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THE EFFECTS OF 23.10.2011 VAN EARTHQUAKE ON NEAR-FIELD AND DAMAGED ON STRUCTURES

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ABSTRACT

A destructive earthquake happened at 13:41 in 23.10.2011 in Van of which Mw: 7.2. The earthquake has been replaced between significant earthquakes in the earthquake history of Turkey by causing more than 600 deaths, over 2000 injured people, leaving thousands of people homeless and more than one billion dollars of economic loss. The earthquake has been felt in some settlements, especially in Lake Van Basin where earthquake has always been neglected. The highest peak acceleration values recorded at Bitlis-Centre Station after Van-Muradiye Station. Maximum structural losses observed in Bitlis after Van and Erciş District. The province of Bitlis settles in Lake Van Basin in the East Anatolian Region of Turkey. Bitlis is about 100km away from the epicentre of the earthquake. The first damage assessment of constructions after earthquake and its evaluation have importance in order to prevent loss of life and property in coming earthquakes. In this study the effects of earthquake on constructions in Bitlis have been observed and evaluated. The goal of this paper is to introduce major reasons for structural damages on the near field of 23.10.2011 Van earthquake at neighbouring province Bitlis. The damages have been observed that they overlap with typical earthquake damages. It has been observed that the negative features of constructions have caused an increase in damage amount. Almost no damages in constructions built according to Turkish Earthquake Code have been observed. And this has proved that codes are enough but buildings have not been constructed according to these regulations.

Keywords: Van earthquake, Bitlis, masonry, reinforced concrete, structural damages, near-field,

23 EKİM 2011 VAN DEPREMİNİN YAKIN ALAN ETKİSİ VE YAPISAL HASARLAR

ÖZET

23.10.2011'de yerel saat 13:41'de M_w=7.2 büyüklüğünde Van merkezli şiddetli bir deprem meydana gelmiştir. Bu deprem 600'den fazla kişinin ölümüne, 2000'in üzerinde kişinin yaralanmasın, binlerce kişinin evsiz kalmasına ve bir milyar dolardan fazla ekonomik kayıplara neden olarak Türkiye'deki önemli tarihsel depremler arasında yerini almıştır. Deprem, depremsellik öğesi ihmal edilen Vangölü Havzasında bulunan yerleşim birimlerinde hissedilmiştir. En büyük ivme değeri Van-Muradiye İstasyonundan sonra Bitlis-Merkez istasyonunda kaydedilmiştir. Van ve Erçiş dışında en büyük yapısal hasarlar Bitlis ve ilçelerinde meydana gelmiştir. Bitlis il merkezi deprem merkez üssüne yaklaşık olarak 100km uzaklıktadır. Deprem sonrasında yapılarda meydana gelen hasarların ilk tespiti ve değerlendirilmesi daha sonraki olası depremlerde oluşabilecek can ve kayıplarının artmaması için önem arzetmektedir. Bu çalışmada depremin Bitlis ilindeki yapılara etkileri gözlemlenmiş ve değerlendirilmiştir. Çalışmanın esas hedefi merkez üssü Van olan depremin yakın alanda komşu olan Bitlis ilindeki yapısal hasarları belirtmektir. Gözlemlenen hasarların tipik deprem hasarları ile birebir örtüştüğü gözlemlenmiştir. Yapıların olumsuz özellikleri, hasar miktarının artmasında önemli bir rolü olmuştur. Depreme dayanıklı yapı tasarım yönetmeliklerine uygun inşa edilen yapılarda neredeyse hiç hasara rastlanmamıştır. Bu da yapı tasarım yönetmeliklerinin yeterli olduğu ancak yapıların yönetmeliklere uygun inşa edilmediği gerçeğinin bir kez daha ortaya koymuştur.

Anahtar Kelimeler: Van depremi, Bitlis, yığma yapı, betonarme, yapısal hasar, yakın alan

1. Inroduction

In general terms, the risk can be defined as the combination of probability of occurrence and the consequence of a specified hazardous event. Otherwise, the value of risk depends on the severity of hazard and the vulnerability of the elements which will be affected by the hazardous event (Kundak, 2006). Earthquake damages will increase according to vulnerability of urban and rural building stocks. The size of earthquakes and

the negative structural features will be caused an increase in damage amount. Knowing the properties of buildings that have been negatively influenced to the seismic behaviour of buildings under earthquakes will be put forward to ensure more serious approaches to reduce the level of damage risk after earthquakes.
The first damage assessment of buildings after earthquake and its evaluation have importance in order to decide to repair buildings and reinforcement or destruction of buildings according to the degree of damage. The possibility of occurring damage according to the size of earthquake is greater on buildings that have not been constructed according to earthquake codes. By the way there can be damages in buildings constructed according to earthquake codes after severe earthquake. Therefore, the determination of damage and doing the necessary strengthening continuation of this is one of the important topic of civil and earthquake engineering (Celep, 2004).

The province of Bitlis settles in Lake Van Basin in the East Anatolian Region of Turkey which is considered to be one of the important provinces of that strategic corridor of Turkey. Bitlis is a town in and the capital of Bitlis Province which was 70,000 (including the surrounding villages) as of 2,000. The town is located at an elevation of 1,400 metres, 15 km from Lake Van, in the steep-sided valley of the Bitlis River, a tributary of the Tigris River. A popular folk etymology explanation, without any historical basis, is that it is derived from "Batlis", the name of a general said to have built Bitlis castle by the order of Alexander the Great (Armenian Soviet Encyclopaedia, 1976).

