UNIFORM HAZARD SPECTRA AND SIMULATED STRONG GROUND MOTION FOR BAM, IRAN

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ABSTRACT :

The Bam earthquake of 26 December 2003(Mw6.5) occurred near the city of Bam in the southeast of Iran.

1) We have used M<5.0 aftershocks that occurred throughout the area which recorded by Building House Research Center strong ground motion network & have simulated strong-ground-motion using empirical green function method. For this, we generated 10 models for Bam fault.
2) We have estimated Uniform hazard spectra based on seismotectonics and seismicity of the Bam regions. The controlling magnitude for return period of 475 and 2475 years have been estimated based on deggregation of hazard.
3) The comparisons were based on the pseudo-acceleration spectra (PSA) in Bam station. The comparison between estimated uniform hazard response spectra (UHRS) and simulated response spectra shows that UHRS estimate less value of spectra at longer periods. This is very important for sites closed to fault as the case of Bam station, which is already at very close distance to Bam fault compare to other stations. The second important point is related to the selection of simulation method. The results of simulation indicate we need more detail information regarding to seismological parameters, site geology and attenuations in Bam region.

KEYWORDS: Bam earthquake, uniform hazard spectra, simulated spectra, strong ground motion

1. INTRODUCTION

Ground motion estimation for the purpose of earthquake hazard analysis may be carried out in some routine and accurate empirical or theoretical manner. Earthquake hazard analysis requires the use of knowledge from disciplines other than seismology. Geology is needed to help us to define location, configuration and potential of seismic sources, particularly, know active faults. Geophysical techniques are needed to help define those seismic sources not readily observable at the earth's surface. Mathematics, particularly an understanding of probability and statistics is important in the increasingly prevalent probabilistic evaluations. Geotechnical engineering is very useful in estimating the effect of local site conditions on ground motion.the distribution of active faults around Bam region is shown in figure 1.the distribution of historical and instrumental earthquakes around Bam is shown in figure 1.

