Peak Ground Acceleration on Bedrock and Uniform Seismic Hazard Spectra for Different Regions of Golpayegan, Iran

Amirhossein Soltani Afarani, Gholamreza Ghodrati Amiri, Seyed Ali Razavian Amrei

Abstract: The present paper was done under the title of peak ground acceleration(PGA) on bedrock and uniform seismic hazard spectra(UHS) for different regions of Golpayegan city. A set of seismic sources, historical and instrumental seismicity data within the radius of 200 kilometers from the city center since the year 1316 until now has been collected and used. Kijko[2000] method has been applied for estimating the seismic parameters considering lack of suitable seismic data, inaccuracy of the available information and uncertainty of magnitude in different periods. The calculations were performed by using the logic tree method, Five weighted attenuation relationships were used; including Ghodrati et al (2007), 0.3; Ambraseys et al (1996), 0.2 ; Campbell-Bozorgnia (2000), 0.15 ; Campbell-Bozorgnia (2009), 0.15 and Akkar & Bommer(2010), 0.2. Furthermore in order to determine the seismic spectra based on weighted attenuation spectral relationships, and also for the reason of being spectral and more suitable with the conditions of the zone, Ambraseys et al (1996), 0.3 ; Ghodrati et al (2010), 0.3 ; Campbell (1997), 0.2 & Berge-Thierry (2003), 0.2 were used. The SEISRISKIII (1987) software was used to calculate the earthquake hazard. The results of this analysis were submitted including the spectra and maps for 10% and 2% probability of event in 50 years.

Keywords: Seismic hazard analysis, Peak Ground Acceleration (PGA), Uniform seismic hazard spectra, uniform spectra, attenuation relations, Golpayegan and Iran.

I. INTRODUCTION

Golpayegan with the longitude and latitude 29.50, 46.33, is Golpayegan city center.This city with the area 2421 sq. Km is located in the north-west of isfahan province.this city is limited by mahallat and khomein from north,khansar from south ,meymeh from East and aligudarz from west . Height of city is 1818 meters above sea level,population in census of 2011 have been 54752 people. It is one of the most important cities of the province and country. There are numerous important historical, religious and industrial places in Golpayegan, including googad citadel and two large dams; koocheri and golpayegan. Given the past recorded history of earthquakes and faults in the range of the city, the possibility of another earthquake event is inevitable.

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Due to the lack of detailed engineering design of structures, especially in older structures, if a large earthquake in this city happens, a terrible tragedy will be experienced. Probabilistic analysis is one of modern methods in analyzing seismic risk. In this analysis, the uncertainty within different parameters is taken in consideration and results are presented logically. In this study, it was sought to accurately identify both local area faults and numerous attenuation relations suitable for the region to ensure more reliable results [1].

II. SEISMOTECTONICS

Due to active faults in the surrounding areas, Golpayegan is among active seismic places. Throughout the present study, in order to evaluate the seismic hazard in the region, all sources of possible earthquakes and their ability to generate strong ground movement have been collected. A list of critical faults in the range of 200 km is given in Table 1 and in Figure 1 some of the faults in the studied areas are shown.

Table 1: Main Faults within 200 km Radius of Golpayegan

No.	Faults
1	Main thrust of the Zagros
2	Main young zagros
3	Doroud
4	Muteh
5	Aligudarz
6	Golpayegan
7	Kucheri
8	Zefreh-kashan
9	Kuh borji thrust
10	Bid-e-hend
11	Talkhab
12	Daraan

III. THE PEAK EARTHQUAKE MAGNITUDE AND FAULT RUPTURE LENGTH APPENDIX

To estimate the relationship between the peak expected magnitude and fault length, seismotectonic and geotectonic behaviors of the concerned area were taken into consideration and the following relation was used [2].

M_s=1.259+1.244Log L (1)

Where, In Eq. (1), M_s is the surface magnitude and L is the rupture length in meter.

