Study of a new hysteretic damper for control against earthquakes and a new visco-plastic damper for control against earthquakes and low-amplitude excitations

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Two new hysteretic and hybrid hysteretic-viscoelastic (visco-plastic) dampers with axial performance have been developed in this research for control of structures. A set of rectangular yielding plates has been considered as the energy dissipating part for the first device. For the other damper, two viscoelastic layers are added to this configuration to make the system to be effective in control performance against low-amplitude excitations as well as high-amplitude motions. Both dampers are configured in such a way that can provide the loading conditions as pure-bending for the yielding part during cyclic motions based on a flexural yielding mechanism. The dissipator part is placed into a steel surrounding rigid box which has only one sliding translational degree of freedom along its longitudinal axis. Accordingly, the devices can perform as tension/compression pistons with sufficient stability in other directions. The proposed devices can be used in various types of structural systems such as moment-resisting or braced frames and even coupled shear wall systems with the capability of dual or multiple-installation in each frame bay. In this research the hysteresis behavior of these damping devices has been numerically and experimentally investigated. Then as a parametric study, the effects of various design parameters on the damper hysteretic behavior were studied. According to observed results, the proposed damping systems exhibit high-capacity and energy dissipation capability at low-values of story drifts. Moreover, the physical specimens experiencing ductility values from 15 to 38 during the tests, exhibit a broad range of ultimate capacity from 23 to 245 kN. Overall, the dampers are found to have nonlinear behavior with consistent strain hardening and preserve their stability and performance during a large number of consecutive cyclic motions. Moreover, the control performance of the developed dampers have been analyzed at the end of this study considering four 5, 10, 15 and 20-story buildings against sever earthquakes as well as low-amplitude excitations. The observed results showed that the maximum seismic response of the analyzed structures is averagely decreased by 61, 55 and 70 percent for maximum lateral drift, maximum shear force and residual drift, respectively for stories. In the case of low-amplitude excitations, a response reduction averagely equal to 85 and 70 percent was observed for maximum lateral drifts and shear forces of stories. Overall, the dampers exhibit a high-level of performance and effectiveness in structural control against sever earthquakes and low-amplitude excitations.

Keywords: Passive control, hysteretic damper, viscoelastic layers, visco-plastic damper, pure-bending yielding mechanism, sever earthquake, low-amplitude excitation.