DEVELOPMENT AND IMPLEMENTATION OF A TESTING FACILITY FOR REAL-TIME HYBRID SIMULATION WITH A NONLINEAR SPECIMEN

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ABSTRACT

Real-time hybrid simulation (RTHS) has demonstrated certain advantages over conventional large-scale testing. In an RTHS, the system that is under study is partitioned into a numerical and a physical substructure, where the numerical part is comprised of those elements that are easier to model mathematically, while the physical part consists of those that present a complex behavior difficult to capture in a numerical model. The less complex part of this study is the isolation system, a technology used to protect structures against earthquakes by modifying how they respond to ground motions. Unbonded Fiber Reinforced Elastomeric Isolators (UFREIs) are devices that can accomplish this task and have gained attention in recent years because of their modest but valuable features that make them suitable for implementation in low-rise buildings and in developing countries because of their low cost. Our end goal for this work is to enable the testing of scaled versions of these elastomeric isolators to understand their behavior under shear tests and realistic loading.

A testing instrument was designed and constructed to apply a uniaxial compressive force up to 22kN and a shear force of 8kN simultaneously to the specimens. A testing program was conducted where four primary sources of signal distortion were identified as caused by the servo-hydraulic system. From these results, a mechanics-based model was developed to understand better the dynamics that the sliding table can introduce to the measured signals accounting for inertial and dissipative forces. Two Bouc-Wen models were implemented to simulate the behavior of the UFREIs. The first only accounts for the hysteretic behavior of the isolator, and the second accounts for the additional nonlinearities found in the isolator's behavior. These models were assembled in a virtual RTHS which is available to users interested in learning the applications of RTHS of a base-isolated structure with a nonlinear component.

An RTHS experiment was conducted in the IISL where the control system comprised a delay compensator and a proportional-integral controller, which exhibited a good tracking performance with minimal delay and low RMSE. However, it can increase the distortion of the oil-column

resonance in the measured signals. The simulation captures the behavior of the isolated structure for small displacements for large displacements. However, it underestimates the displacement of the full-scale specimen. The RTHS showed a better approximation of the displacement of the full-scale structure than the theoretical behavior approximated by the Bouc-Wen models.