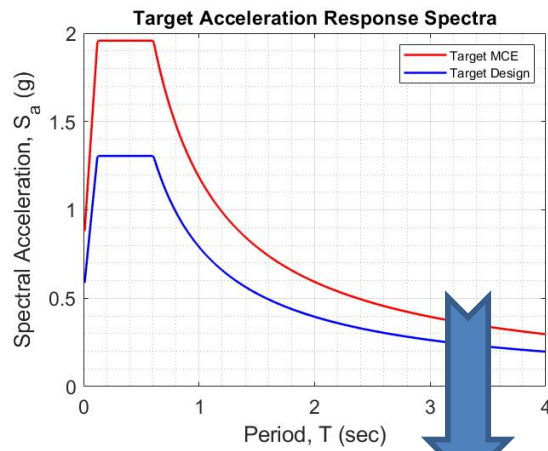
Select a site in downtown Los Angeles, Risk category II

Soil class D (Stiff soil): S_s : 1.958, S_1 : 0.697

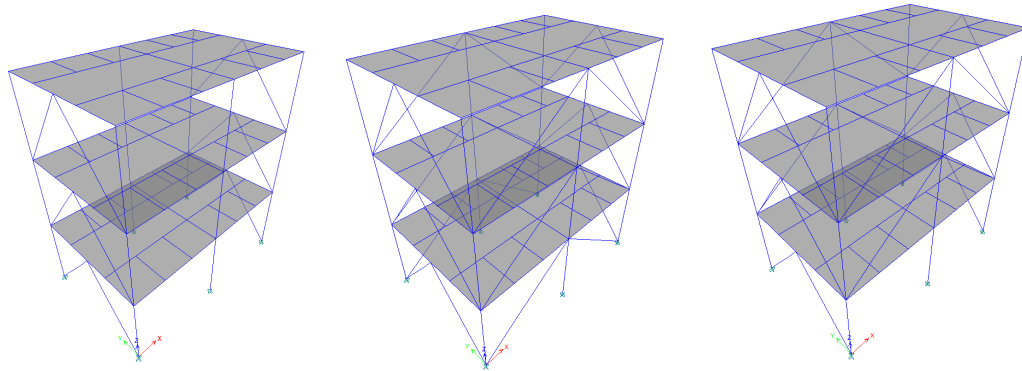
Select family of recorded motions (motion suite utilized for upgrade study)

Motion conditioning & scaling to within 90%MCE

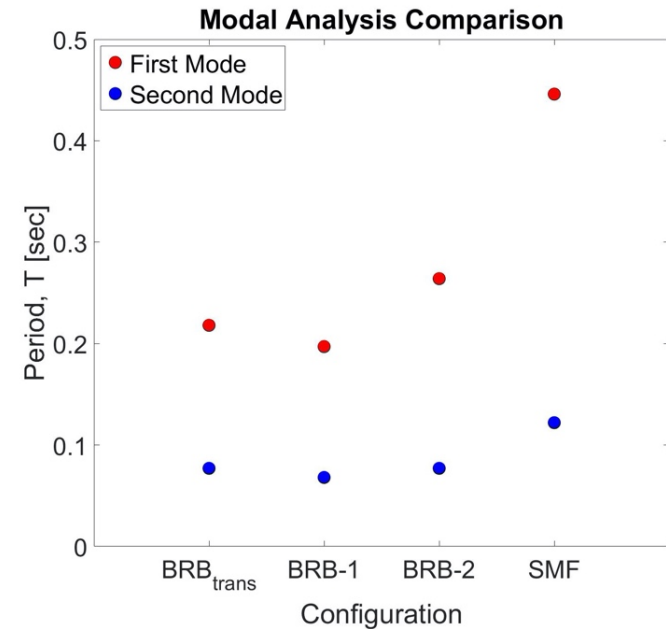
Conducting NL finite element simulations in two platforms: 1) OpenSees & 2) ETABs



Expected Model Building Performance

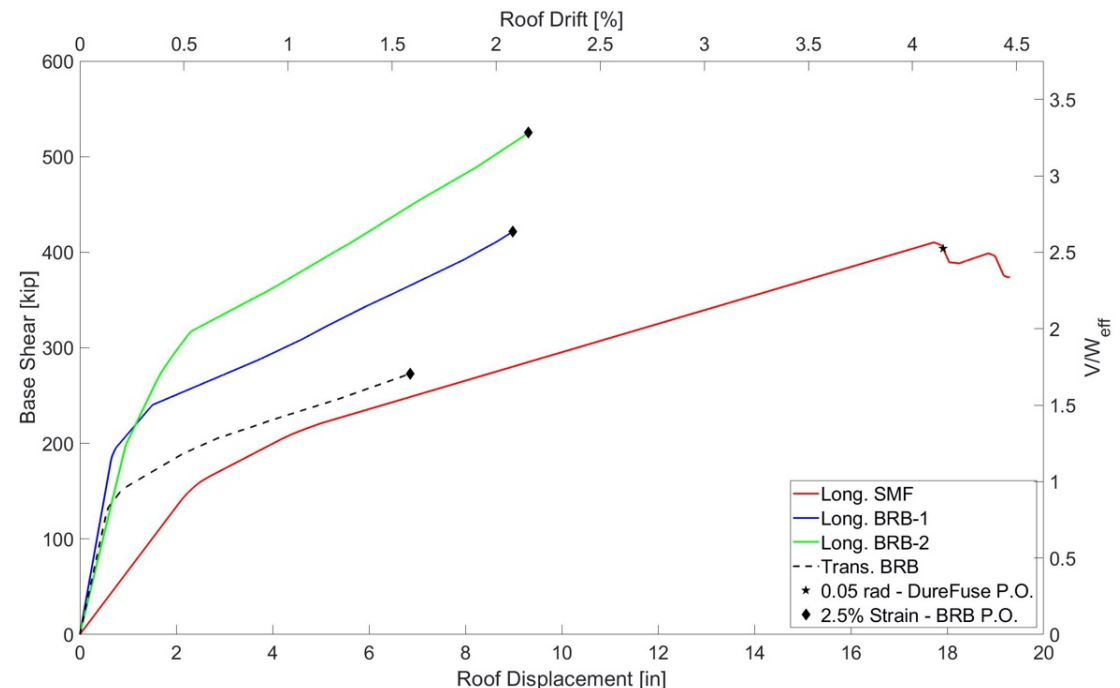


ETabs FE model isometrics:
SMF, BRB-1, BRB-2 (left-right)

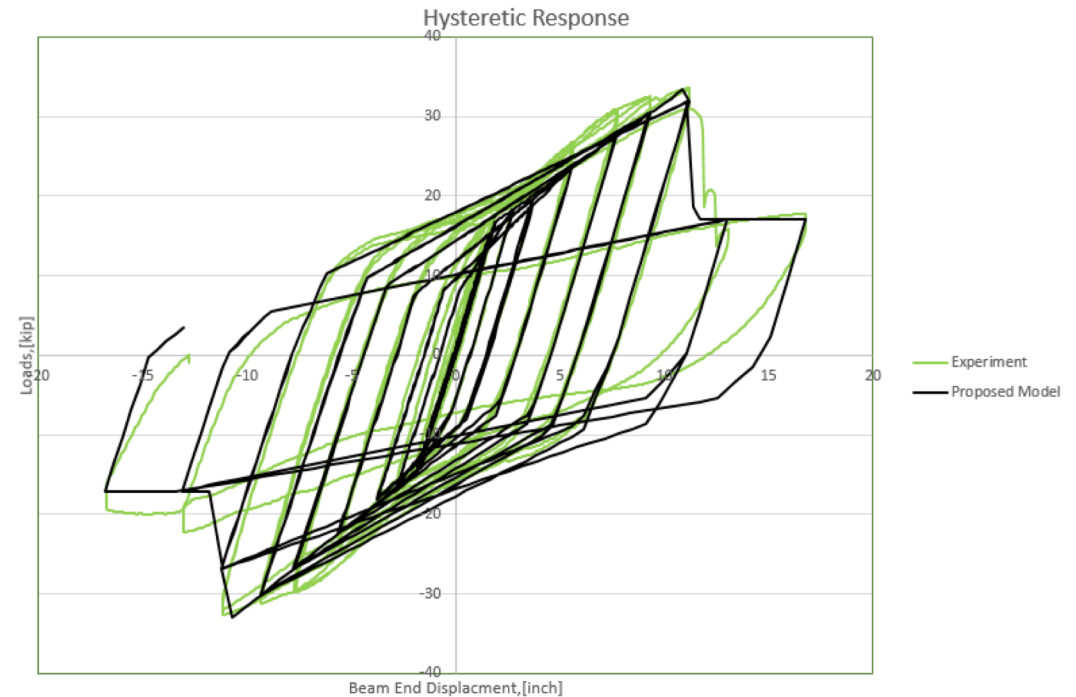
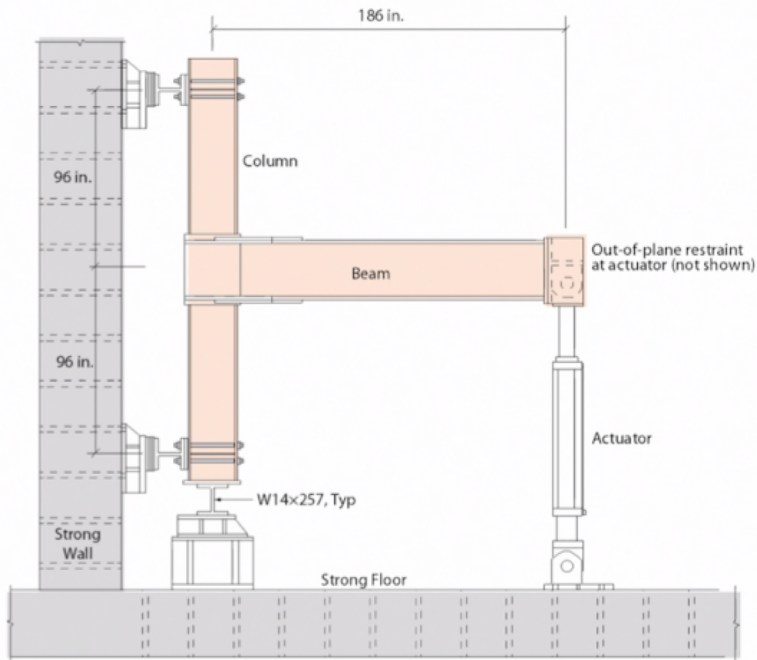


Nonlinear pushover analysis

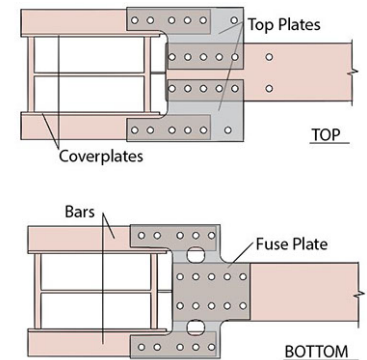
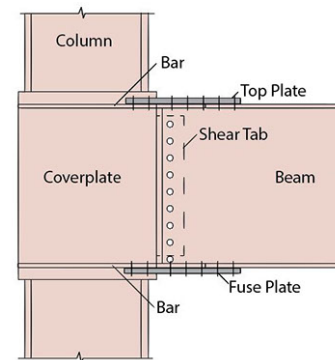
- Softer, ductile SMF response
- Stiffest configuration BRB-1
- Consistent elastic stiffness in all BRB configurations
- ~2% roof drift capacity (@BRB PL)
- ~4% roof drift capacity (@SMF PL)



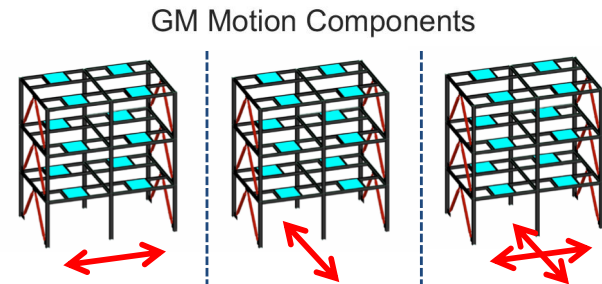
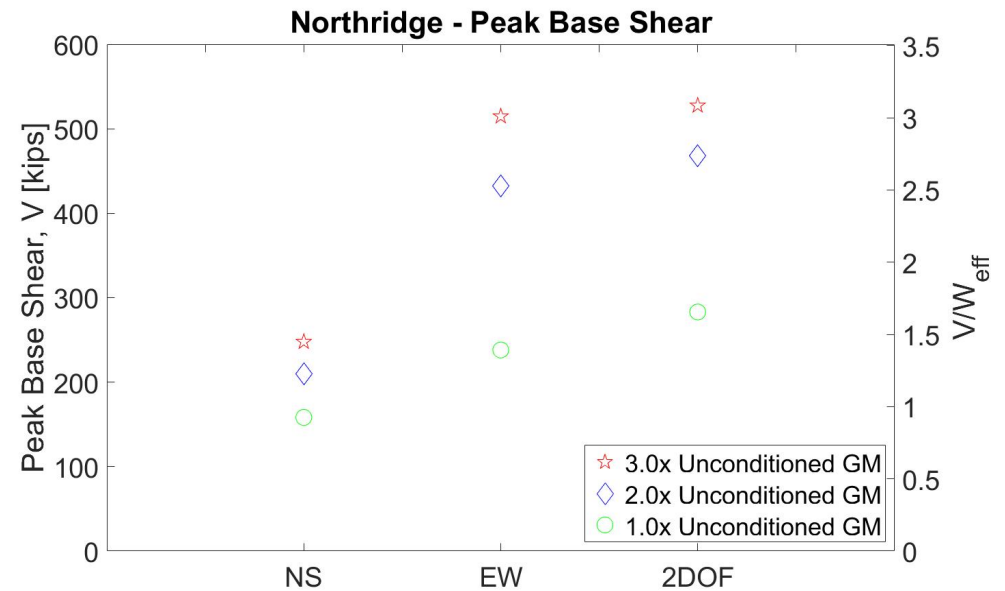
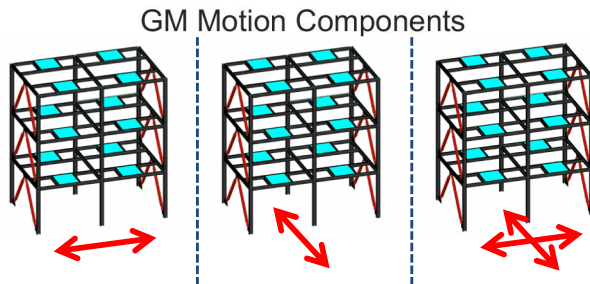
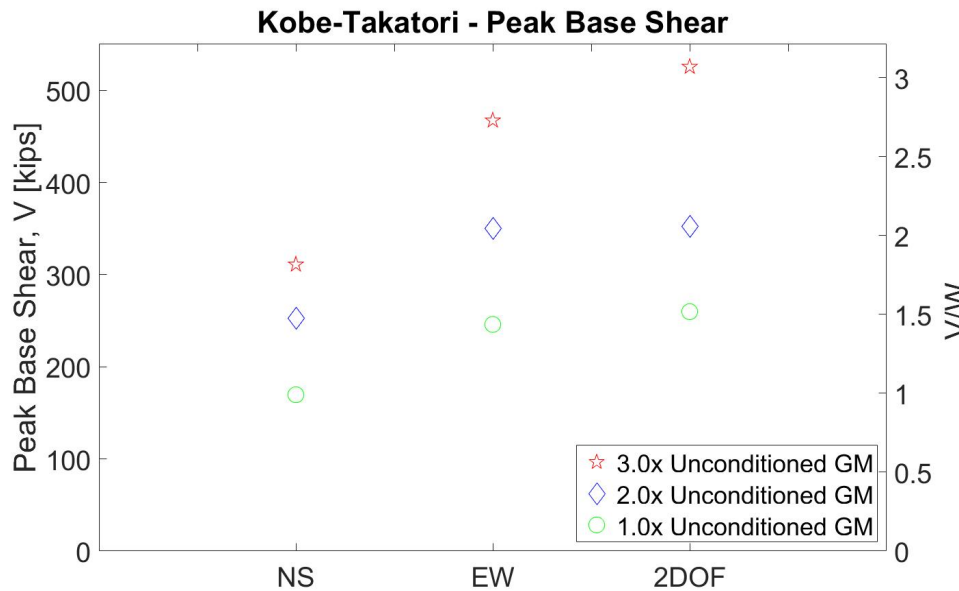
Numerical Modeling: *Connection Level*



- DuraFuse used in the SMF configuration – offers simple, replaceable yielding moment connection
- DuraFuse connection modeling (Liu et al.) within OpenSees of the tests of Richards et al.

