Ali ATEŞ[1]

Latif Onur UĞUR[2]

Rıfat AKBIYIKLI[3]

A.Hakan MUTLU[4]

İnan KESKİN[5]

1 Duzce University Faculty of Technology Civil Engineering Department, Konuralp Campus 81620 Düzce–Turkey; aliates@duzce.edu.tr, atesali2000@gmail.com

[2] Duzce University Faculty of Technology Civil Engineering Department, Konuralp Campus 81620 Düzce–Turkey

[3] Duzce University Faculty of Technology Civil Engineering Department, Konuralp Campus 81620 Düzce–Turkey

[4] Ministery of Education, Presidential of Construction and Real Estate, Ankara–Turkey

[5] Department of Civil Engineering, Geotechnical Division, Karabuk University, 78050, Karabuk–Turkey

SEISMIC POWER OF DUZCE FAULT AND CASUALTIES IN DUZCE REGION ASSESSMENT BY EXPERIMENTAL MODELS AND GIS

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Abstract

In order to found of urban centers in high-risk earthquake zones, these cities put potentially at hazard of serious injury. Most of the hazard effects caused by earthquakes are due to developing urban models in the fault zones. Non-considered development of urban sites in near fault sites has caused the occurrence of earthquake leads to a human tragedy. Duzce region is only a city which is placed in the vulnarability with a very high relative hazard. Duzce fault is placed in the close environment of the city and some parts of the city are established along the fault. The Duzce fault is a significant tectonic feature in the environment of the city. Duzce region has experienced destructive earthquakes during history as a consequence of locating in proximity to the Duzce fault. In this research, seismic power of Duzce fault and casualties in Duzce region is predicted based on experimental models and GIS. The results indicate that the Duzce fault could cause earthquakes with magnitude over 7.4 in the Richter scale. Sopposing seismic activity Duzce fault scenario, 987 casualties were prediscted at night of total population in Duzce region including 1267 people dead, 678 people injured

1. Introduction

Earthquake is direct consequence of shifting tectonic plates which its vibrational energy propagates as seismic waves. Cities grow results in occupying new lands with geomorphological hazards [Mogimi,2009]. Unplanned development of urban sites in near fault areas has caused the occurrence of earthquake leads to a human tragedy [Kemalbasmanj et al.,20013]. Unpredicted risk, unsuitable hazard management, high exposure of element at risk and susceptible constructions are four major factors which can lead to rise casualties and losses of property in earthquake occurance [Hassanzadeh et al., 2013]. A risk evaluation can be performed either in a qualitative, semi-quantitative, or quantitative poisition. The compatibility of an evaluation procedure bounds up with the existing input data, wanted results and on the nature of the hazrd problems. Different damage and losses estimation techniques are used to quantify the potential social and economic losses from an earthquake [Ara,2013]. One of the fundemental necessities of hazard administration for cities pending after or even before an earthquake is the judgement of a well-enriched geo-database [Karimzadeh, 2014]. The losses forecast can be achieved by approaches utilizing GIS technique and population scattering data and a specialized computer based pattern procedure. With the help of the utilizing GIS, it is possible to evaluate the construction hazard and combining population losses. Hence, the GIS technology by supplying maps of seismic hazard based on calculating models plays a distinct role in seismic hazard administration [Mansouri, 2008].

2. Material And Methods

2.1. Study Area

2.1.1. Active fault and active faults in study area

Duzce city is situated between the 39051 north latitude and 31008 east longitude. The study area situated in North Anatolian Fault Zone (NAFZ) and first degree earth quake zone, (Fig.1). Duzce has been affected by the active faults. The 1957 Bolu (M=7) and 1967 Adapazarı (M=7.1) aerthquake have occured on the Bolu–Abant Dokurcun segments of NAFZ. The active and probably active faults are Duzce, Hendek and Çilimli in the close proximity of the study area.

Fig.1. Study Area

The 30 km east segment of the 130 km fault rupture has occured on the west part of duzce fault reaching to Efteni lake during the 1999 M=7.4 earthquake.

2.2. Collection of Data

The data obtained in this research are categorized in two categories as: (a). spatial data including satellite images of ASTER, land use map of Duzce, demographic blocks, geological map 1:100,000 of Duzce and digital elevation model (DEM) with a allocation of 20 meters and (b). Non-spatial data including the urban land use type and the area regarded to each type, the quality of contructions, number of floors and constructions intencity.

