Research Project Highlight

System Level Performance Evaluation of Earthquake Resilient Bridges Using Hybrid Simulation

Project # NCTRKA

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Start-End Dates:
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Abstract

In order to complement and extend the previously conducted research on resilient bridge columns, seismic performance of complete, full-scale bridge systems with resilient columns is investigated in this project using the hybrid simulation (HS) approach. HS tests of a single column, single bent overpass bridge with two spans (refer to *Project Image Part* (*a*)) will be conducted for the two configurations of the bridge: (a) with a conventionally designed reinforced concrete column following Caltrans SDC and AASHTO specifications, and (b) with a resilient dual shell rocking column post-tensioned with a high strength bar. In the conducted HS tests, the columns will be simulated as the experimental substructure, while the remainder of the bridge will be simulated as the analytical substructure. HS tests will be performed using three directional ground motions

In order to capture the interaction of the tested column and the modeled bridge superstructure in the most possible accurate manner, the test setup will control four (two translational and two rotational) experimental degrees of freedom (DOF) as shown in the *Project Image Part* (*b*). Four horizontal actuators, specially arranged as shown in the *Project Image Part* (*b*), will be used to control these four DOF. Meanwhile, two vertical actuators will be used to apply the axial force that varies as a result of the gravity loading, the vertical component of the earthquake excitation, and the overturning moments due to the horizontal earthquake components.

The conducted tests will be used to tune analytical models that will in turn be utilized in the context of performance based earthquake engineering (PBEE) for the considered prototype and similar bridges. The HS tests and consequent analyses are expected to provide valuable insight into the seismic response enhancement of California bridges due to the use of the resilient dual-shell rocking column.

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Deliverables

A PEER report and several conference and journal papers describing the pre-test analyses, conducted HS, results of the HS, post-test analyses and demonstration of the PBEE methodology.

Research Impact

Highway bridges in California constitute one of the most important components of the transportation system. Proper functioning and operation of these bridges are essential for resiliency of the California communities as well as for purposes of post-earthquake recovery. Conventional CALTRANS bridge design philosophy is based on preventing any damage to the deck, cap beam, joints, etc., while dissipating the energy due to ground motion through inelastic ductile response of the bridge columns.

Although this approach is useful to prevent significant damage or collapse of the bridges, it involves risks affecting the resilience and post-earthquake recovery because of the need to close the bridge for traffic for potential column repairs. Furthermore, the presence of residual drifts at the end of inelastic response introduces challenges for the repair operations, which may increase the downtime and monetary losses. For increasing the highway bridge resilience, research has been conducted in recent years, which consist of the development of damage-resistant, re-centering column designs (referred to as resilient columns), and evaluation of these designs with quasi-static and shaking table tests. Although these experiments provided valuable information on the performance of the developed designs and their corresponding response enhancement, the obtained results were limited to the local column level and did not include the investigation of a complete bridge that contains these resilient columns (i.e. without consideration of the response of the entire bridge system and the interaction of the resilient column with the remainder of the bridge).

The conducted system level HS tests and the accompanying PBEE are expected to complement the previous and ongoing research efforts on resilient columns and extend the outcome of such research to resilient bridges and transportation systems.

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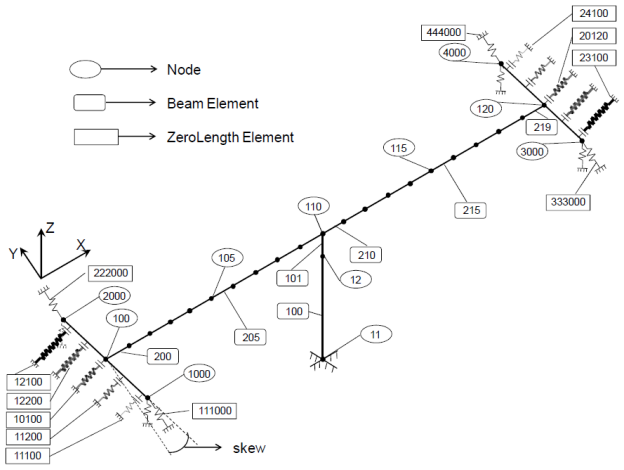
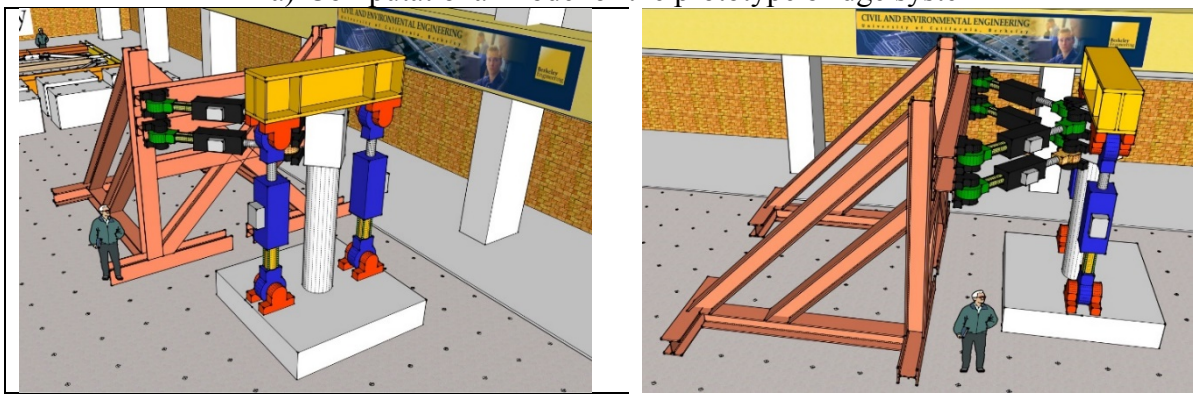
Project Images



a) Computational model of the prototype bridge system



b) Setup for a single column bent (Element 100 above) as a physical substructure in the HS

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