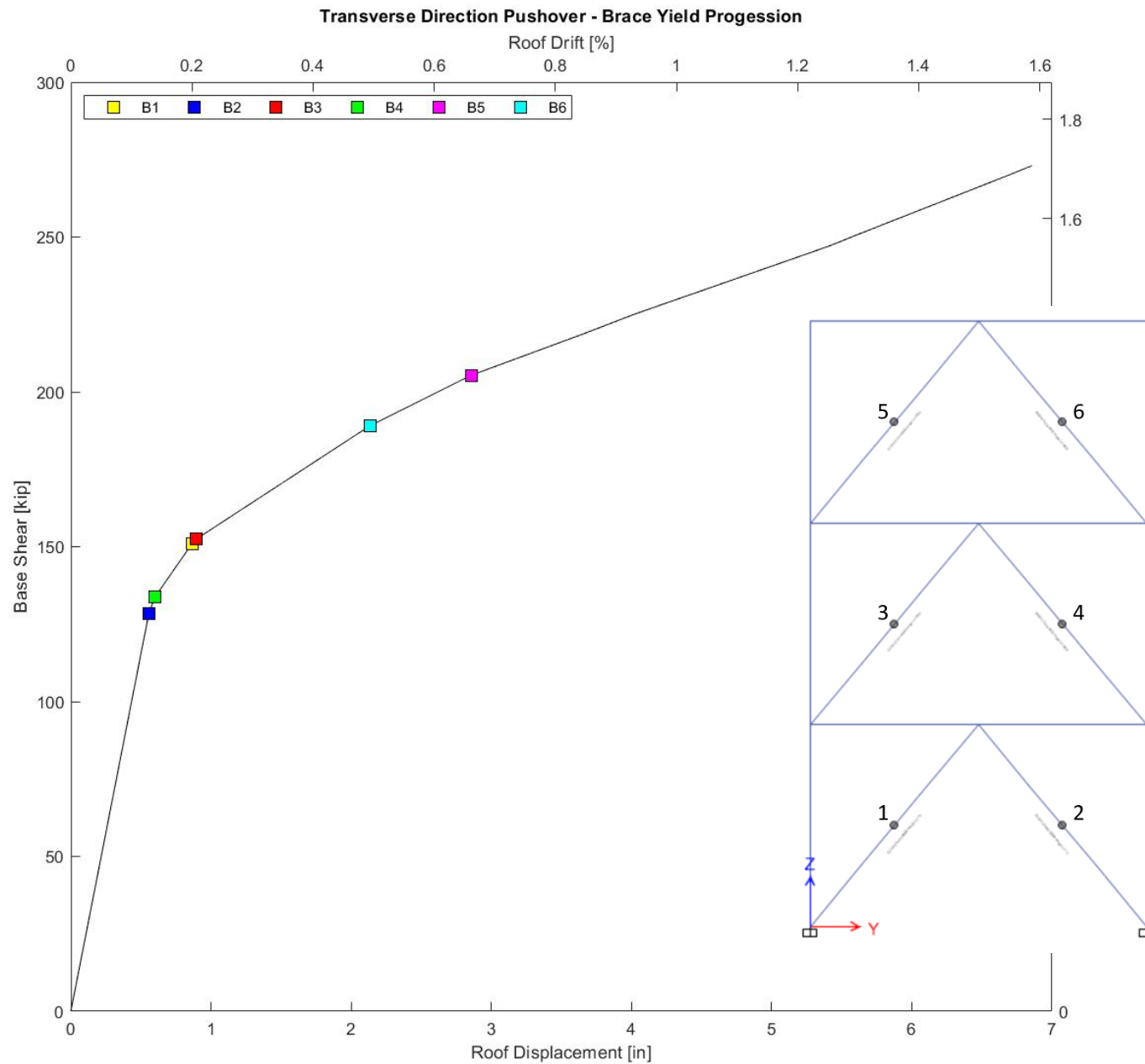


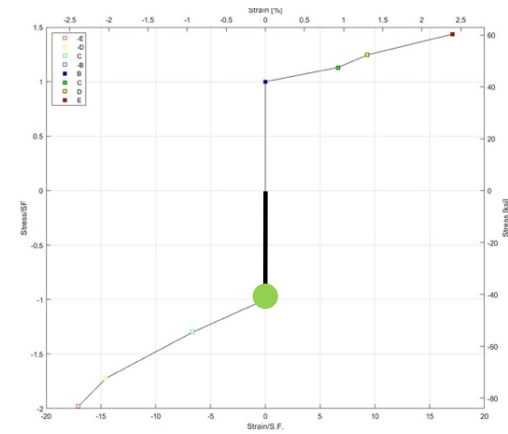
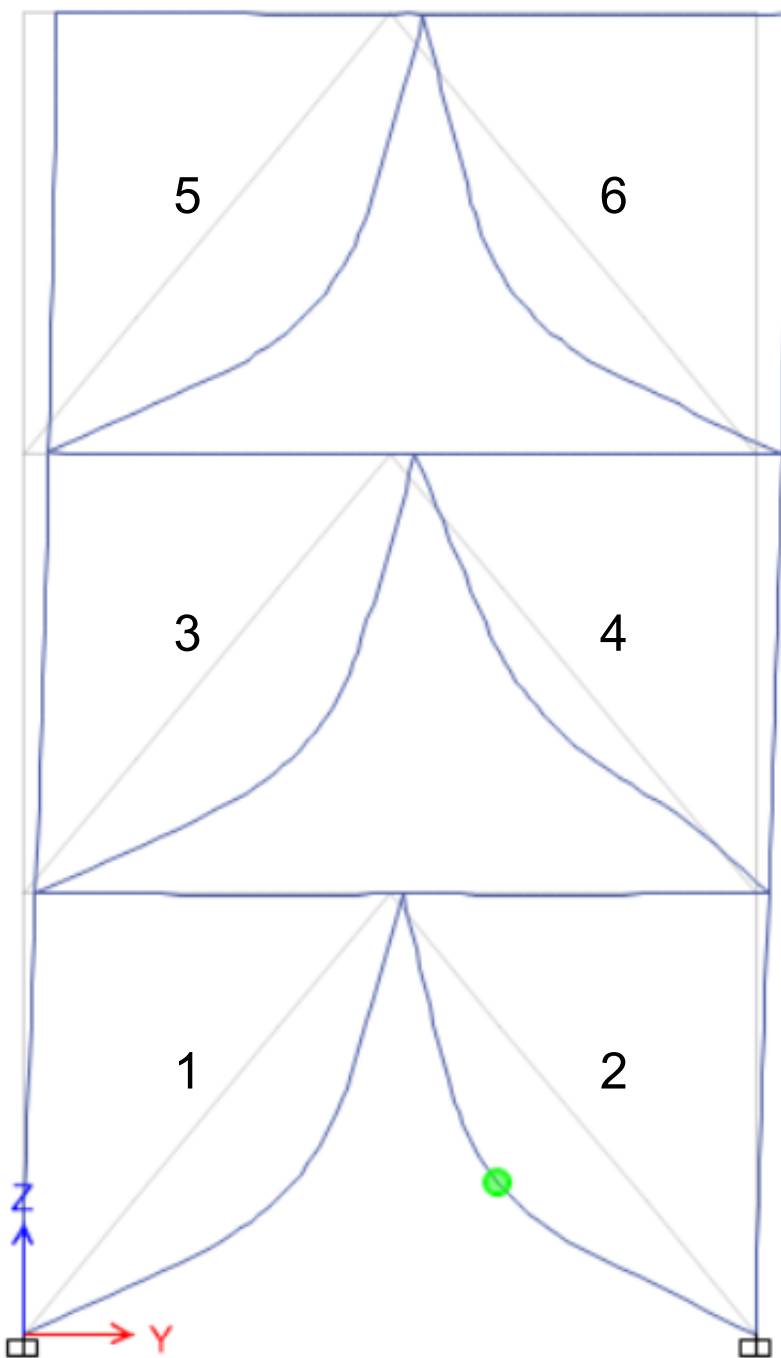
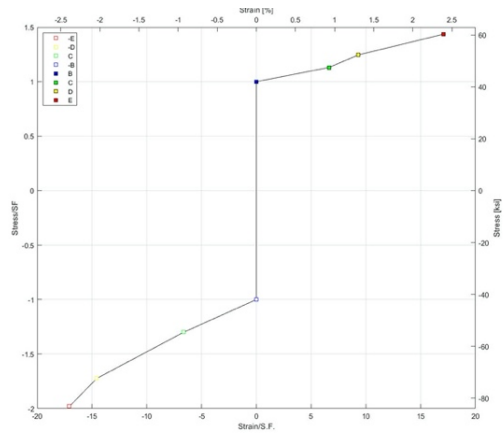
Numerical Modeling: *System-Level*

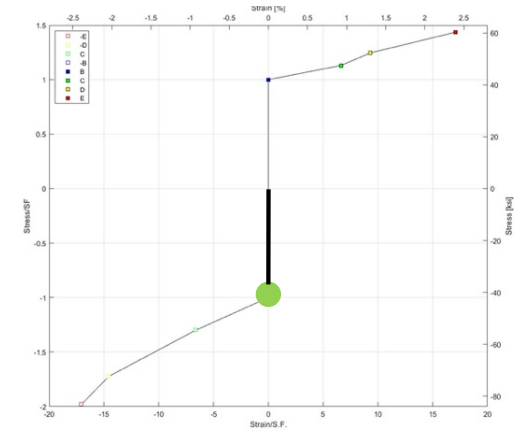
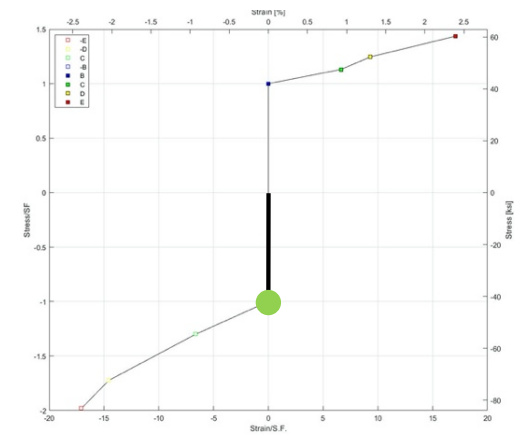
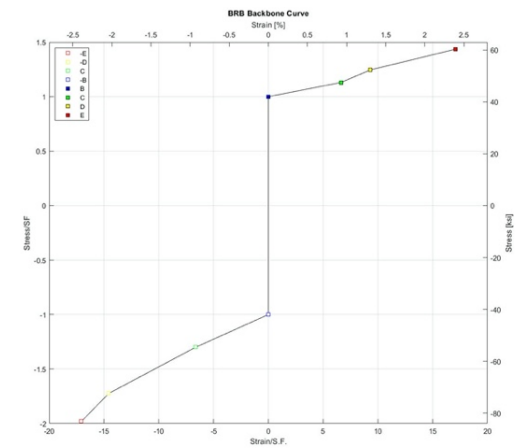
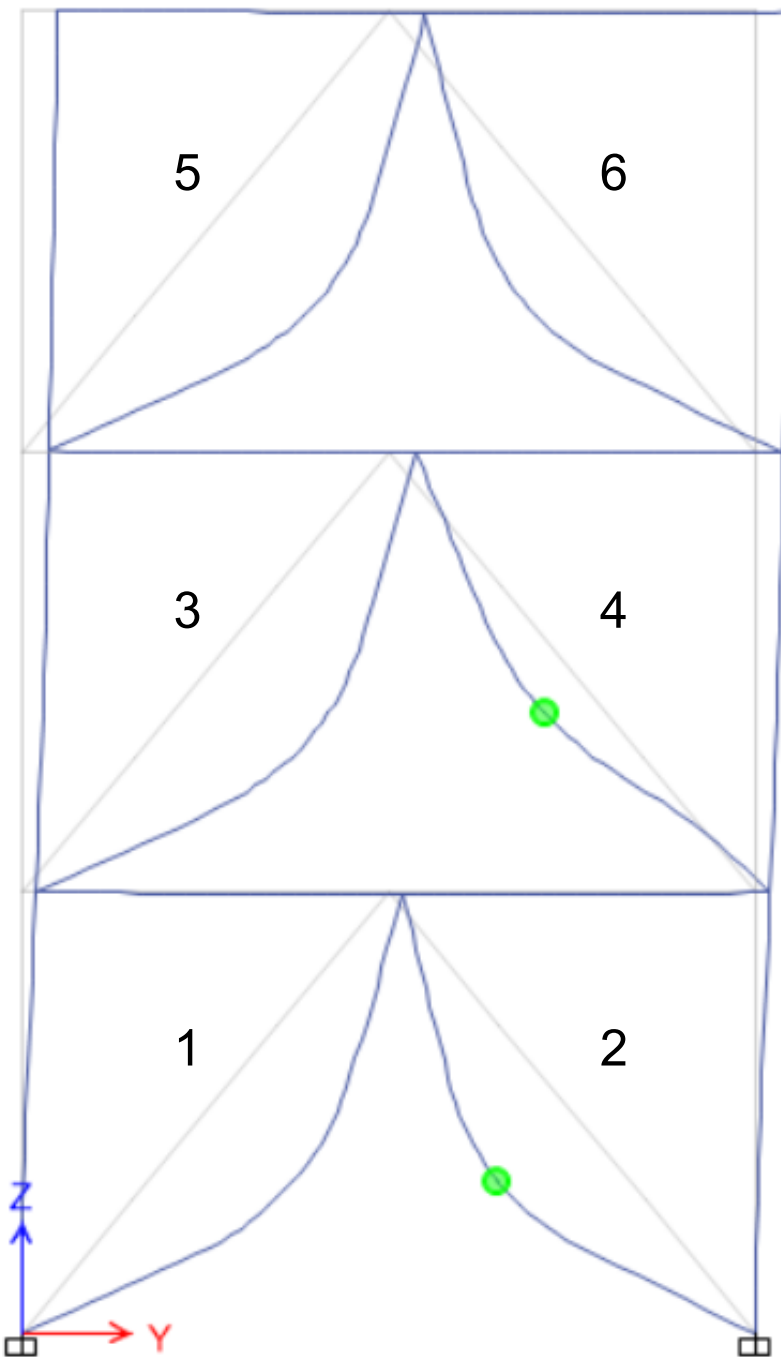
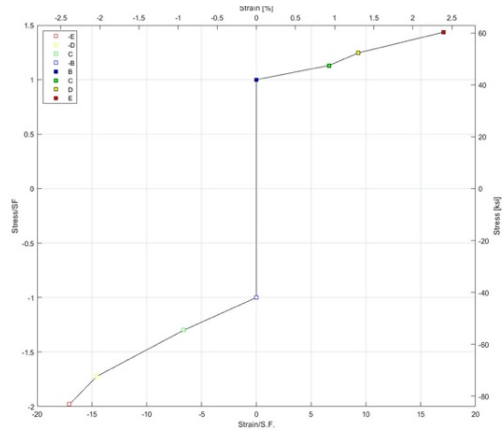
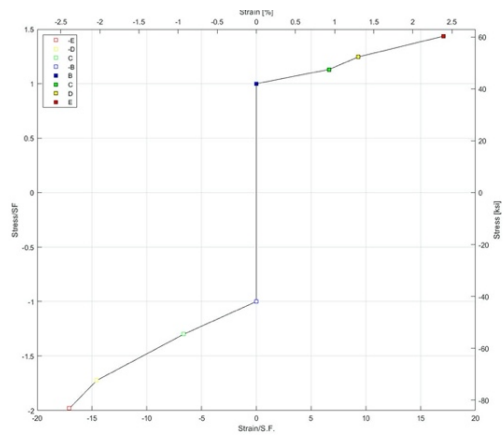
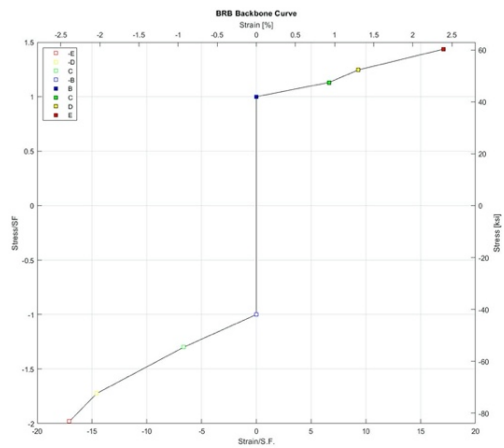


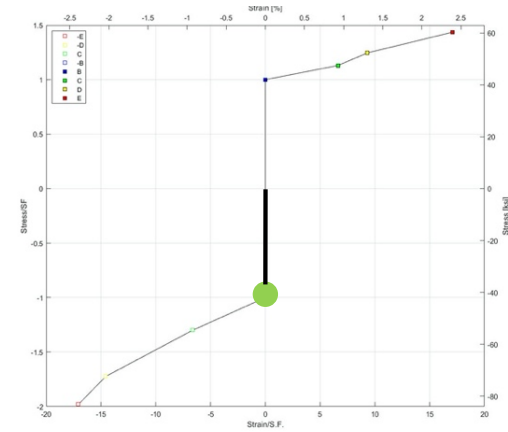
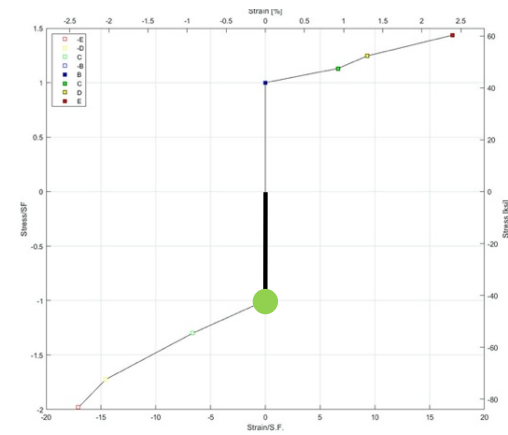
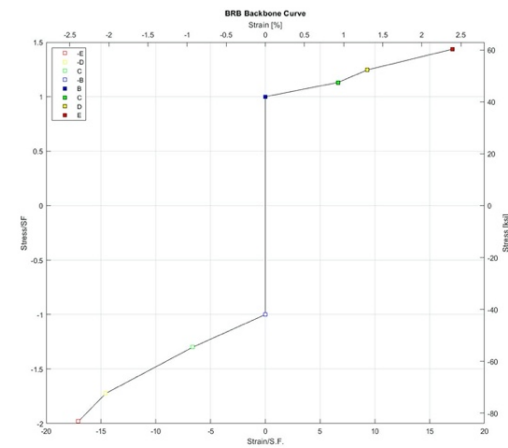
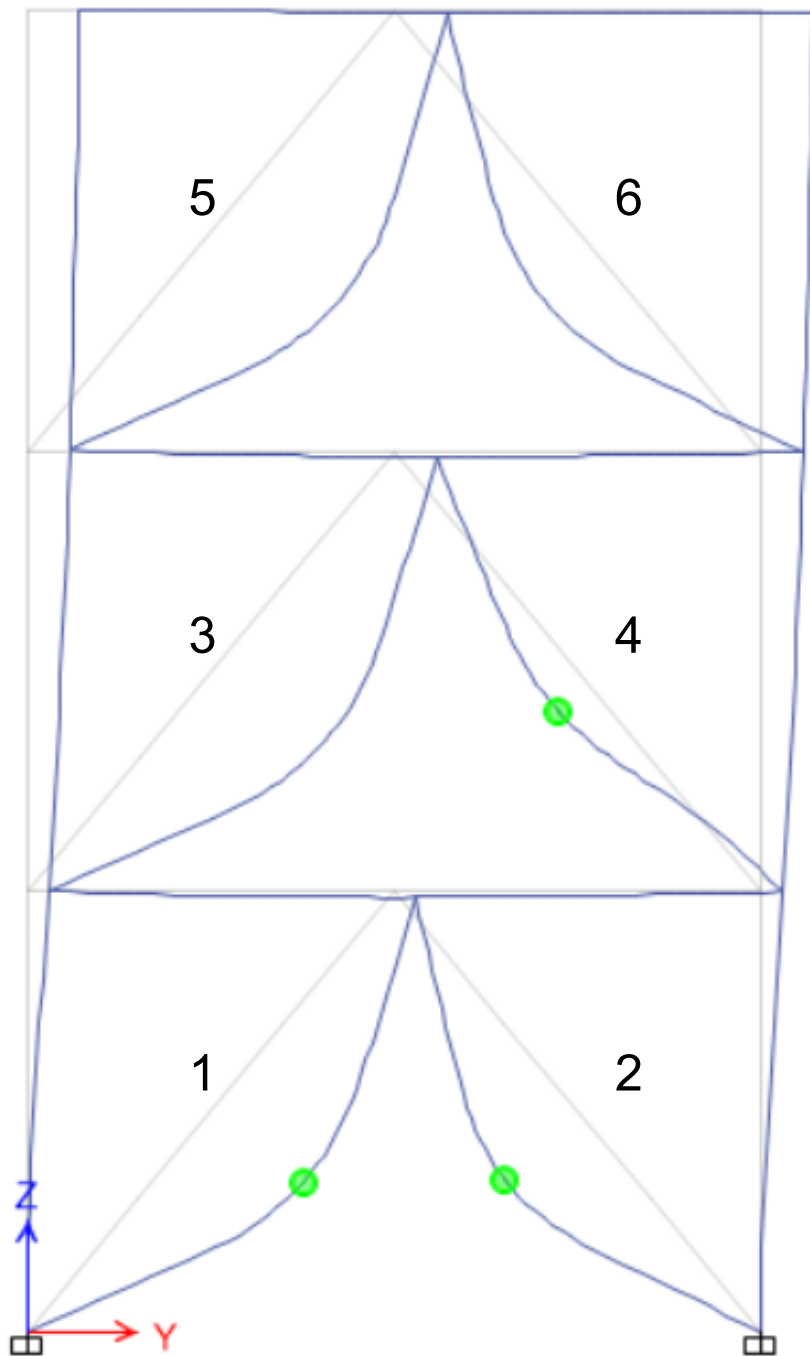
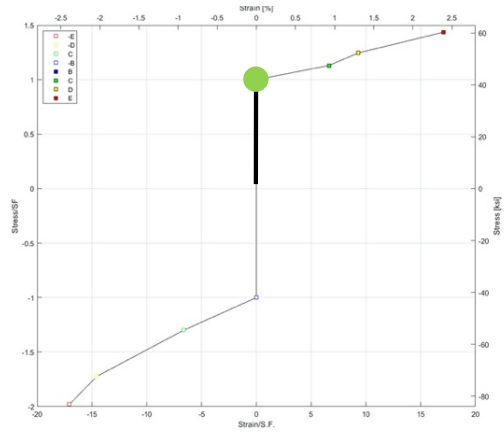
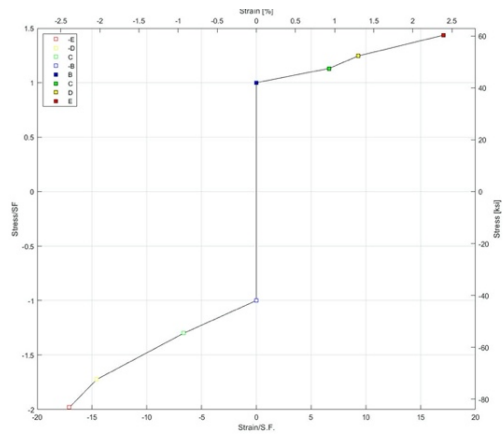
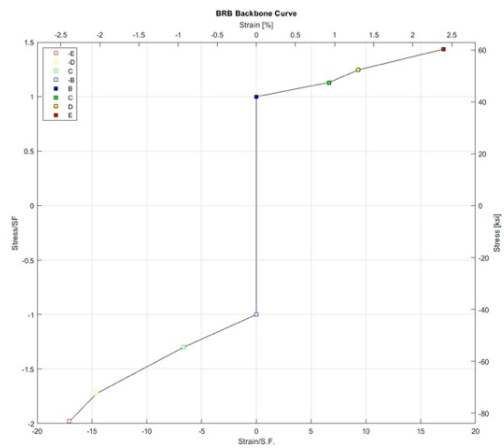
- Potential to investigate impact of MDOF input excitation on LFRS
- Etabs predictions (Morano et al.)

