SEISMIC ACCELERATION RISK ANALYSIS OF IRAN

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SUMMARY

Previously developed frequency-magnitude correlations for various seismotectonic provinces of Iran together with an appropriate attenuation law are used to analyze the risks for occurrance of various peak ground accelerations. Expected peak ground accelerations for various regions for several values of focal distances and return periods are obtained. Probabilistic risks for different peak ground accelerations and various time durations are calculated for a range of focal distances. The results show that the seismicity vary substantially in the region. While Zagros provinces show the highest level of seismic activities, the Elburz mountain regions have the highest risk in producing distructive earthquakes.

INTRODUCTION

Iran is a region of high seismicity. Several destructive earthquakes have occurred in various parts of the country in the past few decades. Studies of seismicity of Iran were reported in (Ref. 1-7). Works on seismic risk of Iran are rather limited. (Ref. 8-17) cover the available reports.

In (Ref. 12) the seismicity of the seismotectonic provinces of Iran was considered. The earthquake records for the time duration (1900 to 1976) were separated for various seismotectonic provinces, complied and statistically analyzed. Frequency-magnitude correlations of the log-linear type for different provinces were established.

In the present work, earthquake peak ground acceleration risks for various regions of Iran are studied. An appropriate decay law of the seismic waves is employed and the expected peak accelerations for several return periods and different focal distances in various provinces are obtained and discussed. Poisson stochastic is used and the probabilistic risks for occurrance of various peak ground accelerations in different seismotectonic provinces for several time durations and focal distances are evaluated. The results are compared with those of the other models.

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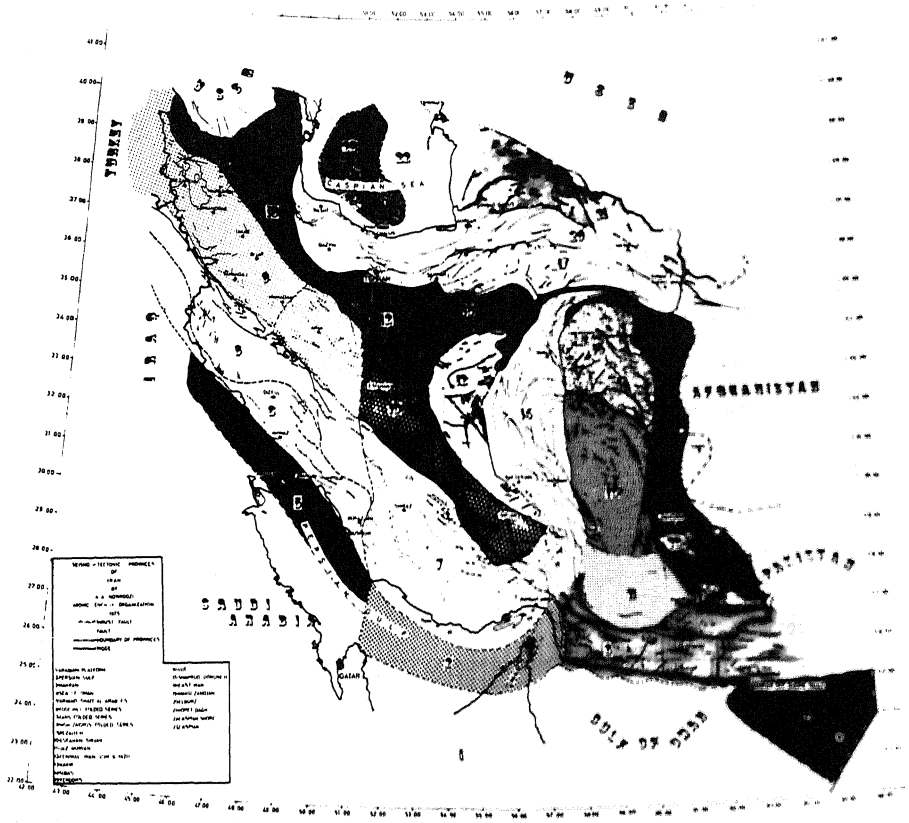

Fig. 1. Seismotectonic provinces of Iran.