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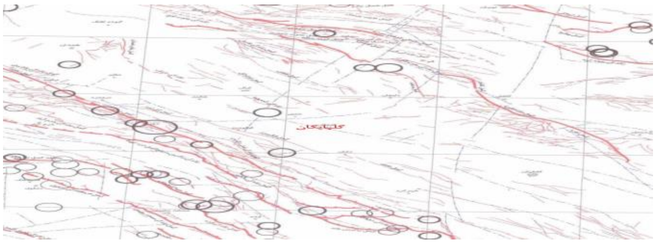

Figure 1: Main Faults within 200 km Radius of the Golpayegan City [3]

IV. SEISMICITY

The history of past earthquakes in each width is an indication of the Seismicity of that area. Thus, in order to conceive the Seismicity features, we should have a comprehensive list of occurred earthquakes in the area. In the present work, a number of earthquakes in a radius of 200 km of Golpayegan city were collected and considered.

A. Historical Earthquakes:

The historical documents indicate that the historical earthquakes occurred before 1900. As far as the collected information from old and historical books was concerned, their validity may be under question because they may have exaggerated the extent of the damage and destruction in excess negligence. However, the existence of such places could be important in the process of gathering information. Among the most important historical earthquakes, the following ones are to be mentioned [4].

- January 5, 1316 AD earthquake with magnitude 6.2 on the Richter scale, Golpayegan
- 1495 AD earthquakes with magnitude 5.9 Richter scale,Jebaal
- June 11, 1853 with a magnitude of 5.5 on the Richter scale
- September 28, 1876 a magnitude 5.8 earthquake on the Richter scale
- January 23,1907 AD earthquake with magnitude 7.4 on the richter scale,silakhor. the largest known earthquakes in the Zagros zone has been estimated that the number of dead between 6000 and 8000.

B. Instrumental Earthquakes:

In spite of the uncertainties in estimating the epicenter, focal depth, and magnitude of earthquakes in seismic data in twentieth century, these earthquakes are crucial with regard to the instrumental registration. From 1963, with the installation of seismography network, the uncertainties in their estimations were prominently decreased. A list of instrumental earthquakes in Golpayegan from 1900 to the present has been collected, the most important of which is the website of international seismological center [3].

C. Earthquake Magnitude:

In the present study, the surface-wave magnitude, Ms, was used in order to analyze the seismic hazard magnitude. As far as, the collected magnitudes were not of Ms type, they were converted to Ms. Thus, in order to convert the wave magnitude and Local magnitude to Ms, Table 2 [1] was employed. Moreover, in order to convert mb to Ms, equation 2 was used [5].

$Ms = 1.21*m_b - 1.29$ (2)

Where, Ms and mb stand for the surface-wave magnitude and the body-wave magnitude respectively.

Table 2: Magnitude Convert [1]

Ms	Mw	Ml
3.6	4.5	4.3
4.6	5.2	5.3
5.6	5.8	5.8
6.6	6.6	6.3
7.3	7.3	6.8

V. SEISMICITY PARAMETERS OF GOLPAYEGAN

Seismicity parameters or the peak expected magnitude, Mmax, λ, and β are among the basics of the seismicity of a place. They are used to indicate the seismicity of a place. Collecting earthquake data for Golpayegan according to the fundamental assumption in estimating Seismicity parameters, Filtered data was evaluated in Poisson distribution. The method that was used for elimination of beforeshocks and aftershocks is the variable windowing method in time and space domains Gardner and Knopoff [6].

A. Determination of Seismicity Parameters:

In this paper, in order to estimate the seismic parameters due to the shortage of appropriate seismic data and the uncertainty of earthquake magnitude, the Kijko method [7] was used based on the probabilistic method of peak likelihood estimation. In this method, according to the faults of Seismic data and the low accuracy at different times, their occurrence in determination of seismicity parameters Mmax, λ, and β are used. The results of applying this method includes determination of the seismic parameters (Table 3), the return period, probability of event and the magnitude of seismic events at different times. In Figure (2) estimation of the return period of earthquakes in Golpayegan (Kijko method) is presented.