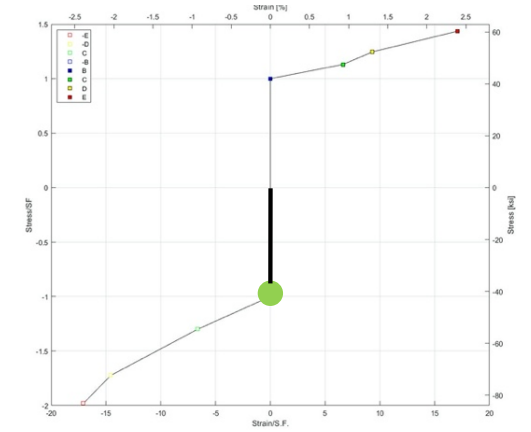
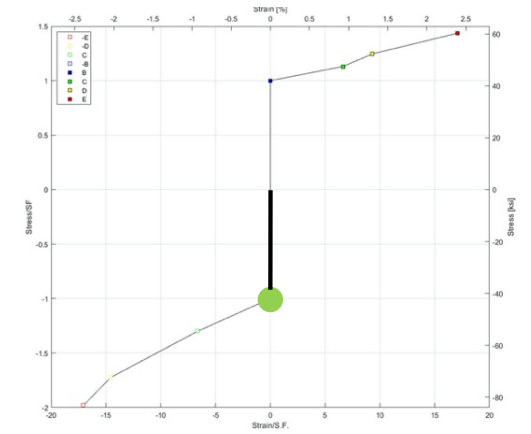
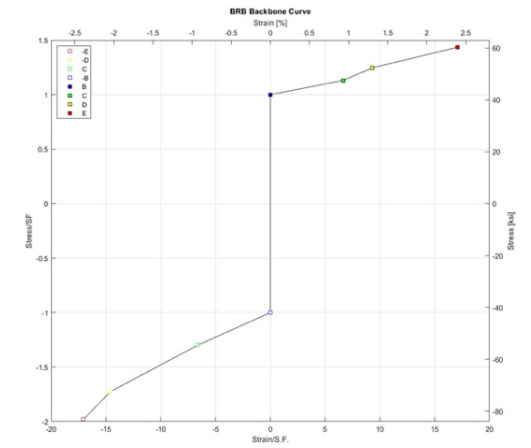
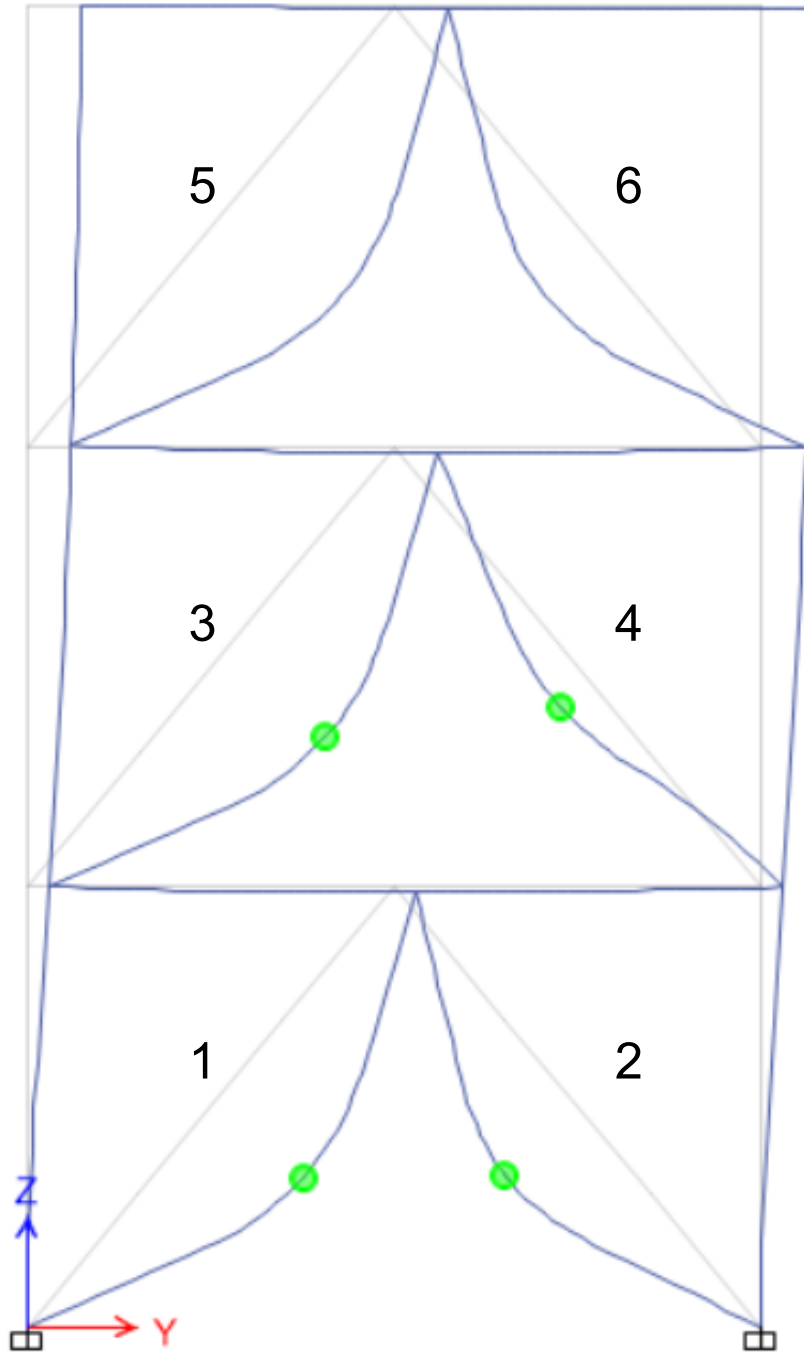
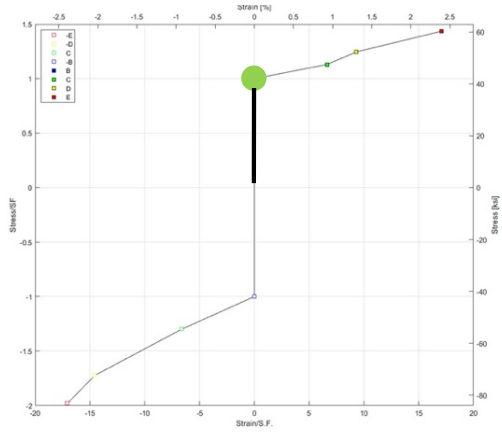
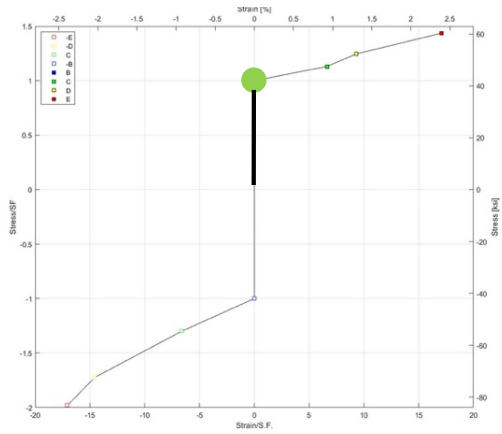
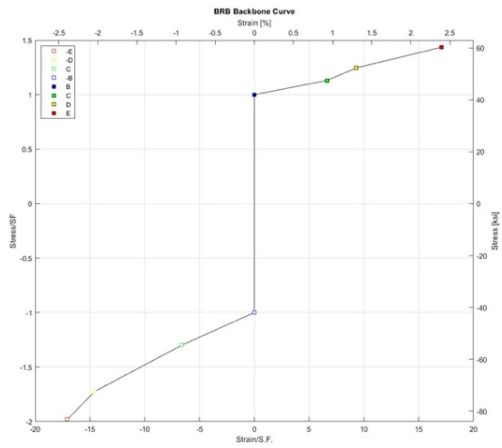
Sequential attainment of limit states within BRB (or SMF) components

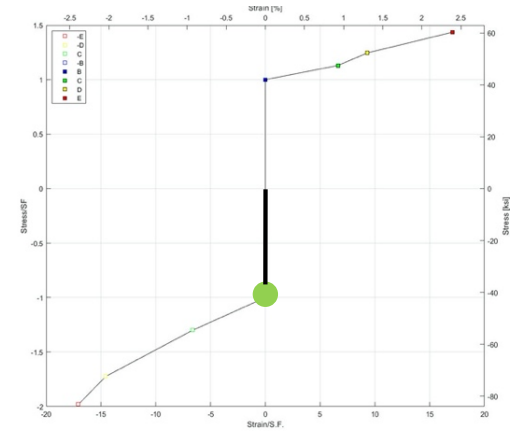
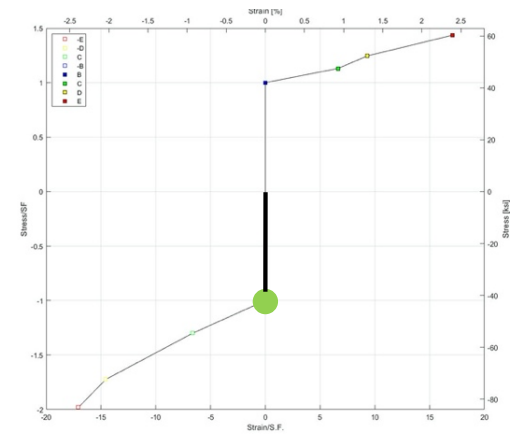
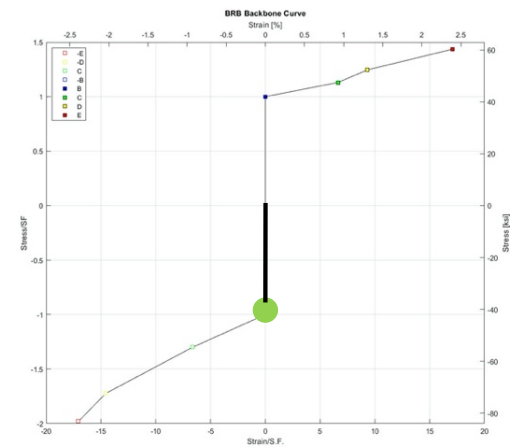
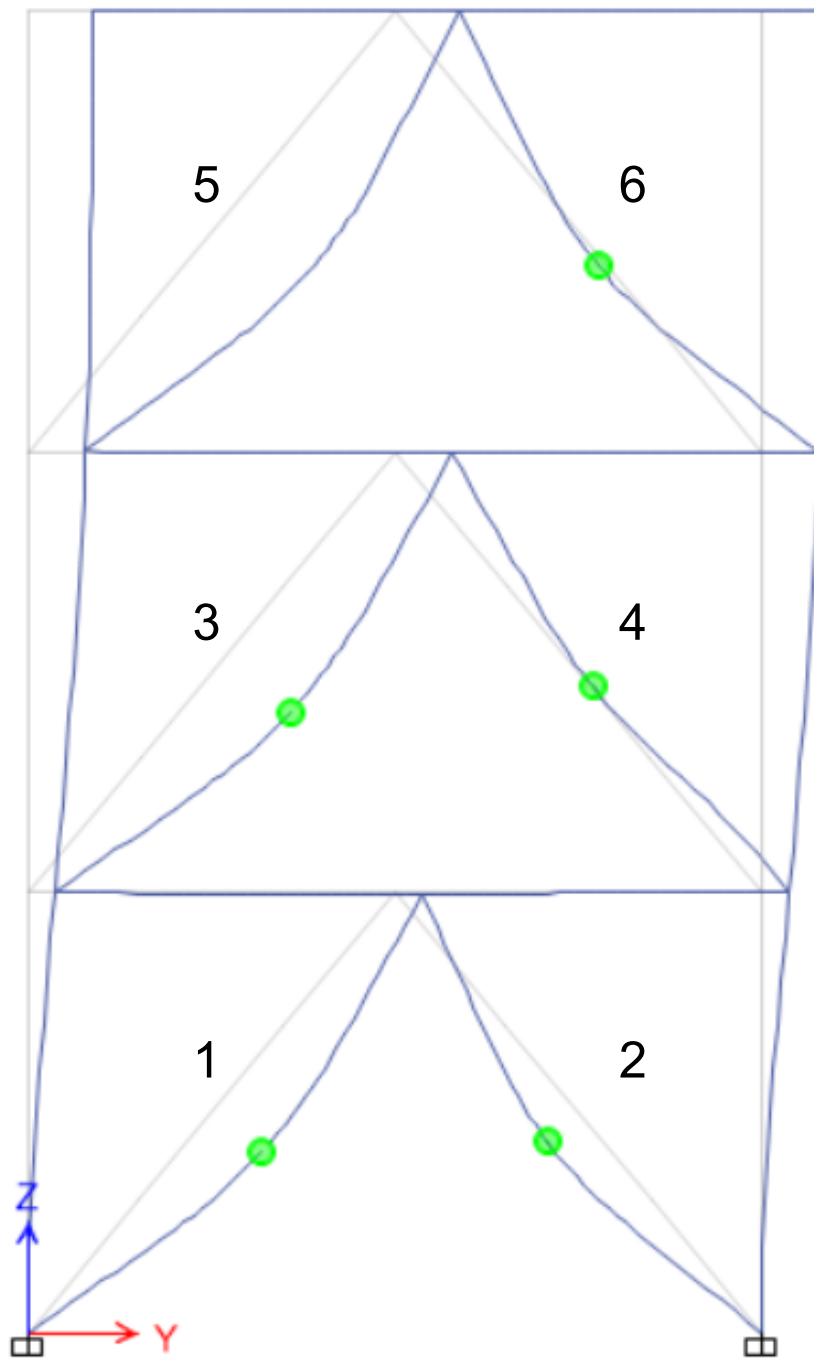
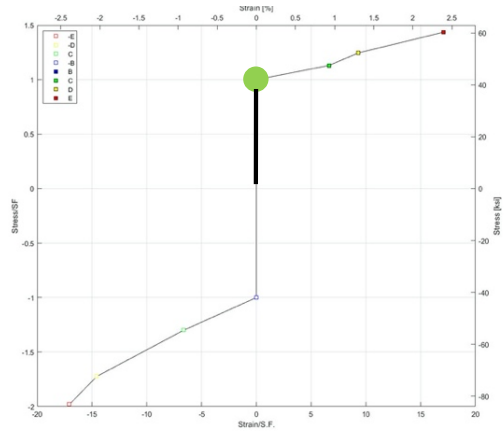
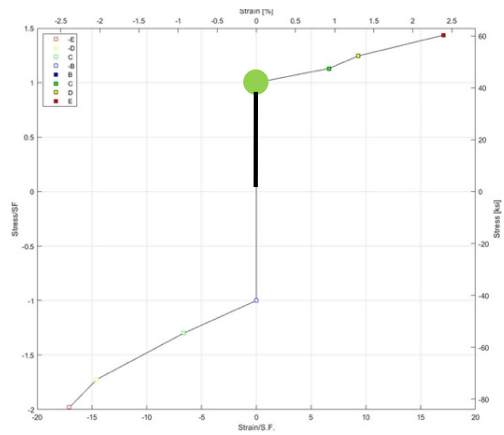
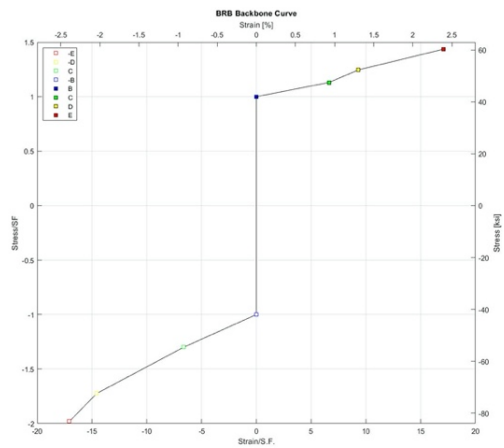