Lake Van basin is located in Eastern Turkey that has suffered very severe tectonic deformation (Horasan et al 2007; Toker et al 2007). Destructive earthquakes that will be occurred in Lake Van Basin will be effect Bitlis and its districts which were also in this basin (Işık, 2010). In this context 23.11.2011 Van earthquake was felt strongly in Bitlis and its towns.

In this study the effects of this earthquake on constructions in Bitlis have been observed and evaluated. This paper gives information about the characteristics of the site and soil conditions for Bitlis. Furthermore, it also gives information about tectonic settings and seismicity of Lake Van Basin especially Bitlis. The damages to reinforced-concrete (RC) and masonry structures after earthquake are observed, evaluated and recommendations made. The distance from the study area to the epicentre of Van earthquake is given in Fig.1.

Fig.1. The distance from study to the epicentre of Van earthquake

A destructive earthquake happened at 13:41 in 23.10.2011 in Van of which Mw: 7.2. The earthquake has been felt in some settlements, especially in Lake Van Basin where earthquake has always been neglected. The earthquake epicentre was located directly between Erciş district and Van City. Bitlis is about 100km away from the epicentre of the earthquake. Adilcevaz District is about 60km away from earthquake epicentre. The maximum structural losses observed in Van and Erciş District. Erciş district was the most heavily damaged area in this earthquake. Maximum structural losses observed in Bitlis after Van and Erciş District (Fig. 2.)

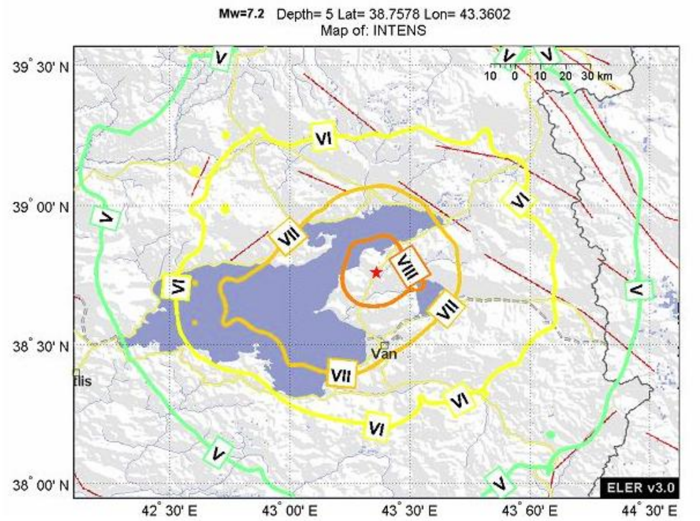

Fig.2. Instrumental intensities associated with the main shock (Koeri, 2011)

Turkish National Strong Ground Network operated by AFAD recorded the strong ground motion data for calculating the peak acceleration values for 23 October Van earthquake. Bitlis-Centre Station is 116 km away from epicentre of earthquake. The peak acceleration values recorded at Bitlis-Centre Station were 89.66, 102.24 and 35.51 cm/s^2 in north–south, east–west and vertical direction, respectively. The peak acceleration values for 23 October Van Earthquake is given in Table 1.

Table 1. The peak acceleration values for 23 October Van Earthquake (AFAD, 2011).

	STATION		Type of Accelerometer	Accelerometer Values (gal)			Distance R_{epi} (km)	Share Wave Velocity V_{s30}(m/sn)
No	CITY	TOWN		NS	EW	UD		
1	Van	Muradiye	SMACH	178.5	168.5	75.5	42	293
2	Muş	Malazgirt	SMACH	44.5	56.0	25.May	95	311
3	**Bitlis**	**Centre**	**CMG-5TD**	**89.66**	**102.24**	**35.51**	**116**	**Alluvial**
4	Ağrı	Centre	CMG-5TD	18.45	15.08	7.21	121	295
5	Siirt	Centre	CMG-5TD	9.90	9.16	7.04	158	Alluvial

2. Local Geology

The local geological soil conditions have been affected and changed the characteristics of seismic activity. It is a known fact that this may cause damages cause damage on the existing structures that have been built on these grounds (Borcherdt, 1990). Lake Van Basin which contains Bitlis, has been located at that known as Bitlis Thrust Zone in geological terminology that was a collapsed tectonic basin which have been relatively to Eastern Taurus (Ozkaymak et al, 2003). Orogenic movements have occurred in the field until third phase of Miocene. Volcanic events have been caused to form many faults, depressions and large lakes in this period (Facenna et al, 2006; Köse, 2004).