Table 3: Values of Seismic Parameters in the Range of 200 km Golpayegan (kijko Method) [6]

	Results
Beta	1.98 +- .01 (b = .86 +- .01)
Lambda	8.00 +- .67 (for Mmin = 3.00)
Mmax	7.90 +- .54 (for SIG(Xmax) = .20)

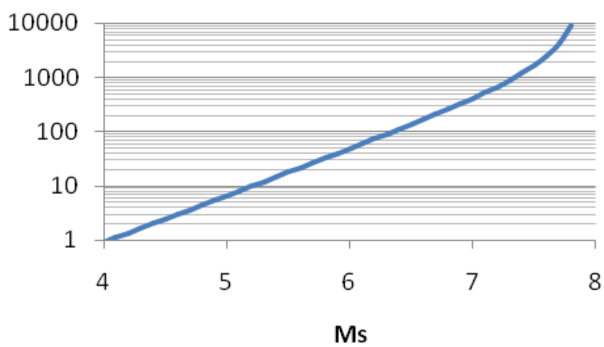

Figure 2: Estimation of the Return Period of Earthquakes in Golpayegan (Kijko Method)

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VI. SEISMIC HAZARD ANALYSIS

The present paper aims at providing Peak Ground Acceleration (PGA) on bedrock and uniform seismic hazard spectra (UHS) for different regions of Golpayegan using Probabilistic Seismic Hazard Analysis. In this method, the procedure starts with identifying and modeling the distribution of seismic sources, evaluation of recurrence relationship, evaluation of local site effects such as soil types, estimation of activity rate for probable earthquakes, evaluation of attenuation relationships for peak ground acceleration, geotechnical characteristics of sediments, topographic effects resources and the probabilistic analysis of the risk of earthquakes the likely location of earthquakes causing them the determination of the acceleration spectra on bedrock has been used.

A. 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. The needed points are as follow, sourcespecifications, direction of the wave propagation, geology and topography effects of the site, magnitude, refraction and energy absorption due to the properties of the material through which the waves pass, fault mechanism, reflection, and distance from seismic source. Knowing about just above mentioned points, here are Five weighted attenuation relationship used:Ghodrati et al (2007)[8] 0.3,ambraseys et al (1996)[9] 0.2 ,campbell-Bozorgnia (2000)[10] 0.15,campbell-Bozorgnia (2009)[11] 0.15 ,akkar-bommer(2010)[12] 0.2 .in order to determine the acceleration spectra from weighted attenuation spectral relations: ambraseys et al (1996)[9] 0.3 ,Ghodrati et al (2010) [13]0.3, campbell (1997)[14] 0.2 & Berge-Thierry (2003)[15]0.2 for the reason of being spectral and more suitability with conditions of the zone used. The reason for using the Logic-tree method is that using a single attenuation relationship is not an appropriate choice because the uncertainty of given data is not as reliable as desired. Moreover, the local 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 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 local relationship.

B. Probabilistic Seismic Hazard Analysis:

In this part, based on the modeled seismic sources, seismic parameters, and SEISRISK III software [16], the peak horizontal acceleration on bedrock (PGA) and horizontal spectral acceleration, each with 10% and 2% PE in 50 years (equivalent to a return period of 475 and 2475 years) in accordance with the levels of 1 and 2 of Seismic Rehabilitation of Existing Building [17], for a 14×7 network where surround Golpayegan appropriately, were estimated. As far as the type of soil is unknown, in each place of the network, exact calculations for soil type 3 (the most probable soil type in the area) based on Iranian Code of Practice for Seismic Resistant Design of Buildings [18] were done. The maps for peak ground acceleration on bedrock (PGA) and horizontal spectral acceleration based upon the soil type of Golpayegan city for the 0.1,0.3, 0.5, 1, 2 periods are presented in Figures 3 to 8.

