Probabilistic seismic hazard analysis for Saravan City

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Abstract
In this paper the methods and results of seismic hazard evaluation of Saravan city are presented. The city of Saravan is located in active subduction zone of Makrun in Sistan Province of Iran. Despite of tectonically active situation, there are few documented historical and instruments earthquakes in this area. The strong ground motions of study area are estimated by both probabilistic and deterministic methods. For this, firstly; the seismotectonic map of area with scale of 1:25000 is produced using the land sat data. Then, the seismicity parameters of different seismic zones are estimated by combined of earthquake epicenters and fault lengths. The attenuation relationships of Campbell- Bozorgnia (2006) and Ambraseys - Douglas (2003) are used. Finally, the hazard computation was carried out with SEISRISK III (Bender and Perkins, 1987). By this, the PGHA and PGVA in bedrock of Saravan city are proposed as 0.14g, 0.21g and 0.08g and 0.12g for return periods of 75 and 475, recurrently.

Keywords: *seismic hazard, Probabilistic method, subduction zone, faultSaravan city,*

Introduction
Today, the importance of seismic hazard knowledge in risk reduction and urban planning is well known (Papoulia & Slejko 1997). Iran as one of the world seismicity countries in recent years experience many destroyed earthquakes, such as Ferdows earthquakes (dasht Bayaz) (1968), Tabas (1978), Sefydabeh (1993), Bojnord (1996), Zyrkuh Ghaen (1997), Bam (2003), Zarand (2005), and ... Each of these had heavy victim and casulty
The casualties and damages suffered of earthquakes in Iran are very high in comparison with other seismic countries. The experience of other countries has shown that with seismic hazard study and use of result of these studies in construction structures can be reduced the damages of Earthquakes (Mantynemi et al., 2008; Wiemer et al., 2008; Anth & Iyengar., 2006). The Probabilistic seismic hazard analysis (PSHA) estimates the probability of accidence of strong ground motion parameters at a site due to all possible future earthquakes as visualized by the previous hazard scenario. The usefulness of PSHA in quantifying safety of man-made structures has been discussed extensively in the literature (Kanth and Lyengar., 2006).
In this study, the standard methods of PSHA are used for horizontal and vertical peak ground estimations of Saran city.

Seismotectonic of study area
The study area is located between Loot district and Makran zone in south-east of Iran (Nogol Sadat 1992). Tectonic of this area was investigated by different peoples (Stocklin 1968, Tackin 1972, Nabavi 1355, Eftekharnejad 1359, Berberian & King 1981, Griffis & et al. 1983). In the literature this area are named as South loot or loot - Sistan (Nogol Sadat 1989),

Mountains of east (Alavi 1991) the fault zone shear Iranshahr - Birjand (Samani and Ashtari 1992). In spite of the tectonically active situation, there is less information about the characteristics of the active faults in this area. Then, one of the important step of this study was the producing a seismotectonic map of region. For this, based on the existing maps and reports the preliminary active faults were produced and its completed and corrected using the aerial photographs interpretations, satellite images processing and site visits. By this several new active faults such as Nagphn, Tradan, Samukan were introduced and the trend and locatons of some main faults likes Saravan fault, Symysh, Pyshamg, Firoozabad, Qasreqand, Bamposht were corrected. The main trends of faults in this area are Northwest- Southeast and East - West (Table 3). Because the low of population and less importance of commercial and political situations the seismic history of area is not well recorded. The only historical earthquake reported in radios of 150 km of Saran city is the earthquake of 815 AD with Ms 5.5d (Barbarian 1977).

