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EVALUATION OF SEISMIC AMPLIFICATION ON EARTHQUAKE DAMAGES OF REINFORCED CONCRETE STRUCTURES DUE TO 12 NOVEMBER DUZCE EARTHQUAKE 1999 IN DUZCE, TURKEY

Keywords: *Building damage/Duzce earthquake, site effects, seismic amplification*

Abstract

Duzce Turkey earthquake with Mw= 7.2 occured on 12 November 1999 at 6.58 a.m. (local time) in western Turkey and caused the loss of life and heavy damage, as well. In this region where the earthquakes occured, a large number of reinforced concrete structures were affected. This study is devoted to assess the damages on reinforced concrete structures due to the 12 November Duzce earthquake 1999 in Duzce region. Damages observed in the structures may be occur due to the several reasons such as site effect, soil amplifications, poor construction quality, low concrete strength, unqualified detailing in beam-clomn joints, the stronger beam than clomn, constructing soft storeys and weak storeys, inefficient reinforcement, wrogn end hook and short clomns. This study revealed that most of the damaged structures were not designed and constructed Turkish earthquake codde which is Specifications for structres to be built in Seismic Zones.

1. Introduction

There have been important research efforts have been performed to research the performance of different engineeering structures during earthquakes such as reinforced concrete building, minarets, towers etc. Watanable et al. [1995] introduced a study related to damages to steel structures during the 1995 Hyogoken–Nanbu earthquake. Performance of reinforced concrete buildings during the 1999 Kocaeli earthquake was evaluated by Sezen et al. [2003]. Dogangun [2004] made a detailed observation on the reinforcedbuildings in the 2003 Bingol earthquake. Many structural damages were observed in the Duzce provisional epicentral area. Bayrakter et al.[2007] presented the field investigations of masonary buildings during the March 25th and 28 th, 2004 Askale in Erzurum and July 2nd, 2004 Doğubeyazıt earthquakes in Agri. Mondal and Rai [2008] studied the performance of harbour structures in Adaman Islands during the 2004 Sumatra earthquake. Adanur [2010] reported the performances of masonary buildings during the December 20 th and 27 th, 2007 Bala (Ankara) earthquakes. The March 8 th, 2010 earthquakes that hit kovancılar and Palu districts of Elazıg province in Turkey and their impacts on masanory and concrete buildings were studied by Celep et al.[2011] and Cetinkaya [2011]. Further more, Damage on reinforced concrete buildings due to consecutive earthquakes in Van in Turkey was examined by Ates et al. [2013]. Saatcioglu and Bruneau [2002] observed the performance of structures during the 13 March 1992 Erzincan earthquake in Turkey. Bruneau [2002] described the damage of reinforced concrete, masonary, and steel structures during the 17 August 1999 Marmara earthquake in Turkey. Additinally, Korkmaz [2007] discussed the performance of reinforced concrete buildings during recent earthquakes in Turkey. Duzce earthquake occured on November 12 in Duzce city located in North Western Turkey. A total of 2000 buildings were damaged or collapsed in the city center and its vicinity after the Duzce earthquake. In the study area that is affected by the earthquake, most of the reinforced concrete buildings were approximately damaged. The field investigations of buildings just after the earthquakes to undeerstand their performance is important. In order to comprehend the behaviour of damaged reinforced concrete structures and to trace the their performance during the earthquakes, some assessments based on the field studies are presented in this article.

2. Description of study site

Stusy area is just situated between Ankara and Istanbul; Ankara is 240km away to the East and Istanbul is 228km away to the West. The road of D-100 passes through Duzce and TEM Highway passes around it. Duzce is placed into the plateau of The West Black sea coast. The city is surrounded to the West by Sakarya, to the Northeast by Zonguldak and to the East by Bolu. The distance from East to West is 23 km and from North to South is 20 km. The city of Duzce is situated in the middle of the plain on a pressure ridge-type hill and is probably tectonically controlled (Fig. 1).

Fig. 1. View of the study area

3. Geological Setting

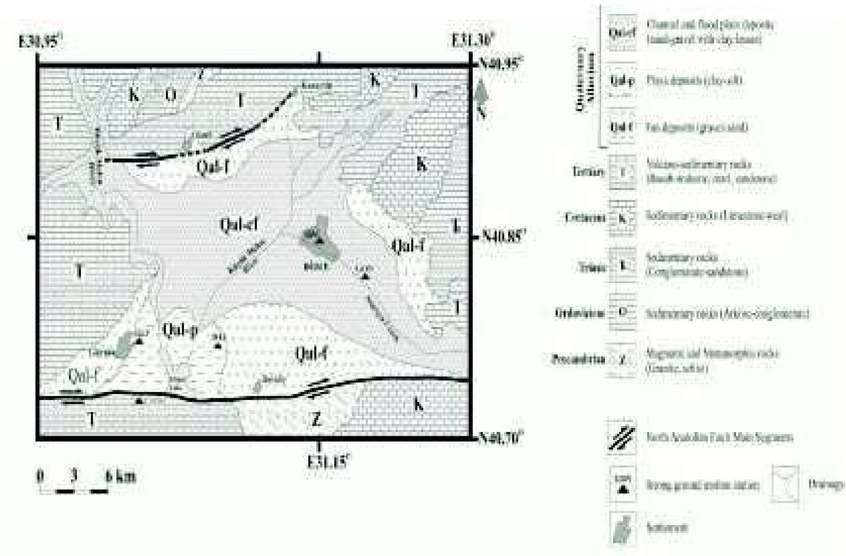
The Duzce Basin was formed by the activities of the North Anatolian Fault (NAF) as a graben-like basin. The basin is bounded by the active Gölyaka-Eftani-Beyköy Fault in the south and the Çilimli-Konuralp Fault in the north. The Çilimli-Konuralp Fault is relatively less active than the Gölyaka-Eftani-Beyköy Fault. These faults are part of the south and north segments of the NAF and they are the main elements shaping the morphology of the region.

