

Overview of NHERI Lehigh Experimental Facility

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NHERI Lehigh EF



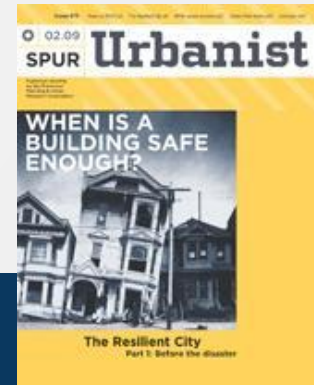
NHERI Lehigh EF Mission

- The mission of the NHERI Lehigh Experimental Facility is to operate a safe, fully functional state-of-the-art multi-user facility which enables transformative research for natural hazard loss reduction.
- The NHERI Lehigh EF will focus on large-scale, multi-direction, simulations which include real-time hybrid simulations that combine physical experiments with computer-based simulations for evaluating performance of large-scale components and systems.
- The NHERI Lehigh EF is committed to be open for use by the research community.

Vision for NHERI Lehigh EF

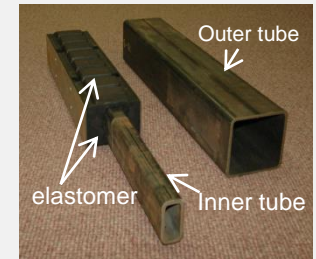
To advance natural hazards engineering research & education

- Provide next generation facility to achieve and enable:
 - Advancements in experimental methods for natural hazard research
 - Transformative research for natural hazard loss reduction
 - Close integration of analytical (numerical) simulations and experiments
- Resulting in:
 - Improved renewal and retrofit of the built environment
 - Exploitation of new emerging materials
 - Development of innovative, resilient structural concepts
 - Economical design approaches toward natural hazard mitigation
 - Development of more accurate physics-based computational simulation models



Example: Vision for NHERI Lehigh EF

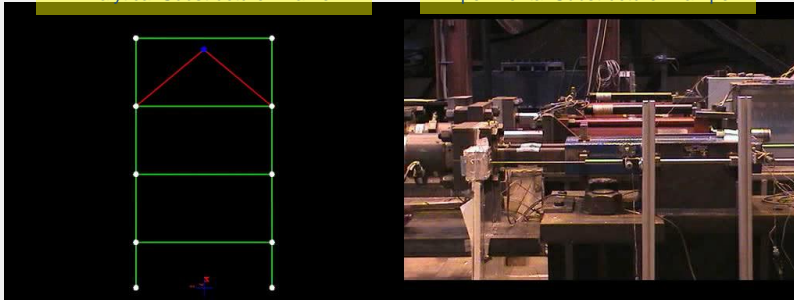
Real-time Hybrid Simulations (RTHS) to Validate PBD for Seismically Resilient Steel Structures Using Supplemental Dampers