The structure and metamorphism of an area of 84 km^2 lying on the Taurus Mountains of South-East Turkey was studied by researchers. The country around the city of Bitlis was mapped on 1/10.000 scale. The stratigraphical relations of the metamorphic rock units are quite obscure. Two major rock units mainly composed of unfossiliferous metamorphic rocks are distinguished on the basis of structural and petrographic evidences. Three deformation phases accompanied with progressive and retrogressive metamorphism were distinguished. In the first phase, penetrative foliation which is sub parallel to original bedding, has been produced. In the second phase both bedding and foliation have been deformed by tight folding. Open folds and an incipient foliation have developed in the third phase. The rocks are metamorphosed to the biotite and garnet grade of the greenschist facies. Intense thrusting of Alpine age and dynamic metamorphism in these thrust zones are observed.(Boray, 1976).

Metamorphic rocks belongs to Bitlis Massif, upper cretaceous Ahlat-Adilcevaz melange, Ahlat conglomerate, Miocene Adilcevaz limestone, Pliocene-quaternary volcanic rocks and alluvial deposits have been given surface in Bitlis and its around (Jeo-Massif, 2003; TOKI,2006).

Bitlis Centre is located at steep slopes on both sides of Kışla and Güzeldere. It is located in the steep-sided valley of both these rivers. Generally basalts columns have been found in slopes of rivers (Tabban, 2000). Mountains have been formed %90 of Bitlis. Plateaus and plains have been formed only %10 of Bitlis. The important mountain in Bitlis known as Bitlis Mountain exceeds 3.000m high. Two clear basalt flows and terrace levels formed by these flows have been observed in Bitlis Valley. The fluvial sediment deposits and other current flows overlies in most place has been observed (Biçek, 2006). Tuff which was formed by basaltic flows has been observed in Bitlis Valley and in Rahva Plateau (Altınlı, 1966). Geological map of Lake Van Basin is given in Fig.3. There was no soil problem noted down for collapsed, heavily damaged and undamaged buildings in the city centre of Bitlis.

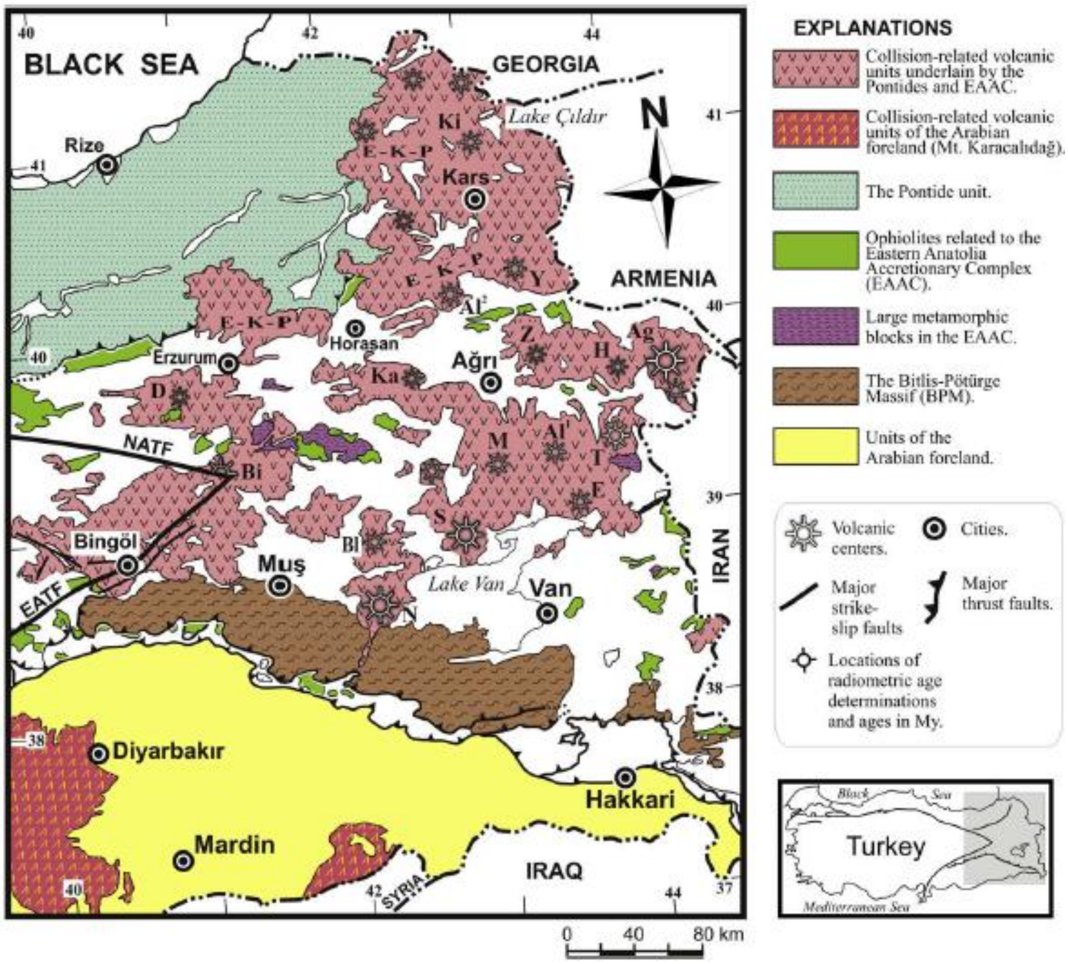

Fig.3. Geological map of the Lake Van region. N – Nemrut Volcano, S – Süphan Volcano in the immediate vicinity of the lake. EATF – East Anatolian Fault; NATF – North Anatolian Fault (Litt, 2009)

