

Update on Salt Lake City and County Building Base Isolation

2021 SEAU EDUCATION CONFERENCE



Jerod G. Johnson, PhD, SE
Reaveley Engineers + Associates

Salt Lake City and County Building

- Project Background
- Recent Studies and Updates
- The Magna Earthquake



Salt Lake City and County Building



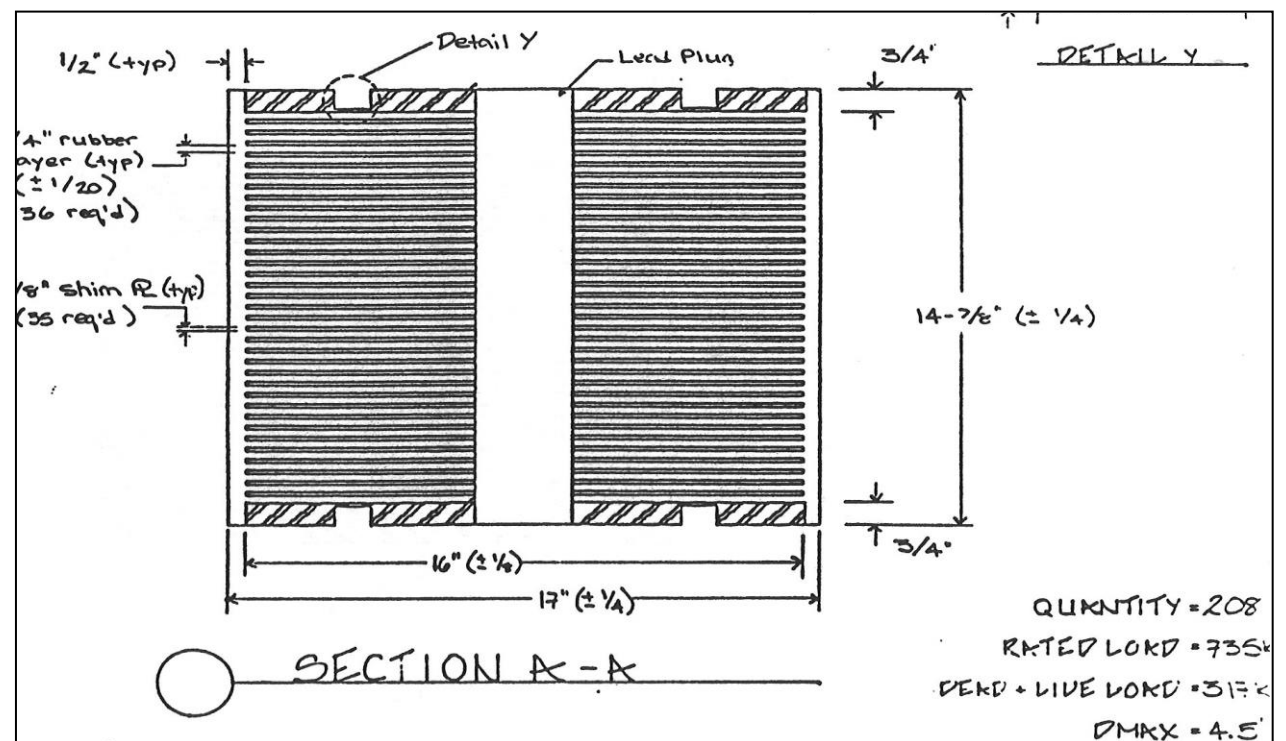
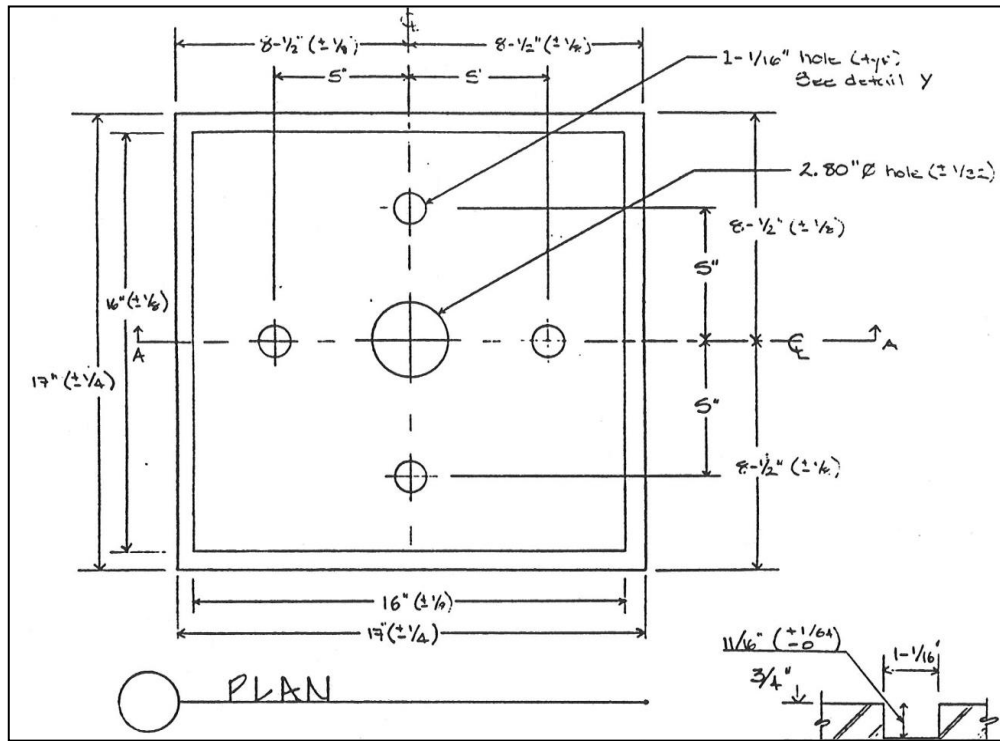
Salt Lake City and County Building

- Originally Completed in 1894
- Sandstone, URM Bearing/non bearing walls, Reinf. Concrete
- 5 Stories
- 175,000 Square Feet
- Clock Tower 256 Feet Above Ground Level
- Richardsonian Romanesque Architecture
- National Historic Register

Salt Lake City and County Building – Renovation 1980's

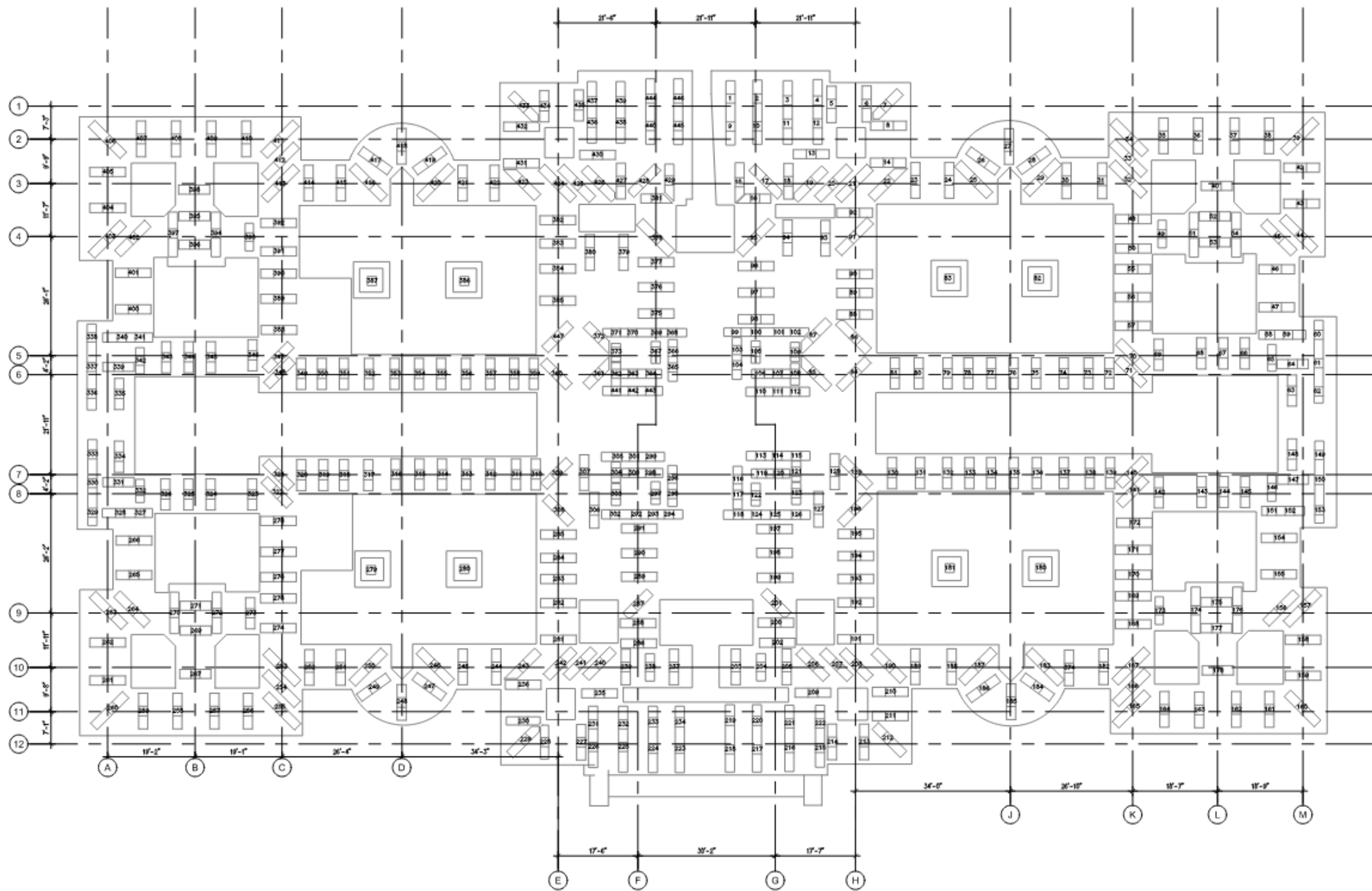
- Base Isolation Selected
- 443 Rectilinear Isolators (239 w/ lead, 204 w/o lead)
- 1985 UBC prescribed 0.1g lateral acceleration for ductile structures
- Renovation design used 0.2g
- Scaled versions of 1979 Imperial Valley Earthquake
 - Arrays #7, #8 and Bond Corner Accelerograms
- Isolators measuring 17" x 17" x 15"
- System Displacement of 4 inches



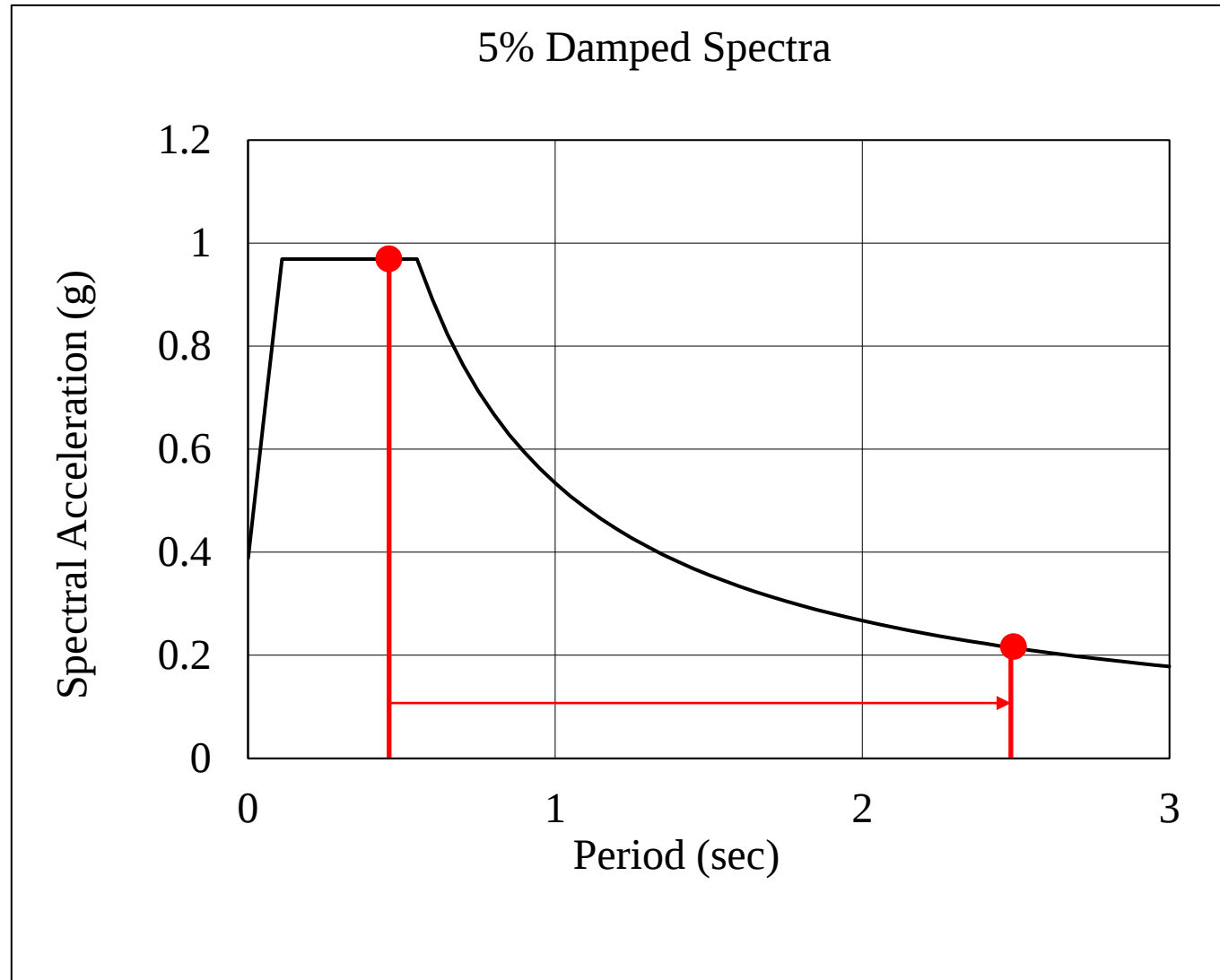


Note: top and bottom mounting plates developed for shear transfer only.

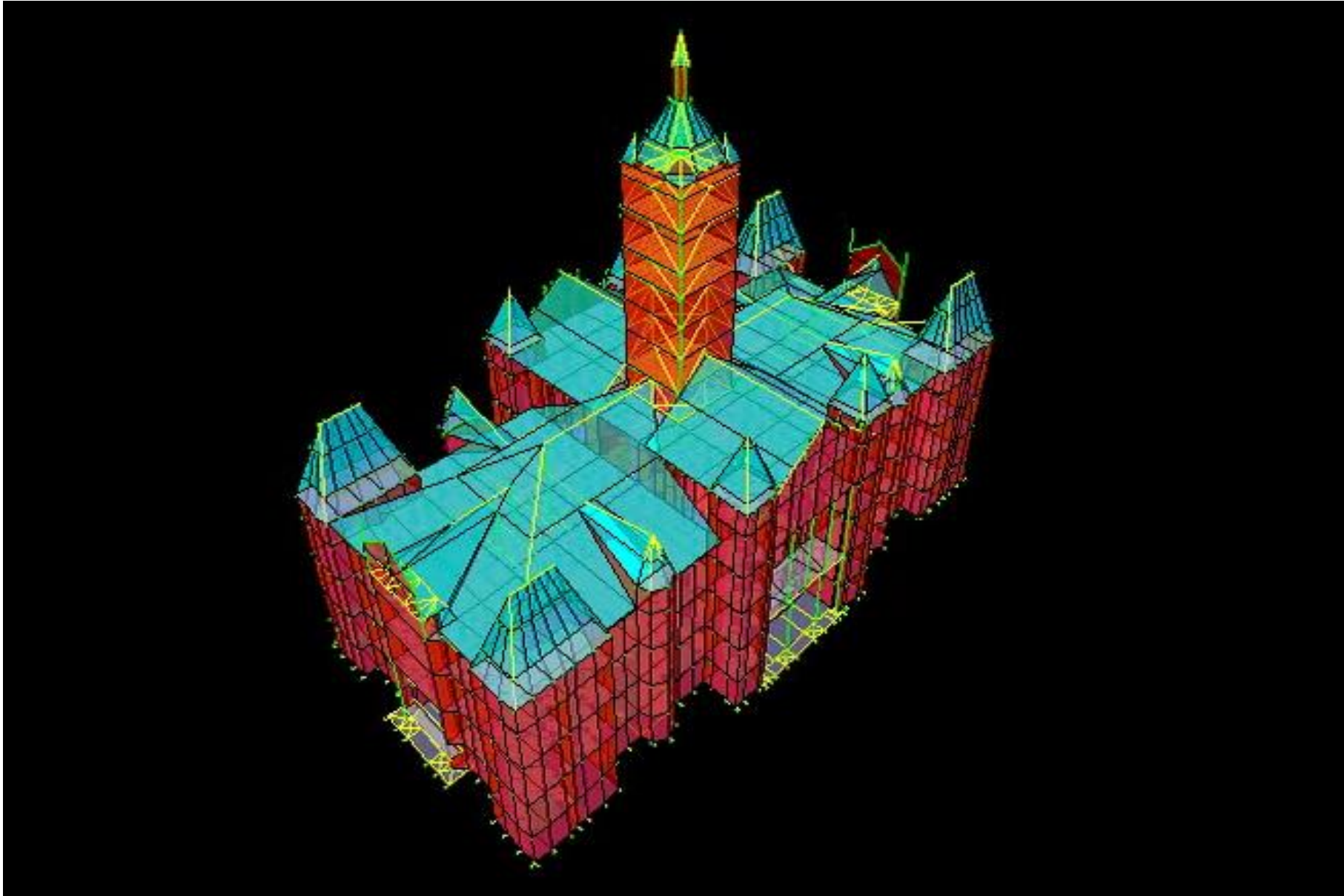
Isolator Details



Why Base Isolation?