Rate Dependent Compressed Elastomeric Damper

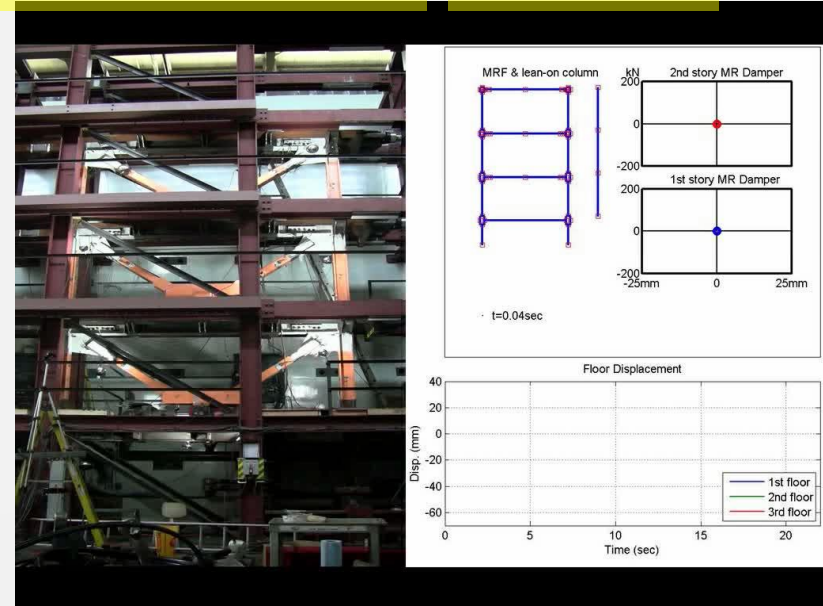
Analytical Substructure: Frame

Experimental Substructure: Damper



Experimental Substructure: Frame + dampers

Analytical Substructure: MRF + Gravity

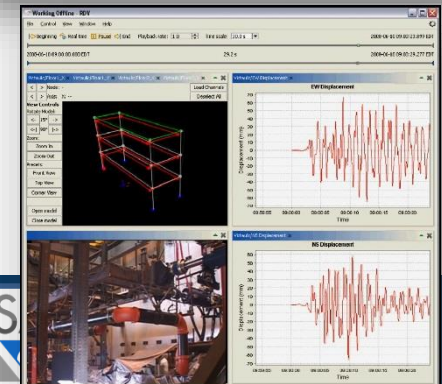


RTHS of 3-story Frame with Elastomeric Dampers

RTHS of 3-story Building System with Semi-active MR Dampers

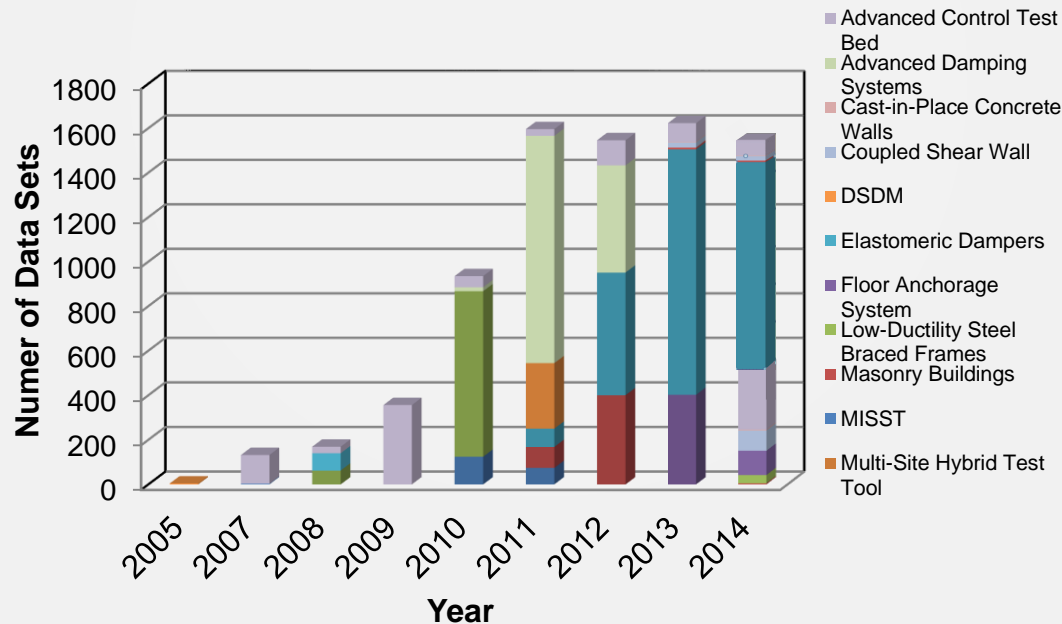
NHERI Lehigh EF

- Former NEES Site: Real-time Multi-directional (RTMD) Earthquake Simulation Facility
- Unique facility
 - Portfolio of equipment, instrumentation, infrastructure, testbeds, and experimental simulation control protocols for large-scale multi-directional testing
 - Concurrent multiple large-scale experiments
 - Operated by experienced staff
- Facility exists within ATLSS Center to provide access to additional resources and ATLSS infrastructure



NEES@Lehigh Testing

- Demand and Throughput History – NEES@Lehigh
 - 23 research projects (pre-NEESR, NEESR, shared-use)
 - 7891 tests performed at NEES@Lehigh since 2005
 - 1810 tests have involved large-scale real-time hybrid simulations