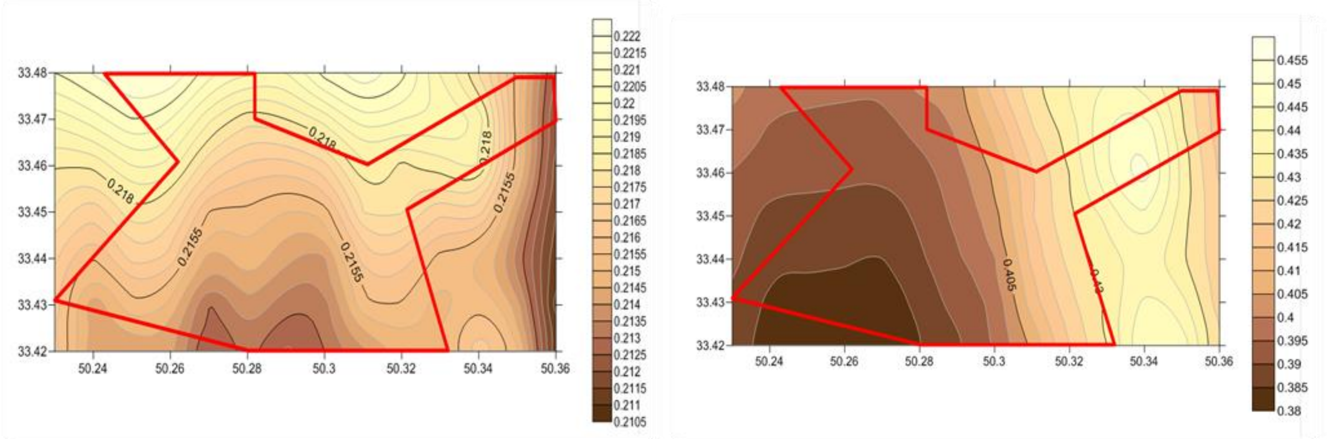

Figure 3: Zoning Maps of PGA with 10% and 2% PE in 50 years (Left to Right), and the Border of Golpayegan

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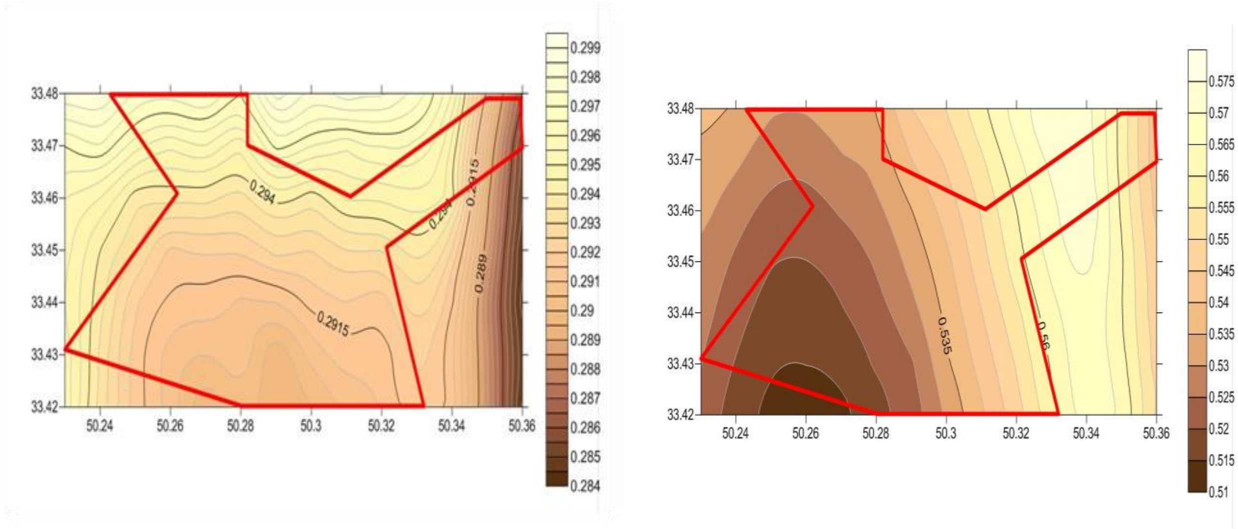

Figure 4: Zoning Maps of 0.1 s Spectral Acceleration with 10% and 2% PE in 50 Years (Left to Right) in Soil Type 3, and the Border of Golpayegan (Thick Line)

