Seismic Hazard Analysis Of Van Province Of Turkey

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ABSTRACT

Within the framework of the performance based earthquake engineering, the seismic hazard analysis for the Van province in Turkey is performed in probabilistic manner. It is noteworthy that, in probabilistic seismic hazard assessment, as a first stage, data from geological studies and records from the instrumental period were compiled to make a seismic source characterization for the study region. Then, a seismic hazard model by using EZ-FRISK software is implemented and the probabilistic seismic hazard curves were developed based on the selected appropriate attenuation relationships, at rock sites, with a probability of exceedance of 2%, 10% and 50% in 50-year periods. The results of probabilistic seismic hazard analyses revealed peak acceleration values for a typical rock site as 0.47g for 50% probability of exceedance in 50 years, 1.09g for 10% probability of exceedance in 50 years and 1.91 g for 2% probability of exceedance in 50 years. The obtained results are compared with N-S&E-W component taken from Muradiye station after the earthquake which occurred on 23.10.2011 in Van, N-S & E-W componenttaken from Van station after the earthquake which occurred on 9.11.2011 in Van, and the spectral responsesproposed for seismic evaluation and retrofit of building structure in Turkey Earthquake Code, Section 7.

At the end of this study, it is apprehended that for the performance evaluation of the existing structures Code proposed earthquake response spectra are not sufficient and the current estimations show that the potential seismic hazard in research area of the Turkey is not well-estimated in the code..

Keywords: Seismic Hazard, Performance Evaluation, Response Spectra, Van province

1. INTRODUCTION

Van is a city at an altitude of 1750 metres in southeastern Turkey's Van Province, and is located on the eastern shore of Lake Van. In 2010 the official population figure for Van was nearly 500,000. The city land is surrounded by volcanic high mountains. Its history dates to B.C. 10. Century and its original name is Tuşba.

The seismicity of Van has been investigated in the light of performance based –engineering in this study. Performance-based earthquake engineering seeks to improve seismic risk decision-making through assessment and design methods that have a strong scientific basis and that express options in terms that enable stakeholders to make informed decisions. Given the inherent uncertainty and variability in seismic response, it follows that a performance-based methodology should be formalized within a probabilistic basis. The framework has four main analysis steps: Hazard analysis, structural/nonstructural analysis, damage analysis, and loss

analysis. The first assessment step entails a hazard analysis, through which one evaluates one or more ground motion Intensity Measures (IM). For standard earthquake intensity measures (such as peak ground acceleration or spectral acceleration) is obtained through conventional probabilistic seismic hazard analyses. Typically, IM is described as a mean annual probability of exceedance, which is specific to the location and design characteristics of thefacility (Moehle and Deierlein, 2004).
In this study, a probabilistic seismic hazard analysis is applied for the assessment of potential losses as a part of an ongoing research entitled as Seismic Hazard and Risk Assessment of Van.

2. METHODOLOGY

The seismic hazard analysis approach is based on the model developed originally by Cornell (1968) who quantified it in terms of the probability of exceedance of the design level peak ground acceleration (PGA). The procedure for conducting a probabilistic seismic hazard analysis includes seismic source characterization, size distribution and rate of occurrence determination for the source, ground motion estimation and, lastly, probability analysis.

In the current study, since the neotectonic faults are not identified in the research area clearly, earthquake sources are characterized as area source zones. Area seismic sources are often defined where specific fault data are not known, but seismicity does exist. Area sources assume that the rate of occurrence is uniform throughout. Therefore, every location within the area has equal probability that an event will occur.

All seismic sources, that can generate strong ground shaking in Van and surroundings, are classified into 12 areal seismic zones: (Fig.1) (1) Bitlis Zagros Suture zone; (2) Başkale fault zone; (3) HasanTimur fault zone; (4) Malazgirt fault zone; (5) Erciş fault zone; (6) Suphan Fault zone ; and (7) Van Like Southern Boundary fault (Utkucu, 2006) (8) Çaldıran fault zone (9) First fault zone (Ketin, 1977) (10)Second fault zone (Ketin, 1977) (11) Third fault zone (Ketin, 1977) (12) Fourth fault zone (Ketin, 1977).

