ANALYTICAL AND EMPIRICAL FRAGILITY FUNCTIONS FOR REGIONALLY ASSESSING NON-DUCTILE INFILLED FRAMES

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The regional seismic risk assessment of reinforced concrete (RC) building portfolios is critical to earthquake engineering due to their high vulnerability and significance in areas prone to seismic activity. A pertinent aspect in regional seismic risk applications is the ability to accurately quantify the exceedance of any structural demand-based performance level, generally quantified via fragility functions.

To this end, this study presents the derivation of fragility functions for large-scale seismic risk applications of non-ductile RC buildings with masonry infills characteristic of the Italian peninsula and Southern Europe. This was done using two methods: 1) an analytical approach using numerical models and analysis, and 2) an empirical approach whereby fragility functions were constructed based on past damage survey reports and estimates of the ground motion intensity at each site location.

The analytical fragility functions were derived using an extensive database of archetype buildings developed to represent pre-1970s sub-standard seismic design (1970s-1980s) and construction practices in Italy based on an extensive literature review and interviews with practising engineers and architects. Fragility functions for several taxonomy classes were derived for multiple damage states using extensive non-linear time-history analysis of detailed numerical models and hazard-consistent ground motions. These ground motions were selected via the average spectral acceleration intensity measure, which has been shown to notably reduce dispersion and biased when analysing these typologies.

The empirical fragility functions were derived using data collected for 8502 buildings with this structural typology following the L'Aquila 2009 event in Italy. This involved processing the post-earthquake survey data available in the DaDO database managed by the Eucentre Foundation into a format compatible with the analytical approach. Knowing the damage states of these buildings, the fragility functions were fitted using the intensities estimated for each site location, which were obtained from Shake Maps for the specific rupture events. As the intensity measure adopted was average spectral acceleration, Shake Maps were not available from the local authorities such as INGV; hence, they were derived from scratch following the same process. This involved the use of ground motion models, spatial correlations and other methods to generate suitable Shake Maps, which in itself presented interesting observations for what concerns regional applications of novel intensity measures.

The study derived fragility functions for several building taxonomy types and compared the results. This study shows how recent advances in analytical fragility function development can be integrated with past empirical observations to give more accurate and representative damage estimates for regional assessment. The comparison was very encouraging, although some discrepancies were observed. With further research, it is expected to form a first step toward empirically validating analytical approaches often utilised in research and practice.