3. Tectonics Setting And Seismicity Of Bitlis And Surrounding Area

General tectonic setting of the Eastern Anatolia is mainly controlled by collision of roughly northerly moving Arabian plate with the Anatolian plate along a deformation zone known as Bitlis Thrust Zone (Fig. 4). The collision leads westward extrusion of the Anatolian plate along the two notorious transform faults with different sense of slip, the dextral North Anatolian Fault and the sinistral East Anatolian Fault zones, which join each other in Karlıova Triple Junction (KTJ) in the eastern Anatolia (Fig. 4). In the east of KTJ, however, the collision caused deformation is largely accommodated within the Eastern Anatolian Block through distributed NW-SE trending dextral faults and NE–SW trending sinistral faults representing escape tectonics, and shortening of the continental lithosphere along the Caucasus thrust zone. East–west trending Mush-Lake Van and Pasinler ramp basins constitute other conspicuous tectonic properties within the eastern Anatolia (Sengor et al. 1985; Barka and Kadinsky-Cade, 1998; Mc Clusky et al. 2000; Reilinger et al 2006; Utkucu, 2006).

The East Anatolian Fault Zone is a 550 km-long, approximately northeast-trending, sinistral strike-slip fault zone (Fig. 4) that comprises a series of faults arranged parallel, sub parallel or obliquely to the general trend. The Bitlis Suture is a complex continent-continent and continent-ocean collisional boundary that lies north of fold-and-thrust belt of the Arabian platform and extends from south-eastern Turkey to the Zagros Mountains in Iran (Homke, 2007; Bonnin et al 1996; Piper et al 2008; Stern et al 2008; Lyberis et al 1992). The area to the east of Karlıova triple junction is characterized by a N–S compressional tectonic regime (Fig. 4).

Conjugate strike-slip faults of dextral and sinistral character paralleling to North and East Anatolian fault zones are the dominant structural elements of the region. Some of these structures include Agrı Fault, Bulanık Fault, Çaldıran Fault, Ercis¸ Fault, Horasan Fault, Iğdır Fault, Malazgirt Fault, Süphan Fault, Balıklıgölü Fault Zone, Baskale Fault, Çobandede Fault Zone, Dumlu Fault Zone, Hasan Timur Fault Zone, Kavakbası Fault, Kagızman Fault Zone, Doğubayazıt Fault Zone, Karayazı Fault, Tutak Fault Zone, Yüksekova–Semdinli Fault Zone and the Northeast Anatolian Fault Zone (Fig.5.)(Bozkurt, 2001).

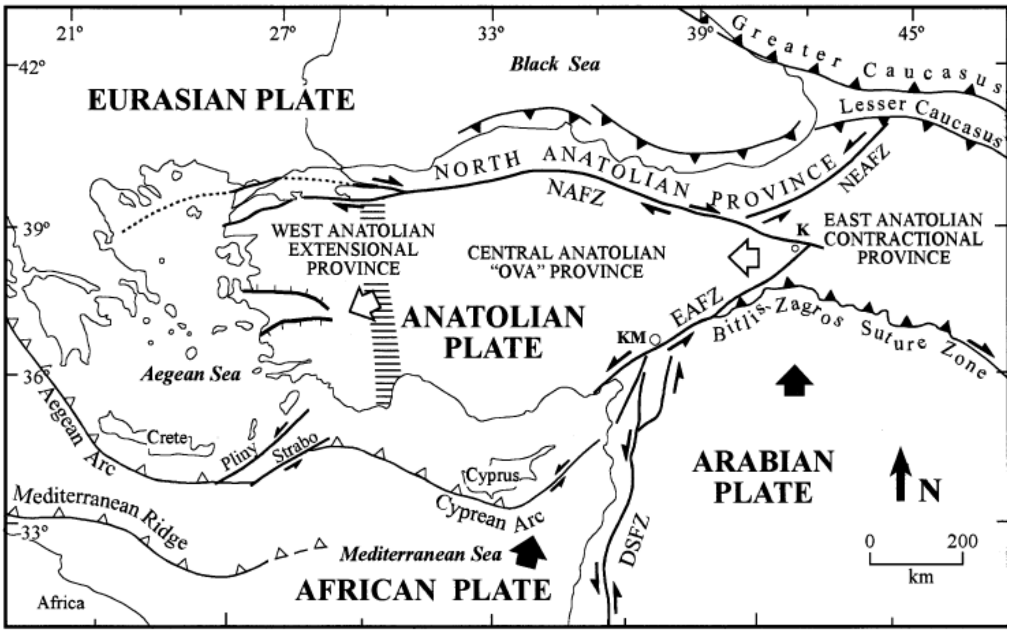

Fig.4. Tectonic map of Turkey including major structural features (from Bozkurt, 2001)

The faults are seismically active and form the source for many earthquakes. Some of the major earthquakes in the 20th Century are 13 September 1924 Pasinler (M = 6.8), 1975 Lice (M = 6.6), 24 November 1976 Çaldıran (M = 7.3), 30 October 1983 Horasan–Narman (M= 6.8), 5 May 1986 (M =5.8) and 6 June 1986 Doğanşehir (M = 5.6) earthquakes (Bozkurt, 2001).