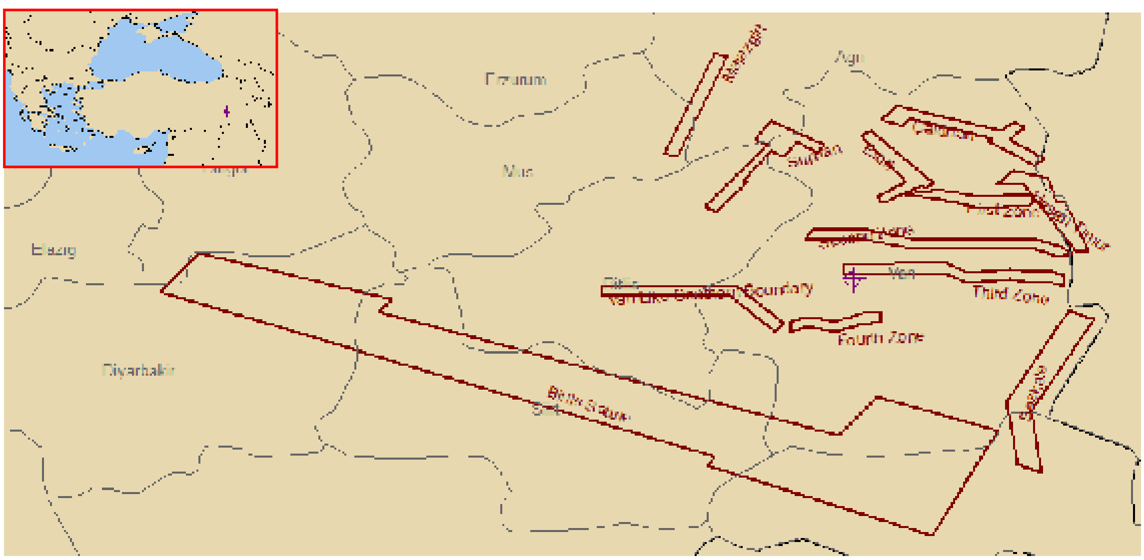

Figure 1. Earthquake areal zones (Bitlis Zagros Suture zone, Başkale fault zone, HasanTimur fault zone, Malazgirt fault zone, Erciş fault zone, Suphan Fault zone, Van Like Southern Boundary fault, Çaldıran fault zone, First fault zone, Second fault zone, Third fault zone, Fourth fault zone) in Van and surroundings

On any given fault within any given region, earthquakes occur at irregular intervals in time,

and one of the basic activities in seismology has long been the search for meaningful patterns in the time sequences of earthquake occurrence (Dowrick, 2003). Among a number of recurrence laws have been proposed, in this study, Gutenberg and Richter law was used. Because, there is no available evidence to determine whether the Gutenberg –Richter or some other recurrence laws are correct.
During any given interval in time, the general underlying pattern or distribution of size of events is that first described by Gutenberg and Richter, who derived an empirical relationship between magnitude and frequency of the form

$$\log N = a - b.M \qquad (1)$$

where N is the number of shocks of magnitude at least M per unit time and unit area, and A and b are seismic constants for any given region (Dowrick, 2003).

In a seismic hazard modeling study of Van, a plot of M against log N was constructedby utilizing the values indicated in Table 1 and the best-fit line of the form of Eqn. 1 was determined by regression analysis (Fig. 2).

Tablo 1.Recurrence numbers of earthquakes in terms of magnitude and the logarithmic values of these recurrence numbers

Ms	AverageMs	Frequency	Log N	Mass Frequency	Log N
4,0 -- 4,5	4,25	65	1.81291	140	2,14612
4,5 -- 5,0	4,75	42	1.62324	75	1,87506
5,0 -- 5,5	5,25	18	1.25527	33	1,51851
5,5 -- 6,0	5,75	10	1.00000	15	1,17609
6,0 – 6,5	6,25	4	0.60205	5	0,69897
6,5 – 7,0	6,75	1	0,00000	1	0,00000