Qualitative Time History Demonstration

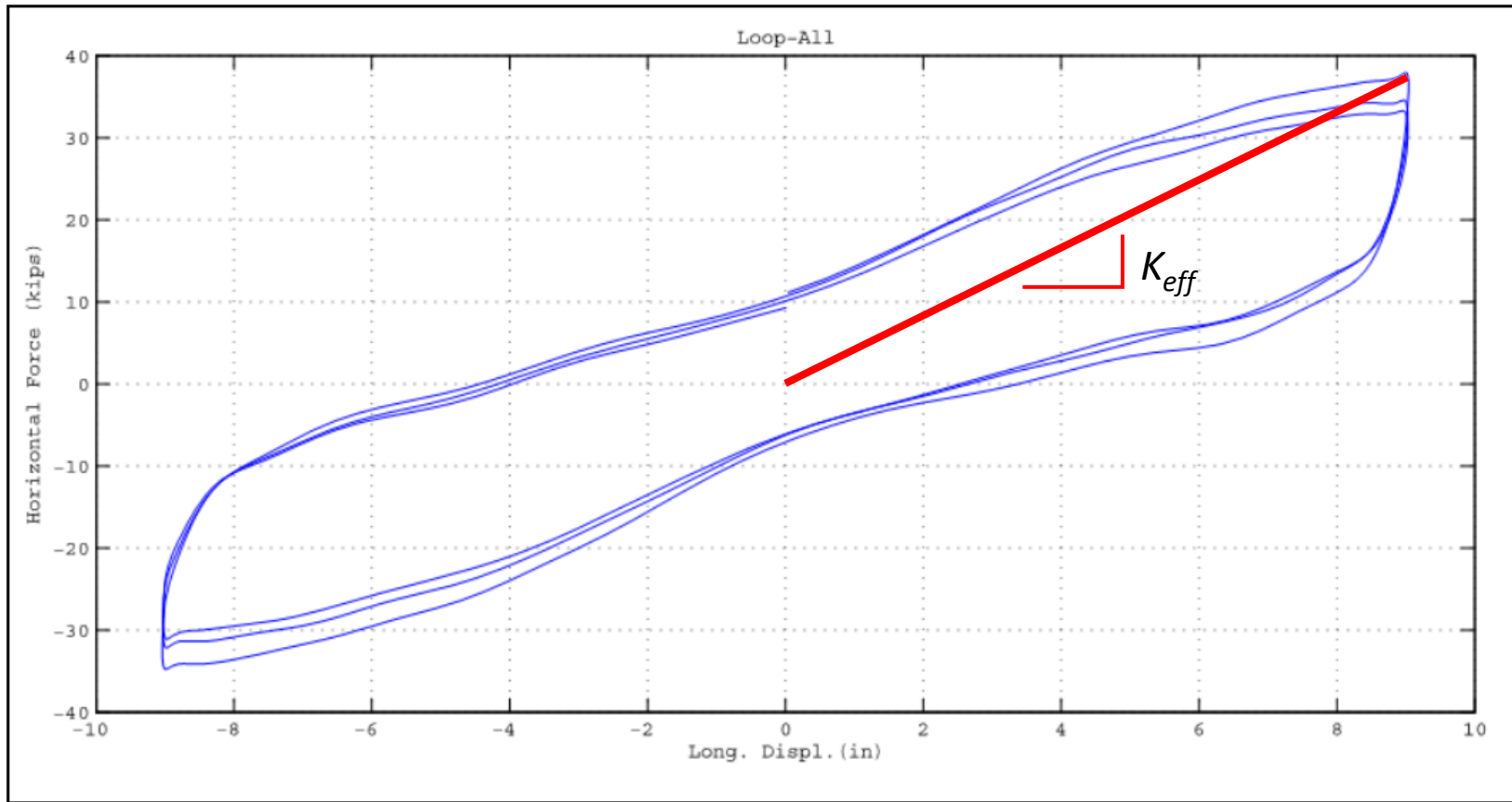


Conservancy Committee - 2007

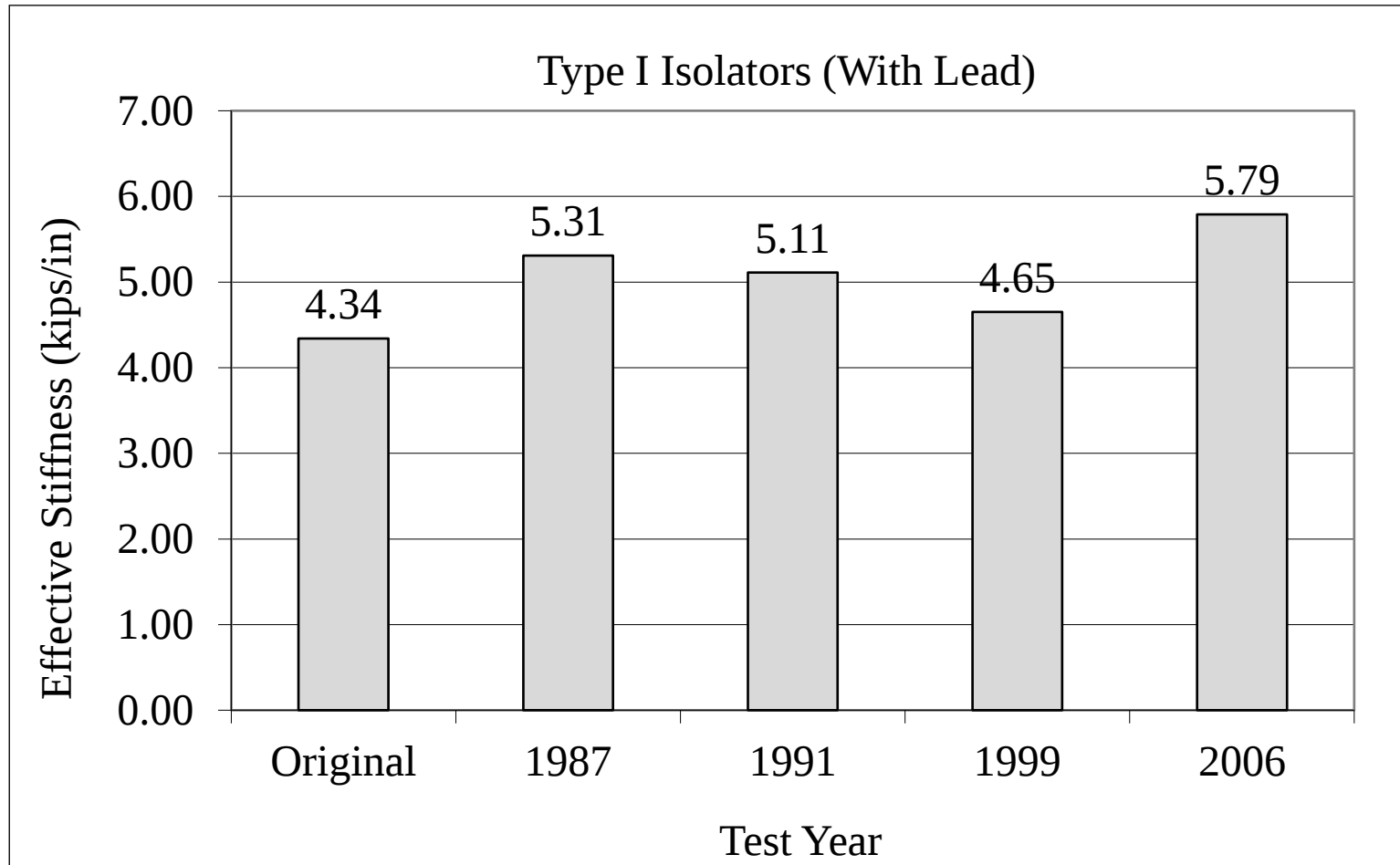
- Hardening of Elastomers?
- Softening of Elastomers with Repeated Testing?
- Ability of Isolators to Perform for Significant Seismic Event?
- Viscoelastic Effects?
- Moat Bumpers?



Effective Isolator Stiffness



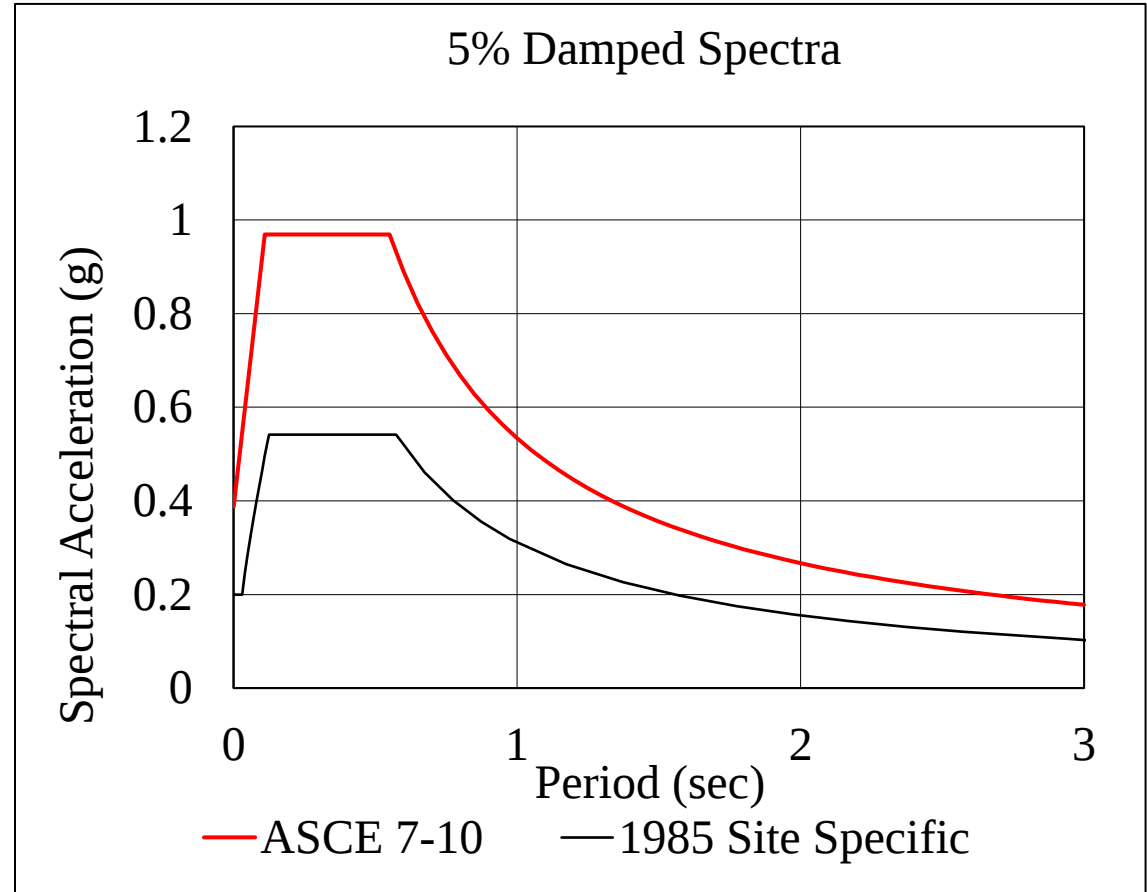
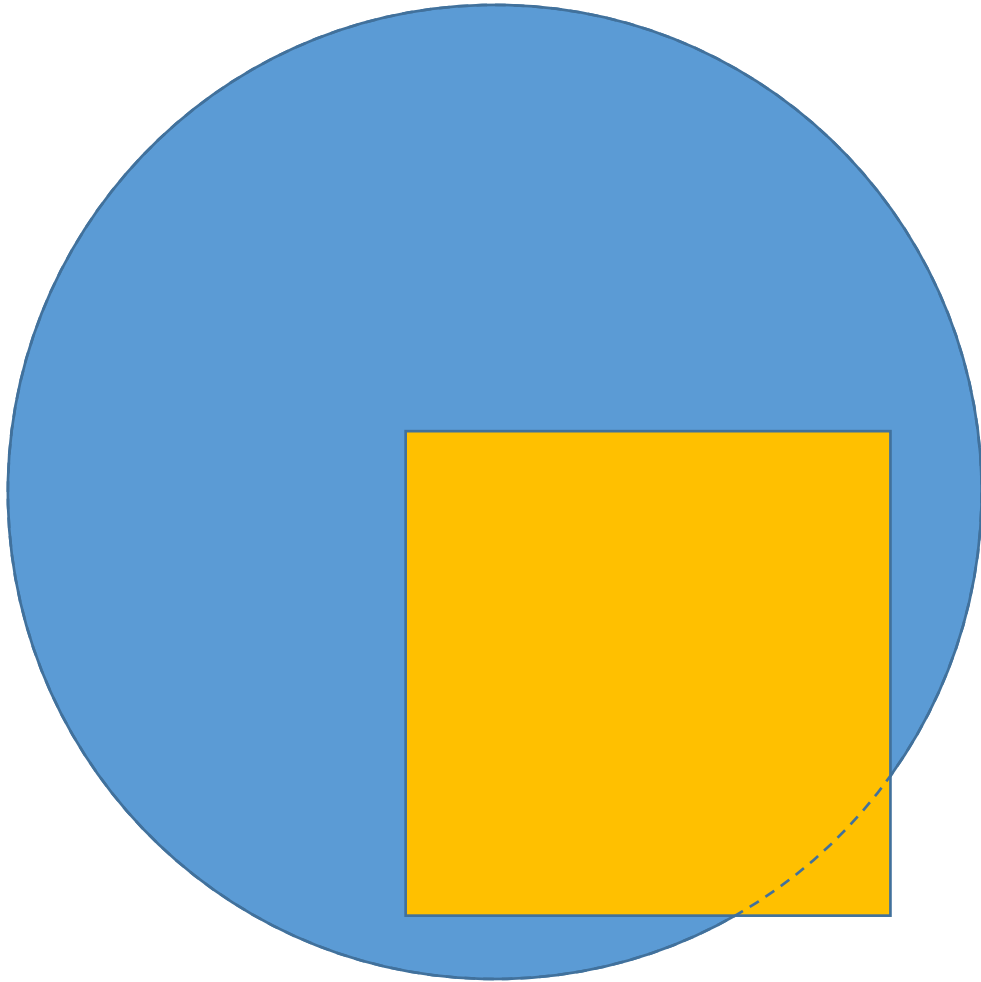
Conservancy Committee - 2007