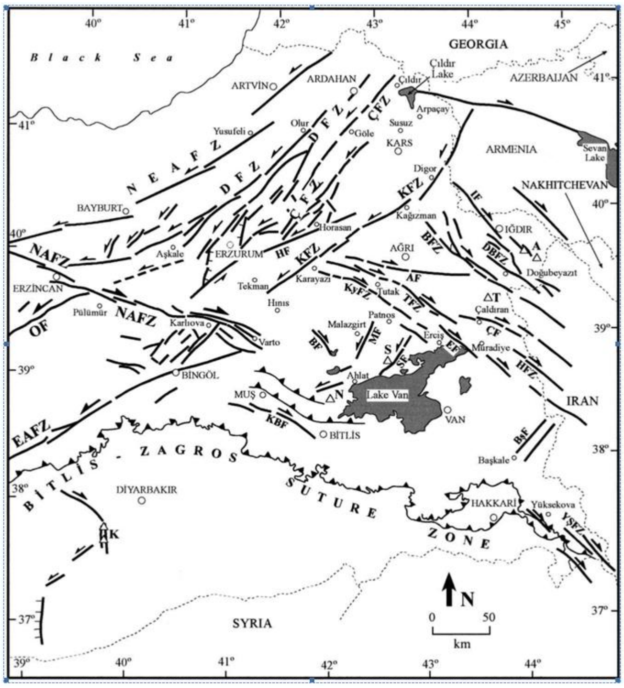

Fig.5. Active faults of Eastern Anatolian Province (Bozkurt, 2001)

Bitlis Centre is in first degree of seismic zones in current seismic hazard map of Turkey (Fig.6.). Fig.6. indicates first and second degree of seismic zones.

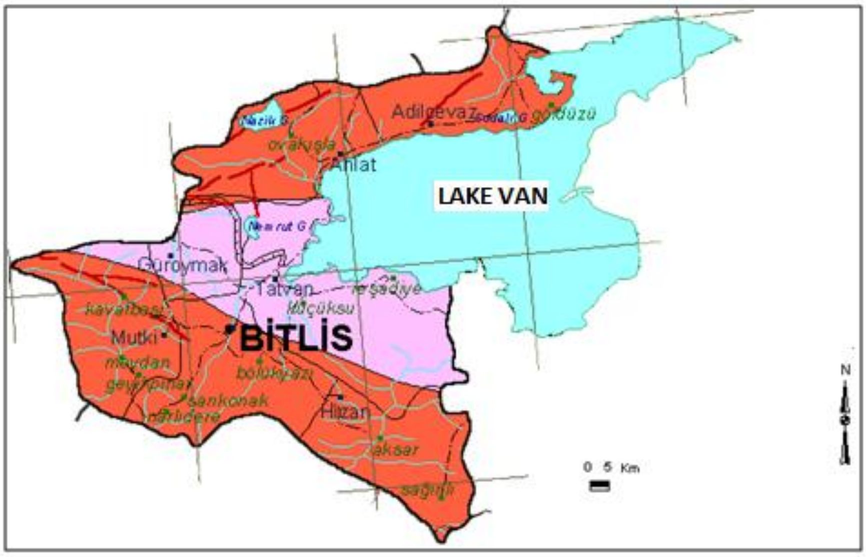

Fig.6. Seismic hazard map of Bitlis where the red areas indicate first degree zone with a minimum effective acceleration of 0.40 g and the pink areas for the second degree with 0.30 g

Lake Van basin has been seismically active region as indicated by historical sources. Table 2 tabulates the significant earthquakes occurred Bitlis and surrounding area before 20th century.

Table 2. The significant earthquakes occurred Bitlis and surrounding area before 20th century

No	Date	Lat. (°)	Lan. (°)	Location	M	I
1	461	39.10	42.50	Malazgirt		X
2	1012	39.10	42.50	Malazgirt		VII
3	1101	38.50	43.50	Ahlat - Van		VI
4	1110	38.50	43.50	Ahlat - Van		VIII
5	1111	38.50	42.70	Ahlat - Van		IX
6	1208	38.70	42.50	Ahlat-Van-Bitlis-Muş	6.5	
7	1245	38.74	42.50	Ahlat - Bitlis- Van - Muş		VIII
8	1246	38.90	42.90	Lake Van (Ahlat - Erçiş –Van)		VIII
9	1275	38.40	42.10	Bitlis- Ahlat -Erciş – Van		VII
10	1276	38.90	42.50	Bitlis- Ahlat -Erciş – Van		VIII
11	1282	38.90	42.90	Ahlat – Erçiş		VII
12	1345	39.10	42.50	Malazgirt		VIII
13	1363	38.70	41.50	Muş and surrounding		IX
14	1415	38.50	43.00	Van Gölü		V
15	1439	38.50	42.10	Nemrut		VI
16	1441	38.35	42.10	Nemrut		VIII
17	1444	38.50	43.40	Nemrut - Van		VI
18	1546	38.50	43.40	Van - Bitlis		V
19	1582	38.35	42.10	Bitlis and surrounding		VIII
20	1646	38.50	43.40	Van and surrounding		VII
21	1647	39.15	44.00	Van - Muş -Bitlis		IX
22	1648	38.30	43.70	Van and surrounding	6,7	VIII
23	1670	38.00	42.00	Hizan - Siirt	6.6	
24	1682	38.40	42.10	Bitlis		
25	1696	39.10	43.70	Çaldıran - Bitlis	6,8	X
26	1701	38.50	43.40	Van and surrounding		VIII
27	1704	38.50	43.40	Van		VII
28	1705	38.40	42.10	Bitlis	6,7	IX-X
29	1715	38.70	43.50	Van - Erçiş	6,6	VIII
30	1869	38.40	42.10	Bitlis and surrounding		VII
31	1871	38.50	43.40	Van -Nemrut	5,5	VII
32	30.05.1881	38.50	43.40	Van and surrounding	7,3	IX
33	1884	37.50	42.50	Bitlis - Pervari	6,9	
34	1891	38.80	42.50	Malazgirt- Adilcevaz-Bitlis	5,5	VIII
35	1892	39.10	42.50	Malazgirt - Muş		VII

