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The Relations between Seismic Results and Groundwater near the Gokpinar Damp Area, Denizli, Turkey

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***Abstract*—**The understanding of geotechnical characteristics of near-surface material and the effects of the groundwater is very important problem in such as site studies. For showing the relations between seismic data and groundwater, we selected about 25 km^2 as the study area. It has been presented which is a detailed work of seismic data and groundwater depths of Gokpinar Damp area. Seismic waves velocity (Vp and Vs) are very important parameters showing the soil properties. The seismic records were used the method of the multichannel analysis of surface waves near area of Gokpinar Damp area. Sixty sites in this area have been investigated with survey lines about 60 m in length. MASW (Multichannel analysis of surface wave) method has been used to generate one-dimensional shear wave velocity profile at locations. These shear wave velocities are used to estimate equivalent shear wave velocity in the study area at every 2 and 5 m intervals up to a depth of 45 m. Levels of equivalent shear wave velocity of soil are used the classified of the study area. After the results of the study, it must be considered as components of urban planning and building design of Gokpinar Damp area, Denizli and the application and use of these results should be required and enforced by municipal authorities.

***Keywords*—**Seismic data, Gokpinar Damp, urban planning, Denizli.

I. Introduction

GEOPHYSICAL data are collected to delineate Gokpinar Damp area, Denizli city of Turkey for the microzoning purposes. A total of sixty geophysical refraction profiles were conducted inside of the study area. Multiple numbers of shot gathers were collected along a linear survey line by moving both source and the receiver spread. It was the first arrivals of compressional waves to extract Vs, Vp and Vs/Vp information, respectively. To generate the Vs and Vp profiles, every shot was gathered the all traces for analyzing, and then two dimensional velocity maps were constructed from the multiple shooting profiles. The Vp and Vs are higher in the southwestern part of the study area (900–1900 m/s and 360-600 m/s from the surface to a depth of about 6 and 10 m respectively) as compared to the northwestern parts of the study area (400–900 m/s and 160-360 m/s for the same depth).

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The unconsolidated materials of can have a profound effect on the spatial distribution of earthquake ground motion amplification, resulting in a large variation in the severity of damage to buildings, transportation corridors, and other lifeline infrastructures. This has been experienced during the earthquakes of Buldan in 2005. To be able to carry out a seismic microzonation study for young sedimentary basins, a large amount of input data is required on the 3-D structure of the basin, the stratigraphy of the unconsolidated deposits, and their geotechnical and geophysical characteristics. In many locations in developing countries, such data are lacking or only available for a few sites.

The aim of the study is to mainly investigate the geological, seismic and geotechnical site characteristics, and to perform site classification of alluvial and terrace deposits at Gokpinar Damp area. In order to determine the p and s wave velocity for a depth of 6m and 10m from the surface, or its generalization to different depths, mostly in-situ seismic methods are utilized to derive the shear-wave velocity as a function of depth. The relationships between the geologic units and their p and s wave velocity results, vertical variations with respect to the sediment type and Vp and Vs with the information collected. Then the average wave velocity for the upper 6m and 10 m of the soil profile were determined and the site classes based on the seismic codes were utilized in this zonation study.

II. Location and Geology of Study Area

Gokpinar Damp area is located at southeastern part Denizli city, Turkey. It covers an area of 5 km^2 and geographically located between latitude 37°46'57" and 37°45'07" and longitude 29°10'47" and 29°06'56”. Fig. 1 shows the study area location, simplified geological map of the study area and profile locations. The profile locations are illustrated on 3D topographic view with the geology map. The study area is about 5 km^2 and is mainly of Quaternary sediments. Denizli Basin as a whole is bounded in the north by the Cökelezdag Horst and in the south by the Babadag and Honazdag Horsts. In the central part, it is traversed by one of the faults of the Laodikia Fault Zone that also controls the northern margin of the Acipayam Graben. It is a NW–SW elongated basin approximately 50 km long and 25 km wide, and comprises two Quaternary sub-basins, namely the Curuksu Graben in the north and the Laodikia Graben in the south, separated by a large basin-parallel topographical high along which Late Miocene–Pliocene fluvio-lacustrine deposits are exposed (Fig. 1). The Çuruksu graben is controlled in the north by the

Pamukkale Fault Zone and in the south by the Laodikia Fault Zone. The Laodikia Graben is controlled by one of the branches of Laodikia Fault Zone in the north and Babadag Fault in the south. To the east of Denizli town center, north of Honaz and around Kaklık the Denizli Basin has a staircase geometry delimited in the south by the Honaz and Kaklık Faults, around which the main boundary faults of the NE–SW trending Baklan and Acipayam grabens interfere [1].

