FINITE FAULT SIMULATION OF STRONG GROUND MOTION, FOR THE 2013, SARAVAN-IRAN EARTHQUKAE

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ABSTRACT

The strong ground motion records of passed earthquakes are usefull sources in planning strong structures. In many parts of the world these records don't exist, or are less. Without real records, ground motion modelings would be necessary. in this study we use accelegram data of 2013 saravan earthquake, recorded in 33 stations (BHRC) in the position of 25-29 North latitudes and of 57-63 east longitudes. We use this data to model the ground motion and characterize source parameters and rupture propagation. by modeling the fault, northeast to southwest rupture propagation would be observed, also the strike and dip of the fault are estimated, 200 and 35 respectively. The epi-center locates in the position of 28/2 North latitudes and 62/1 east longitudes in the depth of 48 Km. The stree drop is estimated to be 70 bars. With calculating simulated peak ground motion and without interfering the site effects, the best agreement with attenuation patterns are observed.

INTRODUCTION

The choice of ground motion modeling has a significant impact on the hazard estimates for an active seismic zone. Simulation procedures provide a means of including specific information about the earthquake source, the wave propagation path between the source and the site and the local site response. Simulation procedures also provide a means of estimating the dependence of strong ground motions on variations in specific fault parameters. A number of possible methods that could be used to generate synthetic records include (i) deterministic methods, (ii) stochastic methods, (iii) empirical Green's function, (iv) semi-empirical methods, (v) composite source models, and (vi) hybrid methods.
Finite fault modeling has been an important tool for the prediction of ground motion near the epicenters of large earthquakes (Hartzel, 1978).

One of the most useful methods to simulate ground motion for a large earthquake is based on the simulation of a number of small earthquakes as subfaults that comprise a big fault. A large fault is divided

into N subfaults and each subfault is considered as a small point source (Hartzel, 1978). The ground motions contributed by each subfault can be calculated by the stochastic point-source method and then summed at the observation point, with a proper time delay, to obtain the ground motion from the entire fault. The Spectrum of each subfault is calculated by source point modeling. We used the dynamic corner frequency approach. In this model, the corner frequency is a function of time, and the rupture history controls the frequency content of the simulated time series of each subfault. The characteristics of a large earthquake such as the geometric of the fault, the slip distribution and the fault directivity, effects the amplitude, frequency and duration of the ground motion. Simulation is among considering a half-space model and a single event. The acceleration spectrum is modeled by
a spectrum with a ω2 shape, where ω = angular frequency (Aki, 1967).
The simulated results are compared with recorded ones on both frequency and time domain. The good agreement between the simulations and records, at both low and high frequencies, gives us confidence in our simulation model parameters.

2013 SARAVAN-IRAN EARTHQUAKE

At 10:44 UTC (15:14 local time), April 16, 2013, an Mw 7.7 earthquake struck the Saravan region in South eastern Iran. The earthquake had reportedly 41 victims and more than 180 injured people. One of the victims was for the Iran region and the 40 remained were reported from Pakistan (most of the victims were for the Pakistan, although the epicenter was located in Iran). The epicenter of Saravan earthquake of 16 April 2013 of Mw 7.7 occurred in about 35 km to the city of Gosht (about 4000 inhabitant), and the epicentral region was a sparsely populated area. The event destroyed 300 houses, left a further 1000 homeless and damaged 500 more houses in nearby villages, focusing in Pakistan region. reports on Focal mechanisms (i.e.by USGS) show mostly normal having a little strike-slip component. this event can be associated with subduction of oceanic lithosphere beneath the Makran coast.

