TECTONICAL GROUND RUPTURES IN URBAN AREAS: KARAHAYIT (DENIZLI-TURKEY) CASE

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Abstract - Natural hazards are one of the deadly threats to urban areas. Seismic activity and ground ruptures, are common geo-hazard, distorts infrastructures and buildings. The ground movements caused by the ruptures are continuous. Ground ruptures can easily be traced on the surface. They can be covered by pavements and structures and may need underground visualization techniques to trace them in urban areas. In this study, the tectonic cracks have been found out in Karahayit town. Additionally the deformations on the pavements and buildings related to the crack movements have been determined.

Index Terms - ground rupture, urbanization, GPR, Denizli.

I. INTRODUCTION

Tectonical ground cracks are widespread in seismically active areas and they induce a series of geo-hazards to urban areas like distorted roads-pipelines, wrecked buildings, etc. The tectonic activities in the Aegean region are linked to the movement of the Anatolian plate and it is in progress for 14 million years [1], [2]. The seismicity causes widely tectonic extensions and horst-graben systems in E-W directions (Buyuk Menderes Graben, Kucuk Menderes Graben). The NW-SE directed grabens (Gediz Graben, Denizli Graben, Dinar-Civril Graben) are located in the eastern part of the Aegen region while the ones directed NE-SW (Baklan Graben, Acıgol Graben, Burdur Graben) are formed at the far east of the region (Figure 1). The tectonic extensions commonly form travertine structures where they cross the hydrothermal fluids discharged by tectonically controlled thermal springs [3]. A number of travertine occurrences like the famous Pamukkale travertine (a UNESCO World Heritage Site) can be traced along the fault zones.

This travertine accumulation generates some brittle morphotectonic structures [4], [5] which are prone to tensional deformations under the ongoing tectonic movements. This process is harmful for infrastructures, facilities and buildings located on it. Ironically these types of lands attract the civilization due to thermal springs and natural resources not in the past but also in recent times.

This study has focused on ground ruptures generated by tensile tectonic movements in Karahayit town near Pamukkale (Denizli). The propagation of the cracks has been traced by ground penetration radar (GPR). The ground and building damages have been recorded along the rupture zone and 3D model of the area has been put forth.

II. SITE SETTINGS

SW Turkey is seismically an active area. Karahayit town, termed one of the major thermal centers, is located in Denizli province at SW Turkey (Figure 1). A historic town Hierapolis near Pamukkale is only a couple of kilometers away from the study area where the civilization goes on for thousand years. The region is under extensional stress regime since the Latest Oligocene-Early Miocene [6] and this process has been formed a number of horst and graben systems in SW Turkey.