Instrumental earthquakes in radius of 150 km around the Saravan city have been obtained from International Institute of Seismology, Geophysical Institute of Tehran University and the U.S. Geological Survey websites. For prepared the earthquake data bank a different magnitude scales of Mw, Ms, mb and ML are converted to the a single generic (dowlas magnitude) using the method proposed by Nautuli (1979). By this, the generic magnitude assigned equal ML or mb for earthquakes less than 6 take equivalent with Ms for larger than 6. The generic magnitude is assumed to be equal to moment magnitude in the hazard calculation. All the instrumental earthquakes have focal depth less than 15 km and are thus restricted to the upper crust. The largest of these events was earthquake of June 13, 1934 M 6.9 which located on the 43 km of Northwest of Saravan city. The epicenter distributions of earthquakes are shown in Fig.1.

2-Source model and Seismic parameters estimations

One of the basic elements in assessing seismic hazards is to recognize seismic sources that could affect the particular location at which the hazard is being evaluated. In this study the source models were developed using earthquake catalogs, tectonic boundaries and faults mechanism, structure trends fault segmentation and geological situation. As results, the study area is divided in the nine source seismicity and then seismicity parameters of each zone are estimated. In this study, the procedure of Gardner and Knopoff (1974) are used for elimination of foreshocks and aftershocks from the catalog.

The methods of Gutenberg- Richter (1956) and Kijko and Sellevoll (1988) are used for estimations of seismic parameters in all region(Table1).

The procedure of Michetti et al., (2005) accepted for assign the seismic parameters to the different seismic zones. In this methods the coefficient of b obtained for region are used for all zones and coefficient of a assign for each zone based on the ratio of total active fault length and number of earthquakes.

3-Magnitude and attenuation scaling law

In this study, the following scaling laws are used for estimation of MCE of faults:

-Nowroozi (1985) $Ms = 1.259 + 1.244 \log L'$

-Ambraseys & Mellvilel (1982) $Ms = 4.629 + 1.429 \log L'$

The data of some past earthquake of East Iran which along with the surface rupture is shown if Fig.2 and Table 2. It could be seen that the above relationships are shown good agreement with the history rupture of this area. In all of relations L' are the fault rupture. It has been assumed in the past that no more than half of the total fault length will rupture during a single MCE event (Albee and Smith, 1966). Although, this is not always so, for example, in the 1943 Tottori, Japan earthquake, the rupture propagated beyond the mapped length of the Shikano fault (Richter, 1958). As a result, it is felt justifiable to use more than half of the total fault length for the estimation of the MCE magnitudes, especially for shorter faults. In this study, MCE magnitudes are estimated using logic tree as the following steps:

a) The equal weights assigned for all relationships

b) Surface faulting (L') equal of 50% and 37% of fault length (L) are used

c) For L>100km the weights of 0.6 and 0.4 give to $L'_{37\%}$ and $L'_{50\%}$,

d) For L <100km the weights of 0.6 and 0.4 give to $L'_{50\%}$ and $L'_{37\%}$,

f) For 100>L>50 the weight of 0.5 give to the both of $L'_{37\%}$ and $L'_{50\%}$

g) For shorter faults (less than about 25 km), L' assume equal to the total length of fault.

The averaged of two empirical attenuation relationship of Campbell and Bozorgnia (2003) and Ambraseys and Douglas (2003) are used for horizontal and vertical acceleration.

4-Results and Discussion

The basic principles to develop a probabilistic approach are the following:

1. A seismotectonic zonation is assumed as input data.
2. The seismic activity inside each seismotectonic zone is homogenous spatially and temporally.
3. There are enough data to characterize the activity of the seismotectonic sources.
4. There is knowledge of the attenuation process in each source with the distance to calculate the seismic hazard assessment in terms of velocity, acceleration or whichever other kind of output parameter.

In this study SeisriskIII software packages was used to perform this process and estimation of peak ground acceleration in Saravan city. This program is based on the assumption that the site acceleration has a Poisson distribution with a mean annual rate. The program can accommodate any attenuation relationships in digitized format and generate a table of peak ground accelerations and the cumulative distribution of the acceleration for each specified site. It is also capable of modeling acceleration variability and permits the option of earthquake location uncertainty, as well as smooth variation of seismicity across the boundaries of the zone. The results of peak ground acceleration, PGA, are shown in Table 3 . As we can see, the horizontal and vertical acceleration in bed rock of Saravan for return period of 475 years 0.21g and .16g are estimated.

