

12th National Conference on Earthquake Engineering
Salt Lake City, Utah
27 June - 1 July 2022
Hosted by the Earthquake Engineering Research Institute

Practical force-limiting deformable connections in buildings with rocking base mechanism and limited higher-mode responses

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ABSTRACT

Buildings with lateral force resisting systems that have base rocking mechanism (e.g. precast post-tensioned rocking shear walls, self-centering special concentrically braced frames) or base flexural yielding mechanism (e.g. reinforced concrete shear walls) can develop floor accelerations and force responses with large magnitude even though they have limited first mode response. High floor accelerations and force responses are primarily developed due to the contribution of the second and higher mode responses in the dynamic response of these buildings. Practical force-limiting deformable connections between the floor-diaphragms of a flexible gravity load resisting system and the stiff vertically-oriented lateral force resisting systems with rocking base mechanism or flexural yielding base mechanism have been developed to reduce the seismic-induced horizontal floor accelerations and force responses of these buildings [1-7]. The force-limiting connections consist of limited-strength load-carrying hysteretic components (friction devices or buckling-restrained braces) and low damping rubber bearings. Full-scale experimental tests validated the force-deformation response of the components of the force-limiting connections. Experimental and numerical research validated the dynamic response of buildings with rocking base mechanism and force-limiting connections. More specifically, shake-table tests of a half-scale, four-story precast rocking shear wall building show that the force-limiting connections can limit the seismic response of the building and potentially minimize the damage of structural and non-structural components. Results from numerical simulations of a nine-story self-centering special concentrically braced frame building model subjected to design basis earthquake ground motions show that the use of force-limiting connections reduces the brace forces, connection forces, and floor total accelerations. The dispersion of the brace forces, connection forces, and floor total accelerations in the nine-story building model with force-limiting connections are significantly reduced compared to the brace forces, connection forces, and floor total accelerations for the nine-story building model with rigid-elastic connections. The use of the force-limiting connections enhances the reliability of the building against earthquakes by reducing the sensitivity of building's structural response to the variations of the characteristics of the earthquake ground motions. The nine-story building models with force-limiting connections have story drifts similar to those of the nine-story building model with rigid-elastic connections.

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Tsampras G., Sause R., Fleischman R. B., Restrepo J. I., Nema A., Zhang Z., Practical force-limiting deformable connections in buildings with rocking base mechanism and limited higher-mode responses. *Proceedings of the 12th National Conference in Earthquake Engineering*, Earthquake Engineering Research Institute, Salt Lake City, UT. 2022.

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