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Preparation the Site Specific Spectrum for Civil Regions of Zagross Mountains

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ABSTRACT

In this paper the site specific spectra for a region of the Zagros Mountains containing 5 cities in Kurdistan province of Iran is prepared. For this purpose, all the occurred earthquakes, containing both historical and instrumental events, in each 5 city have been gathered then main earthquakes was prepared by elimination the aftershocks, foreshocks, and the incorrect reported events from the data and main earthquakes were taken into consideration to calculate the seismic parameters by Kijko [2000] method considering uncertainty in magnitude and incomplete earthquake catalogue.

All seismic sources of the region are modeled and recurrence relationship is established. After adequate attenuation relationships were selected, The peak ground acceleration over the bedrock (PGA) is then calculated for the four hazard level introduced in FEMA 356 in each city according to the probabilistic seismic hazard analysis and using the Poisson's probability distribution function for prediction of earthquake occurrence in future with a return period of 75, 225, 475 and 2475 years.

Then, according to the soil type resulted from geotechnical explorations, the site specific spectrum for each city is prepared using Newmark-Hall method and compared with the design spectrum suggested by Iranian code of practice for seismic resistant design of buildings.

INTRODUCTION

Zagros region is a vast region lied from northwestern to southwestern of Iran. In this paper the site specific spectra using Newmark-Hall method for five cities in Kurdistan province of Iran including Sanandaj, Kamyaran, Marivan, Saqhez, and Baneh are prepared. The Kurdistan province of Iran is located in Zagros region. The kurdistan province has fundamental installations and attractive places for tourists and its many other potentialities for development can make it as one of the significant places of the country. Then any strong earthquake may make considerable damages in this area. So, the importance of such studies is apparent.

The studied regions encircle around of each five studied city with the radius of 200 km. Fig.1 showed active faults in the studied region and location of five studied cities.

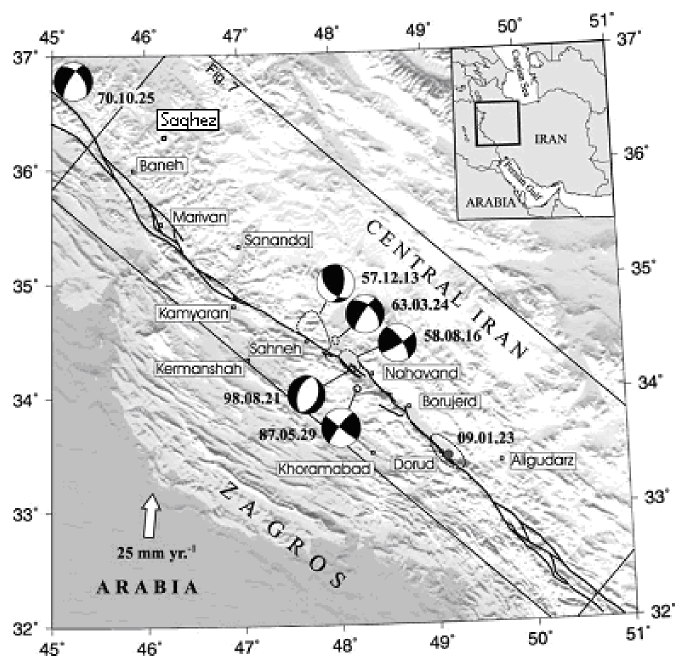

Fig.1. The map of active faults and location of five studied cities including Sanandaj, Kamyaran, Marivan, Saqhez, and Baneh (Talebian, M., Jackson, J., 2002)

GEOLOGIC BACKGROUND

Based on geological and geotectonical references, five represented cities including Sanandaj, Saqhez, Baneh, Marivan, and Kamyaran are situated in the zone of Sanandaj-Sirjan band [as an independent region of the central Iran] and also located near to the zone of high Zagros.

The actively deforming Zagros fold–thrust belt is a result of the collision of Arabia with continental Eurasia (Fig. 2).The separation of Arabia from Africa and its subsequent collision with Eurasia was the last of a series of separation/ collision events, all of which combined create the extensive Alpine–Himalayan orogenic system. The Zagros fold–thrust belt is bounded on the northeast by both the Main Zagros Reverse fault and Main Recent fault. The Main Zagros Reverse fault is a proposed suture zone between the Arabian plate and Eurasia. The Main Recent fault, a young, active, right lateral fault, follows the trace of the Main Zagros Reverse fault from Turkey to approximately 328 S (Fig. 2). The Main Zagros Reverse fault is also the southern margin of the Sanandaj–Sirjan zone. The Sanandaj–Sirjan zone is a region of polyphase deformation, the latest reflecting the collision of Arabia and Eurasia and the subsequent southward propagation of the fold–thrust belt. At the northeastern edge of the Sanandaj–Sirjan zone is the Urumieh Dokhtar arc (Fig 2). Interpreted to be an Andean type magmatic arc that has been active from the late Jurassic through present, the Urumieh Dokhtar Arc represents the subduction of the Neotethys ocean as Africa moved northward with respect to Eurasia.