Example Project & Testing Types

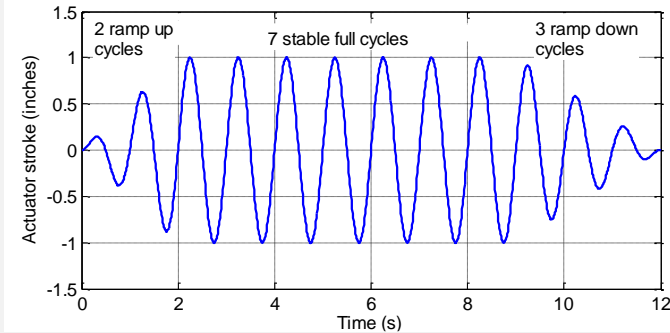
Test Specimen	Mode of Testing
R/C bridge-soil-foundation	Distributed hybrid simulations
Building with piping system	Multi-directional real-time hybrid simulations
Self-centering beam-to-column moment connections	Characterization tests
Self-centering frame systems	Characterization, hybrid simulations
R/C bridge with MR dampers	Real-time hybrid simulations
Passive and semi-active dampers	Characterization, hybrid and real-time hybrid simulations
Steel frame building with MR dampers	Real-time hybrid simulations with single and multiple experimental substructures, real-time distributed hybrid simulations
Tsunami-driven debris	Dynamic impact loading
Post-tensioned coupled shear wall systems	Characterization testing, multi-mode dynamic testing
Laterally and axially loaded SSI pile tests	Characterization testing, quasi-static testing

Full-Scale Nonlinear Viscous Dampers

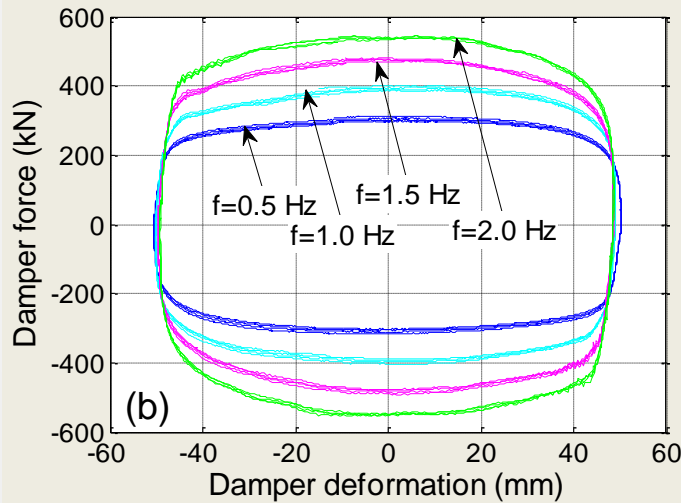
Characterization testing



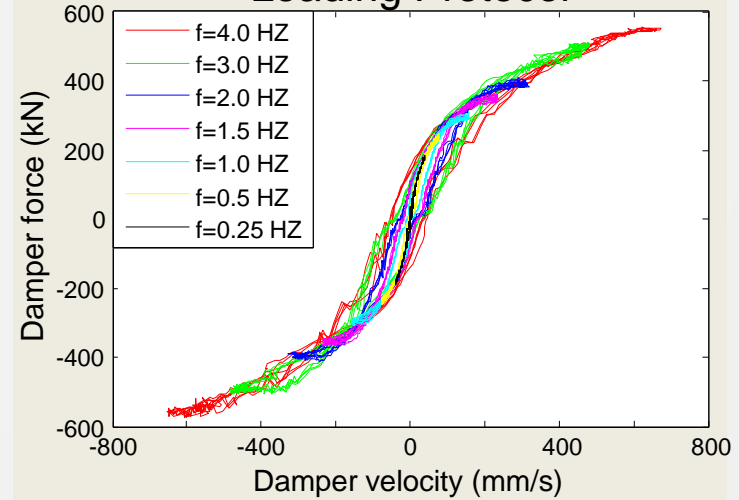
Damper testbed



Loading Protocol



Damper force - deformation



Damper force - velocity

Multi-directional Large-Scale Real-time Hybrid Simulation of 3-story Building with Piping System – Lehigh

