RSGIS TECHNIQUES AND SURVEY ANALYSIS FOR EARTHQUAKE STUDY IN ESFAHAN IRAN

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Abstract

GIS is effective in carrying out geological, civil engineering analysis as automated processes within the GIS, and different outcomes resulting form changed input parameters, assumptions and scenarios can be easily compared with due consideration given to uncertainties in methodology and the input data. The modern space-based remote sensing, spatial science and geo information technologies have opened up efficient means for tectonic studies and evaluation of earthquake risk and mitigation strategy. Fault rupture and associated surface deformation, can be observed using Aster satellite data. The measurement of fault displacements using satellite image in Esfahan has brought more care for rehabilitation and vulnerability. The field checks and lab analysis beside remote sensing techniques show that Esfahan may be affected by 5-6 Richter earthquakes. In this research, the earthquake hazard analysis of Emam Square (Naghsh-e-Jahan) is being evaluated as a case study.

Introduction

The maximum economical casualties caused by natural disaster between 1900-2005 occurred in Asia and Pacific. During the last 55 year Asian Pacific has tolerated around 588 billion US Dollar. Around 33 person of economical casualties belong to earthquake (www.unescap.org). Only in 2004 the world faced with 10 natural disaster 5 of this amount belong to Asian and Pacific and have around 55 billion USD economical lost. According to UN report in 2005 Iran are listed Among 15 countries in the world that faced with natural disaster and some of the Iran neighboring countries in Asia such as Armenia, Turkey, Afghanistan, India, Russian Federation and Georgia faced with Natural Disaster.

Emergency situations in urban areas require: 1) excellent coordination between different relief /rescue groups; 2) appropriate information (especially geo-referenced information); and 3) intelligence in communicating orders and information to different participants. Natural disasters like earthquake have devastating effect on life and property.

For this, study of neo tectonics and geology of a particular region is very important. Remote sensing (RS) and Geographical Information System (GIS) are a recently emerging technology, which can play a vital role as tools for study of natural disasters.

The earth observation satellites provide comprehensive, synoptic and multi-temporal coverage of large areas for a wide range of scales, from entire continents to details of a few meters in real time and at frequent intervals and thus have become valuable for continuous monitoring of earth and its atmosphere (Roy et al., 2000). In this research, the earthquake hazard analysis of Emam Square (Naghsh-e-Jahan) is being evaluated. According to the latest regional seismicity data, extensive filed survey and the studies conducted on seismicity of epicenters deterministic and probabilistic methods have been considered. ASTER satellite data of the study area, dated 12 Jan 2006 was geometrically corrected using digital maps of area with scale 1:25000 and remote sensing techniques were applied to extract faults and other structural feature which are considered as parameters for earthquake study. The extensive field observations were carried out to determine resistance of the building against future earthquakes using digital schumize hammer, share tester for masonry walls, canin and covermeter.

Study Area

The study area is central part of Iran and bounded by Longitude ($51^\circ\ 41' E$) Latitude ($32^\circ\ 29' N$) (Figure .1).