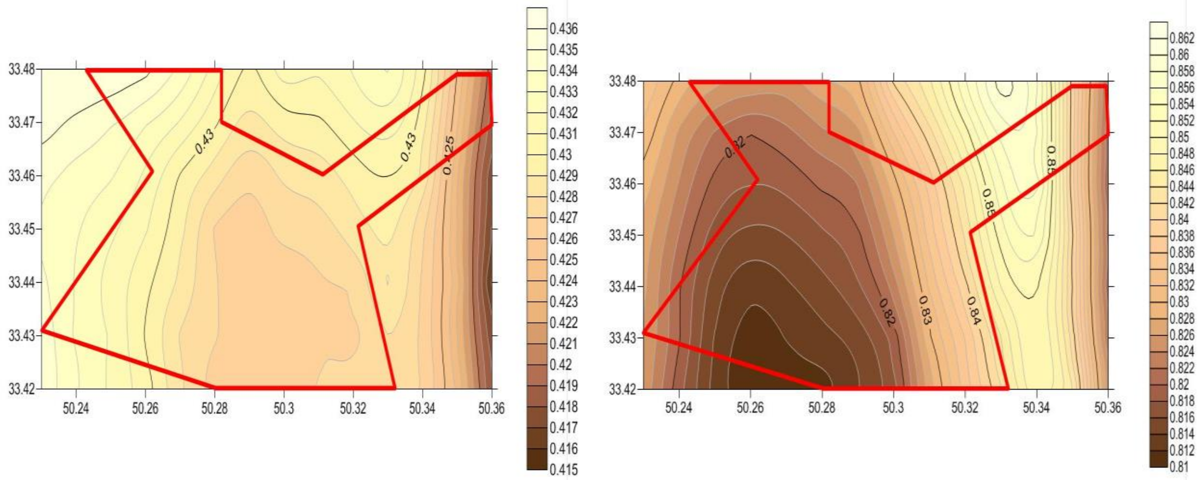

Figure 5: Zoning Maps of 0.3s Spectral Acceleration with 10% and 2% PE in 50 Years (Left to Right) in Soil Type 3, and the Border of Golpayegan (Thick Line)

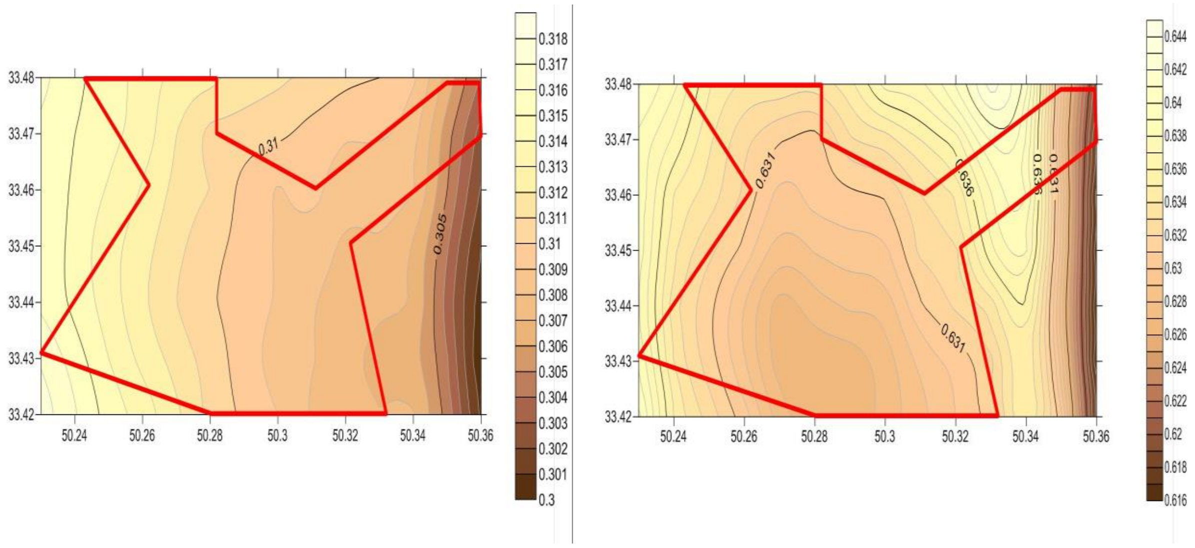

Figure 6: Zoning Maps Of 0.5 S Spectral Acceleration with 10% and 2% PE in 50 years (Left to Right) in Soil Type 3, and the Border of Golpayegan

