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Seismic Hazard Analysis of Golsar district in Rasht Metropolis

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Abstract

Golsar is located in north-west of Rasht the capital city of Guilan province. This region, according to standards 2800, is identified among the regions with relatively high risk of earthquake. A set of historical and instrumental seismicity data used in radius of 200 km which covers the period twelveth century until now. Kijko method has been applied for estimating for parameters considering of the available information. Estimating the peak ground acceleration on Bedrock (PGA) with five different attenuation relationship, with a probability of occurrence of 10% in 50 years, is 0.31g in Galsar Rasht region. Meanwhile in order to determine the seismic spectra based on weighed attenuation spectral relations, and also for the reason of being spectral and more suitable with the condition of the zone were used. The horizontal spectral acceleration in the 0.3 second period has the highest value for 2% and 10% probability of occurrence. The earthquake hazard in Golsar zone was calculated using SEISRISK III (1987) software.

Keywords: Seismic hazard analysis, Peak ground acceleration (PGA), Uniform seismic hazard spectra (UHS), Attenuation relationships.

1. Introduction

Golsar district in Gilan province has been one of the most favored residential areas during the last decade where residential construction is thriving. Golsar region due to important and seismic faults is identified as an active earthquake risk region. Therefore, due to the advantages of uniform hazard spectra and their application in earthquake safety design, it is reasonable to conduct studies to determine uniform hazard spectra, especially in seismic areas of the country. On Seismic hazard analysis studies, analysis of more than 35 provincial cities in central theses was conducted by Gholamreza Ghodrati and Seyed Ali Razavian, including the Seismic hazard analysis studies of different areas of Tehran, Hamedan, Isfahan, Tabriz, Khorramabad, Arak, Behbahan, Shahrekord, Kashan, Zanjan, Shiraz, Golpayegan, Manjil, Sanandaj, Bandar Abbas, Ilam, Karaj and the like. The structure made of layers of alluvial land in the area with high humidity and so is placed in '3rd' level according to 2800 standard definition (Fekri, 2015).

2. Seismotectonics

Golsar region due to important and seismic faults is identified as an active earthquake risk region. All possible seismic resources have been collected within a radius of 200 km due to the earthquake hazard assessment in this area. The most important faults are known as Masuleh fault, Lahijan fault, Rudbar fault, North Qazvin fault, Alamut fault, Zanjan fault, Talesh fault, Sangavar fault, Bozqush fault, Soltaniyeh fault, Bonan fault, Khazar fault, Taleghan fault and Kushk-e Nosrat fault
Golsar region due to important and seismic faults is identified as an active earthquake risk .

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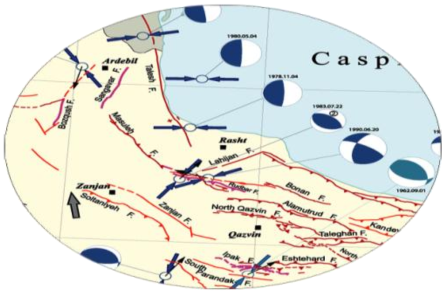

Fig.1. Main Faults within 200 km Radius of Golsar

3. Seismicity Study of the Area

To achieve the seismic characteristics of each area, a complete list of earthquakes in the area should be compiled and reviewed. In this study firstly the information of historical and instrumental earthquakes in a radius of 200 km of Golsar must be collected.

3.1. historical earthquakes (before 1900 –non-registered by an instrument):

Such earthquakes were collected from old records such as old and historical books itineraries and sometimes oral speech was concerned. Gathering the historical data needed to be found in historical record with the existed experienced demands, however; problems, shortages and uncertainties of such data must be concerned. The book written by Ambraseys- Melville was used for the historical earthquakes information (Ambraseys & Melville, 1982).

Table1
Historical Earthquakes Occurred in the Studied Area

DATE	LAT	LONG	M
10 Dec 1119	35° 42' 0"	49° 53' 59.9994"	6.5
15 Aug 1485	36° 42' 0"	50° 30' 0"	7.2
1593	37° 47' 59.9994"	47° 30' 0"	6.1
20 Apr 1608	36° 23' 59.9994"	50° 30' 0"	7.6
3 Feb 1678	37° 12' 0"	50° 0' 0"	6.5
16 Dec 1808	36° 23' 59.9994"	50° 17' 59.9994"	5.9
13 May 1844	37° 23' 59.9994"	48° 0' 0"	6.9
30 Dec 1863	38° 12' 0"	48° 36' 0"	6.1
20 Oct 1876	35° 47' 59.9994"	49° 47' 59.9994"	5.7
22 Mar 1879	37° 47' 59.9994"	47° 53' 59.9994"	6.7
4 Jan 1896	37° 47' 59.9994"	48° 23' 59.9994"	6.7

3.2. Instrumental earthquake recorded

The earthquakes happened after 1900 and are crucial with regard to the instrumental registration such earthquakes are divided to two periods of time, from 1900 to 1963 and the earthquakes happened from 1964 to the present. All earthquakes were estimated and the instrumental earthquakes information collected in website of international seismological center (international seismological center, 2015).