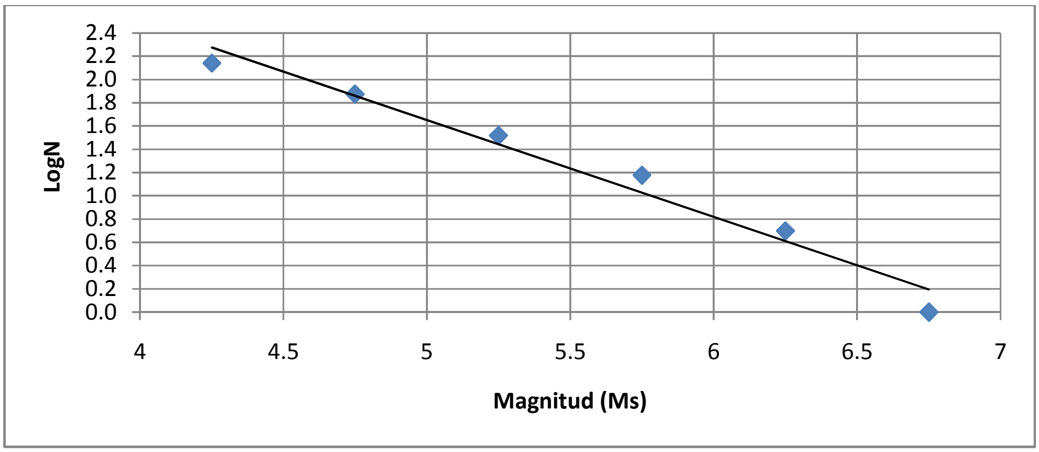

Figure 2.Gütenberg-Richter magnitude–frequency relationship for earthquakes from Van and surrounding data

In probabilistic seismic hazard analysis, beside magnitude–frequency relationship which is calculated for Van province as logN = 5,8248 – 0,8344 M , a relationships between magnitude and fault rupture parameters of length L_{sub}(km), width W (km), area A (km^2) and displacement D (m) is also required. In a study of a worldwide database of 244 earthquakes, for strike-slip fault types Wells and Coppersmith (1994) obtained:

$$Mw = 4.33 + 1.49 \log Lsub \qquad s = 0.2 \qquad (2)$$

where*s* is the residual standard deviation

In Eastern Anatolia region, previously recorded strong ground motion acceleration records are limited. Therefore, in this current analysis, worldwide applicable three empirical attenuation relationships are utilized to perform the seismic hazard analysis. Attenuation relationships for rock sites employed in this study are Abrahamson-Silva (1997), Ambraseys et al. (2005), Boore - Joyner - Fumal (1997) and Idriss (2008) Fig. 3.

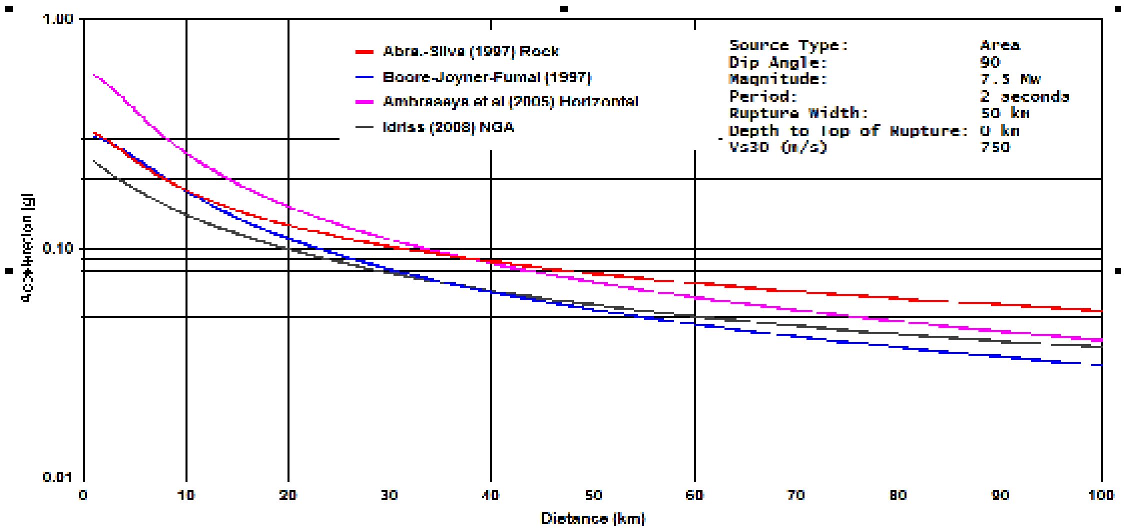

Figure 3.Abra-Silva (1997), Ambraseyes et al (2005), Boore-Joyner-Fumal (1997)and Idriss (2008) attenuation relationships for rock sites.

3. SEISMIC HAZARD ANALYSIS RESULTS

After the compilation of the seismic hazard analysis data, the procedure for conducting a probabilistic seismic hazard analysis, by using EZ-FRISK (Risk Engineering, Inc, 1997; McGuire R., 2004) software, was employed to produce the PGA as a function of return periods (Figure 4), and uniform probability response spectra for selected return periods (Fig. 5)

The results of probabilistic seismic hazard analysis for Van are presented in terms of spectral responses at 5% damping for the return periods of 72, 474.6 and 2474.9 years (Fig. 5). The results are compared with N-S&E-W component taken from Muradiye station after the earthquake which occurred on 23.10.2011 in Van, N-S & E-W component taken from Van station after the earthquake which occurred on 9.11.2011 in Van, and the spectral responsesproposed for seismic evaluation and retrofit of building structure in Turkey Earthquake Code, Section 7.