The interpretations presented in the balanced crosssections are based on 1:100,000 and 1:250,000 geologic maps from the National Iranian Oil Company and Iranian Geological Survey. Although the maps show detailed surface geology, important aspects of the Zagros orogen are not known, such as the dip of the basement surface and the stratigraphic level (base of Cambrian section or within the basement) of the master de´collement. The following iscussion describes and provides the rationale for the interpretations of the structures that are shown in the balanced cross-sections. The interpretations are based on map patterns, strike and dip data, changes in stratigraphic thicknesses across strike and select borehole data. The lack of published seismic data inhibits knowing completely the geometry of structures at depth, the depth to basement or how basement topography may change through the orogen. Even with these handicaps, knowing the undeformed thickness of strata (,12 km, and depth to basement (,11 km) determined from travel times for local earthquakes) at the front of the Zagros fold thrust belt, provide a minimum depth to basement. In addition, using the constraints of equal line lengths, kinematic compatibility and detailed analysis of the geometry of rocks at the surface can provide insight into a wide variety of structures present at depth, including detachment folds, fault propagation folds, fault-bend folds, imbricate fans, and duplexes.(McQuarrie, M. 2004).

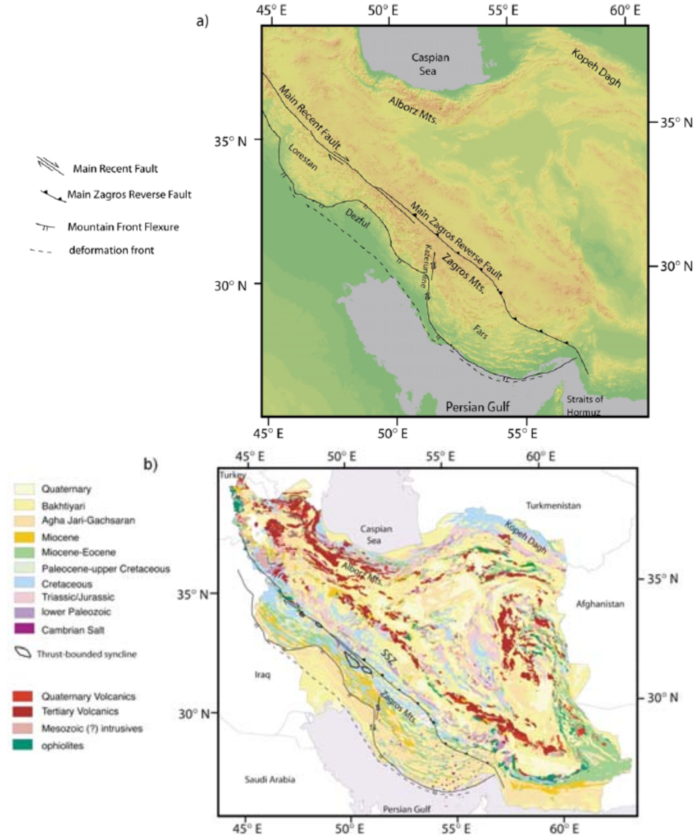

Fig.2. (a) Topographic map of the Arabia /Eurasia collision zone in Iran. Reds indicate topography .1.5 km. (b) Geologic map of Iran. SSZ represents the Sanandaj–Sirjan zone. Open ovals south of the Main Zagros Reverse fault represent thrust-bounded synclines. (McQuarrie, M. 2004).

MODEL OF SEISMOTECHTONIC OF STUDIED REGIONS

Based on seismotectonic, the studied region contains the seismotectonic units of Maraghe-Sirjan (including two tectonic zones: Sanandaj-Sirjan and Oroumiye-Dokhtar in the middle of Zagros and central Iran), the high Zagros , the driven folded thrust of Zagros and Central Alborz.