4. Converting the Prepared Magnitude to Surface-Wave Magnitude

In order to convert mb to Ms, the relationship of committee on Iranian Large Dams (1994) was applied as followed: Ms=1.21mb -1.29, where Ms stands for surface-wave magnitude and mb for body-wave magnitude.

In order to convert ML (Local Magnitude) to Ms, the existed table in Green and Hall (1994) was employed; the linear interpolation was used for the values of ML.

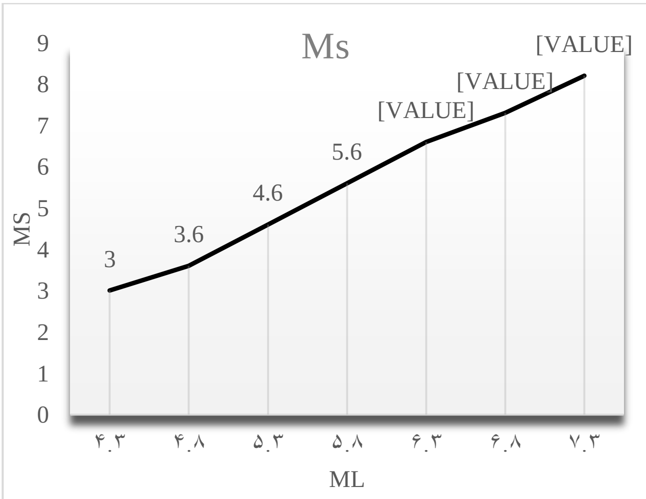

Fig.2. Converting ML to Ms (According to the Green Hall (table)

Converting Mw to Ms:

- If Mw < 6.0, then Mw= mb
- If Mw > 6.0, then Mw=Ms

5. Determining The Minimum Harmful Magnitude And Eliminating The Lower Magnitudes (Ms:4)

The aim of the present study was to find the minimum magnitude causing the constructions to harm. In this step the earthquakes with Ms< 4 were omitted.

6. Eliminating the Before Shocks And Aftershocks Using Gardner-Knopoff Method

The process of seismic analysis was estimated with the assumption of Poissonic earthquakes. However; before-and-after shocks must be eliminated. The method used in the present study was windowing method in time and place domains (Gardner and Knopoff, 1974).

7. Determination of Seismicity Parameters Using Kijko Method

Seismicity parameters λ and β are among the basics of the seismicity of a place. The seismic parameters due to the shortage of appropriate seismic data and the uncertainty of earthquake magnitude, the Kijko method (2000) were estimated. In this method, the earthquake magnitude error at different times was estimated separately. The results of applying this method include determination of the seismic parameters, the return period, probability of event, and the magnitude of seismic event at different times was presented.

Table 2
Values of Seismic Parameters in the Studied Area
(Kijko Method)

RESULTS		
Beta	1.76+-0.03	(b = 0.77 +- 0.01)
Lambda	48.76+-0.4	(for Mmin = 3.00)
M_max	8.20+-0.51	(for SIG(Xmax) = 0.10)

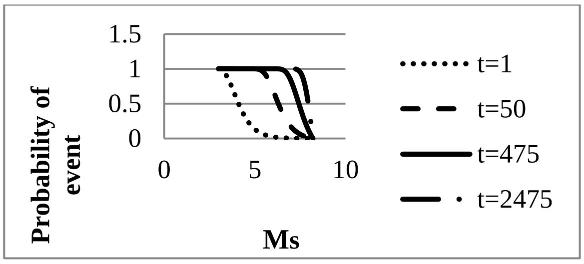

Fig.3. Probability of the event according to surface-wave magnitude in Golsar region using Kijko method

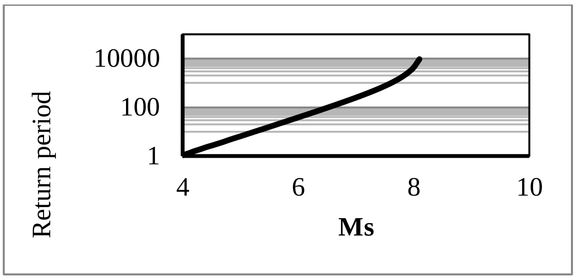

Fig. 4. Estimation of the Return Period of Earthquakes in Golsar (Kijko Method)

8. Seismic Hazard Analysis

This paper aims at providing Peak Ground Acceleration (PGA) on bedrock and Uniform Seismic Hazard spectra (USH) using probabilistic Seismic Hazard Analysis.

