



Novel Seismic Resilient Bridge Columns Based on Iron-Based Shape Memory Alloy (FeSMA) Bars



国家大型地震工程模拟研究设施
National Facility for Earthquake Engineering Simulation



建筑工程学院
School of Civil Engineering

Huanpeng Hong, Ph.D.

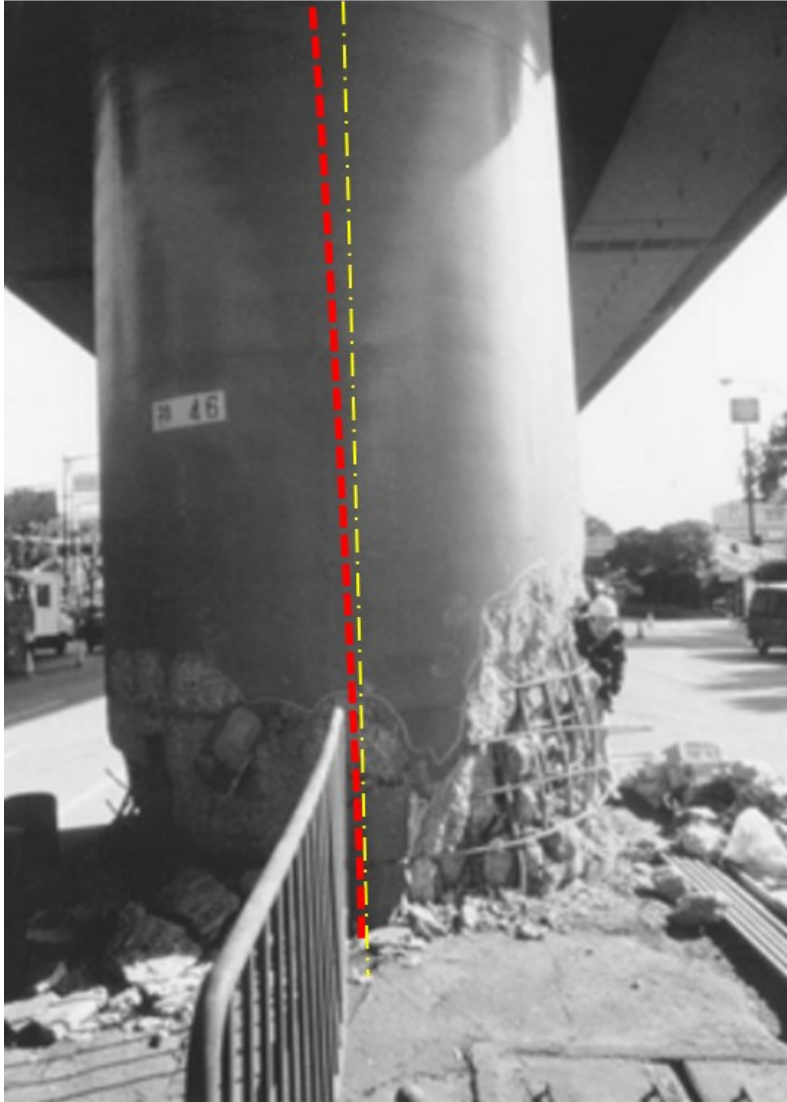
Associate Professor

National Science Center for Earthquake Engineering (NSCEE)

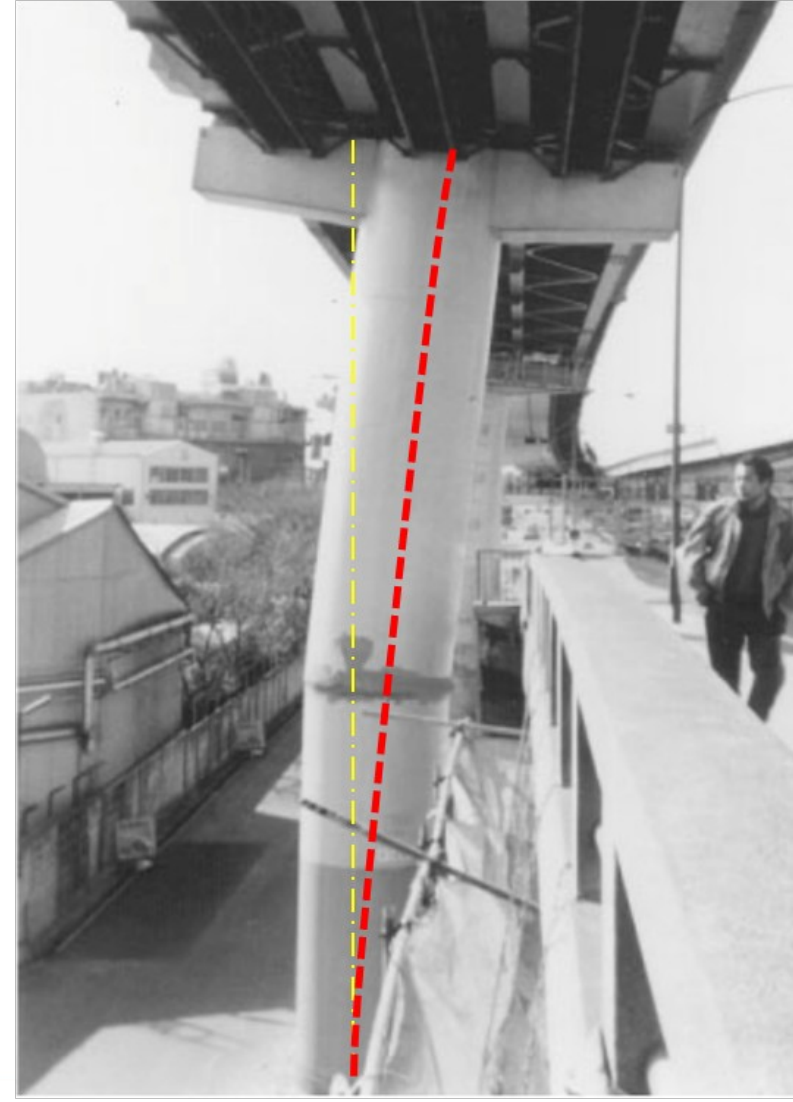
June 7, 2026

Traditional RC columns after an earthquake

Residual drift



Residual drift



Difficulty in demolition and reconstruction

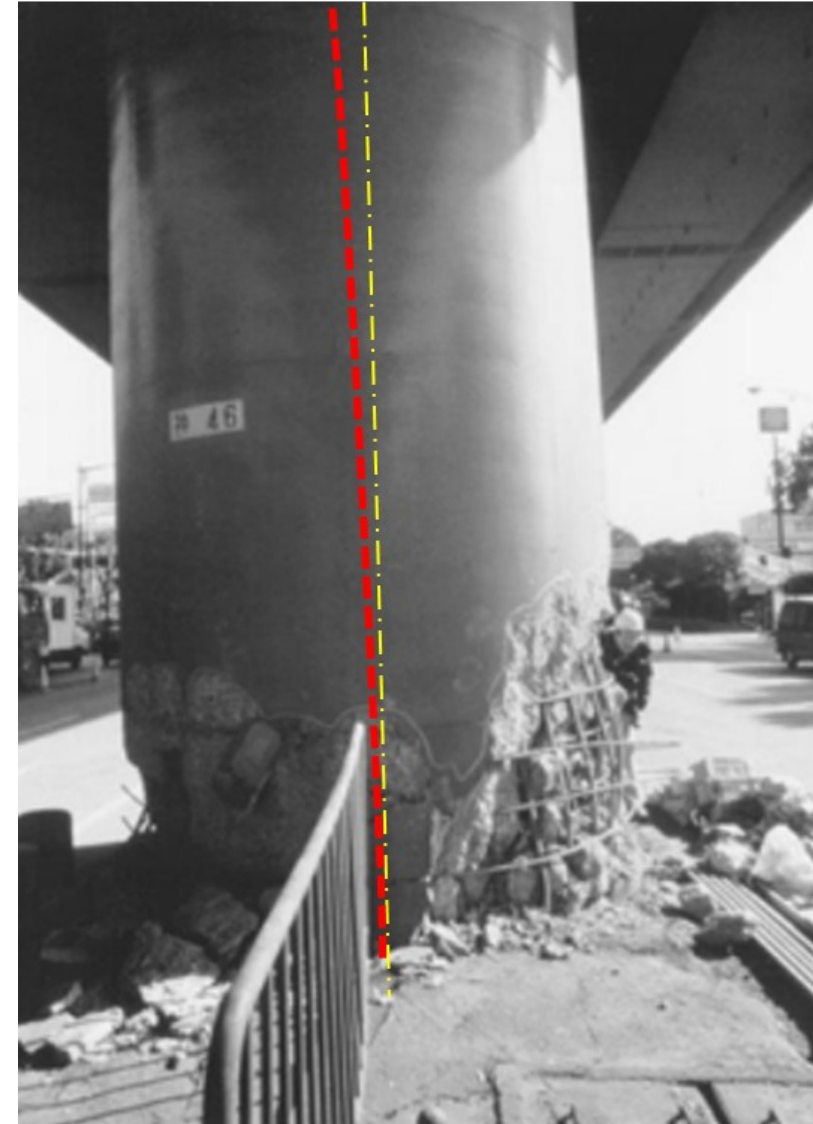
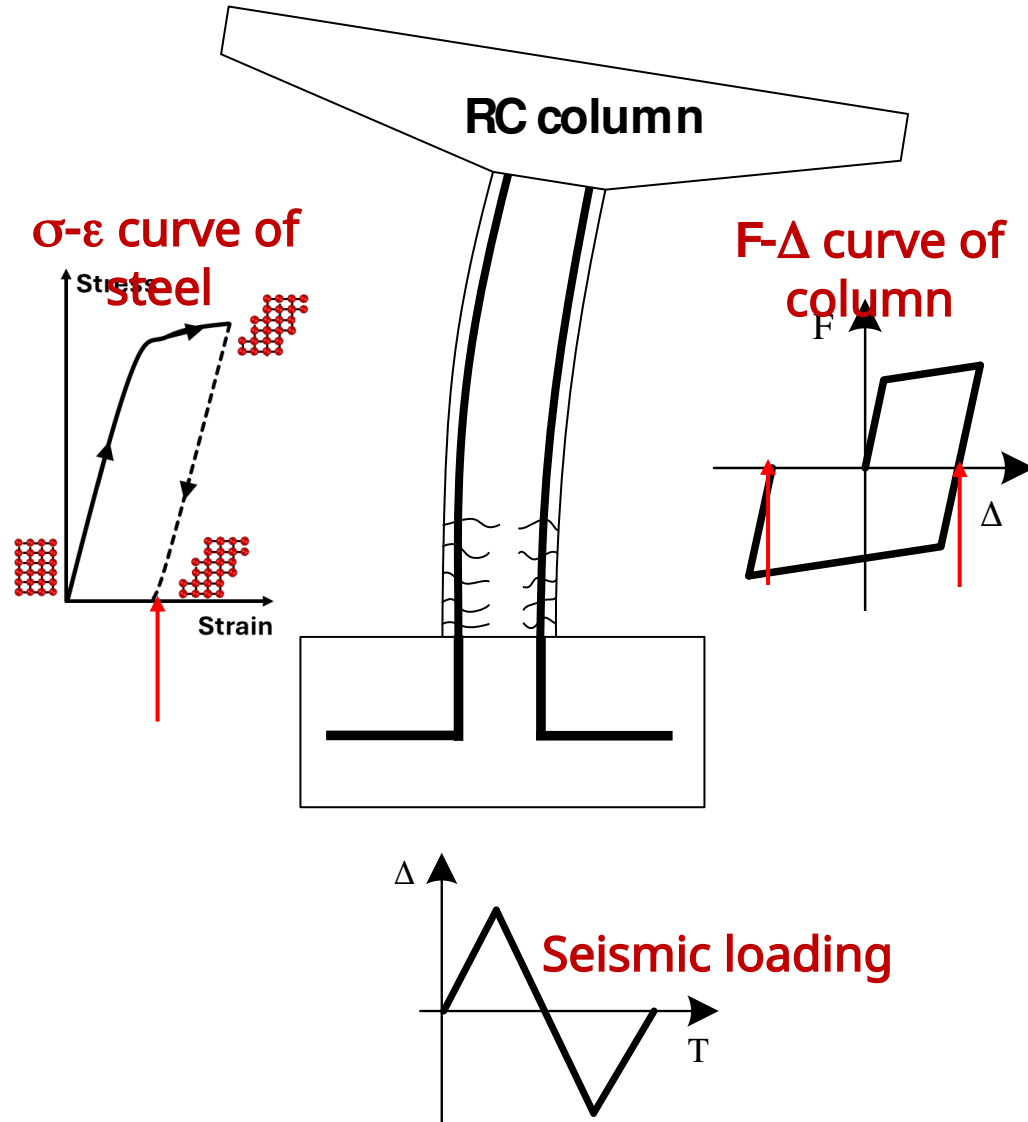
Girder Falling / Nonstructural elements damage



Difficulty in demolition and reconstruction



Major limitations of traditional RC columns



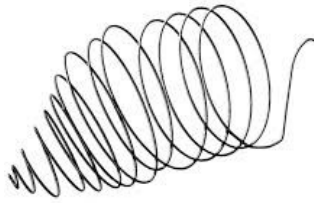
What is Shape Memory Alloy (SMA)?

