Research Project Highlight

Effects of Reinforcement Characteristics on the Response and Stability of Elastomeric Isolation Systems

Project # NCTRDK

Principal Investigator
Dimitrios Konstantinidis, Associate Professor, University of California, Berkeley

Research Team
Eduardo Montalto, Graduate Student Researcher, University of California, Berkeley

Start-End Dates:
02/01/25 - 01/31/26

Abstract
Elastomeric seismic isolators are used extensively as earthquake protective devices to enhance the resiliency of buildings and infrastructure. To evaluate the performance of these structures, it is necessary to accurately characterize the limit states of the isolation devices, including shear failure and lateral instability. Although the instability limit state under lateral deformation has been previously studied, no rational formulation is available to predict it. The proposed research aims to improve the prediction of the response and limit states of elastomeric isolators under the combined action of vertical and lateral loading, specifically by accounting for the effects of steel reinforcement bending. This will be achieved through component (Phase 1) and system-level shake table (Phase 2) testing and complemented by high-fidelity numerical simulations. The objectives of the research are to: (1) quantify the effect of steel shim thickness on the critical loads of elastomeric isolators under different levels of lateral deformation, (2) develop enhanced analytical formulations for the lateral response and stability limits of elastomeric isolators that account for reinforcement flexibility and avoid the issues of excessive conservatism or the lack thereof inherent in current ad hoc approaches, (3) provide design recommendations for the steel shims to ensure satisfactory performance under large deformations, and (4) validate a recently developed macroscopic model that, among other effects, accounts for the reinforcement behavior, and implement this model in the OpenSees platform. The experimental campaign will be conducted at PEER's facilities at UC Berkeley. Test Phase 1 will utilize the bearing testing machine that is currently being configured at PEER, and Test Phase 2 will make use of the shake table. The project will benefit from a significant in-kind donation of 15 rubber bearings by Dynamic Isolation Systems.

Deliverables
As outcomes of this project, we will produce a PEER report and several conference and journal papers that detail the research accomplishments. The experimental and numerical results will be utilized to develop analytical formulations that describe the mechanical response and stability of rubber bearings under lateral deformation, with a specific emphasis on the impact of steel shim bending. Additionally, design recommendations will be proposed based on these findings. The validated model will be

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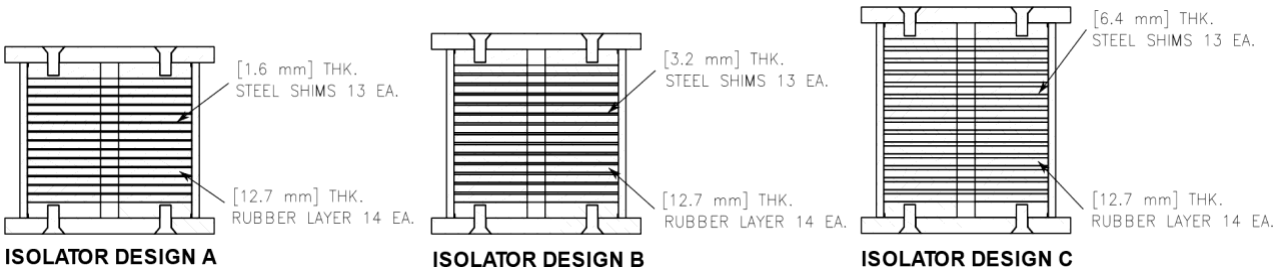
implemented in the OpenSees platform, accompanied by comprehensive documentation to facilitate its application.

Research Impact

The outcomes of this research are expected to significantly influence engineering practice, enhancing both design and analysis procedures. The analytical formulations developed for predicting the coupled lateral-vertical response will be used in preliminary design to more accurately estimate isolation displacements. Additionally, the analytical formulation to estimate the instability limit state will play a crucial role in assessing isolator stability, a key design consideration for these devices, both at preliminary and final design stages. The numerical model, once implemented in OpenSees, will facilitate more accurate response history analyses, particularly when axial load effects in the isolators are expected to be significant. Moreover, design recommendations for steel shims will allow their design to account for their response under large compressive loads at large lateral deformations, which is currently neglected in practice due to the lack of design criteria. The PI's role on ASCE 7's Seismic Subcommittee and Task Committee on Seismic Isolation will enable a pathway for integrating this study's recommendations into practice.

Project Image



Schematic drawings of the three isolator designs

PEER Center – 325 Davis Hall, UC Berkeley, CA 94720 | peer_center@berkeley.edu