The historical seismicity of the region corresponds mostly to the 27 November 1945 earthquake M8.0 earthquake on the coastline of the Makran (370km south of the epicenter). Two other important earthquakes in the epicentral region of the 2013 earthquake were 18 April 1983 (Saravan earthquake), Mw7.0, and 18 January 2011, Mw7.2 (Dalbandin, Pakistan).
According to BHRC (Iranian Building and Housing Research Center) report, this event was recorded by 33 sets of digital accelerograph in Iran Strong Ground Motion Network. The epicenter of Saravan earthquake of 16 April 2013 of Mw 7.7 is illustrated in Fig.1

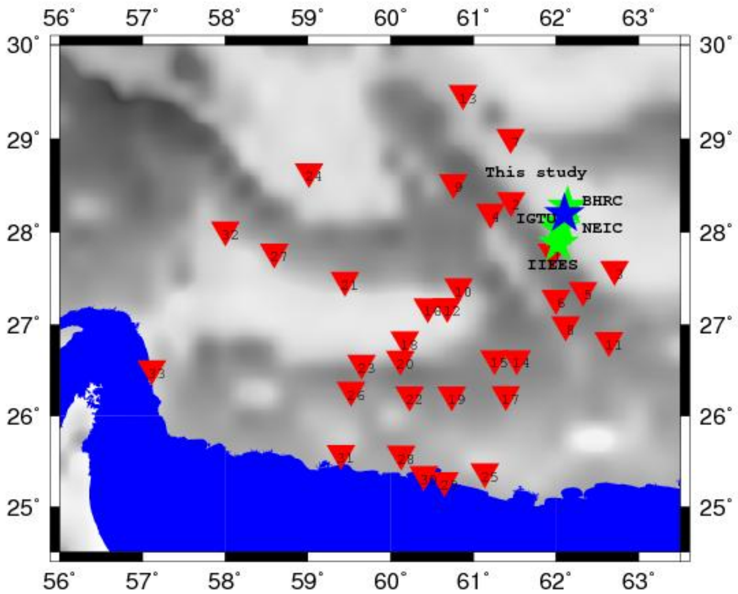

Figure 1. the epicenter report and the locations of 33 stations of BHRC.

SIMULATION ANALYSIS

In this study, stochastic simulation is used to model saravan earthquake and to Characterize source parameters and rupture propagation. accelerogram data of 33 stations related to building and housing research center has been used. After correcting the accelerogram, the maximum value of PGA(186 cm/s^2) is shown up in sabz gaz station on the T component. The comparison of PGA (peak ground acceleration) between corrected and simulated accelerograms for horizontal components are shown in Fig. 2.

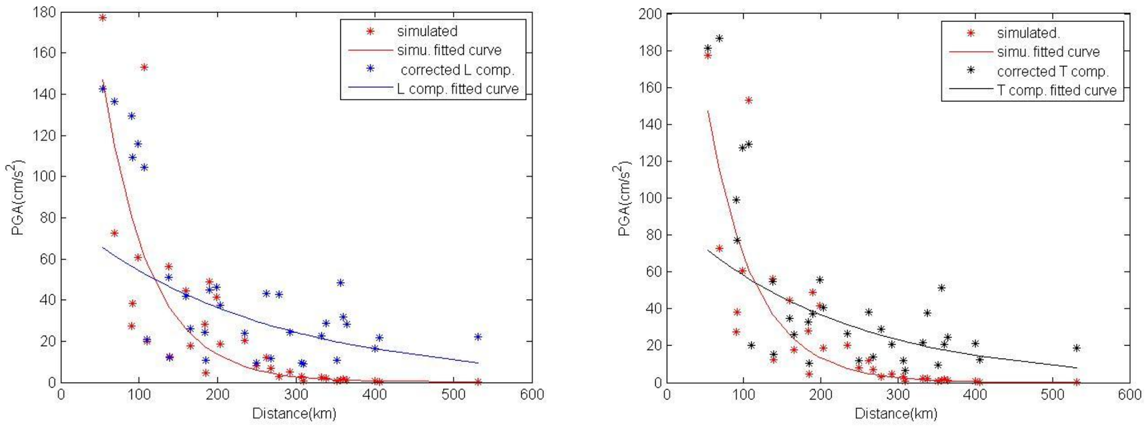

Figure 2. comparison between corrected and simulated PGA for 2 components in 33 stations.

