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SEISMIC FRAGILITY ASSESSMENT OF STEEL STRUCTURES WITH HYBRID YEILDING RING DAMPER

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Seismic resilience-based design of structures is an emerging field in earthquake engineering. Low-damage structural systems with the ability to reduce the structural and non-structural damages are candidates for these purposes. Among the various proposed low-damage systems, structural steel frames with ring metallic dampers capable of dissipating the seismic input energy in a fuse part through yielding are proved to be acceptable low-damage seismic resisting systems (Mansouri et al., 2016; Andalib et al., 2018).

This paper investigates the seismic fragility of steel frames equipped with a recently proposed dual-performance energy dissipating system known as dual-performance ring damper (Moaddab & Tizhoosh, 2018; Zahrai & Cheraghi; 2017, Cheraghi & Zahrai; 2017). The dual performance damper called TRYD (three ring damper) had been developed to absorb and dissipate seismic input energy at different levels of ground motion intensity. Proposed system is composed of a main fuse to dissipate energy at high-level drift demands encountered in severe earthquakes and an auxiliary fuse to control the responses at lower drift demands normally occurred in moderate earthquakes. The hybrid damper is basically a displacement-dependent device which dissipates seismic energy by yielding of outer and inner rings.

This paper first develops and compares the fragility curves of 3-, 9- and 20-story steel structures equipped with both common ring damper (Andalib et al., 2018) and TRYD dampers by considering the three Engineering Demand Parameters (EDPs), namely Peak inter-story drift ratio (PIDR), peak floor acceleration (PFA) as well as peak residual inter-story drift ratio (PRIDR) utilizing a large set of strong ground motions composed of 22 records scaled to maximum considered earthquake (MCE) intensity level.

This paper dealt with the comparative seismic fragility assessment of 3-, 9- and 20-story steel moment resisting frames equipped with dual performance level ring dampers (TRYD) and conventional ring dampers using statistical and probabilistic analysis of nonlinear time-history analyses outputs under a large set of ground motion records scaled to MCE-level intensity. Results showed remarkable reduction in two important engineering demand parameters (EDPs) including the peak inter-story drift ratio (PIDR) and the peak residual inter-story drift ratio (PRIDR) for systems equipped with D-TADAS dampers in contrast to the conventional ring dampers. All the above enhancements stem from improvements in strength and hysteretic energy dissipation characteristics of the device and its intrinsic low stiffness degradation. Evaluation of the fragility curves showed, on average, 30% reduction in PIDR and 55% reduction in PRIDR. Reduction in PRIDR was more pronounced for short-period models than the medium- and long-period models. Slight reduction in peak floor acceleration (PFA) was observed for the medium- and long-period models. Statistical hypothesis tests showed that the above-mentioned reduction occurred only in mean values (or equivalently, in median values). In other words, the record-to-record variability of responses did not show reduction by replacing ring dampers with TRYD ones and even some increase in dispersion of results was observed for the PRIDR values. Results of this study demonstrate that TRYD equipped buildings are more seismic resilient compared with ring equipped buildings.

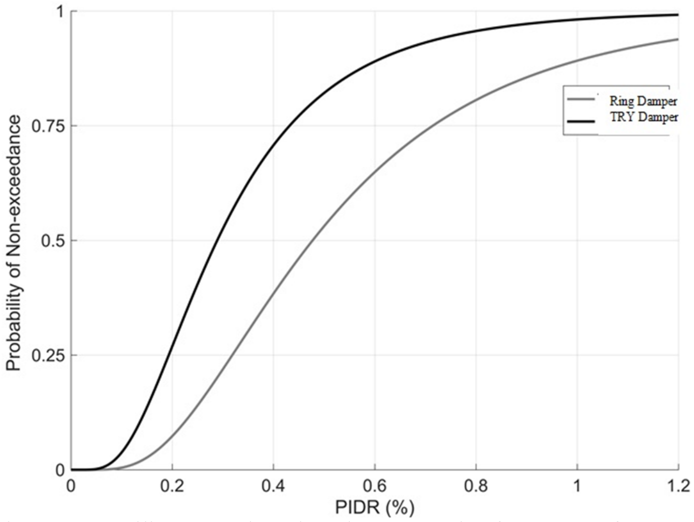

Figure 1. Fragility curves based on the PIDR value for 9-strory frame.

Table 1. Lognormal CDF fit parameters extracted from the PIDR values: (a) Ring damper, (b) TRY damper.

(a) Ring damper					
Model	θ_{PIDR}(%)	β_{RTR}	β_c	β_q	β_{tot}
3-story	0.4474	0.5350	0.10	0.25	0.60
9-story	1.1030	0.5351	0.10	0.25	0.60
20-story	1.7618	0.5349	0.10	0.25	0.60

(b) TRY damper					
Model	θ_{PIDR}(%)	β_{RTR}	β_c	β_q	β_{tot}
3-story	0.2889	0.5323	0.10	0.25	0.59
9-story	0.8787	0.5357	0.10	0.25	0.60
20-story	1.2156	0.5385	0.10	0.25	0.60

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