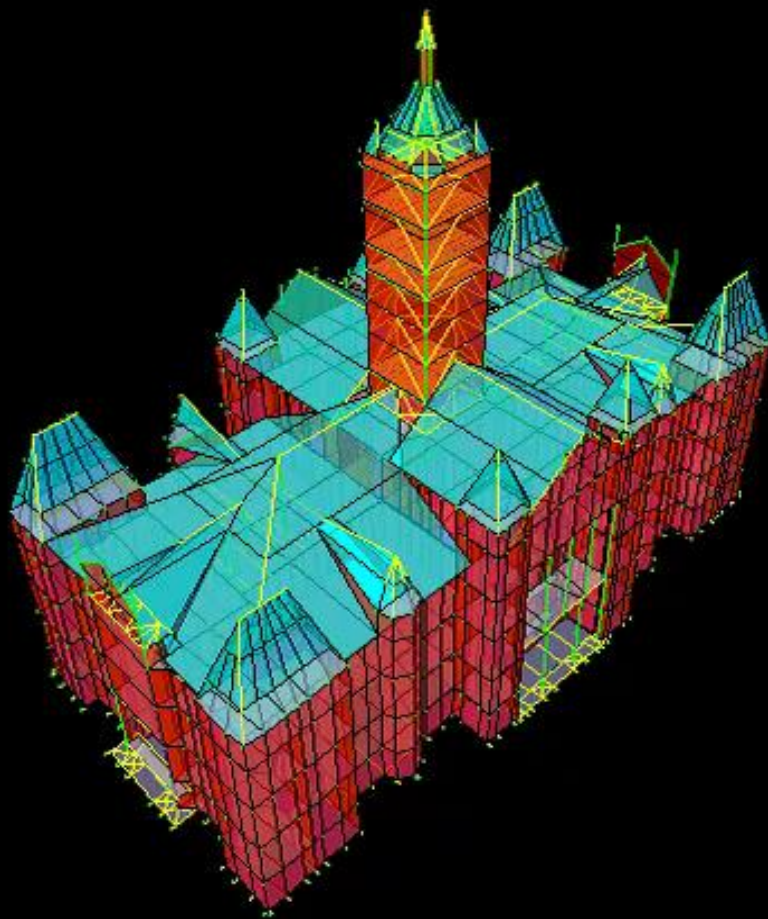
Comparison to Utah State Capitol

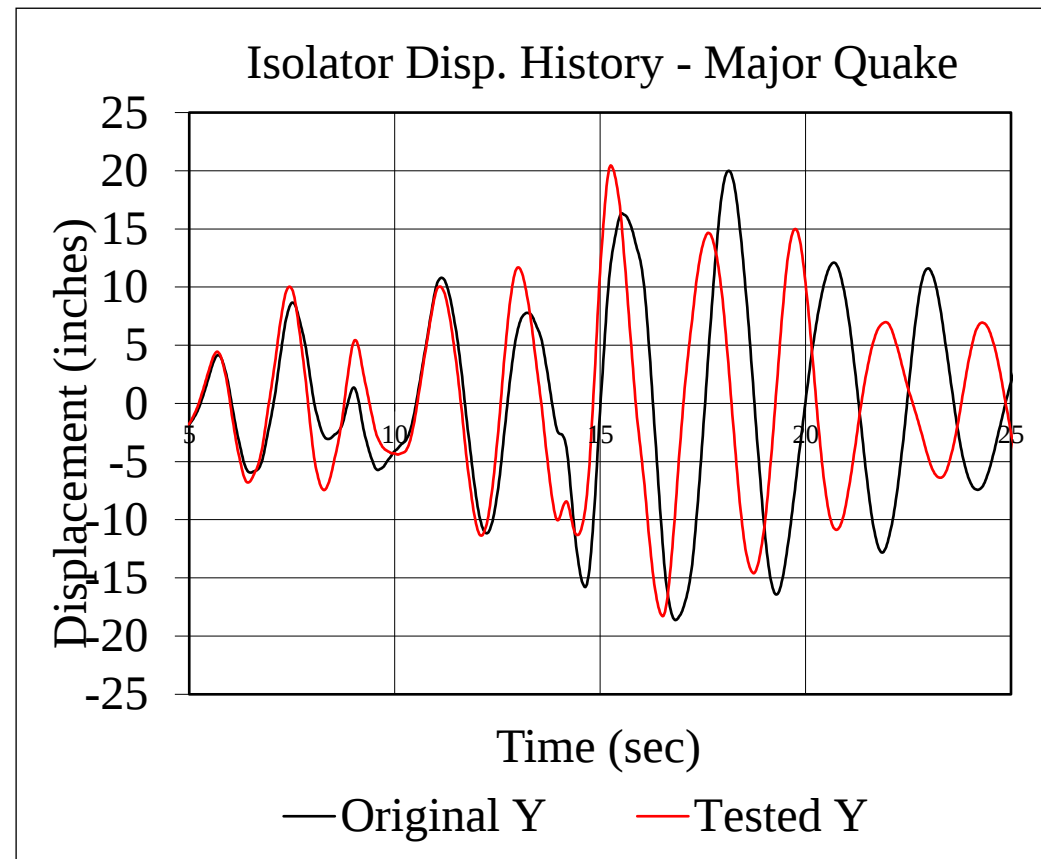
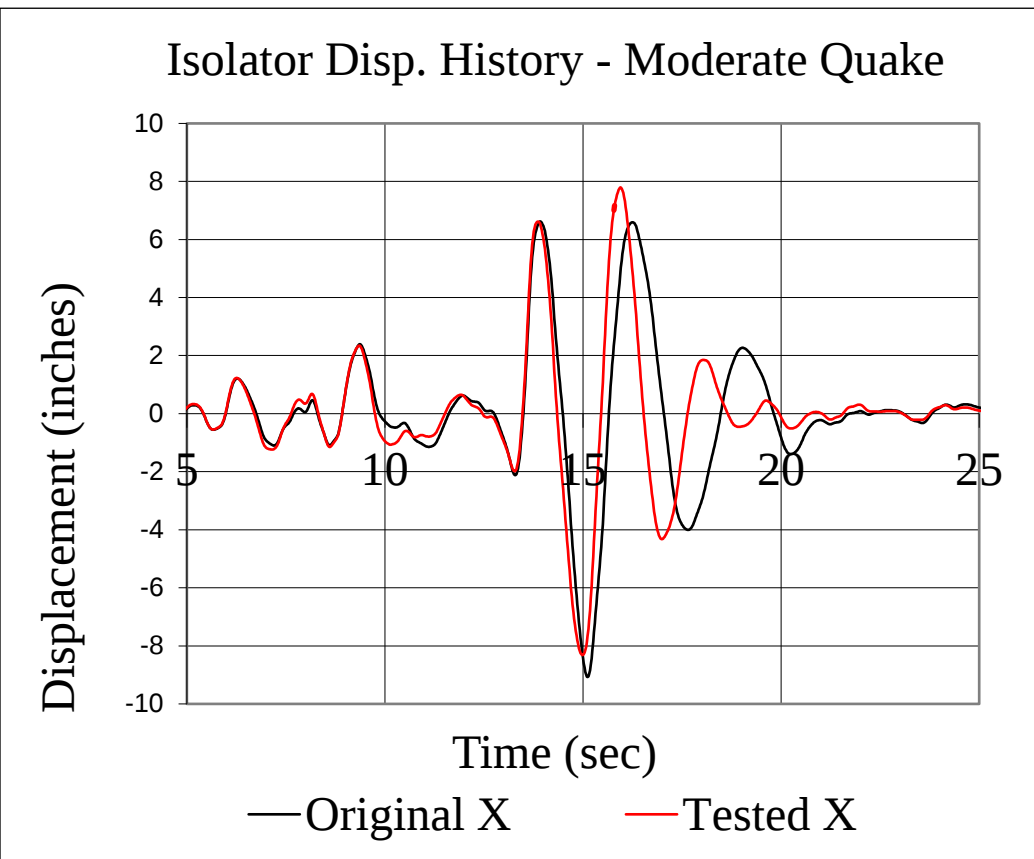


Comparison to Utah State Capitol



Moat Bumpers????

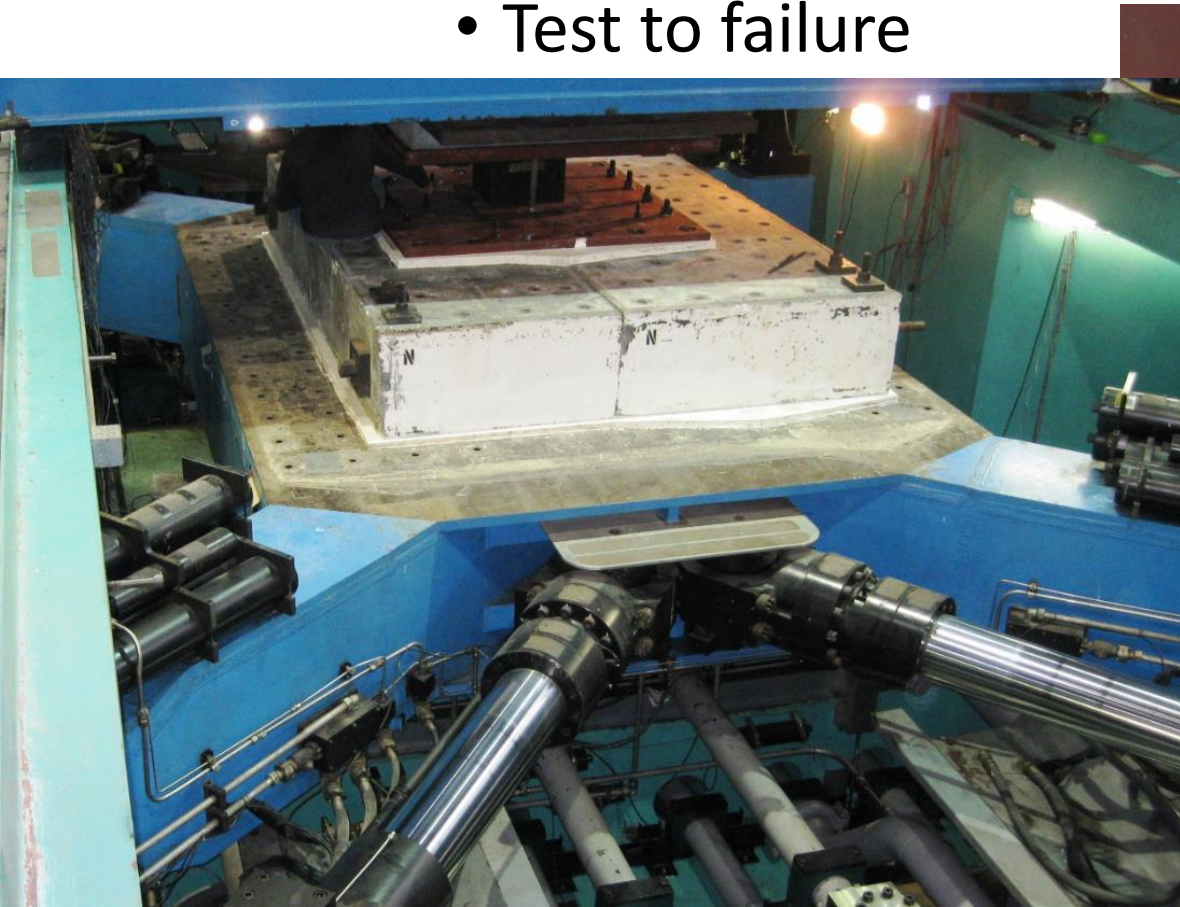




Hardening or Softening of Elastomers?

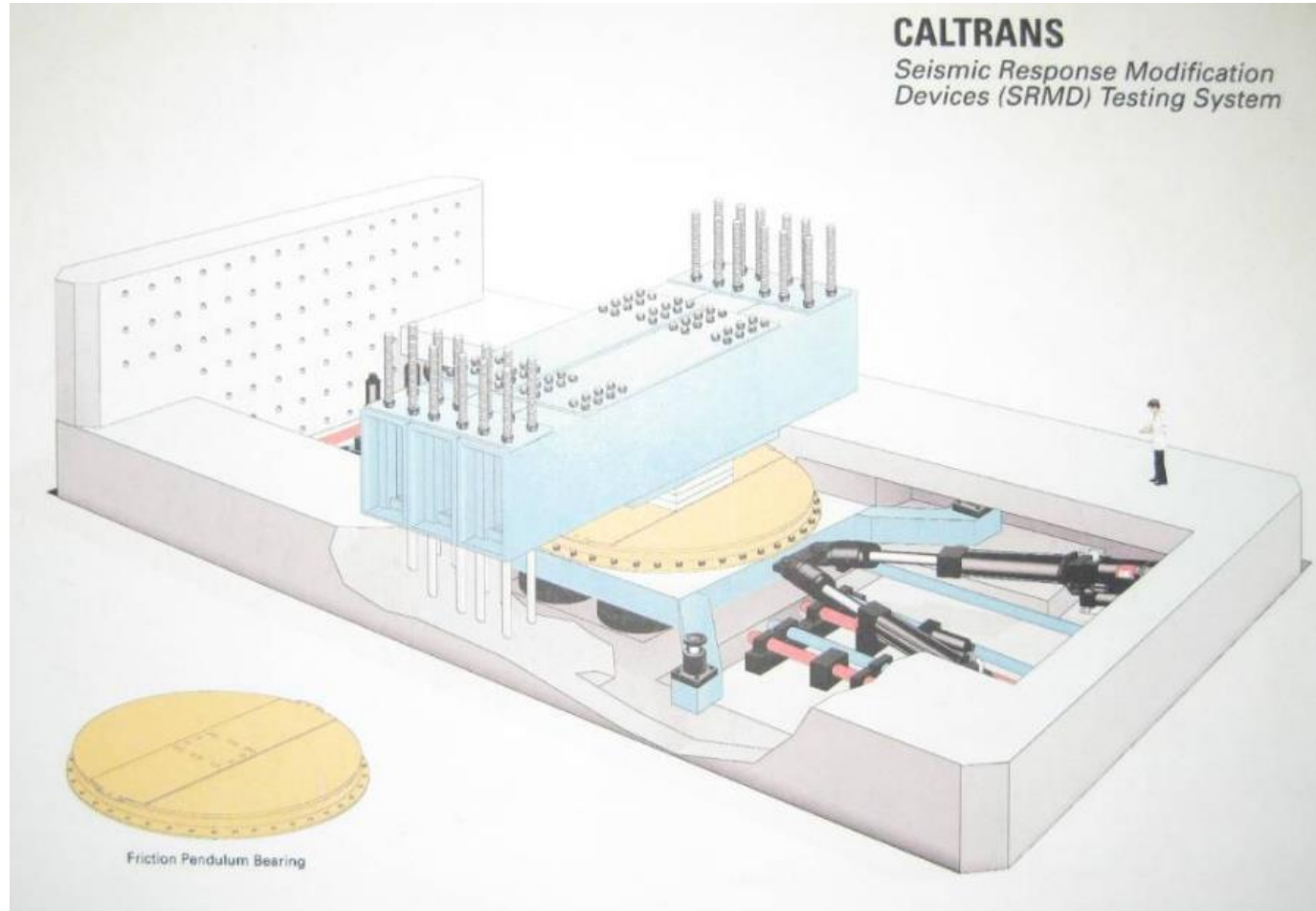
Testing Update – Modern Protocol

- CALTRANS – UCSD Powell Lab
- Full axial load ($\sim 350\text{k}$)
- Rate of load (~ 2.5 sec/cycle)
- Test to failure



Testing Protocol

- UCSD – Charles Lee Powell Structural Laboratory



Testing Protocol

- 3 Sinusoidal Waves to 4.6 inches at slow rate (to match earlier tests)
- 3 Sinusoidal Waves Starting at 4 inches at realistic rate (2.5 seconds per cycle – Visco-elastic effects)
- Each subsequent test increases amplitude by 1 inch
- Approximately 20 minutes between tests
- Continue until either material or stability failure is apparent
- 4 Isolators Tested; 2 lead core, 2 w/o lead core, orthogonal vs diagonal
- Axial Load of 350 kips