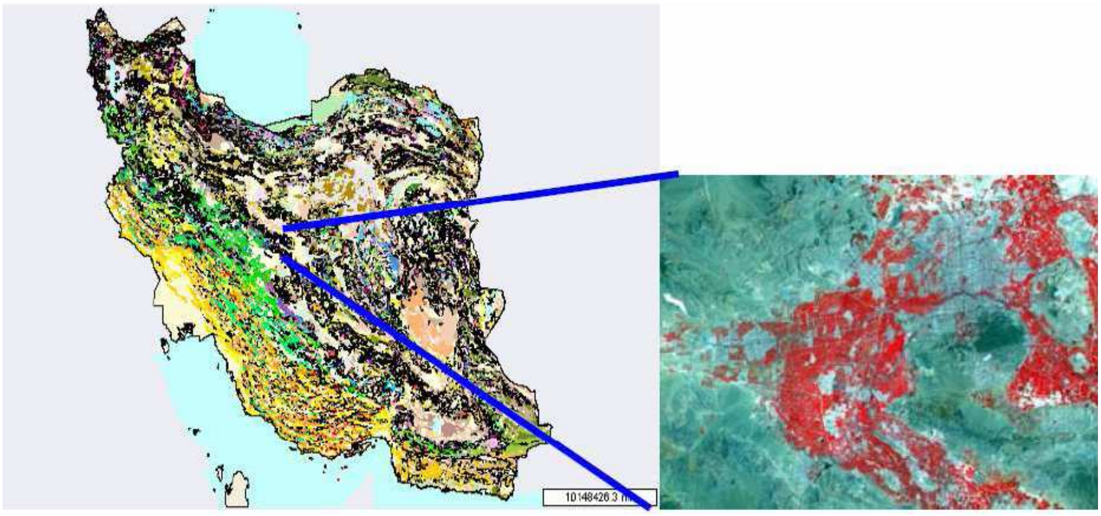

Figure 1. Study area

The coordinates of Emam Square are as follows:Longitude ($51^\circ\ 41' E$) Latitude ($32^\circ\ 29' N$). Esfahan city is one of the most historical city in the world and because of its importance has been selected for this study.

Methodology

In this study ASTER image was selected to extract linear structural features using ENVI 4.2 software. The satellite image was geometrically corrected with help of digital topography map in scale 1:25000, and FCC was made. Different enhancement was carried out to highlight the lineaments and faults. Using image elements and field survey, faults were recognized and digitally digitized on the image. The buffer technique in Arcview environment was applied for all faults. The same buffer technique is also applied for 150 KM from Esfahan city on the basis of statistic historical earthquakes in Esfahan, Iran (Figure 2).

In order to determine resistance of the building against future earthquakes, digital schumize hammer, share tester for masonry walls, canin and covermeter are used for 100 houses which are masonry type.

Digital topography map of Emam Square area, Esfahan, Iran in scale 1:2000 was introduce to GIS environment and using 3D model extension of Arcview software the 3D model was created. Data collected for all buildings are also introduced to Arcview environment for analysis and to define Non engineering and engineering buildings. Basically, in this method we classify buildings from Non-engineering to engineering buildings. The concept for classification of the building is given on the basis of properties of the material used in building against earthquake about 5 Richters. The 5 Richters earthquakes also assumed on the basis of the statistic historical data recorded by Iranian geophysics organization.

Tectonic Seismicity of the Region

The occurred earthquakes of this region can be classified in two periods:

1. Historical seismicity, prior to 1900.

2. Instrumental seismicity, after 1900.

Among other natural disasters, earthquake has been considered as a devastating and fatal occurrence effects of which could have been missed by the authorities, historians and writers in the past. The first recorded earthquake in Iran dates back to the forth century BC, where the ancient city of Ray was completely demolished. Since our national records are based on historical documentations, proving their being decisive does not seem to be a difficult task. The magnitude of historical seismicity is determined based on the damages they have caused in a given area. Many researchers like Berberian, Nabavi and Ambersiz have been through restless studies regarding historical seismicity the results of which have become seismic data. Among all these reports the list provided by Ambersiz in 1982 about historical seismicity in Iran contains more uniformity when compared to the similar works. Figure 2. shows the active faults of Iran and the location of the site. In the begging of this report the seismic tectonics of the region and the most important seismicity patterns specifically the region under study are being introduced. In the next step the parameters of the seismicity are considered, including the fundamental faults; patterns and hazard analysis are based on the existing data from International Institute of Earthquake Engineering and Seismology (IIEES). The seismicity cataloging is used in seismologic engineering and analysis. Based on the zonation of the region under study the related seismicity parameters for deterministic and probabilistic analysis on: maximization of magnitude seismicity, annual occurrence rate and β parameters have been assessed through the common procedures.