➤ SMA is a smart material

- Smart materials refer to materials whose properties can be changed in a controlled manner by external stimuli, such as stress, temperature, photon, electric or magnetic fields, etc.

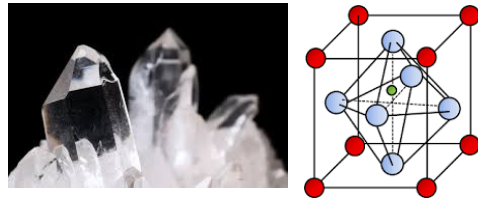
Shape memory alloy

Stress – Temperature - Strain



Piezoelectric materials

Stress – voltage



Photovoltaic materials

Photon – electric current



Ferrofluids

Magnetic field – motion



➤ SMA is a functional metal material

- Compared with structural metal materials, functional metal materials are usually NOT used alone to manufacture large structures, but only used locally when special functions are needed.

Conventional structural metal materials – Steel

buildings/ bridges



Stainless steel

kitchen items



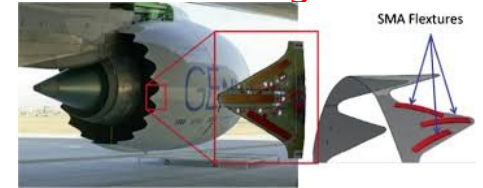
Titanium alloy

Engine blades



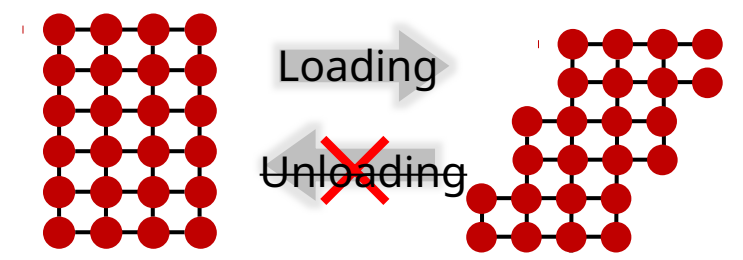
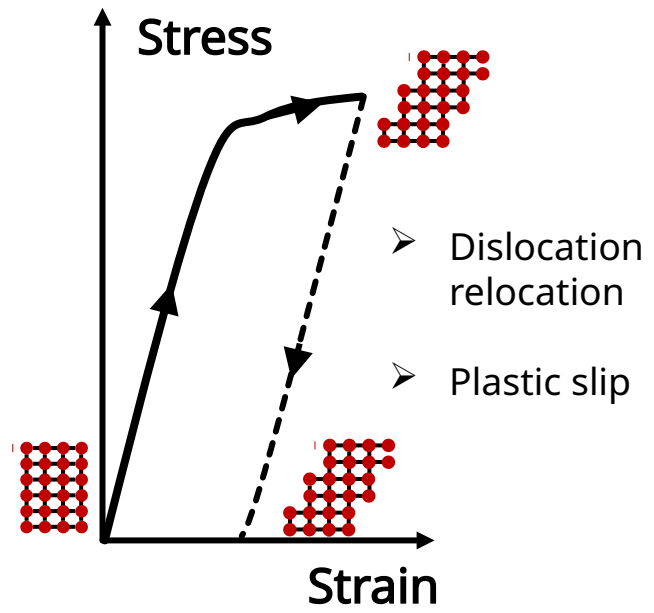
Shape memory alloy

Deformable engine nozzle



Traditional Metal & Smart Metal: Shape Memory Alloy (SMA)

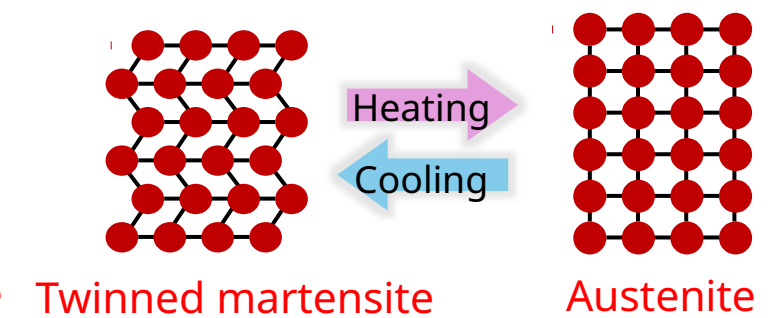
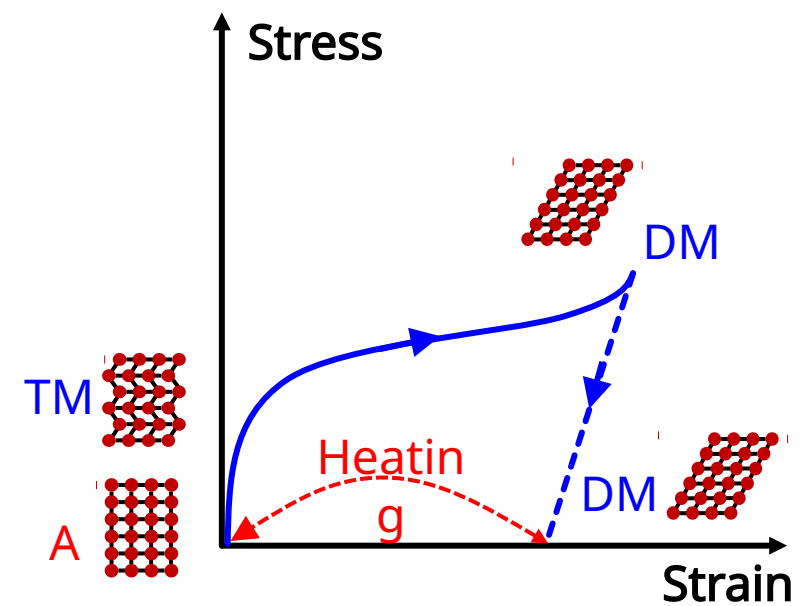
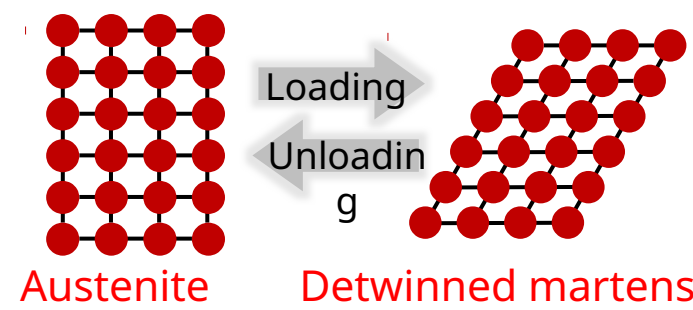
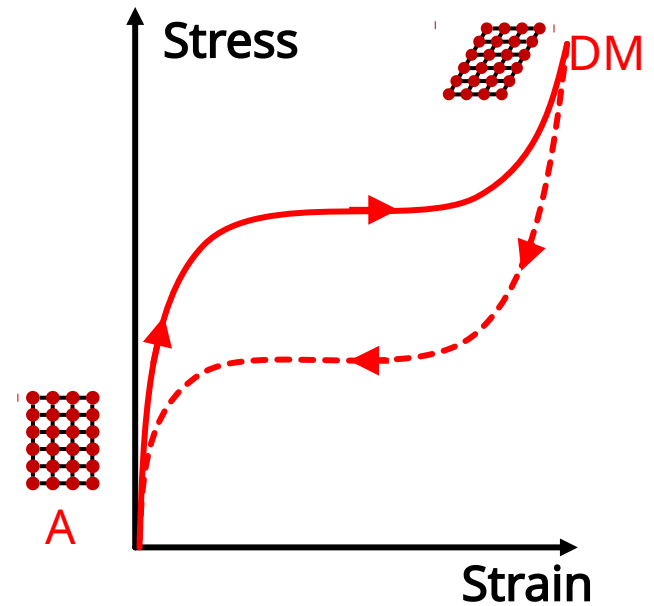
Traditional Metal
(Plastic Deformation)



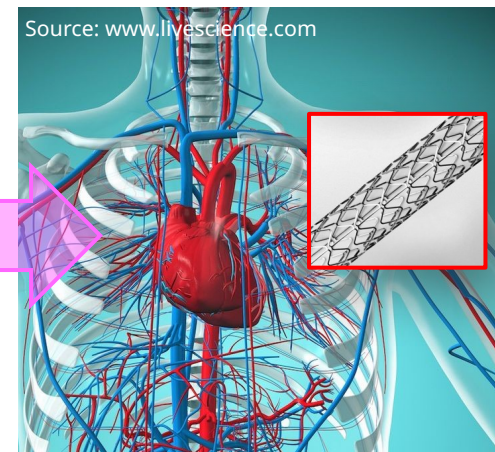
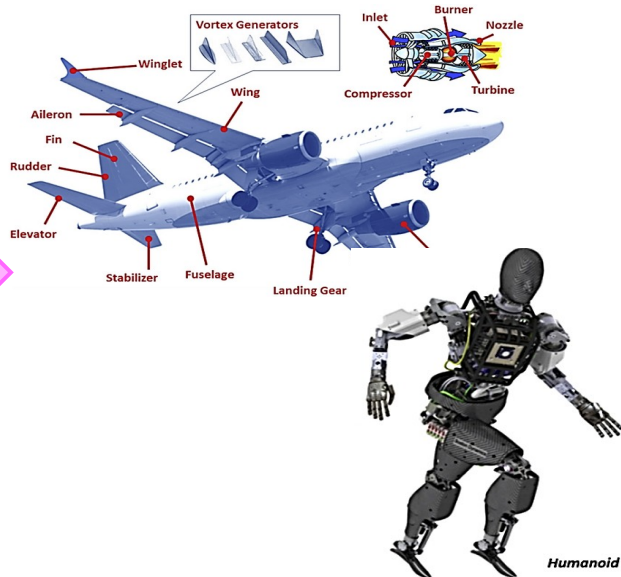
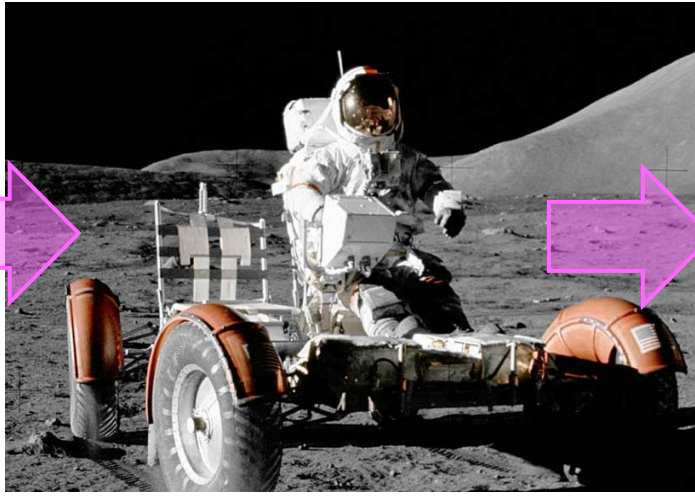
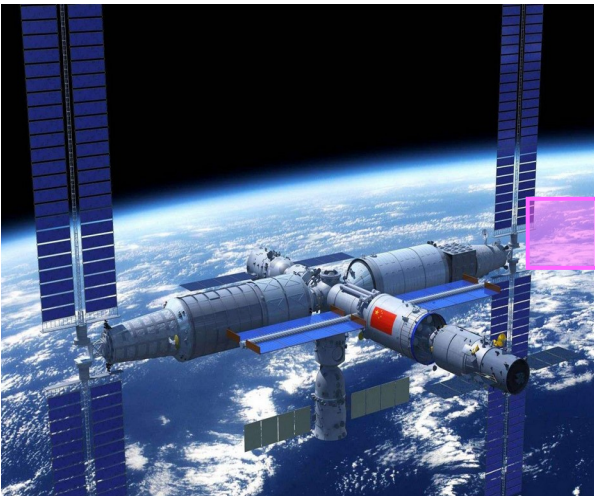
Shape Memory Alloy (SMA)

Superelastic Effect

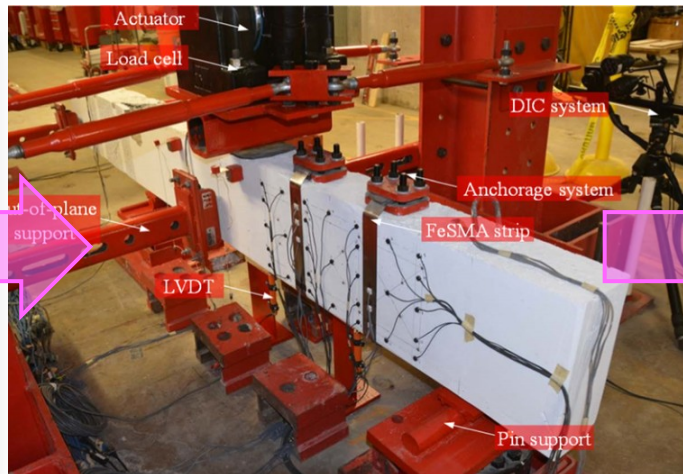
Shape Memory Effect



What SMA has been used for?