Based on the performed studies, the studied region, a part of Zagros, is situated in the collided part of Iran, Arabia and Caucasus and mainly has got involved in vertical strike-slip and transitional motions. Structural elements of studied region consist of faults with north-west; south-east direction and reverse strike-slip reverse mechanism. Vertical component along these structures is mainly reversed (compressive) [Harvard Seismology education,(2007); Hesami, K., et. al, (2001); Berberian, M., (1981)]. Release rate analysis of seismic moment of earthquakes in the studied region shows that main part of energy releases along the strike-slip moving faults. But this is incompatible with the expected shortening of the region. So, this is the fact that increases the probability of moderate and severe earthquakes [Tchalenko, J. S.,et. al, (1974)]. Most of the past earthquakes in the region were those have small depth and in many cases the bedrock is involved in deformations. The mean Moho depth is about 50 km and the depth of the seismic stratum has been assessed 8-12 km. [Maggi, A., et. al, 2002], According to focal mechanism of past earthquakes and tectonic evidences, the mechanisms of the reverse faults are predominant in the studied region but the effect of the reverse strike-slip faults can't be ignored. Groups of young faults of Zagros as reverse strike-slip faults are most active faults of the region which encircle its young and principal deformations.

Fig.2 displays the centroid depth determined from body wave modeling. These vary from 4 to 20 km, with typical uncertainties being ± 4 km.

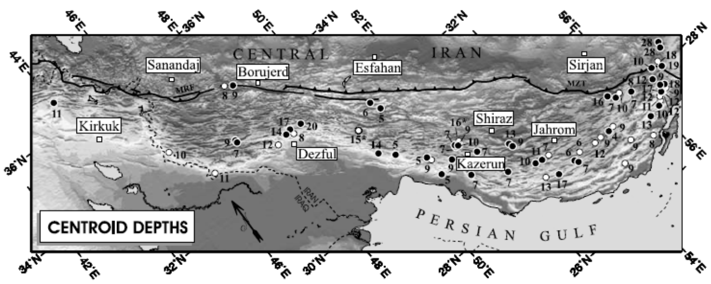

Fig.3. Earthquake centroid depths determined from body wave modeling. Numbers are depth in km. block circles are those determined from long period P and SH waves. Open circles are those determined from P waves alone. The two depths marked with stars (15 and 16*) are earthquakes whose depths were estimated from SH wave alone (Talebian M. and Jackson J. 2004).*

BASIC STEPS IN THE ASSESSMENT OF THE NEWMARK-HALL SPECTRA

The basic steps involved in constructing NewMark-Hall spectra are outlined below:

(1) Establish the expected PGA value for the design earthquake by probabilistic procedures.

(2) Calculate the corresponding expected peak values of ground velocity and displacement using the relations

$$v = c_1 \frac{a}{g} \qquad\qquad d = c_2 \frac{v^2}{a}$$

Where a, v, and d represent the design PGA, PGV, and PGD, respectively; g is the acceleration due to appropriately for the known site conditions.

(3) Having established numerical values for a, v, and d, multiply them by their respective amplification factors: α_a, α_v, and α_d corresponding to the 50^{th} percentile. Plot the results on tripartite log paper as a series of straight lines parallel to the respective axes (e.g., a line of amplitude $\alpha_d d$ should be parallel with the displacement axis).

(4) The design spectrum curve must approach the design PGA as the frequency increases. Let f_1 be the frequency on the design spectrum corresponding to the point of intersection of the lines associated with $\alpha_v v$ and $\alpha_a a$. The amplified ground acceleration ($\alpha_a a$) should approach the design PGA in a linear fashion starting at $4 * f_1$ (approximately 8 Hz) and ending at approximately 33 Hz [Green R.A., et. al, 1994].

<u>Establish The Expected PGA Value By Probabilistic Procedures</u>

The objective of seismic assessment is to assess the parameters of the strong ground motion. In this paper, the peak horizontal ground acceleration over the bedrock (PGA) is calculated by a probabilistic seismic hazard assessment. For this reason, first of all, all the occurred earthquakes in a radius of 200 km of each studied cities have been gathered. After elimination of the aftershocks and foreshocks Gardner, J.K., and Knopoff, L. [1974], the main earthquakes were taken into consideration to calculate the seismic parameters by Kijko[2000] method. The seismotectonic model of the each considered regions and the seismic sources of the regions have been modeled. In this research, each city with its vicinity has been meshed as vertical and horizontal lines that the distance between every two subsequent vertical lines is 1.66 km and the distance between every two subsequent horizontal lines is 1.82 km, and the peak ground acceleration over the bedrock(PGA) is calculated for each point of the mesh using the logic tree method and the five attenuation relationships: Ghodrati[2006] with weighted coefficient 0.3,Ramazi [1999] with weighted coefficient 0.2,Zarea' [1999] with weighted coefficient 0.2,Ambraseys and Bommer [1991] weighted coefficient 0.15, and Sarma and Srbulov [1996] with weighted coefficient 0.15.