FREQUENCY-MAGNITUDE CORRELATIONS

The seismotectonic provinces of Iran as developed by Nowroozi (Ref. 2) was used for risk analysis in Ref. (12-17) and in this work. Fig. 1 is a reproduction of the seismotectonic map of Iran. In (Ref. 12) the earthquake data for different seismotectonic provinces were fitted to log-linear frequency-magnitude relationships of the form

$$\log N = a - bM. \qquad (1)$$

Here, M is the magnitude of the earthquake and N is the expected number of earthquakes with magnitude greater or equal to M in one year. The coefficients a and b were evaluated by a least square error method. The results are listed in Table 1.

Table 1. The values of constant parameters and the estimated expected ground accelerations in units of 'g' for a focal distance of 20 km for several return periods.

PROVINCES	Constant Parameters a	b	Expected accelerations (g) Return Periods (years) 20	50	100	200
1 ARABIAN PALTFORM	3.8645	0.9677				
2 PERSIAN GULF	4.9983	1.1035	0.13	0.15	0.17	0.20
3 MAKRAN	4.5262	1.0194	0.13	0.15	0.18	0.21
4 SEA OF OMAN	2.7892	0.6486	0.17	0.23	0.29	0.37
5 ARVAND-SHATT-AL-ARAB	4.5475	1.0550	0.12	0.14	0.16	0.19
6 FOOTHILL FOLDED SERIES	6.1002	1.2026	0.16	0.19	0.21	0.24
7 FARS FOLDED SERIES	6.4654	1.1708	0.20	0.24	0.27	0.31
* 8 HIGH ZAGROS FOLDED SERIES	4.8465	0.9623	0.18	0.22	0.25	0.30
	4.6752	0.9220	0.19	0.23	0.27	0.32
9 REZAIYEH	4.1007	0.8667	0.16	0.21	0.24	0.29
10 ESFAHAN-SIRJAN	4.3337	1.1055	0.10	0.11	0.13	0.15
11 JAZ-MURIAN	5.0667	1.0667	0.14	0.16	0.17	0.20
12 CENTRAL IRAN	2.4947	0.6192	0.13	0.15	0.17	0.20
13 KAVIR	3.1006	0.8214	0.11	0.13	0.16	0.19
14 TABAS	4.2626	0.8868	0.17	0.21	0.25	0.29
15 FERDOWS	2.8295	0.6490	0.17	0.24	0.30	0.38
16 LUT	3.6952	0.8751	0.13	0.16	0.19	0.22
17 SHAHRUD-DORUNEH	4.3742	0.9032	0.17	0.21	0.25	0.29
*18 EAST IRAN	2.5724	0.6321	0.16	0.21	0.27	0.34
	3.1637	0.7273	0.16	0.21	0.25	0.31
19 MAKU-ZANDJAN	3.3338	0.8191	0.12	0.16	0.19	0.23
*20 ELBURZ	3.6935	0.7776	0.18	0.23	0.28	0.34
	1.8490	0.4944	0.18	0.26	0.36	0.48
*21 KOPET-DAGH	3.5461	0.7502	0.18	0.24	0.29	0.36
	1.8506	0.4935	0.18	0.26	0.36	0.49
22 CASPIAN SHORE	3.5619	0.8059	0.15	0.19	0.23	0.28

*Estimations are based on two data bases.

Based on these coefficients, the mean return periods for several magnitudes were evaluated in (Ref. 12). Accordingly, in every 50 years, a magnitude 7 earthquake is expected to occur in the provinces of Sea of Oman, Fars, Ferdows, Elburz, and Kopet-Dagh. Mean return periods for the same magnitude in High Zagros, Rezaiyeh, Tabas, and Shahrud-Doruneh provinces are about 70 to 100 years. An earthquake with magnitude 6 is expected to occur in Fars province in every 4 years and in the provinces of Oman, Foot-Hill, High Zagros, Rezaiyeh, Tabas, Ferdows, Elburz and Kopet-Dagh in every 8 to 13 years. In the remaining provinces with the exception of Esfahan-Sirjan, Arvand-Shatt-al-Arab, and Kavir provinces, the mean return period is about 20 years.