Saidi et al. SR-99 off-ramp bridge, Seattle (2017)



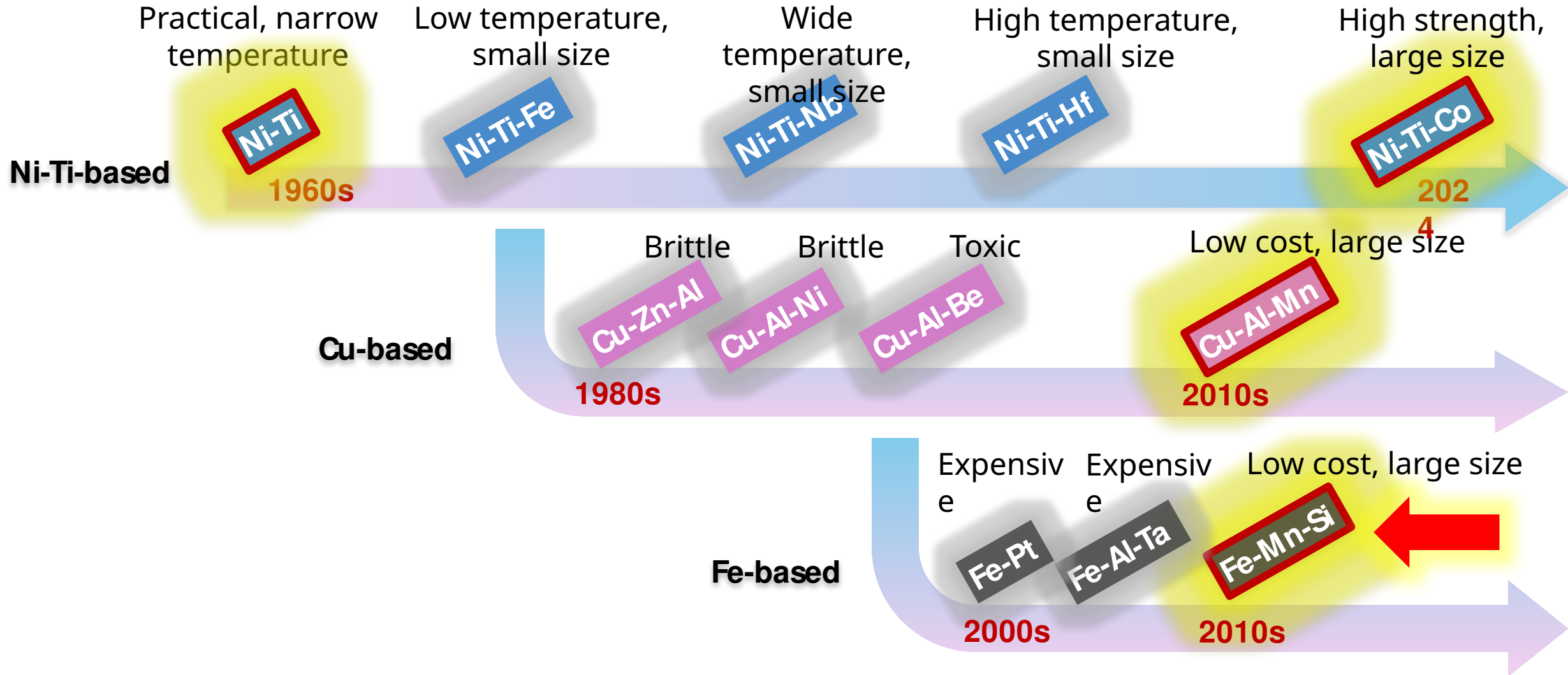
Hong et al. Engineering Structures (2025)



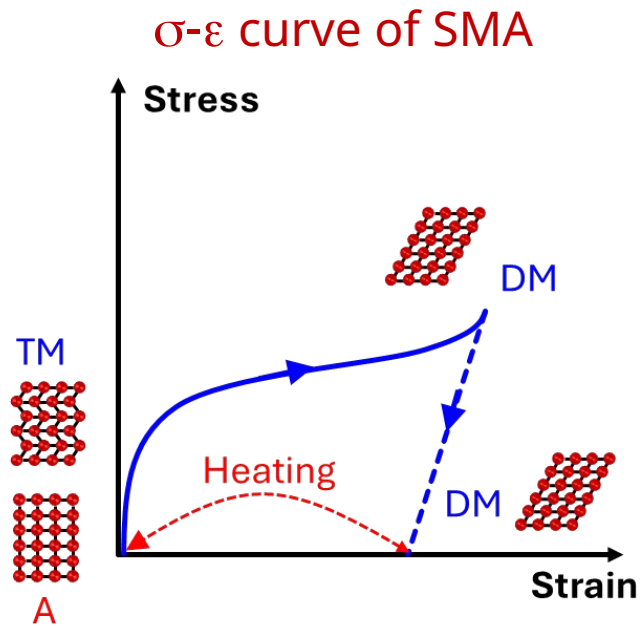
Hong et al. Journal of Building Engineering (2025)



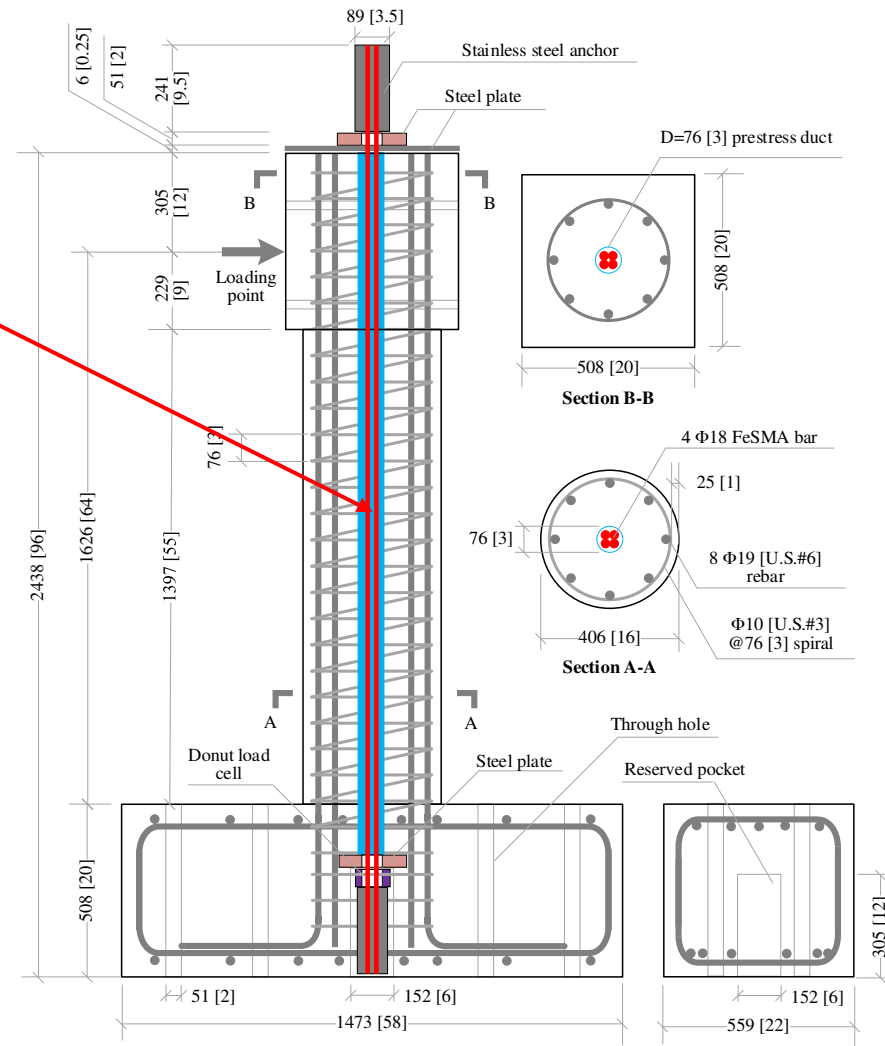
Development history of SMA



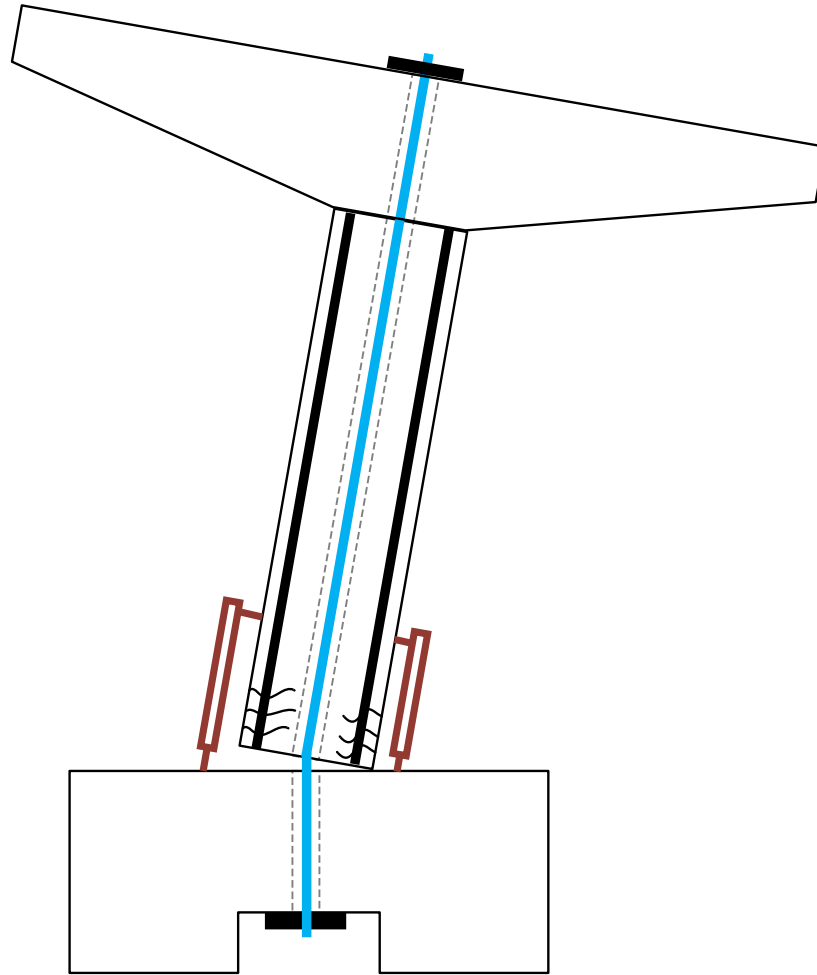
FeSMA post-tensioned rocking column



SMA
prestress
bars



Traditional post-tensioning materials



High strength steel strand



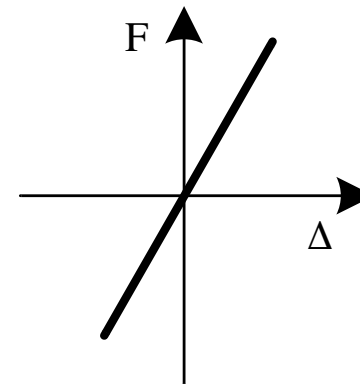
Fiber reinforced plastic (FRP) tendon



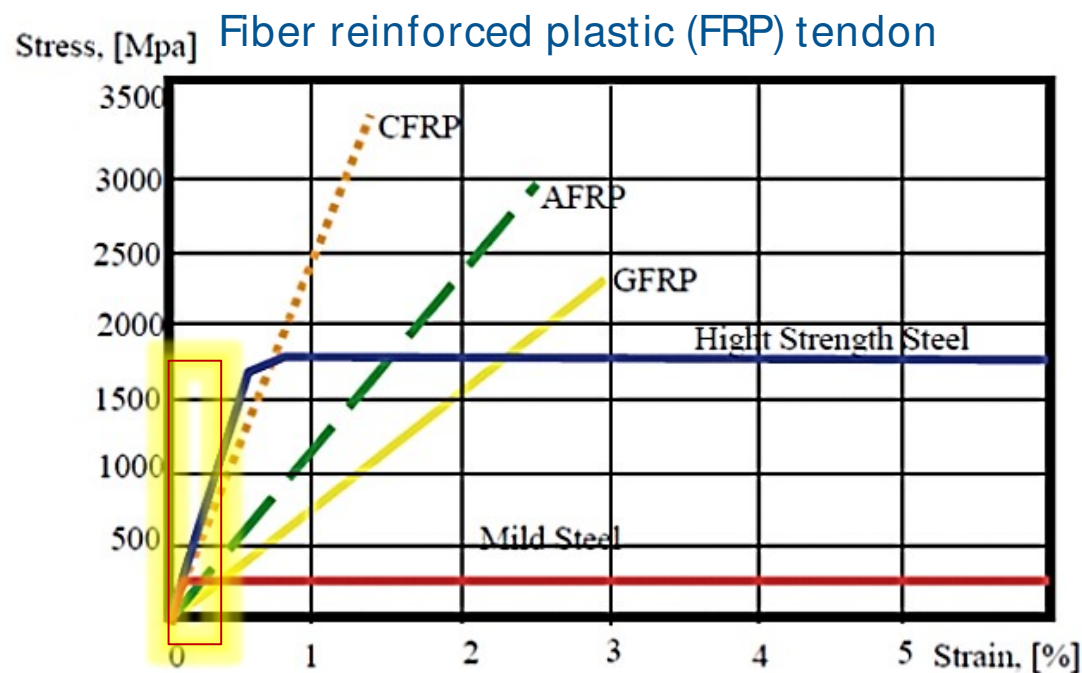
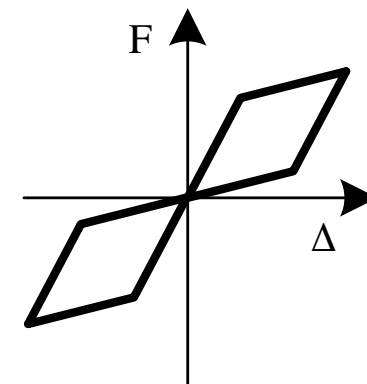
Traditional post-tensioned columns