The Düzce Plain forming the mid-section of the basin presents a low inclined topography toward the southwest (toward Lake Efteni). The drainage network which has developed based on the morphology of the basin has NE-SW and E-W flows. The Küçük Melen River and Asarsuyu Creek drain the surface waters of the basin into Lake Efteni.

The Büyük Melen River subsequently discharges the waters of Lake Eftani to the Black Sea with a S-N flowing direction (Fig. 2). The hydrologic and morphologic features in the basin are the results of the intense tectonic activity that controls the basin structure and overall slope of the plain. The base rocks of the region consisted of a group of Precambrian Magmatic and Metamorphic rocks (Z) (Fig. 2). Schists and granitic rocks are the base rocks on which there is a thick sedimentary sequence. The sequence starts with the Ordovician arkose and conglomerate sedimentary rocks (O) [Ulutaş et. al., 2012].

Alternating Triassic sandstone and conglomerate rocks (TR) overlay the Ordovician rocks outcrop in east of the basin. Cretaceous limestonemarl intercalations (K) on the Triassic rocks are widely observed in the region. Tertiary volcano-sedimentary rocks (T) with flysch character in some places deposited on the Cretaceous rocks. The volcano-sedimentary unit composed of intercalated basalt-andesite, marl and sandstone lithologies. Basalts and andesites are the dominant lithologies in the southwestern part of the region. The youngest unit is the alluvium deposited in the basin. The thickness and lithologic variation of the alluvium depend on the tectonic setting that directly affects the morphology and basin geometry. Alluvial fan deposits (Qal-f) on the north and south mountainsides, channel and flood plain deposits (Qal-cf) in the impact areas of the Küçük Melen and Büyük Melen Rivers and Asarsuyu Creek, and lacustrine-playa deposits (Qal-p) around Lake Eftani were deposited under the effects of tectonic forces. Alluvial fan deposits consist of gravelsand, channel and flood plain deposits contain sandgravel with clay lenses and lacustrine-playa deposits are composed of clay-silt type sediments [Ulutaş et. al., 2012].

Fig. 2. Geological map of the Düzce Basin and surrounding [Ulutaş et. al., 2012]



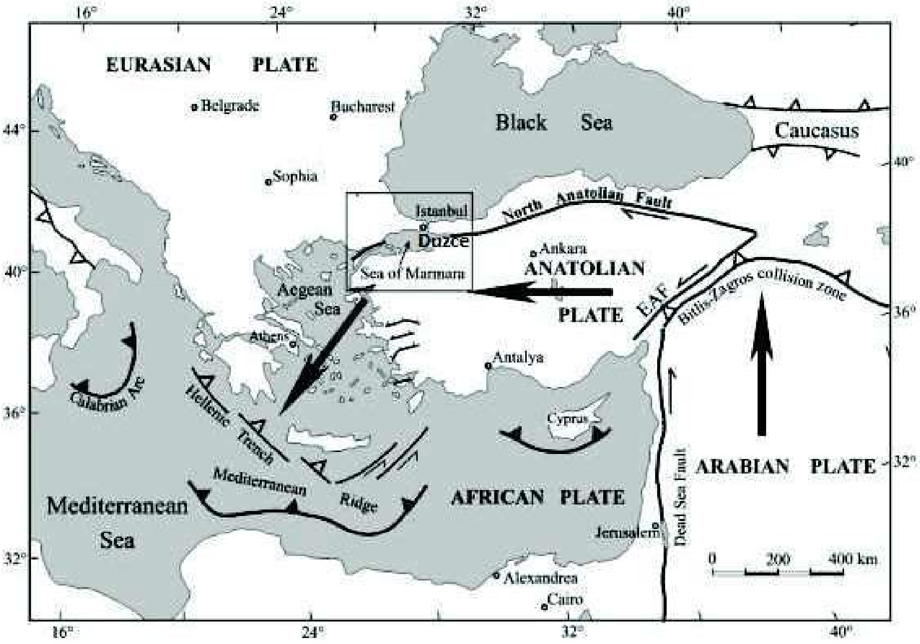
4. Seismotectonics and Seismicity

The majority of earthquakes happened to Turkey can be attributed to the relative movements of Eurasian Plate, African Plate and Arabian Plate which is still in progress. The Arabian/African and Eurasian plates move north and south towards each other with a result, Turkey is being squeezed out westwards (Fig.3).

The Duzce provincial plain is a pull-apart type basin that is controlled by the lateral strike slip fault system in the NAFZ (North Anatolian Fault Zone) [Gökten et. al.,1998]. Paleo and neo-tectonic active faults exist at the north and south of the plain. There are several faults which are parallel and oblique to these major faults. During the 12 November 1999 Duzce earthquake, the surface rupture ranged through Golyaka, south of the city of Duzce, to the Kaynaşlı district, east of the city, and ended in the Asarsu Valley and the Bolu Tunnel [Gökten et. al.,1998].

The study area is located in the Pontides, one of Turkey's tectonic units. The Pontides are a part of the Alpine mountain formation starting from the Czechoslovakian Carpathians, passing through Romania, Yugoslavia and Bulgaria and then eastward along the Black Sea coast to the Little Caucasus in Iran and extending to the Indian platform [Kartal et. al., 2014] (Fig. 3). According to the theories of plate tectonics, the Alpine mountain formation system was formed by the collision of island arcs and continents [Dewey and Bird, 1970]. The Alpine system, a collision orogenic belt, is a result of the extinction of the former Tethys Ocean [Şengör and Yılmaz,1981]. The island arc series of volcanics around the Alpine mountain formation developed throughout this entire belt.