GROUND ACCELERATIONS

Donovan (Ref. 18) used the data for a number of earthquakes all around the world and developed a correlation between the peak ground acceleration, earthquake magnitude and the focal distance. This correlation was employed in the present study. The expected peak ground accelerations in different seismotectonic provinces for several values of focal distances and return periods are evaluated. The results for a focal distance of 20 km are listed in Table 1. This table clearly shows the relative seismicity of various regions. Accordingly, in a time period of 20 years and at a focal distance of 20 km, it is expected that an acceleration of 0.18 to 0.20 g to occur in Fars, Elburz, Kopet-Dagh and High Zagros provinces. In the same time period, the provinces of Esfahan-Sirjan, Kavir and Arvand-Shatt-Al-Arab will experience an acceleration of about 0.10 g. The expected accelerations in the other provinces are about 0.13 to 0.17 g.

For a return period of 200 years and a focal distance of 20 km, Elburz and Kopet-Dagh provinces are expected to experience accelerations as high as 0.5 g; the corresponding peak acceleration for the provinces of Sea of Oman, Ferdows and East Iran is about 0.35 g. The expected acceleration for Fars, High Zagros and Caspian Shore provinces is about 0.3 g. The lowest expected acceleration is 0.15 g for Esfahan-Sirjan province. This latter result is in agreement with the existence of undamaged several century old historical buildings in the city of Esfahan.

Figure 2 shows the variations of peak ground accelerations with the focal distances for a number of seismotectonic provinces in Iran for a return period of 50 years. In this time duration, Elburz and Fars provinces are expected to experience an acceleration of about 0.30 g at a small focal distance of about 15 km, followed by 0.22 g for Foothill province 0.17 g for Arvand-Shatt-Al-Arab province, and 0.13 g for Esfahan-Sirjan province. Detailed calculations of (Ref. 15) indicates that for long return periods the expected acceleration is highest for Elburz and Kopet-Dagh provinces. Esfahan-Sirjan province has the lowest expected ground acceleration in the country for any return periods.

PROBABILISTIC RISKS FOR VARIOUS ACCELERATIONS

Using the Poisson stochastics, the probabilistic risks for occurrance of various accelerations in different seismotectonic provinces for several time durations and focal distances are evaluated. (See (Ref. 16) for details). Fig. 3 shows the probabilitistic risks for a focal distance of 30 km and a time duration of 30 years for a number of seismotectonic provinces in Iran. It appears that the expected risk is minimum for Esfahan-Sirjan province. Fars province has the highest risk for accelerations of about 0.1 to 0.15 g. Elburz and Kopet-Dagh provinces have the highest risk for accelerations more than 0.15 g.

In Fig's. 4, 5 comparisons are made between the predicted acceleration risks of the present seismotectonic model with those of the source models discussed in (Ref. 9) for the cities of Abadan, Ahwaz, Shiraz, Bandar-Abbas

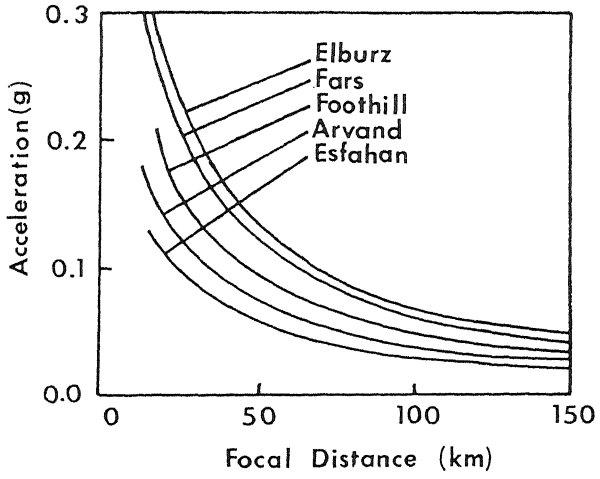

Fig. 2. Expected peak ground accelerations for a range of focal distances and a return period of 50 years.