- Only works in elastic range
- Additional damper is needed

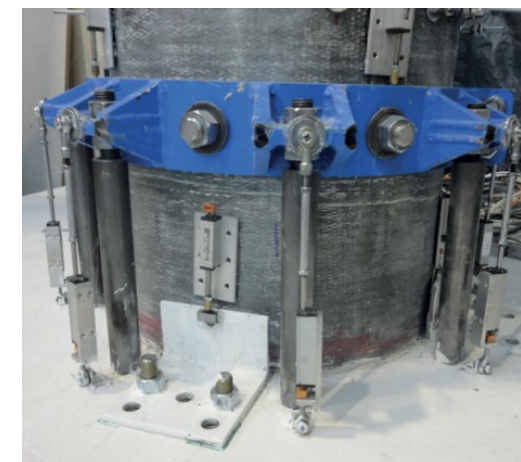
Without energy dissipator



With energy dissipator



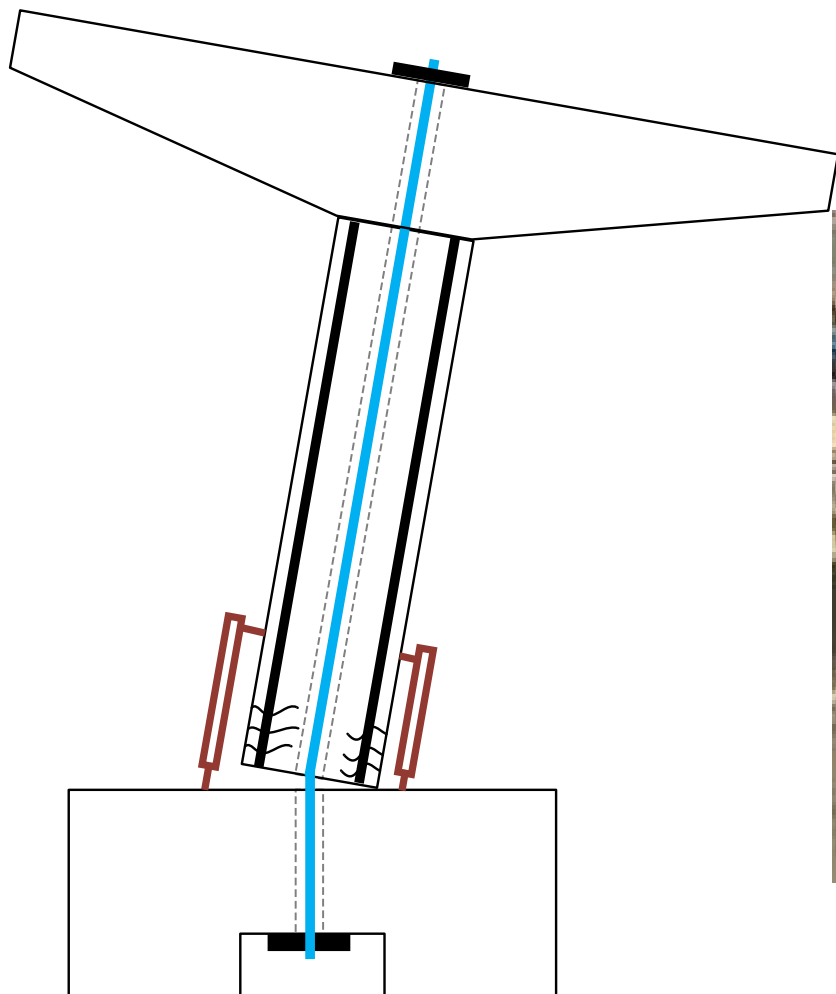
Zaman et al.
(2013)



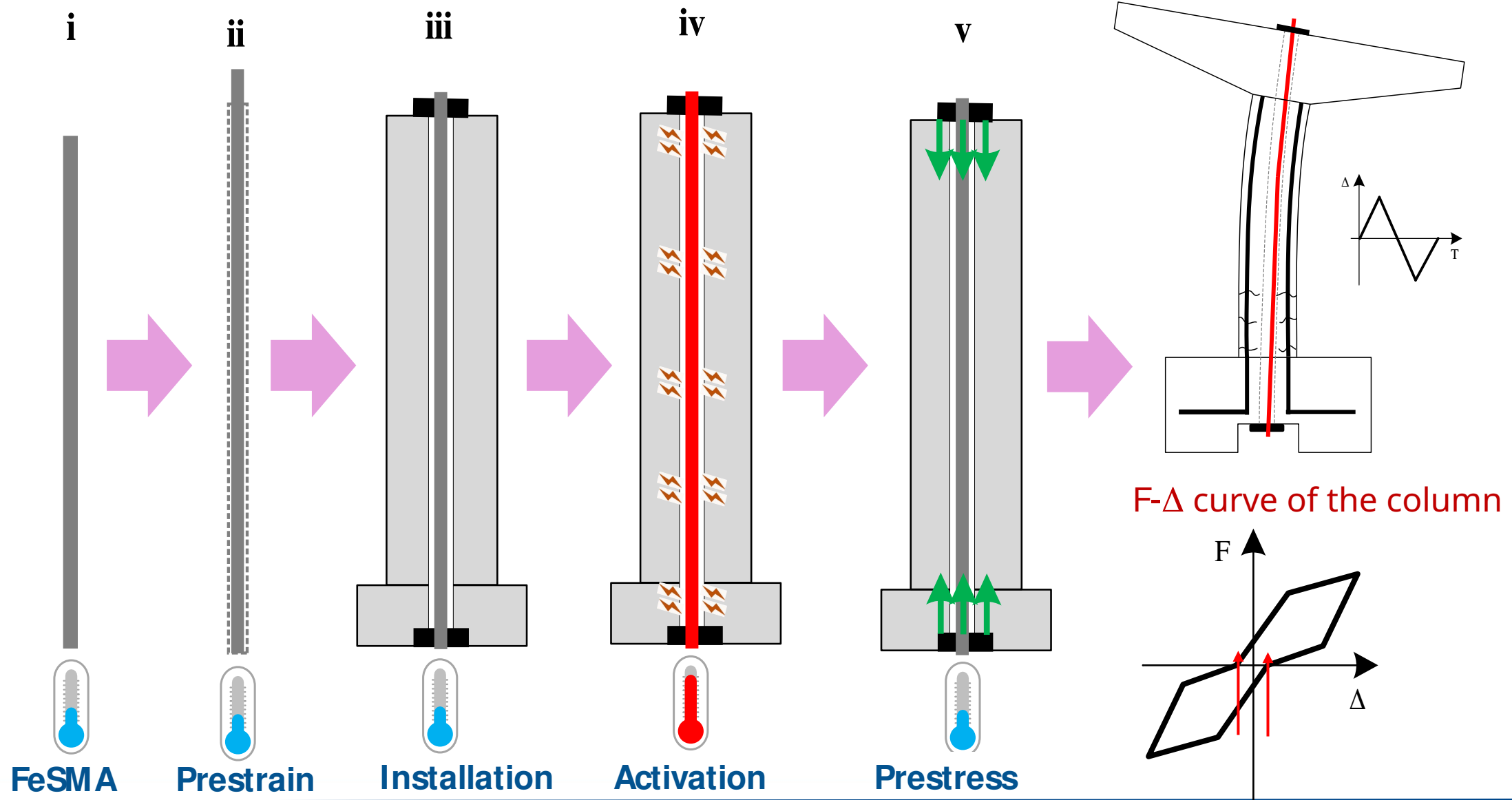
White et al. (2016)

Traditional post-tensioned columns

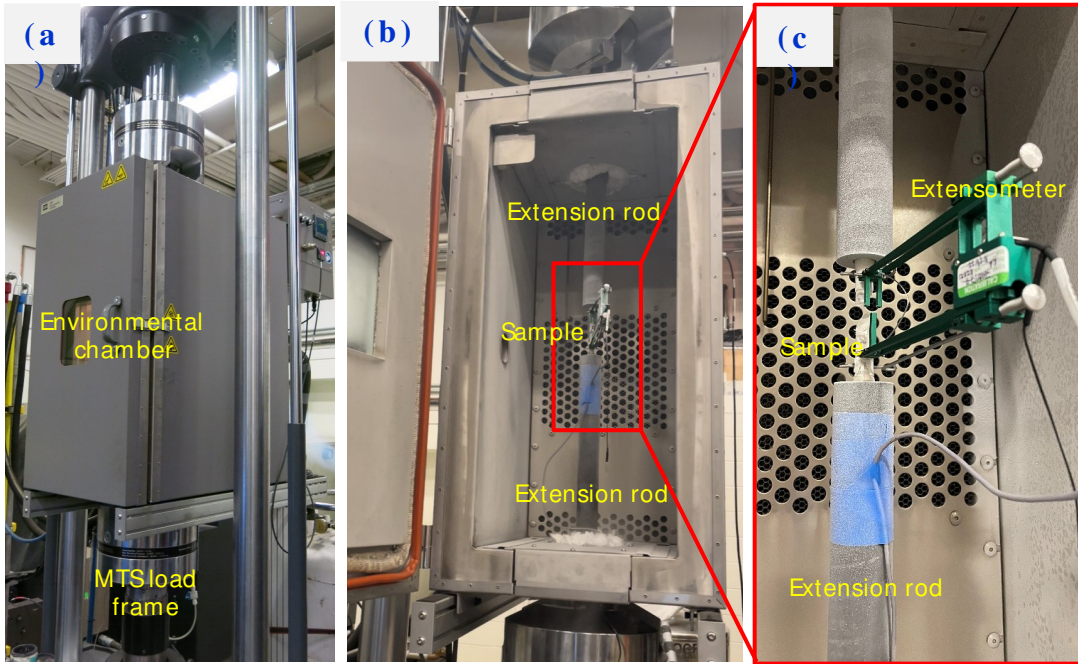
- Hydraulic devices are needed
- On-site post-tensioning is needed