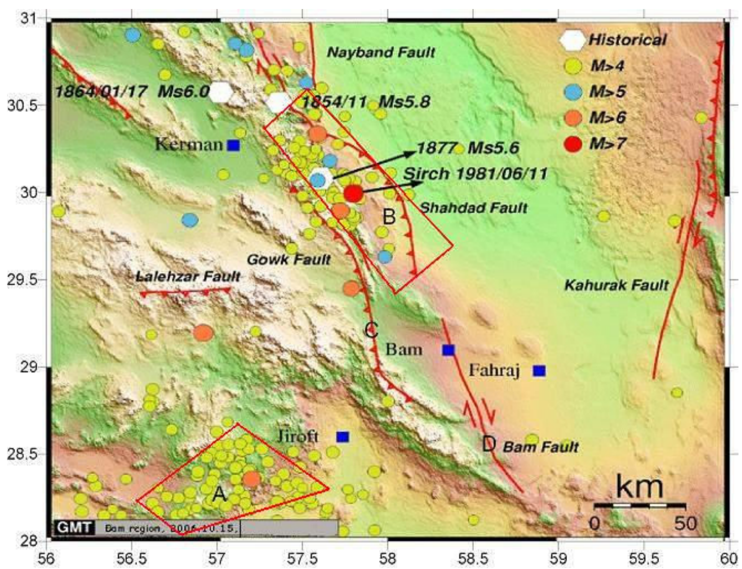

Figure 1. Active faults and seismicity around Bam

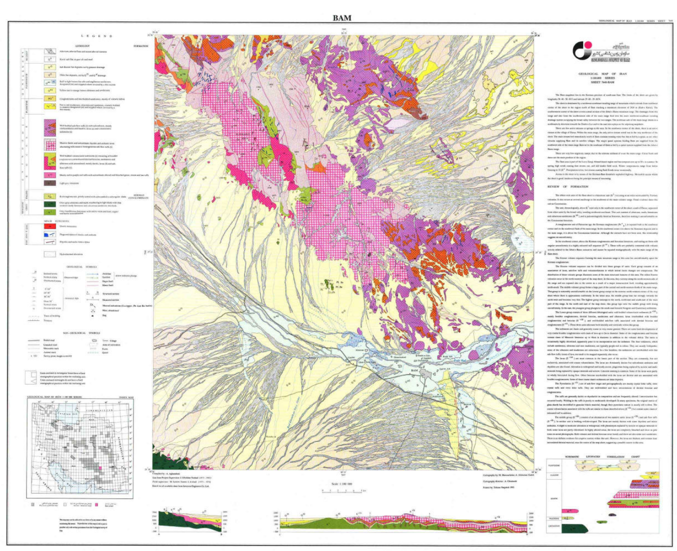

Figure2. Geological Map of Bam

2- EARTHQUAKE HAZARD ANALYSIS

The basis for earthquake hazard analysis of seismicity or the occurrence of the earthquake in space and time. The historic record my contain reports of earthquake that occurred during the hundreds and in some cases thousands of years of recorded human history. The instrumental record yields information about those earthquakes for which actual instrumental evidence exists. Ambreseys and Melville (1982) had studied the historical and instrumental earthquakes in Iran. For this study, the IIEES catalogue, which is based on the reports from international seismological institutes, and reports from Ambreseys and Melville (1982) have been used.

On the basis of geological and seismological studies source zones have been identified. For each source zone seismicity parameters have been estimated after omitting foreshocks and aftershocks from the catalogue. Then source zones and attenuation relation given by Zare (2004),and Ambreseys et al (2003) have been use to estimate horizontal peak ground acceleration for return periods of 475 and 2475 years. Figures 3 to 4 shows hazard map for return periods of 475 and 2475 years for Bam region.