Isolator in SRMD



Contemporary Testing Protocol



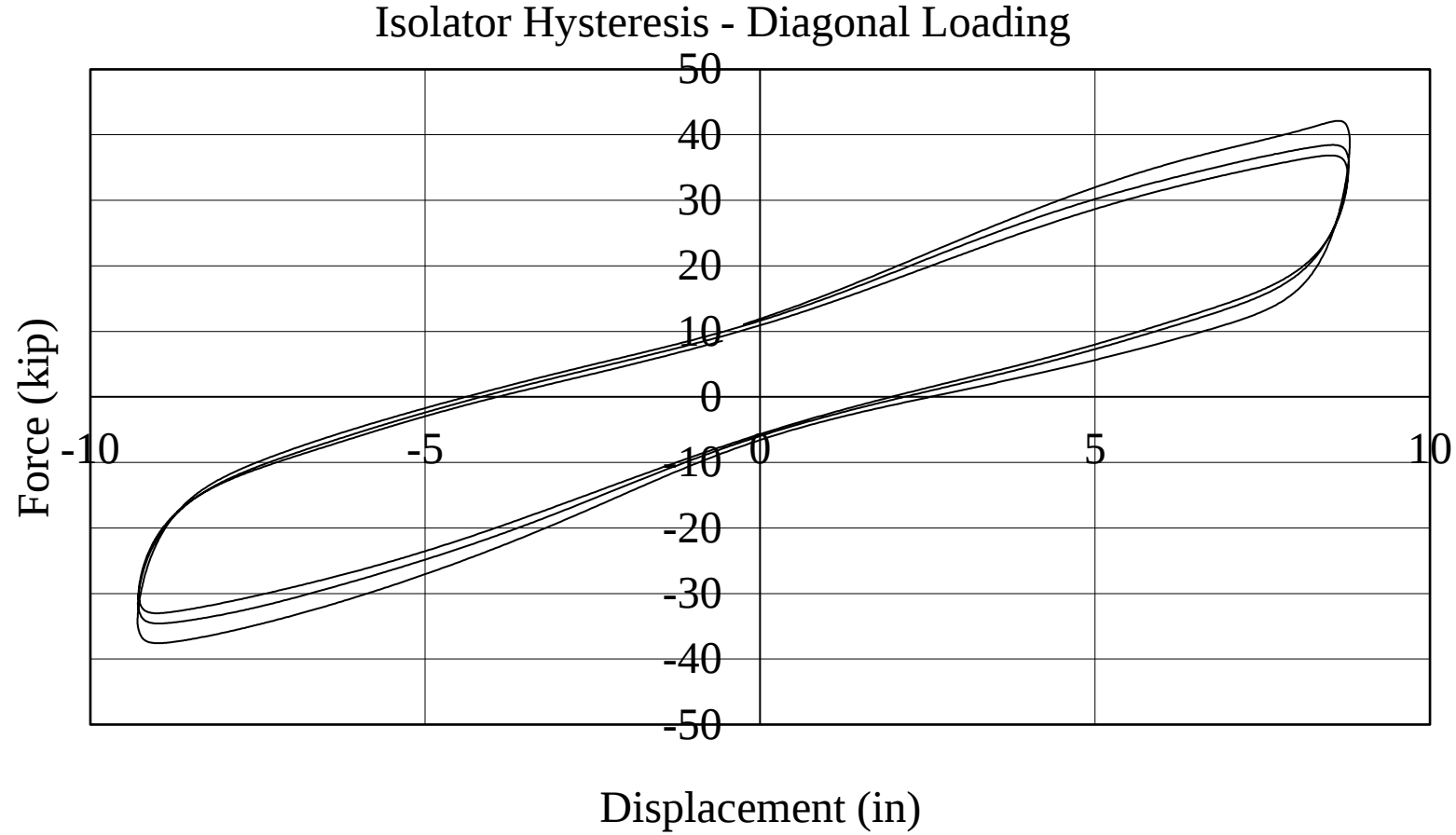
Contemporary Testing Protocol



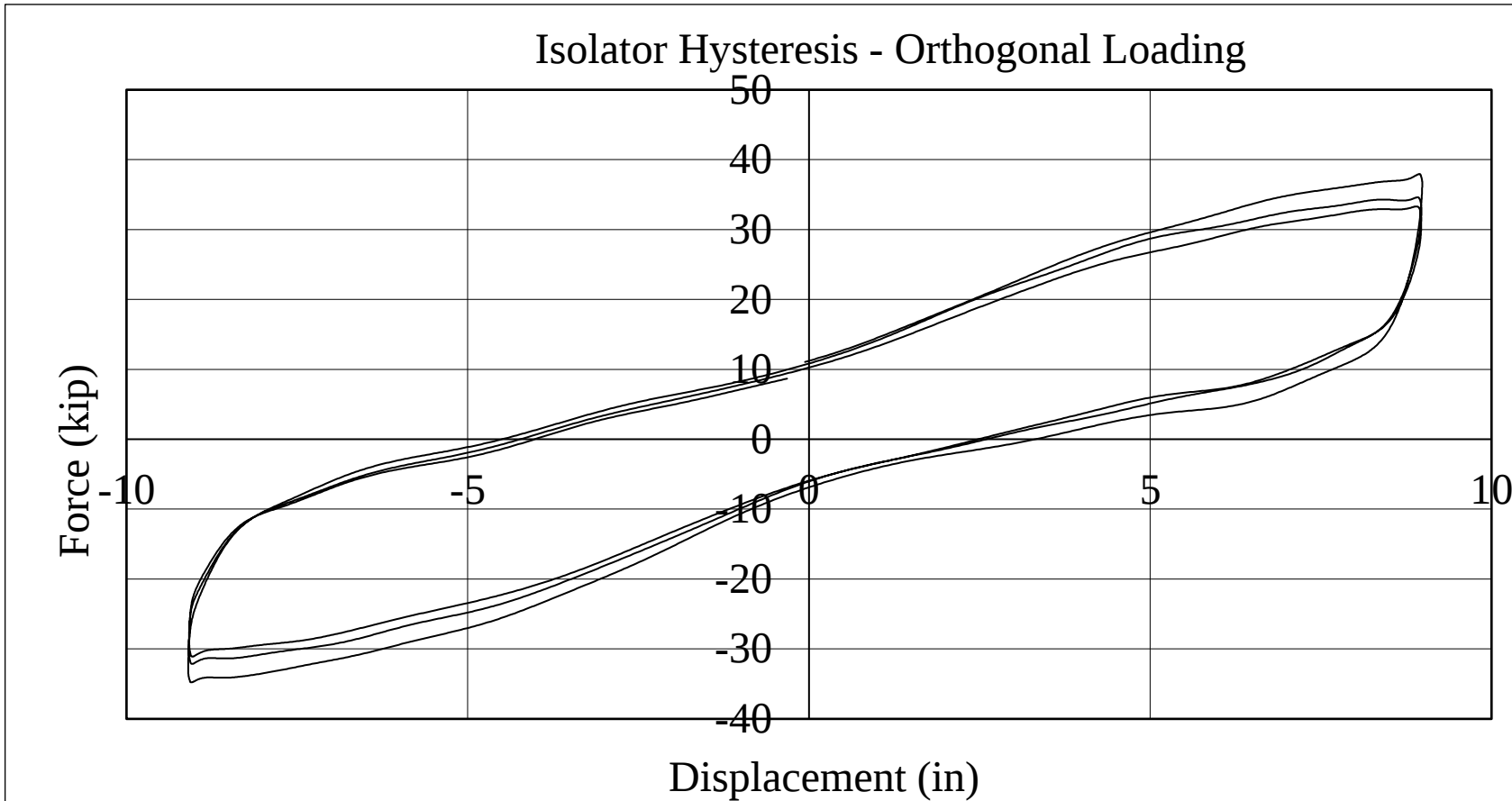
Contemporary Testing Protocol



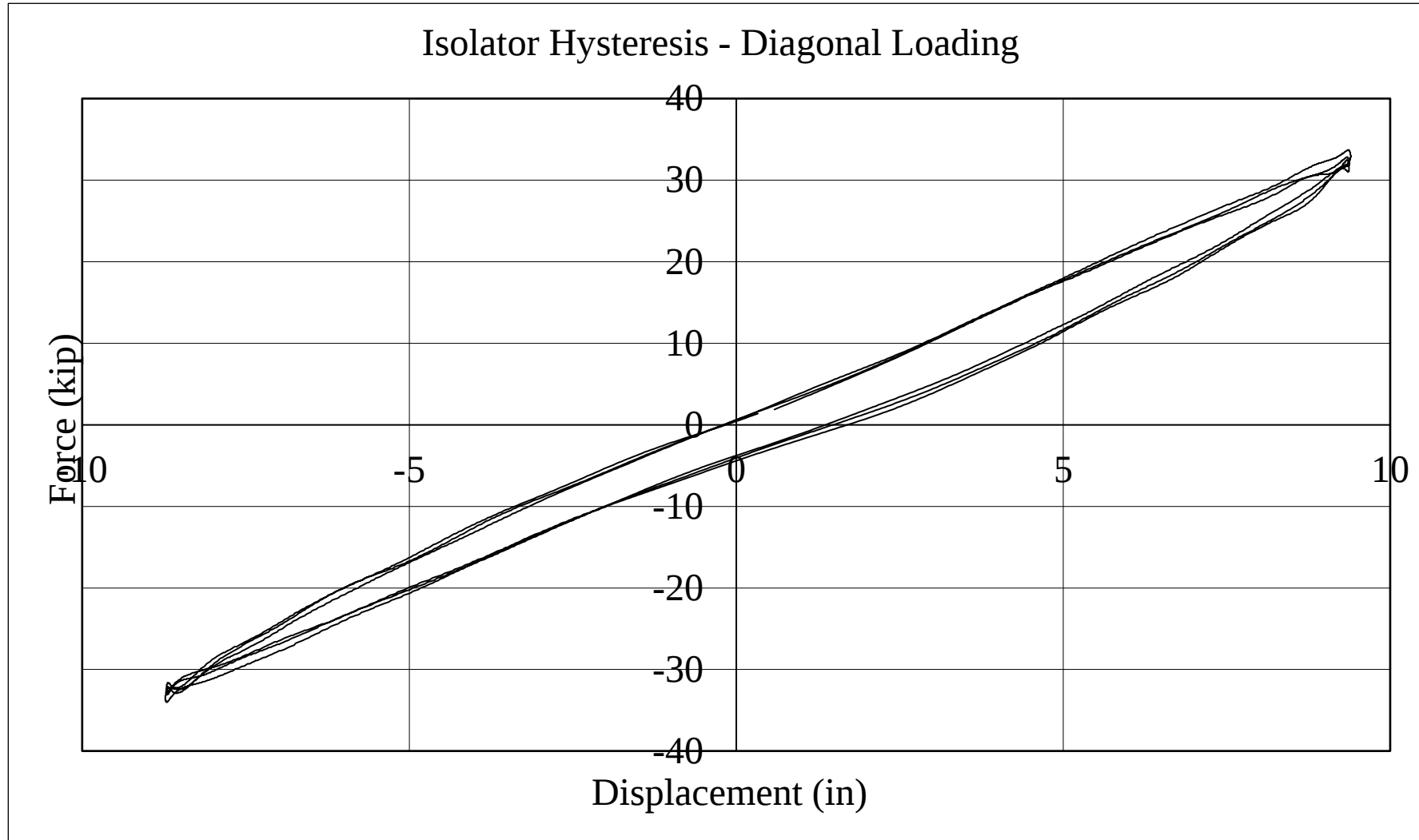
Contemporary Testing Protocol



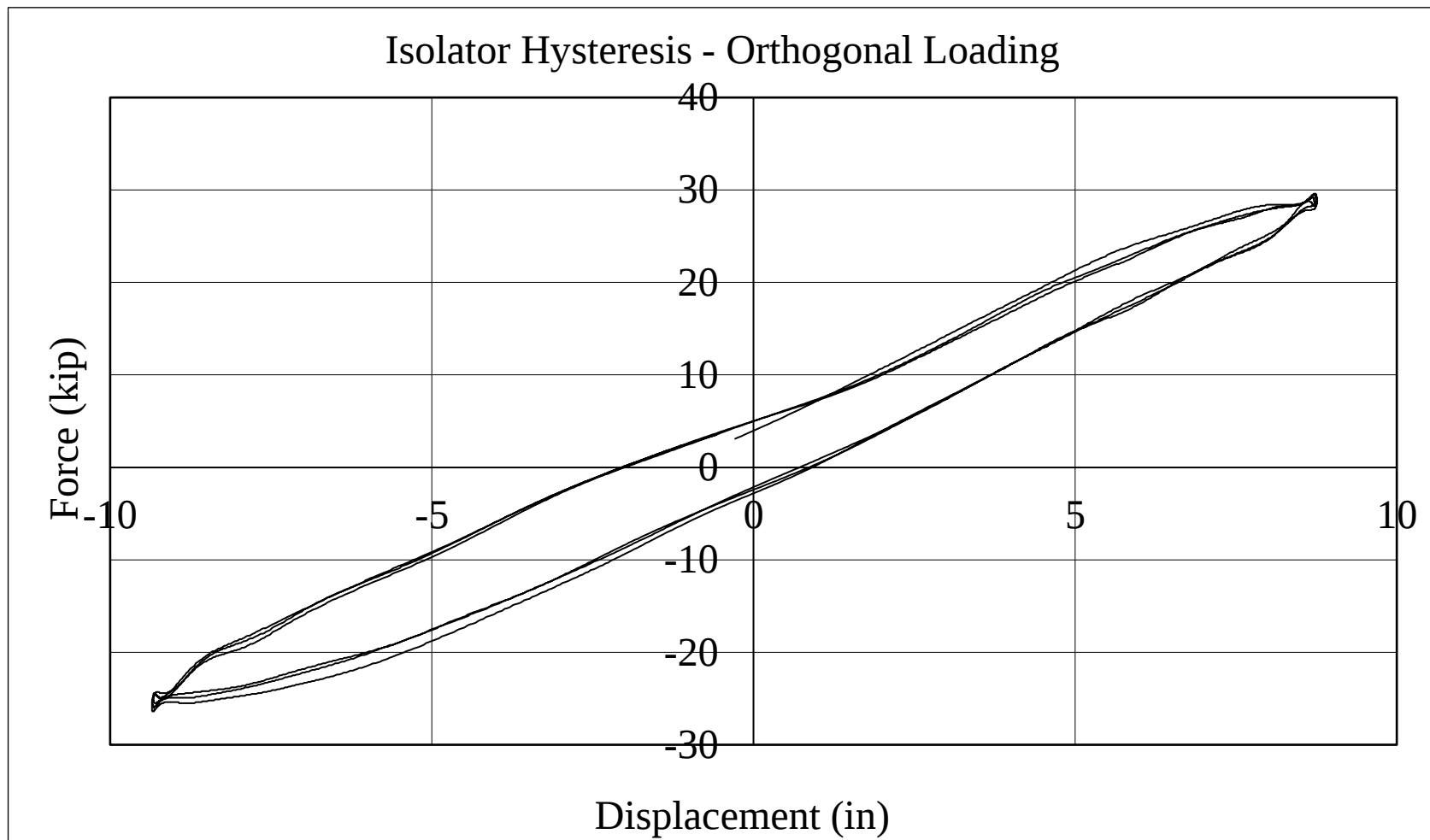
Contemporary Testing Protocol



Contemporary Testing Protocol

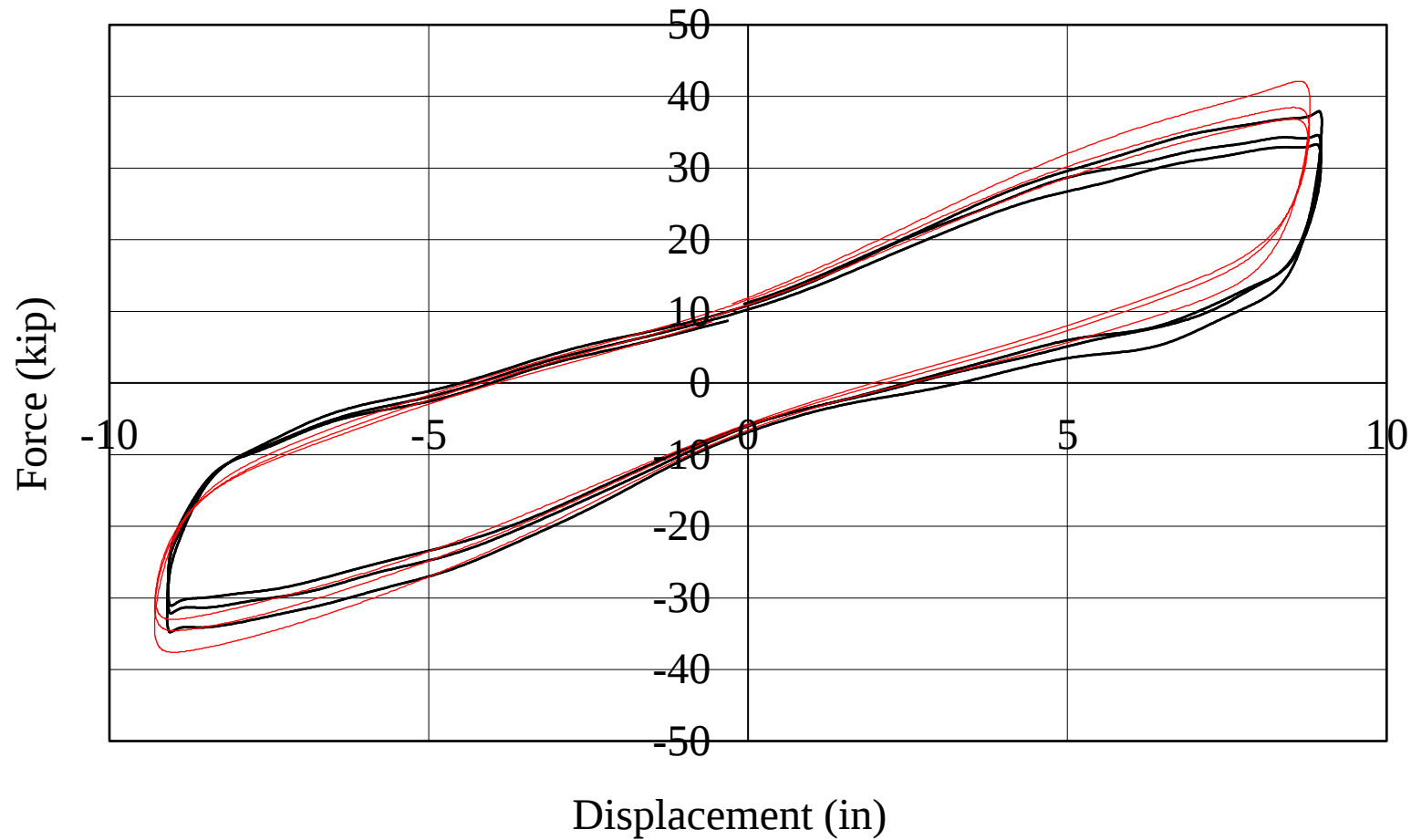


Contemporary Testing Protocol

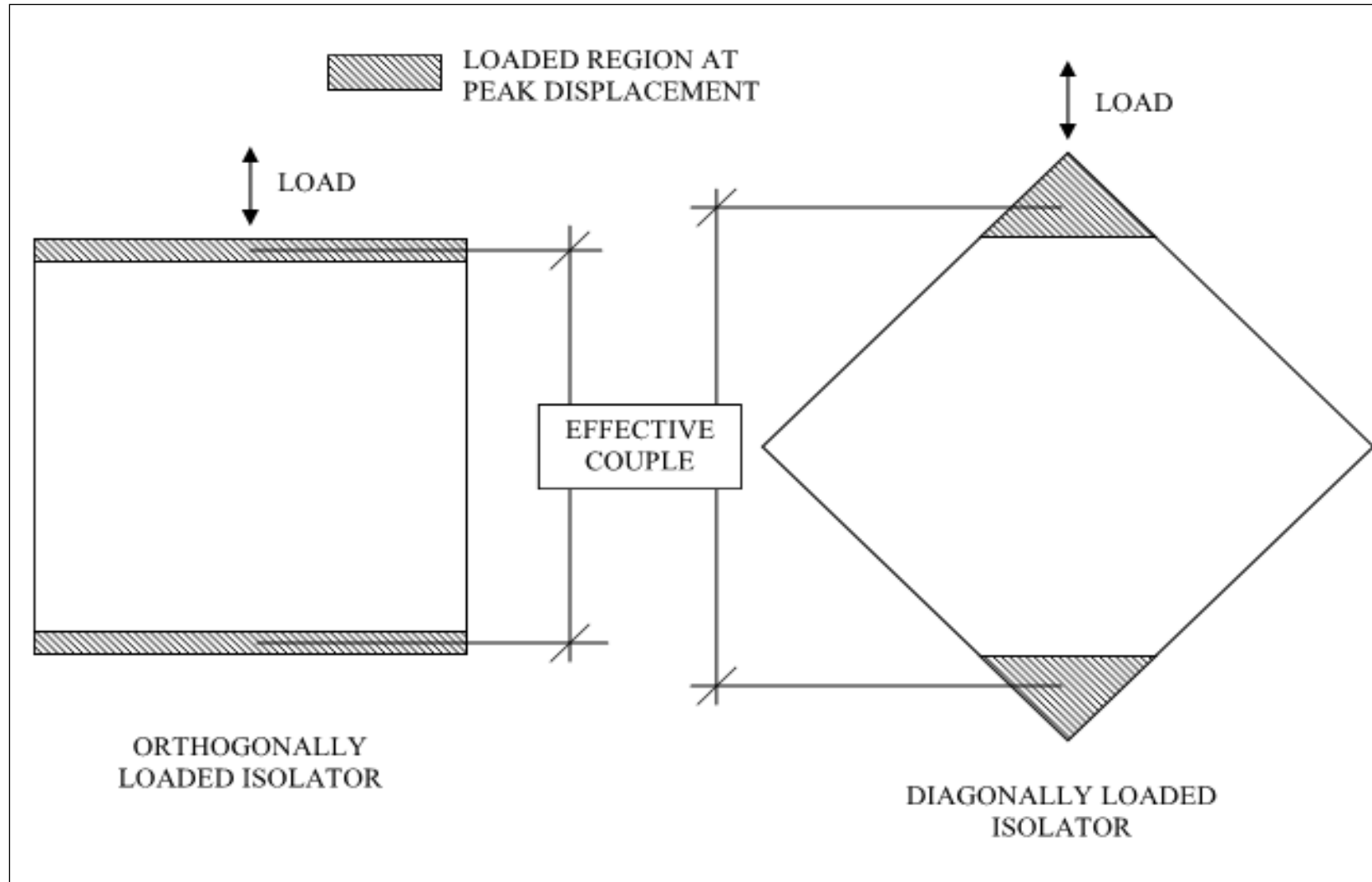


Orthogonal vs Diagonal?