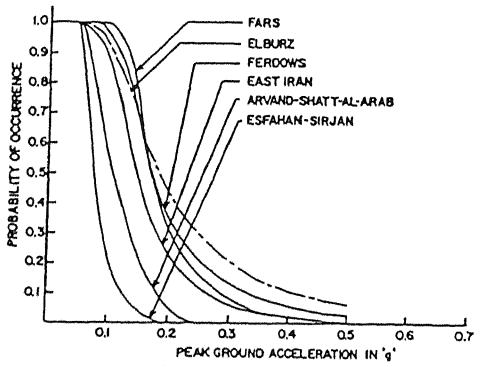

Fig. 3. Seismic acceleration risks for a focal distance of 30 km and a time duration of 30 years.

and Lar. It is generally observed that the present model predicts higher risks than those of (Ref. 9). Further comparisons for other cities of Iran were made in (Ref. 16, 17) with similar conclusions.

Code of Federal Regulation (Ref. 19) requires that where the locations of highest intensity historically reported earthquakes cannot be reasonably related to a tectonic structure, but are identified with a tectonic province in which the site is located, the acceleration at the site must be determined assuming that these earthquakes occur at the site. Earthquakes in Iran are

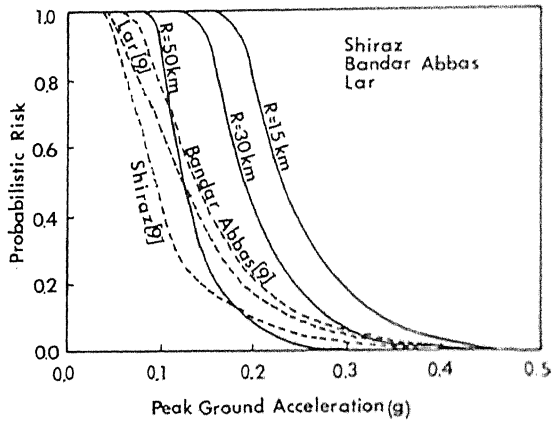

Fig. 4. Seismic acceleration risks.

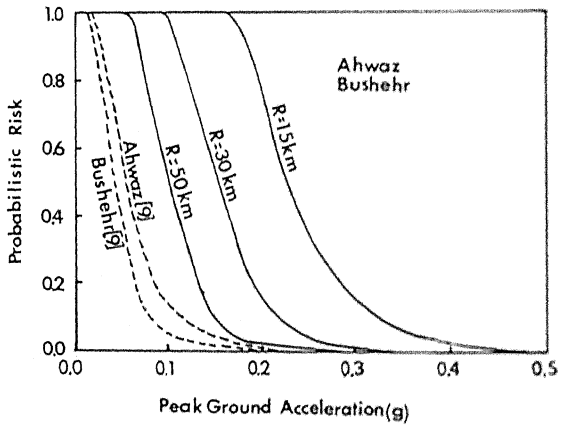

Fig. 5. Seismic acceleration risks.

scattered all around the country and have rarely been associated with definite causative faults. A few exceptions are discussed in (Ref. 1,2). Thus, the present seismotectonic model appears to be more suitable than the source models for earthquake risk assessments in Iran.

CONCLUSIONS

Iran appears to be one of the most seismically active regions of the world; however, seismicity of the entire country is not uniform but differs

significantly from province to province.

For a short time duration (i.e, less than 30 years), the expected peak ground accelerations are the highest, for Fars, Ferdows, and Tabas provinces, and the least for Esfahan-Sirjan and Arvand-Shatt-al-Arab provinces. For a large time exposure (i.e. more than 200 years) the expected peak ground acceleration is the highest for Elburz, Kopet-Dagh, and Ferdows provinces. Still, Esfahan-Sirjan province has the lowest value.

The probalistic seismic risks of various seismotectonic provinces of Iran show variation depending on time durations and the level of accelerations. For a time duration of 30 years, the probability of occurrance of 0.05 g acceleration is nearly one in the entire country. Esfahan-Sirjan has the lowest risk, the probability of having 0.2 g acceleration is negligible in this province. While Fars province has one of the highest levels of risk for peak acceleration smaller than 0.15 g, Elburz, Kopet-Dagh, and Ferdows provinces have the highest level of risk when acceleration is more than 0.15 g.