2.3. Analysis of Data

In this research due to the importance of exposed specifications, at first seismic power of Duzce fault computed using the quantitative correlations models of of Noroozi and Ashjai, Selmoonez, Ambersize and Melvil, Norrozi, Cooper Esmit and Zare [Mousa Abedini1 and Nader Sarmasti, 2016]. Next step, an earthquake scenario for constructions vulnerability evaluation is supposed utilizing the GIS analysis. Further more, casualties are predicted regarding this scenario and seismicity qualifications of typical constructions in Duzce in Turkey.

3. Results

3.1. Seismic Power Analysis of Fault

Different correlations are suggested to seismic power evaluation of faults. In these formulas seismic power is directly proportional to the

faults length [Hosseinpur, 2006]. Empirical formulas existed in the literature or determining the seismic power and relative density of faults are given below:

A) The correlation of Nowroozi and Mohajer Ashjai [1987], (Eq.1).

$$Ms=5.4 +\log_{L} \quad (1)$$

Where Ms: is the earthquake magnitude on the Richter scale and L: is half the length of the fault in km [Nowroozi and Mohajer Ashjai ,1987].

B) The correlation of Nowroozi [1985], (Eq.2).

$$Ms=1,259+1,244\ \mathrm{Log}_{L} \quad (2)$$

Where L: is half the length of the fault in meters [Nowroozi,1985].

C) The correlation of Coppersmith for slip faults [1994], (Eq.3).

$$M_S=5.16+1.12\ \mathrm{Log}_{L} \quad (3)$$

Where L: is half the length of the fault in km [Hosseinpur, 2006].

D) The formula of Zare [2000] (Eq.4)

$$M_S=3.66+0.91\ \mathrm{Ln}\ L \quad (4)$$

Where L: is half the length of the fault in km [Zare, 2000].

G) Determining the relative intensity of the earthquake at the epicenter (Io) by the formula of Ambersaiz and Melville in Mercali scale (Eq.5).

$$I_o=1.3\ M_S-0.09 \quad (5)$$

Where Io: is the intensity of the earthquake at the epicenter in the Mercali scale, Ms: is magnitude on earthquake in the Richter scale [Sadatriazirad et al.,2008].

To evaluate the seismic power of Duzce fault utilizing the above correlations, the length of the fault in the Duzce region area was measured by means of ArcGIS10.2 software.

As there is distrubution in the compuation of Duzce fault seismicity value by different refered correlations, the average value of these computations is utilized in this research (Fig.2). This averaged value is 7.2 Richter which indicates a relatively compliance with reality (Tables 1).

Table 1. Seismic power maximum of Duzce fault in Richter scale

Empirical Formulas	Seismic Power (Richter)
Nowroozi and Ashjai	7.2
Nowroozi	7.3
Coopersmith	7.2
Zare	7.2
Average	7.2