Fig. 3. Neotectonic provinces of Turkey and major active fault zones [Okay et. al.,2000]



The study area is an active subsidence and deposition area controlled by lateral strike slip faults surrounded by pre-Quaterney-aged rocks. Detailed descriptions of the plain before the Quaternary units were excluded from the scope of this study. Simsek and Dalkilic [1997] investigated three different groups of alluvial deposits existing in the study area; the general properties of each group are summarised as follows:

(1) River alluvial deposits (Qal-l)- These are coarse, granular materials that contain various round, high-strength, well-graded particles and are mostly blocked materials formed by gypsum and magmatic structures, depending on the flooding regime of the flat plains of Asarsu and Ugursu.

(2) Lake sediments of sand/gravel elevations (Qal-2)- This group is found in the northern, north-eastern and eastern parts of the basin. It consists mostly of brown-coloured, silty clayey sand and gravel levels and is located deep in the soil stratigraphy. Moreover, the clayey surfaces have approximately 5 m of clayey elevations due to the side transitions. The gravel is fine- and coarse-grained, consisting of curved, half-spherical shapes and grouped in the soft and firm class.

(3) Lake sediments of clay, silty clay and elevations of clayey silt (Qal-3). These sediments are observed in the centre of the flat plain in the western part of Duzce Province. According to samples taken along the river during research drilling, the thickness of the unit varies between 3 and 8 m, the upper section being brown in colour and the lower part grey. The unit is formed of

clay, silty clay and sandy silt and is in a soft, moderately solid state. It is highly plastic and contains amounts of supplementary material.

Historical earthquakes have been recorded on the Abant-Bayramoren segment in the south of the region. The great earthquake of 17 August 1668 (M_S $=$ 8) caused a disaster in Anatolia [Demirtaş, 2000], with aftershocks continuing for 6 months [Ambrays, 1998]. Between 1890 and 1967, there were 12 earthquakes. The Bolu-Gerede earthquake (M_W =7.3) of 2 January 1944 was a major one, recorded after the implementation of instruments for scientific measurement of magnitude. It was noted that 2,381 people died and 50,000 houses were damaged [Tasman, 1944]. The 17 August 1999 Marmara and 12 November 1999 Duzce earthquakes occurred on the western segment of the North Anatolian Fault. The measured average value of the horizontal ground acceleration in Duzce Province was 0.51 g [Demirtaş, 2000].

5. Physical dynamic soil properties

The purposel of the geophsicalinvestigations are to define the geometry of the soil layer down to the bedrock and to determine the lateral and vertical variation of P and S wave velocities with an integrated analysis of reflected, refracted and surface waves [Berilgen, 2007].

The geophsical and mechanical properties of the soil layers play an impotant role in the dynamic response of the surficial layers [Tezcan et. al.,2002]. All investigations about the soils should be determined by the way of in situ and laboratory testing. The fllowing information about the subsoil layer is considered to the most essential; layer, thickness, angle of inclination and general stragraphy, strength properties, grain size distrubution, consolidation data, minerology, natural moisture content, Atterberg limits, unitweights, shear strength, relative density, overconsolidation ratio, ion Exchange capacity, sensivity, swelling, shear modulus,cyclic shear strength, seismic wave volocities, intensity of cracks, permeability, etc. [Tezcan et. al., 2002]. In the following stage, the variations of shear modulus, G, and critical damping ratio ß, by the amount of shear strain are discussed.The shear modulus of the soil may be estimated eassily from shear wave velocity test. As an explosive charge or hammer is used to produce waves in the soils. The velocity is measured by applying the exicitation at one borehole and measuring the velocity at another borehole or by applying an excitation on the ground and measuring the velocity at a borehole [Tezcan et. al., 2002]. The basic period of ground is an important factor for the earthqauke resistant design of buildings. The period of the ground may be predicted by the way of an analytical or field studies.

The modulus of elasticity E and shear modulus of soils can be determined by applying axial and torsional vibrations to the cylindirical sample through the resonant colomn testing procedure [Tezcan et. al., 2002]. The shear modulus of soils can be obtained by finding the shear wave velocity V_S and calcultaed from the equation given by,

$$G=\rho V_S \qquad (1)$$

Where ρ=mass per unit volume.

During the soil investigations Standard Penetrations Tests (SPT-N) were performedd, disturbed and undisturbed soil samples were obtained. The laboratory investigations comprised granulometry and consistency limits tests, as well as triaxial compression and consolidation tests [Ozaydın et. al., 2005].

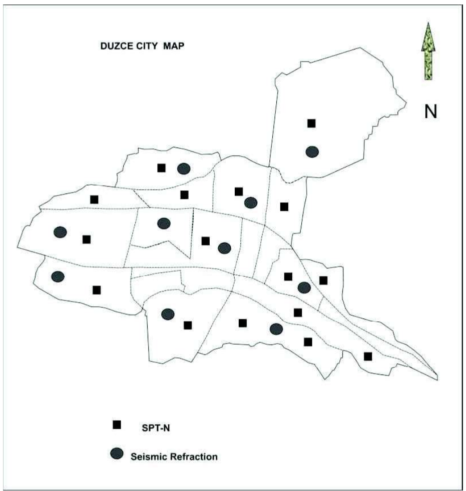
When the shear wave velocity is not measured, the Standard Penetration Test (SPT-N), can be used to determine the shear wave velocity, $V_{S,}$ using the empirical relation as applied by Fujiwara [Tezcan and Fujiwa, 1972].

$$V_S= 92.1N^{0.33} \text{ m/s} \qquad (2)$$

6. Geotechnical Study

For evaluation of subsurface soil conditions, a total of 34 Standard Penetration Test (SPT-N) and 25 seismic refraction studies were executed in the study area. The depth of the boreholes ranged between 19.5 and 22 and carried out SPTs at 1.5 m intervals.