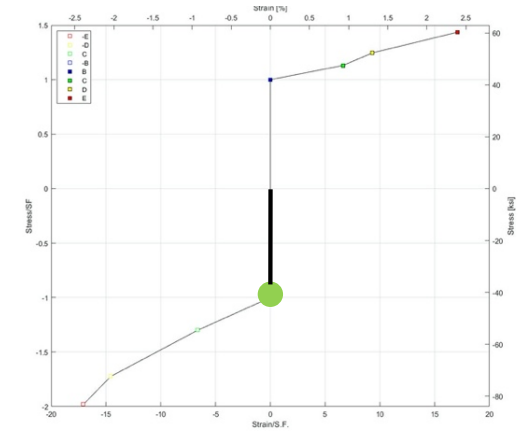
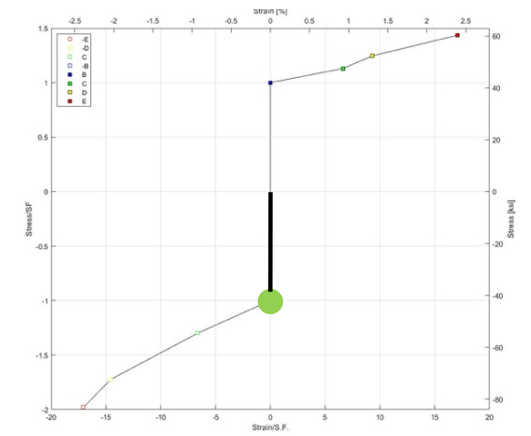
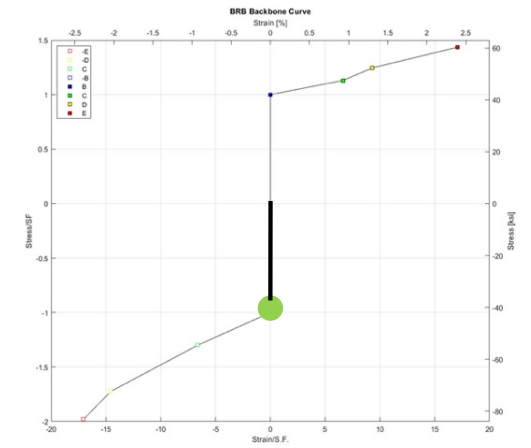
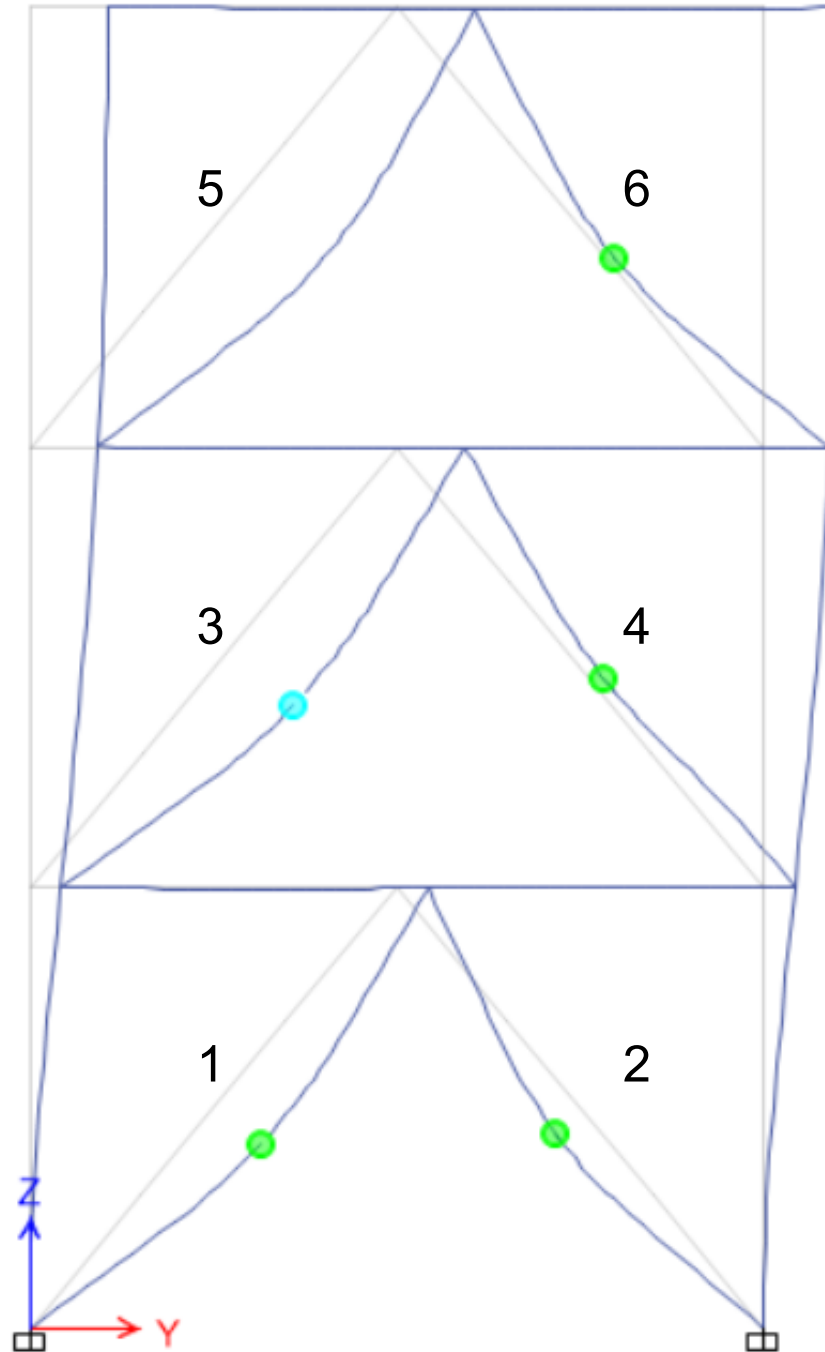
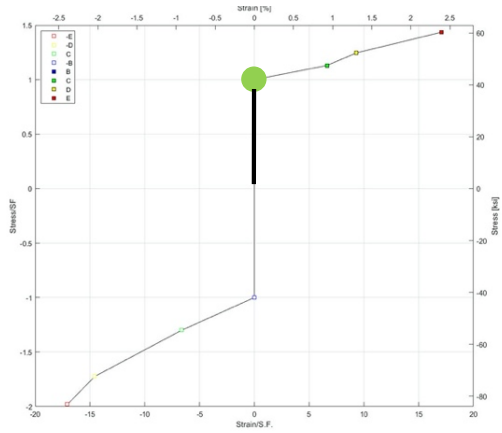
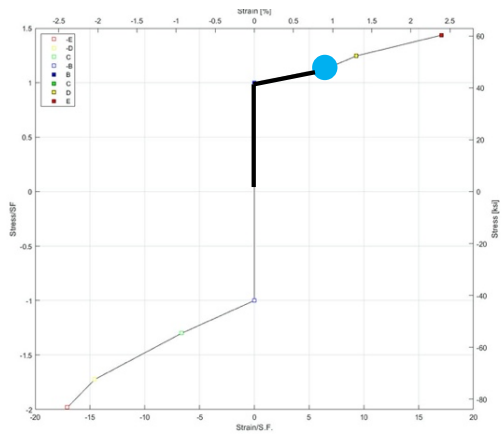
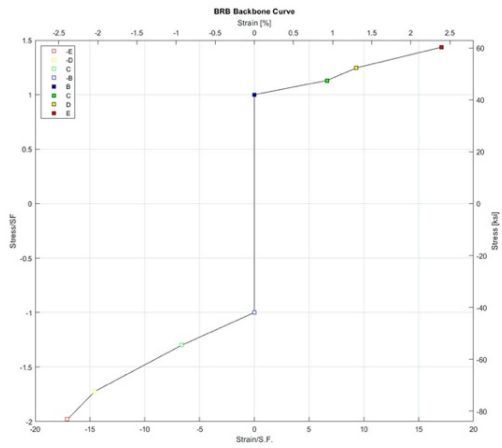


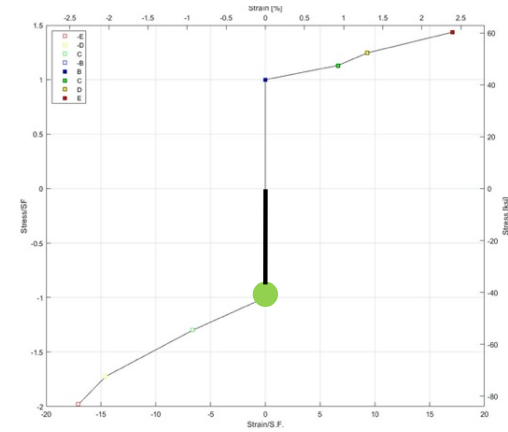
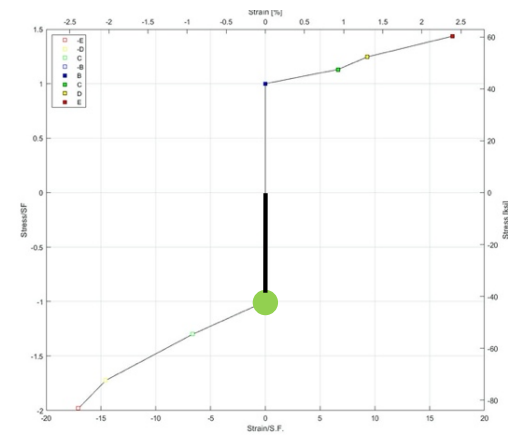
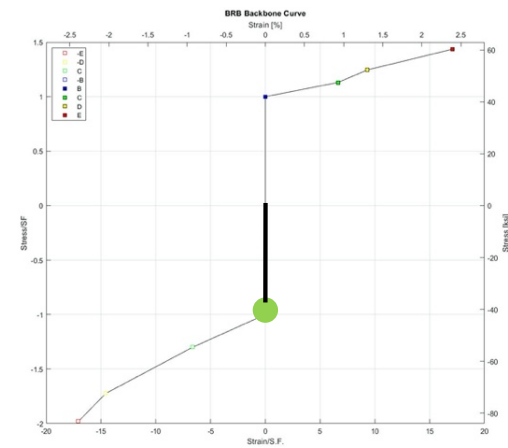
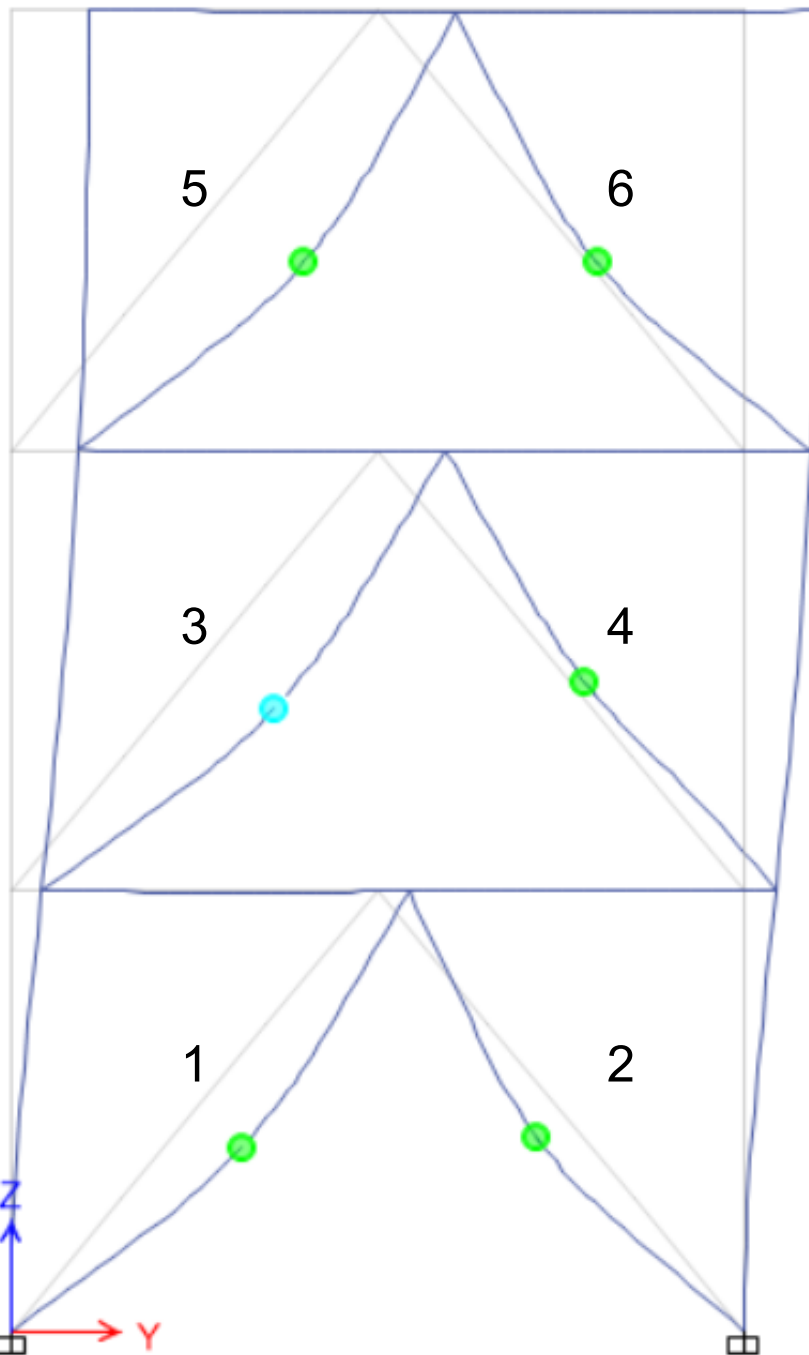
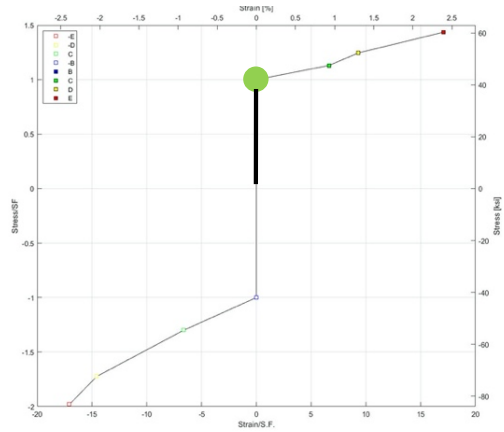
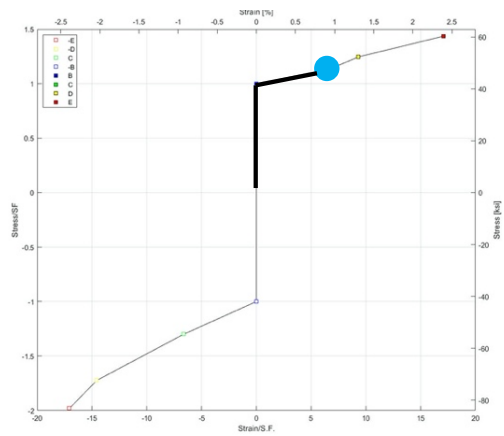
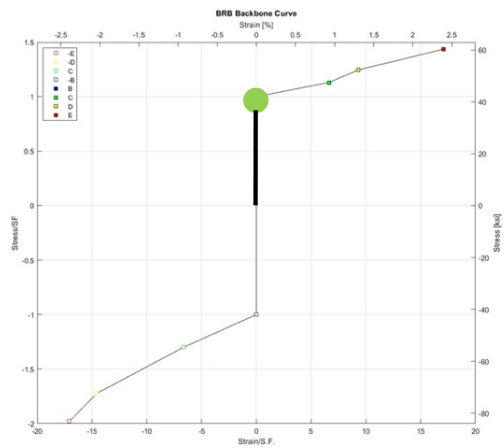


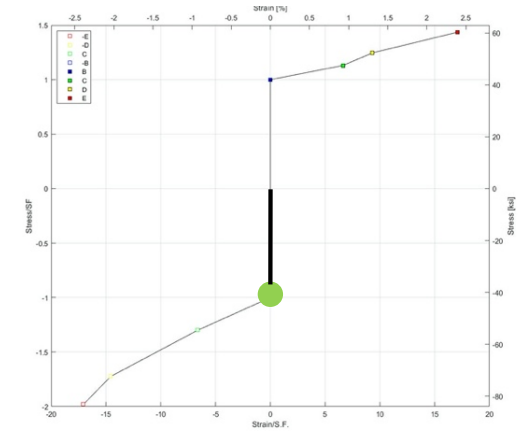
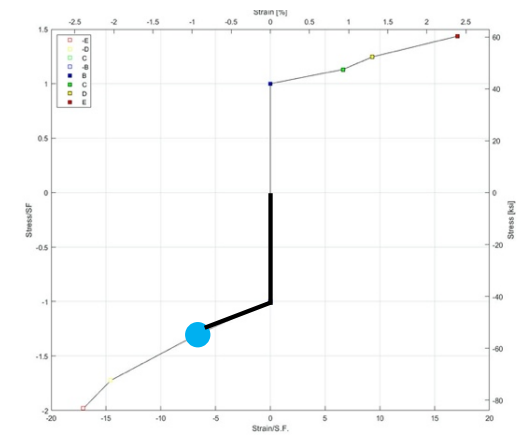
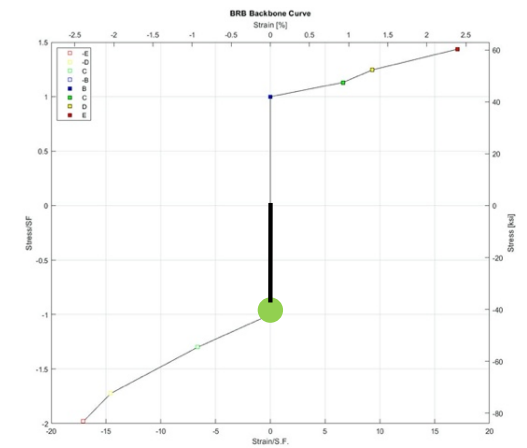
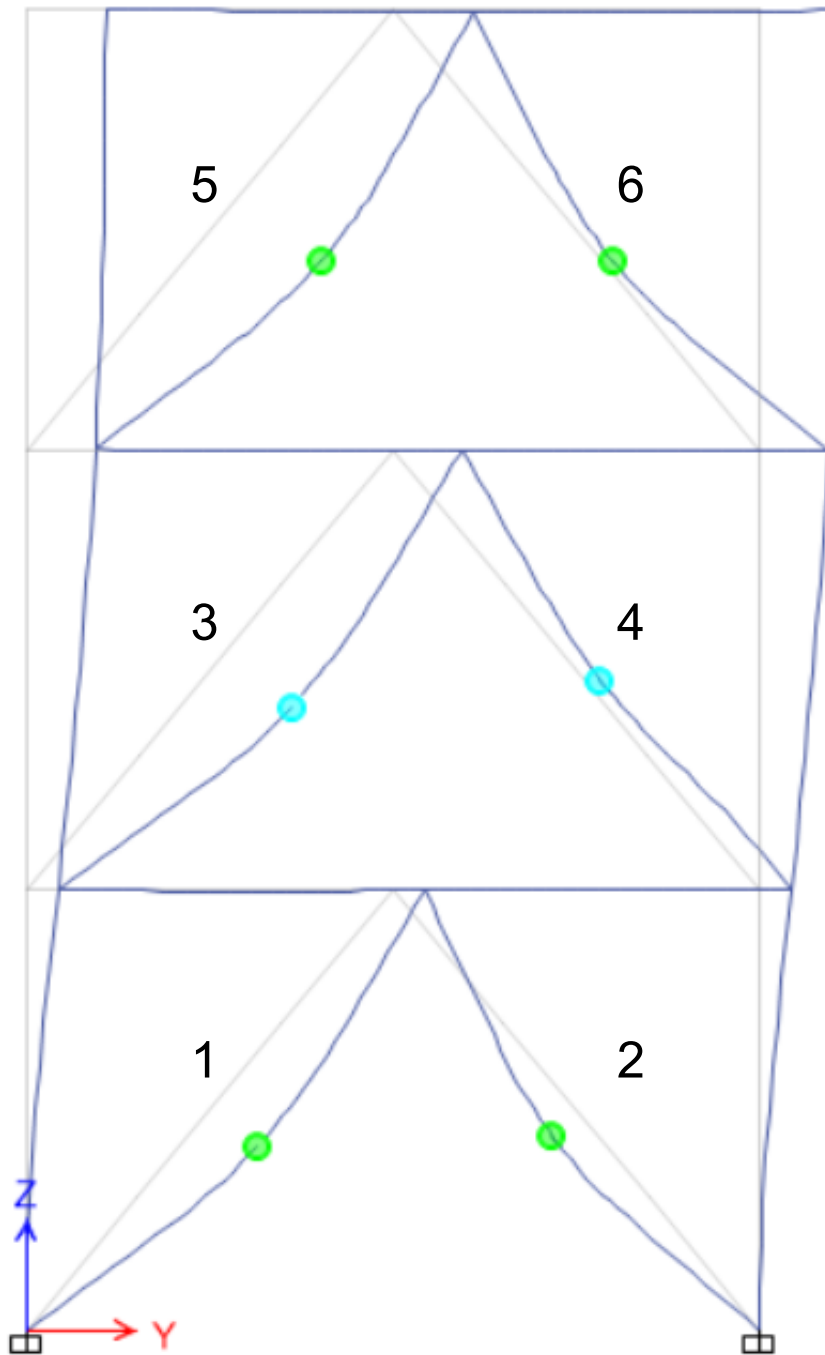
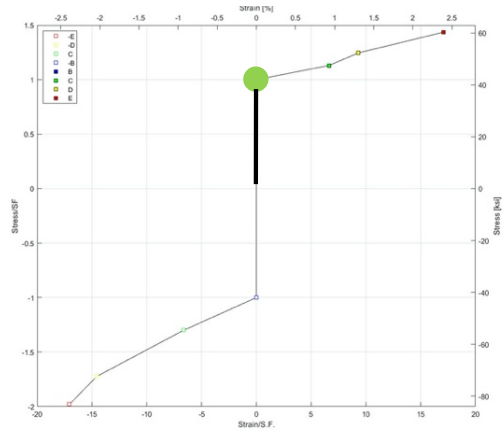
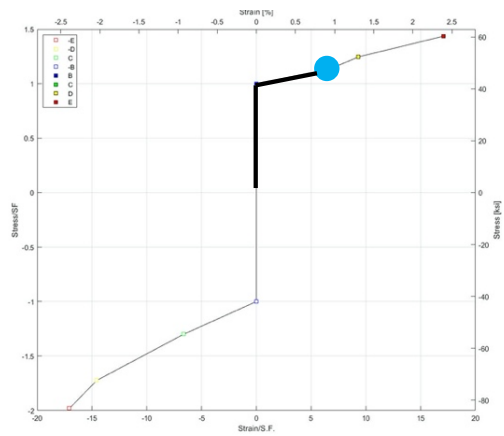
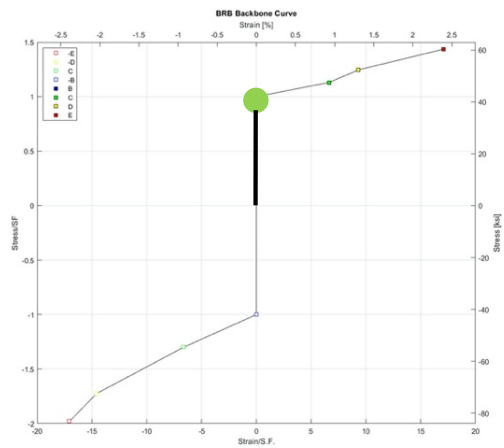