These calculations have been performed by the SEISRISK III (Bender, B., and Perkins, D. M. [1987]) of four hazard levels corresponding with the introduced hazard levels in FEMA365. The results, for each city, show the peak ground acceleration over the bedrock (PGA) for the probability of 50%, 20%, 10%, 2% of exceedance during a 50 year economic life time of structures that are equal to an earthquake with a return period of 75, 225, 475 and 2475 years, respectively.

The probabilistic seismic hazard assessment of Sanandaj, Iran has been performed by Ghodrati et. al. (2009), The probabilistic seismic hazard assessment for four reminded cities have been performed as same procedures and methods as Sanandaj city.

The results of probabilistic seismic hazard assessment for studied cities, seismicity parameters for studied region and the average value of PGA according to four hazard levels, calculated for each five studied city, have been showed in table 1. The four represented hazard levels, represented with H-L-1, H-L-2, H-L-3, and H-L-4, are equal to an earthquake with a return period of 75, 225, 475 and 2475 years, respectively.

Table1. The result of probabilistic seismic hazard assessment for studied cities

		Studied cities in zagros region				
		Sanandaj	Kamyaran	Marivan	Saqhez	Baneh
Seismicity parameters	β	2.22	2.39	2.34	2.12	2.32
	Mmax	7.66	7.81	7.41	7.37	7.77
	λ	0.27	0.50	1.75	0.26	0.61
PGA (g)	H-L-1	0.094	0.29	0.31	0.23	0.26
	H-L-2	0.129	0.36	0.39	0.28	0.31
	H-L-3	0.155	o.41	0.44	0.33	0.37
	H-L-4	0.218	0.53	0.57	0.42	0.48

Constructing The Newmark-Hall Spectra

After calculating of average value of PGA for each five studied city, the Newmark-Hall spectra corresponding to these values of PGA have been prepared.

The Newmark-Hall spectra for five studied cities have been shown in Fig.4 to Fig. 23.

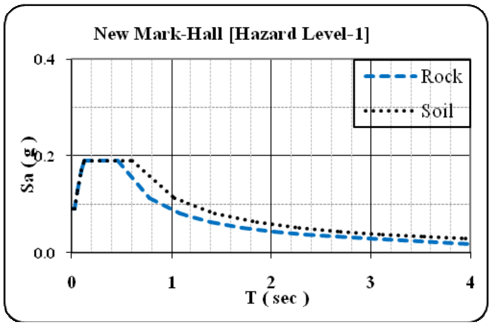

Fig. 4. Spectral acceleratio for Sanadaj with 75-year return period using New Mark-Hall method

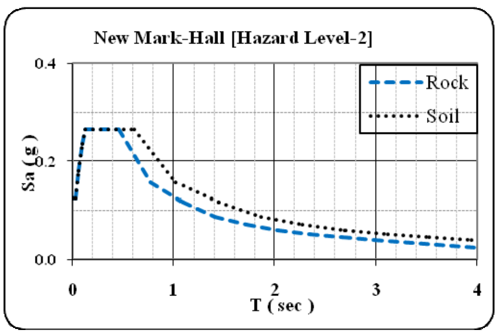

Fig. 5. Spectral acceleratio for Sanadaj with 225-year return period using New Mark-Hall method

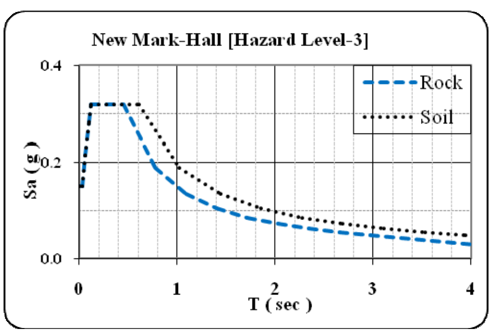

Fig. 6. Spectral acceleratio for Sanadaj with 475-year return period using New Mark-Hall method

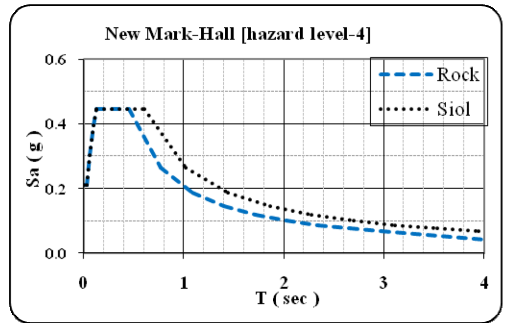

Fig. 7. Spectral acceleratio for Sanadaj with 2475-year return period using New Mark-Hall method