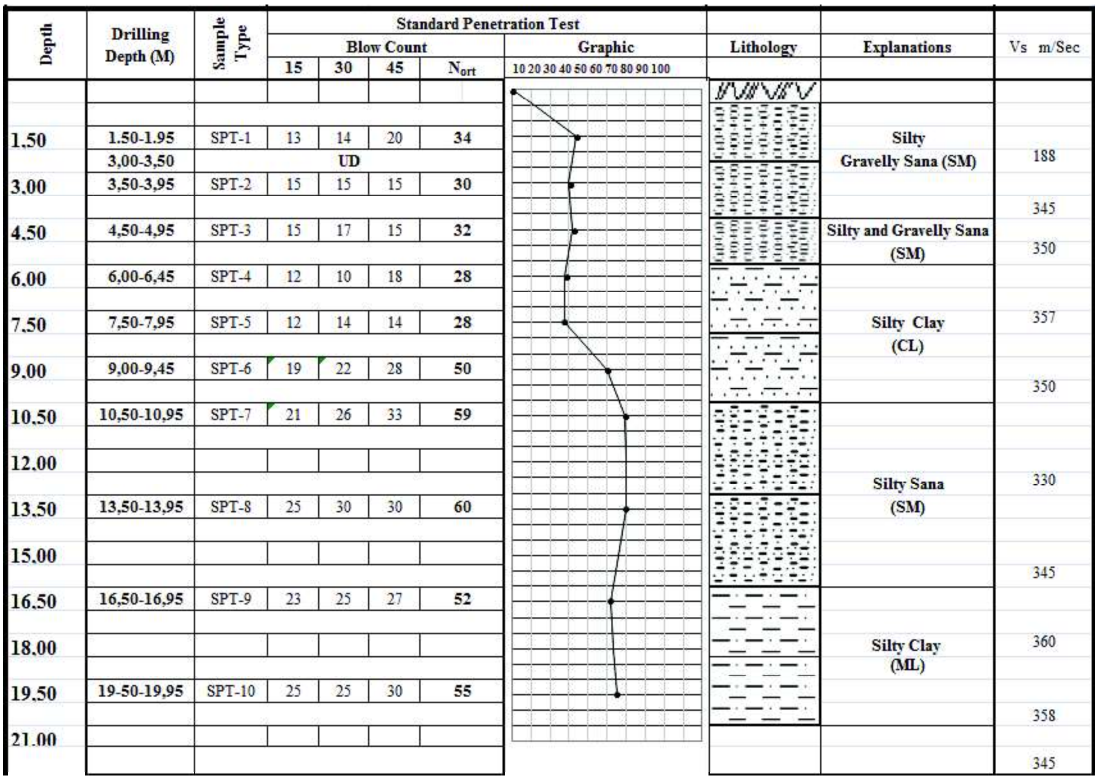
Fig. 4. Location of the SPT and sesimic studies



Geotechnical properties of the samples whivh are atterberg limits sieve and hydrometer tests were performed on the disturbed and undisturbed samples in the laboratory. Laboratory results revealed approximately 73 % of the samples were fine-grained soils, dominantly sity and sandy soils. The soils in the study area mainly contains silty and sandy materials. The coarse grained soils varying from well- graded to poorly graded degree. The depth og ground water is 5 to 8 meters, but at some locations water levels nearly out comes towards surface.

Seismic studies were executed using an ABEM Terrolog MK-6 and included P-S wave measurements to determine the thickness and shear wave velocity of the layers-important parameters in the ground response analyses.In the seismic studies, 12P and S-geophones were used. It is well konown that the average shear-wave velocity of the uppermost 30 mnof the ground is an impoartant factor [Borcherd and Dobry et. al., 2000]. The total length of the seismic refraction distance was about 36 m. The P-wave velocities ranged between 362 and 1600 m/s with an average of 635 m/s while S-wave velocities were between 188 and 360 m/s with an average of 187 m/s. Herein, (Fig. 5) presents a sapmle soil profile for analyses from the location and refracrtion point.

Fig. 5. A sample of soil profile for analyses in Duzce City



7. Ground motions and amplification spectra

One dimensional shear wave propagation analysis have been conducted, from bedrock to surface, for types of soil profiles using the Cyberg Quake computer program. Düzce city is located on a large quaternary alluvial plane. Its name implies "flatland" and topography is indeed uniform over the entire city and the surrounding farmlands. Young alluvial deposits having thicknesses exceeding 70 meters consist of sand and gravel series. The water table has seasonal variations between 2 and 5 meters. This apparent uniformity of soil conditions over Düzce valley also implies uniformity of ground motion intensity throughout the city during the two earthquakes.

The time history motion assumed at bedrock level is the EW component of the 1999 duzce, Turkey earthquake, recorded at the Duzce Meteorological Station. Further more, the amplitudes of the Duzce record are scaled down from a maximum of 0.81g to a small value correspond to the estimated bedrock peak accelerstion of 0.4g. in Bolu and Duzce stations, during the main shock of the Duzce, Turkey earthquake of December 12, 1999. The response spectrum curves of the record at the surface for soil profiles, for 5,10,15 and 20% damping values, are shown in (Fig.6), together with the elastic design spectrum curve of the 1998 Turkish Earthquake Code. It is seen that, for the 5% damping case, there is a magnification, of the order ofx4, much gereater than the maximum 2.5 recommended by the 1998 Turkish earthquake Code [Tezcan et. al., 2002]. For the scaled accelerograms for study area in Duzce, time series of acceleration, velocity, and displacement for the two different artificial accelerograms are given in (Fig. 6 and 7), Table 1. The spectral acceleration vs. time plot of the Duzce earthquake, spectrum defined in and the fundamental period the analyzed frames are also shown (Fig.8).

The amplification spectra of the surface motion have been determined for the study area soills are shown in Fig 9. Here, when it can be observed that when the peak ground acceleration of the bedrock motion is 0.04 g, and there can be seen distinct peaks at periods T1=3 sec, T2=0,3 sec, T3=2sec (Fig. 8). Thus, buildings with natural periods of vibrations close to these values are very much susceptible to heavy damages. In fact, many structures with mainly two and three storey high with periods falling into the range of T=0.3-1 sec., either totally collapsed or heavily damaged beyond repair in Duzce, during the Duzce Earthquake of November 12, 1999. There has been no structures in Duzce, in 1999, with a natural period close to T1=0.3sec, to have been tested by overlapping vibration as known resonance compliance period of the soil. From now on, this phonemenon stands however, as a warning to future design of building with such a long period of vibration.