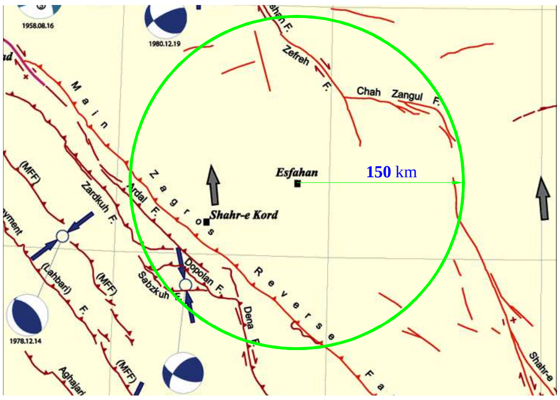

Figure 2. The procedure of the historical and instrumental layout in the region under study

Finally by using the current terminologies in the technological literature in relation to deterministic and probabilistic methods, maximization of maximum credible earthquake (MCE) probabilistic analysis for different levels of different return periods for the duration of the structure's life time. The peak ground acceleration has been accounted for in this research. Seismicity magnitude, annual reoccurrence rate and β parameter are considered here.

The Investigation Related To Earthquake And The Tectonics Of The Designated Region

Based on seismic data, the seismic activities in Iran are limited to high Zagros regions in comparison with center and east of Iran. In the recent years, many studies have been conducted on the characteristics of earthquake in Iran as follows:

1- Nouroozi: Iran is divided in 23 major areas containing epicenters, 1976.
2- Tavakoli: Iran is divided in 20 major areas containing epicenters, based on tectonics models and modified tectonic catalogue.
3- Berberian: Iran is divided in 4 major seismo-tectonic areas, 1976.

Some of the major faults around Esfahan (within 150km Radius) are: the Main Zargos Revers fault, Ardal, Zardkuh, Dopolan, Sabzkoh, Dena, Kashan, Zafre, Chah Zangol and Kolaghazi.

The Faults Extraction using Aster Satellite Image

ASTER image was introduced to ENVI software and using image elements structural feature like lineaments and main faults are extracted. The distribution of main active faults in Iran has been evaluated by Berberian in 1976. The characteristics of these faults can be summarized as follows:

The Main Zagros Reverse Fault (MZRF)

The Zagros fault with (N 130 E) elongation enters Iraq through Marivan (North-western border of Iran Iraq) and enters Iran in the Sardasht region the crosses the Turkish boarder. MZRF is 1350km long. The trend of MZRF begins from Turkish boarder in the NW and ends in Bandar Abbas (SW). From this point the Zagros fault with 250km elongation continues (N 170 E). The fault is of pressurized- thrust type. Richarson and Liss have called it a thrust zone for the first time and Ganser called it the main thrust line in 1960. Falcon, in 1976 called it Zagros. Thrust, while Berberian (1976) called it Main Zagros Reverse Fault (MZRF) because of its varity in sections with different types of dips.

The Ardal Fault

This is a thrust fault, 100km long running NE-SW. Though it didn't have anything to do with the Naghan earthquake, which is on this fault's path, the tectonic and geomorphic evidences show that this fault is considered to be an active and quake generating one.

The Zardkuh Fault

This Quaternary thrust fault is one of fundamental group of high elevation faults on Zagros belt which is bent towards W-SE and is about 130km long.

The Dopolan Fault

Another wide angle thrust fault running W-SE which is about 110km long. This fault joins Dena fault eastwards and Sabzkoh fault westwards.

The Sabzkuh Fault

It is thrust fault running similar to Dopolan fault with 120km length, bent on both ends.

The Dena Fault

This fault is about 130km long with almost NS pattern which joins Shalamzar and main Zagros faults in the north, and in the south to Kazeroon fault. This is a rectified strike-slip-fault with a reverse constituent.

The Kashan Fault

This fault is 80km long with almost NS pattern which joins Zafre fault in the east and it is of the rectified strike-slip kind.