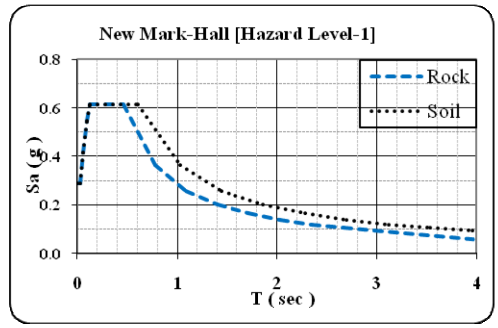

Fig. 8. Spectral acceleratio for Kamyaran with 75-year return period using New Mark-Hall method

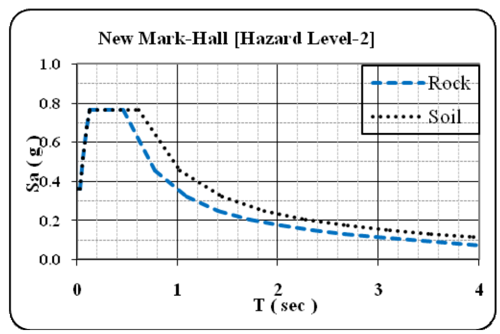

Fig. 9. Spectral acceleratio for Kamyaran with 225-year return period using New Mark-Hall method

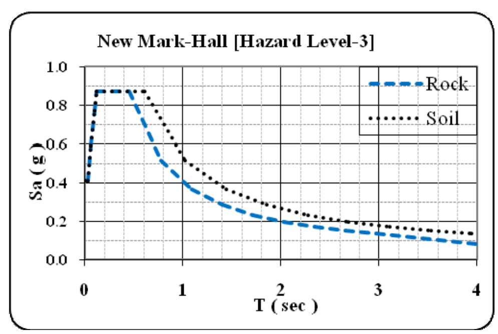

Fig. 10. Spectral acceleratio for Kamyaran with 475-year return period using New Mark-Hall method

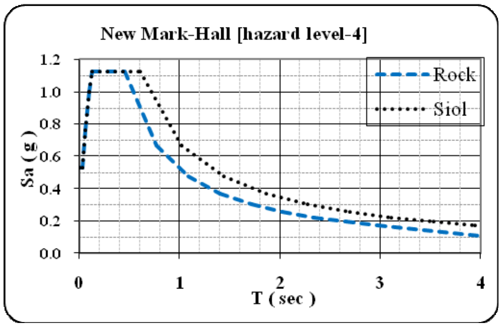

Fig. 11. Spectral acceleratio for Kamyaran with 2475-year return period using New Mark-Hall method

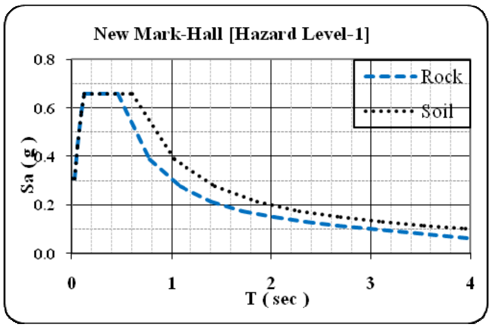

Fig. 12. Spectral acceleratio for Marivan with 75-year return period using New Mark-Hall method

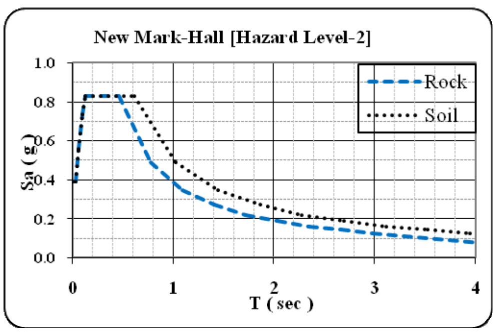

Fig. 13. Spectral acceleratio for Marivan with 225-year return period using New Mark-Hall method

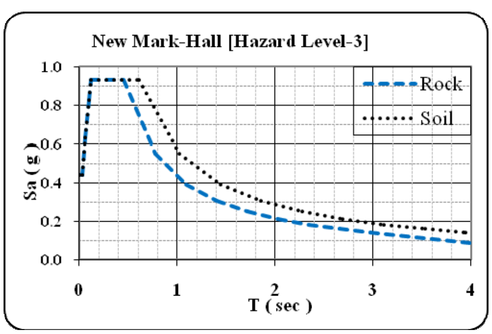

Fig. 14. Spectral acceleratio for Marivan with 475-year return period using New Mark-Hall method

