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APPLYING MONTE CARLO SIMULATIONS IN SEISMIC HAZARD ASSESSMENT FOR LANGAROUD REGION – PROBABLE EARTHQUAKE SCENARIOS

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An estimation of the probabilistic seismic hazard was carried out based on the Monte Carlo simulation to assess the levels of peak ground motion on the bedrock for maximum acceleration and its spatial values in the Langaroud region. Monte Carlo process with stochastic simulation estimates earthquake hazard (Weatherill, 2009). This method takes into account the uncertainty in the input parameters by generating random numbers in a powerful manner (Yazdani et al., 2012). Parameters can be introduced as distribution functions with observational averages and standard deviations. This method is compatible with the popular PSHA studies, and similar results are obtained using similar inputs (Musson and Sargeant, 2007). A uniform catalog prepared includes 25 historical earthquakes and 382 instrumental earthquakes with $M_W \geq 4$ of global and local resources by the end of April 2018. Most of the study area is located in the Alborz seismotectonic sub province. Therefore, due to the incompleteness of the data and considering the uncertainty in determining the magnitude of the earthquakes, the seismic parameters have been calculated for the Alborz seismotectonic subprovince. A map of the major and minor faults of the region is prepared and according to the focal mechanism of the major and minor faults, their location in the provinces of the seismotectonics and the distribution of the epicenter of earthquakes in the region, 14 potential seismic sources have been identified. The maximum magnitude of each of the seismic sources is calculated according to the empirical relationships and the Kijko and Sellevoll (1992) probabilistic method. The annual activity rates of events in each source is calculated from the annual rate of each seismotectonic sub province, using the spatial distribution function (Shi et al., 1992). There are some well-known local attenuation relationships proposed, such as Ghodrati Amiri et al. (2010), Soghrat et al. (2012) and Zafarani and Soghrat (2012) presented for Iran region, but in this study, to account for the effects of fault mechanism, three mean regional equations of prediction of the ground motion Atkinson and Boore (2011), Campbell and Bozorgnia (2008) and Chiou and Youngs (2008) with equal weights have been used. Based on these data, using the EqHaz software, two synthetic catalogs of 50,000 and 475,000 years are produced in return periods of 50 and 475 years, respectively. The results are presented as hazard curves and seismic hazard zonation maps for maximum acceleration and spectral accelerations of 0.2, 0.5 and 5 Hz with a 5% damping for the average return periods of 50 and 475 years for the ground motion in bedrock of Langaroud region. The scenario earthquakes are estimated using 3-dimensional deaggregation of seismic hazard by magnitude, distance bins and standard deviations for maximum acceleration and spectral acceleration of the range of 0.2, 0.5 and 5 Hz with 5% damping for the average return periods of 50 and 475 years in the city of Langaroud which shows that as the return period increases, the dominant scenario will be closer to the earthquakes that are closest to it. For example, during the return period of 50 years, the scenario earthquake is at a frequency of 0.5 Hz with a magnitude 6.1 at a distance of 42.5 km from Langaroud. While the scenario earthquake was set at the same frequency and magnitude for the return period of 475 years at a distance of 12.5 km from Langaroud (Table 1). According to the modal values, and also due to the map of the sources in this region, it can be concluded that in the Langaroud region, source 7 contains the Lahijan fault, has the dominate share in the earthquake hazard during the period of 475 years, which the earthquake epicenter of 1678/2/3, Ms = 6.5 closest historical earthquake occurred at a distance of approximately 13 km west of Langaroud has occurred in this source. In the return period of 50 years, sources 6, 7 and 8, respectively, include Roudbar, Lahijan, Kelishom faults, which are dominant in the earthquake hazard. An historical earthquake occurred with Ms= 6.1 (1639 AD) and Roudbar earthquake with M_w=7.4 (1990 AD) at distances 67 km southwest and 85 km southwest of Langaroud, have occurred in the source 6 respectively. Two other historical earthquakes with Ms= 6.8 (1052 AD) and Ms= 7.2 (1485AD) at distances 67.5 km and 63 km south east of Langaroud, have occurred in the source number 8, respectively. These events confirm the high risk of the mentioned sources in the region.

Table1. Deaggregation results for PGA and spectral accelerations of 0.2, 0.5 and 5 Hz for return periods of 50 and 475 years in Langaroud city considering the amounts of bins ΔR= 5 km , $\Delta M = 0 \cdot 2$ for distance and magnitude, respectively.

Return period (yrs)	PGA			SA (0.2Hz)			SA (0.5Hz)			SA (5Hz)		
	Modal Mag.	Modal Dis. (km)	Stdv. times sigma	Modal Mag.	Modal Dis. (km)	Stdv. times sigma	Modal Mag.	Modal Dis. (km)	Stdv. times sigma	Modal Mag.	Modal Dis. (km)	Stdv. Times sigma
50	6.1	57.5	0.76	6.3	57.5	0.68	6.1	42.5	0.84	6.1	47.5	0.83
475	6.1	12.5	0.83	6.3	12.5	0.99	6.1	12.5	0.65	6.1	12.5	0.68

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