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Probabilistic and Deterministic Seismic Hazard Assessment: A Case Study in Babol

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Abstract: The risk of earthquake ground motion parameters in seismic design of structures and Vulnerability and risk assessment of these structures against earthquake damage are important. The damages caused by the earthquake engineering and seismology of the social and economic consequences are assessed. This paper determined seismic hazard analysis in Babol via deterministic and probabilistic methods. Deterministic and probabilistic methods seem to be practical tools for mutual control of results and to overcome the weakness of approach alone. In the deterministic approach, the strong-motion parameters are estimated for the maximum credible earthquake, assumed to occur at the closest possible distance from the site of interest, without considering the likelihood of its occurrence during a specified exposure period. On the other hand, the probabilistic approach integrates the effects of all earthquakes expected to occur at different locations during a specified life period, with the associated uncertainties and randomness taken into account. The calculated bedrock horizontal and vertical peak ground acceleration (PGA) for different years return period of the study area are presented.

Key words: Active fault; Seismic hazard assessment; Return period; Babol

INTRODUCTION

Babol is one of the town in Mazandaran province that is located 13 km south of the Caspian Sea and the Elburz Mountains is located approximately 10 km south of Babol. The city is located between 36°, 5'-36°, 35' north latitude and 52°, 30'-52°, 45' east of the Greenwich meridian. High concentration of population in the city and existence of active faults has caused risk of natural disaster such as earthquake should be considered further. Accordingly, study of the risk of earthquake and estimation of ground motion parameter and also risk assessment of structures against earthquake damage caused by the earthquake in point of view science of seismology and Earthquake Engineering and economic development projects are of great importance. So it is up to the importance and risk of each project is conducted by design or retrofitted in contrast to earthquake based on the design parameters and appropriate methods until secure performance have provided. Analyses were carried out using the earthquake catalogue available over a radius of 200 km around Babol city. For seismic studies, complete and homogeneous catalog of earthquakes is required. Therefore, first analysis was used to obtain the magnitude of the Gutenberg - Richter method.

The cumulative and non-cumulative number of events is plotted against magnitude as illustrated in Figure 1. In this paper, an earthquake of at least magnitude then the catalog can be considered completed in M=4.2.

Because of the seismic data from the most reputable sites based on the M_b and also the large data both M_b and M_s registered were few. Providing region skipped the following relationship between the national committee of dams was used [1].

$$M_s = 1.205m_b\text{-}1.23 \quad (1)$$

Seismogenic Sources: The seism tectonic conditions of Babol are under the influence of the condition of the Iranian tectonic plate in Middle East. The most significant and primary faults in the vicinity of Babol including Khazar, North Alborz, Kandevan, Mosha, North Tehran, Astaneh and Atari. Based on these criteria, the study site

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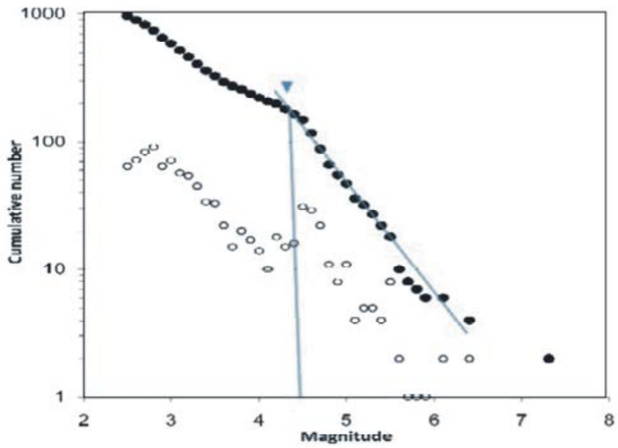