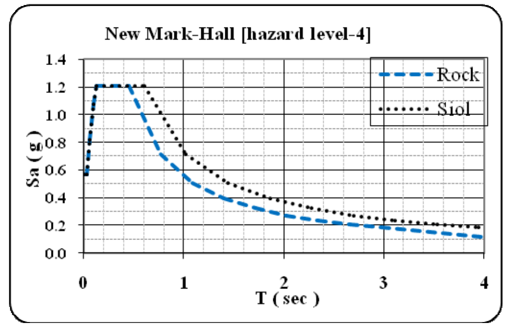

Fig. 15. Spectral acceleratio for Marivan with 2475-year return period using New Mark-Hall method

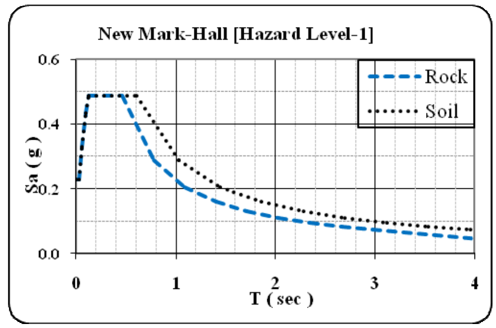

Fig. 16. Spectral acceleratio for Saqhez with 75-year return period using New Mark-Hall method

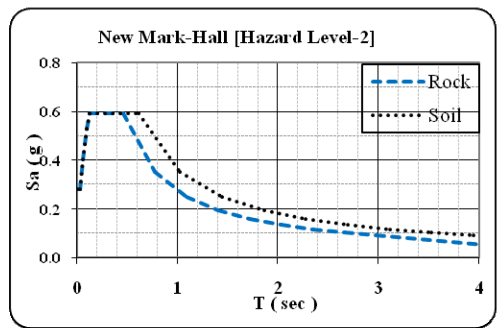

Fig. 17. Spectral acceleratio for Saqhez with 225-year return period using New Mark-Hall method

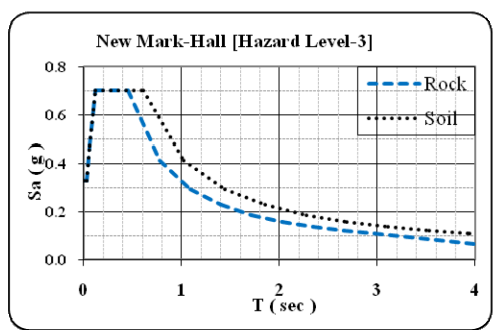

Fig. 18. Spectral acceleratio for Saqhez with 475-year return period using New Mark-Hall method

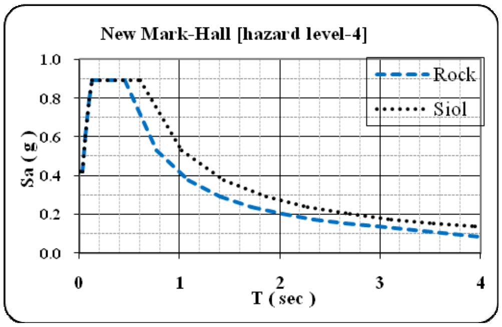

Fig. 19. Spectral acceleratio for Saqhez with 2475-year return period using New Mark-Hall method

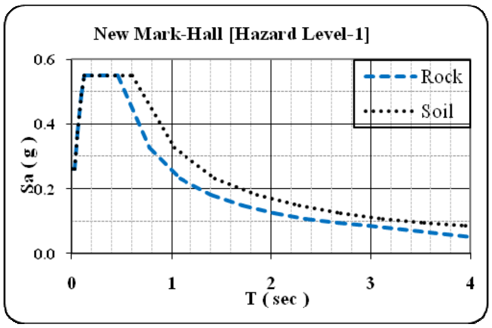

Fig. 20. Spectral acceleratio for Baneh with 75-year return period using New Mark-Hall method

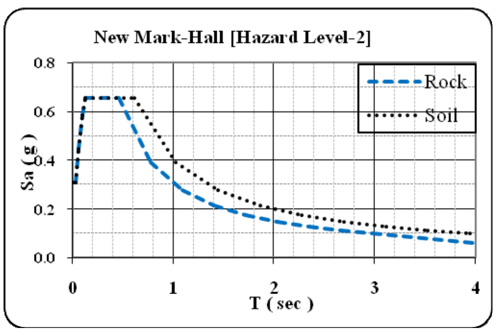

Fig. 21. Spectral acceleratio for Baneh with 225-year return period using New Mark-Hall method

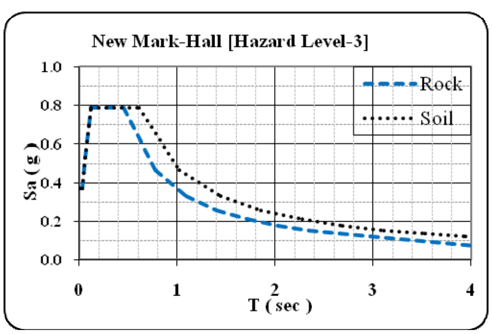

Fig. 22. Spectral acceleratio for Baneh with 475-year return period using New Mark-Hall method