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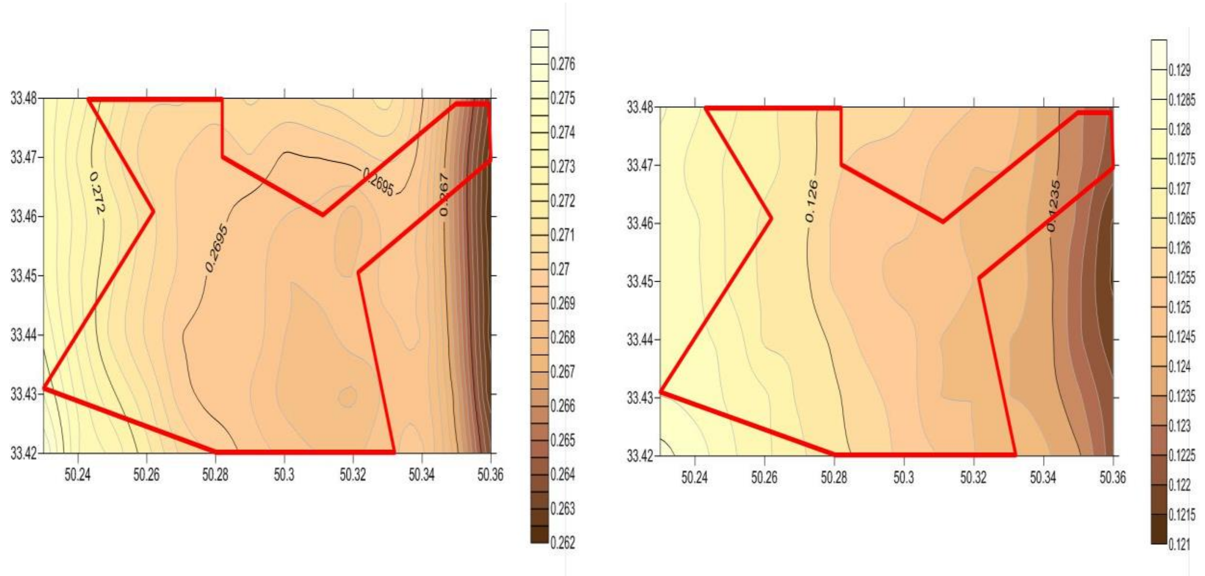

Figure 7: Zoning Maps of 1.0 S Spectral Acceleration With 10% and 2% Pe in 50 Years (Left to Right) in Soil Type 3, and The Border of Golpayegan