The ground motion modeling has been done by Exsim software, the input parameters for the program have been shown in Tab. 2. the window function applied on the Exsim program is assumed to be Saragoni-Hart window. The length and width of the fault are estimated 127 And 28 respectively (Wells and Coppersmith, 1994). The slip distribution is assumed to be random. Quality factor value is considered as 52.63 (Mahood, Hamzehloo, 2009). The simulated acceleration and the corrected acceleration and their spectrums are compared with each other. the best fitting results have been extracted. comparison between the corrected Fourier amplitudes and simulated ones in sabz gaz station is illustrated in Fig 3. The best compatibility is observed between 0.1-5 Hz. comparison between the corrected time-history and simulated ones in sabz gaz station is illustrated in Fig 4. The best compatibility is observed between L component and simulated ones.

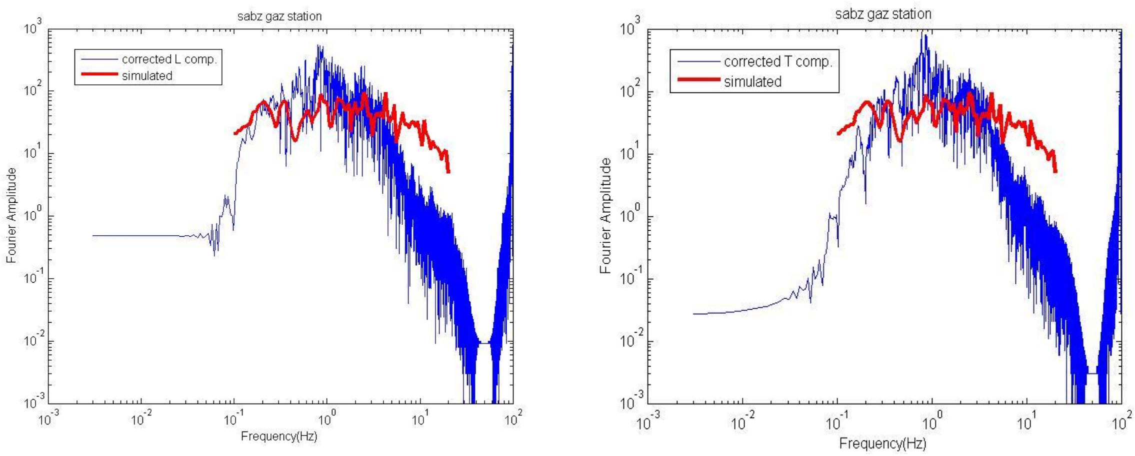

Figure 3. Fourier spectrum comparison between horizontal components and simulated ones in sabz gaz station

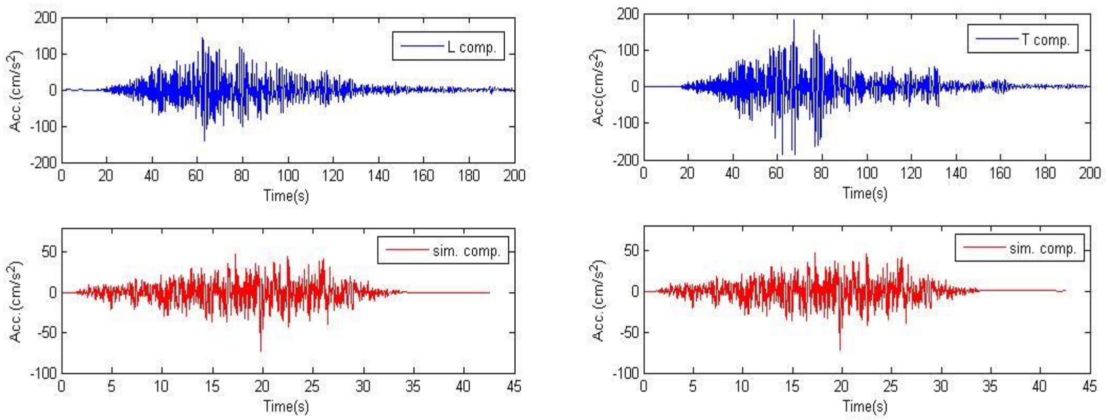

Figure 4. time-history comparison between horizontal components and simulated ones in sabz gaz station.

The results show that The epi-center is located in 28.2 North latitudes and 62.1 East longitudes ,which is compared with other agency reports (Tab. 1). considering 15 subfaults along length and 5 along the width, the hypocenter is located in the (15,4) element which causes the depth to be 48 kilometers. The magnitude is considered 7.7 and the stress drop is estimated about 70 bars. Rupture propagation shows the directivity pattern from northwest to southeast. the strike and dip of the fault are calculated 200 and 35 degrees respectively which exactly suites the propagation. The widespread of accelerations on the shake-map shows the exact orientation of the fault (Fig. 5).