5-Reference

1-Akhlaghi, F., 2009., Seismic Hazard Analysis For Saravan City By Probabilistic and Deterministical Method., Master Of Science Thesis., Azad University, Sciences and Researches Branch

2-Ambraseys. N. N., & Douglas. J., 2003. Near field horizontal and vertical earthquake ground motions, Soil Dynamics and Earthquake Engineering 23 (2003) 1-18.

3- Campbell, K. W., & Bozorgnia, Y. 2003. Erratum: Updated near-source ground-motion (attenuation) relations for the horizontal and vertical components of peak ground acceleration and acceleration response spectra. Bulletin of the Seismological Society of America, 93(3), 1413.

4- Campbell. K and Bozorgnia. Y,2007., Campbell-Bozorgnia NGA Ground Motion Relations for the Geometric Mean Horizontal Component of Peak and Spectral Ground Motion Parameters,California,. 28-EERI, 1989. "The Basics of Seismic Risk Analysis", Earthquake Spectra, 5, pp. 675-702.

5- Gardner, J. K. & Knopoff, L., 1974. Is the sequence of earthquake in Southern California, with aftershocks removed, Poissonian. Bull. Seism. Soc Am. 64, 1363-1367.

6-Ghosh, A. K. 2005., Probabilistic seismic hazard analysis for a site, Nuclear Engineering and Design 236 (2006) 1192–1200.

7-Hafezi Moghadas, N., 2002., Site effect and Strong Ground Motion Study in East Central Iran (Kerman and Khorasan province) Doctora Of Science Thesis., Tarbiat Modares of Univercity

8- Kanth1, S. T. G. R .and Iyengar R. N. 2006 Seismic hazard estimation for Mumbai city. Current Science, 1494 VOL. 91, NO. 11, 10 DECEMBER 2006.

9-Kijko, A. and Sellevoll, M. A., Estimation of earthquake hazard parameters from incomplete data files. Part I. Bull. Seismol. Soc. Am., 1989, 79, 645–654.

10- Papoulia, J., E.,Slejko, D., 1997., Seismic Hazard Assessment in Lonian Isalnds Based on Observation Macroseismic Intensities, Natural Hazards, 14: 179-187

Table 1: Seismicity Parameters Estimated by Gutenberg- Richter & Kijko – Sellovel Method

Method	α(M=4.5)	β
Gutenberg-Richter	0.45	1.29
Kijko	0.38	1.28

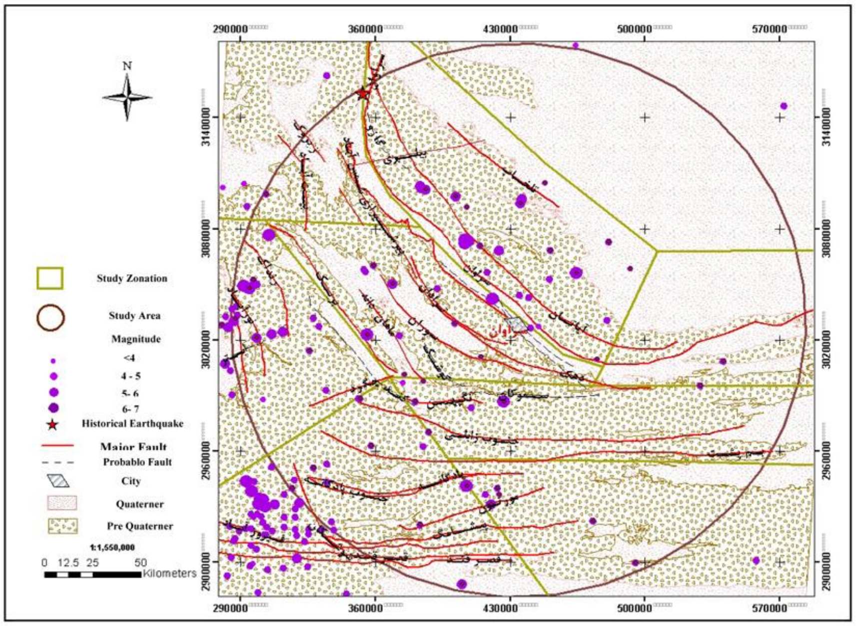

Figure 1: Seimotectonic and sismozonation map of area

Table 2: Comparison of length of fault rupture and occurred earthquake in East Iran (Hafezi Moghadas 1381)