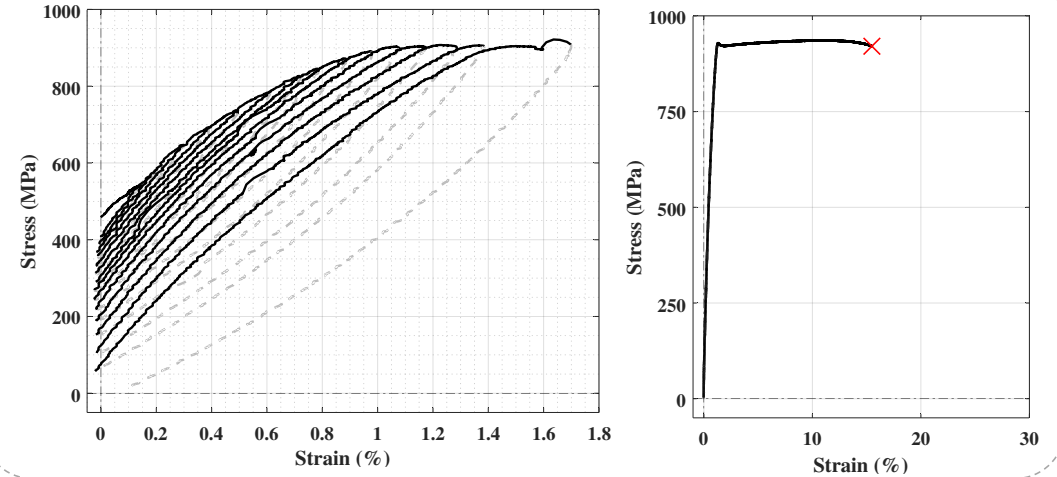
SMA prestressed column



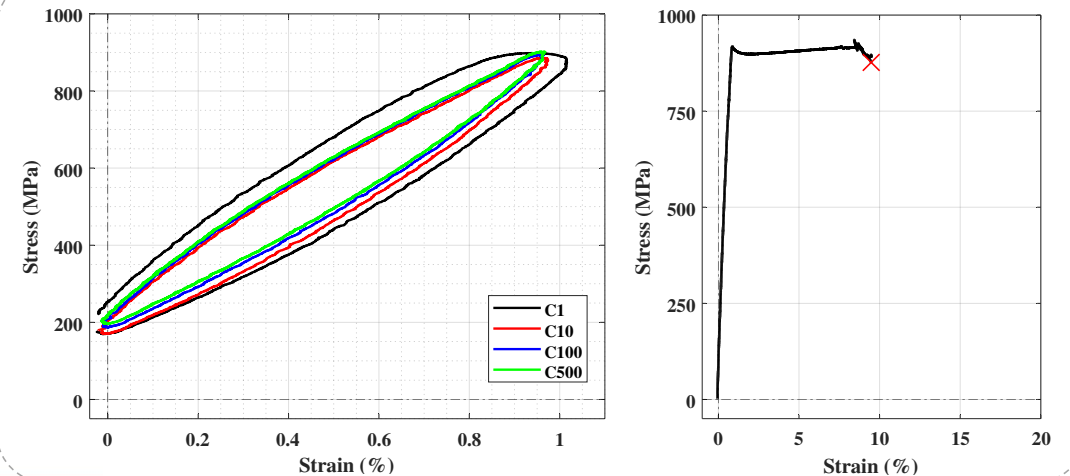
SMA material characterization



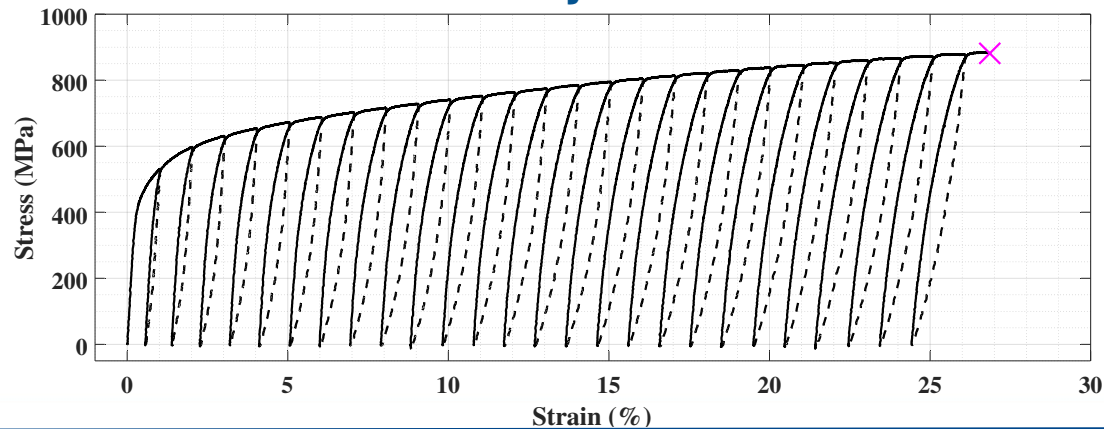
Prestress behavior



Low-cycle fatigue behavior



Incremental cyclic behavior



SMA material characterization

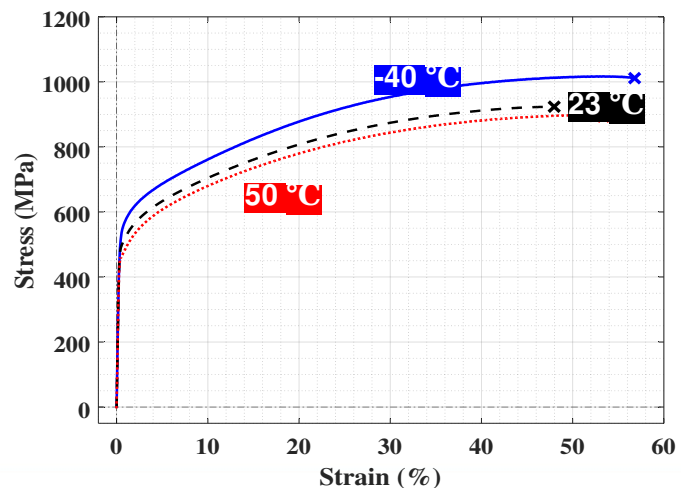
Extremely Hot
Temperature



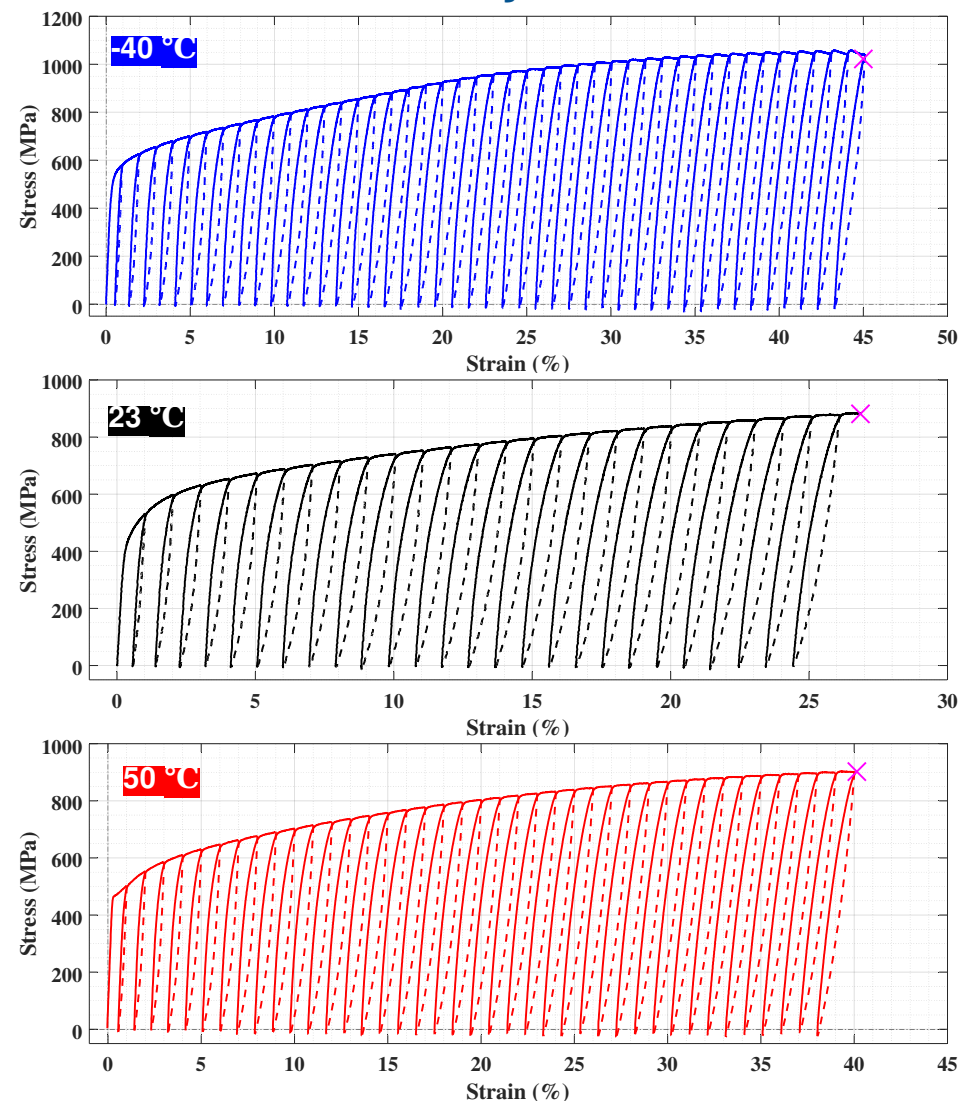
Extremely Cold
Temperature



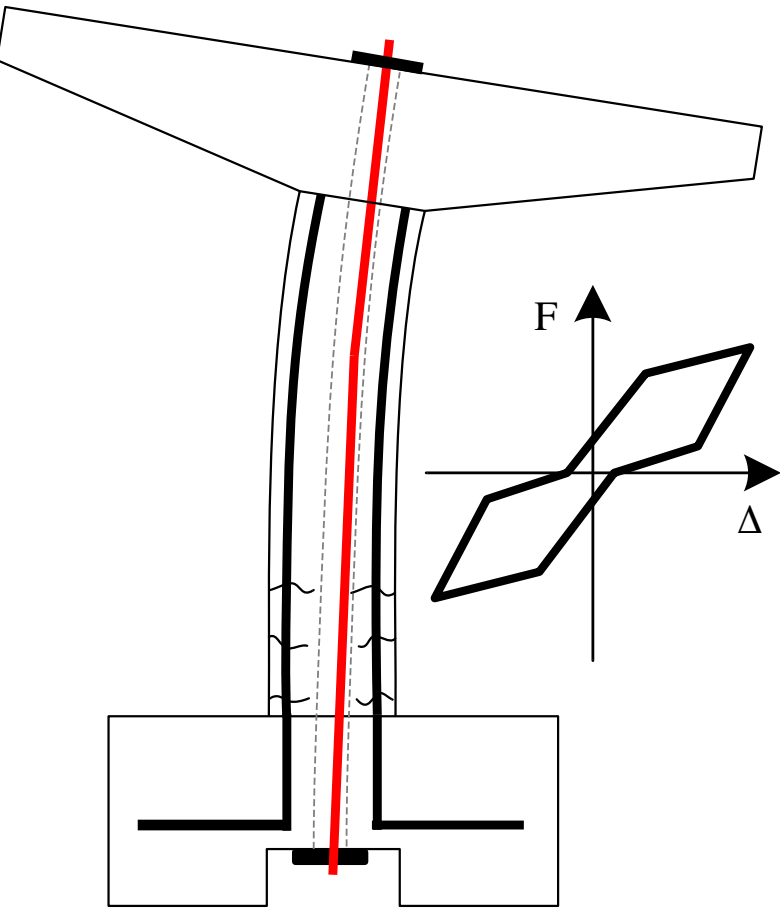
Monotonic tensile behavior



Incremental cyclic behavior



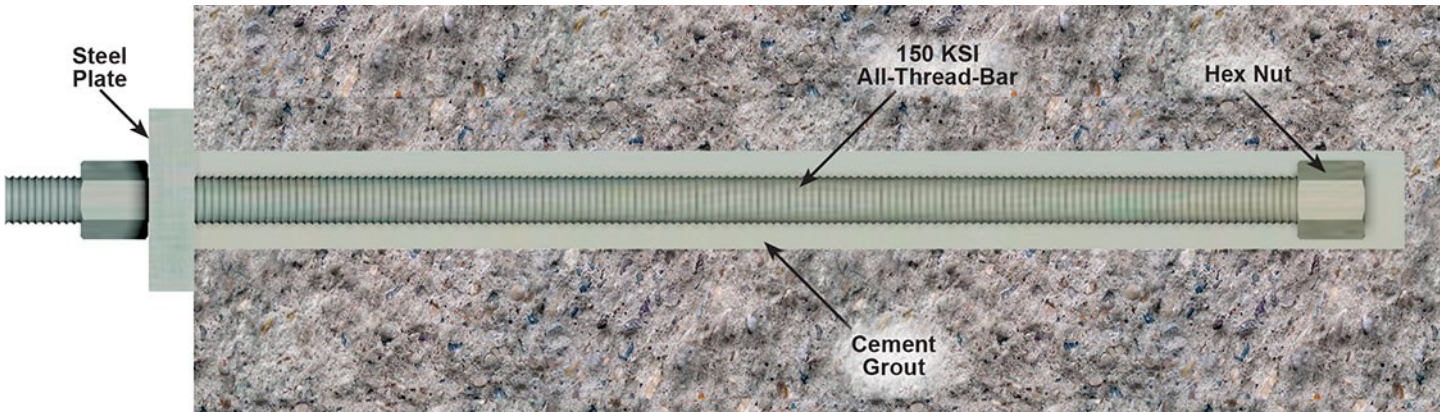
Challenges of anchoring SMA – Traditional methods