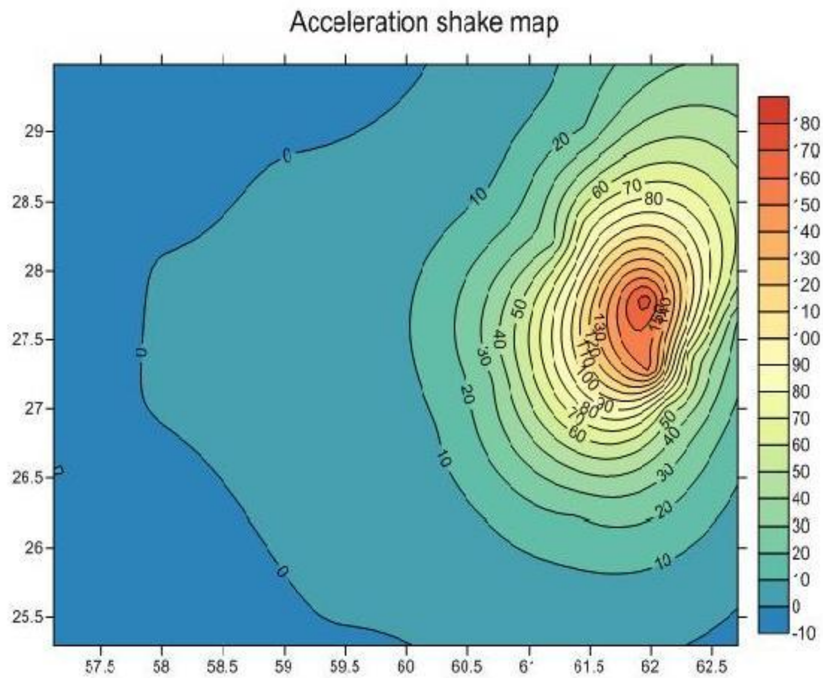

Figure 5. acceleration shake-map

Table1. Different agency reports on saravan earthquake, compared with this study.

Reference	**Latitude**	**Longitude**	**Magnitude**	**Depth(Km)**
IGUT	28.04	62.03	Mn=7.5	95
IIEES	27.88	62.03	Mb=7.7	70
HRVD	27.89	62.21	Mw=7.7	50.8
BHRC	28.28	62.14	Mw=7.8	
USGS	28.107	62.053	Mw=7.8	82
This study	28.2	62.1	Mw=7.7	48

Table2. Exsim input parameters.

Value	Exsim parameters
7.7	Magnitude
70(bars)	stress drop
$52.63f^{1.02}$	Q(f)Quality factor
T_0 + 0.1 R (Km)	Time duration
0.04(s)	kappa
127 Km × 28 Km	Fault plane dimension
15 5	Subfaults along strike and dip
26(Km)	Depth of the top
50%	(Pulsing Percent)
Saragoni-Hart	Window function
3.5(Km/sec)	Shear velocity
0.8β	Rupture velocity
2.8 g/cm^3	density
5%	damping
Random	Slip distribution
15 × 4	Hypo source

CONCLUSIONS

The simulation results show that slip propagates from northeast to southwest. Resulting fault shape, represents a faulting process with 200 degrees strike and 32 degrees dip. the (15,4) element at the southeast corner shows the fracture initiation which locates at 28/2 North latitudes and 62/1 east longitudes. the acceptable wave and spectrum missfit, represents the valid parameter estimation. Without considering the site effect on the results, acceleration drops at some stations, which can approve the unrecognized effect of the site. Decendence of acceleraton among increasing distance has a good consistence of the attenuation pattern. Stress drop is estimated to be 70 bars which refers to the high potential energy extracted out of the region and it can also approve subduction adventure. The best simulation compatibility occurs at frequency range between 0.1 -5 Hz which seems to be the best range of modeling. Time-history comparison shows that the best fitting results happens between the L components and simulated ones.

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