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Evaluation of Horizontal Seismic Hazard of Naghan, Iran

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***Abstract*—**This paper presents probabilistic horizontal seismic hazard assessment of Naghan, Iran. It displays the probabilistic estimate of Peak Ground Horizontal Acceleration (PGHA) for the return period of 475, 950 and 2475 years. The output of the probabilistic seismic hazard analysis is based on peak ground acceleration (PGA), which is the most common criterion in designing of buildings. A catalogue of seismic events that includes both historical and instrumental events was developed and covers the period from 840 to 2009. The seismic sources that affect the hazard in Naghan were identified within the radius of 200 km and the recurrence relationships of these sources were generated by Kijko and Sellevoll. Finally Peak Ground Horizontal Acceleration (PGHA) has been prepared to indicate the earthquake hazard of Naghan for different hazard levels by using SEISRISK III software.

***Keywords*—**Seismic Hazard Assessment, Seismicity Parameters, PGA, Naghan, Iran

I. Introduction

IRAN, one of the most seismic countries of the world, is situated over the Himalayan-Alpied seismic belt. Naghan with the past important earthquakes in the west of Iran, very close to Shahrekord. Due to the past earthquakes it needs a very precise investigation of seismicity and seismic hazard. This paper presents probabilistic horizontal seismic hazard assessment of Naghan. The value of PGA, is proposed to be 0.3g for the region containing Naghan city by Iranian Code of Practice for Seismic Resistant Design of Buildings [1]; however by considering the importance of the city cause of including many infrastructures, investigation with more details and accuracies are necessary for calculating PGA (design basis acceleration).

II. Seismotectonic Structure Of Naghan

Naghan city is situated on the west plateau of central Zagros Mountain. In order to evaluate the seismic hazard of a region or zone, all the probable seismic sources must be detected and their potential to produce strong ground motion must be checked. The major faults in Naghan region are Zagros, Dena, Ardal, Cherou, Gazolk, South Rokh, Dopolan and Zardkooh. The location of these faults with respect to Naghan is shown in Figure 1.

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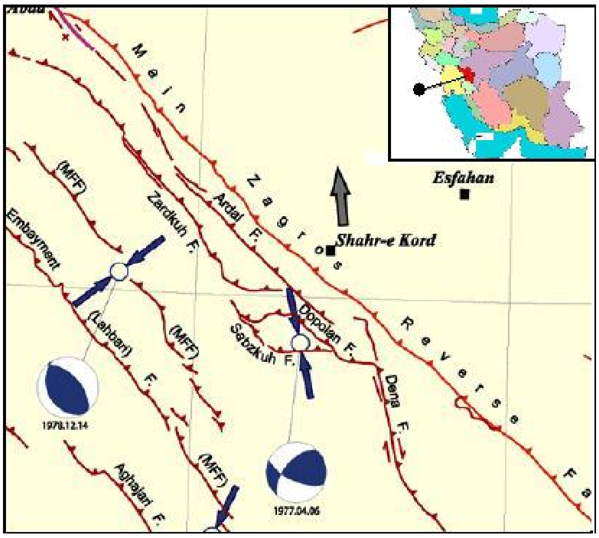

Fig. 1 The active faults of Naghan [2]

III. Seismicity Of Naghan

The seismicity of each region is indicated by the past earthquakes occurred in that region and to obtain the seismotectonic properties, a thorough list of each region's earthquake events must be collected and studied.

The happened earthquakes in this area have categorized with respect to information accuracy, into two categories:

Historical earthquakes (earthquakes occurred before the year 1900)

Instrumentally recorded earthquakes (earthquakes occurred from the year 1900 up to now).

Our knowledge of earthquakes that occurred before the 20th century is based on data collection from historical and ancient documents; as a result, overestimation might be present in the data. The magnitudes of historical earthquakes due to the destructive effects and their social outcomes have been estimated by researchers like Ambrasys and Melvile [3] by consideration of many historical notes. The investigation of the Catalogue of earthquakes shows that several earthquakes have occurred with M>6. Seismic data after the year 1900 are important since instruments record them, although they might possess different inaccuracies in the location of epicenter, amount of focal depth and earthquake magnitude. A catalogue of seismic events that includes both historical and instrumental events was developed in a radius of 200 km around Naghan and covers the period from 840 to 2009.The main earthquakes affected the area of Naghan include: in 840 A.D. with magnitude of 6.5, in 1666 A.D. with magnitude of 6.5, in 1880 A.D. and magnitude of 6.0, in 1953 A.D. and magnitude of 7.2, in 1977 A.D. and magnitude of 6.0 [3].

The Naghan earthquake of magnitude 6 (Ms) occurred on 6 April 1977 in the mountainous area of Chahar Mahal Bakhtiari, in the High Zagros, south of Shahr-e-Kord. It killed 348 people, injured about 200, and caused destruction over an area of 150 Km^2.

IV. Naghan Seismicity Parameters

The evaluation of seismicity parameters is performed based on the seismic data of earthquakes occurred in the region under study and employing probabilistic methods. Since there are various magnitude scales in catalogue, in order to homogenize these scale all magnitudes were converted in Ms using relationships presented by Iranian Committee of Large Dams [4]. The seismic catalogue has been collected, assuming that earthquakes follow a Poisson distribution. The method which is used to eliminate the foreshocks and aftershocks is the variable windowing method in time and space domains [5].