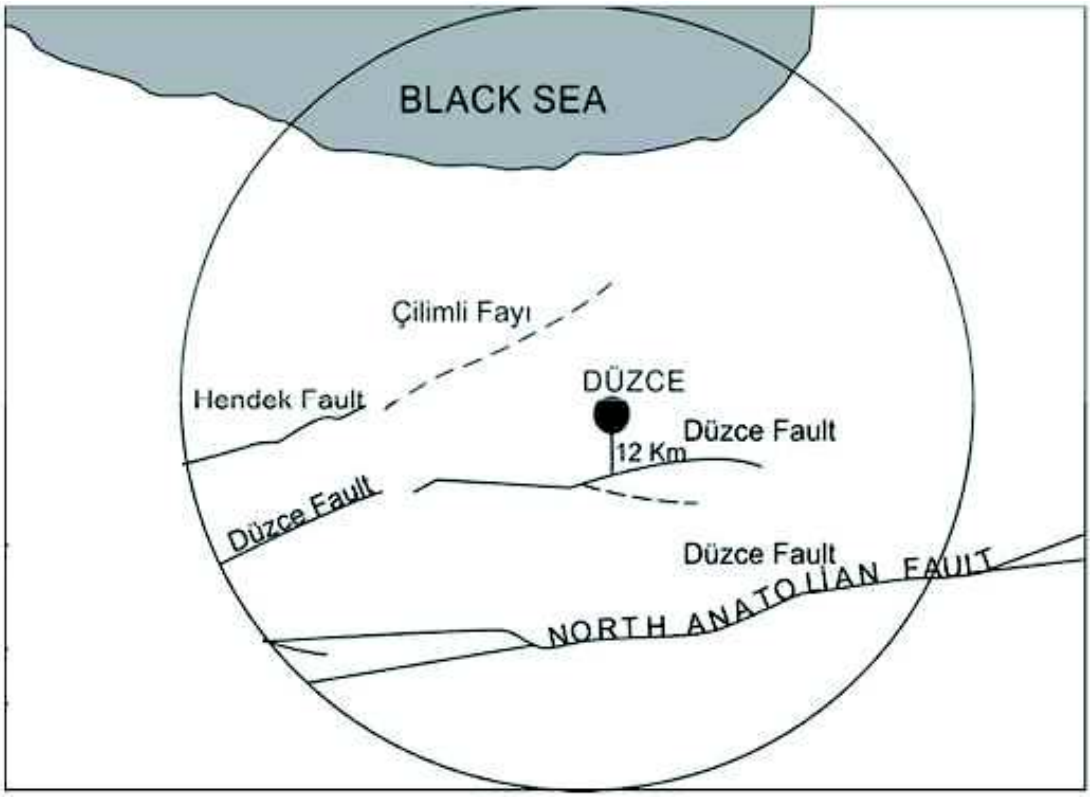

Fig. 2. Active Faults Around Bolu and Duzce

3.2. Vulnerability Analysis

3.2.1. City Vulnerability Estimation

The weighted overlay is one of the overlay analysis tools included in the Spatial Analysis extension. Generally, it is utilized to solve multi-criteria problems such as optimal site selection. It is a procedure for performing a prevalent scale of values to varied and dissimilar inputs to occur an combined analysis. In this research, the relative importance of different criterions is detected by the conductor through assigning a weighting factor for any criterion. Following, the
assigned weight of each criterion is multiplied by the option score and the total score for each alternative acquired by summing the results [Yachk, 2005]. In this research to evaluate the urban vulnerability against earthquake risk, a series of natural and human factors collected according to various professional thoughts. Next, vulnerability of Duzce region against earthquake is predicted utilizing the weighted overlay precedure and multi-criteria analysis. Required layers of information regarding the standards in the procedures of urban vulnerability is the first useful stage of this investigation. After obatining data, the privacy of faults was followed with ArcGIS10.2 software buffer function.
After this phase, with interrupt overlapping function; the interface section between buffer layer and layers of geology, slope, urban land use and demographic units was studied as anew layer with a database. In the following steps, utilizing the polygon conversion to raster based on the data fields of descriptive tables were removed raster layers. Layers based on the present fields standardized in the five priority categories. As the sought layers importance is the different same, layers should be marked. In order to mark the layers, different professional thouhts are utilized through drafting a questionnaire and the final score is mentioned in the Table 2. Concequently, vulnerability of Duzce region against earthquake was modeled by associating and overlapping layers utilizing the weight overlap indexical procedure based on the final weight of criteria (Fig.3).

Table 2. The Final Rating Criteria

Row	Criteria	Criteria's Weight
1	Geological Formations	12
2	Geological Formations	9,8
3	Slope	7,6
4	Population Density	9.5

Row	Criteria	Criteria's Weight
5	Building Density (%)	4,9
6	Quality Buildings	11.3
7	Size (M2)	3.7
8	Land Use	5,9
9	Building Floors	6.9

