PERFORMANCE ASSESSMENT OF ISOLATED STRUCTURES WITH ADDED DAMPING

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In the last 20 years, seismic isolation and dampers have been very effective in the design of structures to mitigate seismic risk (Morgan and Mahin, 2011). The isolator drastically reduces the main frequency of the structure and subsequently lowers the acceleration of the floors. With high-velocity pulses and high displacement demands, many near field (NF) situations require impractical isolator bearing dimensions and designs. Consequently, supplemental damping is needed to reduce the horizontal displacement demands, otherwise structural integrity could potentially be jeopardized (Providakis, 2008). The combined isolation system of HDR or LRB with viscous dampers seems to work well in the NF regions. Unfortunately, this combined system does not perform desirably in moderate or strong FF events due to the secondary forces produced by the dampers and their complex coupling effects (Providakis, 2008), as well as the higher modes effects.

To address the problem stated above, the efficiency of providing different LRB systems for actual RC buildings, in combination with supplemental dampers, was investigated by many researchers. The response of this combined isolation action as well as the superstructure behaviour seems to be effective for NF ground motions (Alhamaydeh et al., 2013).

Lack of clear-cut method for selecting design parameters and the combination of these two systems and decision on how to reduce structural damage caused reluctance of clients to use these systems. Performance-based design provides a useful framework for developing the relationships among the characteristics of the ground motion, base-isolated structure and viscous damper and to evaluate the ability of design approaches to achieve targeted performance goals.

Performance-based earthquake engineering seeks to improve seismic risk decision-making through assessment and design methods that have a strong scientific basis and that express options in terms that enable stakeholders to make informed decisions. The methodology needs to be underpinned by a consistent procedure that characterizes the important seismic hazard and engineering aspects of the problem, and that relates these quantitatively to the defined performance metrics (Günay and Mosalam, 2012).The mathematical formulation for evaluating decision variables and providing decision support to the owner/user, considering uncertainties inherent in all parts of the process, is provided by the PEER framework equation (Zareian and Krawinkler, 2009).

Maximum Considered Earthquake (MCE) shaking has an annual frequency of exceedance of 1 in 2,500 or 4x10-4 per year. When integrated with the hazard curve, this typically results in an annual frequency of collapse. The collapse margin ratio, CMR, is the ratio of the median 5%-damped spectral acceleration of the collapse level ground motions, to the 5% damped spectral acceleration of the MCE ground motions at the fundamental period of the seismic-force-resisting system.

Case Study was performed on the 5-story perimeter steel resisting frame. ASCE 7-10 used for seismic design requirements for seismically isolated structures. The software Sap2000 is used for primary design. Frames contain three-bay 5 meters span and story height of 3.5 meters. According to FEMA P695, a set of 28 pairs of ground motions recorded at sites less than 10 km from fault rupture, referred to as the "Near-Field" record set is considered for analysis. Incremental dynamic analysis for NF accelerograms is done by OpenSees in 2D model. In Figure 1, the fragility curve for CP is shown for all 3 structures with lognormal distribution. CMR and mean annual frequency of collapse for earthquake with the probability of 1% in 2500 years, for models are shown in Table 1.

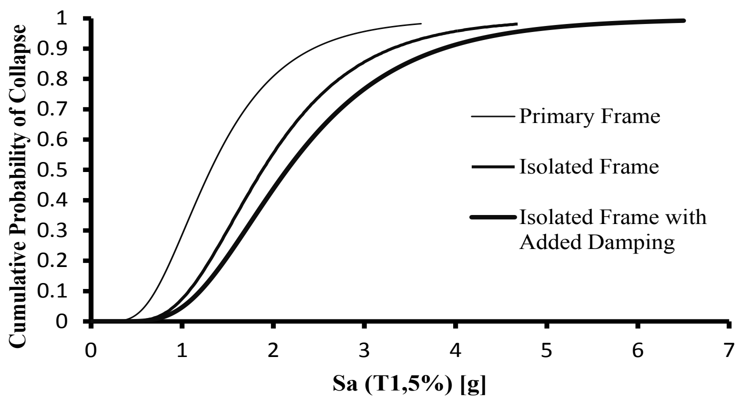

Figure 1. Collapse fragility curves for frames with lognormal distribution

Table 1. Collapse Margin Ratio (CMR) and Mean Annual Frequency of Collapse for MCE

All Cases	Primary Frame			Isolated Frame			Isolated Frame with Added Damping		
	Sa_{MCE}	λ_{MCE}	CMR	Sa_{MCE}	λ_{MCE}	CMR	Sa_{MCE}	λ_{MCE}	CMR
Results	0.465g	1.38E-5	2.385	0.289g	3.72E-9	6.528	0.226g	2.94E-10	8.26

Performance assessment presented in this paper, provides a good framework for evaluating structures containing isolator and viscous damper, to achieve the targeted performance goals. Hence, a framework was set and using performance parameters like: spectral acceleration for operational levels, mean frequency of exceedance of limit states, annual frequency of collapse, collapse margin ratio, performance evaluation for structures containing isolators and dampers was conducted. The offered method facilitates operational comparison among different structural systems. Studies showed that base isolated structure with added damping have better seismic performance comparably to base isolated structures regarding seismic demand and the CMR and mean annual frequency of collapse.

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