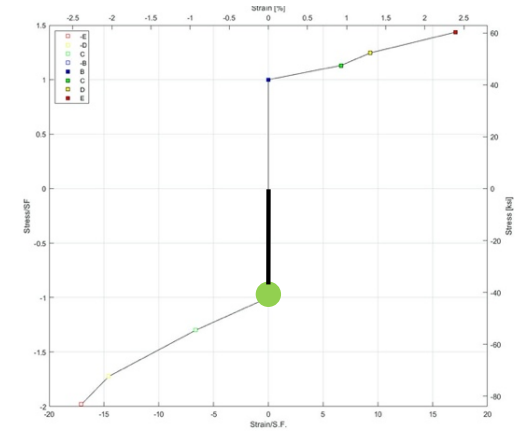
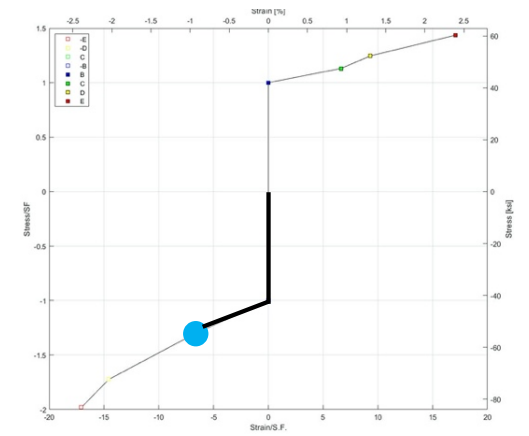
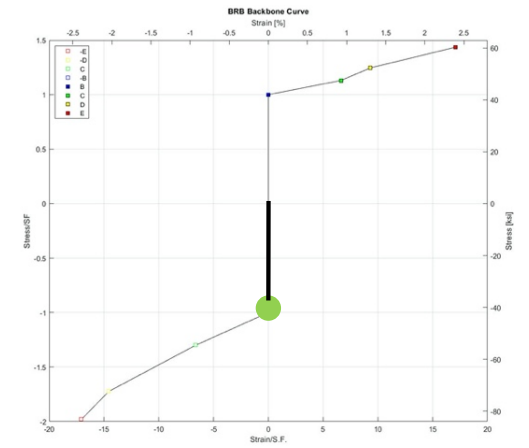
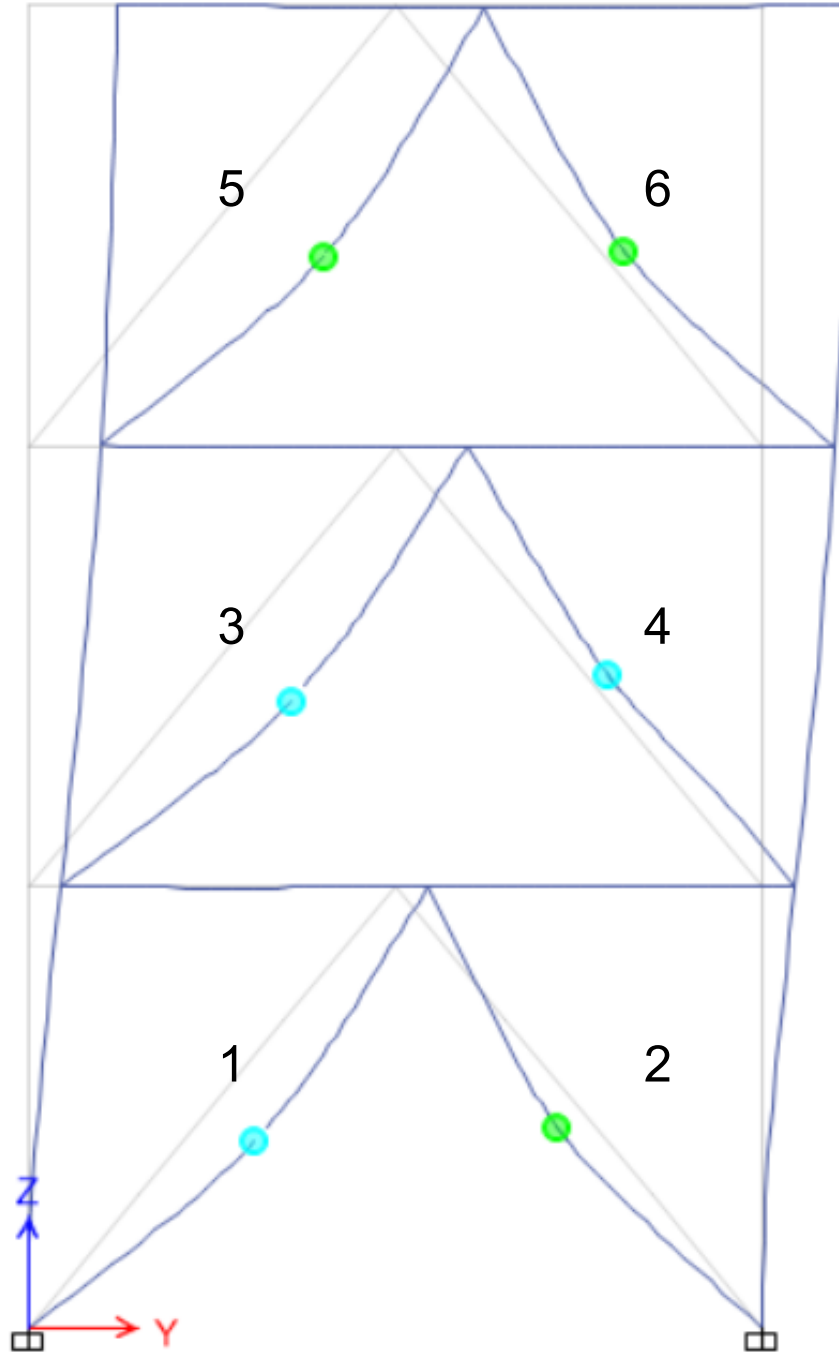
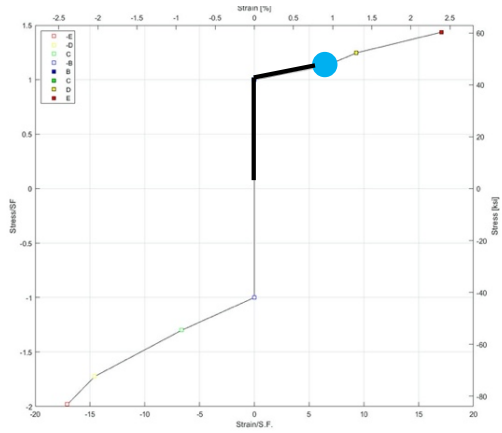
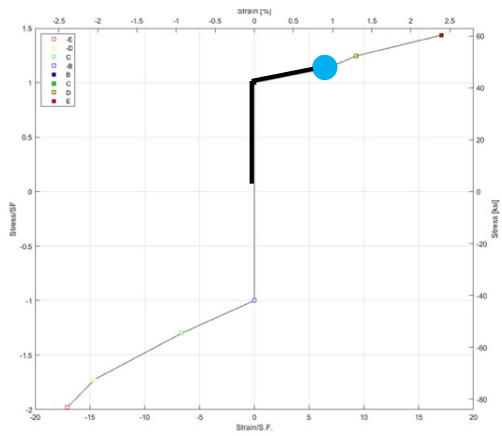
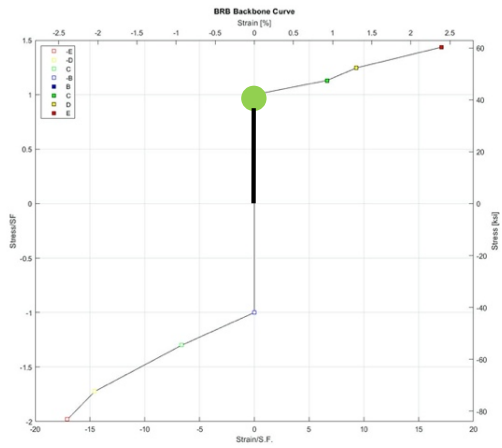


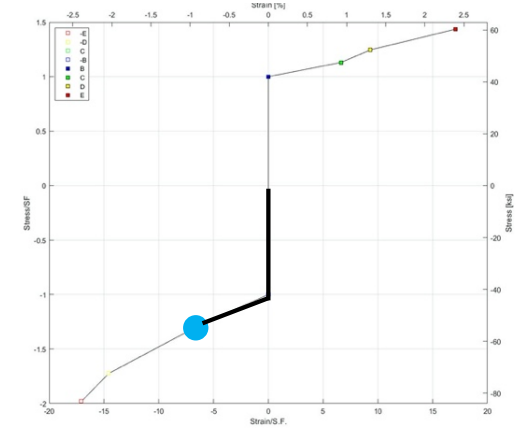
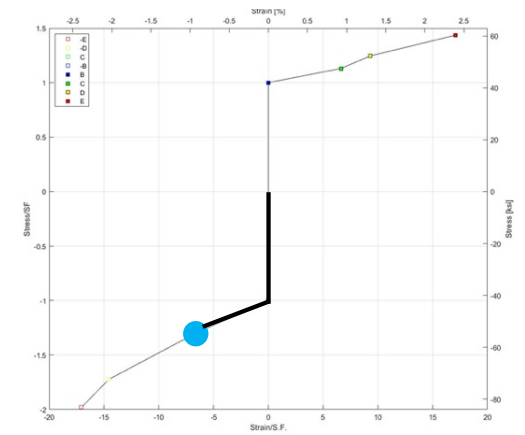
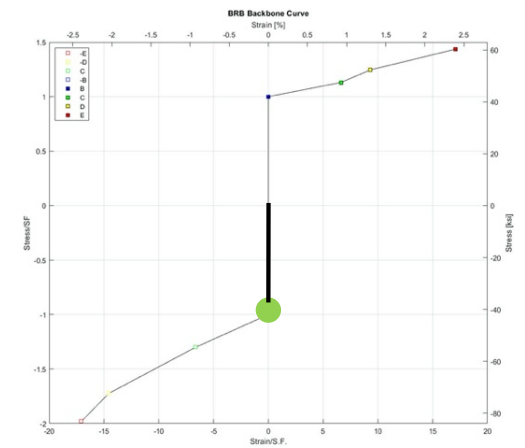
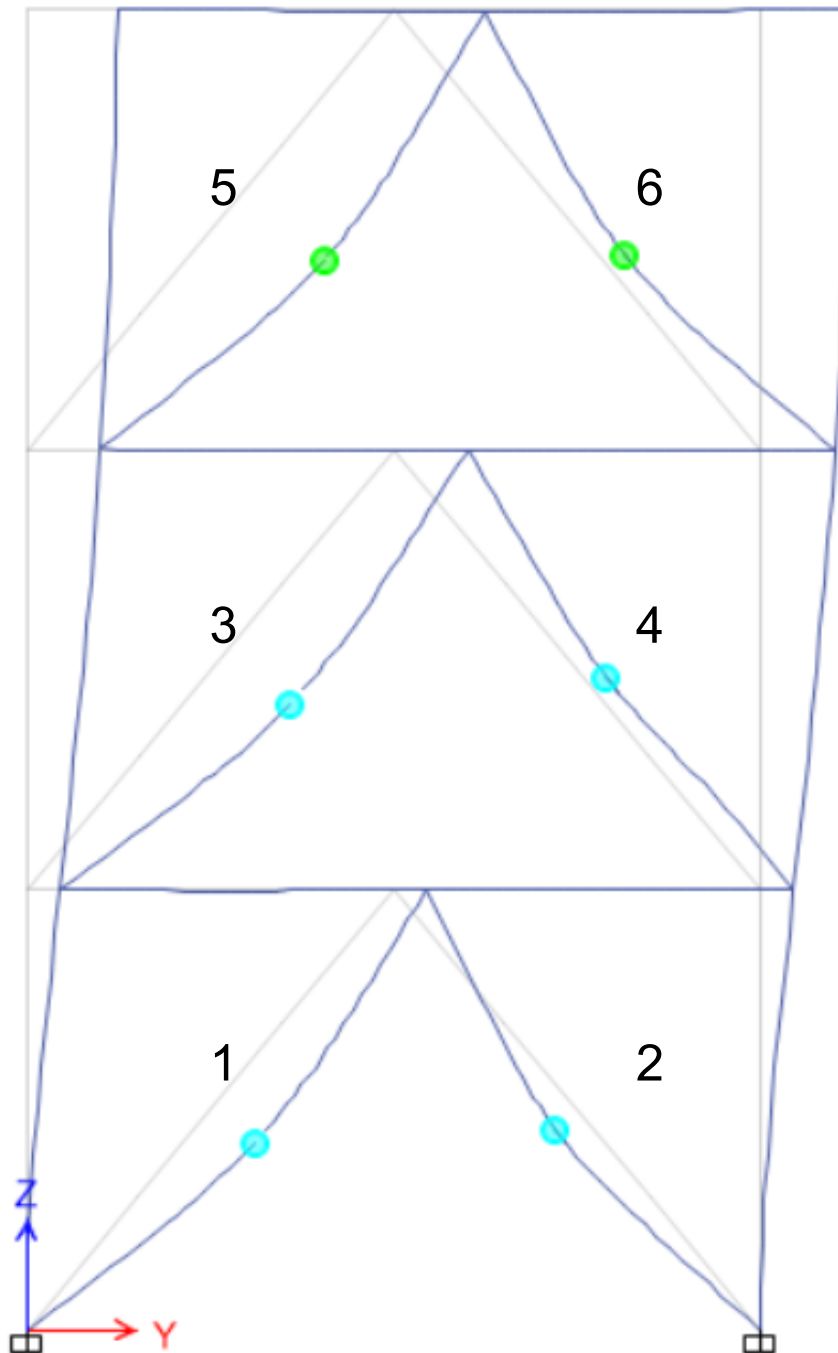
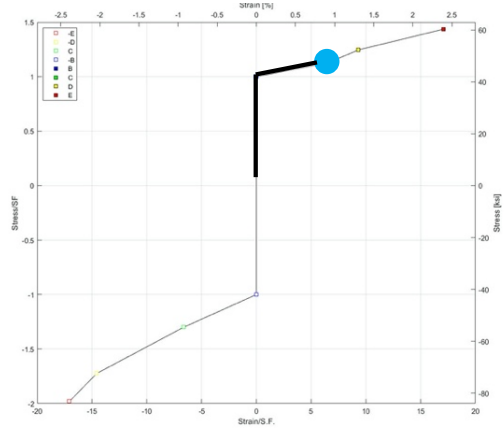
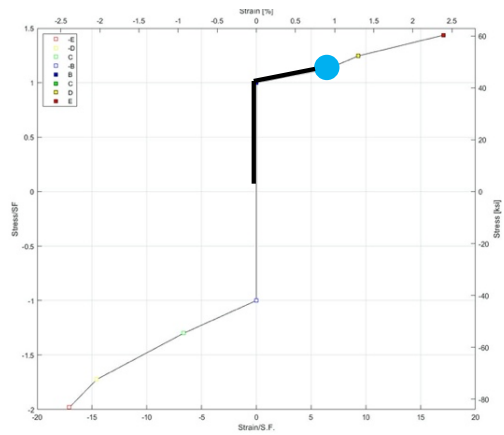
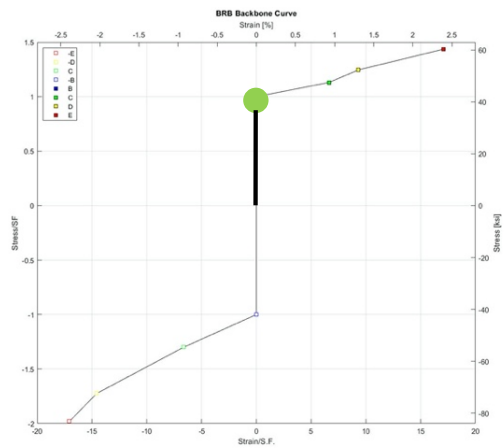