RTHS: 1994 Northridge EQ, Canogo Park (MCE)

Beginning Real time Play End Playbackrate: 1.0 Time scale: 30.0 s 2008-06-10 09:00:00.000 EDT

2008-06-10 09:00:00.000 EDT 29.2 s 2008-06-10 09:00:29.277 EDT

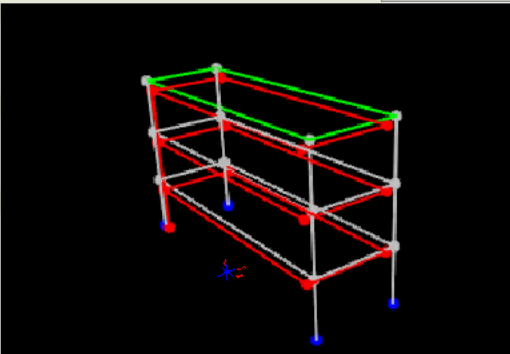
Victaulic/Floor1_X x Victaulic/Floor1_Y x Victaulic/Floor2_Y x

< > Node: - Load Channels
< > Axis: X: -- Deselect All

Rotate Model:
<- 15° ->
<-| 90° |->

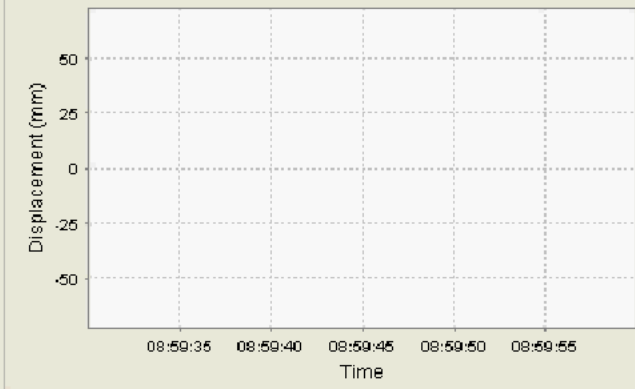
Zoom:
Zoom In
Zoom Out

Presets:
Front View
Top View
Corner View
Open model



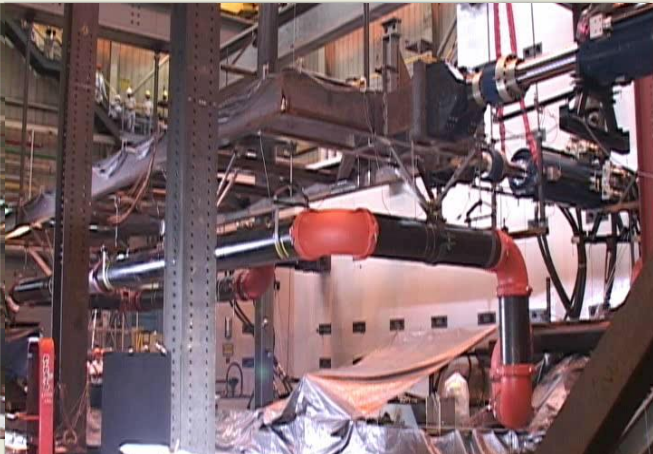
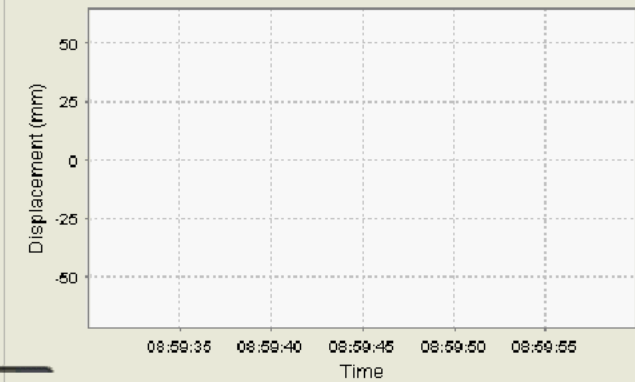
Victaulic/EW Displacement x