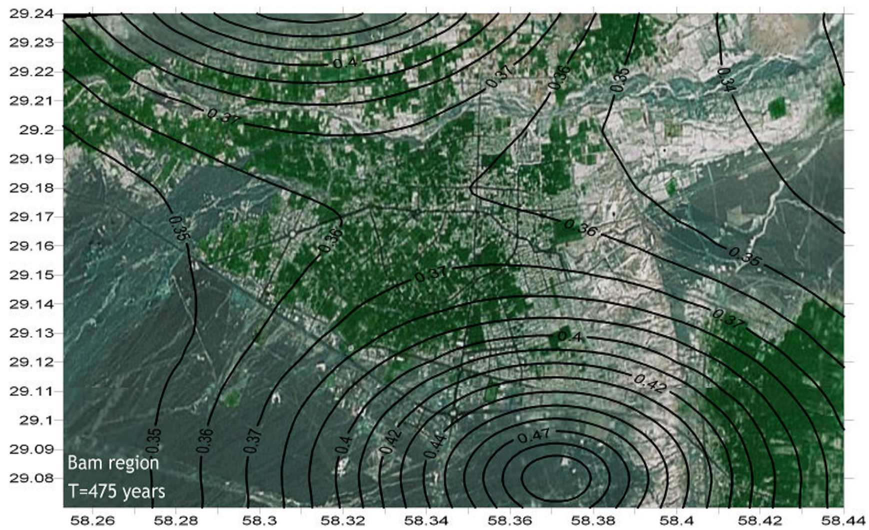

Figure 3. PGA map for return period of 475 years

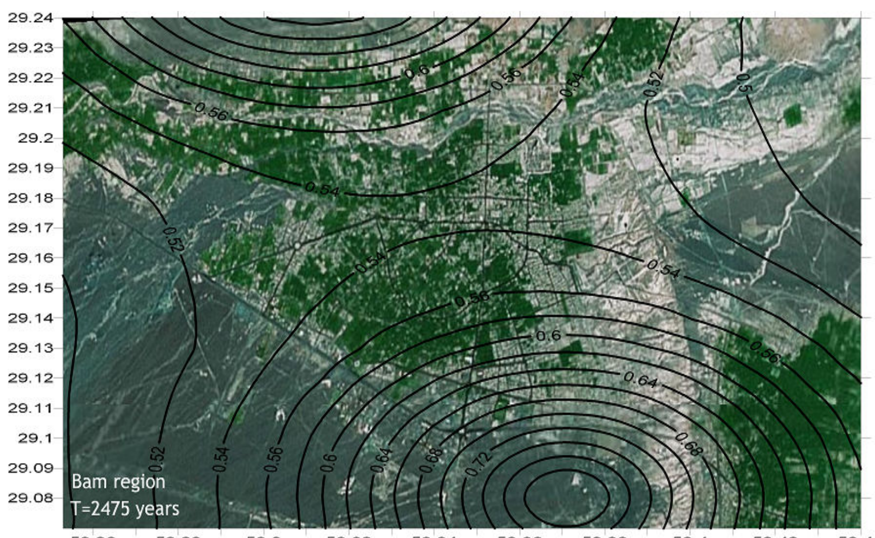

Figure 4. PGA map for return period of 2475 years

3- UNIFORM HAZARD SPECTRA

The uniform hazard response spectra (UHRS) is an efficient means of representing seismic hazards for probabilistic performance evaluation of structures. The UHRS have been estimated based on seismotectonics and seismicity and site condition in Bam region. In this study the UHRS have been estimated for one site. The UHRS are generated for 10% and 2% in 50 years at this site by considering the site condition.(The site class may be taken for Class 3 since the site fundamental frequency was about 2 to 5 Hz ,Zare et al.1999). Figure 5 shows the UHRS at this site for the return period of 475 and 2475 years.

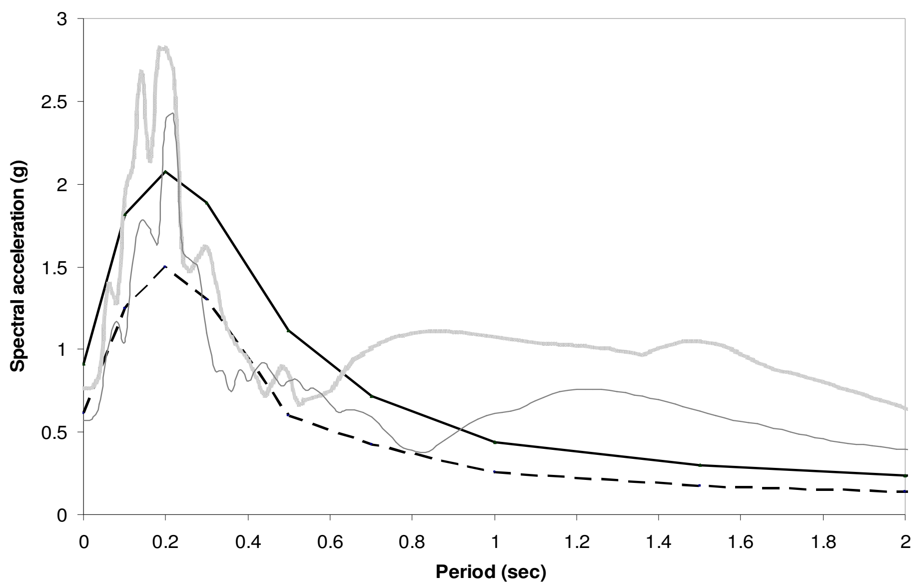

Figure 5. Response spectra (5% Damping) at the Bam Station. Absarved Response Spectra fault normal (light grey) Absarved Response Spectra fault parallel (thick grey) compared whit Uniform hazard spectra ,T=475years (dash black) Uniform hazard spectra ,T=2475years (thick black)

4- SIMULATION STRONG-GROUND-MOTION BY USING EMPIRICAL GREEN FUNCTION METHOD

Using records of small earthquakes can overcome the limited resolution of existing structural models. The idea of studying large earthquakes by means of seismograms of small earthquakes, used as empirical Green's function (EGF), was introduced initially by [Hartzell, 1978, and Wu, 1978]. Later methods proposed by [Hadley & Helmberger, 1980; Irikura, 1983; Wald et al, 1988; Joyner & Boore, 1986; Boatwright, 1988; Wennerberg 1990; Hutchings et al, 1990; Aki & Irikura, 1991] are modifications of EGF's method. In empirical Green's function approach rupture propagation and radiation pattern were specified deterministically and the source propagation and radiation effects were included empirically by assuming that the motions observed from aftershocks contained this information [Somerville et al., 1991].