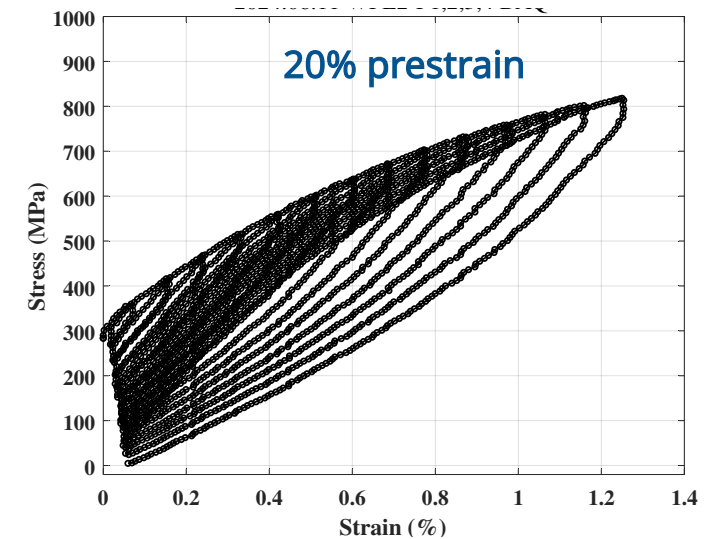
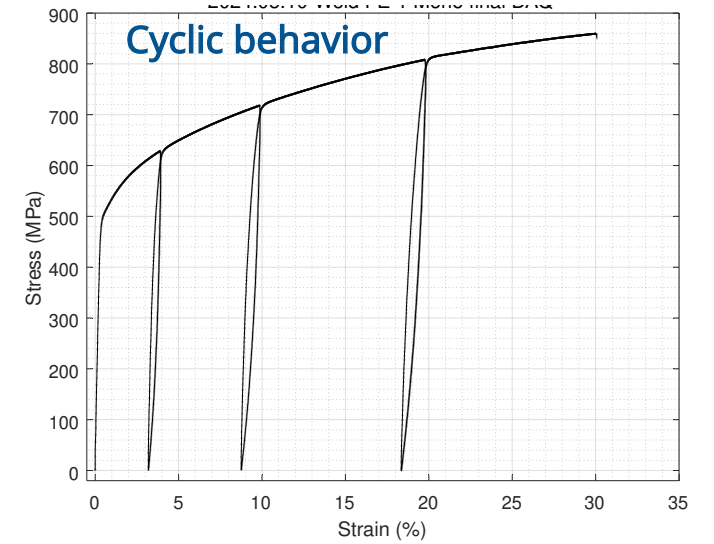
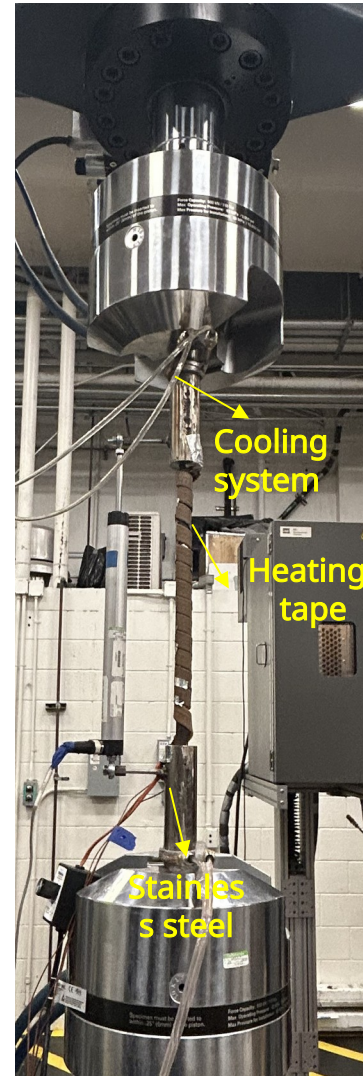
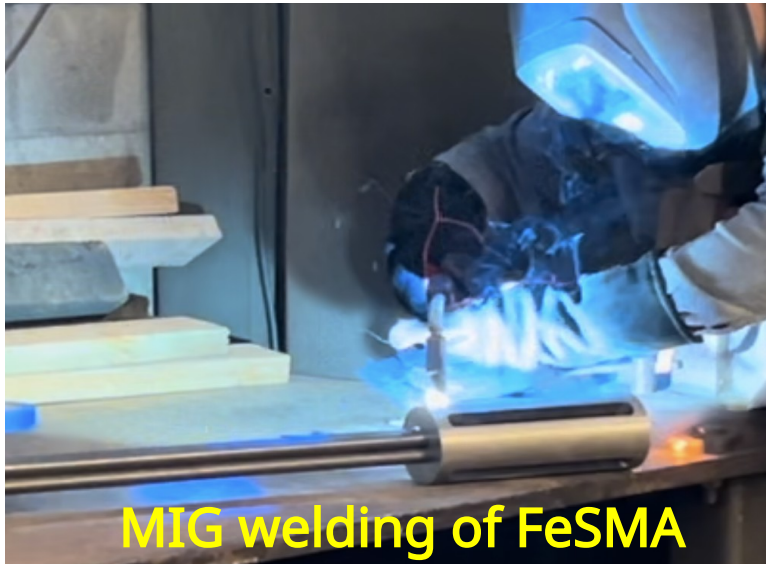
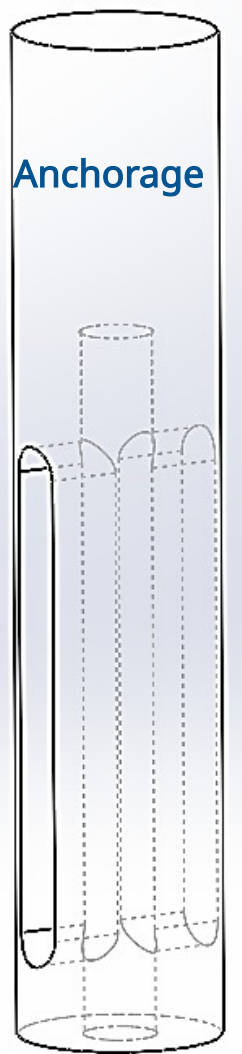
Shear screw anchoring



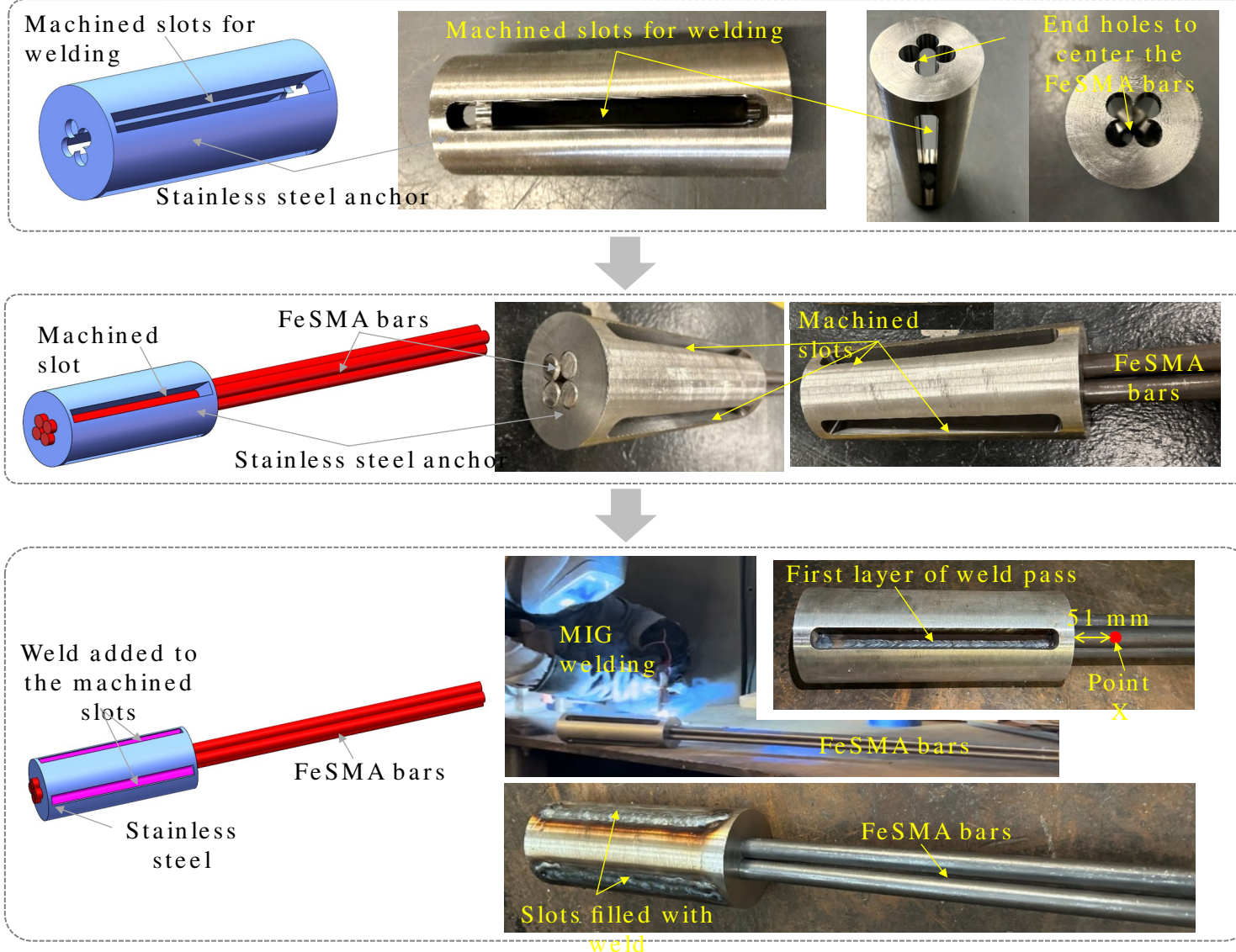
Chemical or grout filling anchoring



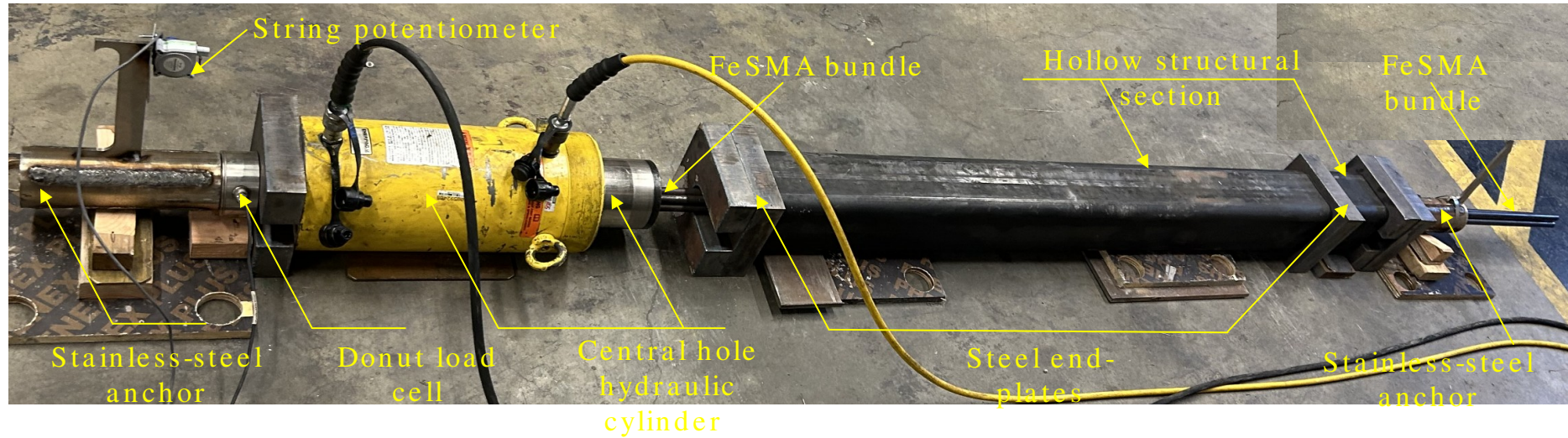
Metal inert gas (MIG) welding anchoring



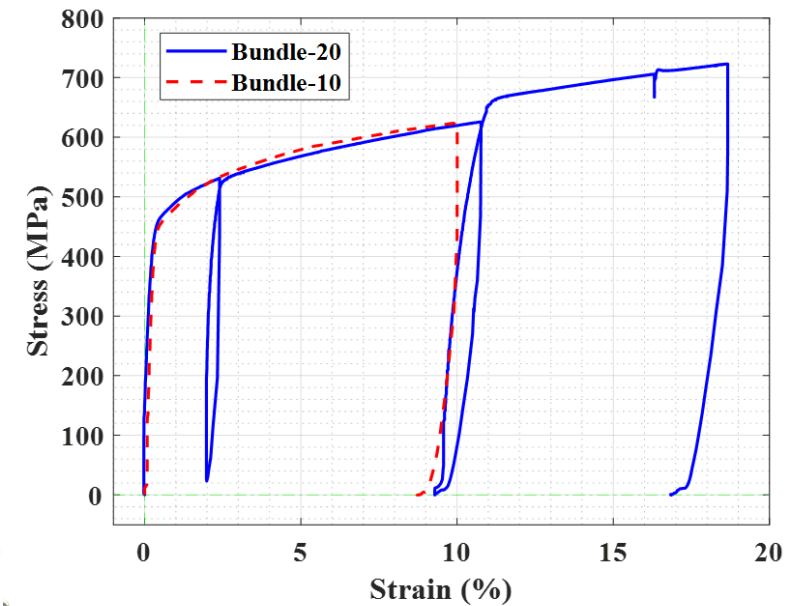
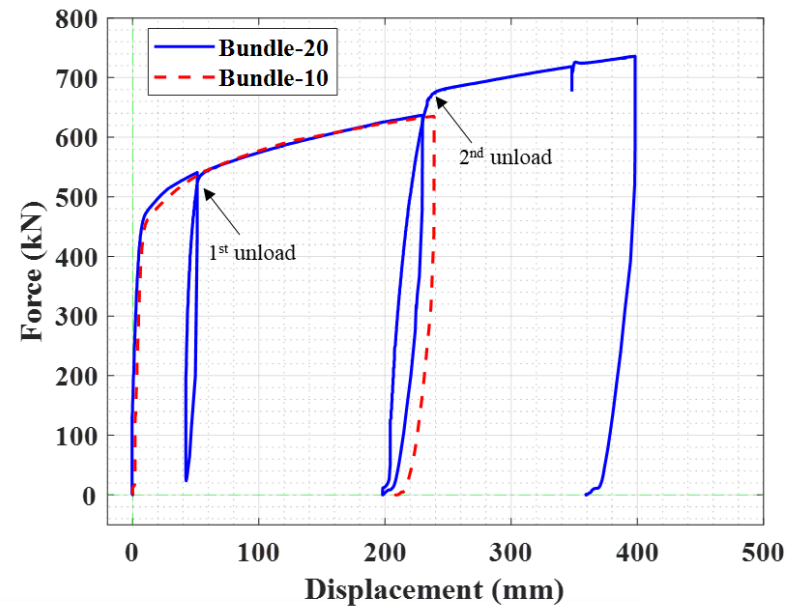
100-Ton level large scale SMA anchorage