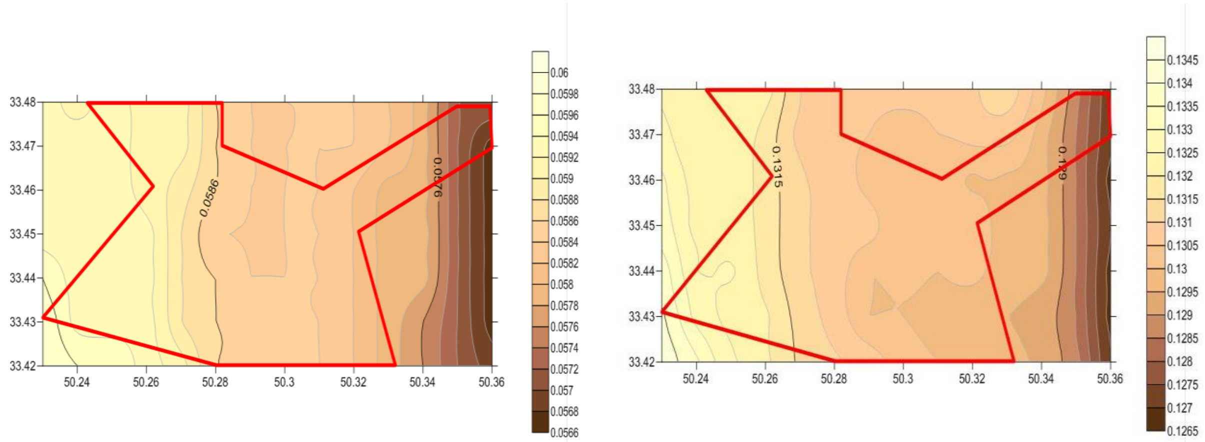

Figure 8: Zoning Maps of 2.0 s Spectral Acceleration with 10% and 2% PE in 50 years (Left to Right) in Soil Type 3, and the Border of Golpayegan

VII. Uniform Hazard Spectra (UHS)

The uniform hazard spectra (UHS) are formed in the form of a response in which any time, there is the sameprobability range for its occurrence. Throughout these spectra, within all periods in the life of the structure, the probability of occurrence is considered as the same. In other words, in designing a structure, the return period of spectral acceleration for different periods is considered the same. For this purpose, in any part of the network with given seismic hazard, this range is obtained for different periods.

In Figure 9, the uniform hazard spectra for the soil type and risk levels 1 and 2 based on Seismic Rehabilitation of Existing Building for Golpayegan city are presented. The spectra in these figures are presented as the peak, minimum and average values of spectral acceleration at different points in the range of the network. Also to compare the risk levels 1 based on Iranian Code of Practice for Seismic Resistant Design of Buildings [15] and 70% and the standard range for the risk level 2, the standard spectra range of Iranian Code of Practice for Seismic Resistant Design of Buildings [15] and 150% of it is presented.

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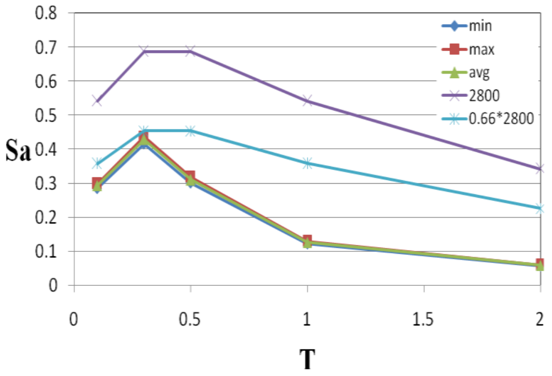

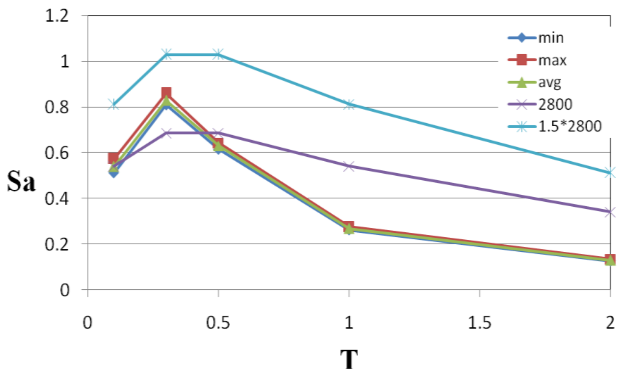

Figure 9: UHS for Soil Type 3, with 10% and 2% PE in 50 Years (Up to Down)

VIII. CONCLUSION

1- PGA with a probability of event equal to10% in 50 years (return period of 475 years or risk level 1of seismic rehabilitation instruction of the existing buildings) in Golpayegan varies from 0.20g to 0.23g, which has been mentioned to be 0.25g in Iranian Code of Practice for Seismic Resistant Design of Buildings [15], (2800 standard). 2- PGA with a probability of event equal to 2% in 50 years (return period of 2475 years or risk level 2 of seismic rehabilitation instruction of the existing buildings) in Golpayegan varies from 0.38g to 0.46g. 3- The horizontal spectral acceleration comprises the highest values in the North East of Golpayegan comparing to other regions. 4- By observing the uniform hazard spectra, we conclude 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 up to 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 Code of Practice for Seismic Resistant Design of Buildings (2800 standard).

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