Fig. 1: Distribution affluence of earthquake magnitude to 150 Km radius

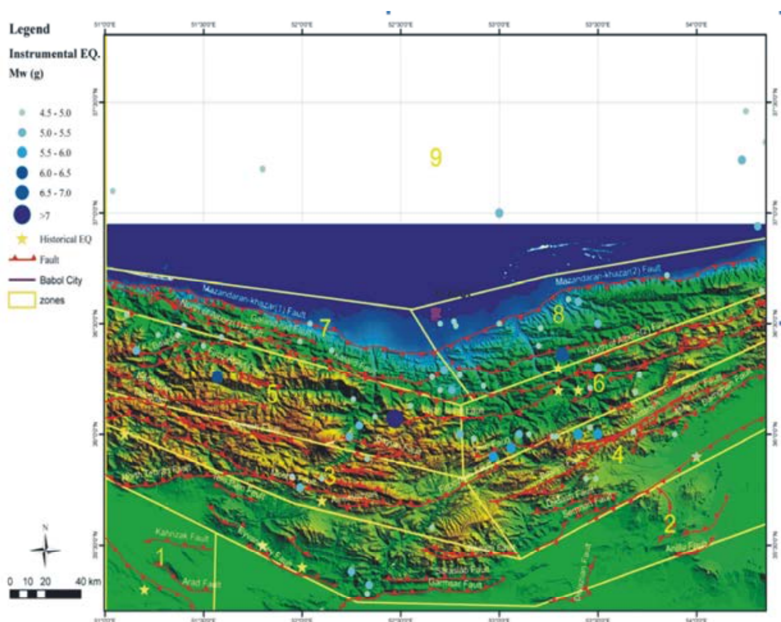

Fig. 2: Models of seismic sources in the Babol city on satellite image

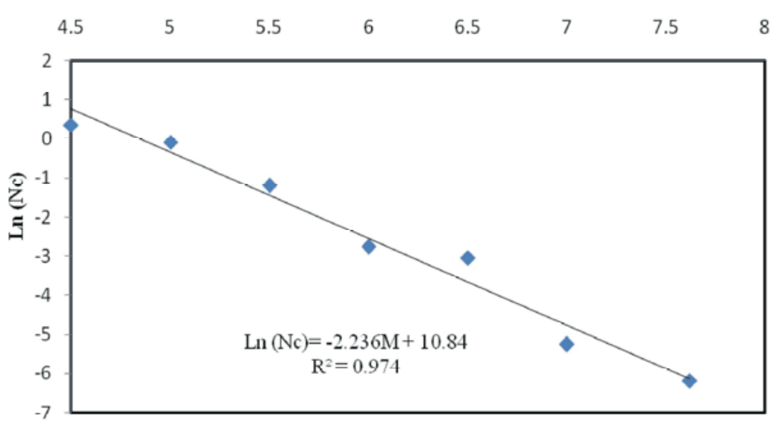

Fig. 3: Frequency magnitude relationship for the study area

is divided into 9 seismic regions. The seismic source on the existing resolution satellite images are shown in Figure 2. Based on the mechanism of seismic faulting and fault zones are marked. Identification of sources of seismic zone and seismic hazard analysis is essential. The purpose of the seismic source zones are used in plants. In this area the same conditions exist which have to be separated. A number of seismic source zones, depends on the structure and distribution of earthquakes in that area. Selection of large areas to the maximum magnitude of the largest historical earthquake fault or the largest total area is devoted to conservative results which is expected to be extremely high.

Regional Recurrence Interval: Uncertainty in size of earthquake produced by earth source zone can be described by various recurrence laws such as Gutenburg - Ritchter (G-R) [2] relation, Mertz and Cornell [3], Shah *et al*. [4] etc. In present investigation simple and widely used G-R relation was used to evaluate the seismic hazard parameter b. It assumes an exponential distribution of magnitude and is generally expressed as follows:

$$Log\ N = \alpha\ \text{-}bM \qquad (2)$$

Where 'a' and 'b' are positive, real constants. 'a' describes the seismic activity (log number of events with M=0) and 'b' which typically close to 1 is a tectonics parameter describing the relative abundance of large to smaller shocks. For a certain range and time interval, Eq. (2) will provide the number of earthquakes, (N) with magnitude, (M). Figure 3 presents the logarithm of the cumulative earthquake per year for M, where M is the magnitude in particular interval. A straight line fit in least square sense for the complete set of earth magnitude range which is as follows:

$$Log\ N = 10.84 - 2.236$$

From the above equation a seismic parameter 'a' is 10.84 and 'b' is 2.236 with a correlation coefficient of 0.974.

Probabilistic Seismic Hazard Analysis: The widely accepted probabilistic approach used in our investigation was developed by Cornell [5] and was transferred into a numerical algorithm by McGuire [6]. A scheme of this approach is shown in Figure 4. The method is based on a specific probabilistic mathematical model.