EW Displacement



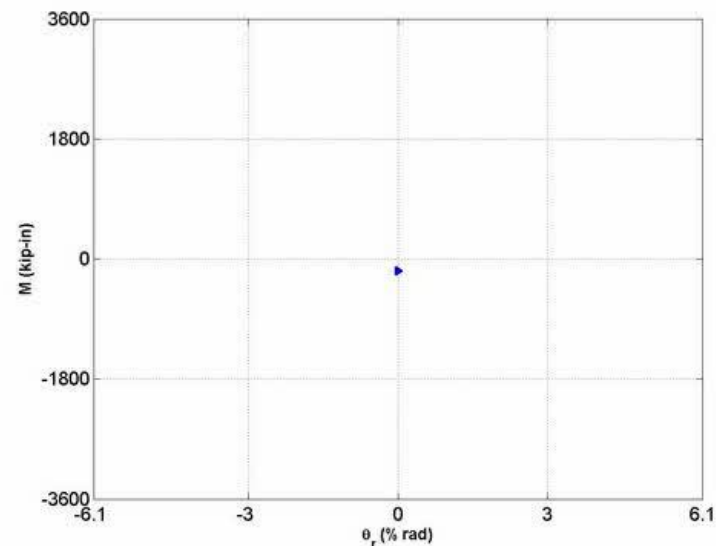
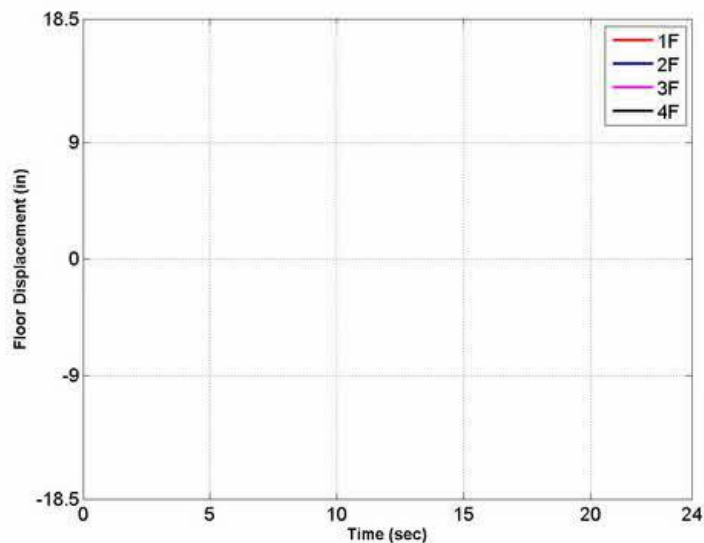
Victaulic/NS Displacement x

NS Displacement

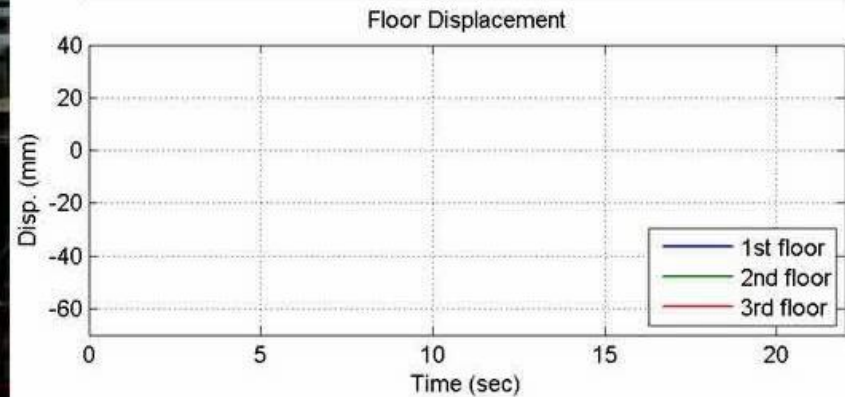
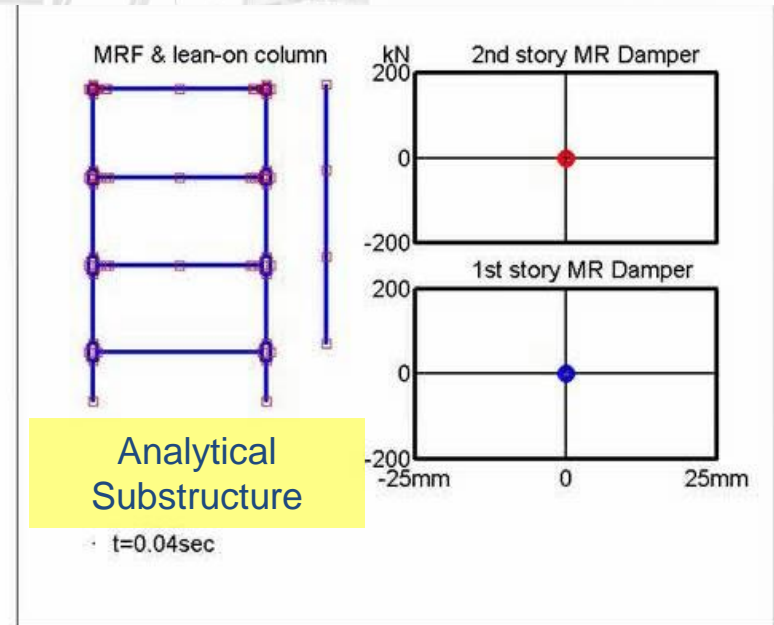


