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TYPE AND DISTRIBUTION OF DAMAGE IN THE DINAR (TURKEY) EARTHQUAKE (OCTOBER 1, 1995)

Prof. P. Carydis* & Assist. Prof. E. Lekkas**
*National Technical University of Athens,
Polytechnic Campus 175 00 Zografos Athens, Greece
**University of Athens,
Panepistimioupoli 157 84 Athens, Greece

Abstract

The earthquake at Dinar (Turkey, 1 October 1995) that caused extensive damages and many deaths is described and some evidence on the high seismicity of the region are given. Geological conditions varying from rock to loose soils in different sections of the city are also discussed in relation with damage to all construction types. Damage is highly localised in some sections of the city suggesting that it is controlled by geology.

Introduction

On October 1, 1995, at 5:57 p.m. local time, a strong earthquake measuring 6.1 on the Richter scale hit the city of Dinar, Turkey, causing casualties and extensive damage to buildings. The epicenter of the quake has coordinates 38°00´N and 30°10´E and is a few kilometers southwest of Dinar.

The main shock record obtained at Dinar Meteorology Station indicates horizontal PGA levels of 0.28g in both horizontal directions and 0.11 in the vertical direction. The horizontal components sustained 0.15g level for about 14 sec and indicate a second s-wave arrival about 10 sec after the first arrival. From an s- and p- wave arrival time difference of about 3 sec, an approximate hypocentral distance of 18 km can be estimated. Starting on September 26, six days prior to the earthquake a number of preshocks were observed with magnitudes varying from 3.4 to 4.8. This earlier seismic activity alerted people and many had left the town or had moved outside of their houses when the main shock struck.

According to official reports, the deaths are between 90 and 100, while the wounded are between 230 and 270 persons. According to the first investigations that were made, about 40-50% of the houses were destroyed. More specifically, 2,043 buildings were totally destroyed, including several government buildings, while about 4,500 buildings were heavily damaged (CARYDIS et al, 1995).

Geological setting

Geographically Dinar lies in the so-called “Region of Lakes” of southwestern Anatolia. Dinar is situated between the provincial centers of Afyon and Burdur on the main highway to Antalya in the south. The elevation of Dinar varies between 860 and 950 meters.

As far as the neo-tectonic provinces of Turkey are concerned, Dinar is located in the transition zone between the central Anatolian “Ova” provinces and the western Anatolian extensional provinces. The meeting point of the Hellenic Arc and the Cyprus Arc, to the south of the Adana-Cicilia basin, is in the Region of the Lakes (WESTAWAY, 1990; ZANCHI et al, 1990). This region is dissected by NE-SW trending fault zones of normal and possibly strike-slip motion (I.M.R.E., 1973).

The surficial geology of the hills to the east of town consists of Cretaceous and Eocene limestones and Oligocene marly limestones (Fig. 1). The plateau is covered with Quaternary alluvium containing sand, gravel and clay (M.T.A., 1973). The transition areas at the foot of the hills are covered by continental deposits (Fig. 2). Reports indicate that NW-SE trending fault ruptures have been observed at Dinar city and at about 5 km northeast of the city following the earthquake.

Seismicity

Dinar is in the First Degree Hazard Zone of the official earthquake hazard zonation map of Turkey. Over the course of two millennia, at least 20 earthquakes of intensities of VIII and above have affected the region (ERGIN et al, 1964, ERGIN et al, 1971). Earthquakes of this century that have caused damage in Dinar occurred on October 3, 1914 (Ms=7.0), August 7, 1925 (Ms=6.0) and May 12, 1971 (Ms=6.2). All of these events had normal faulting mechanisms (MINDEVALLI, 1990; YILMAZTURK & KENAR, 1986). The 1914 earthquake, associated with a 23-km fault rupture along the southeast coast of the Burdur Lake, approximately 60 km south of Dinar, destroyed about 17,000 houses and killed 4,000 people. The 1925 earthquake destroyed about 2,500 houses and killed 330 people. In the 1971 earthquake, 1,487 houses were destroyed at Burdur, killing 57 people.

Damage and spatial distribution of damage

Building structures in Dinar range from one to five stories. There is no industrial facility in town. Along the main streets, groundfloors are generally occupied by commercial use. Buildings with more than three stories are almost all reinforced concrete constructions. Buildings with a lower number of stories tend to be partly reinforced concrete and mostly brick masonry. Stone masonry and adobe buildings are very few.

Most of the four- and five-story reinforced concrete apartment buildings were either heavily damaged or totally collapsed. Some three-story buildings suffered similar damage. One- or two-story building collapses were rare. Initial estimates based on preliminary walking surveys indicate that approximately 30 buildings totally

Fig. 1 Marly limestone that outcrops at the east part of Dinar city.

Fig. 2 View of the west, flat section of Dinar city that is covered by recent (Holocene) sand, gravel and clay deposits.

Fig. 3 View looking east at the part built on bedrock outcrops (limestone and marly limestone). At this particular section of the city, damage was limited.

Fig. 4 Collapse of a multistorey R/C building at central Dinar where thin, loose formations are present.