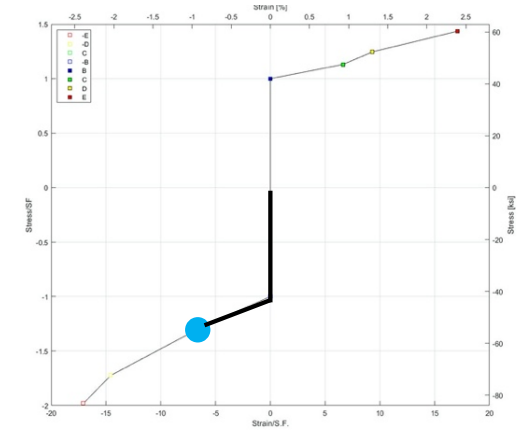
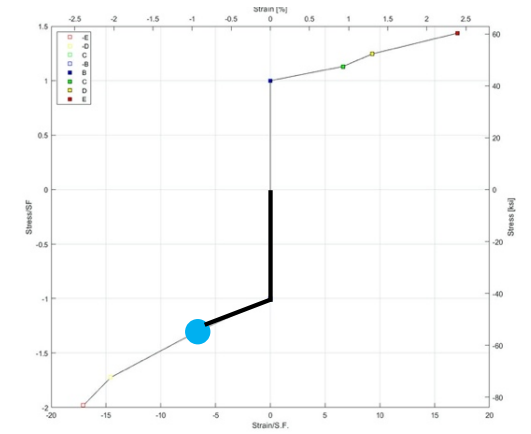
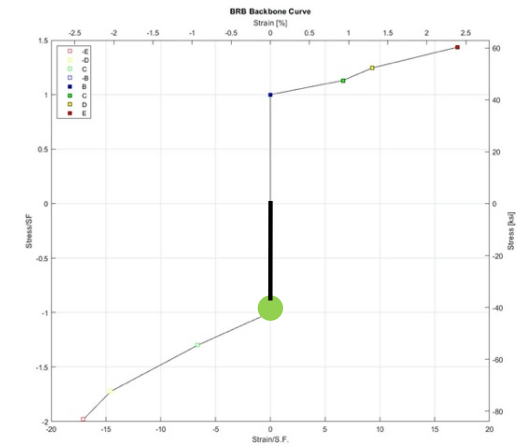
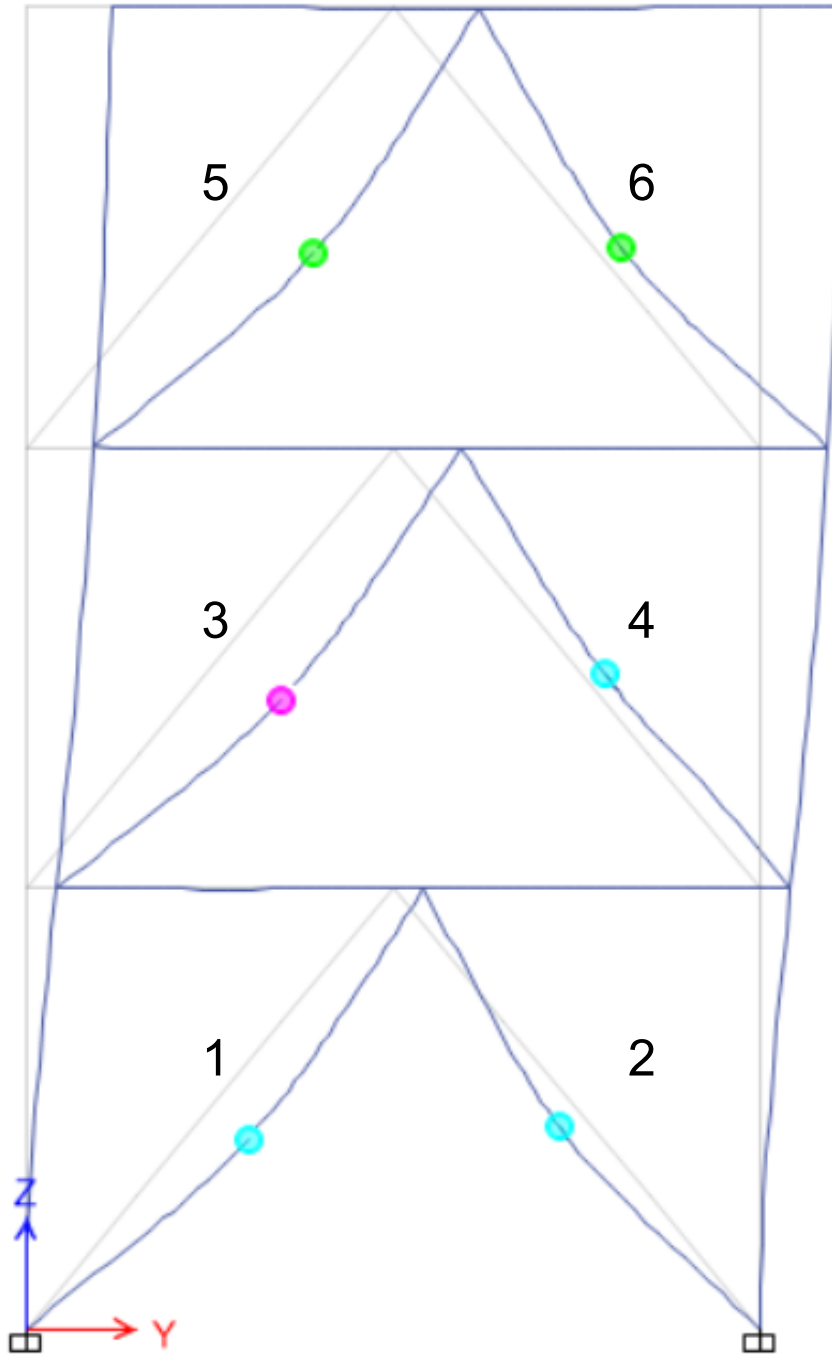
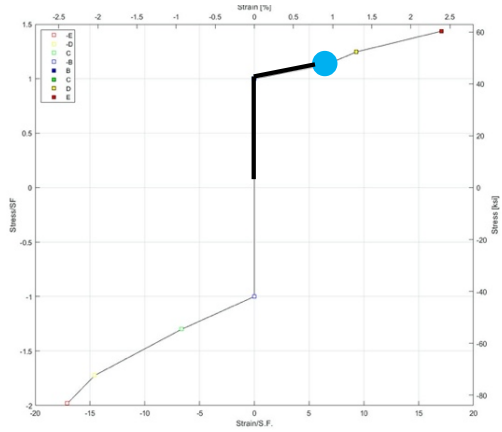
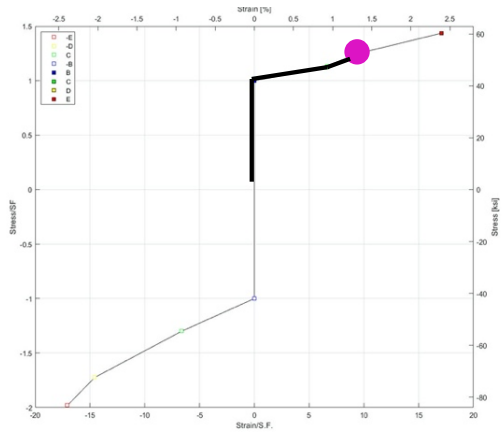
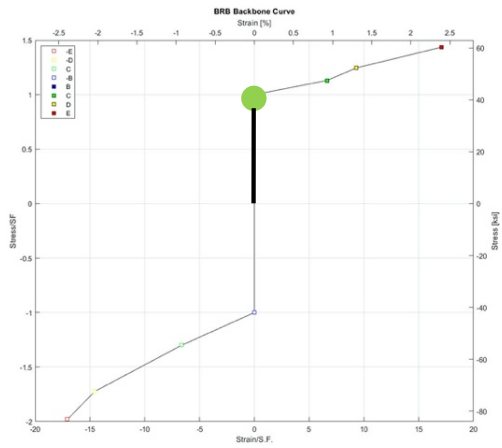


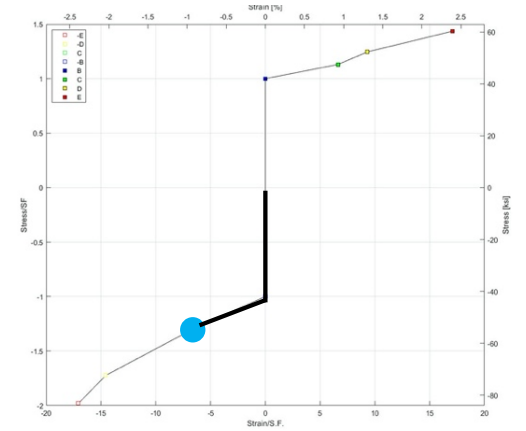
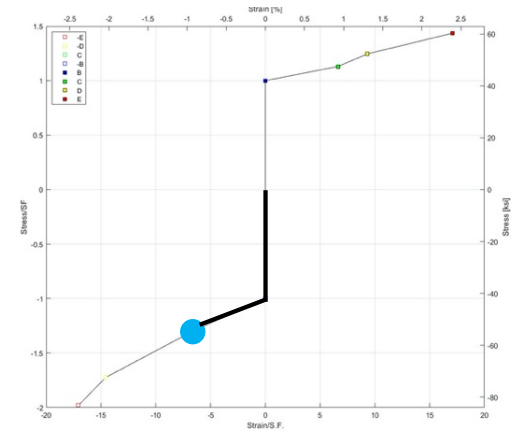
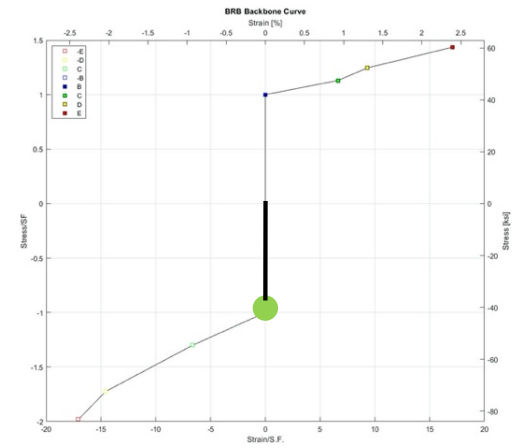
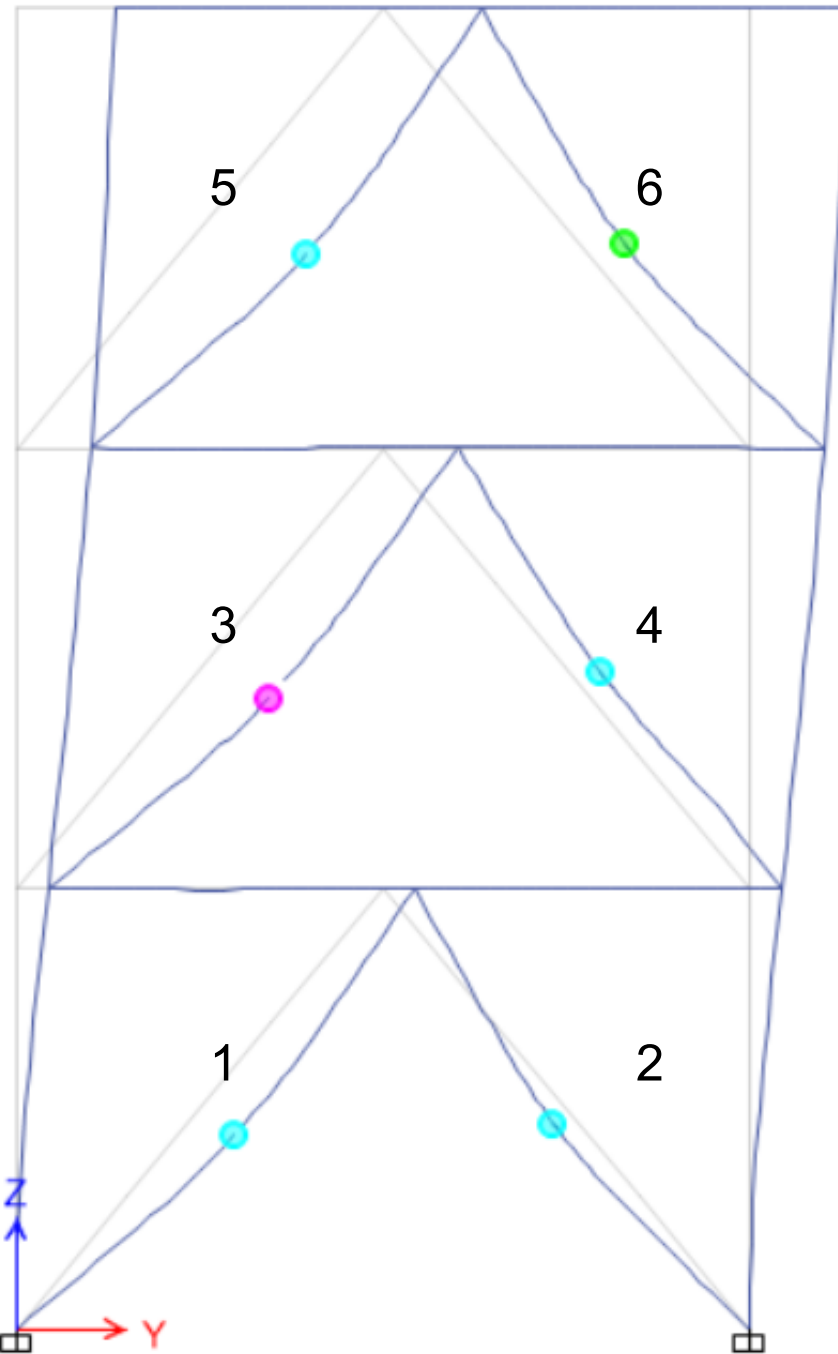
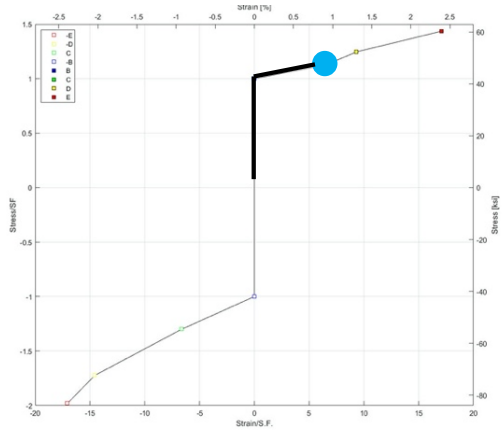
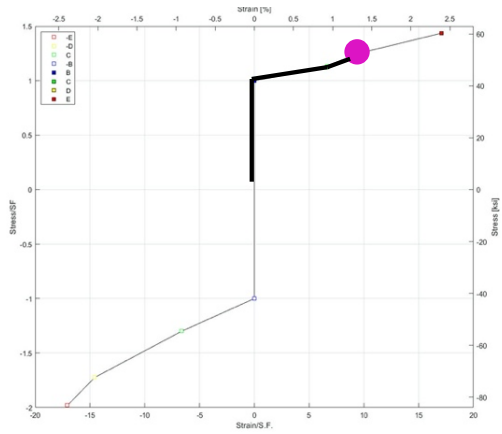
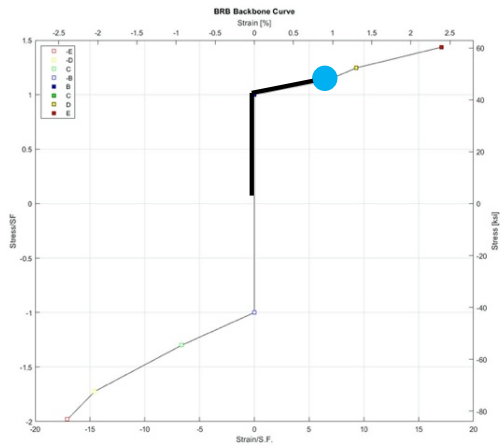


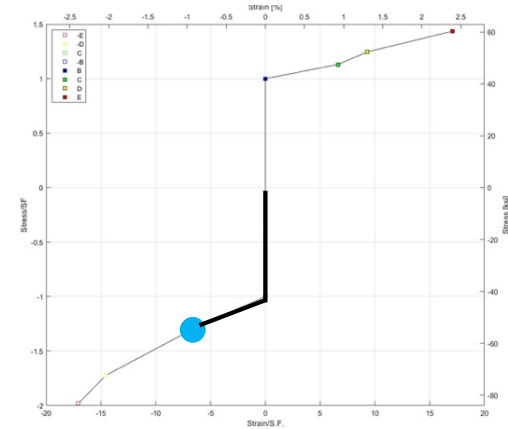
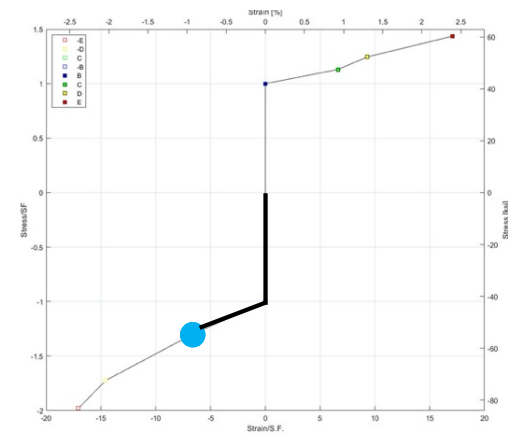
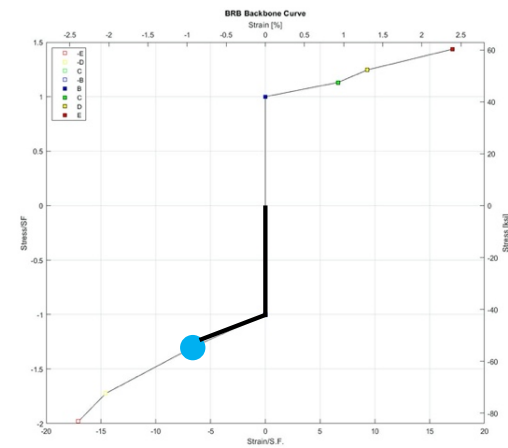
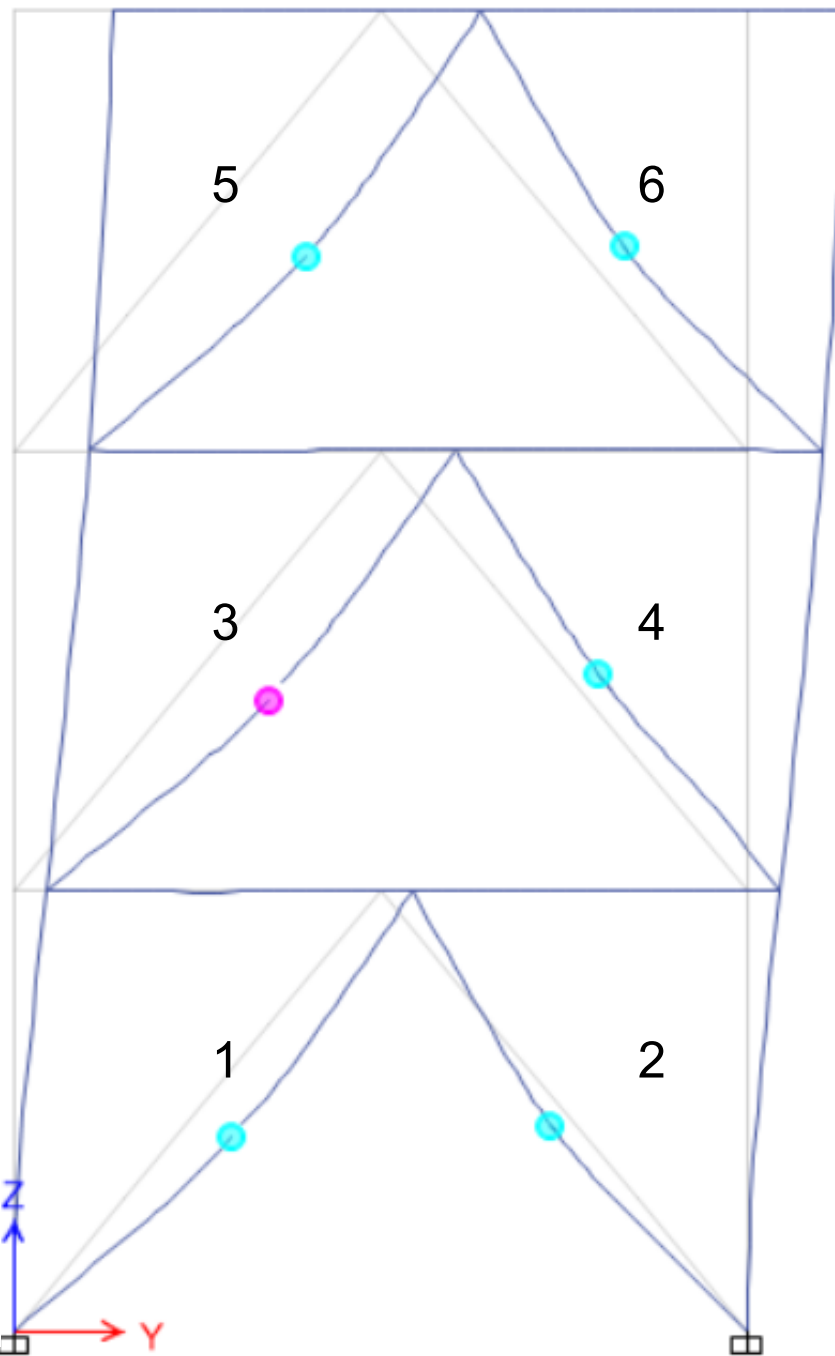
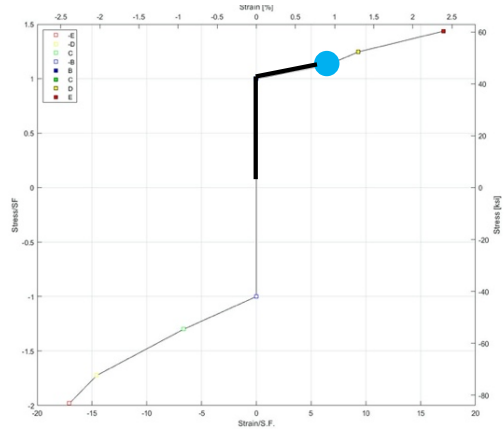
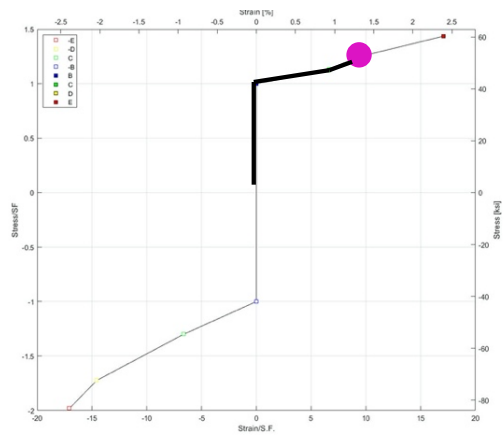
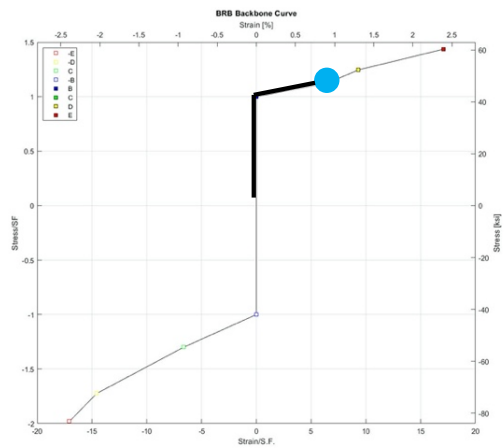