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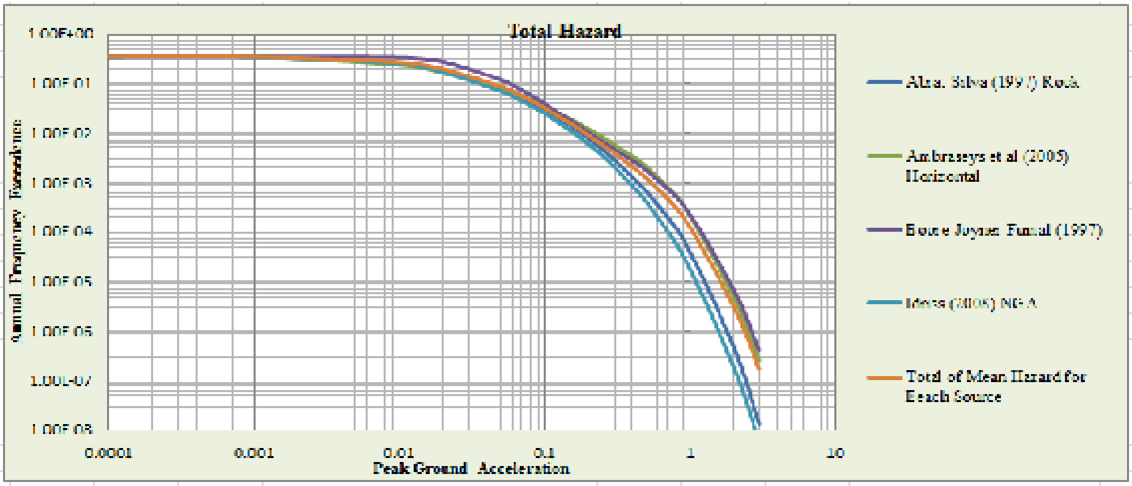

Figure 4. Peak ground acceleration (PGA) atVan with varying return periods

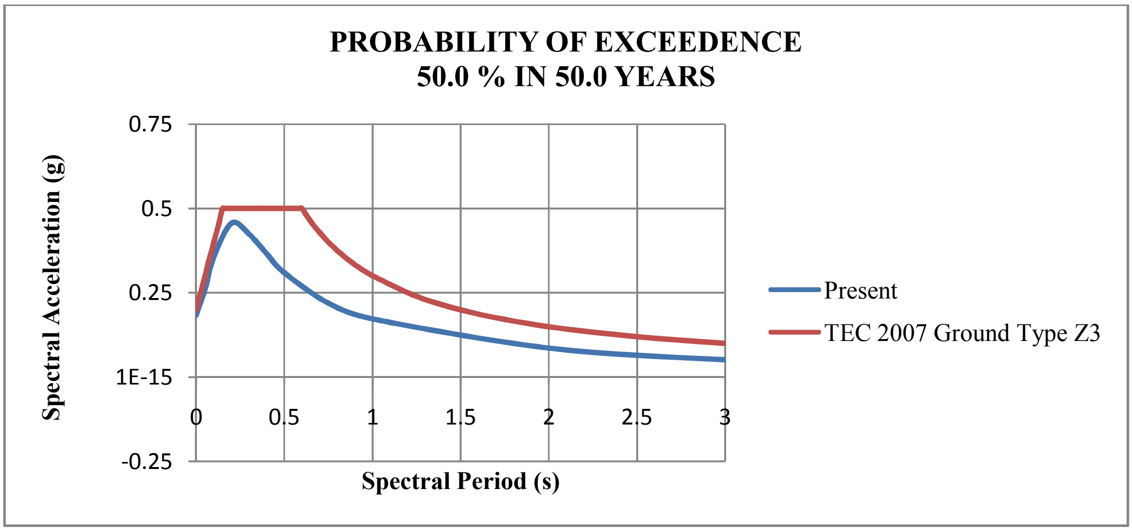

Fig. 5a.Comparison of the spectral response ofpresent study andTurkey Earthquake Code at 5% damping for the return period of 72 years in Van