The EGF method used here . The summation of the small events (EGFs) is thus based on scaling relations between small and large events. The number of sub events or EGFs is N3, where the scaling parameter N is an integer value determined as the ratio of the moment of the target event and the moment of the small event. Because this number is relatively small, the discretization of the rupture process is quite coarse, which produces high-frequency spatial and temporal aliasing effects [Bour & Cara, 1997]. On the other hand, a lack of high-frequency content above the corner frequency of the EGFs results in deficiencies in the high-frequency

part of the large event. Therefore, some approaches [e.g. Wennerberg, 1990] use random summation to artificially generate high frequencies.
In this approach, Green's functions for each portion of the fault are calculated and convolved with source functions at each point along the rupture surface. Here, we use empirical Green's functions and synthesize ground motion from 0.3 to 25.0 Hz. Because of, there are more available and the signal to noise is better for recorded earthquake. In order to use M<5 events instead of very small events, impulsive point shear source empirical Green's functions were generated by deconvolving out the source contribution of moderate earthquakes. We model 10 different scenarios and calculate acceleration response spectra.in figure6 Abserved and predicted Response Spectra be compared.

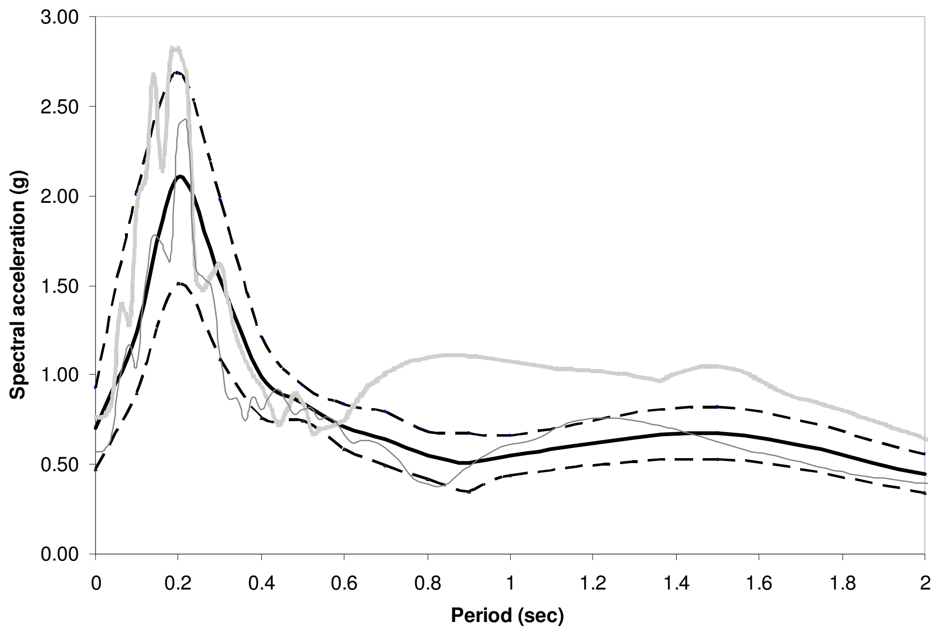

Figure 6. Response spectra(5 percent Damping) at the Bam Station. Abserved Response Spectra fault normal(light grey) Abserved Response Spectra fault parallel(thick grey)compared whit values predicted: thick black curve,50% exceedance level ;dashed curves, σ -standard deviation.