Because in many provinces in Iran seismicity is diffused and earthquakes cannot be reasonably related to a causative fault, it is more reasonable to use the seismotectonic model for risk assessments. For many provinces in Iran this model yields a risk value which is comparable or more than the risks obtained based on other models.

REFERENCES

1. Nowroozi, A.A., Seismotectonic of the Persian Plateau, Eastern Turkey, Caucasus, and Hindu-Kush region. Bull. Seis. Soc. Am. 61, 317-341 (1971).

2. Nowroozi, A.A., Seismotectonic Provinces of Iran. Bull. Seis. Soc. Am. 66, 1249-1276 (1976).

3. Banisadr, M., The Seismicity of Iran, 1900-1960. Publication No. 1. Technical Research and Standard Bureau, Plan and Budget Oraganization of Iran (1971).

4. Berberian, M., Contribution to the Seismotectonics of Iran, Geol. Surv. of Iran, Report No. 39 (1976).

5. Berberian, M., Earthquake Faulting and Bedding Thrust Associated with the Tabas-E-Golshan (Iran) Earthquake of September 16, 1978. Bull. Seis. Soc. Am. 69, 1861-1887 (1979).

6. Shoja-Taheri, J. and Naizi, Seismicity of the Iranian Palteau and Bordering Regions. Bull. Seis. Soc. Am. 71, 477-489 (1981).

7. Nabavi, M.S., Aspects of the Seismic Behavior of Iran. Ph.D. Thesis, University of London (1977).

8. Neghabat, F. and Liu, S.C., Earthquake Regionalization of Iran, Proc. of 7th World Conf. Earthquake Eng. Delhi, India, Paper 5, 551-536 (1977).

9. Rowshandel, B., Newmat-Nasser, S. and Adeli, H., A Tentative Study of Seismic Risk in Iran. Iranian J. Sci. Tech. 7, 211-241 (1978).

10. Rowshandel, B., Nemat-Nasser, S, and Corotis, R.B., A Comparative Seismic Hazard Study for Azarbaigan Province of Iran. Bull. Seis. Soc. Am. 71, 335-362 (1981).

11. Ahmadi, G. and Nowroozi, A.A., Earthquake Risk Analysis of the Far Province. Proceeding of first Engineering Seminar, Shiraz University, Shiraz, February 1978.

12. Ahmadi, G. and Nowroozi, A.A., Earthquake Risk Analysis of Iran-I: Frequency-Magnitude Correlations for Various Seismotectonic Provinces, J. Earth Space Physics, Tehran University Press 9, 27-48 (1980).

13. Ahmadi, G. and Nowroozi, A.A., Earthquake Risk Analysis of Iran-II: Probabilistic Seismic Risks for Various Magnitudes, J. Earth Space Physics, Tehran University Press 10, 1-19 (1981).

14. Ahmadi, G. and Nowroozi, Earthquake Risk Analysis of Iran-III. Intensity Estimates for Various Return Periods and Epicentral Distances, Bull. Iranian Pet. Indust. No. 80, 1-13 (1980).

15. Ahmadi, G., Mostaghel, N. and Nowroozi, A.A., Earthquake Risk Analysis of Iran-IV: Peak Ground Acceleration Risks for Various Return Periods and Focal Distances," Bull. Iranian Pet. Indust. No. 82, 1-21 (1981).

16. Ahmadi, G., Mostaghel, N. and Nowroozi, A.A., Earthquake Risk Analysis of Iran V: Probablistic Risk for Various Peak Ground Accelerations. Submitted to J. The Earth and Space Physics, Tehran University Press.

17. Nowroozi, A.A. and Ahmadi, G., Analysis of Earthquake Risk in Iran based on Seismotectonic Provinces, Submitted to Bull. Seis. Soc. Am.

18. Donovan, N.C., A Statistical Evaluation of Strong Motion Data Including the February 9, 1971, San Fernando Earthquake. Proc. 5th World Conf. Earthquake Eng. Paper 155. Rome (1973).

19. Code of Federal Regulation, Title 10, National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia (1981).