Reliability of the proposed anchorage



- Bundle-20: 20% prestrain level
- Bundle-10: 10% prestrain level



Construction process



(a)

Tie the rebar cage, reserve a prestress conduit



(b)

Cast the concrete



(c)

Column model after demolding

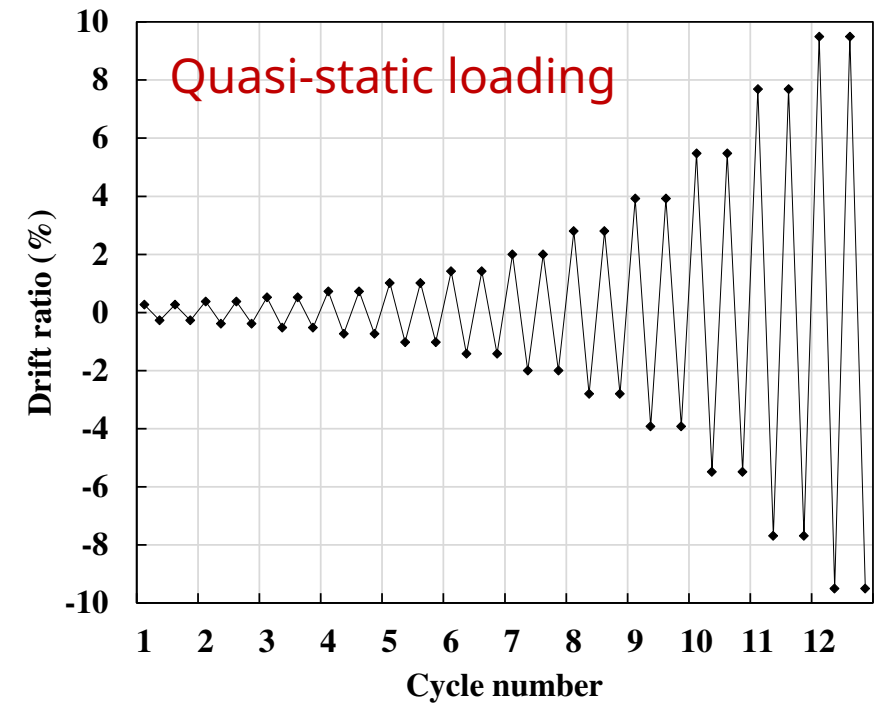
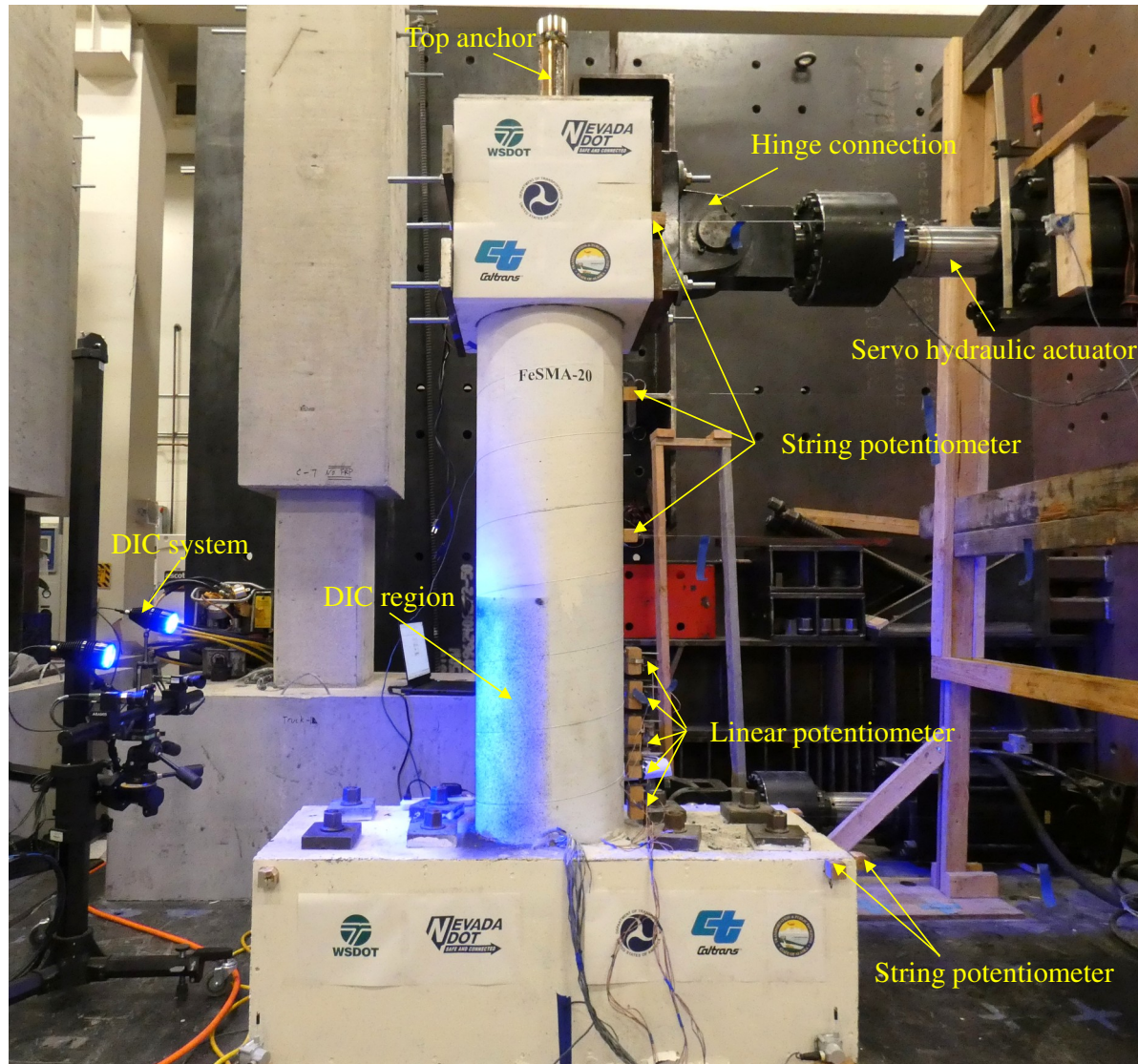


(d)

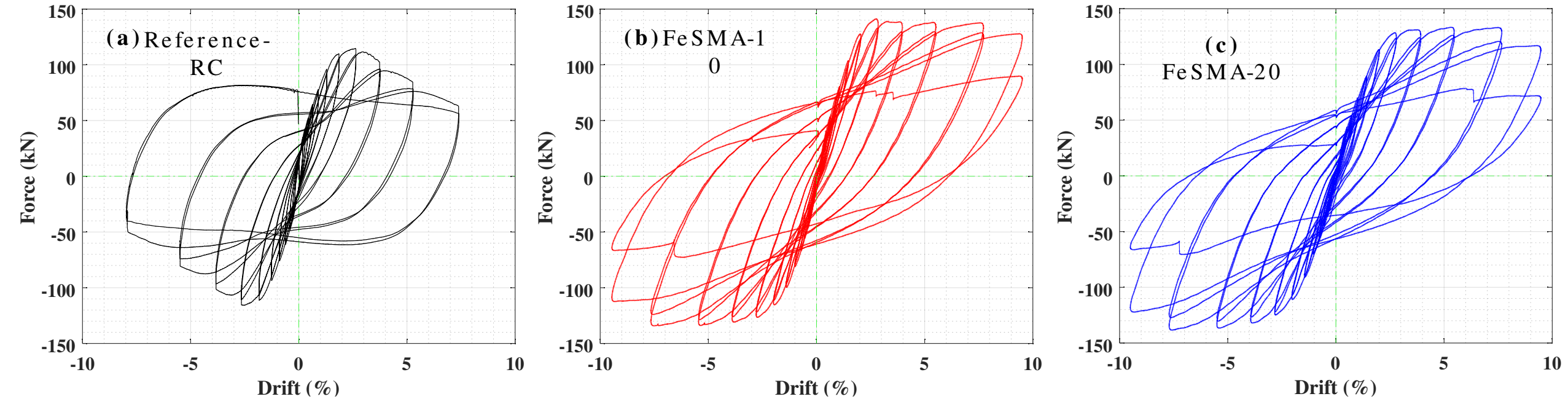
Activate the SMA by heating tape



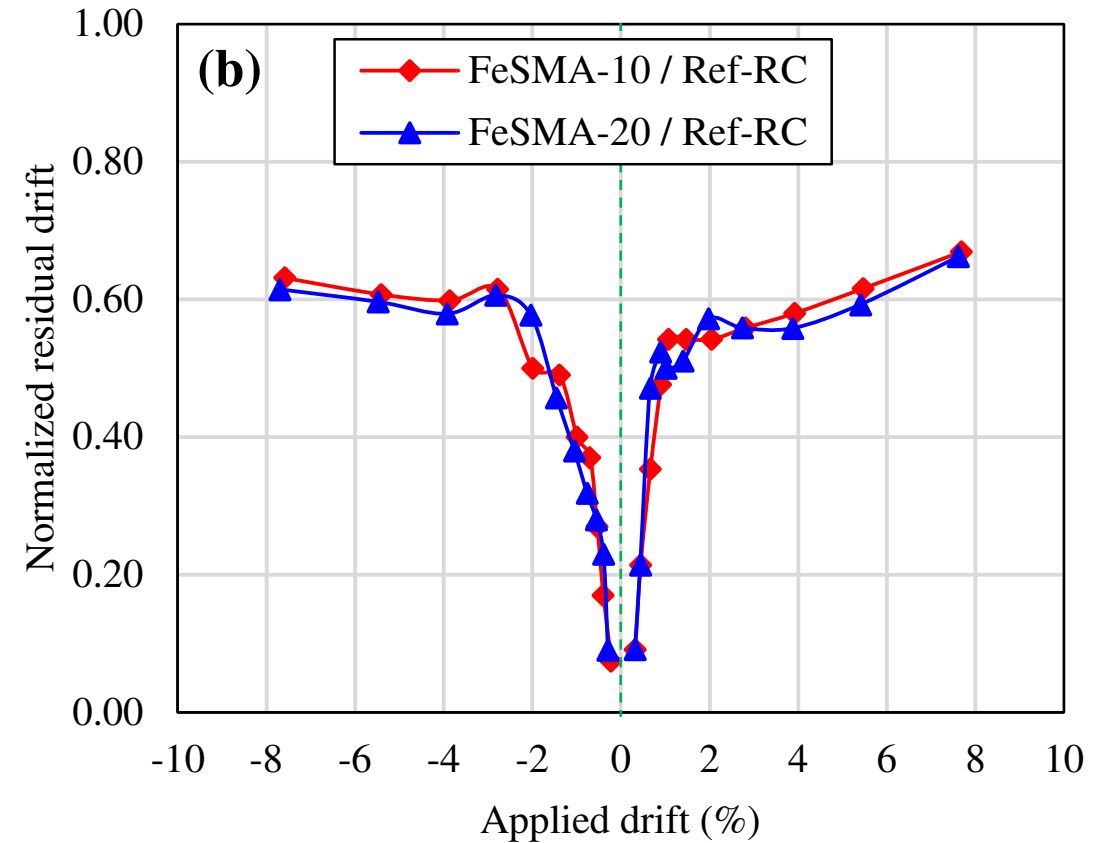
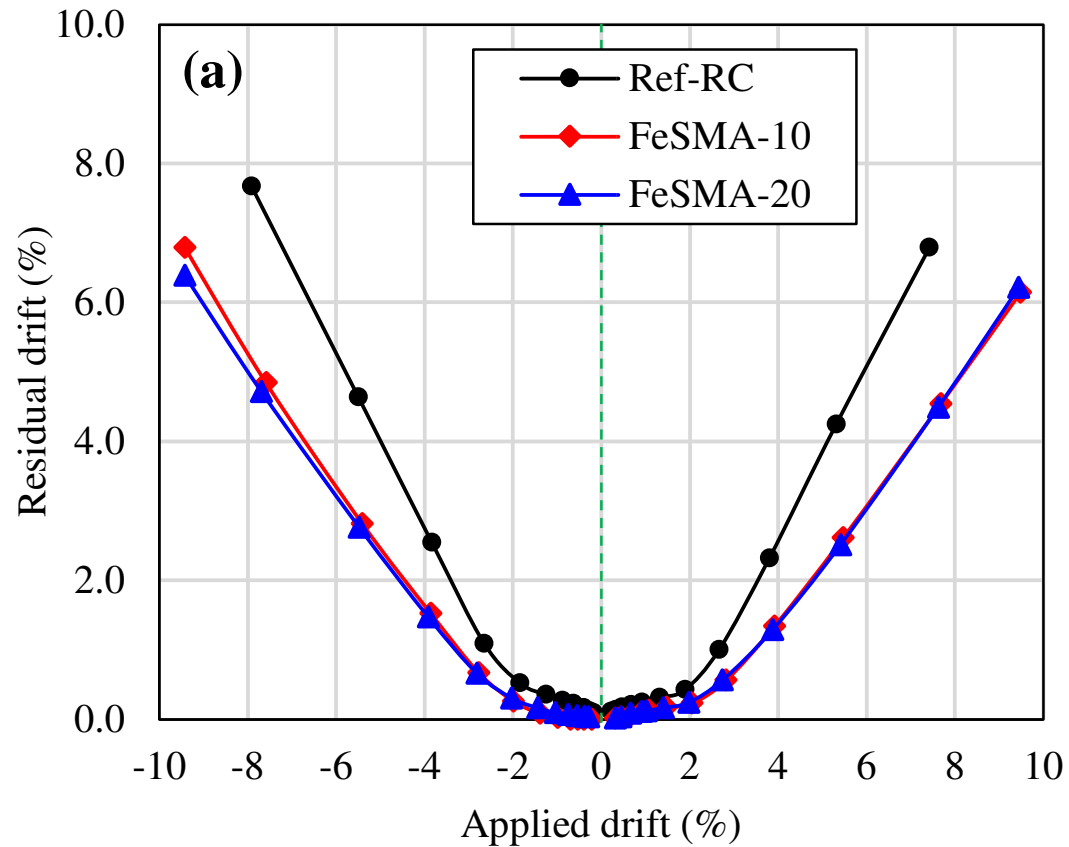
Test setup



