Real-time-hybrid-simulation of multi-degree-of-freedom systems with multiple time steps

Lanxi Liu and Arun Prakash

School of Civil Engineering, *Purdue University*, *West Lafayette*, *IN 47906*, *U.S.A.*

ABSTRACT

Computational simulation and physical experiments are both widely used in testing the response of a structure under earthquake loadings, but physical experiments can be expensive for large problems and numerical may result in the loss of important structural behavior caused by a large amount of assumptions. Real-time hybrid simulation (RTHS) is a combination of these two approaches, which uses both a numerical and physical substructures that interact in real time to simulate structural behavior. The numerical and physical substructures are connected using a transfer system that enforces compatibility between them. The physical substructure needs to be run at a very high frequency (usually 1024 Hz) to ensure stability. This necessitates the numerical substructure be also computed at a correspondingly small time-step (1 millisecond). This research develops a method to speed up the numerical computation and enables the use of larger, more realistic numerical models within RTHS. The numerical substructure is split into multiple parts each solved at a different time-step, then coupled back together to obtain the global RTHS response. The portion closest to the experimental substructure is solved at a smaller time-step that meets the 1-millisecond limit, and the remaining portion is solved at a larger time-step. Multi-time-step RTHS is compared with single-time-step RTHS, in terms of the numerical error and computational time. This approach is shown to preserve accuracy of the computed result while meeting real-time constraint for RTHS computation. The current approach enhances our ability to study important structural dynamics with advanced numerical models.