The Zafreh Fault

This fault is located in North of the City of Esfahan, if begins from the NW end of Kashan fault and joins the E end of Chah Zangool fault which continues northwards on the E side of the Esfahan province. This fault is 150 km long and is of the rectified strike- slip fault.

The Chah Zangool

This fault is 150 km long, beginning west eastwards and changes in the middle and continues north southwards.

This fault is of the rectified- strike kind and it joins Zafre fault in the east and at the end towards south seismicity joins the continuation of Dehshir fault.

Conclusions

Figure 3 illustrates the diagram of the site risk based on Ambraseys & Simpson's spectra obtained Through Spectral Attenuation Relation. It is worth mentioning that the risk curves are for specific alternative periods.

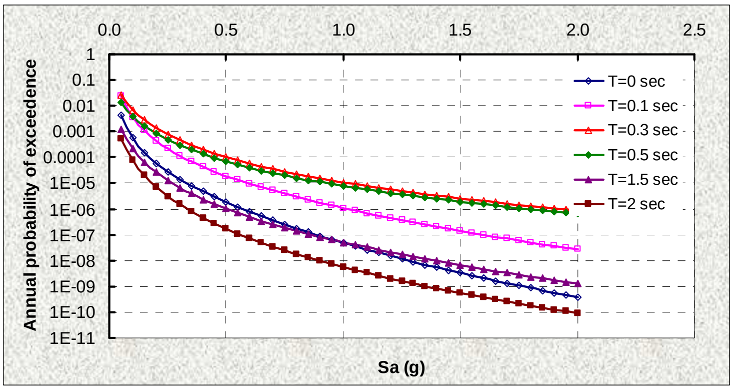

Figure 3- The diagram of hazard analysis curves based on Ambreasys & Simpson's spectra obtained Through Spectral Attenuation Relation

The result of the analysis in relation to risk levels of seismicity 1 and 2 are based on Ambreasys and Simpson's attenuation relation which is illustrated in Figure 4 and the volume of spectra is compared with standard 2800. According to the existing rehabilitation instruction for the buildings against seismicity code in case the obtained spectra acceleration of the designed spectra for the site is less then 70% of the same in (standard 2800) accord, the indicated value of the accord will establish the base [12].

Figure 13 illustrates the behavior of the designed spectra of the site through UHS method for two levels of risk.

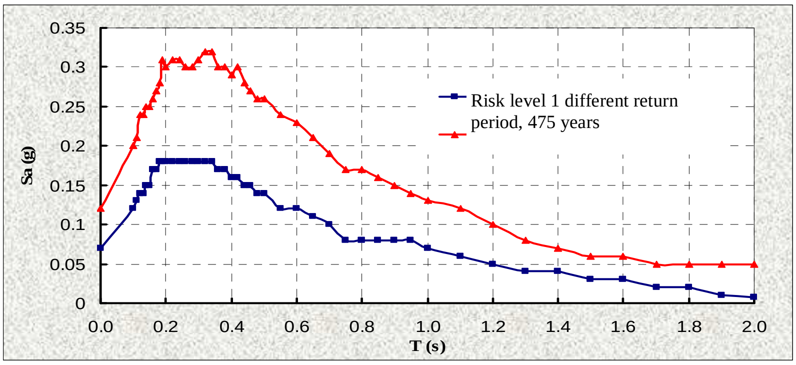

Figure 4- The risk levels of seimicity, 1 and 2, UHS method based on Ambrasys & Simpson relationship (1996)