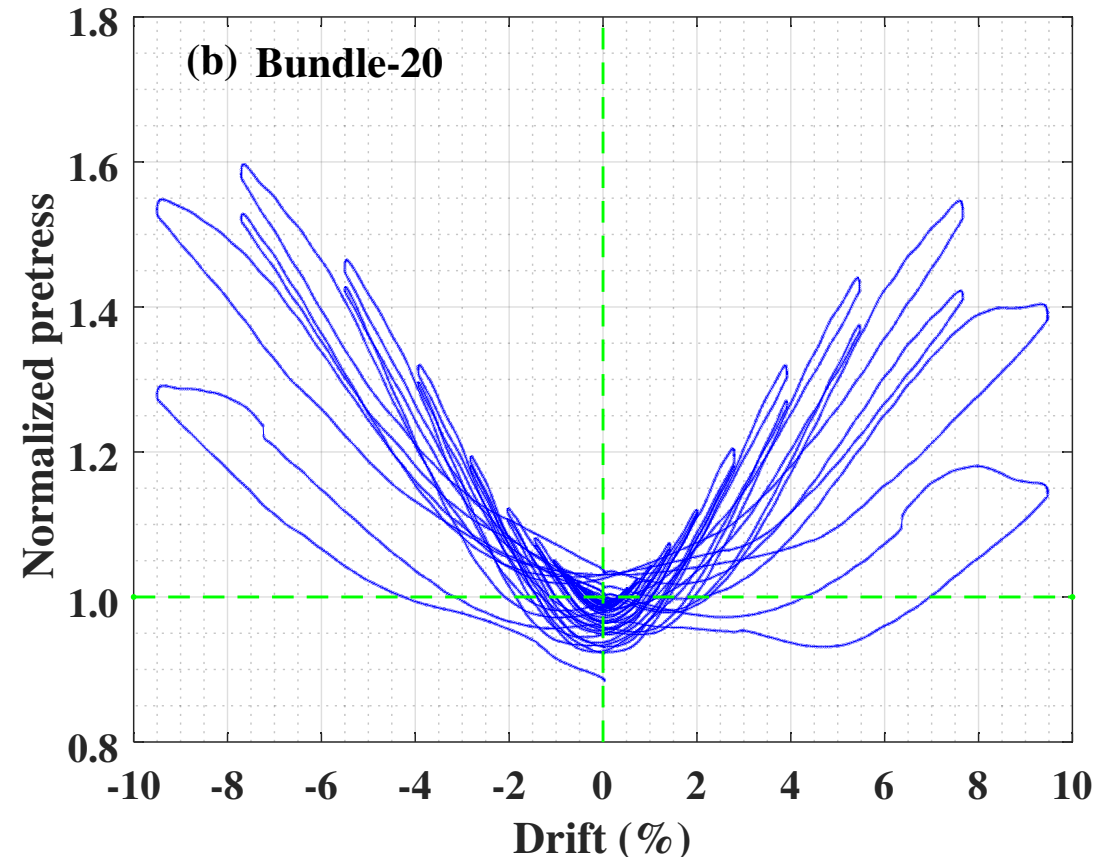
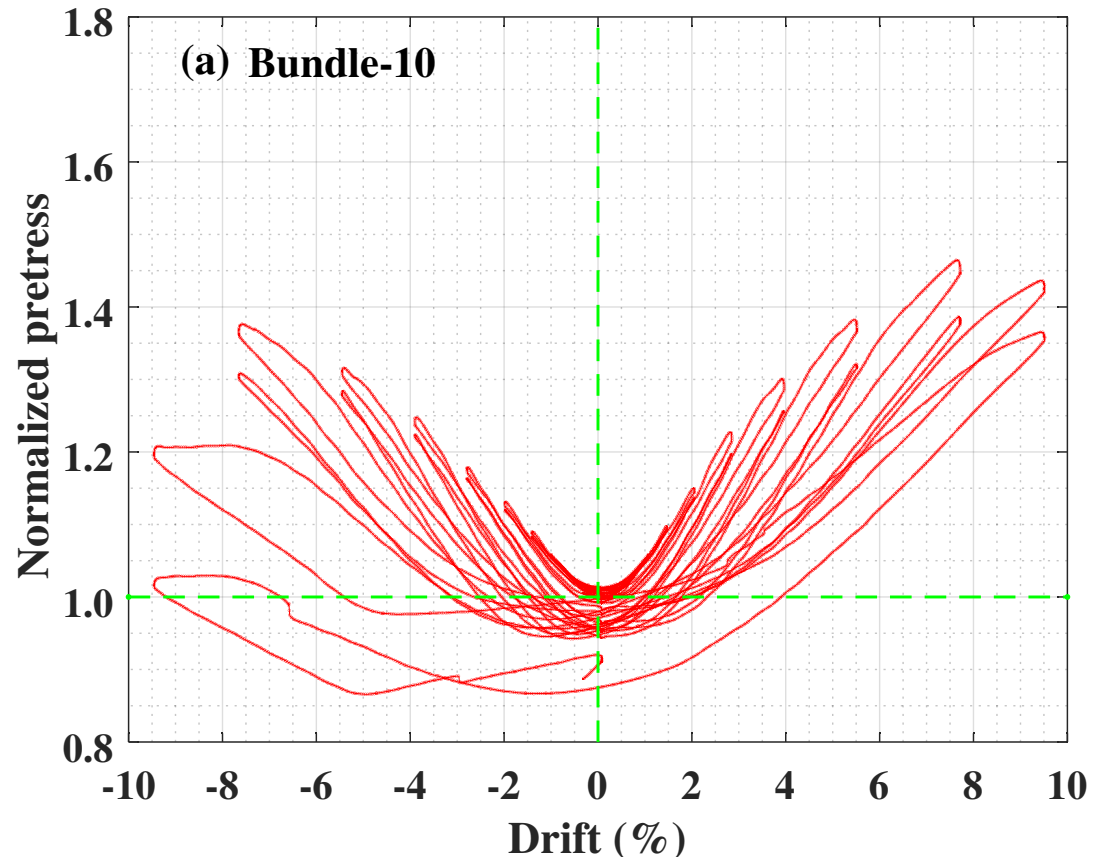
Lateral force versus drift



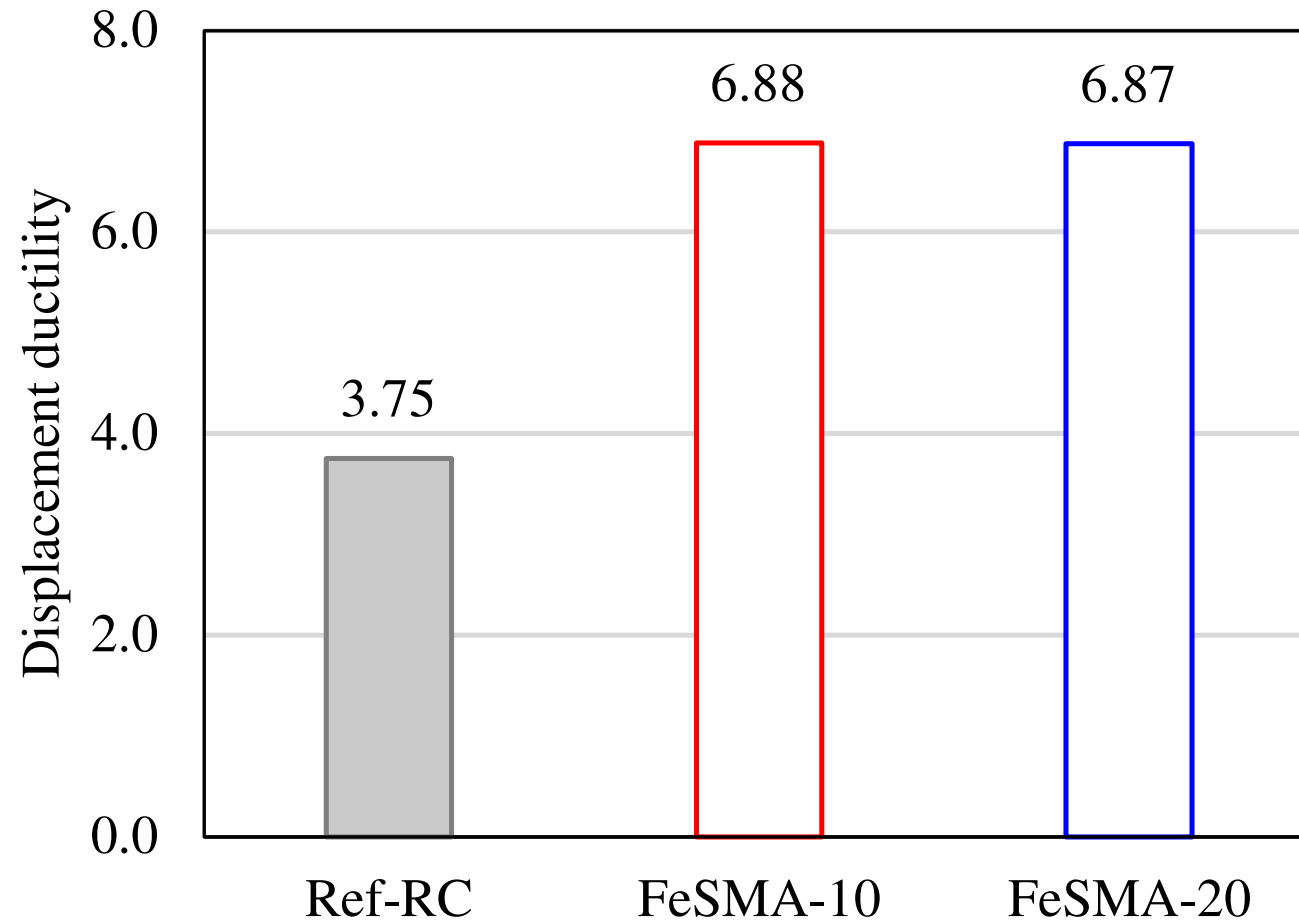
Residual drift versus applied drift



Residual drift versus applied drift



Displacement ductility



- Huanpeng Hong; Bora Gencturk; M. Saiid Saiidi; Botong Zheng; Xiaoying Pan; Seismic performance of self-centering columns post-tensioned with iron-based shape memory alloy (FeSMA) bars, **Engineering Structures**, 2025, 334: 120218. (CiteScore 11.2) **Editor's Featured Paper.**
- Huanpeng Hong; Bora Gencturk; M Saiid Saiidi; Material characterization of iron-based shape memory alloys for use in self-centering columns, **Smart Materials and Structures**, 2024, 33:075001. (CiteScore 6.1)
- Huanpeng Hong; Bora Gencturk; Abdeldjelil Belarbi; Active confinement of large-scale reinforced concrete columns using iron-based shape memory alloy (FeSMA) strips, **Journal of Building Engineering**, 2025, 108, 112848. (CiteScore 11.5)





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Thank you!

