SEISMIC FRAGILITY ESTIMATION UNDER ORTHOGONAL EARTHQUAKE EXCITATIONS

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Estimation of fragility functions using dynamic structural analysis is an important step in a number of seismic assessment procedures. This paper discusses the multicomponent seismic fragility curves based on beta distribution by considering the Iran–specific characteristics to manage the earthquake risk in the region. The seismic design of low- and mid-rise RC-MRFs are carried out according to the Iranian Code of Practice for Seismic Resistant Design of Buildings (Standard No. 2800), and the analytical models are formed accordingly in ZEUS-NL platform. A new optimal intensity measure (IM) called $S_{a,Avg}$ is used to obtain reliable fragility–based database for earthquake damage and loss estimation of RC buildings stock. Consequently, it's shown that including vertical ground motion in the analysis is highly recommended for reliable seismic assessment of RC buildings. Unfortunately, differences in structural characteristics cause significant deviations on damage and loss estimation by influencing the resulting fragility curves. The aim of this study is to provide fragility information to inquire effects of ground motion parameters and Iranian construction practice state on structural vulnerability in the presence of vertical component of earthquake. Structural deficiencies of RC buildings stock in Iran can be classified in three groups: Design deficiencies, detailing deficiencies and constructional deficiencies. To this end, three subclasses named Class1, Class2 and Class3 are considered in the current study, which Class1 has the lowest and Class3 has the highest seismic design criteria and construction qualities.

In order to consider the effect of vertical earthquake component, a procedure was originally proposed by Newmark et al. (1973) and has since been widely used in the seismic codes. It was suggested that the average peak vertical-to-horizontal spectral ratio could be taken as 2/3. This implies that the vertical-to-horizontal ratio is also 2/3 assuming constant amplification.

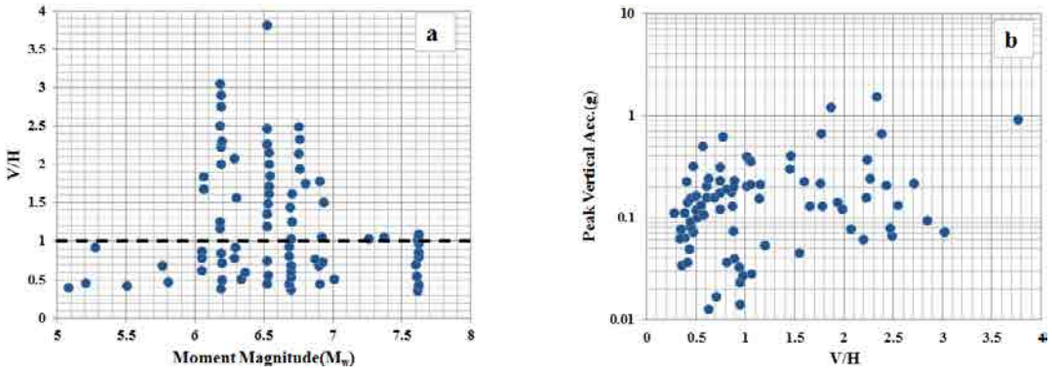

Figure 1. Ratios of peak vertical to horizontal acceleration (V/H) plotted against (a) moment magnitude, and (b) peak vertical acceleration (dashed line indicate the sample median)

In Figure 1, the authors presented the plot of the V/H ratio against the magnitude of the events for a large database of 80 earthquake records in the range of 5-7.6 Mw. It may be seen that the median V/H ratio is equal to 1.02, being much higher than the commonly accepted value of 0.67, which confirms that the 2/3 rule in current seismic design codes seems unreasonable.

Interstorey Drift ratio (ISD% = θ) is considered to be the primary and most important global EDP for collapse criterion. This failure criterion places an upper limit on the acceptable storey drift of the structure. For more rigorous analysis, ISD% limit per each individual structure from push over analysis with loading profile of first mode shape was estimated.

To estimate the seismic fragilities, the capacity values must be specified in a probabilistic sense. The deterministic seismic structural capacity value corresponding to the damage levels from IDA are considered as the median capacity value. Figure 2 shows the probability density distribution of structural damage ratio under various levels of IM and beta fitting distributions for mid-rise typical models.

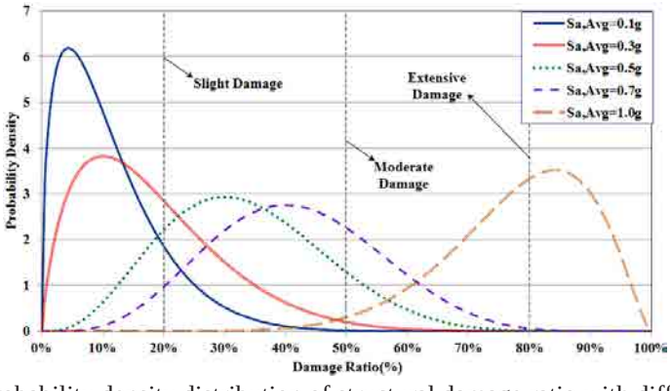

Figure 2. The probability density distribution of structural damage ratio with different intensities

Following Gardoni et al. (2002a), approximate confidence bounds are obtained using a first-order analysis. These bounds approximately correspond to 5% and 95% confidence level on the fragility estimates. Figure 3 shows the fragility curves with confidence bounds for all buildings for moderate damage and collapse modes.

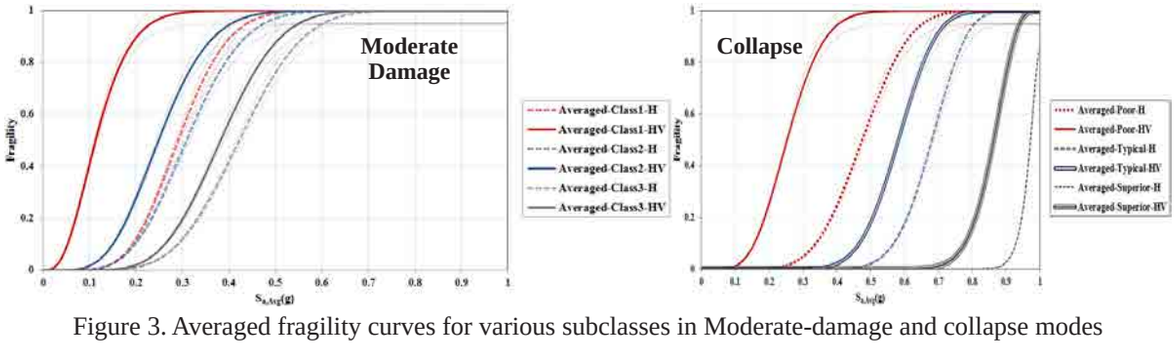

Figure 3. Averaged fragility curves for various subclasses in Moderate-damage and collapse modes

Taking into account the above observations, RC-MRFs subjected to the concurrent horizontal and vertical seismic excitations could be more vulnerable than those subjected to horizontal ground motion only. Therefore, including vertical ground motion in the analysis is highly recommended for reliable seismic assessment of RC buildings.

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