# Research Project Highlight

# Seismic Performance of Isolated Bridges under Extreme Shaking

*TSRP Topic – Protective Systems, PBE – M7*

**Principal Investigator**
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**Research Team** – to be determined

**Start-End Dates:**
2/15/2021-2/14/2022

**Abstract**
Seismic isolation is a proven strategy for protecting critical infrastructure, such as signature bridges and high-speed elevated rail, from the damaging effects of design-level earthquake ground shaking. While the performance of seismically isolated transportation infrastructure under design level ground motions has been widely verified, the risk posed under beyond design basis shaking requires more refined modeling of bearing models for prediction of isolator displacements and assessment of failure modes including pounding or deck unseating. Most past studies have relied on bilinear models of bearings under design level motions. Recent experimental studies have shown that lead rubber bearings (LRB) widely used in bridges have strength degradation from heating of the lead that can substantially increase isolator displacements especially for long duration shaking. LRB can also exhibit strain hardening of the rubber at large strains. Various bearing models have been proposed to capture these and other nonlinear characteristics of LRB, however, a review of existing models showed that one model is not able to capture all dominant characteristics observed in experimental measurements of bearing to large strains.

This study aims to develop improved bearing models for bridges to more accurately predict displacements. The use of restrainers and supplemental damping will be considered for mitigation of pounding or unseating, and to limit demands on bearings, expansion joints, rails and other components that cross the isolation interface. Models of bridge and elevated railway structures with advanced bearing models and contact interface will be used to examine the structural response sensitivity in terms of isolation gap and isolation system modeling parameters.

**Deliverables**
The results of this project will be published in a PEER report, conference, and journal papers to describe the seismic isolation bearing models and impact models for bridges, methodology of the research, and results from the simulations. The bearing models and impact models will be available in OpenSees software.

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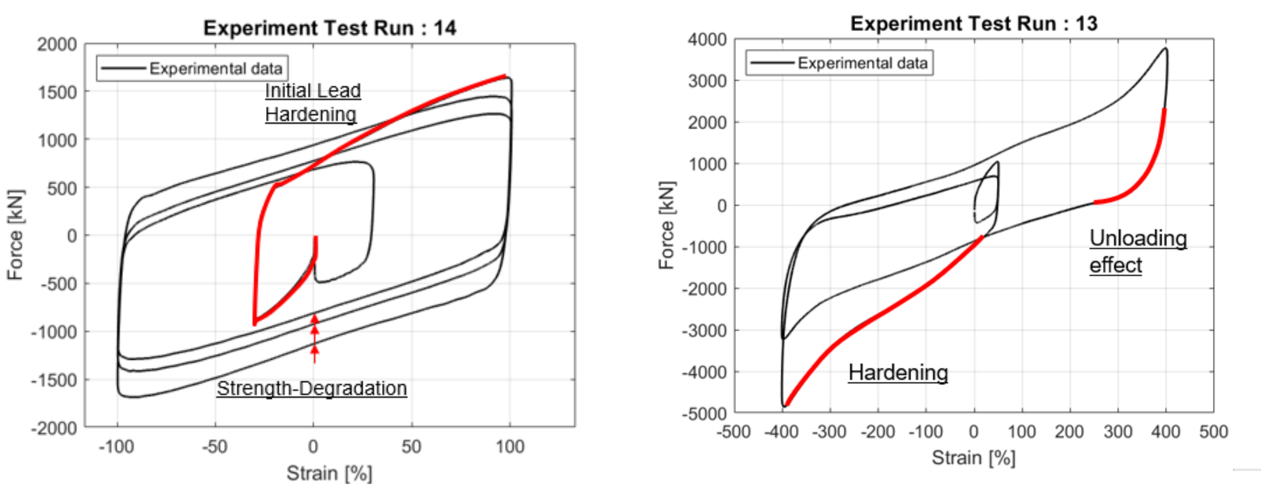
**Research Impact**
PBEE for the evaluation of new and existing seismically isolated transportation infrastructure considering beyond design basis earthquakes will require more accurate modeling of bearing models for prediction of isolator displacements and assessment of failure modes including pounding or deck unseating. Past studies for seismically isolated structures have mainly considered the response for design level shaking for which simplified bearing models are adequate. In light of recent studies demonstrating unacceptable risk of collapse for seismically isolated buildings designed to current standards, the probability of failure of isolated transportation infrastructure needs to be further investigated. These structures require high confidence in seismic responses given the low level of redundancy that makes them vulnerable to modeling uncertainty. Large displacements at expansion joints are of concern while pounding between decks or deck to abutment and unseating has been cited as a major source of damage to bridges leading to catastrophic failure. Further, restrainers and deck pounding can result in a large transfer of forces between decks and/or substructure, negating the isolation effect. State of the art models of seismically isolated bridges and elevated rail considering the isolation system behavior is necessary to capture these potential failure models. This study will focus on modeling of LRB including restrainers and contact models for the consideration of pounding. Complete bridge and elevated railway models will be developed to assess the reliability of seismically isolated transportation infrastructure under extreme shaking and propose effective mitigation measures.

**Project Image**




Nonlinear behavior in LRB experimental tests: lead initial lead hardening and strength degradation, rubber hardening and unloading effects