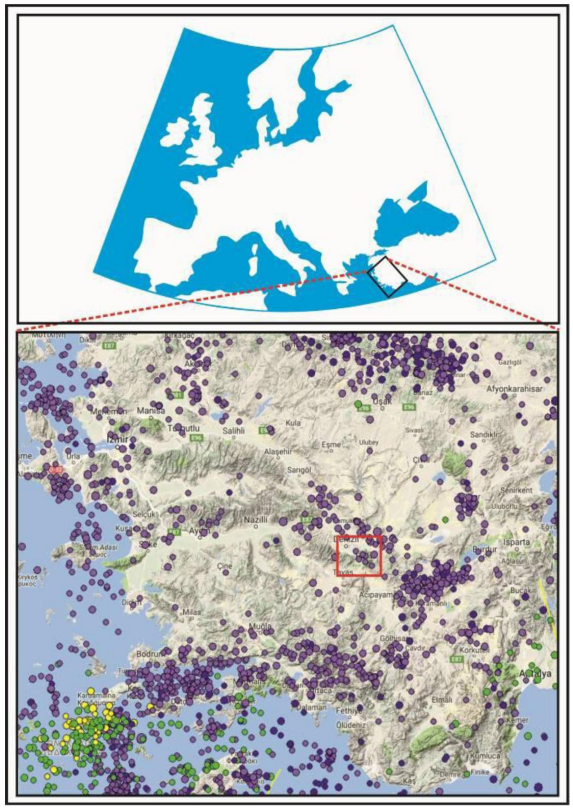
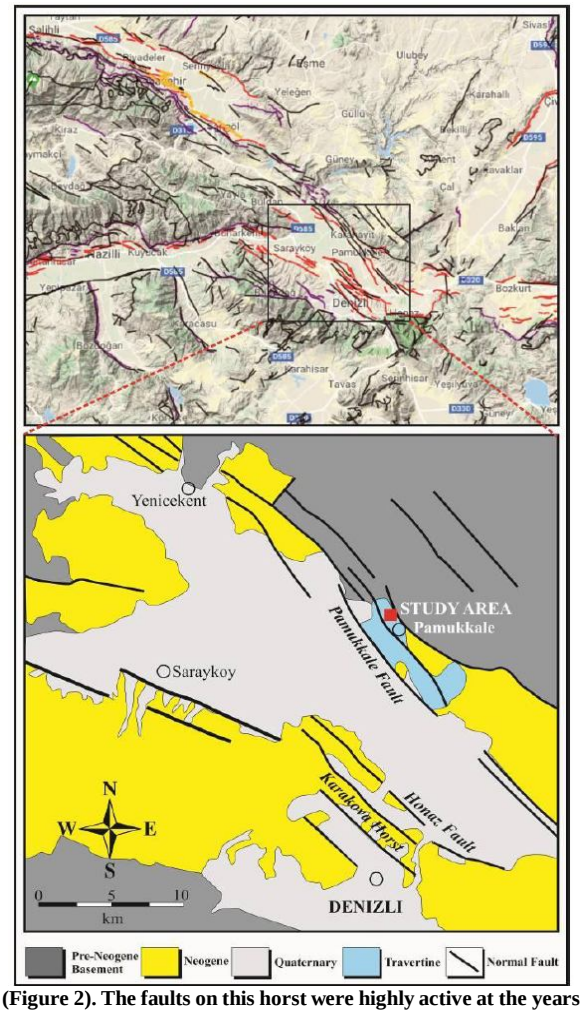


Fig. 1 Location map of the study are and seismic activity in SW Turkey.

The Denizli Basin lies in NW-SE direction, 62 km in length and its width ranges from 7 to 28 km [7]. The Pamukkale fault at northeast and Babadag-Honaz

faults at southeast bound the graben. There are a number of fault lines parallel to the basin boundaries and located in between Babadag and Pamukkale. The Karakova horst is positioned between the boundary fault lines



(Figure 2). The faults on this horst were highly active at the years from 2000 to 2004 [8].

Fig. 2: The active fault lines and simplified geological map of the Karahayit and surrounding area

The horsts of the region are of Pre-Neogene bedrock those are the oldest aged ones.

The graben is formed by Quaternary aged alluvium units and it is surrounded by Neogene terrestrial sediments. Some alluvial fans and river sediments are deposited in alluvial unit (Figure 2). The travertine outcrops can be traced along the some fault lines on the locations like Pamukkale and Karahayit where this study was carried on. The travertine outcrops in Pamukkale and Karahayit have been started at Upper Miocene-Upper Pliocene and the travertine accumulation is still going on along the Pamukkale fault line [9].

The early historic records of seismic activity in the study area were taken at M.S. 60 and Hierapolis antique city has been destroyed. The destructive earthquakes were recorded at M.S. 494, 700, 1358, 1651, 1717, 1887 and 1899 around Denizli, Pamukkale, Honaz and Saraykoy [10]. The largest earthquakes in the region are not greater than magnitude 6.0 since the instrumental recording has been started (Figure 3).

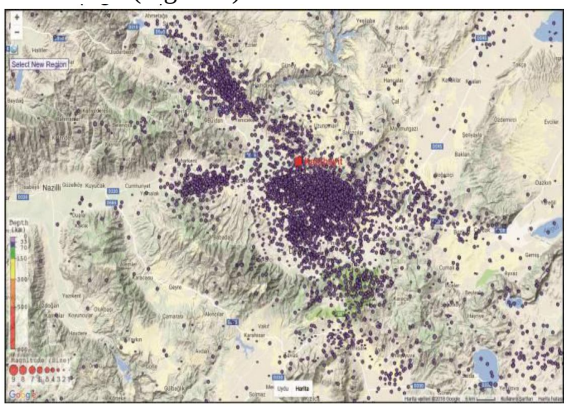


Fig. 3: The earthquakes (>M2) in study area (IRIS)

There are a large number of travertine outcrops at SW of the Pamukkale fault and travertine ridges are dominant around Karahayit town [11]. Travertine was piled up both in the cracks (banded travertine) and on the surface (laminated travertine) (Figure 4). These bands and laminas are symmetrical on the both sides and looks like onyx. They have firm and stiff structure and could be colorful from red to white. The 3D model of the area is illustrated in Figure 5 which demonstrated that the study area is located on a travertine ridge.