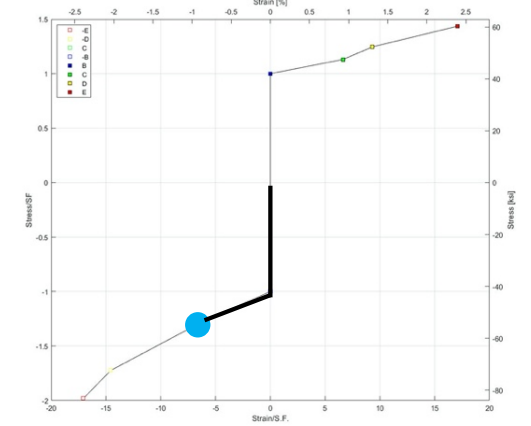
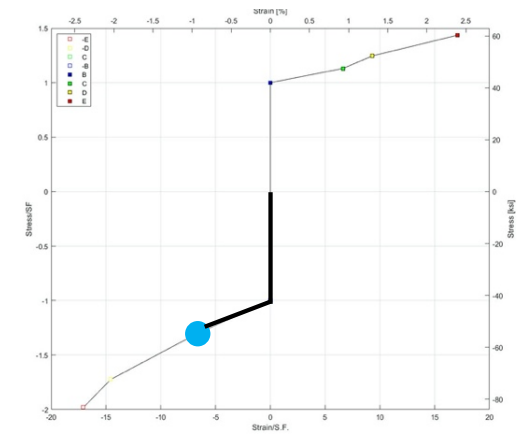
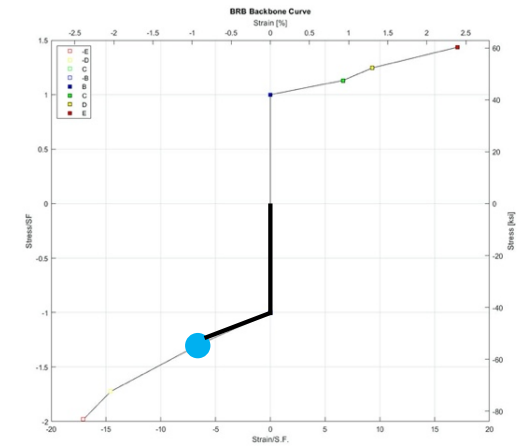
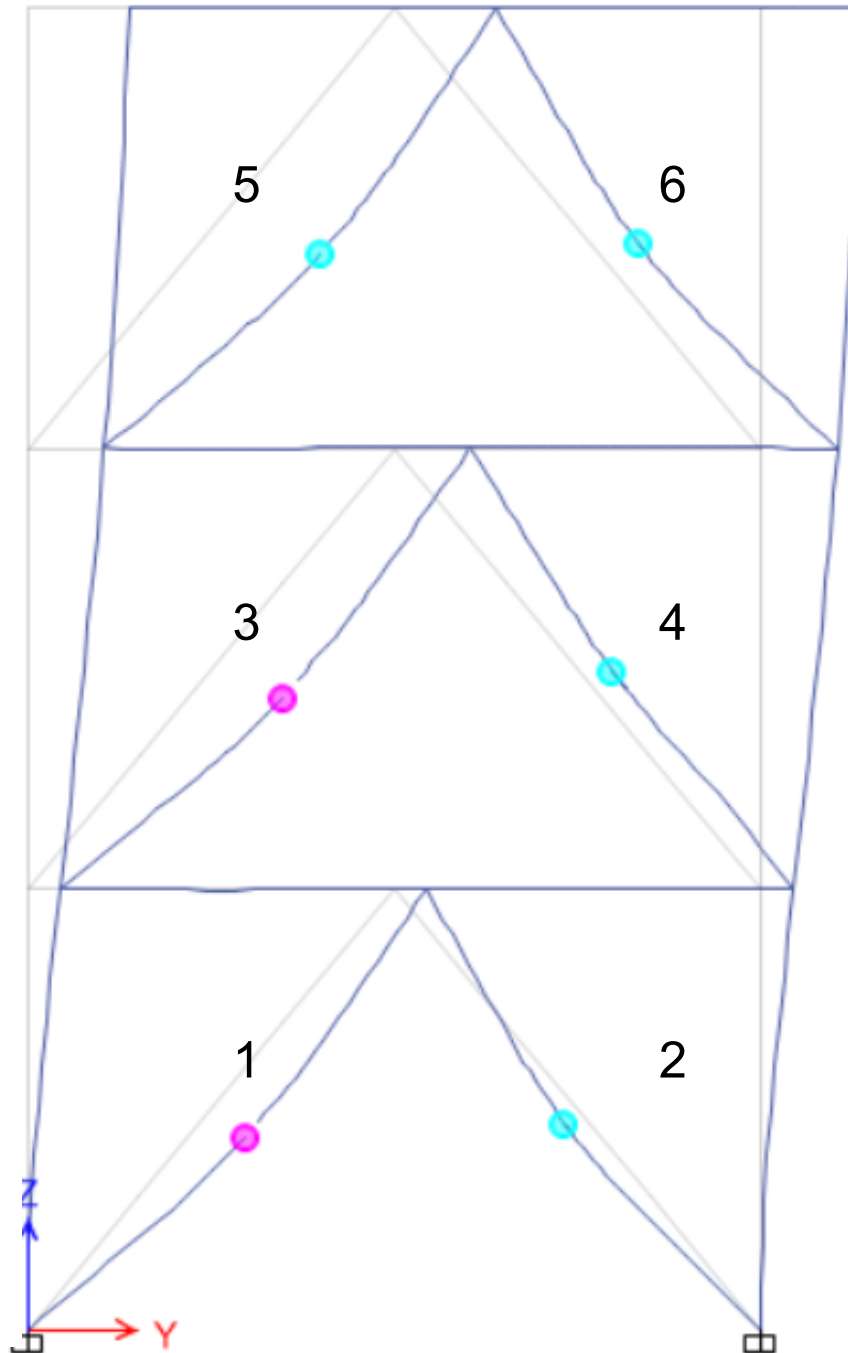
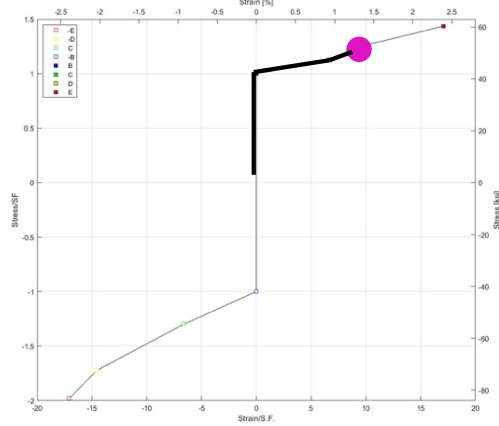
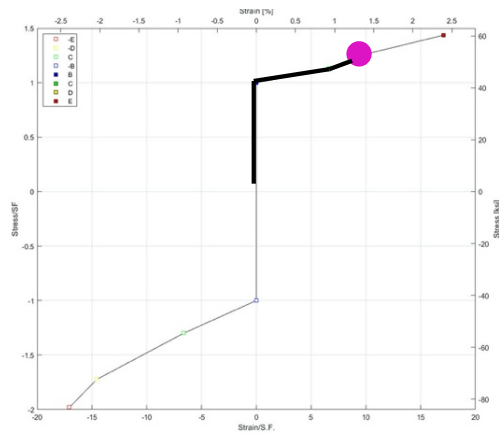
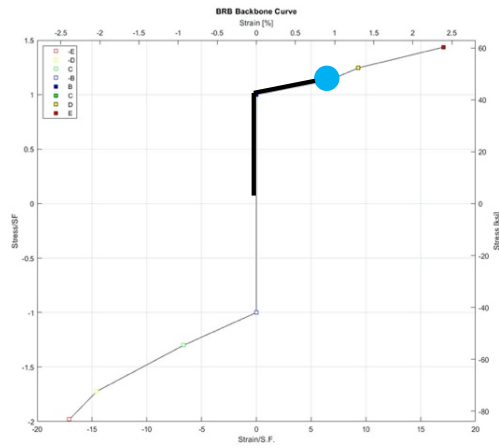


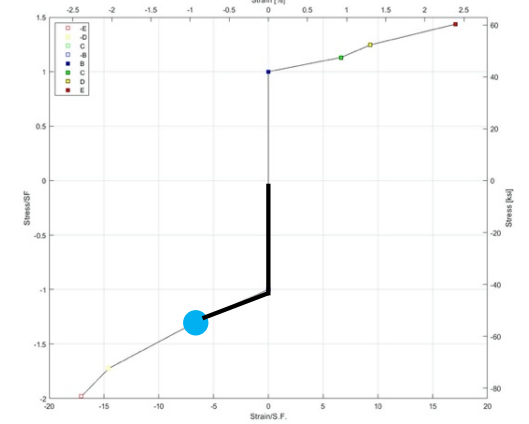
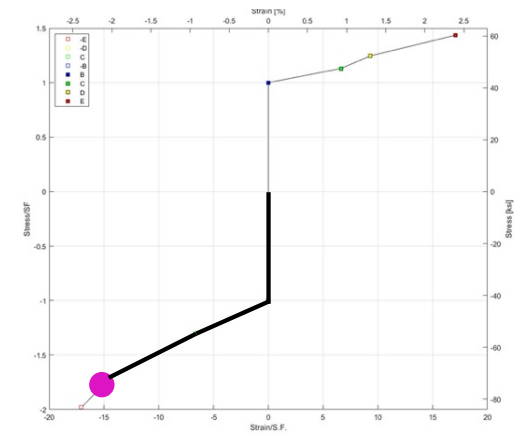
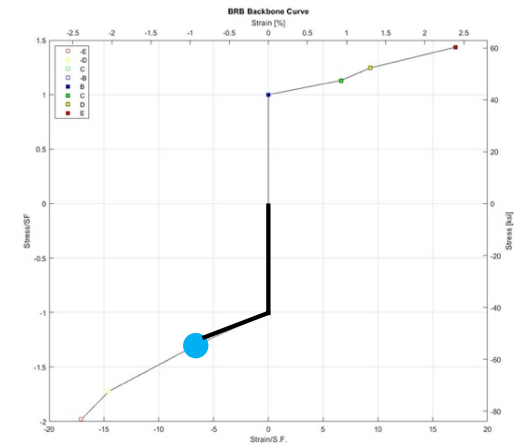
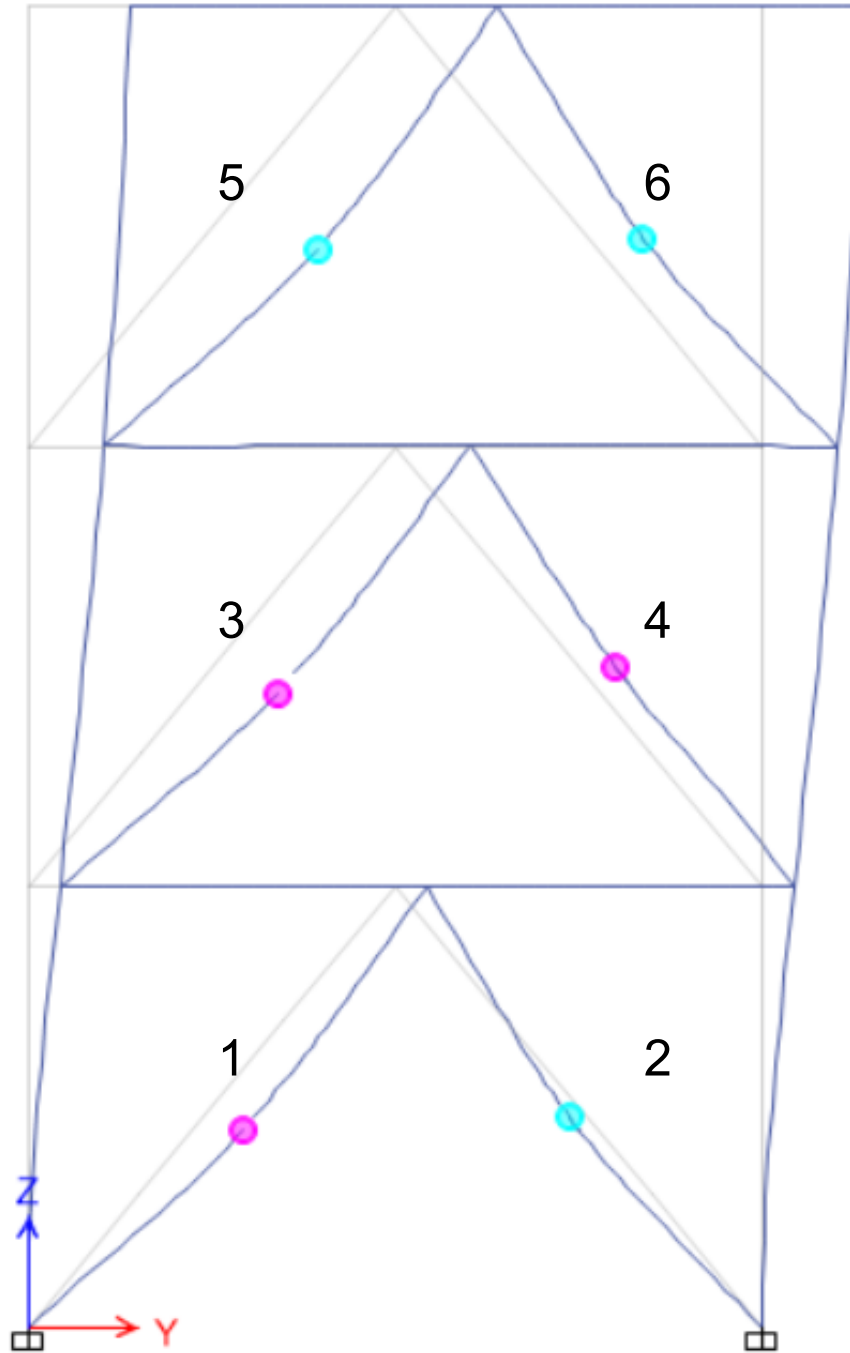
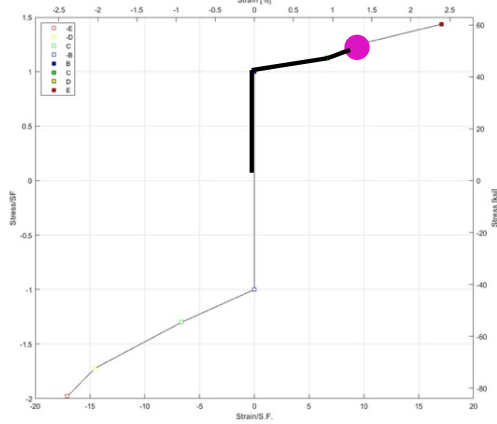
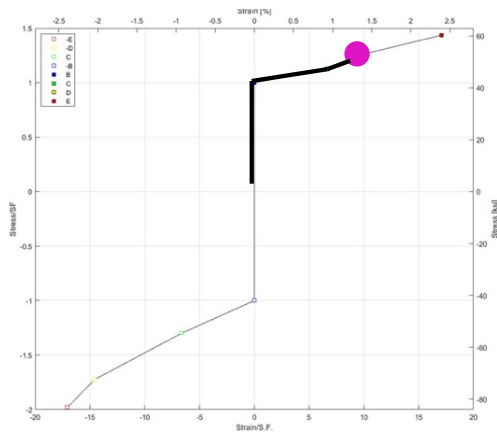
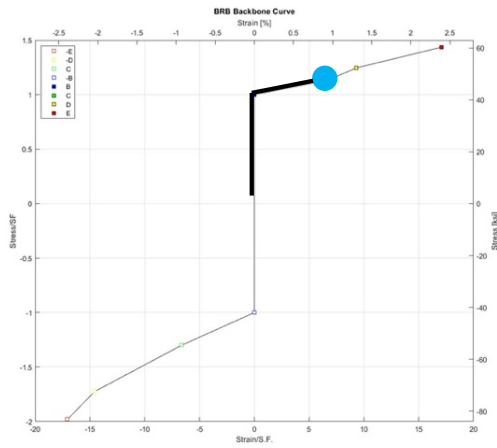