Area	Rupture Length of Fault	Length of Fault	Magnitude
Tabas	85	85	7.4
Dasht Bayaz	70	120	7.4
Dasht Bayaz	50	120	7.1
Abyaz	20	125	6.6
Abyaz	15	125	6.6
Abyaz	125	125	7.4
Golba	20	140	6.4
Ravar	15	-	6.2

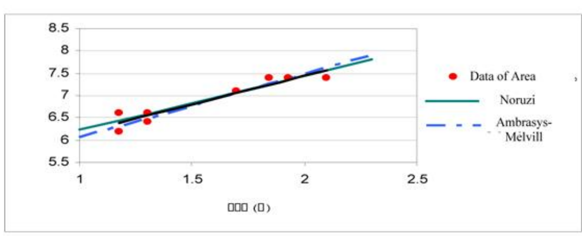

Figure2: compartion regional data and experimental relations

Table 3:Estimated maximum earthquake in Major fault

Name of Fault	Fault Lenght	Noruzi	Ambrasys	Mean
Apatan 3	81	6.9	6.8	6.9
Apatan 2	141.0	7.2	7.1	7.2
Berick	105.9	7.0	7.0	7.0
Bamposht 1	120.5	7.1	7.0	7.1
Bilari	121	7.1	7.0	7.1
Padegane	92.0	7.0	6.9	7.0
Jonube zaboli1	184	7.3	7.3	7.3
Jonube saravan 1	51	6.7	6.5	6.6
Jonube saravan 2	52.5	6.7	6.6	6.6
Dehak 1	67.5	6.8	6.7	6.8
Dehak 2	74.5	6.9	6.8	6.8
Saravan 3	145.0	7.2	7.2	7.2
Saravan 4	83.0	6.9	6.8	6.9
Ghasre ghand 2	200.5	7.4	7.4	7.4

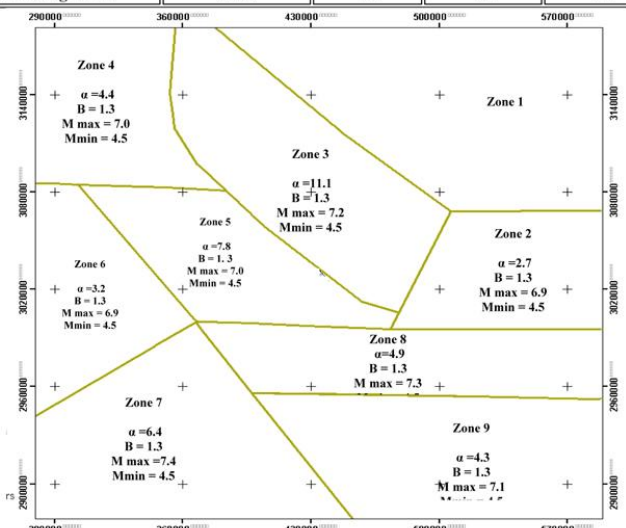

Figure3: Seismic zonation and sismicity parameters.

Table 4: Peak Horizontal Ground Acceleration in Saravan City

Return Period (Year)	PGHA			PGVA
	Campbell- Bozorgnia 2006	Ambraseys- Douglas 2003	Mean	Ambraseys- Douglas 2003
75	0.14	0.14	0.14	0.08
475	0.23	0.20	0.21	0.12
2500	0.32	0.26	0.29	0.16