Bitlis is constantly under the influence of micro and macro earthquakes when examining the historical and instrumental earthquakes. Thus, it will not be difficult to say that Bitlis can remain under the influence of larger earthquakes (Işık et al, 2012). Therefore buildings must be constructed according to the earthquake codes especially in Lake Van Basin where earthquake has always been neglected. The studies about seismic hazard analysis about the region that has been made by United States Geological Survey (USGS) also shown that Lake Van Basin is in quite a bit high risk zone (Fig.7.).

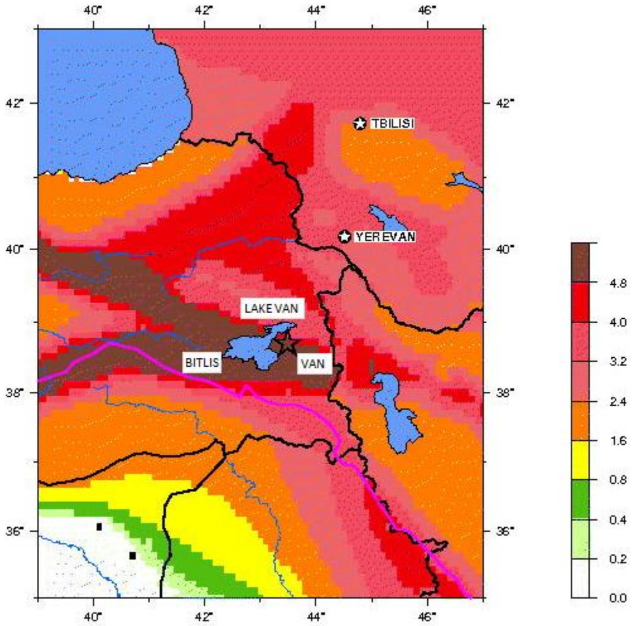

Fig.7. Seismic hazard map of Lake Van Basin (USGS, 2011)

The results of a work by Kutanis et al. will form the basis for the replacement of the existing earthquake design spectra in evaluation of earthquake performances of the existing buildings in Bitlis province (Fig.8). It is apprehended that for the performance evaluation of the existing structures the 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 underestimated in the code (Kutanis et al., 2010). Therefore, site-specific design spectra for the region should be developed, especially for local sites.

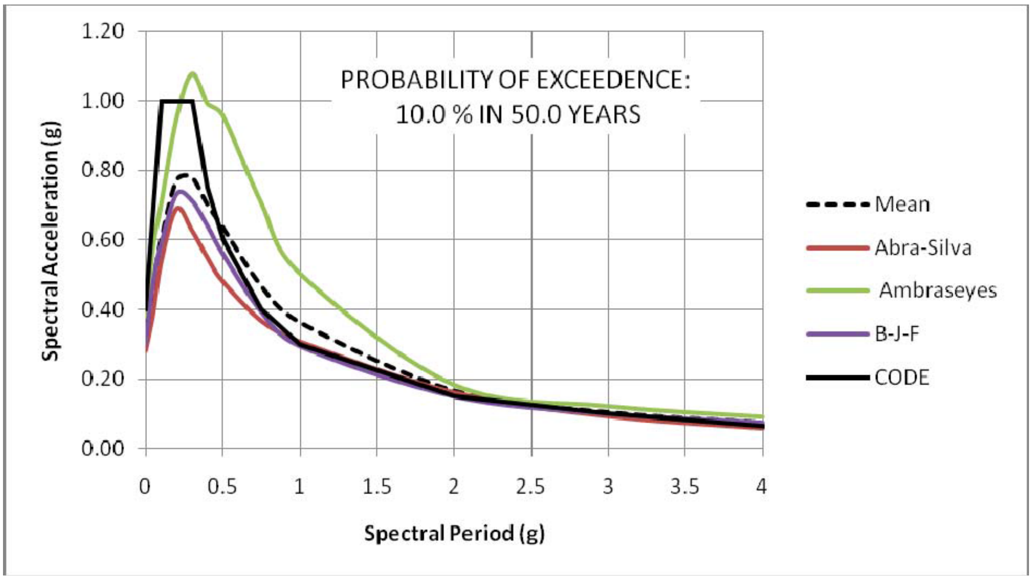

Fig.8. Comparison of spectral responses at 5% damping for the return period of 474.6 years in Bitlis (Kutanis et al. 2010).