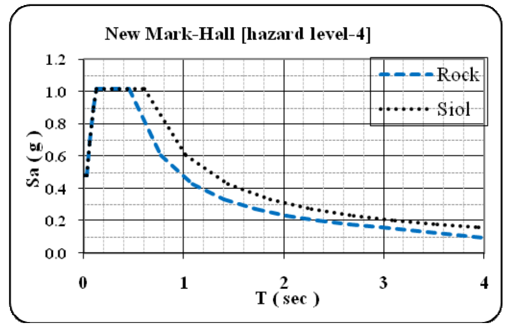

Fig. 23. Spectral acceleratio for Baneh with 2475-year return period using New Mark-Hall method

CONCLUSION

In this study, the average values of peak horizontal ground acceleration over the bedrock for five cities including Sanandaj, Kamyaran, Marivan, Saqhez, and Baneh are presented according to four hazard levels that show the average values of PGA for 50%, 20%, 10%, and 2% probability of being exceeded during life cycles of 50 years.

The Fig. 4 to Fig. 23 show the spectral accelerations prepared for each of five studied cities and four represented hazard levels correspond to the average values of PGA for rock and soil site.

The comparison of spectral acceleration calculated by Iranian code for soil type I with spectral acceleration calculated by Newmark-Hall method for rock site with 10% probability of being exceeded during life cycles of 50 years for studied cities including Sanandaj, Kamyaran, Marivan, Saqhez, and Baneh show in Fig. 24, Fig. 26, Fig. 28, Fig. 30, and Fig. 32 respectively.

The comparison of spectral acceleration calculated by Iranian code for soil type III with spectral acceleration calculated by Newmark-Hall method for soil site with 10% probability of being exceeded during life cycles of 50 years for studied cities including Sanandaj, Kamyaran, Marivan, Saqhez, and Baneh show in Fig. 25, Fig. 27, Fig. 29, Fig. 31 and Fig. 33 respectively.

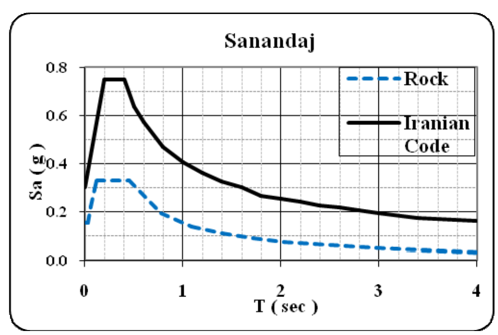

Fig.24. comparison of Sa. Calculated by Iranian code for Soil type I with Sa. Calculated by NM-H method for Rock Site with 475-year return period for Sanandaj

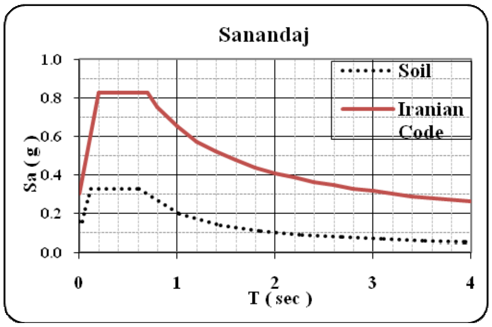

Fig.25. comparison of Sa. Calculated by Iranian code for Soil type III with Sa. Calculated by NM-H method for Soil Site with 475-year return period for Sanandaj

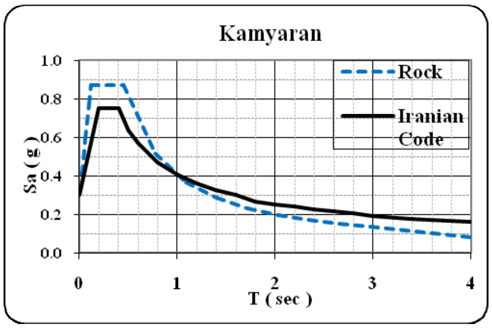

Fig.26. comparison of Sa. Calculated by Iranian code for Soil type I with Sa. Calculated by NM-H method for Rock Site with 475-year return period for Kamyaran

