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A RECURRENT SWITCHING TECHNIQUE FOR ENERGY DISSIPATERS IN HIGH DAMPED STRUCTURAL SYSTEMS

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ABSTRACT

In some new approaches in seismic design of structures large energy dissipaters are needed to reduce lateral deformation of the system. Mass Isolation is one of these approaches in which damping devices are located in between two parts of a structural system with far apart natural frequencies (Yuji et al., 2004). In this approach behavior of the system subjected to lateral excitation is unduly dependent on the characteristics of energy dissipaters. Using nonlinear viscous dashpots or active controllable ones are considered typical approaches to improve damping characteristics of such systems (Ziyaeifar, 2002; Ziyaeifar et al., 2012). In this work, a recurrent switching technique for energy dissipaters in mass isolated systems is proposed that can be used for active and passive devices (viscous or frictional) to improve their effectiveness in reducing structural responses during lateral excitation.

METHODOLOGY

In mass isolation technique damping devices are located between two separate parts of a structural system. The first part is a flexible subsystem that carries the main part of the system mass (Mass Subsystem) and connected to the second part of the system (Stiffness Subsystem) using large energy dissipaters.

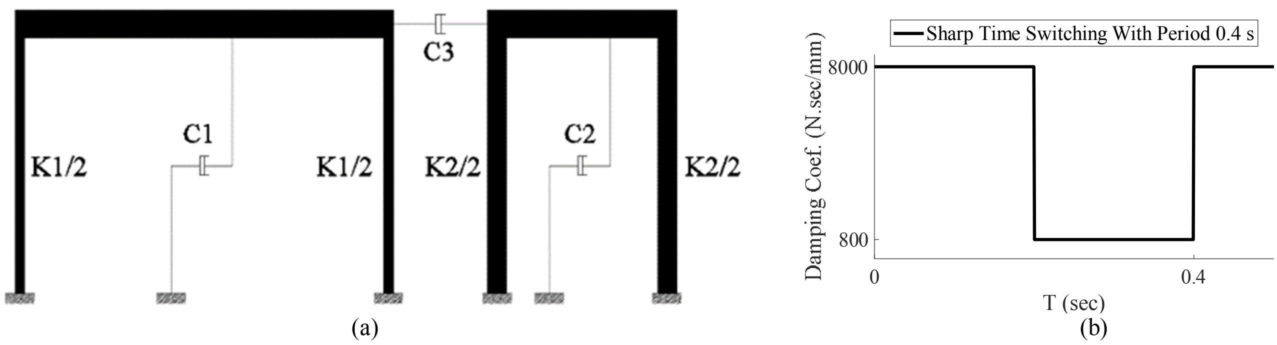

Figure 1. (a) Mass isolation model, (b) recurrent switching method.

To reduce lateral force and deformation of the Stiffness Subsystem, it is decided to transform dashpot reaction forces to a high frequency pulse type recurrent load process to add to the acceleration of this subsystem and mobilize its inertial forces. The inertial forces come in balance with reaction forces of dashpot and reduces the level of lateral force on the Stiffness Subsystem. This idea has already been used in a wide range of mechanical equipment such as Jackhammers and Impact-drills to reduce their handling forces. A simple example on reduction in reaction forces in case of recurrent loading is the single degree of freedom system subjected to harmonic loads in which dynamic magnification factor for its steady state response in case of high frequency excitation is always much less than unity (Clough & Penzien, 2003).

In this work, a simple model for mass isolation approach is used to verify this notion. The model, shown in Figure 1-a, is consisted of a soft Mass Subsystem (left figure) with natural period of 2.0 second and a Stiffness Subsystem with the natural period of 0.2 second (right figure).

The subsystems are connected together by a viscous device that is capable of going through recurrent switching in its damping constant C3 (from 10% till 100% of its capacity in sharp or sinusoidal steps as shown in Figure 1-b). The model has gone through time integration analyses subjected to different earthquake records in terms of damping constant C3 (from 0.0 till 25000 N.s/mm) and recurrent switching periods (from T = 0.01 s up to T = 0.4 s).

RESULT AND CONCLUSION

The results of time integration analyses for sharp switching steps in terms of maximum displacement for mass and Stiffness Subsystems are shown in Figure 2. According to this figure, recurrent switching can substantially reduce structural responses with respect non-recurrent passive systems.

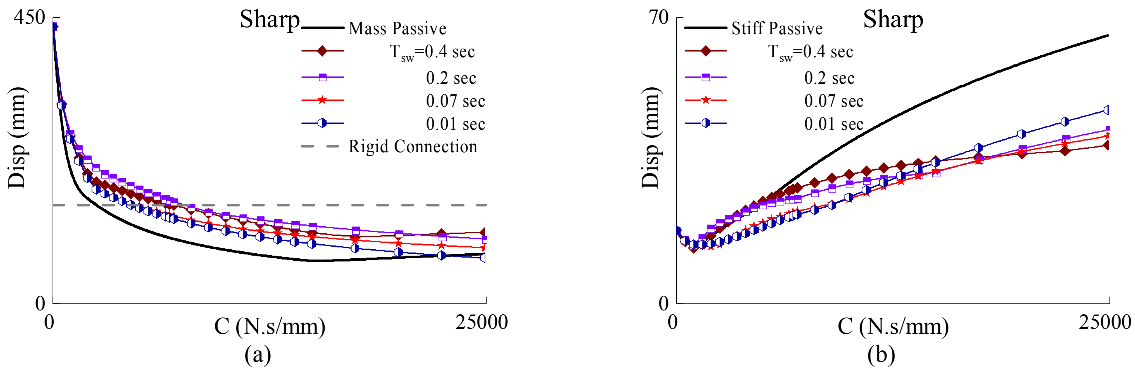

Figure 2. Maximum responses of Mass and Stiffness Subsystems.

By using recurrent switching dampers, the displacement of the Mass Subsystem is increased compared to those in non-recurrent passive state, but the amount of this rise is negligible. In addition, the sensitivity of the structural behavior on the input acceleration time history decreases, and the damping switch speed does not significantly affect the displacement of the structure. Moreover, no significant difference between the various switch speeds was observed.

In this work, further investigations on other parameters such as structural acceleration and damping force have not been made for brevity. After examining all the results, several optimal points can be determined according to the expected structural requirements.

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