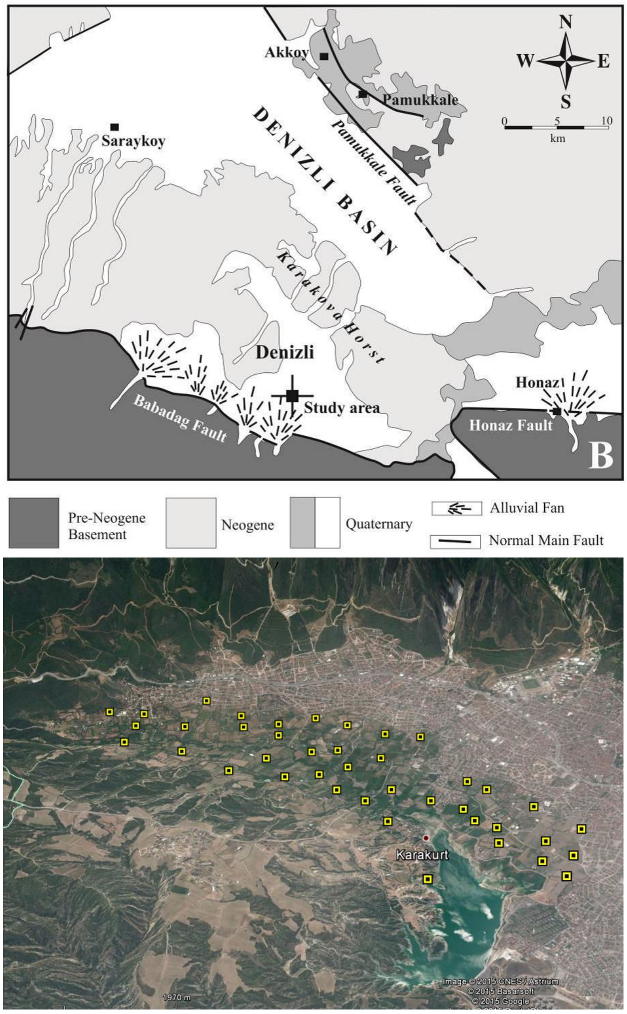

Fig. 1 The simplified geological map of the study area [1] and the google map of the stud area and profile locations

In the study area there is a combined hydraulic system that involves on end aquifers which controlled by geology and structural characteristics. The aquifers show lithological diversities both in lateral and vertical directions and interconnected with faults and similar discontinuities [2]. They are charged by rains and underground water flow comes from pre-Neogene rock units at the south of the study area (Figs. 1 and 2). Hydro geologically the geological units are classified into three groups (Fig. 2):

i. Permeable units: Neogene aged sandstone, conglomerate and silty-sand conglomerate which include siltstone and claystone levels.
ii. Semipermeable units: Quaternary aged alluvium and fan delta sediments.
iii. Impermeable units: Quaternary aged clay-silt-sand-gravel, sand-silt-clay mixtures and organic clay.

III. Seismic Wave Velocity and Application of Methodologies

Seismic waves are generated by active source which means that seismic energy is intentionally generated at a specific location relative to the geophone spread and the recording begins when the source energy is imparted into the ground [3], [4].

The choice of equipment (source type, geophone type, and number) and testing configuration (geophone interval, spread length and offset distance) is closely linked to the scope of the test and to the technique to be used in the field because of the different frequency interest range of the methods. This study is mainly interested in a depth of 30 m and more, so the related configuration and equipment was chosen for that purpose. In this study, seismic record was preferred as the active surface wave methods, to obtain the p and s waves velocity profiles of the subsurface. In the unconsolidated soil, the characterization of the dipping layers or a higher velocity layer on the top of a lower velocity layer is performed by using p and s wave techniques. Usually when such proposed studies are performed in a project area, they require a pattern of measurements which should be dense enough to determine a given geological setting in terms of p and s wave velocity classification and to develop a representative map reflecting site conditions.