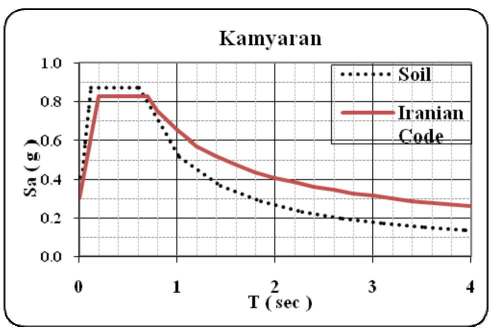

Fig.27. comparison of Sa. Calculated by Iranian code for Soil type III with Sa. Calculated by NM-H method for Soil Site with 475-year return period for Kamyaran

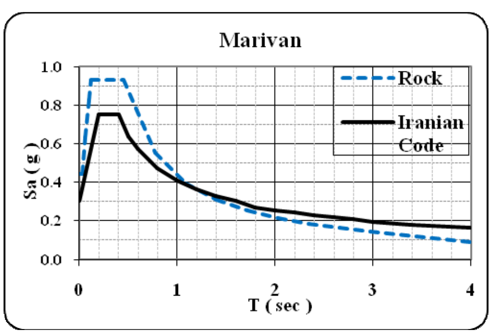

Fig.28. comparison of Sa. Calculated by Iranian code for Soil type I with Sa. Calculated by NM-H method for Rock Site with 475-year return period for Marivan

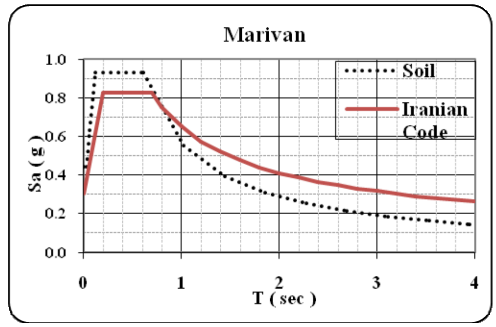

Fig.29. comparison of Sa. Calculated by Iranian code for Soil type III with Sa. Calculated by NM-H method for Soil Site with 475-year return period for Marivan

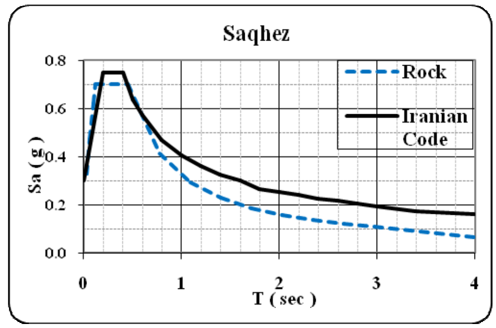

Fig.30. comparison of Sa. Calculated by Iranian code for Soil type I with Sa. Calculated by NM-H method for Rock Site with 475-year return period for Saqhez

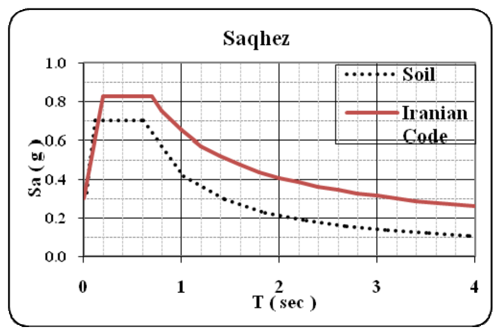

Fig.31. comparison of Sa. Calculated by Iranian code for Soil type III with Sa. Calculated by NM-H method for Soil Site with 475-year return period for Saqhez

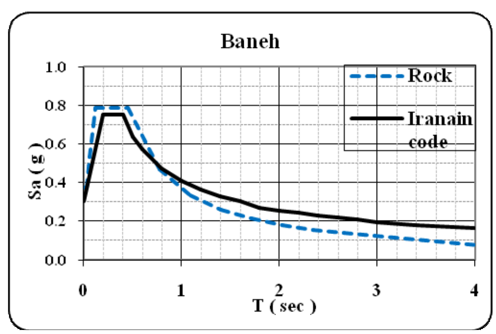

Fig.32. comparison of Sa. Calculated by Iranian code for Soil type I with Sa. Calculated by NM-H method for Rock Site with 475-year return period for Baneh

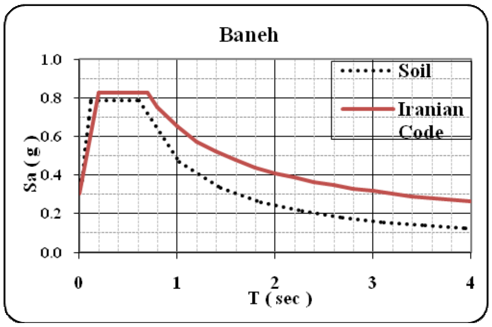

Fig.33. comparison of Sa. Calculated by Iranian code for Soil type III with Sa. Calculated by NM-H method for Soil Site with 475-year return period for Baneh

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