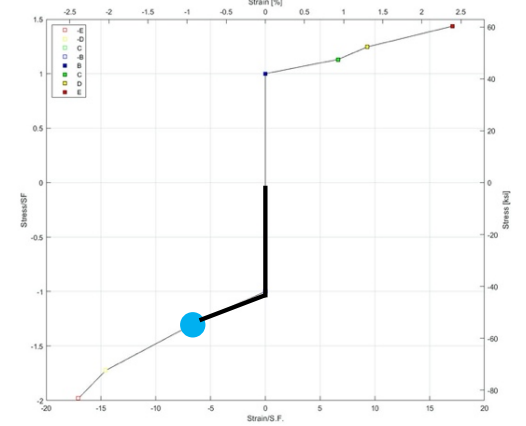
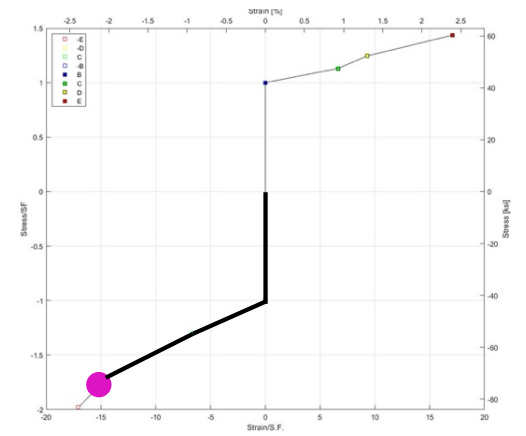
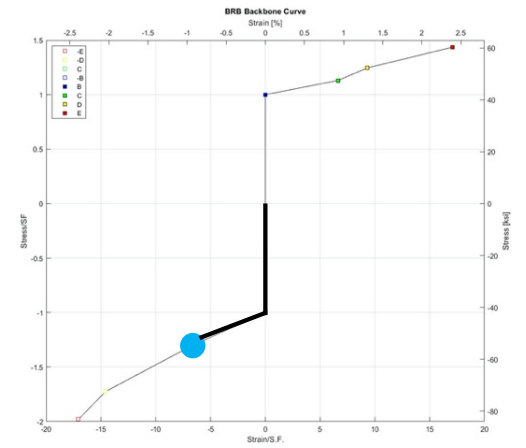
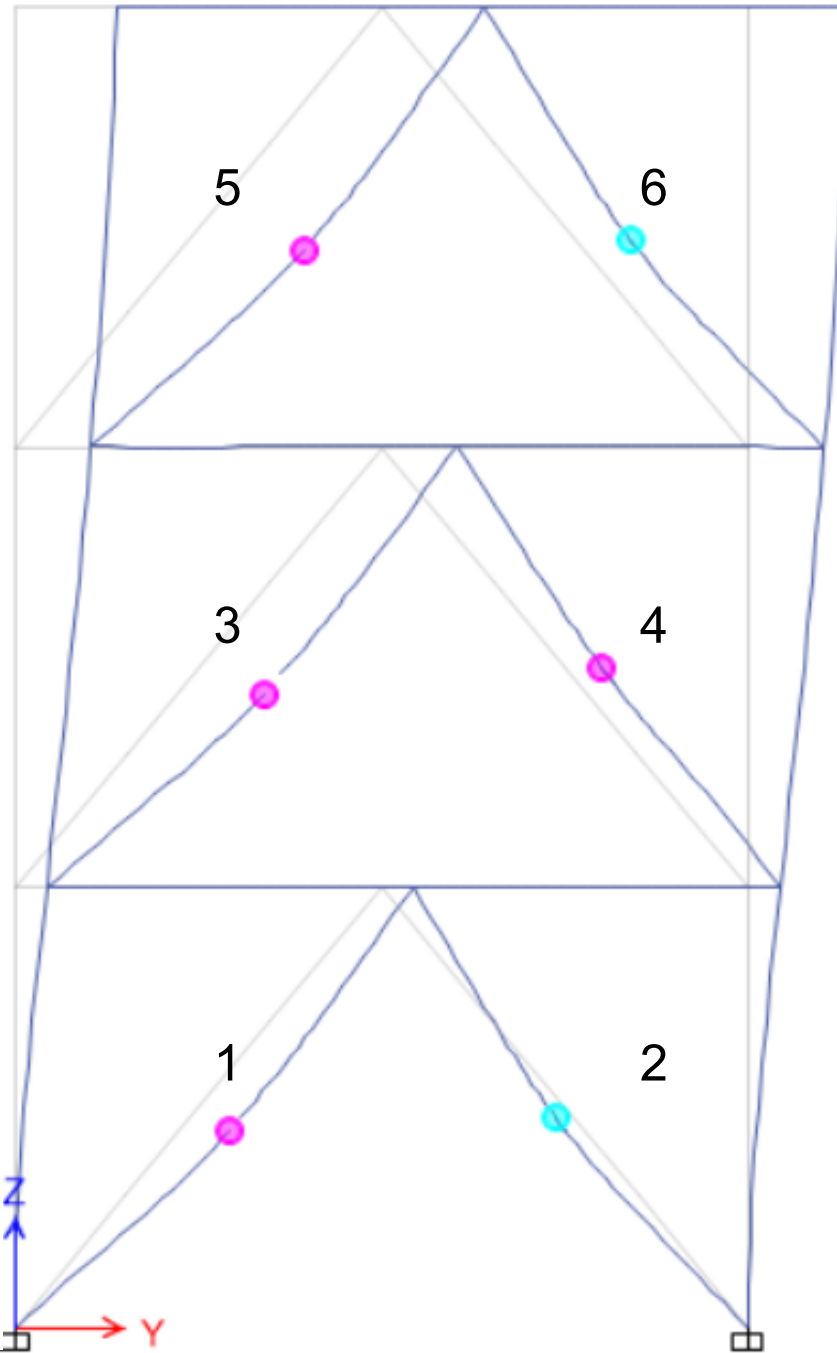
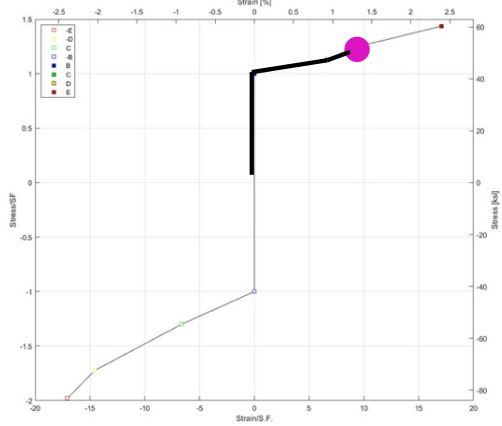
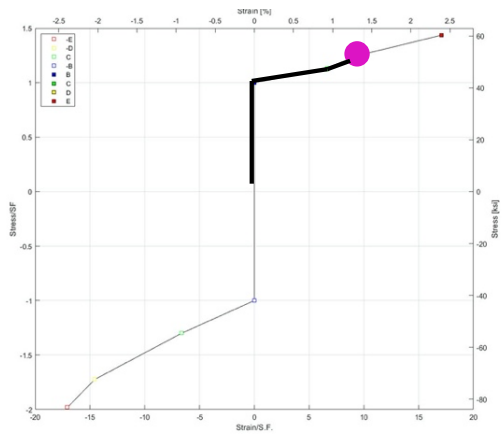
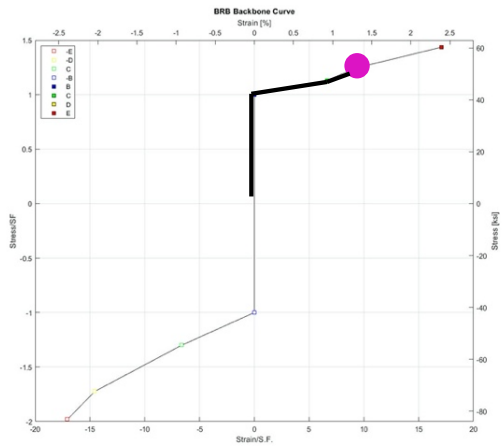


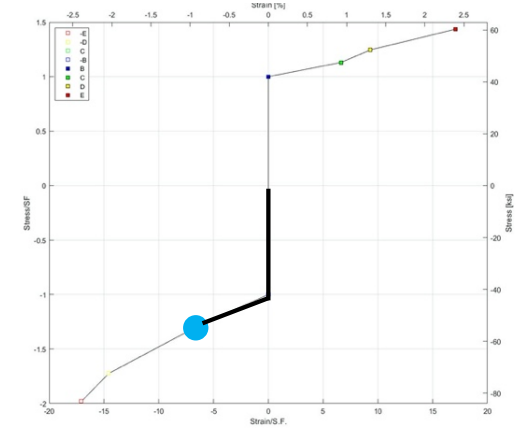
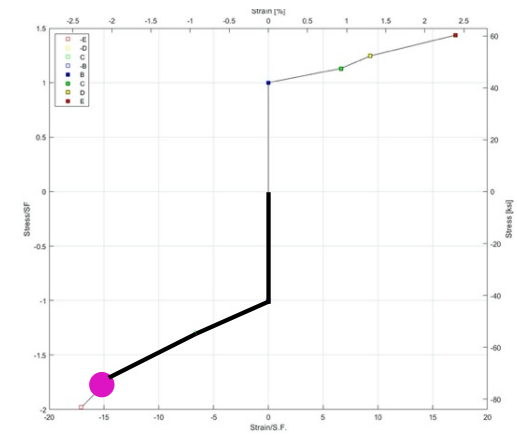
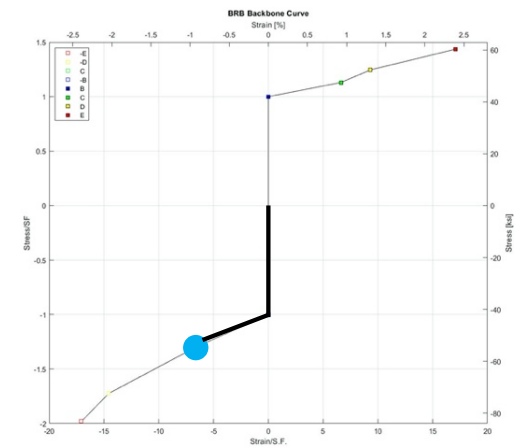
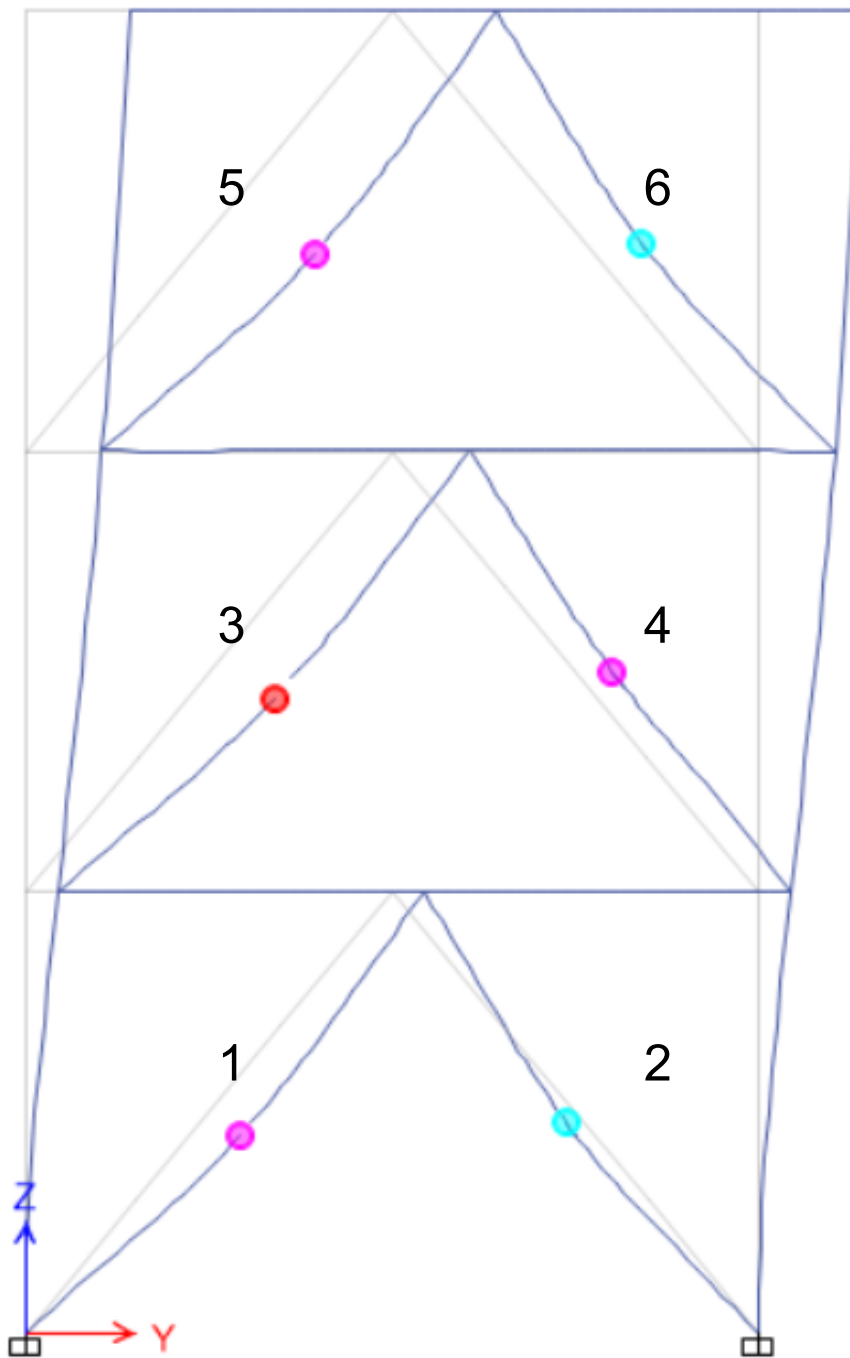
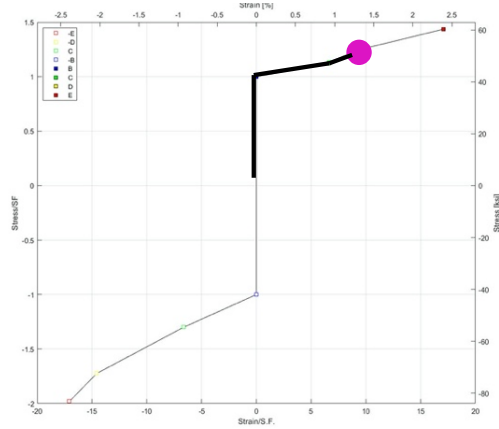
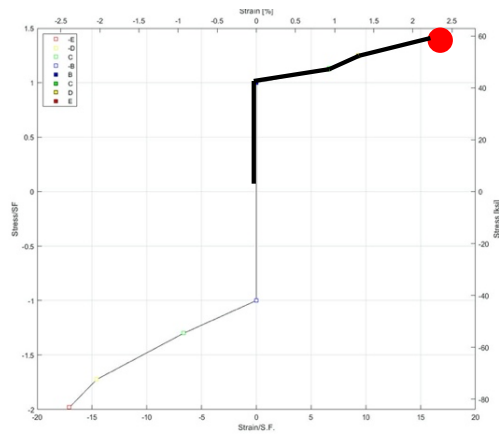
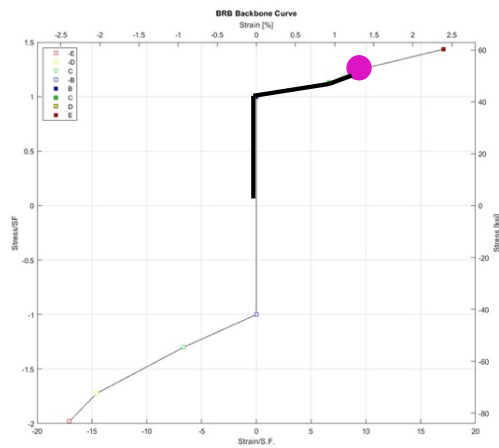






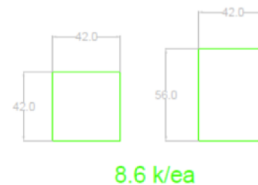
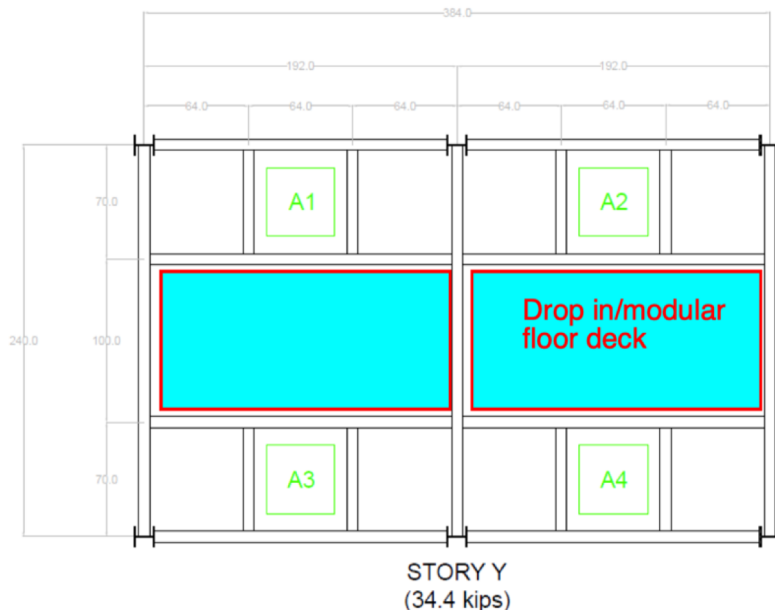






Modular Floor System

- Testbed building required a modular floor deck solution, within the designated **stair study space**
- Design, detailing & fabrication of two types of (easy to install) drop-in floor systems: 1) light-weight (sheathing over steel decking, ~6kip/floor) and 2) heavy-weight (composite decking with PIP concrete, ~12kip/floor)
- Supplemental mass: ~30kip/floor (148kips all LW floors; 166kips all HW floors)



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Concluding Remarks: *MTB² Applications*

- MTB2 is intended to be a community available tool for delivering a wide-variety of seismic details for nonstructural elements, including:
 - Seismic protective systems
 - Lateral force resisting systems
 - Contents, including protective strategies
 - Wide variety of nonstructural systems
 - Stairs (drop-in central floor region)
 - Facades (ease of attachment at perimeter)
 - Floor-mounted and/or floor-hung mechanical, systems
 - Floor-floor interior wall assemblies
- As it will be tested first upon opening of the upgraded LHPOST6, researchers may prepare proposals to utilize MTB² in their work in the coming years