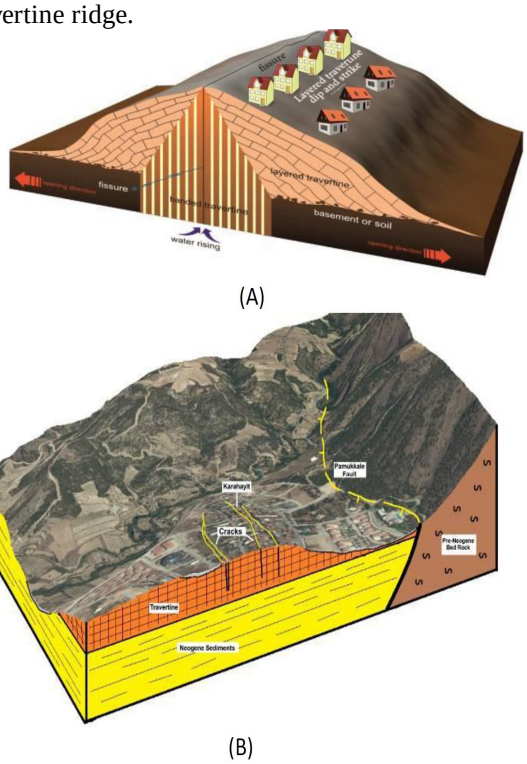


Fig. 4 : (A)Travertine formation modes above an extensional fissure and location of Karahayit town (modified from [12]), (B) 3D model of the study area

III. GROUND RUPTURES, DEFORMATIONS AND RESULTS

Fissure ridge type crack is about 400 meters in length, 1.5 meter in width and it lies through the study area. Its geological position is N200W nearly in north-south direction. They are roughly parallel to each other (Figure 5).



Fig. 5: The position of the cracks in Karahayit town

The cracks have been traced by ground penetration radar (GPR) using by SIR3000 with 400 MHz shielded antenna. It shows them clearly where they are invisible and/or covered by pavements (Figure 6).

The main opening is at the west marked with two closed crack lines and illustrated in Figure 7. There are a large number of deformed buildings and roads where the cracks meet those structures. These buildings had been constructed years ago despite the Turkish Code of Buildings has not allowed it.

The walls and pavements were split up and maintained several times (Figure 8).

The crack development is a continuous process and it means the deformation on the structures is going on for many years. This time is much longer than the serving time of the buildings. There is not any way to stop the movements and the buildings and pavements always need maintenance. The owners and local government has to pay the costs. The best way to avoid these problems is not settle down on this type of locations. Removable and light structures might be constructed to minimize the damages. Some versatile pavement forms can be adapted against the deformations.