4. Observed Damages

The importance of studies, researches and prevention about earthquake have risen after destructive earthquakes in the World especially in recent years. Earthquake damages will increase according to vulnerability of urban building stocks. The negative structural features will increase the size of hazard. Structural damages that occurred after earthquakes in Turkey show that the majority of the existing building stocks in Turkey do not have enough safety.

The damages to reinforced-concrete (RC) and masonry structures after earthquake are observed, evaluated and recommendations made in Bitlis located in Lake Van Basin which is seismically quite active. In this study, the consisting damages on reinforced-concrete and masonry buildings were made by observational assessment at field and researches. During damage assessment, firstly the analysed constructions observed from exterior. Then, whether exterior walls, columns and beams have cracks also whether that the building has been a noticeable lateral displacement. It also studied to describe if there was damage due to ground. In addition, information was collected about the building's history. Then started to investigate the building structural system by entering to the building.

Cement mortar has been used in bearing walls in the region commonly constructed by concrete briquettes. The reason of choosing such construction materials is that they are easily available in this region. The raw material of these briquettes is pumice. The production of pumice is in quite a bit in Lake Van Basin also. It was observed that low-strength concrete briquettes used in the region broken completely or consisted cracks at walls under earthquake (Fig. 9).

Fig.9. Low-strength wall material (briquette) and its damage

Mosques and minarets were also damaged during the earthquake. The damages were generally observed on the top of minarets (Fig.10).

Fig. 10. Minarets damages in Bitlis Centre

Rockfall is a kind of geotechnical damage that could be observed after earthquake. Rockfall incidents occurred Bitlis – Diyarbakır highway and nearby slopes (Fig.11). Careless of selection, design and construction of structural systems in many buildings that have not taken enough or any engineering services was caused negatively to the damage amount. It was observed that beam and column's size was not provided the minimum sizes that given Turkish Earthquakes Codes (Fig.12.).

Fig.11. Rockfall damage

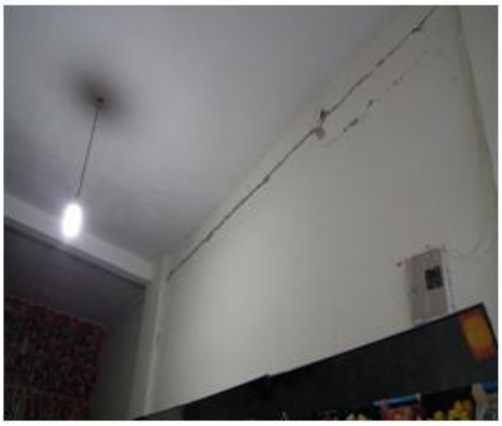

Fig.12. Insufficient size of beam and column

The history of masonry structures built especially in rural region was lied till to resident life of mankind. Most of these structures have not taken engineering services. These structures have not provided the principles of design that were given in Codes also. The %40 of existing buildings is masonry structures in Bitlis (TUIK, 2000). The masonry structures were built with regional stone and soil roof. The roof is heavy condensed soil laid over a wooden slab. The thickness of the condensed soil at the roof is between 30 and 50 cm. Such heavy roofs induce large inertial forces during earthquakes, which result in high stresses on low-strength walls (Akkar et al 2011). These buildings that were built with soil mortar have been collapsed partially or completely during the earthquake (Fig. 13).

Fig. 13. Damages of masonry structures

Another widely used material in masonry structure is regional stone. The binder used in such structures is low-strength cement mortar or clay. Poor quality of this binder is one of the reasons for the structural damages in rural regions (Fig. 14).

Fig. 14. Damages to the poor quality of mortar in Stone structures

Another kind of earthquake damage is X- shaped cracks in the structural walls. These cracks have been continued to the inner of these structural walls (Bayülke, 1995). This typical damage due to earthquake has been observed also in Bitlis (Fig. 15). The most common earthquake damage observed in the roofs is the collapse of the gable walls (Fig. 16). The reason of the vast majority of the collapse of the gable walls is their inadequate connection to the structure and their construction with missing lintels.

Fig.15. Typical structural wall damage

Fig.16. Damaged gamble wall

The problem of pounding is unavoidable in many large cities located in seismically active regions where, due to land usage requirements, buildings are constructed adjacent to each other. The buildings which are adjacent to each other carry a high risk because of different periods because of their different heights and weights of buildings due to the principle of conservation of energy as seen as in past earthquakes (Bal, 2005; Bal et al 2007). Pounding damage in two adjacent buildings in Adilcevaz district is given in Fig.17.

In earthquake-resisting structure design, one of the important point is to avoid the strong beam–weak column behaviour. The main purpose of this approach is to enable the weak element, that is, beams, to lose their bearing capacity initially and contrary to enable the columns to stand for a while to provide living space for people. To achieve this behaviour, Turkish Earthquake Code section 3.3.5 requires the sum of bearing capacity moments of columns should be at least 20 % more than the sum of bearing capacity moments of beams at the same joint for structures which resist the earthquake effects by frames or frame–wall combination (Celebi et al, 2013). The damage was observed because of strong beam and weak column type (Fig.18).