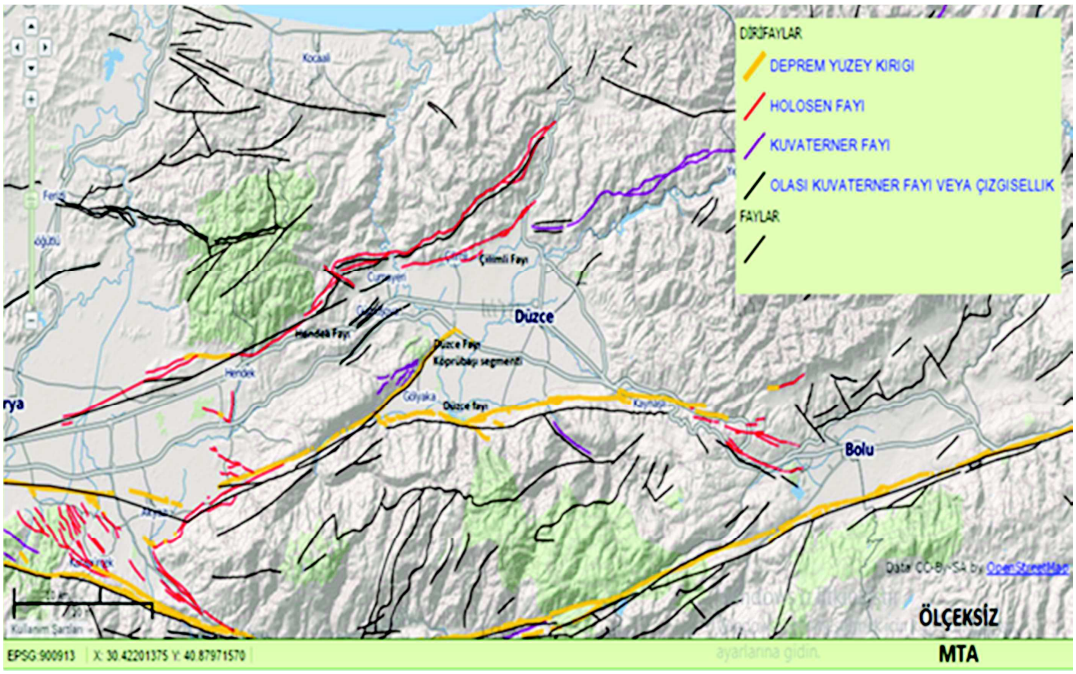

Fig. 3: The Vulnerability Zoning Map of Gölyaka Düzce Region Against Earthquake Hazard

3.2.2. Designing Earthquake Scenario For Building Vulnerability Estimation

Designing scenario is the first phase in assessment seismic vulnerability. Producing and testing earthquake scenarios are operative procedures to earthquake remission that supply opportunities to investigate future actions, and to assimulate prediction of new policies and programs. The assimulations can do communities to develop their understanding of earthquakes and their specific level of hazard. Based on the scenario reports, government and emergency administration agencies can enable to adopt the most suitable techniques, policies, and programs to descend the hazard of earthquakes [Hassanzadeh et al.,2013]. The earthquake scenario detects the magnitude, intensity and other parameters of the earthquake

that software predicts it as possible earthquakes in the area [Amini et al.,2011]. For evaluation casualties' rate, it is required to draft earthquake scenarios for its different densities. Inorder to this aim, the next correlation computes the earthquake hazard average rates to constructions for different densities (Eq.6).

$$\mu_D = 2.5\left(1+\tanh\left[\frac{Io+6.25Vt-13.1}{2.3}\right]\right) \quad (6)$$

In which μD: shows the average degree of hazard, Io: is earthquake intensity in Mercalli and Vi: is seismic vulnerability attributed desired multi-criteria method [Ahadnezhadroveshti ü, 2009]. In this procedure, losses changes output changes between 0 and 1 where zero means no vulnerability or lack of hazard and the number 1 means whole losses of or hazard [Zehrai and Lili, 2004]. With relation to the correlation 6, the amount of hazard to each construction can be categorized into 5 major groups (Table 3).

Table 3. Classification hazard to contructions [Lanta et al.,2009]

The degree of damage	The range of damage	Description	% Of damage to buildings
D1	0-0.3	Minor damage	3-11
D2	0.3-0.5	Moderate damage	12-31
D3	0.5-0.7	Heavy damage	32-61
D4	0.7-0.9	Very heavy damage	62-81
D5	0.9-1.	Complete destruction	81-100

The obtainings show that the majority of constructions in Duzce region are in grade between 0.8 to 1 (D5) with the full destruction vulnerability (Fig.4).