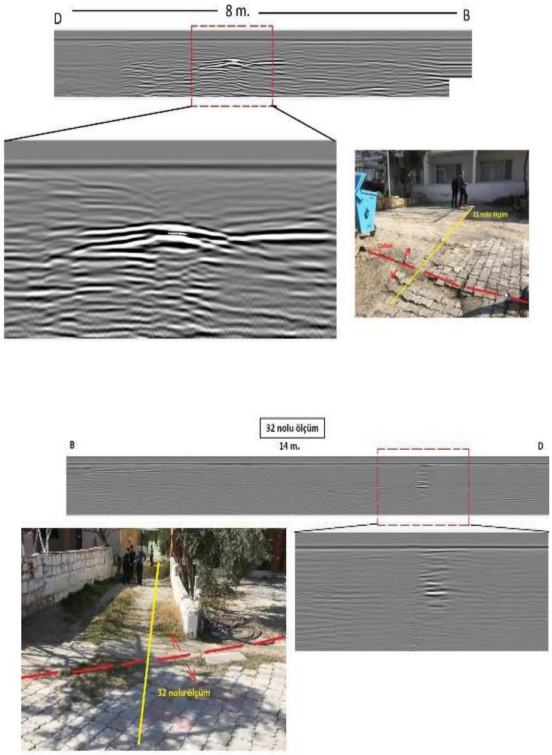


Fig. 6: Tracing cracks by GPR at two different locations



Fig. 7: The main extensional crack

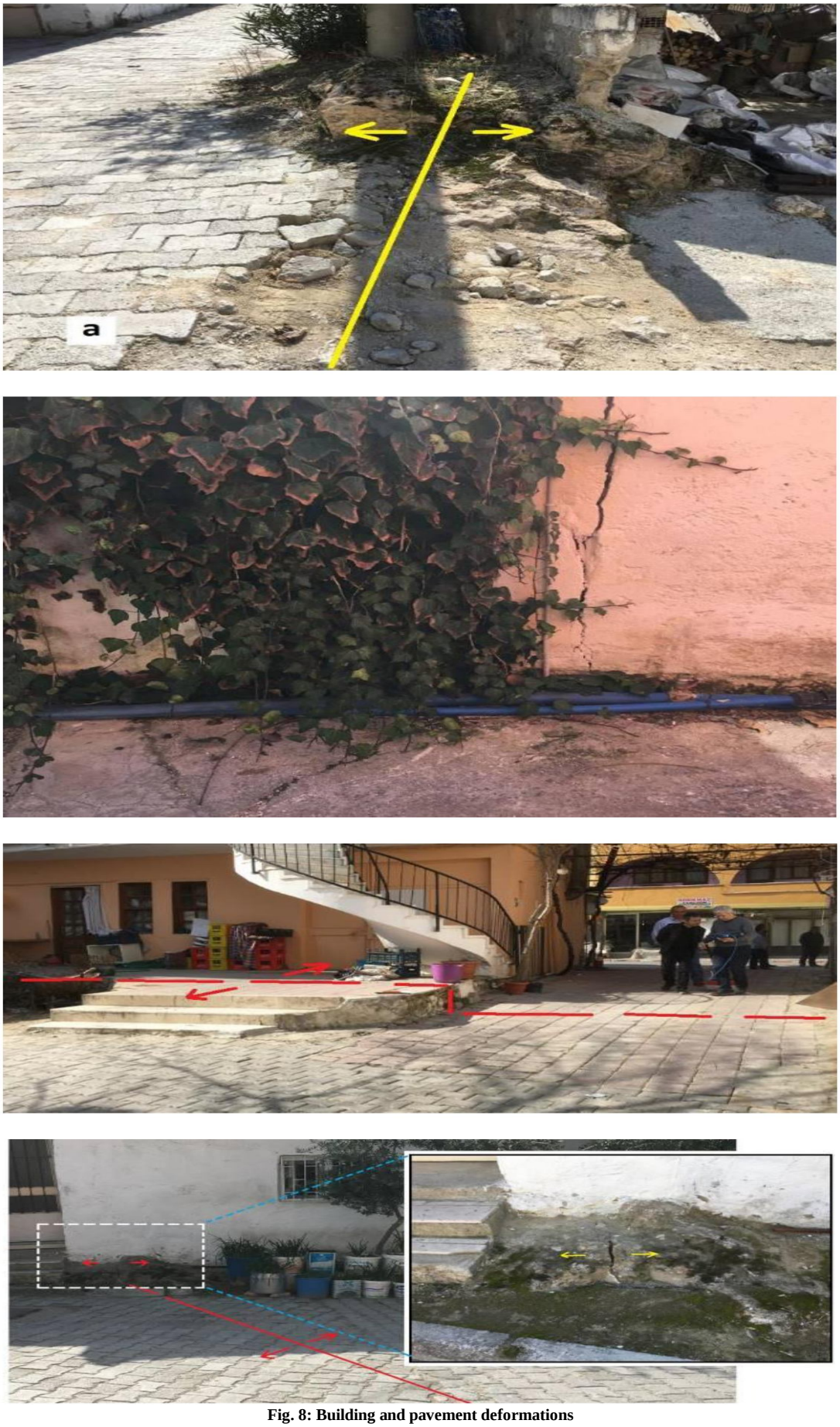


Fig. 8: Building and pavement deformations

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