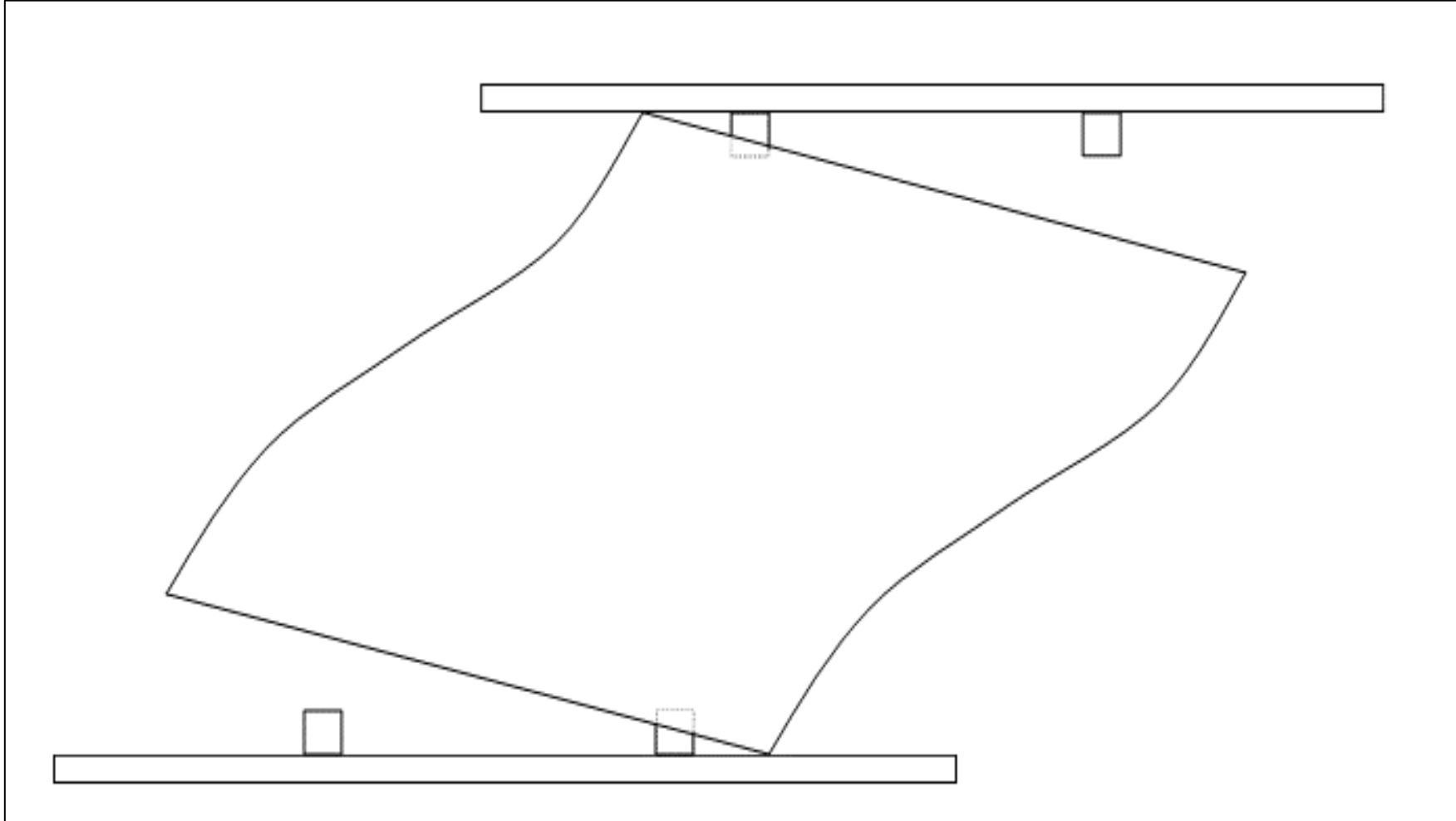
Isolator Hystereses - Superimposed



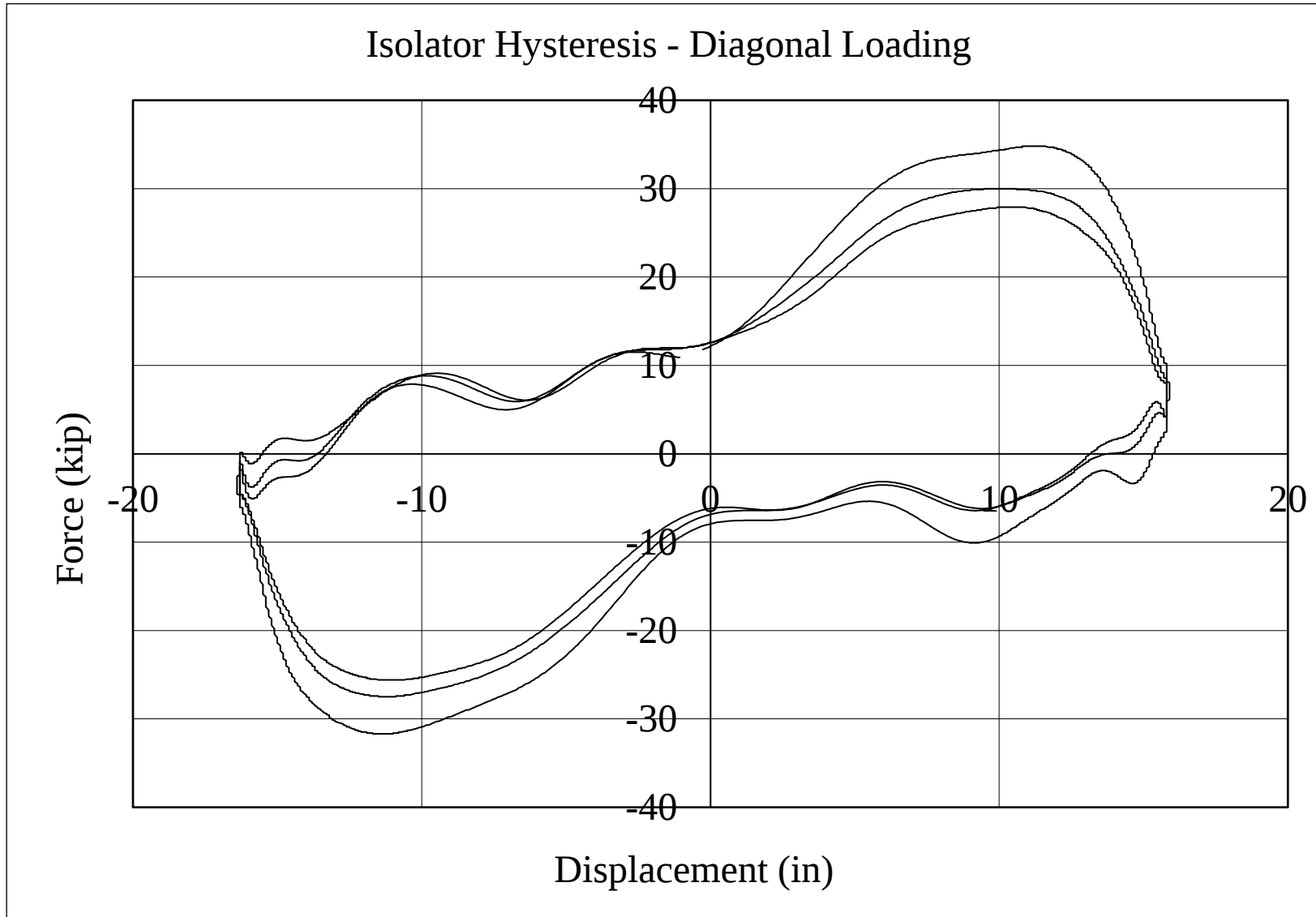
Orthogonal vs Diagonal Loading



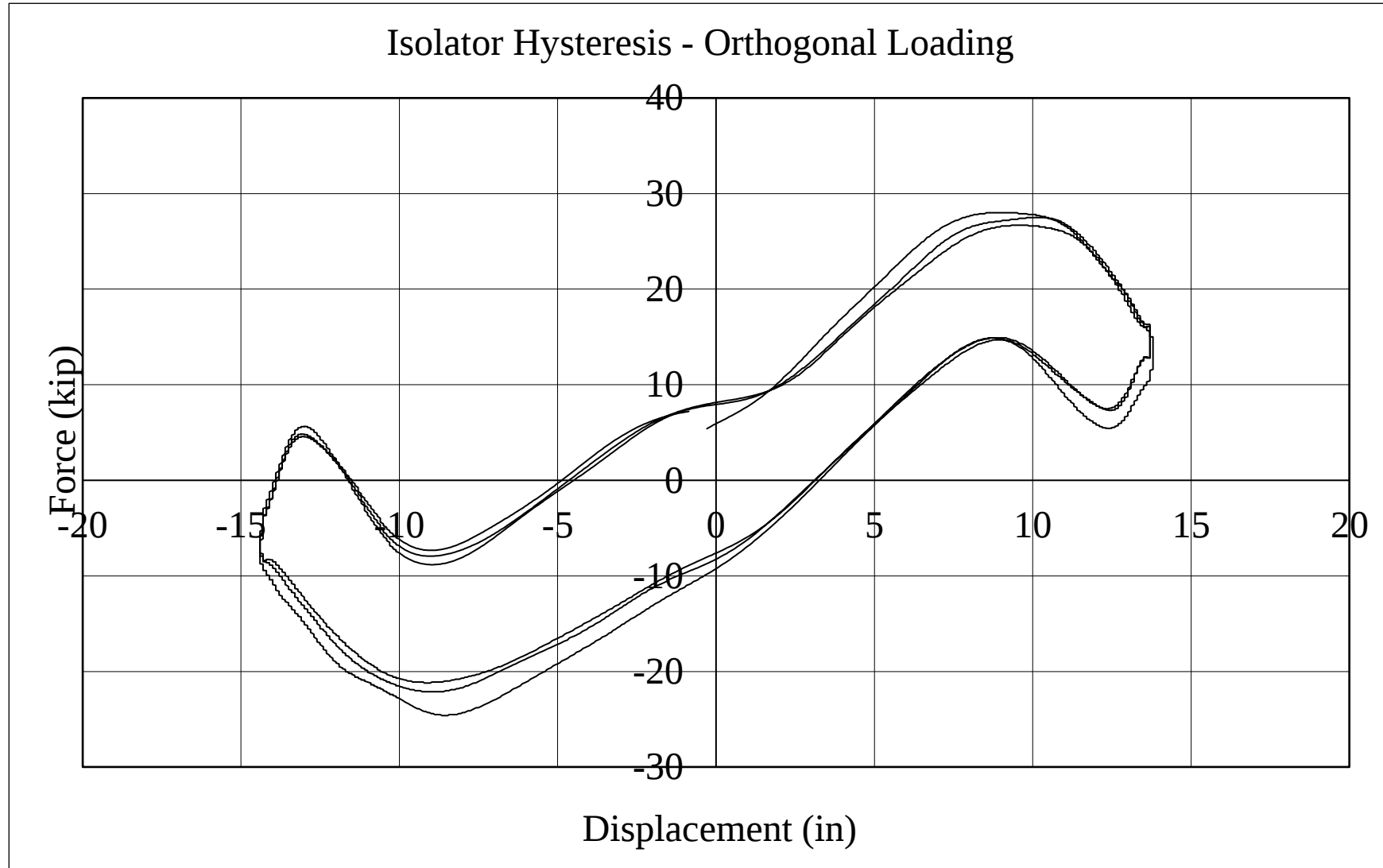
Isolator Roll-over



Diagonal Loading to Failure Threshold

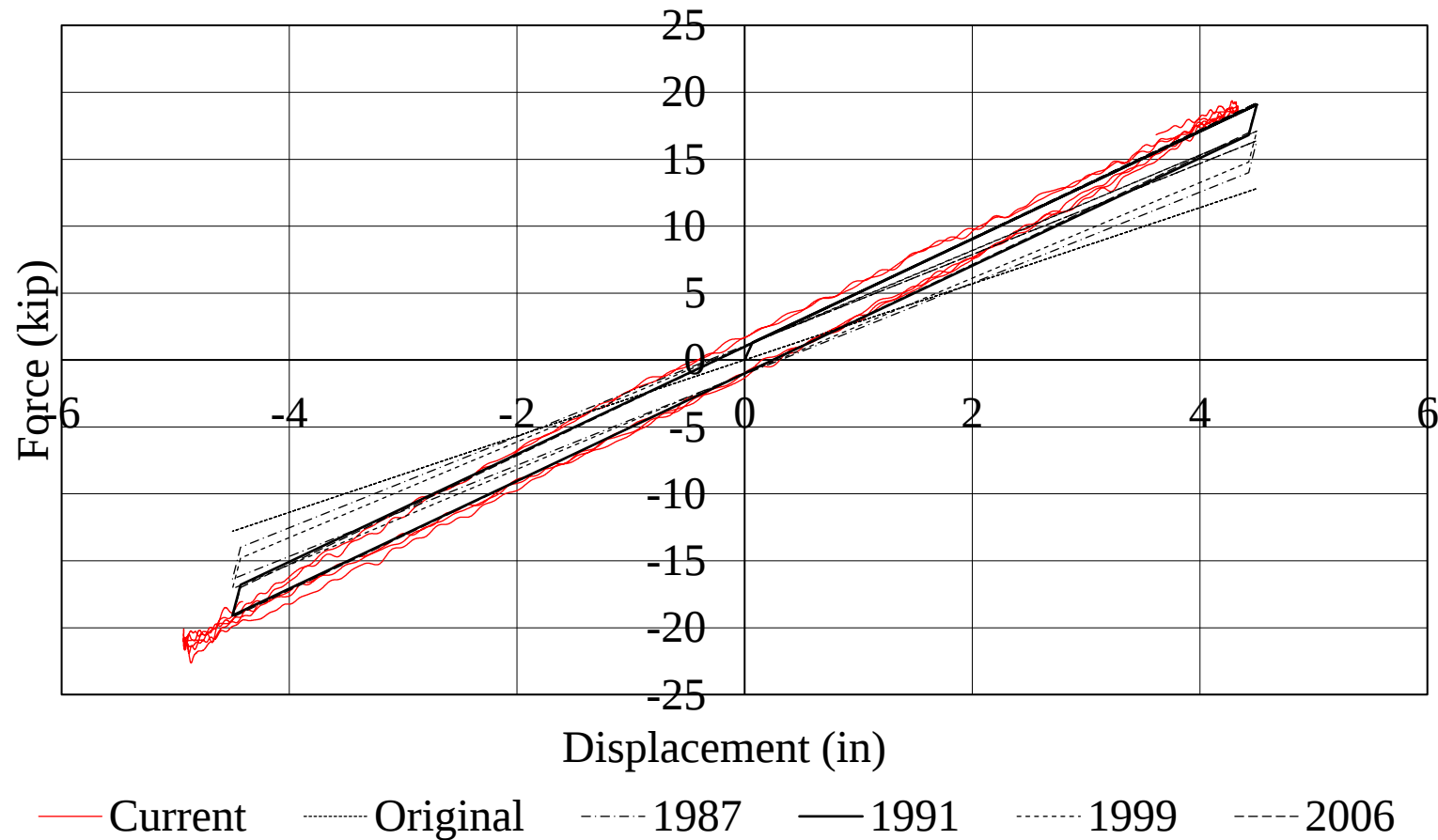


Orthogonal Loading to Failure Threshold



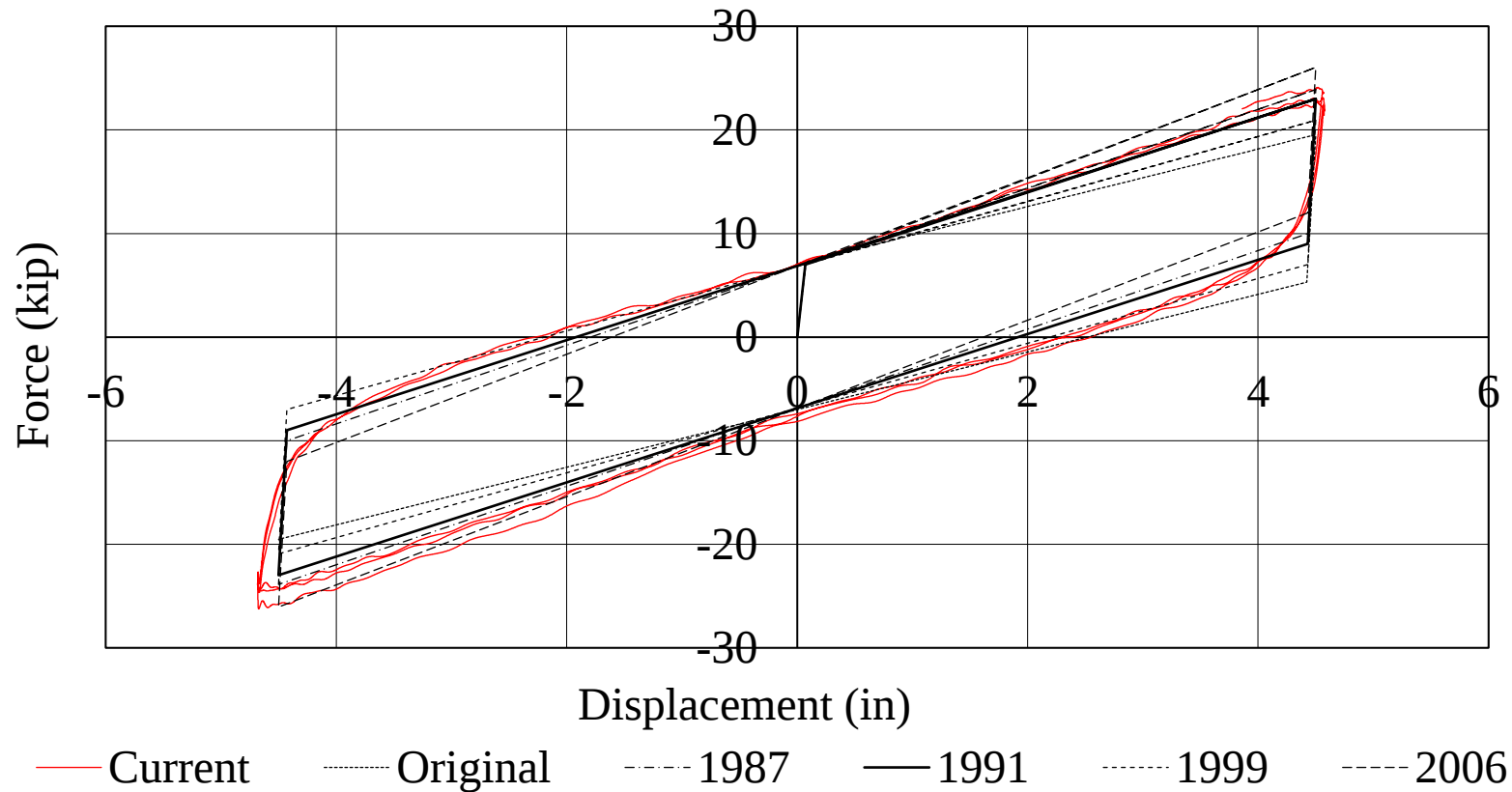
Comparison of Hystereses