Occurance of soil amplification in Duzce, has been shown instrumentally, by Ateş et al. [2015]. Relating this phenomenon, the seismographs installed to record the aftershocks of the Duzce earthquake. During the aftershock of M=7.2, in November 12, 1999, the records taken at the damaged in Duzce displayed unusually large amplitudes.

Table 1. Characteristics of Strong Motions Recorded at the Düzce Station

DATE	COMP	FD(km)	PGA (cm/s^2)	PGV(cm/s)	Longitude N	Longitude E
12 Nov 99	West	8	507	88	40.740	31.210
12 Nov 99	South	8	400	70	40.740	31.210

Fig.6.(a). Response spectra at the surface for soil profiles (West and South component, Metererological Station Duzce record of August 17 and November 12, 1999, a_{max}=0.51g)

(a)

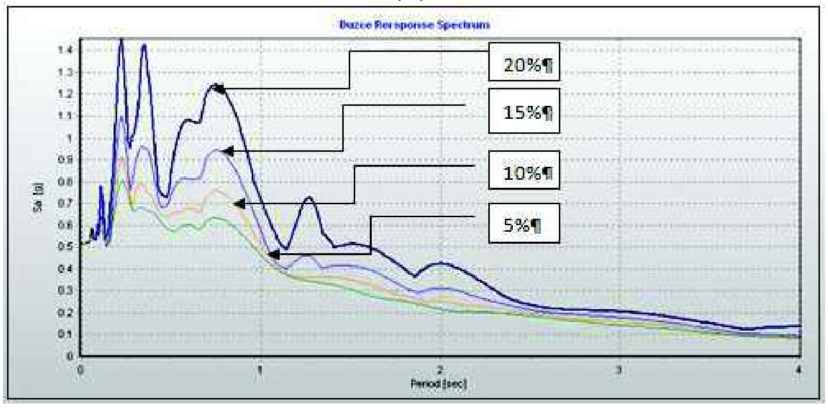


Fig.6. (b) Response spectra at the surface for soil profiles (West and South component, Metererological Station Duzce record of August 17 and November 12, 1999, a_{max}=0.51g) [Akpınar and Binici, 2013]

(b)

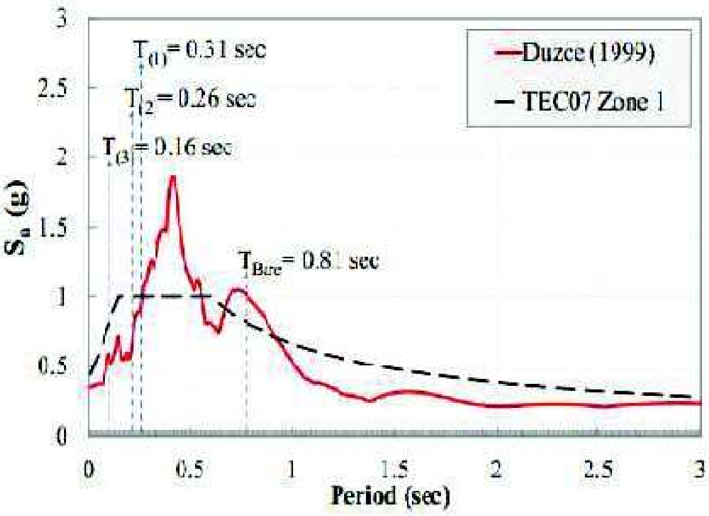


Fig. 7: Real accelerogram recorded during Duzce 99 earthquake at Duzce Station

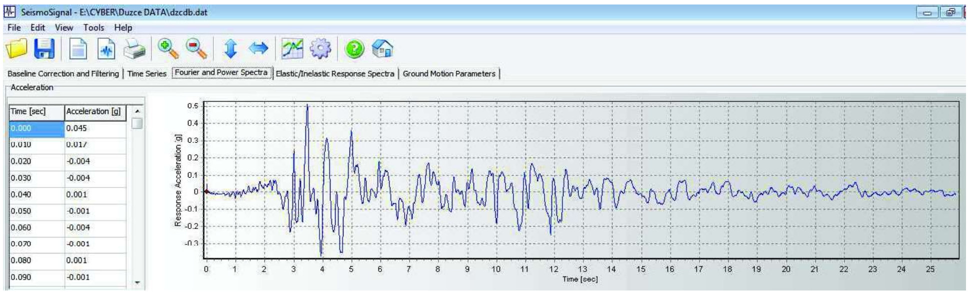
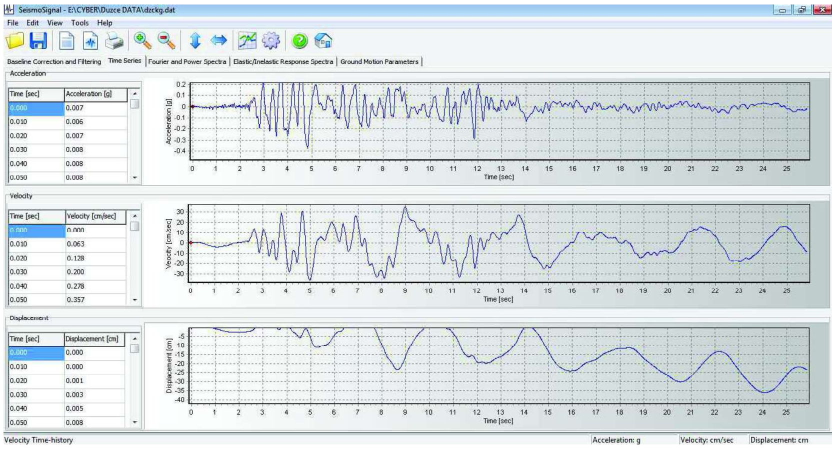
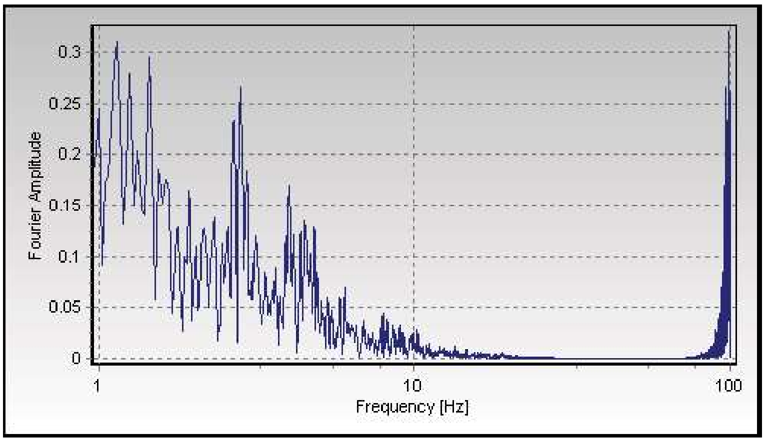


