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DEVELOPMENT OF FRAGILITY CURVES FOR ASYMMETRICAL REINFORCED CONCRETE BUILDINGS EQUIPPED WITH VISCOUS DAMPERS

Mehdi SADEGHI AREF
Ph.D. Student, Islamic Azad University, Science and Research Branch, Tehran, Iran
arefmehdi458@gmail.com

Mohammad Reza MANSOORI
Assistant Professor, Islamic Azad University, Science and Research Branch, Tehran, Iran
m.mansoori@srbiau.ac.ir

Abdolreza SARVGHAD MOGHADAM
Associate Professor, IIEES, Tehran, Iran
moghadam@iiees.ac.ir

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One of the key and precise tools in determining the assessment of the seismic vulnerability of the structures is fragility functions. Many studies have been done on the seismic vulnerability of buildings, but further investigation is required for the fragility function of structures that equipped with dampers. The purpose of this paper is to determine the fragility functions and study the seismic vulnerability of asymmetric concrete structures with different distribution of viscous dampers and different damping ratios.

After performing incremental dynamic analyses for each earthquake records, the maximum values of drift are obtained in each model. After calculating the probability of exceedance of the limit states for each intensity level, the vulnerability curve was constructed by plotting the calculated data versus seismic intensity. Finally, a statistical distribution was fitted to these data points, to obtain the fragility curves which are representations of conditional probability indicating the probability of meeting or exceeding a level of damage under a given input ground motion intensity parameter. This conditional probability can be expressed as:

$$P(\leq D) = \Phi(\frac{Lnx - \lambda}{\zeta}) \tag{1}$$

where Φ is the standard distribution, x is the index of ground motion in the distribution of the normal log, λ is average, and ξ is standard deviation. Standard deviation for each performance level are calculated separately.

The fragility curves are presented in a group to make it possible to compare the different states of the damping distribution. In these curves, WOD means that there is no damper in the model, the WPUD is a state where the damper distribution in the form of a uniform planar and vertical distribution, the WVMD is a state in the model where the damper distribution is in the form of a uniform planar distribution but with a vertical distribution in accordance with the form of the first mode, and WPED means that the damper distribution is in the form of a uniform vertical distribution but the planar distribution has a damping eccentricity.

In all models, it was observed that the vertical damping distribution, in accordance with the form of the first mode, had a more effective role than the uniform vertical damping distribution in reducing the exceedance probability from a considered level of damage. In models with uniform planar mass asymmetry for all stories, the performance of the models that have a vertical damping distribution in accordance with the first mode and a uniform planar damping distribution is better while in models with non-uniform planar mass asymmetry in the stories, the performance of the model with a uniform vertical damping distribution with damping eccentricity is better.

In the case of the planar damping distribution, it was observed that the damping performance is very suitable in the planar damping distribution along with damping eccentricity, where the damping center is near the center of mass of the story. In addition, in general, the performance of the planar damping distribution along with damping eccentricity is better than that of the uniform planar damping distribution.

The dampers had a good performance at a maximum acceleration of 0.8 - 1.3 g for the immediate occupancy performance level in reducing the exceedance probability. The proper performance range for the life safety and collapse prevention performance levels was achieved at a maximum acceleration of 0.9 - 1.4 g and 1.2 - 1.4 g, respectively.

Finally, based on the conclusions that was presented in this paper, for low- and middle-rise buildings with different damping distributions, an attempt was made to estimate the fragility functions based on the number of stories, n and total damping coefficient, c (for ζ=15% and 25%).

Table 1. Development of the fragility functions for mass asymmetric models in different performance levels (n: number of stories and c: total damping coefficient (KN.sec/m) for ζ=15% and 25%).

Damping Distribution Type	Performance Level	Mean λ	Standard Deviation ξ
WOD	IO	0.042*n + 0.516	-0.001*n + 0.132
	LS	0.034*n + 0.739	-0.008*n + 0.022
	CP	0.017*n + 1.137	-0.002*n + 0.068
WPUD	IO	0.067*c*n + 5.39 *c	-0.021*c*n + 0.351*c
	LS	0.047*c*n + 6.032*c	-0.019*c*n + 0.295*c
	CP	0.055*c*n + 6.524*c	-0.009*c*n + 0.191*c
WVMD	IO	0.055*c*n + 5.704*c	-0.018*c*n + 0.317*c
	LS	0.024*c*n + 6.428*c	-0.017*c*n + 0.274*c
	CP	0.068*c*n + 6.692*c	-0.008*c*n + 0.185*c
WPED	IO	0.054*c*n + 5.621*c	-0.019*c*n + 0.327*c
	LS	0.035*c*n + 6.477*c	-0.018*c*n + 0.252*c
	CP	0.078*c*n + 6.555*c	-0.008*c*n + 0.183*c

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