INVESTIGATION ON THE EFFECT OF SERVOVALVE/ACTUATOR DYNAMICS ON FAST HYBRID TESTING

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Hybrid simulation technique has been widely used to study the seismic response of structures [1]. During a hybrid test, the equation of motion of the test structure is solved incrementally to determine the story displacements with respect to the ground for a given earthquake excitation. Hydraulic actuators are used to apply the calculated displacements to the structure. The restoring forces are measured by the actuator and used to calculate the next set of incremental story displacements. Hybrid tests have been performed majorly in pseudo-dynamic fashion such that dynamics of test specimen (i.e., the structural component being physically tested) and testing equipment may be ignored.

To study the behavior of structures employing strain-rate critical components or structures utilizing velocity dependent devices (i.e., semi-active or passive damping devices), the displacement should be applied to the structure in real-time or in near real-time during a hybrid test. When the test is conduced in real time, servo-systems (i.e., servovalve and actuators) can have a significant influence on the performance of dynamic displacement-controlled testing such as real-time hybrid testing [2]. For example, the actuator response delay can significantly aggravate the test accuracy, and even cause instability of the test system; the servovalve controller setting can be limited by the size of the structure mass, which in turn may limit the dynamic performance of the testing system. Although the effect of servo-systems on real-time dynamic tests in displacement control has been investigated [3], such impact on near real-time (fast) hybrid testing has not been systematically investigated.

This paper presents the latest progress in system modeling of dynamic testing in displacement control such as fast hybrid testing. Mathematical models in reference [4] are used to explore the effects of servo-systems on the overall test system. New models are developed to simulate the delay required in fast hybrid testing, which is in addition to the servo-system response delay in real-time dynamic testing. System dynamics including the servo-system dynamics are analyzed to predict the impact of various delays during a hybrid test. A compensation for servo-system response delay is proposed and verified using computer simulation. Guidelines are proposed for sizing servo-hydraulic equipment for fast hybrid testing and for choosing suitable specimens and loading speeds for a certain set of testing facility.

References

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