Fig. 8. Calculated time series charts for the scaled Duzce EQ accelerogram.(EW)



The charekteristics of site amplification at a given site can be attempted to be estimated by analytical methods,that models require as input the geometry of all soil layers from surface to bedrock, their dynamic properties (e.g density, wave, velocity, damping),and the incident bedrock motions. On the other hand, most reliable estimates of site amplification are obatined by analysing the record motions of site during strong earthquakes [Şafak, 2001]. One of the popular methods to estimate the site amplification had been the use of spectral ratios introduced by Borcherdt [1970]. The Spectral ratio is calculated by taking the ratio of Fourier amplitude spectrum (FAS) of a soil site record to that of a reference site record. Reltaing with the investigating the site amplification charecteristics in Duzce site, recorded motion in Duzce station during November 12, 1999 Duzce Earth Quake (EQ) is used to compute spectral ratios with respect to recorded bedrock motions durin the same earth quake (Fig.9).

Fig.9. Response spectra at the surface for soil profiles (Metererological Station Duzce record of November 12, 1999, a_{max}=0.51g)



7.1. H/V ratios (Nakamura's method)

Here, H/V FAS ratios for the records at the study area in Duzce is shown in (Fig. 10) . This figure gives us more evidence which a significant degree of site amplification has occured in Duzce station.

Fig. 10.H/V ratios of Duzce station

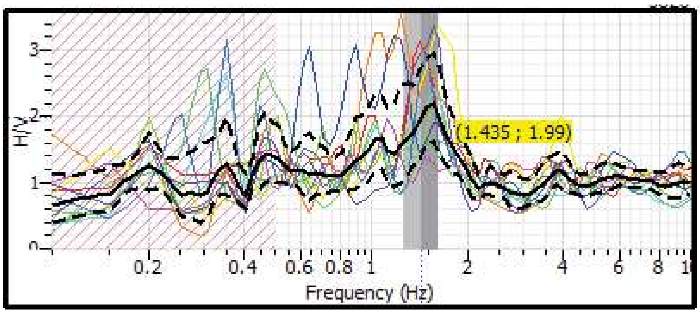
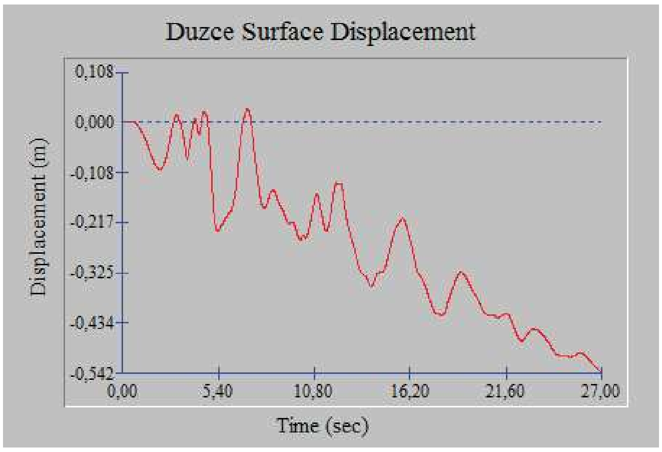
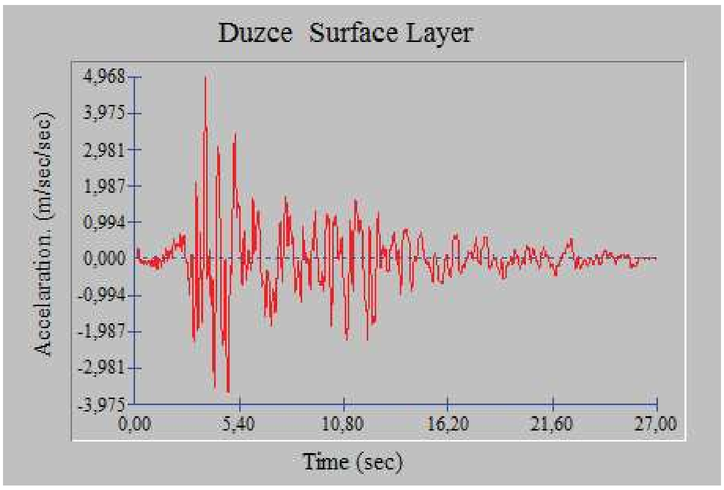


Fig.11. (a), (b), (c). Computed Site Response in Duzce METEK TOKİ area



(a)

(b)



(c)

It can be deduced from the figures and Table 1 that the ground motions recorded at Düzce have high intensities, and it should be considered as having significant damage potential. Directivity of fault rupture towarding to Düzce city, and site amplification characteristics of the Düzce Valley perhaps played important roles on the high intensities of recorded ground motions.