Elastomeric Isolator Hysteresis



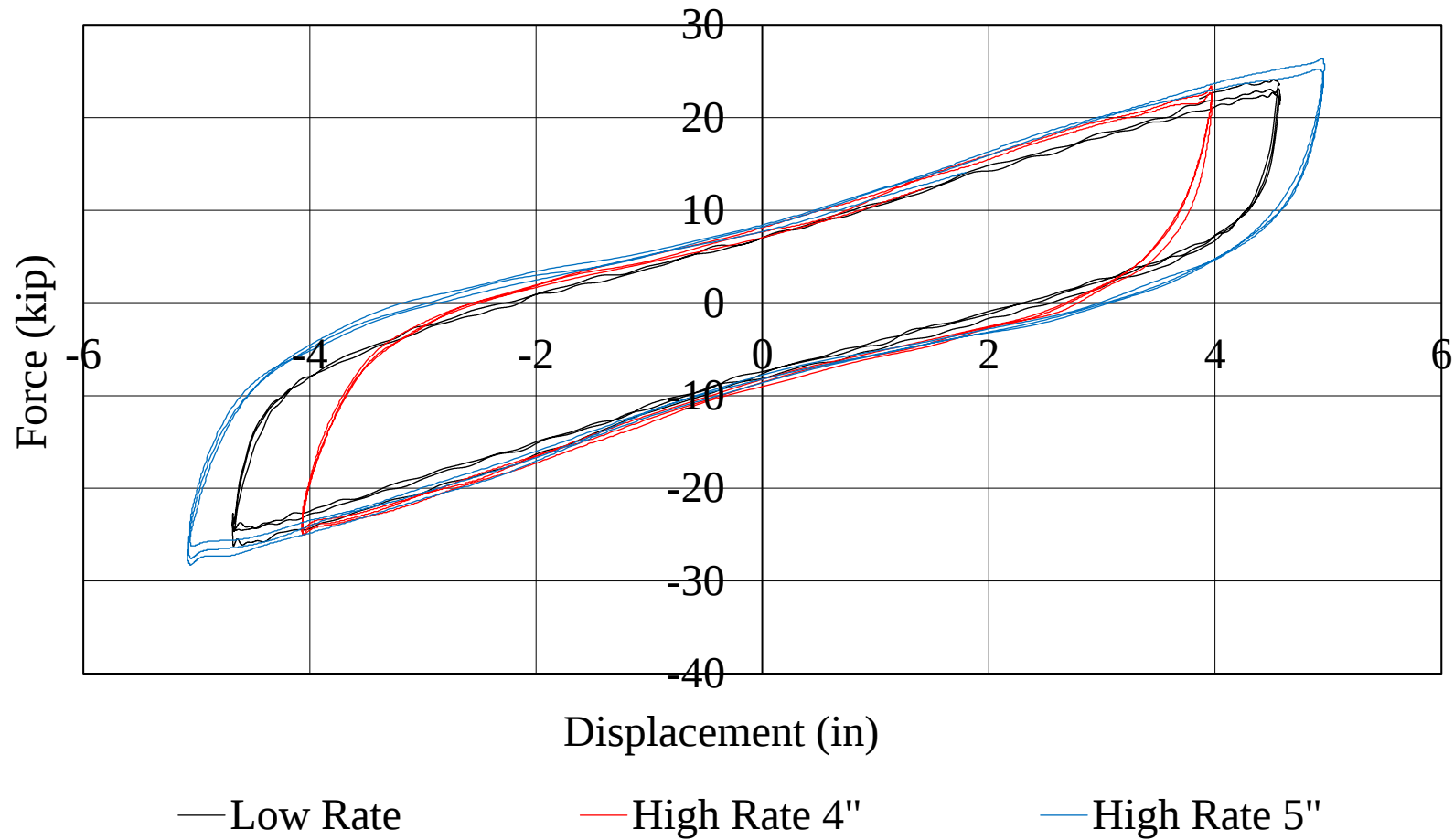
Comparison of Hystereses

Lead Core Isolator Hystereses



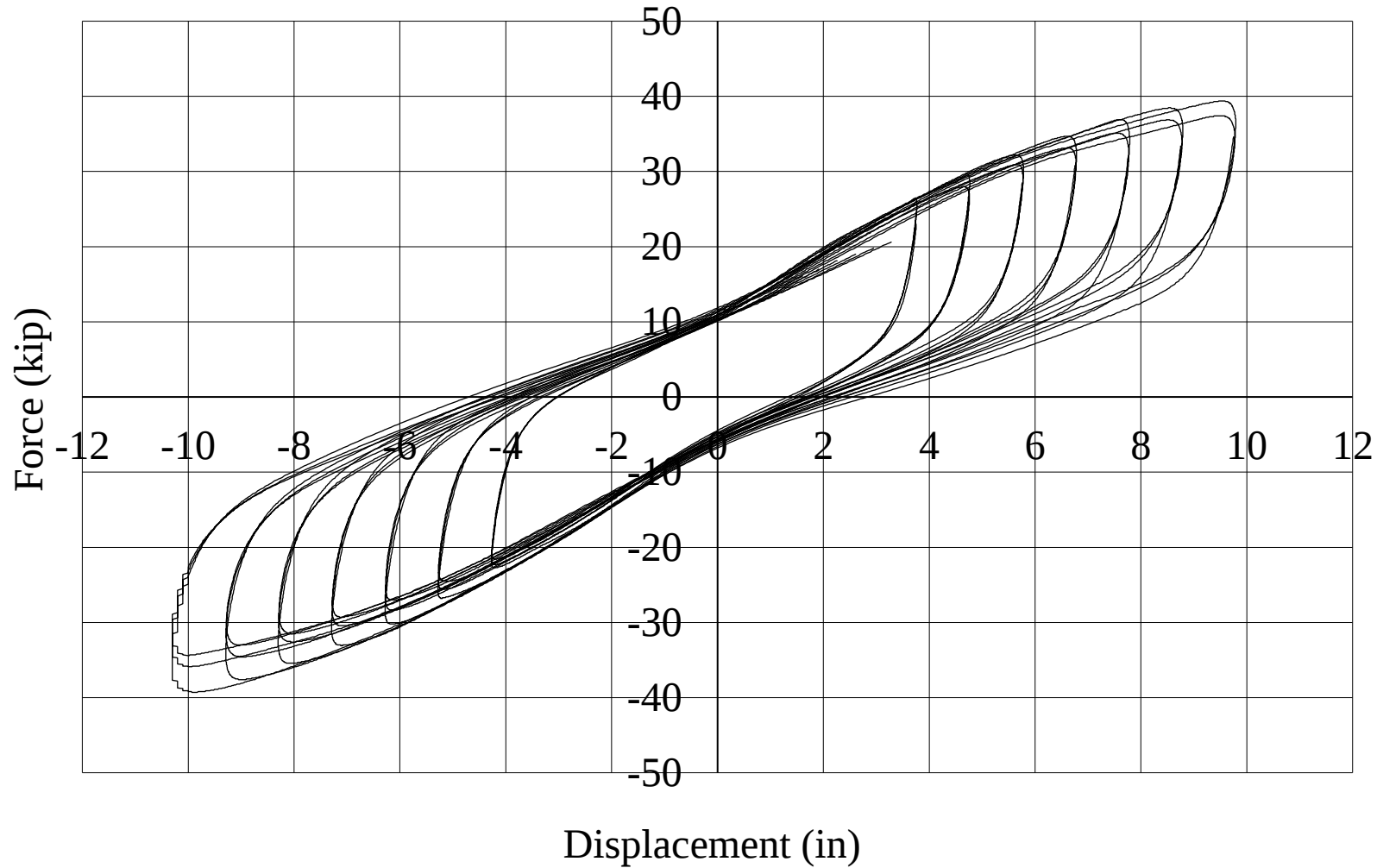
Comparison of Hystereses

Lead Core Isolator Hystereses

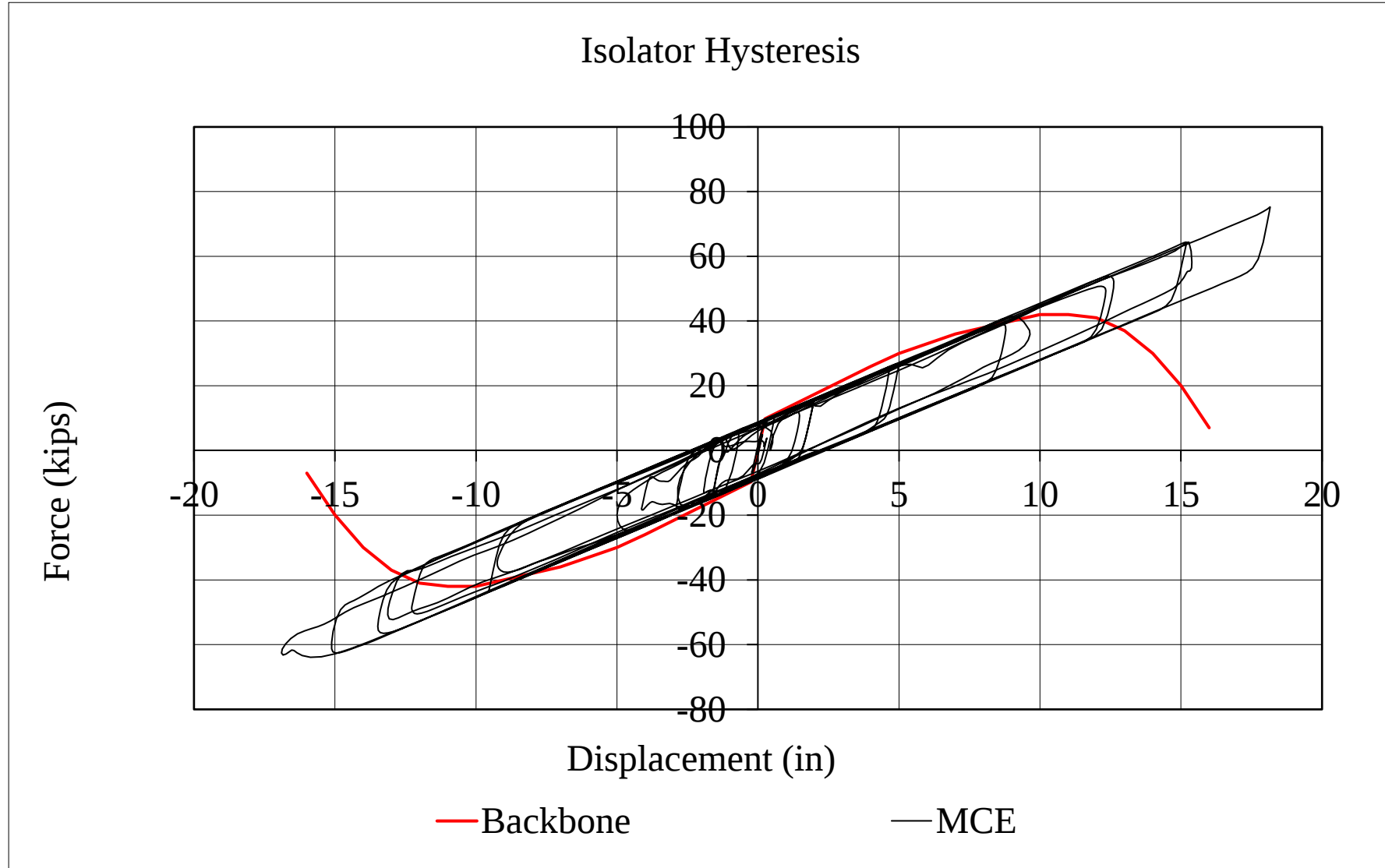


Hystereses of Multiple Subsequent Tests

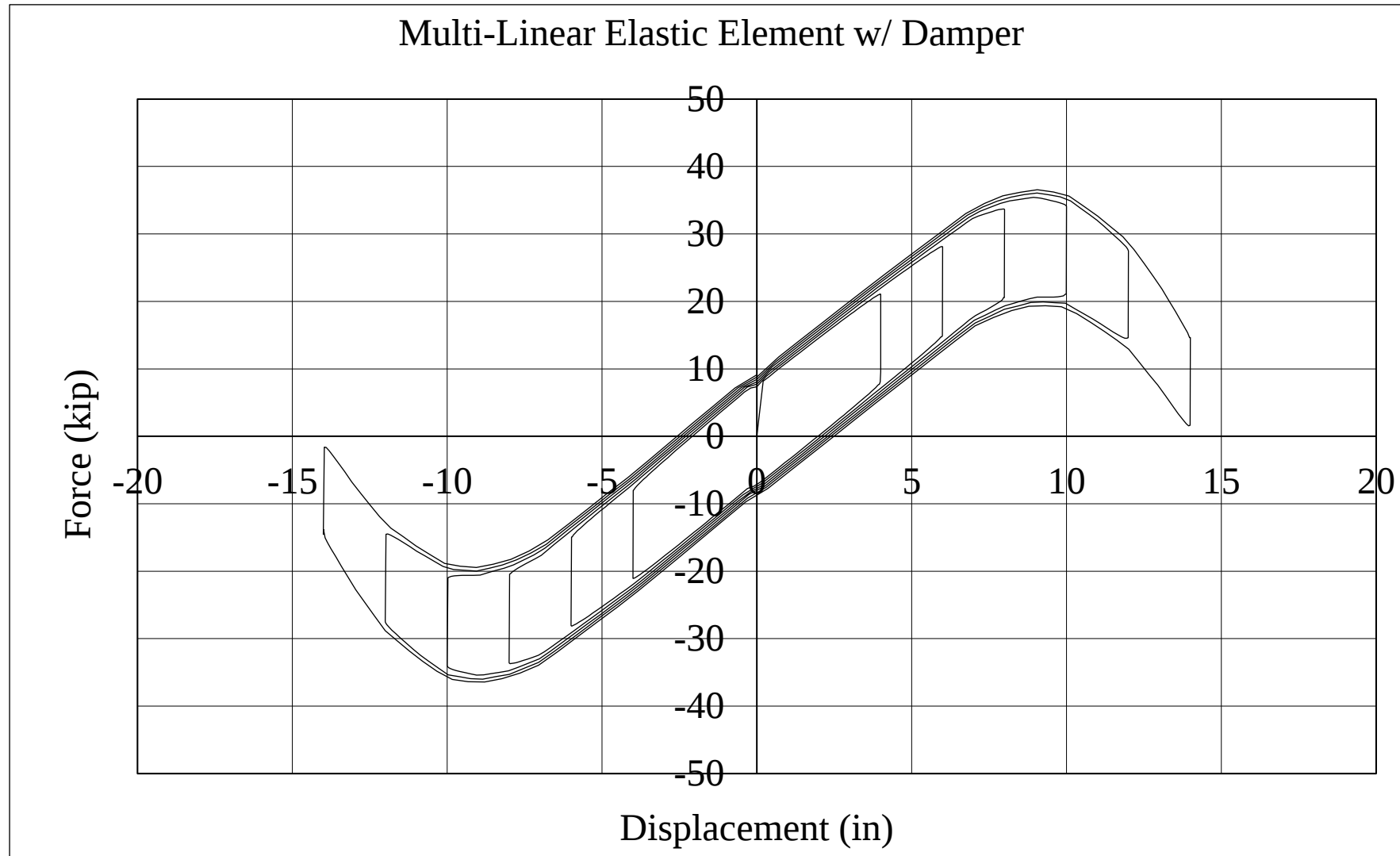
Superimposed Hystereses



Bi-Linear Property vs. Tested Backbone