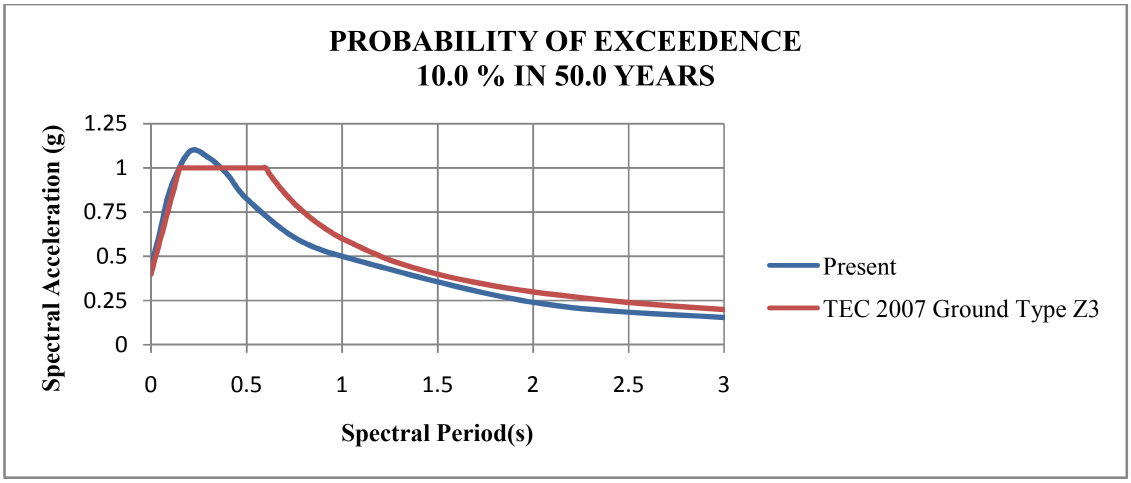

Fig. 5b.Comparison of the spectral responses ofpresent study andTurkey Earthquake Code at 5% damping for the return period of 74,6 years in Van

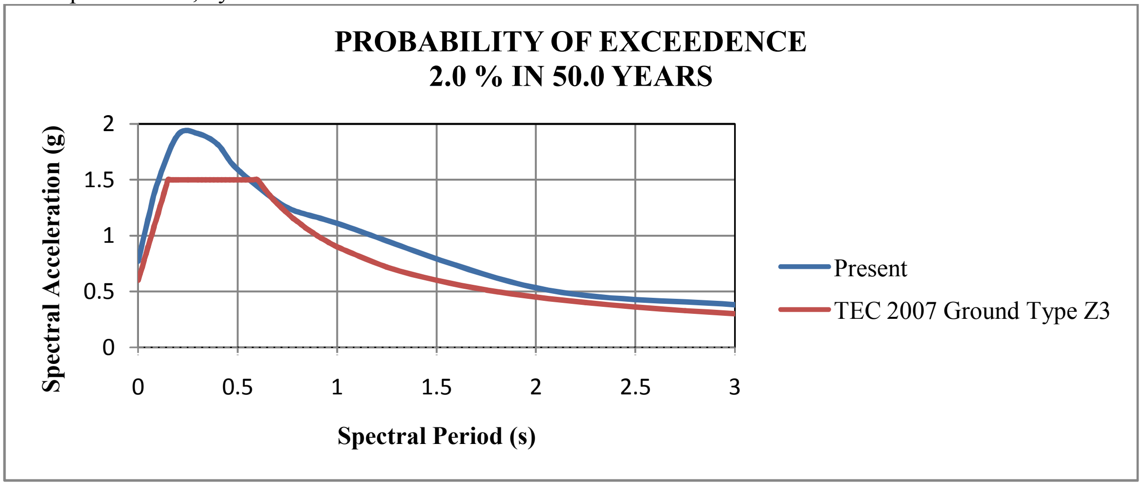

Fig. 5c.Comparison ofthe spectral responses ofpresent study andTurkey Earthquake Code at 5% damping for the return period of 2474,9 years in Van