5- COMPARISON

Studies concerned with evaluating seismic hazards require the prediction of strong ground motion from earthquake that pose a potential threat to the population. In recent years, seismologists have attempted to develop quantitative models of earthquakes rupture process with the ultimate goal of prediction strong ground motion. Simulation procedures provide a means of including specific information about the earthquake source, the wave propagation path between the source and the site and local site response in estimation of ground motion. Simulation procedures also provide a means of estimating the dependence of strong ground motions on variations in specific fault parameters (Somerville et al., 1991).
The strong ground motions have been simulated using a stochastic finite fault model .we simulated 10 records which can occur in Bam station and calculate response spectra. in figure7 is shown the comparison between uniform hazard spectra and predicted response spectra(5 percent Damping) at the Bam Station.

Table 5. 1 Data for uniform hazard and predicted response

Period	*Mean of the synthetics (g)*	*Mean of the synthetics – std (g)*	*Observed value (g)*	*Mean of the synthetics + std (g)*
0	*0.70*	*0.47*	*0.8*	*0.93*
0.1	*1.24*	*0.46*	*2*	*2.02*
0.2	*2.10*	*1.51*	*2.9*	*2.69*
0.3	*1.53*	*1.09*	*1.5*	*1.97*
0.4	*0.99*	*0.76*	*1*	*1.21*
0.5	*0.84*	*0.74*	*0.9*	*0.94*
0.6	*0.71*	*0.59*	*0.85*	*0.83*
0.7	*0.64*	*0.49*	*1*	*0.79*
0.8	*0.55*	*0.42*	*1.1*	*0.68*
0.9	*0.51*	*0.35*	*1.06*	*0.67*
1	*0.55*	*0.44*	*1*	*0.66*
1.5	*0.67*	*0.53*	*0.8*	*0.82*
2	*0.45*	*0.34*	*0.65*	*0.56*

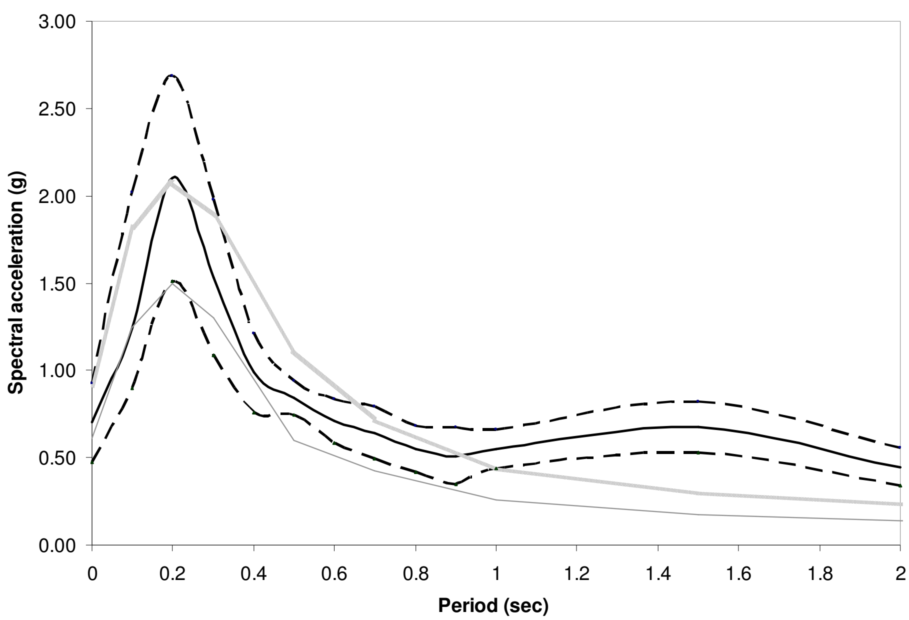

Figure 7. Response spectra (5% Damping) at the Bam Station. Uniform hazard spectra ,T=475years (light grey) Uniform hazard spectra ,T=2475years (thick grey)compared whit values predicted: thick black curve,50% exceedance level ;dashed curves, σ -standard deviation.

6-CONCLUSIONS

Based on the analysis of seismicity and source zones in Bam region and simulated strong ground motion, the following conclusions have emerged for the Bam station site.

1 UHRS estimates less value of spectra at longer periods especially in near fault.
2 More detail information regarding to seismological parameters, site geology and attenuations are needed for simulation of strong ground motion in Bam.

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