Due to the very high importance of the seismicity parameters in seismic hazard evaluation, in this study the new Kijko method [6] has been employed which is based on double truncated Gutenberg-Richter [7] relationship and the maximum likelihood estimation method. In the maximum likelihood estimation method [6], it is possible to use historic and instrumentally recorded data at the same time.

There are three groups of earthquakes data in this method; as follows:

Historical earthquakes (before 1900) with magnitude uncertainty between 0.3 and 0.5

Instrumentally recorded earthquakes from 1900 to 1963 with uncertainty 0.2

Instrumentally recorded earthquakes from 1964 to 2009 with uncertainty 0.1

The values of seismicity parameters β ,λ resulting from this method were: 2.12 and 1.89. The annual average occurrence rate of earthquake versus magnitude for earthquakes with magnitude greater than Ms=4.0 in the extent of 200 km around Naghan is shown in Figure 2 based on these investigations and the performed calculations with Kijko method [6].

V. Evaluation Of Horizontal Seismic Hazard

In order to evaluate Peak Ground Horizontal Acceleration (PGHA) for the return period of 475, 950 and 2475 years, probabilistic seismic hazard analysis method has been used. In this method, seismicity parameters (β, λ) are given to the seismic sources based on the seismicity investigations, then based on earthquake magnitude, distance of epicenter or hypocenter from site and application of an appropriate attenuation relationship, Peak Ground Horizontal Acceleration (PGHA) at the corresponding site is evaluated.

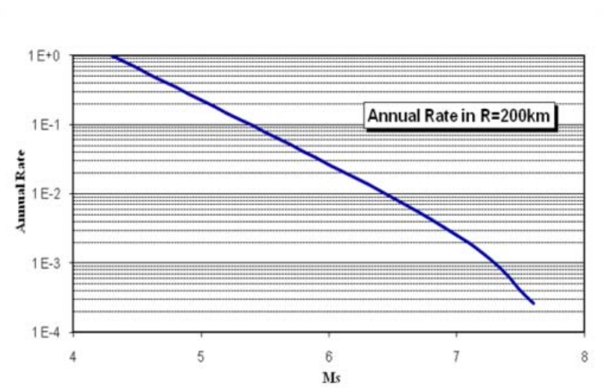

Fig. 2 Annual rates estimated by Kijko method for Naghan

A. Attenuation Relationship

Selection of appropriate attenuation relationship is very important in validity and reliability of the analysis results. Therefore, there are some important notes that must be paid attention for the selection of attenuation relationship. The most important ones are source specifications, magnitude, fault rupture type, distance to the seismogenic sources, geology and topology of site.

Based on the mentioned remarks, in this research three weighted horizontal attenuation relationships; Ghodrati et al. [8], 0.25, Zare et al. [9], 0.25, Campbell [10], 0.25, and Campbell & Bozorgnia [11], 0.25, in Logic Tree method were employed. It should be mentioned that the mean level of these attenuation relations have been used as a base and then their standard deviation were included during the calculation.

B. Relationship between Earthquake Maximum Magnitude and Fault Rupture Length

Several empirical relationships have been presented to express the relation between fault rupture and the earthquake magnitude, an example of which is Nowroozi relationship [12]. Nowroozi presented the following empirical relationship after the study of 10 severe earthquakes in Iran and the investigation of ruptures of active faults like Zagros, North Alborz, North Tabriz, Zafre in Isfahan, Dehshir in south west of Isfahan, Shahre Babak in Kerman and Dorouneh in Makran (Equation 1):

$$M_S = 1.259 + 1.244\, Log\,(L) \quad (1)$$

Where Ms is surface wave magnitude and L is half of rupture length in meter.

C. Probabilistic Seismic Hazard Analysis

For the seismic hazard probabilistic evaluation, the software SEISRISK III [13] was utilized to calculate the Peak Ground Horizontal Acceleration (PGHA) in the specific hazard level in the structure lifetime. In this study the seismic hazard analysis carried out was based on the assumption of an ideal bedrock case and therefore no influence of local soil condition is taken into consideration. For hazard levels, three return periods of 475, 950 and 2475 years were considered.

As a result, our outputs are Peak Ground Horizontal Acceleration (PGHA) with 10%, 5% and 2% probabilities of exceedence in 50-year lifetime of structure. The results of the seismic hazard analysis were: PGA=0.692(g) for 2%, PGA=0.476(g) for 5% and PGHA=0.377(g) for 10%.

VI. Conclusion

This paper presents seismic hazard of Naghan based on Peak Ground Horizontal Acceleration (PGHA) for 10%, 5% and 2% probabilities of exceedence in a time span of 50 years. The significant results of this study can be summarized as:

(1) Providing complete and up-to-date earthquake catalogue which contains both historical and instrumental data for region.

(2) Utilization of different worldwide attenuation relationships using logic tree method. The seismic hazard analysis carried out in this paper was based on the assumption of an ideal bedrock case and therefore no influence of local soil condition is taken into consideration.

(3) The results of the seismic hazard analysis were: PGA=0.692(g) for 2%, PGA=0.476(g) for 5% and PGHA=0.377(g) for 10%.

(4) The comparison of the results with the recommended PGA in Iranian Code of Practice for Seismic Resistant Design of Buildings [1] (0.3g) shows that the recommended PGA is lower than what it has been achieved in this study in the region. This PGA can cause major structural damage in important structures and lifeline systems.

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