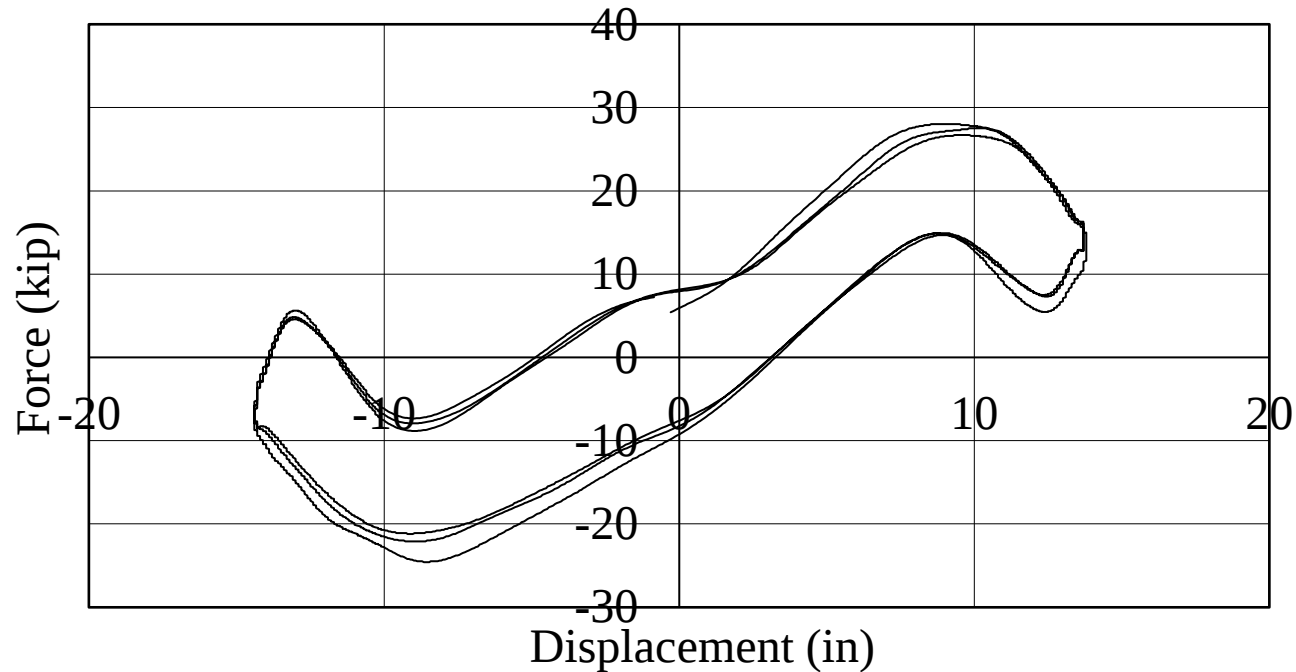


Multi-Linear Elastic Link w/ Damper (MLEED)

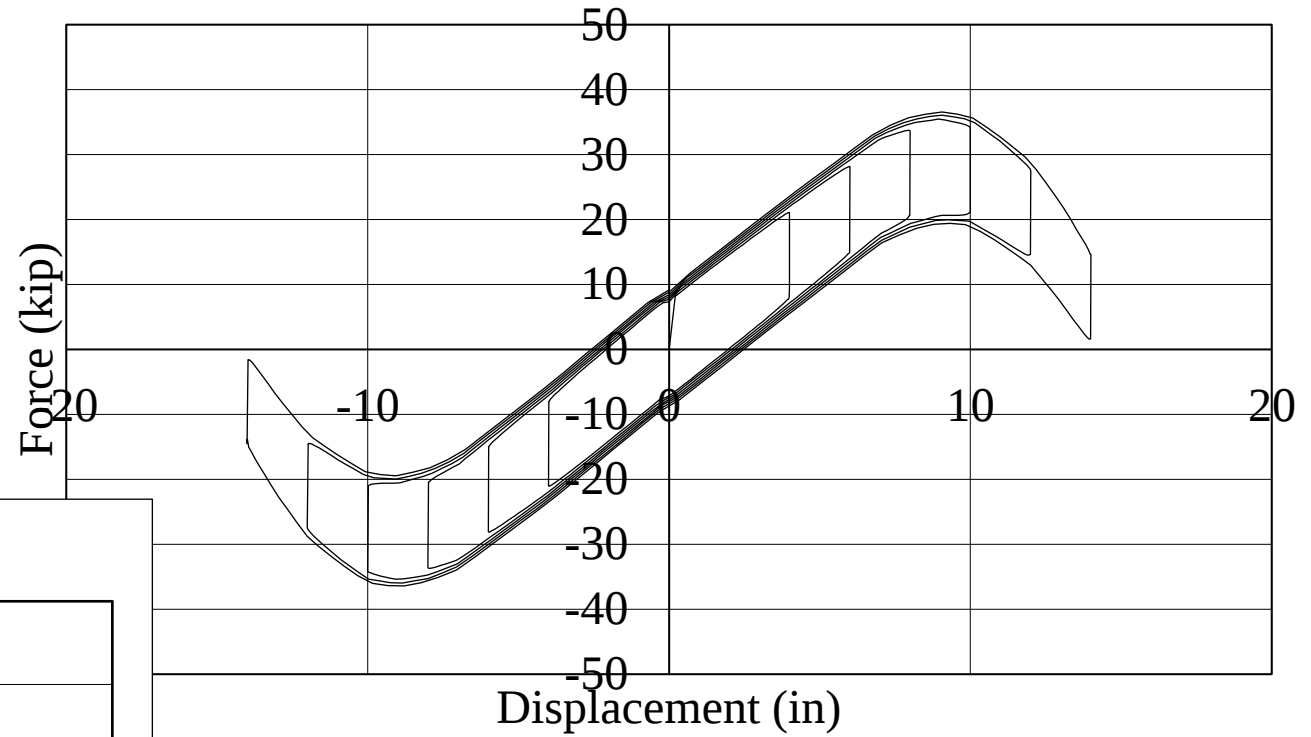


Modeling Isolator Roll-over

Isolator Hysteresis - Orthogonal Loading

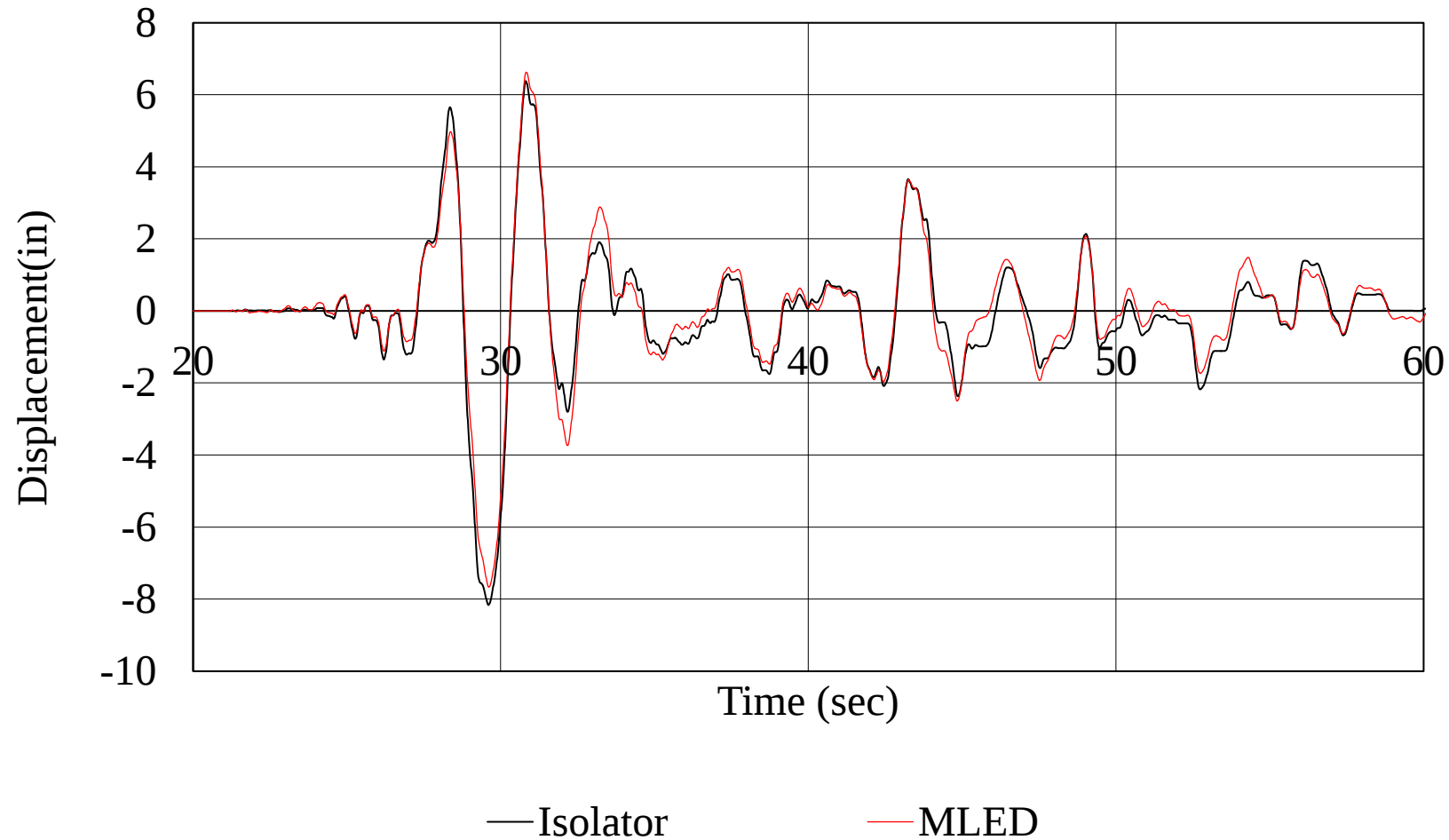


Multi-Linear Elastic Element w/ Damper



Isolator vs. MLED (BSE-1)

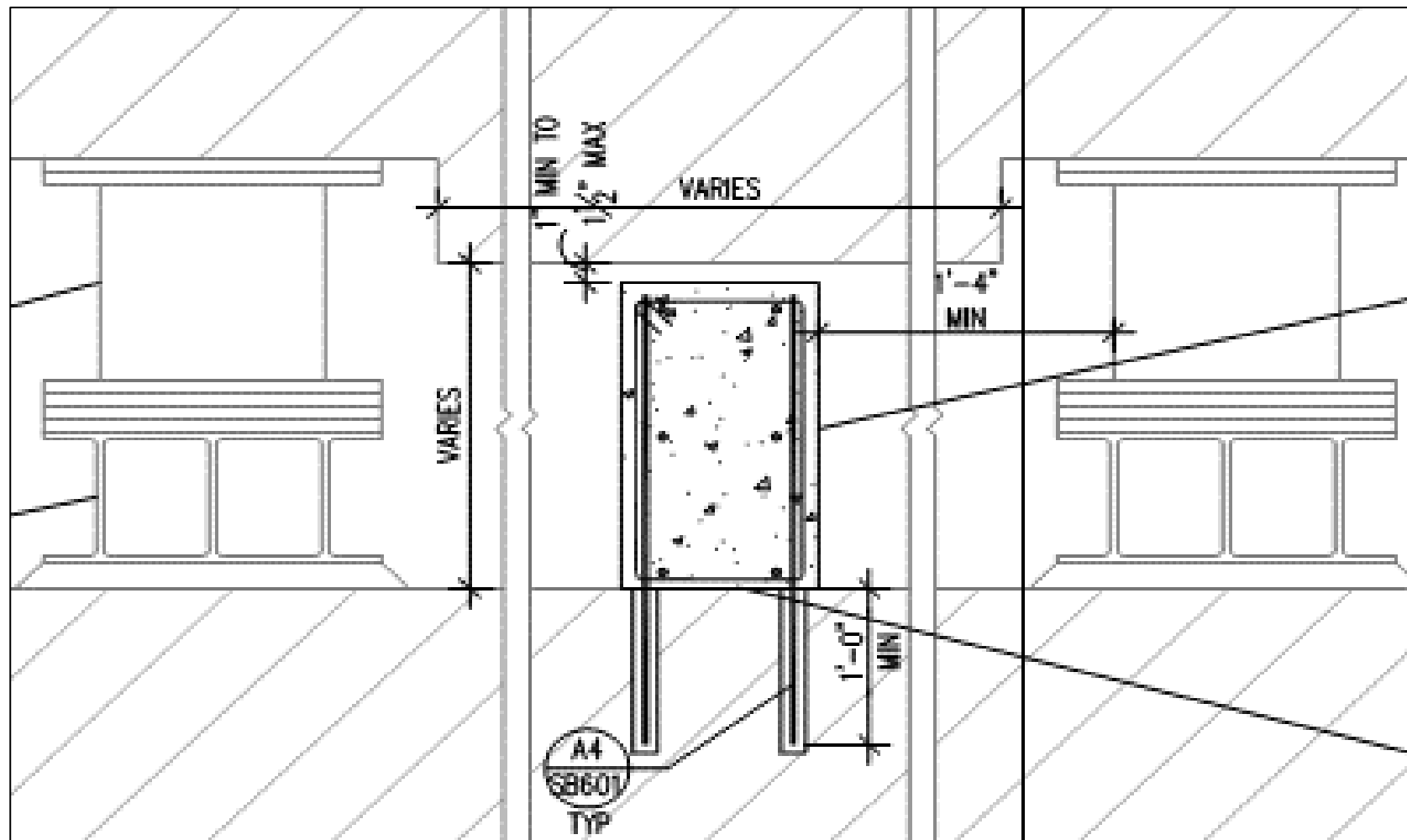
Damped Elastic Link & Isolator Comparison