The results of the analyses for earth quake records delineate a site resonance effect at about 1.3 Hz Frequency, which is consistent with the fundemental frequency of the soil profile.

$$f=\frac{v}{4h}=\frac{188}{4(36)}=1.3 \text{ Hz} \quad (1)$$

Where, v=average shear wave velocity of the soil layers above the bedrock and H=total thicjness of the soil layer above the bedrock [Kramer, 1996].

The micrometer measurements taken at the site in Duzce (METEK TOKI)also demonsrate a fundemental frequency of 1.45 Hz and is approximately consistent with the calculated frequency. According to the summary of the 1-D site response analyses results using the November 12, 1999 Duzce EQ records, the maximum values of bebrock and ground surface acceleration and spectral acceleration (based on the both recorded and computed values) determines a rather high degree of amplification at study site in Duzce, for the base rock acceleration levels of 0.4 g and 0.89 g.

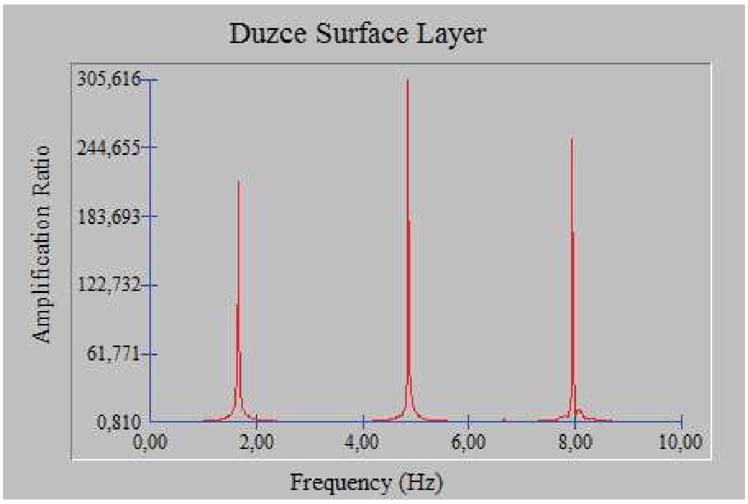
If it looked at the Figure 6, ıt compares linear elastic response spectra of the recorded accelerogramswith the design spectrum in the Turkish Seismic Code [2007] specified for Seismic Zone 1 (most severe) and medium dense deep alluvial soils, having a 10% probability of exceedence in 50 years. Due to the fact that the building stock in the Duzce city consists of structures less than 4 stories, hence having approximate fundamental vibration periods of 0.16-0.8 seconds. Thus, structural damage is certainly expected in Düzce during the earthquake.

5.2.Site response analyses under the long term design earthquake

For the buildings and openning residentail areas in Duzce city, investigations of the site, seismic hazard studies was executed and a site spesific bedrock motion was simulated for the design of the prospective earthquake (Mw=7.2). The design earthquake is expected to occur due to rupture of 40 km long fault segment betweeen Efteni Lake and Bolu to be developped attending ofthe Novembeer 12, 1999 Duzce EQ craking of the fault. Using this bedrock acceleration time history, 1-D anlyses is performed to reseach the site responce and to produce the earthquake parameters needed for structural analysis. The acceleration time history used as bedrock motion is in Fig. 7. With a maximum value of 0.52 g, and the computed ground surface acceleration time history is shown in (Fig. 11c). The maximum value of the computed grond surface acceleration is found to be 0.89 g. The acceleration response spectra obtained from computed ground surface motion is given in (Fig. 6-8)., together with that from the bedrock input motion. Maximum spectral acceleration is found to be 52 g, corresponding to the period of about 0.31 sec.

The transfer function determines how each frequency in the bedrock (input) motion is amplified or deamplified by the soil layers [Fırat et. al., 2015]. The variation of the amplification between ground surface and bedrock motion with respect to frequency is given in (Fig. 12), where the maximum value of amplification is obtained to be 2.1, corresponding to 1.3 Hz frequency.

Fig. 12. Computed amplification ratio curve using simulatted erathquake



Additionally, considering that most of the structures in Duzce city do not conform with the recent code requirements, damage expectations must be even more. An appropriate tool that can be employed for this purpose is the input energy spectra expressed in the energy equivalent velocity spectrum format, shown in (Fig. 11). Here, input energy spectrum defines the total energy imparted into a single degree of freedom (SDOF) system along the strong motion duration, and energy equivalent velocity is related to input energy through kinetic energy formulation [Roussis et. al., 2002]

Therefore spectral input energies can be added as scalar quantities for a SDOF system, and consequently spectral equivalent velocities are added by using the square root of the sum of squares approach for the two earthquake excitations in each direction. In engineering terms, the structures which were weakened and lost a significant portion of their energy dissipation capacities after the first event, were subjected to an even higher energy dissipation demand during the second event. This is in fact a life size, live field testing of a large number of prototype building specimens, which is indeed an expensive experiment [Roussis et. al., 2002].

The seismic zone oof Duzce area is determined as fist degrree earthquake risk zon, where the probability of exeeding the effective peak ground acceleration of 0,52g is 10% in 50 years.

As can be seen from the (Figs 7,8 and 11), a peak ground acceleration value of 0.4 cm/s^2 occured in the N-S direction for Duzce earthquake and 0.89 cm/s^2 in the E-W direction for the Duzce earthquake. It should be noted that these PGA values do not exceed the seismic hazard limit of 0.4g according to the spectra of Turkish Earthquake Code seen in (Fig.6). However, it is thought that soil amplificatioon may occur in the study area. The computed response spectra with damping ratio of 5%, 10%, 15 % and 20% for lateral (N-S,E-W) and vertical componenets are given in Figs. 6 for the mentioned earthquakes. In this context, Shaking of earthquake may be most effective on buildings with natural period of up to approximately 1.5 seconds.