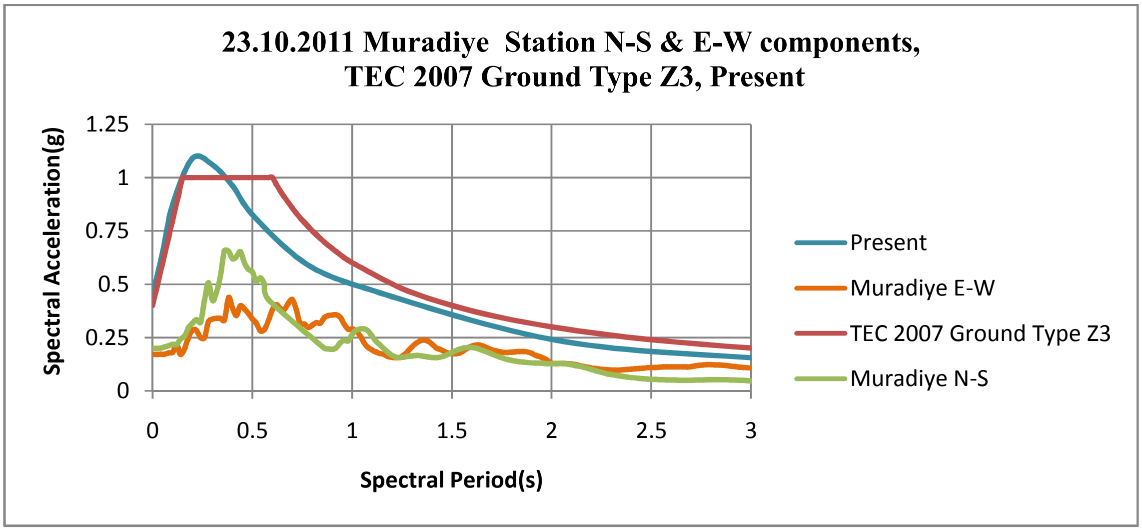

Fig. 5d.Comparison of 23.10.2011 Muradiye Station N-S & E-W components, TEC 2007 GroundType Z3,andpresentstudy

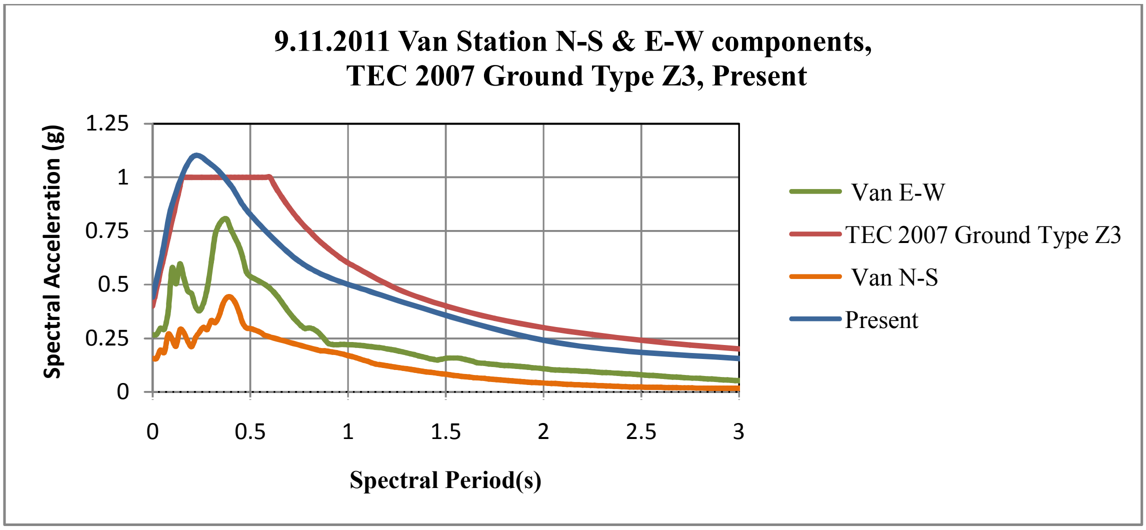

Fig. 5e. Comparison of 9.11.2011 Muradiye Station N-S & E-W components, TEC 2007 GroundType Z3,andpresentstudy

4. SUMMARY AND CONCLUSIONS

By utilizing available data and the use of improved methods, a probabilistic seismic hazard of Van province in Turkey was determined. The study is conducted under the ongoing research entitled as Seismic Hazard and Risk Assessment of Van city. As a first step of the performance based earthquake engineering, it is well understood that the Code proposed spectra should be studied in more detail to represent earthquake demand in the performance evaluation.The results of this work will form the basis for the replacement of the existing earthquake design spectra in evaluation of earthquake performances of the existing buildings in Van province.

In this study, since active faults are not identified clearly, regional areas were used as an earthquake source zones. Future work will increase the resolution of the seismotectonic model by adding specific active faults.

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