ABSTRACT

Castaneda Aguilar, Nestor E. Ph.D., Purdue University, December 2012. Development and Validation of a Real-time Computational Framework for Hybrid Simulation of Dynamically-excited Steel Frame Structures. Major Professor: Shirley Dyke.

The use of traditional techniques such as the shake table or the pseudo-dynamic (PSD) test are often used to validate and disseminate new technologies associated with structural response attenuation. At full-scale, the ability to perform such tests on realistic structures is limited. Real-time hybrid simulation (RTHS) offers an economical and reliable methodology for testing integrated structural systems with rate dependent behaviors. Within a RTHS implementation, critical components of the structural system under evaluation are physically tested, while the more predictable ones are replaced with computational models. Real-time execution, or performing the test with a one-to-one time scale, ensures that the tests yield more realistic responses. As a result, RTHS implementations provide an alternate approach to evaluating structural / rate-dependent systems under actual dynamic and inertial conditions, without need for full-scale structural testing.

One significant challenge for successful RTHS is the availability of robust and reliable simulation tool to accurately represent the physical complexities within the computational counterparts. Accurate computational models are required to ensure compatibility, stability and adequate synchronization between both computational and experimental substructures during testing. In this dissertation, the RT-Frame2D tool is proposed. The development, implementation and validation of this open source real-time computational platform, intended for the hybrid simulation of dynamically-excited steel frame structures is presented.

The computational platform is designed to recreate common sources of nonlinear behavior in steel frame structures, with adequate modeling and integration schemes to enable its flexible implementation within a typical RTHS platform. Through a series of numerical and experimental studies of typical RTHS scenarios, the capabilities of the tool are demonstrated evaluated and validated.