Fig.17. Pounding of two adjacent buildings

Fig. 18. Strong beam-weak column

Large and heavy overhangs that built over the reinforced-concrete frame systems created irregularities in the multi-story buildings under the seismic loads. Damages related to the existence of large and heavy overhangs are given in Fig. 19.

Fig. 19. Damages on the large and heavy overhangs

The staircase system damage is also a kind of damage under earthquake structural system. Damage observed in staircase system is due to insufficient connection between staircase and structural frame system (Fig.20). Fig. 21 is shows how to prevent the damage on the wooden beam by supported wooden log.

Fig.20. Staircase system damage

Fig.21. Wooden beam damage

Separation damages between wall and frame system and structural wall damages caused by door or windows openings were observed in masonry and RC buildings commonly in Bitlis also (Fig.22.).

Fig. 22. Wall damages in masonry and RC buildings

Wall's damages could be continued to the floor. Damage was observed on the floor in the ground story related to the wall damage in masonry structures (Fig. 23). Insufficient longitudinal reinforcing bars and insufficient adherence between concrete and reinforcement caused to damage in RC beams (Fig. 24).

Fig.23. Floor and wall damage in ground story

Fig.24. Beam damage

The quality of concrete that used in the region was very poor. It is observed that the aggregate gradation that used in damaged RC buildings did not provide a particle size distribution. In the damaged buildings, excessive large pieces of stones were observed. The other reason of concrete damage is insufficient thickness of concrete cover that used in structural system elements. Insufficient thickness of concrete caused to corrosion of reinforcement. It is observed from field observations that some of the concretes are easily broken into small pieces by hand (Fig.25). In the Turkish Earthquake Code, it is clearly expressed in section 3.2.5 of that the minimum characteristic strength of concrete must be at least 20 MPa for reinforced concrete structures to be built in earthquake active zones (TEC 2007). This value must be at least 14 MPa in the code that used till 1975 and 16 MPa in the code that used till 1998. The concrete samples were taken from

RC buildings during and after earthquake did not provide any conditions in any Codes that given above. For example the characteristic strength of concrete that used in Adilcevaz High School varied with the average value of 7.6 MPa (Comlekcioglu, 2011). This value is 5.55 MPa for apartment of Central Court (Uzun, 2011). This showed that the characteristic strength of concrete is well below that values that given in all National Codes.

Fig.25. Examples of poor concrete quality

Frame damages are observed in columns more than the other elements of frame system in RC buildings because of columns were built weaker than beams or result of high load bearing then designated load of beam by behaving beam and floor together. Not insufficient shear force bearing capacity of column but also insufficient adherence between concrete and reinforcement was caused to increase damage amount in columns (Bayulke, 1995). Damaged columns showed that reinforcements that were used in structural systems elements are not provided principles of regulatory of reinforcement that given in National Codes. Especially wide spacing of the cross-ties related to buckling of longitudinal reinforcement. The concrete that was in the core region was diffused because of this buckling. Columns damages observed in Bitlis are given in Fig. 26.

Fig.26. Columns damages

5. Conclusions

Lake Van Basin is seismically active. A destructive earthquake happened at 13:41 in 23.10.2011 in Van of which Mw: 7.2. This destructive earthquake was felt most strongly in Bitlis and its districts after Van and Erçiş. In this study the effects of this earthquake on constructions in Bitlis have been observed and evaluated. Based on the field observations, the damages have been observed clearly that they overlap with typical earthquake damages.

The size of earthquakes and the negative structural features have been caused an increase in damage amount. Knowing the properties of buildings that have negatively effect to the seismic behaviour of buildings under earthquakes will be put forward to ensure more serious approaches for reduce the level of damage risk after earthquakes. Most of damaged buildings have not been constructed according to national earthquake codes. Almost no damages in constructions built according to Turkish Earthquake Code have been observed. And this has proved that codes are enough but buildings have not been constructed according to these regulations.

Based on fields observation in Bitlis, the poor quality of workmanship using the low-strength local wall materials, careless of selection, design and construction of structural system, insufficient engineering services, poor connections and poor material quality and heavy roofs in masonry structures, unconfined gamble walls, constructed buildings adjacent, large and heavy overhangs, insufficient longitudinal reinforcing bars, wide spacing at cross ties, using poor quality concrete, insufficient adherence between concrete and reinforcements and improper aggregate gradation were caused to damage. It is observed that very simple engineering principles in design and construction stages are ignored in the wealthy central area due to the lack of adequate control mechanism.

It is practically impossible to perform detailed experimental and analytical studies for each existing building to determine its collapse vulnerability because of time and money constraints. Therefore buildings must be constructed according to national earthquake codes especially in Lake Van Basin where earthquake has always been neglected.

It unfolds the necessity of earthquake effects to be kept in mind during constructing. Due to seismic risks, the reality of earthquake should not be forgotten in Bitlis.

Knowing the reasons of earthquakes damages are very important in terms of minimizing the possible economic and life losses and taking necessary precautions for before, during and after the earthquakes. Recently modern disaster management was emphasized disaster preparedness but also importance of disaster prevention.

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