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MODAL ENERGY TRANSFER IN LARGE STRUCTURAL SYSTEMS USING RECURRENT SWITCHING TECHNIQUE

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ABSTRACT

Improving damping characteristics of large structural systems is usually based on using a massive number of energy dissipater devices (Soong, 1990). However, in case of providing higher relative movement among different parts of a structural system, reduction in the number of such devices in the structural systems is conceivable. Mass isolation technique is a seismic design approach in which a high damped structural system in consisted of a structure divided into two subsystems connected together with a few number of energy dissipaters (Ziyaeifar, 2002; Ziyaeifar et al., 2012). Moreover, since in this approach damping devices are located in between two massive subsystems, there is a possibility of reducing reaction forces of dashpots using recurrent switching techniques that deploys inertial forces to provide balance for the system.

In this work it is decided to improve the efficiency of recurrent switching technique by adapting the dashpot switching frequency with that of the natural frequencies of higher modes of the system. In this case it would be possible to dissipate a part of earthquake input energy in the modes that are not considered effectual in critical responses of the structural system.

METHODOLOGY

In a six story Mass isolated structure shown in Figure 1-a, the recurrent switching technique shown in Figure 1-b is used for the linear viscous dashpot (designated by letter C in the same figure) that connects the two subsystem together at their tops. Natural periods of the stiffness subsystem are very short (0.2, 0.07, 0.042, 0.031, 0.026, 0.023). For the Mass subsystem natural periods are about ten times of the stiffness subsystem.

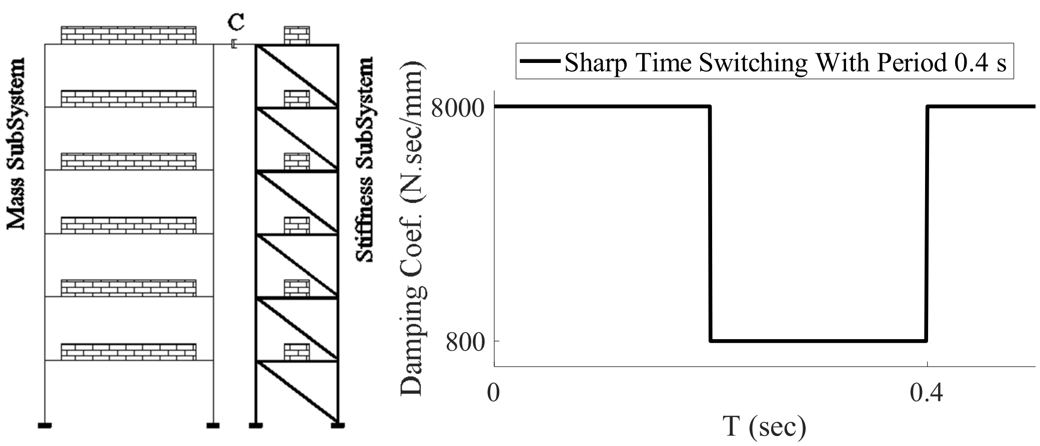

Figure 1. A six story Mass isolated structure (a) and recurrent switching method (b).

In recurrent switching technique damping constant of dashpots continually changes sharply between its maximum and minimum limits, as shown in Figure 1-b for the switching period of 0.4 sec, to mobilize inertial forces in the system and reduce the level reaction loads on the dashpot. Energy dissipation potential of the system in this case can be improved by choosing a switching frequency for the dashpot that can stirs up the higher modes of the stiffness subsystem (for example, modes 2 and 3 with natural periods of 0.07 and 0.042 seconds). In this investigation the mass isolated model has gone through time integration analyses subjected to different earthquake records in terms of damping constant C (from 0.0 till 25000 N.s/mm) and recurrent switching periods of T=0.4, 0.07, 0.042 and 0.01 seconds. The switching period of T=0.4 second matches with the natural period of the third mode of mass subsystem and switching periods of T=0.07 and 0.042 are targeting the second and the third modes of the stiffness subsystem.

In this paper, the recurrent stitching approach is used for energy transfer between vibrational modes of the system. In the accompanying paper, the same recurrent switching technique is used to mobilize inertial forces of a part of the system to counteract the reacting of dashpots.

RESULT AND CONCLUSION

Using this method, stimulating the higher modes of the system reduces the structural responses for the first modes of both subsystems. This in turn, reduces the displacement and force responses of both subsystems (considering all their modes) as shown in Figure 2. However, this approach has negative effect on acceleration responses of the structure due to mobilization of inertial force in the system and excitation of its higher modes. This phenomenon is mostly attributed to the modal energy transfer in the system due to recurrent switching in a designated frequency target.

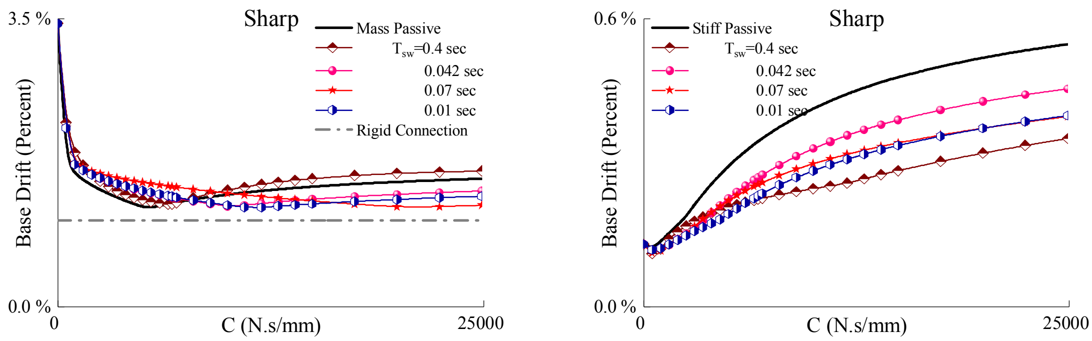

Figure 2. First story drift in terms of switching period a) Mass subsystem, b) Stiffness subsystem.

Using this switching technique in seismic design of structures can be based on using semi active devices with feedback control algorithm or in a more practical passive type approach with a trigger type switching apparatus.

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