Steel bridge bearings are widely used in existing highway bridges in the United States to provide a load transfer mechanism and accommodate movements between the superstructure and substructure. These bearings include steel rocker (expansion) bearings and steel bolster (fixed) bearings. Steel rocker bearings accommodate both translation and rotation of the superstructure, while steel bolster bearings only permit rotation of the superstructure under vehicle braking and thermal actions. Due to a lack of regular maintenance, the in-situ condition of these steel bearings, which have typically been in service for several decades, is often severely corroded. Moreover, these steel bearings are not designed for seismic loads due to a lack of understanding of the seismic hazard posed to bridges in the Central and Eastern United States (CEUS) at the time that many of these bridges were built. As awareness of their susceptibility to corrosion and vulnerability to seismic loads increases among bridge owners and engineers, the seismic performance of steel bridge bearings and their influence on the overall bridge system performance is of major concern, particularly given the importance the highway network plays in providing safe transportation and sustaining economic prosperity. For this reason, the goal of this study is to correlate corrosion level with the performance of steel bearings under seismic loads, thereby providing a means of more accurately assessing the vulnerability of in-situ bridges.

An analytical and finite element study is first undertaken to gain a preliminary understanding of the deformation modes, stiffness, and strength of the considered steel bearings. Corrosion loss quantification and large-scale experimental testing are then conducted on 25 salvaged steel bridge bearings aiming to provide an in-depth understanding of corrosion loss distribution and its influence on the cyclic behavior of steel bearings. Cyclic behavior of steel bearings is experimentally derived for two orthogonal loading directions, allowing for performance assessment of highway bridges under bidirectional seismic excitation. Further, a portfolio of constitutive models that incorporate corrosion effects is created for the steel bridge bearings based on the experimental findings. The seismic performance of the steel bearings and the bridge systems is then numerically evaluated considering two suites of ground motions, a design basis earthquake suite and a maximum credible earthquake suite. The bearing models and simulation results provide a quantitative understanding of how existing highway bridges using steel bearings perform under seismic loads.

Overall, the findings of this study show that significant corrosion can develop on steel bearings over their service life, which can result in major changes to the cyclic behavior of steel bearings with respect to deformation mode and failure pattern. The seismic bridge simulations show that corrosion has limited impact on the overall bridge performance. However, a maximum credible earthquake can cause extensive damage to the bridge components, including the steel bearings.