NEESR-SG Self Centering Damage-Free Seismic Resistant Steel Frame Systems – Princeton, Purdue, Lehigh, MCEER

Large-Scale Hybrid Simulation: MCE (2500 yr Return Period EQ)

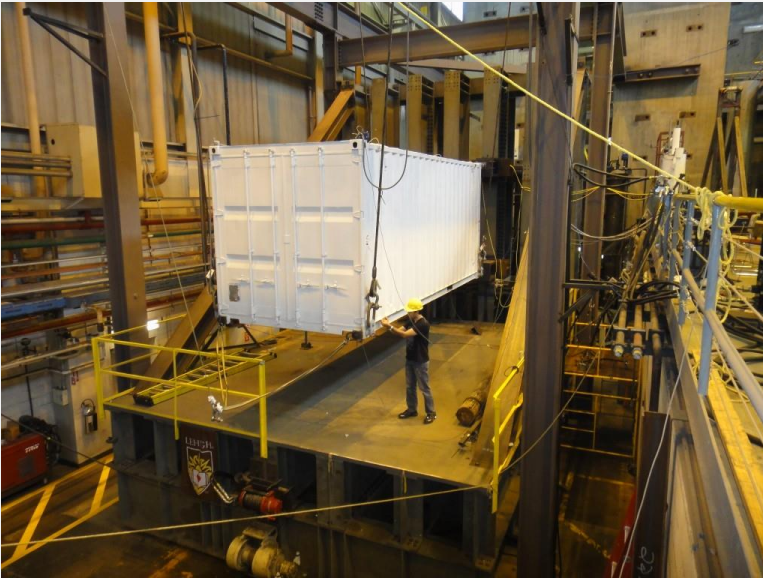


NEESR-SG PBD and Real-time Large-scale Testing to Enable Implementation of Advanced Damping Systems – Purdue, UIUC, CUNY, UConn, Lehigh RTHS: 1994 Northridge EQ (0.80*DBE), Semi-active MR



Experimental Substructure – CBF with MR Dampers

NEESR-CR Impact Forces from Tsunami-driven Debris Dynamic Impact Loading – Univ Hawaii, Oregon St., Lehigh Dynamic Impact Loading



Test Setup Cargo Shipping
Container Debris



High Speed Video of Impact of Cargo
Shipping Container with Structure

Current and Recent NSF Projects at NHERI Lehigh EF

- *Collaborative Research: Semi-Active Controlled Cladding Panels for Multi-Hazard Resilient Buildings.* CMMI 1463497.
PI: Simon Laflamme, Iowa State
- *Collaborative Research: A Resilience-based Seismic Design Methodology for Tall Wood Buildings.* CMMI 1635227.
PI: Shiling Pei, Colorado School of Mines
- *Faculty Early Career Development.* CMMI 1351537.
PI: Shamim Pakzad, Lehigh
- *Collaborative Research: Enhancement of Vertical Elements for Foundation Support by Ureolytic Carbonate Precipitation.* CMMI 1233566.
PI: Muhannad Suleiman, Lehigh

Thank you