8. Structural Damages at Reinforced Concrete Buildings Due To he Duzce earthquake and Field Observations

The Duzce earthquake of November 12 caused significant damage to Duzce city and its environs. This earthquake struct the buildings and the majority reinforced concrete buildings were completely damaged as shown in the (Figs. 13). While designing the concrete quality is very important for the reinforced concrete structures. It was observed that the quality of concrete used was very poor and its charecteristic strength in some structures in the study area was inefficient and under the level of expected strength. It was observed that some piece of concrete were crumbled from a collapsed reinforced concrete building in to dust in the study area. All these deficiencies show that the main problem at the reinforced concrete structures in the study area is poor quality of concrete. The use of low strength concrete observed in the damaged buildings were shown in (Figs.13). Seperately, another source of damage which could cause weaker bond between concrete and steel bars. There are some pictures about damaged beam clomn joints and are given in (Fig.14). Aditionally, it can be seen that confinement reinforcements were not applied at these joints correctly. Hence, the required ductility in these regions can not be supplied. Additionally, reinforcing bars in these joints are inefficient and no tie bars are presented. According to the field surveyings, the most important factor of damage in the reinforced concrete structure is presence of short lap splices and wrong end hook angle. Bisedes, Lack of tranverse reinforcement was observed in the some damaged clomns. These bars should be 90 end hooks. When the earthquake occured, the tiebars were opened up. Special care must be given to the design of tranverse reinforcement because lateral loads cause an increase in the shear force in clomns, beams, structurals walls and beam-clomns joints during earthquake [Ateş, 2015]. In sufficient replacement of tranverse reinforcement was identified in some of the damaged clomns. Most of the structures were two-three storey with a heavy covering over a wooden or concrete slab skeleton (Fig. 13,14). This type of heavy covering cause the seismic demands increase. The wide spacing of bars cause in shear failures, buckling of longitudinal bars and poor confinement of the core concrete. Further more, ıt can be supposed that there has been another reason of the damage about ınadequate clomn cross sectional dimensions. Another reason of damage, strong beam-weak clomn connections have been recognized in reinforced concrete structures which were damaged due to the Duzce earthquake 12 November 1999 (Figs. 13,14). A soft storey is a relatively flexible storey in which its relative horizontal displacement is much larger than the correspoding displacement of other stories. These floors can be especially dangereous in earthquakes because they can not be cope with the lateral forces caused by swaying of the building during an earthquake [Dönmez, 2005 and Ateş, 2015]. Presence of soft storey results in increased deformation demands significantly, and puts the burden of energy dissipation on the storey clomns. Many failures and collapses can be attributed to the increased deformation demands caused by soft stories as well as the lack of deformability of poorly designed clomns. Thus, any sudden changes in the lateral stiffness and strength must be avoided. Soft storey buildings are charecterized by having a storey with too much open space [Dönmez, 2005 and Ateş, 2015].

Fig. 13. Buildings was damaged, and evacuated after the 12 November 1999 Duzce EQ

(a)

(b)

Fig. 14. Buildings was damaged after the 12 November 1999 Duzce EQ

(a)

(b)

9. Conclusions

In order to asessment of the structural damage due to November 12, 1999 Duzce EQ and to provide new residentail places in Duzce city, detailed soil investigations and site response aanalyses were performed. Within the scope of this study, it was tried to understand the cause of structural damages in the past earthquake and to detyermine the dynamic parameters for structural analyses for a prospective earthquake. In thsi study, the findings of an investigation about the effects of local soil properties on soil amplification at the site in Duzce were investigated. Two accelerationtime histories recorded in Duzce during November 12, 1999 Duzce EQ (one is the rockcrop records and the other is ground surface record at the site) were taken into account to evaluate the degree of site amplification in Duzce area By;

1. The peak ground acceleration meassured in Duzce is 0.8 g. this is approximately two times greater than the peak ground acceleration recorded at bedrock at the study site during the November 12, 1999 Duzce Turkey earthquake. The reason for this high value of

amplification is indicated to be the shear wave amplification through the soft and sedimentary soil layers in Duzce basin above the bedrock. Variation of acceleration amplification with frequency indicated a site resonance effect at 1.3 Hz frequency that is considered to be consistent with the site soil profile. Comparing the computed and recorded response during the November 12, 1999 Duzce EQ, site response analysis is further more extended to the case a prospective EQ expected to occur in the Duzce arae.

2. .In some cases, high rate of soil amplification can be observed due to consequence not only of the unfavourable existence of a variety of alluvial sandy soils, but also of the intensity of shaking at bedrock base, and is formed very low range as 0. 01-0.04 g.
3. It is presented that when the intensity of shaking at the bedrock occures relatively large.
4. For prospective earthquakes for this area occuring within the an eppicentral distance of about 40 km, three kinds of distinc predominant periods of the ground were obtained as T1=3 sec, T2=0.3 sec, T3=2 sec. Structures in Duzce , with natural periods of shaking close to any one of these peak ground periods, especially those to be built in the future with a natural period T=3-2 sec, are expected to occuring damages as before and ovelapping resonance effects.
5. The site specific earthquake parameters are investigated to be used in the dynamics of structures to improve the level of the safety against prospective damages.
6. Liquefaction pehenomenon is inevitable in this area, in this context, the precautions against liquefactin to design of structures is taken into account. The alluvial soils are susceptible to liquefaction so that the depth of water level and sandy soils are less than 15 m.
7. Thsi study reveals that clearly importance of microzoning maps, indicating the degree of risky zones of soil amplification and liquefaction with the availability of these kinds of maps, which prepared unfer the responsibility of Duzce local municipal authority, the engineers shell be able to choose the appopriate and safe structural models.
8. At the end of the study, it is inferred that local soil conditions that cause to amplifications of the ground motions during part earthquakes have played a major role in the building damages.

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