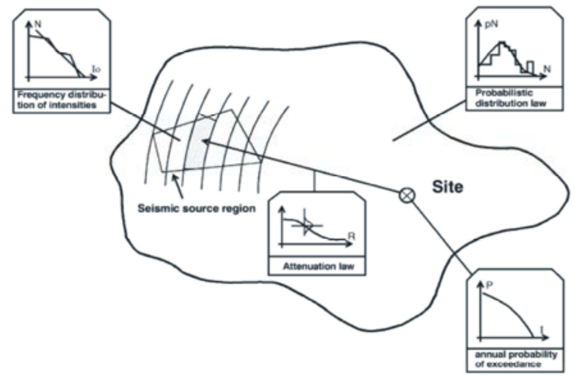

Fig. 4: Scheme of the probabilistic approach of McGuire [6] modified after Sagesser and Mayer-Rosa [7]

Table 1: Parameters of seismic zones used for the PSHA

Zone	β	λ	M_{max}
1	2.23	7.3	7.1
2	2.23	8.7	7.7
3	2.23	8	6.5
4	2.23	8.2	6.5
5	2.23	8.2	7.2
6	2.23	7.8	6.5
7	2.23	7.6	7
8	2.23	8	7
9	2.23	9.9	6.2

It assumed that the distribution of the parameter seismic risk is defined as the probability that at epicentral intensity follows a Poisson process.

This study presents a probabilistic seismic hazard analysis (PSHA) based on the tectonic position and seismicity of the Babol region. Area sources were identified on the basis of geological and seismological studies (Figure 2). For each source zone, seismicity parameters have been estimated after omitting foreshocks and aftershocks from the maximum or upper bound earthquake was chosen for each source zone representing the maximum event to be considered. The seismicity parameters, including the Gutenberg-Richter parameter (β), maximum possible earthquake (M_{max}) and mean activity rate (λ) for each seismic zone used for the PSHA are given in Table 1. A reliable assessment of seismic hazard in a region requires knowledge and understanding of both the seismicity and the attenuation of strong ground motion. Some of the larger uncertainties in earthquake hazard analysis are caused by uncertainties in seismic wave attenuation. Several studies have been conducted to obtain attenuation relationships of peak ground accelerations for different regions of the world. The use of different data bases and published empirical

Table 2: PGA Horizontal with used Deterministic Seismic Hazard Analysis in Babol

			Maximum PGA Horizontal		
Name Fault	M_{max}	R(km)	Campbell and Bozorgnia [8]	Ambraseys and Douglas [9]	Average
Firuzabad	7	85	0.098	0.069	0.084
North Alborz	7.2	44	0.188	0.155	0.171
Khazar fault	7.2	16	0.369	0.364	0.367
Atari	6.9	91	0.088	0.058	0.073
Astaneh	6.8	93	0.082	0.051	0.067
Garmsar	6.8	136	0.057	0.034	0.046
Kandevan	6.7	100	0.073	0.043	0.058
Mosha	7.7	91	0.129	0.136	0.133
North Tehran	7	115	0.075	0.051	0.063
Robatkarim	6.9	184	0.046	0.029	0.037
Kahrizak	6.5	156	0.043	0.021	0.032
Eyvanekey	6.8	143	0.055	0.033	0.044
Rameh	6.5	117	0.057	0.029	0.043
Firuzkuh	6.5	84	0.079	0.042	0.06
Bashm	6.8	96	0.08	0.049	0.065
Diktash	6.4	107	0.059	0.028	0.044
orim	6.6	72	0.096	0.051	0.073
Damghan	7	136	0.064	0.044	0.054
North Damghan	6.2	132	0.043	0.017	0.03
Semnan	6.3	127	0.047	0.021	0.034
Taleqhan	6.7	110	0.067	0.038	0.053
Bayjan	6.6	60	0.114	0.067	0.09