In this method, the procedure includes: identifying and modeling the seismic sources, applying the probability distribution of their possible failures, estimation the seismic power of the springs, examining the seismicity or time distribution of the occurred earthquakes which concludes the recurrence relationship(Recurrence-Magnitude), evaluation of local site effects such as soil types, evaluation and choosing an appropriate attenuation relationship for peak ground acceleration, calculation of the parameters of strong ground movement for designing taking into account the possible uncertainty and finally preparation of uniform acceleration maps and spectrum drawing.

9. Attenuation Relationship

The selection of an appropriate attenuation relationship is of high importance in the reliability of the results taken from seismic hazard assessment. Throughout this process, the following points are to be taken into consideration: belonging to the same region, type of magnitude unit, magnitude range, distance range, how the faults ruptured, variety of soil types, types of rocks, etc. Knowing about just above mentioned points, here are five different attenuation relationship, Ghodrati et al (2007), Akkar & Bommer (2010), Ambraseys et al (1996), Campbell-bozorgnia (2000) and Campbell-bozorgnia (2008) used in the process of providing Peak Ground Acceleration (PGA) on bedrock and uniform seismic hazard spectra (UHS) through the logic-tree method with the weighs of 0.3, 0.2, 0.2, 0.15 and 0.15

respectively. Moreover, in order to provide spectra acceleration map and uniform seismic hazard spectra through logic-tree method, Ambraseys et al (1996), Ghodrati Amiri et al (2010), Change- Campbell (1997) and Berge Thierry et al (2003) are combined with the weighs of 0.3, 0.3, 0.2and 0.2 respectively. The reason for using the Logic-tree method is that using a single attenuation relationship is not an appropriate choice because the certainty of the given data is not as reliable as desired. Moreover, the regional and global relationships which enjoy a higher accuracy in comparison with those of Iran, the other countries' data are used in the provision of their model. Therefore, as a logical conclusion, the best method is the simultaneously use of both different attenuation relationships together with the Logic-tree. Performing in this way, each one compensate for the other one's shortage. There are two parameters in assigning the weigh to the branches of each Logic-tree, including conditions in the given site and considering higher effect of regional relationship. In Table 5 and 7 the used Logic-trees with the weight of each branch are indicated.

Risk Level 1 with 10% and Level 2 with 2% of probability of the event were estimated in 50 years of structures. Determining the maximum Peak Ground Acceleration on bedrock (PGA) was applied using five attenuation relationships mentioned in risk level 1 and 2 (standard 2800, 2013.

Table 3

Peak ground acceleration on Bedrock for Golsar

Akkar & Bommer 2010 [1]		Ambraseys et al 1996 [3]		Campbell & Bozorgnia 2000 [8]		Campbell & bozorgnia 2008 [9]		Ghodrati et al 2007 [12]	
SP1	SP2	SP1	SP2	SP1	SP2	SP1	SP2	SP1	SP2
0.272	0.355	0.279	0.366	0.37	0.489	0.255	0.33	0.369	0.484

Table 4

The used Logic-Tree Together with Weight of each Category for Determination of PGA

Attenuation Relationship	Weight
Akkar & Bommer 2010 [1]	0.2
Ambraseys et al 1996 [3]	0.2
Campbell & Bozognia 2000 [8]	0.15
Campbell & Bozognia 2008 [9]	0.15
Ghodrati et al 2007 [12]	0.3

After using a logical tree with given weights:

The PGA with a 10% probability of occurrence in 50

years (475 year return period or risk level 1) in the Garsar Range of Rasht is 0.31465 g

The PGA with a 2% probability of occurrence in 50 years (2475 year return period or risk level 2) is at 0.41 g.

10. Uniform Hazard Spectrum

A Uniform Hazard Spectrum (UHS) is formed as a response spectrum, related to spectrum lengths which have the same probability of occurrence.

To determine the spectral acceleration using SEISRISK software, four spectral attenuation relations with alternation periods of 0.1 and 0.3 and 0.5 and 1 and 2 were used (Bender & Perkins,1987).