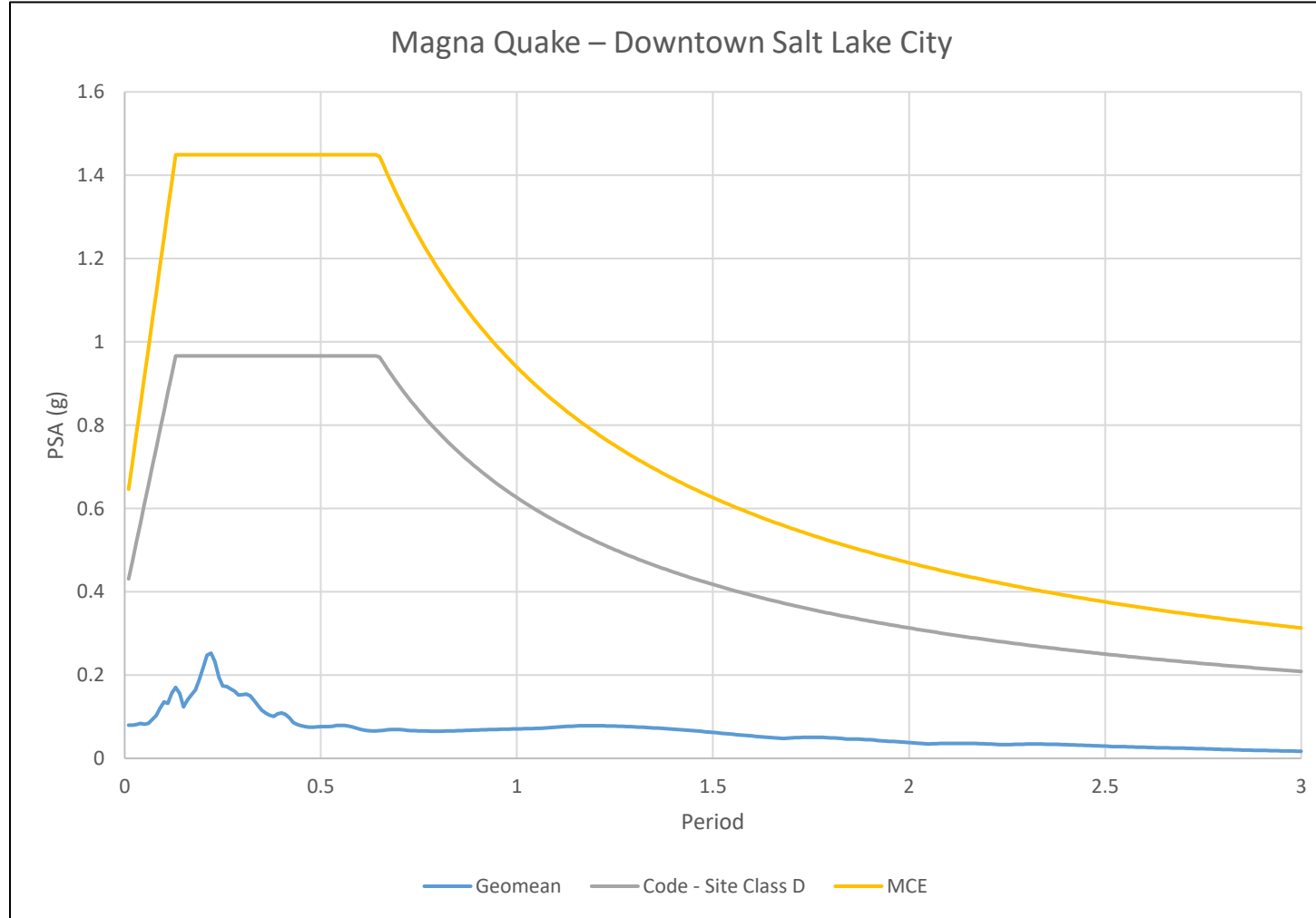
Conclusions

- No clear evidence indicating hardening of elastomers
- Isolators are highly resilient – no evidence of fatigue
- No evidence of significant visco-elastic effect
- Isolators are stable for BSE-1
- Isolators may be unstable for BSE-2, stable for ~70% BSE-2
- Options:
 - Do nothing
 - Supplement receiving system (“catching” piers)
 - Replace isolators

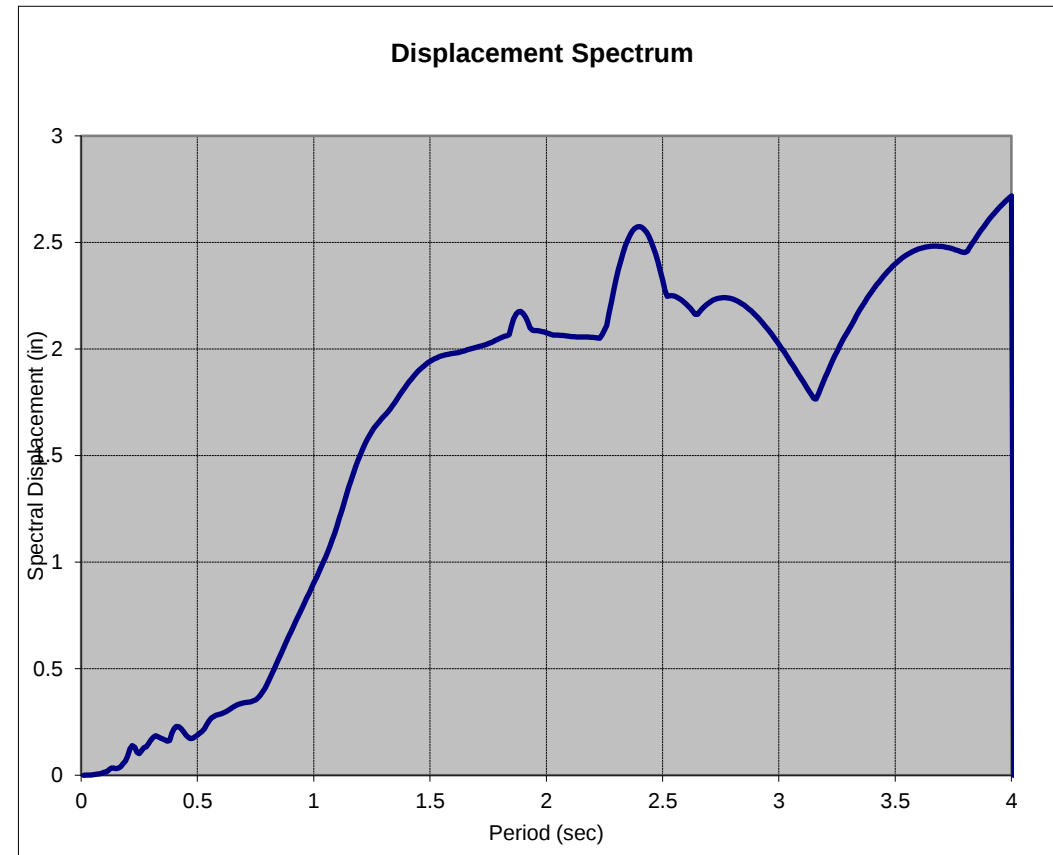
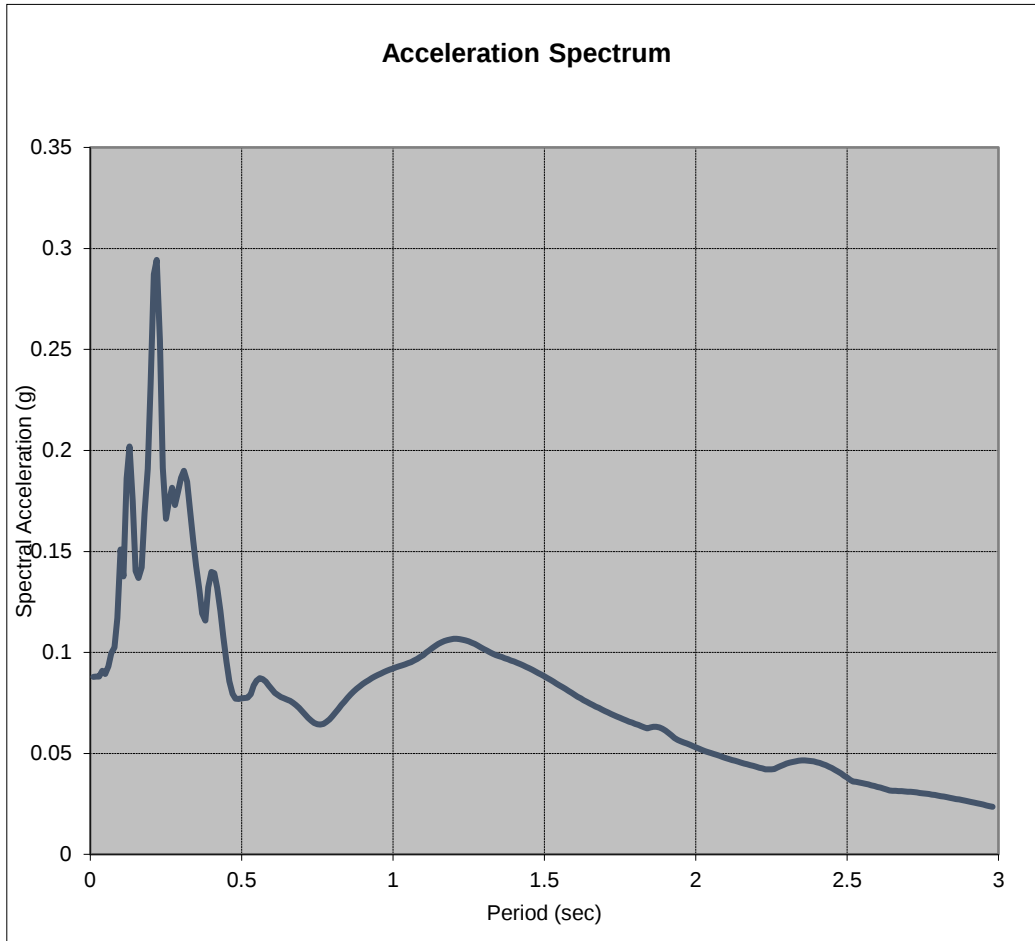
Recent Efforts



March 18, 2020



March 18, 2020



Post Earthquake Observations



Post Earthquake Observations



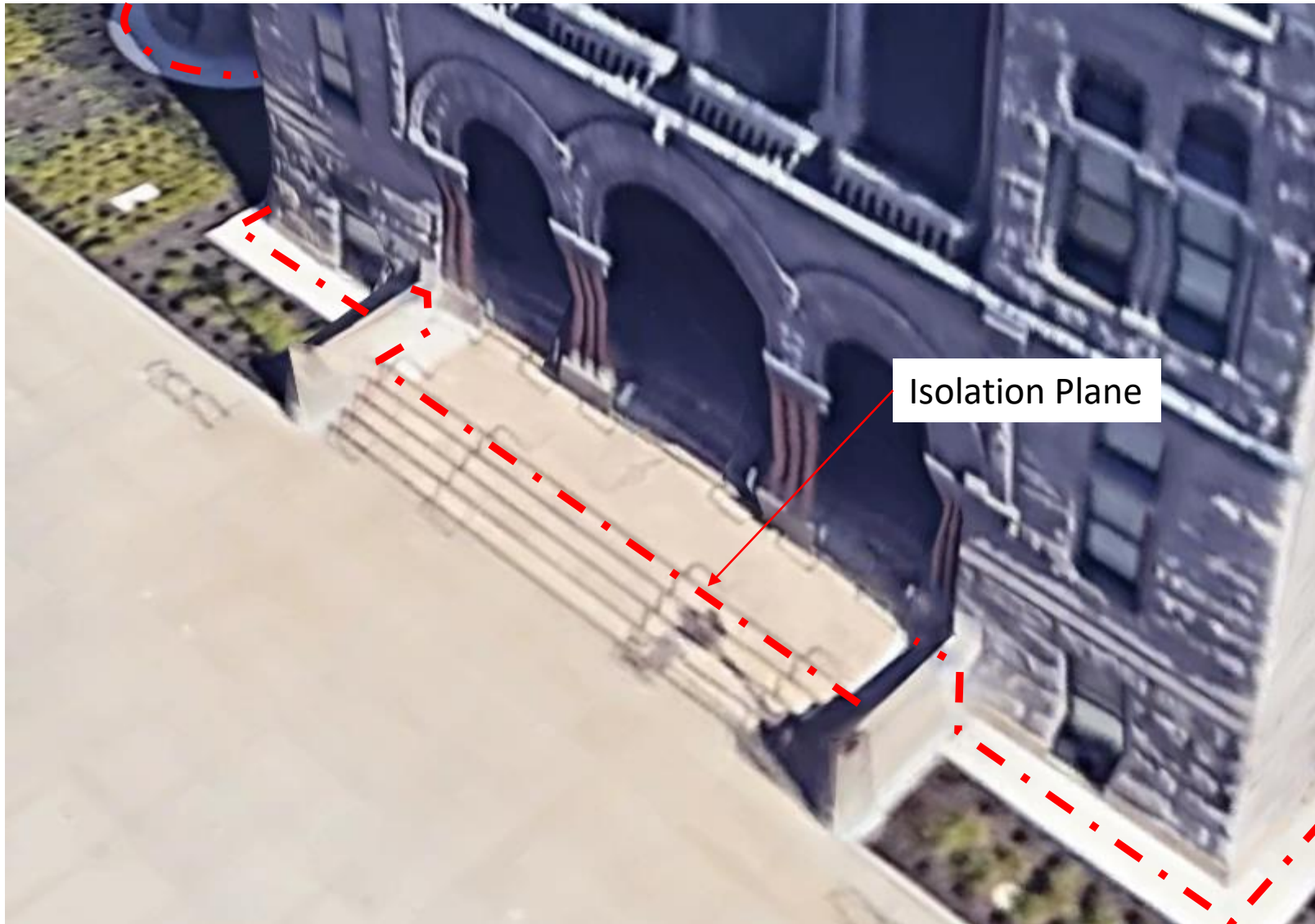
Post Earthquake Observations



Post Earthquake Observations



East & West Stairs



East Stair



West Stair



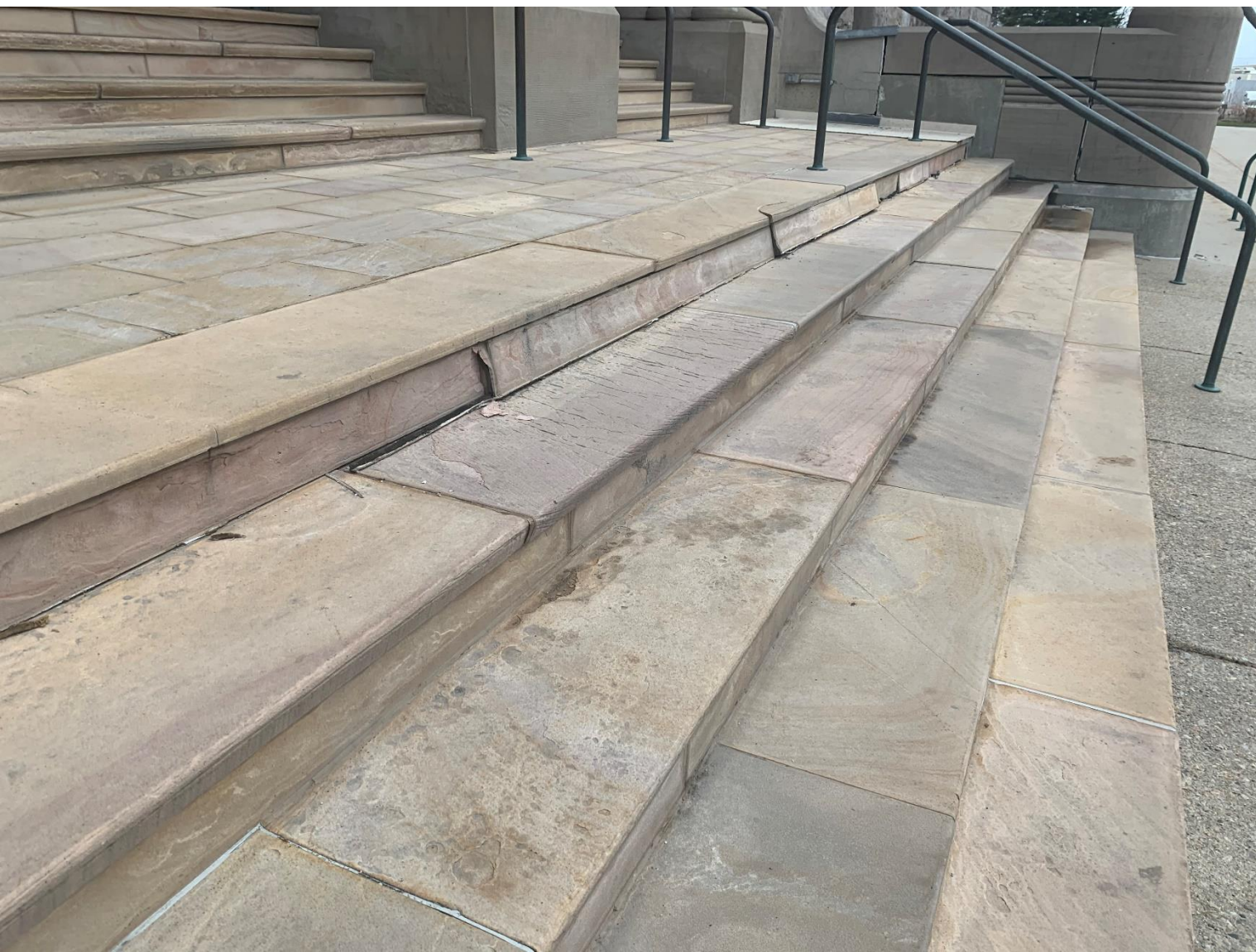
East Stair



East Stair



West Stair



North Stair



East Moat Cover



The End