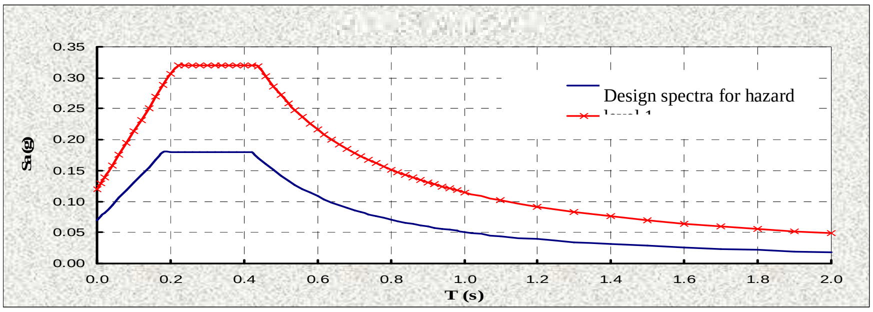

Figure 5- The designed spectra of the site, Emam Square (Naghsh-e-Jahan)

In this study, the deterministic and probabilistic methods have been applied for the seismicity hazard for Emam Square. A brief note on the essential results can be presented as follows:

1. The crude seismic catalogue used here is from the international institute of earthquake engineering seismology (IIEES). The fore and after shocks are eliminated through Zare's method.

2. Because of deficiencies and no uniformity of the elements in the catalogue with historical earthquakes, the site parameters are obtained through Kijko's method and are based on probabilistic analysis.

3. In order to conduct the deterministic and probabilistic Hazard analysis the Zare, Ambraseys & Simpson and Sarma & Srbulov methods and a combination of these three through logic tree have be applied here. We have used these three methods because the first on has a local emphasis and the other two have a wider and international focus, in addition they have reliable agreement.

4. In the seismicity probability method the different return periods of 475 and 2475 years are considered. In the deterministic method based on identified earthquakes in the

proximity of the site and using the obtained fault plans through (IIEES) we were able to identify the imposed seismic maxizimation (MPE).

5. According to the investigations conducted on the site, the following results on the peak ground acceleration have been obtained.

DBE(10% in 50Yr)	MPE(2% in 50 Yr)	MCE (Deterministic)
0.07g	0.12g	0.18g

6. Based on the existing attenuation relationship formula in the technical literature introduced by Ambersayes & Simpson which are for determining acceleration constituents of spectra acceleration design spectra is determined. The obtained spectra velocity is less than 70% of the same in the accord; therefore according to building rehabilitation against earthquake guideline, the standard 2800 should be the base for the seismicity loading for the buildings.

7. On the basis of the Lab analysis for building materials and integrated with GIS techniques the 3D model building is created and building is classified. The dark red to red color shows Non-engineering building (Figure 6). This gives a good vision for decision maker to mitigate and rehabilitate and further management against future earthquakes in Esfahan Iran.

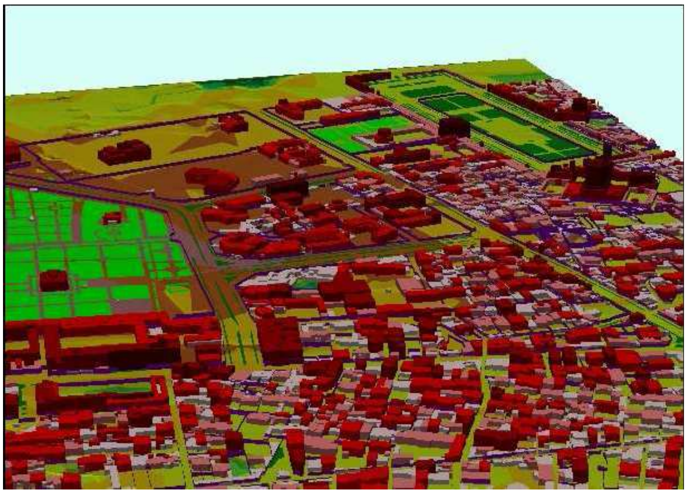

Figure 6- Showing Non-engineering building in Emam Squar, Esfahan Iran

8. This study reveals that the integrated of RSGIS and digital schumize hammer, share tester for masonry walls, canin and covermeter would give better and faster response for the decision makers.

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