Table 5
The used Logic-Tree Together with Weight of each Category for Determination of UHS

Attenuation Relationship	Weight
Ambraseys et al 1996 [3]	0.3
Ghodarati et al 2010 [13]	0.3
Campbell & Bbozorgnia1997 [7]	0.2
Berge Thierry et al 2003 [5]	0.2

Table 6
Spectral acceleration in risk level 1, for periodicities of 0.1, 0.3, 0.5, 1, 2

SP1	0.1	0.3	0.5	1	2
SA	0.6042	0.7734	0.5858	0.2348	0.1128

Table 7
Spectral acceleration in risk level 2, for periodicities of 0.1, 0.3, 0.5, 1, 2

SP2	0.1	0.3	0.5	1	2
SA	0.7992	1.0386	0.8083	0.3405	0.1644

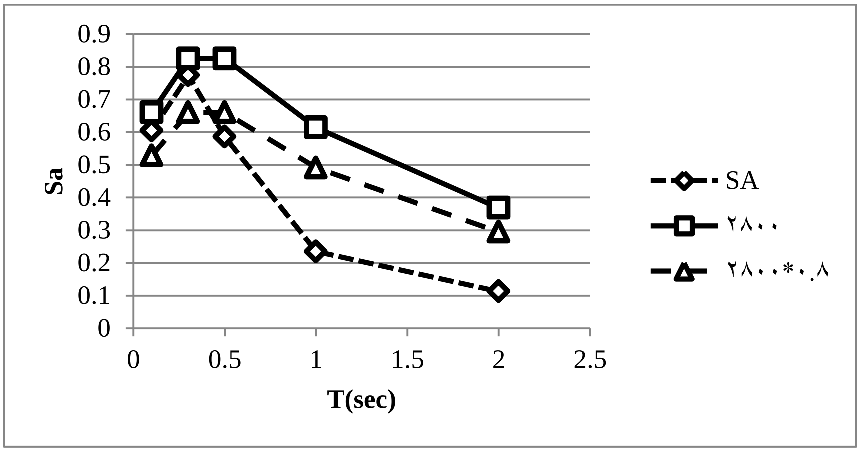

Fig.5. UHS for Soil Type 3, with 2% PE in 50 years useful Life of the Structures in Golsar

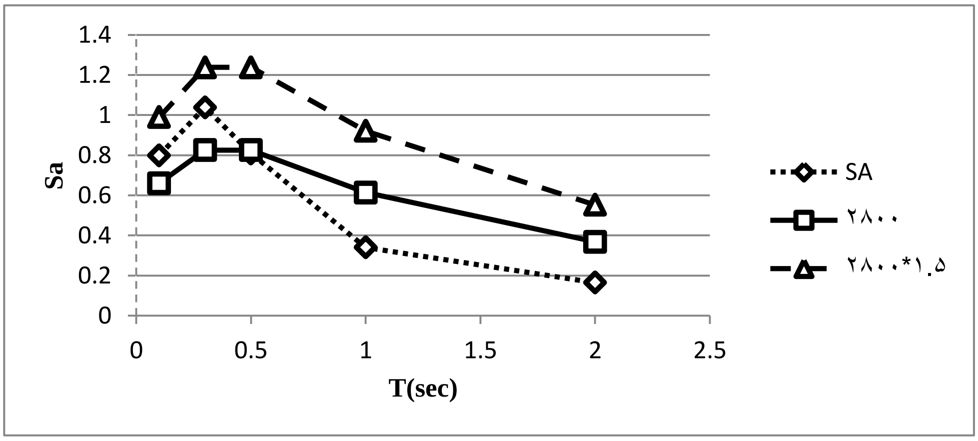

Fig. 6.UHS for Soil Type 3, with 10% PE in 50 years useful Life of the Structures in Golsar

11. Conclusions

Based on the case study of the present paper:

- The closest and largest faults near golsar area are Talesh fault, Lahijan fault respectively.
- According to Kijko results, the probability M=6 magnitude in period of 39 years and the probability of 7 magnitude earthquake in period of 251 years.
- Based on deterministic seismic hazard analysis, with regard to attenuation relationship the maximum acceleration of Talesh fault is 0.36 and maximumacceleration of Lahijan fault is 0.32 on bedrock.
- PGA with a probability of exceediy 10% in 50 years (return period of 475 years or risk level 1) in Golsar region is 0.31 g which has been mentioned to be 0.3 g in Iranian 2800 standard.
- PGA with a probability of the event equals to 2% in 50 years (return period of 2475 years or risk level 2) in Golsar, Rasht is 0.41 g.
- By observing the uniform hazard spectra, It can be concluded that the horizontal spectral acceleration comprises the highest values in the period of 0.3 seconds for both 2% and 10% probabilities of event, so that we observe an increment in spectral acceleration till the period of 0.3 seconds, and then a gradual decrease in spectral acceleration can be seen. This subject can be seen as well in Iranian Seismic Code.

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