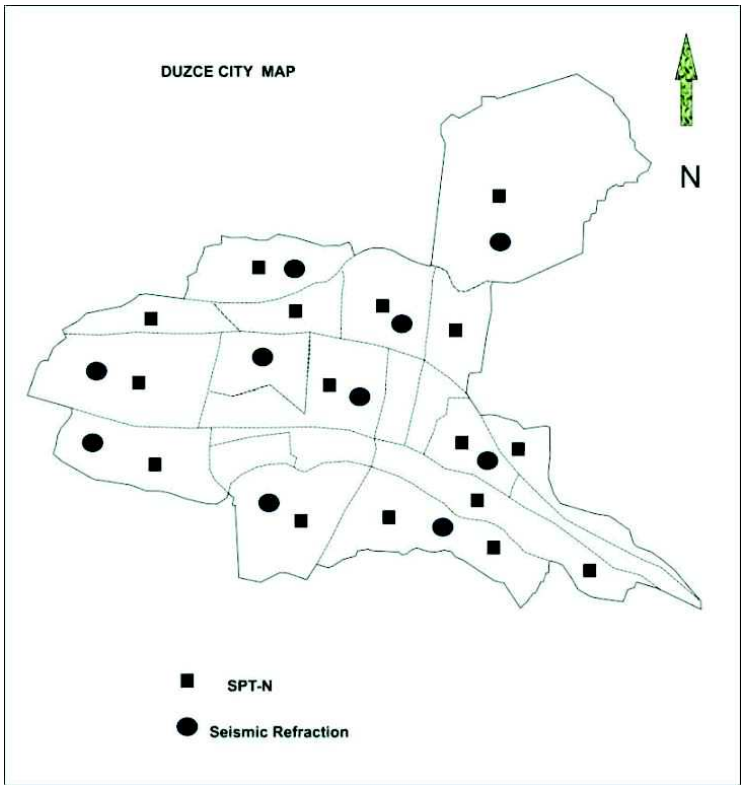

Fig. 4. The buildings vulnerability zoning map of Tabriz metropolitan against earthquake hazard

3.2.3. Population vulnerability estimation

Population vulnerability is a key category of vulnerability analysis described as the degree of population losses from a natural hazard, such as an earthquake. The fatalities due to large-scale earthquakes mostly causes devastating of the construction [Karimzadeh, 2014]. The extent of hazard from an earthquake improving dramatically with increment of population growth, in particular in large cities. Earthquakes induce death and injuries in different ways. Construction fall is the fundemental cause of human fatalities in earthquakes worldwide, accounting for about 75 percent of deaths [Mousa Abedini1 and Nader Sarmasti, 2016].

The probability in each category is predicted attributed to the previous earthquakes losses of population records such as Bam earthquake based on a questionnaire survey with 300 people regarding population vulnerability [Hassanzadeh, 2013]. The vulnerability of a casualties acquired from the next relationship:

$$PV=\sum BPixPKi \quad (7)$$

Where PV: is population vulnerability, Bpi: is number of people in the constructions in each specific hazarded zone, PKi: is probability of being (dead/ hospitalized injured/ injured and not hospitalized/ and not injured) in each specific construction devastation's zones. The number of dead and injured peaople are 710 and 2678 in 1999 Duzce earthquake.

4. Conclusion

Earthquake comprising in urban sites can create grave consequences because of the complex conditions of these sites. Hence, a series of researches is necessary on the assessment of faults seismic power andprediction the hazard caused by probable earthquakes in urban sites. Duzce region is situated on the sidelines and in some places on the Duzce fault where the fault's vertical and horizontal movements can create extra heavy losses. The seismic history of this area can be an trace for possibility of earthquakes formation in the future. Now, Duzce area with a population of about 1600000 people and many high buildings in the privity of active fault zone is extremely growing and developing. On account of the importance of the issue, seismic power of Duzce fault and casualties in Duzce region is predicted attributed to experimental procedures in GIS. The obtainings shows that the Duzce fault create earthquakes with magnitude over 7.4 on the Richter scale. The rate of casualties of such an earthquake is approximately predicted 710 casualties were predicted at night of total population in Duzce dead, 2678 people injured.

As a result, improper improvement of Duzce City in sites dominated of Duzce fault system, this city has appreciated in risk the hazards of earthquakes and the occurrence of earthquakes so strong, it is possible humanitarian hazard is high.

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