



Assessment of Seismic Risk in Turkey

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In most general terms, seismic risk can be computed as a compendium of seismic hazard, physical and social elements exposed to risk and their respective vulnerabilities and fragilities. Earthquake hazard assessment gives the probability that a certain parameter of ground motion such as intensity, PGA, SA, or in more general case, of the seismic process that will be surpassed within a lifetime period.

The population, structures, utilities, systems and socio-economic activities constitute the “Elements at Risk” in urban areas. Vulnerability is defined as the degree of loss to a given element at risk, resulting from the occurrence of a hazard. Vulnerability functions (or fragility curves) of an element at risk represent the probability that its response to earthquake excitation exceeds its various performance limit states based on physical and socio-economic considerations. For a population of buildings exposed to earthquake hazard, the vulnerability relationships relate the probability of exceedence of multiple damage limit states (or being in certain damage state) to given measures of ground motion severity.

The methodology used for the assessment and prioritization of the seismic risk in Turkey follows the methodology developed for the assessment of risk in the Euro-Mediterranean Region (Erdik et al., 2010; Hancilar et al., 2010; Strasser et al., 2008 and Erdik et al., 2008). For the estimation of earthquake losses in the Euro-Mediterranean region, the JRA-3 component of the EU FP6 Project entitled “Network of Research Infrastructures for European Seismology, NERIES” has developed a methodology coded into the software ELER[©]. For the purpose of provincial earthquake risk prioritization in Turkey, the “Hazard” part of this modular routine is replaced with the probabilistic hazard maps and ELER[©] Level 1 risk analysis is performed, using site dependent intensity as ground motion parameter and intensity based vulnerabilities associated with the Turkish building stock. The taxonomy and the physical vulnerability of the building stock in Turkey and the social vulnerabilities in terms of human casualties have been studied by several researchers, such as Erdik et al. (2002), covering in detail the empirical vulnerabilities based on the observational data from past earthquakes and development of analytical vulnerability relationships.

The common option for the assessment of probabilistic loss and the generation of loss exceedance curves is to perform independent probabilistic seismic hazard assessments (PSHA) and to combine the losses at each site for each annual frequency of exceedance. An alternative method involves the use of multiple earthquake scenarios to generate ground motions at all sites of interest, defined through Monte–Carlo simulations based on the seismicity model. There exist numerous studies on the appropriate procedures for the estimation of the probabilistic risk (Robinson et al., 2006; Bommer and Crowley, 2007; Wesson et al., 2009; and Choun and Elnashai, 2010). For the probabilistic risk assessment in this study, the same procedure in FEMA 366 (2008) for USA, with appropriate adaptation to Turkey-specific intensity based vulnerabilities, is utilized. The FEMA procedure applies the single-site PSHA approach to every site in a region independently without considering spatial correlation in the ground motion. Two interrelated risk indicators, the Loss Ratio (LR) which expresses the overall building losses as a fraction the building inventory replacement value corresponding to specific return periods in a specified settlement, and the Annualized Earthquake Loss Ratio (AELR), which expresses estimated annualized loss as the area under the best fit curve obtained from a number of return period – loss ratio pairs. Settlements (provinces and sub-provinces) in Turkey are prioritized with respect to these two parameters and the results highlight the provinces of Istanbul, Kocaeli, Yalova, Erzincan, Amasya, Tokat, Mus, Cankiri, Bolu and Bingol as the highest risk settlements in Turkey.