Table 3: PGA Vertical with used Deterministic Seismic Hazard Analysis in Babol

			Maximum PGA Vertical		
Name Fault	M_{max}	R(km)	Campbell and Bozorgnia [8]	Ambraseys and Douglas [9]	Average
Firuzabad	7	85	0.036	0.036	0.036
North Alborz	7.2	44	0.094	0.087	0.09
Khazar fault	7.2	16	0.233	0.228	0.23
Atari	6.9	91	0.03	0.03	0.03
Astaneh	6.8	93	0.028	0.026	0.027
Garmsar	6.8	136	0.016	0.017	0.017
Kandevan	6.7	100	0.023	0.024	0.024
Mosha	7.7	91	0.052	0.073	0.063
North Tehran	7	115	0.024	0.026	0.025
Robatkarim	6.9	184	0.012	0.014	0.013
Kahrizak	6.5	156	0.011	0.01	0.011
Eyvanekey	6.8	143	0.015	0.016	0.016
Rameh	6.5	117	0.016	0.013	0.015
Firuzkuh	6.5	84	0.026	0.021	0.023
Bashm	6.8	96	0.026	0.025	0.026
Diktash	6.4	107	0.017	0.014	0.016
orim	6.6	72	0.034	0.028	0.031
Damghan	7	136	0.019	0.022	0.02
North Damghan	6.2	132	0.011	0.009	0.01
Semnan	6.3	127	0.013	0.01	0.012
Taleqhan	6.7	110	0.021	0.019	0.02
Bayjan	6.6	60	0.043	0.067	0.39

attenuation relations for peak ground acceleration brings about widely varying results. Thus, it becomes difficult to select a relationship that can be considered appropriate for a specific application. Furthermore, the use of a particular relationship for an area with different geological and tectonic features may lead to results that differ significantly from the actual values. Therefore, two proper attenuation relationships proposed by Campbell and Bozorgnia [8] and Ambraseys and Douglas [9] have been considered.

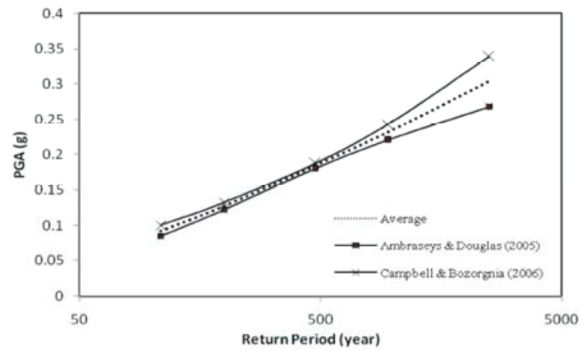

Fig. 5: Bedrock horizontal peak ground acceleration

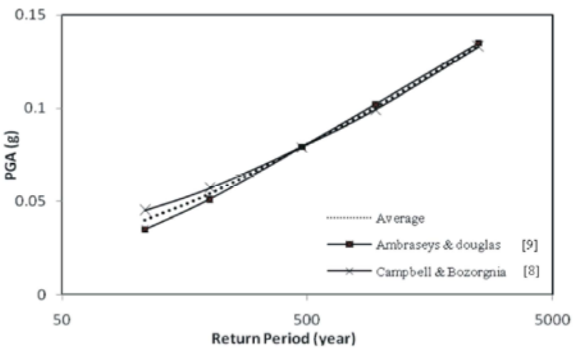

Fig. 6: Bedrock Vertical peak ground acceleration

The calculated bedrock horizontal and vertical peak ground acceleration (PGA) for different years return period of the study area are presented in Figures 5 and 6.

Deterministic Seismic Hazard Analysis: The methodology for this analysis can be described as follows:

First, based on Figure 2 source characterization was completed. Once all of the sources are identified, the controlling earthquakes for each need to be determined. The definition of controlling is somewhat subjective and varies depending on the resulting hazard created if the prospective facility failed. Use of Nowroozi [10], Wells and Coppersmith [11] and Ambraseys and Jackson [12] relationships have determined PGA horizontal and vertical in Babol. The final results are shown in Tables 2 and 3. According to Khazar fault with M_{max} 7.2 had PGA horizontal and vertical equal sequence 0.37 and 0.23 g, respectively.

CONCLUSION

Due to financial losses caused by the earthquake more studies required in order to reduce the risks of earthquakes. Formation of population and residential areas, regardless of the risks from earthquakes and threaten them, especially in significant population center during earthquakes can cause severe losses and damages resulted from the earthquake. In order to reduce the risks of earthquakes and a possible plan of destructive earthquakes, particularly in large cities, preparation of seismic hazard analysis is necessary and inevitable. Thus, the present study has focused on seismic hazard Babol. Variations in computed peak ground acceleration forecasts produced different attenuation relationships, different levels of maximum magnitude (M_{max}) for seismic sources and different depths. Attenuation equation of Campbell and Bozorgnia [8] and Ambraseys and Douglas [9] was used in this study as the most adequate for the seismotectonic characteristics of Babol. The calculated bedrock horizontal and vertical peak ground acceleration (PGA) for different years return period of the study area are presented.

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