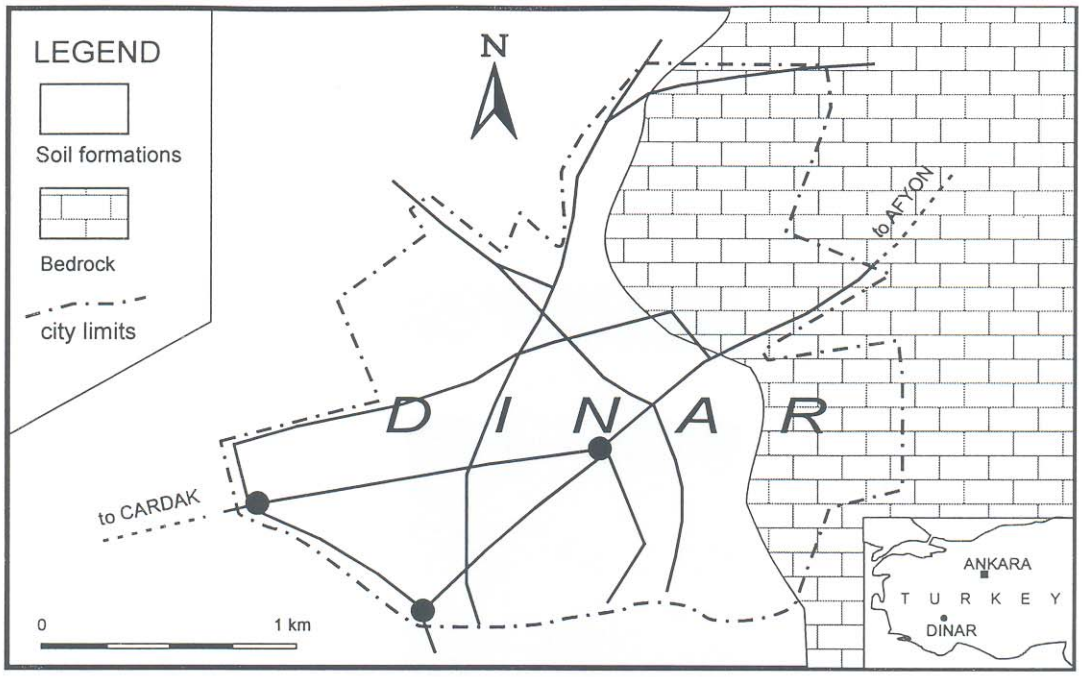

Fig. 5 Geologic sketch map of Dinar city (1. Cretaceous - Eocene limestone and Oligocene marly limestone, 2. Holocene sand gravel and clay deposits).

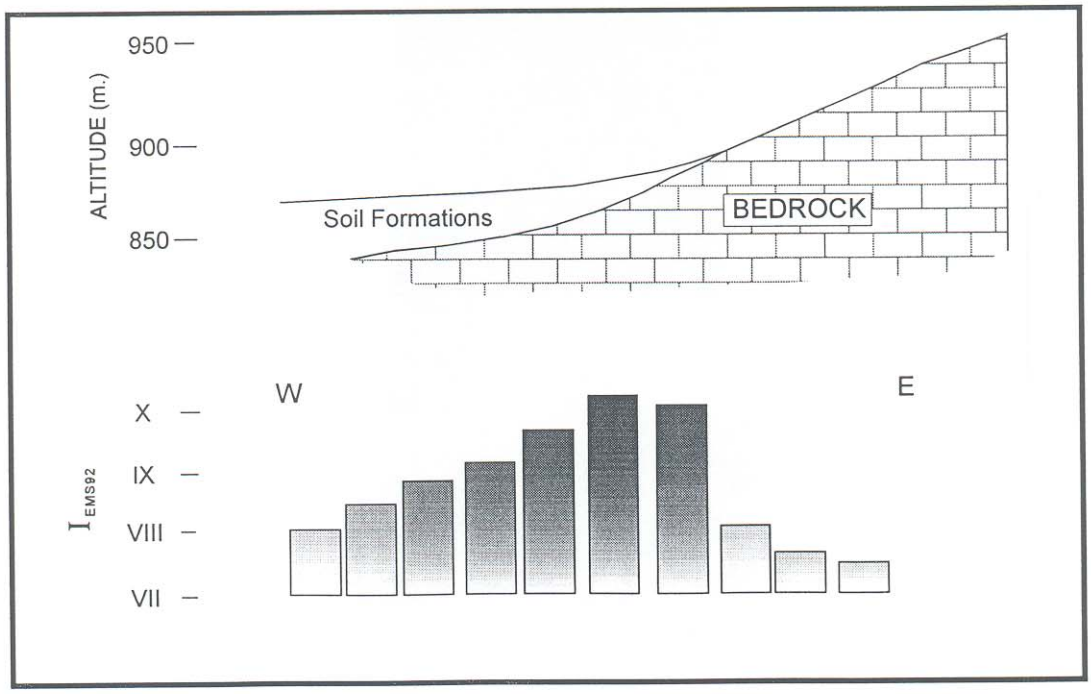

Fig. 6 E-W cross section showing intensity distribution. Note that intensity is getting higher at the city center formed by loose and thin soil formations.

collapsed and around 50 to 60 buildings experienced first-story and occasionally an intermediate story failure.

The great majority of the structures with brick load-bearing walls (two to three stories high residences) suffered medium to heavy damage. Shear failure of walls with diagonal cracks between the windows was very common. In the walls of some of these buildings, hollow clay tile was used.

The damage in Dinar is localised in some sections of the city. In the higher parts of Dinar, where the foundations were on bedrock, the effects of the earthquake on buildings were small or non-existent (Fig. 3). Here the buildings, their chimneys and the minarets were untouched. The damage starts gradually (fractures in chimneys, breaking off of top part of minarets, damage to buildings), as one proceeds towards the lower parts of the city (Fig. 4). Damage reaches a peak in the center of the city and then starts to decrease. The last phenomena occur on thick alluvial deposits (Fig. 5, 6).

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