The selected soil profile acquired from Quaternary sediment at 20 by the combined p and s wave method is given in Fig. 1. As can be seen in Fig. 3, an example of the p wave velocity results of the layers are relatively changes with depth and velocity cross-section. It was taken to study, 20 p and s wave measurements from different locations the seismic response of different lithologies around Gokpinar Damp area, Denizli city. To characterize the geological sites according to their age and depositional settings, these measurements were carried out at Quaternary sediments. The field measurements were conducted by adopting a grid system where the seismic measurement points were attempted to be spaced at about 300 m.

IV. P and S Waves Survey Results and Discussion

The vertical and lateral variation of the p and s wave velocity over the study area was generated for characterizing the sedimentary units and to discriminate the sediment type. The contour maps can be seen in Fig. 4. In creating of Vp and Vs contours maps in Fig. 3, a digital elevation map of the study area was produced from the location values from Google Earth. All of the surfer anomalies were obtained by Vp and Vs values. These velocity anomalies also gave information about the depositional systems dominating the Quaternary period.

The seismic velocity maps and the other geologic with interpolation maps of the study area used to develop for showing the elastic distributions of the Gokpinar Damp area, Denizli city. In the generation of the surface anomaly map of Vp6, Vp10, Vs6, Vs10, Vs30, Vp/s6, Vp/s10, soil amplification for 6 and 10 meters and the water depth from surface maps, ordinary kriging method was performed to quantify the spatial structure of the data (Fig. 4).

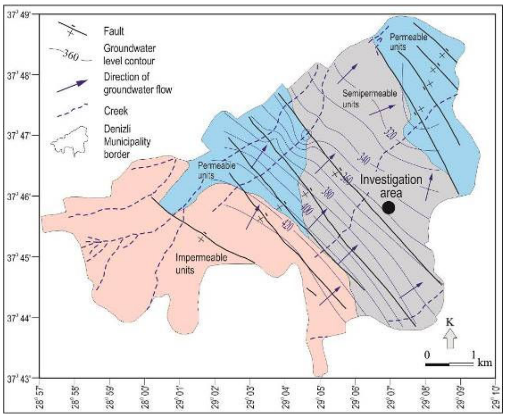

Fig. 2 Hydrogeology map of the study and surrounding area [2]

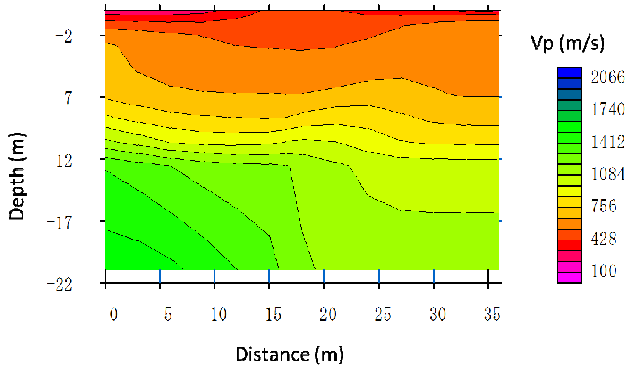

Fig. 3 An example of the two dimensional p wave velocity results of the layers are relatively changes with depth and velocity cross-section

It is known that earthquakes are among the most severe natural disasters causing significant damages such as failure of earth structure, settlement or tipping of buildings, lateral spreading of sloping ground and densification causing vertical settlements. The reasons for these failures can be attributed either due to the compaction of loose deposits of soils or by a phenomenon called liquefaction. Liquefaction has been most abundant in areas where ground water lies within 10 m of the ground surface; few instances of liquefaction have occurred in areas with ground water deeper than 20 m. dense soils, including well-compacted fills, have low susceptibility to liquefaction. Liquefaction potential is evaluated by using the Vs velocity, density of soils and water table depth [5]. Very important parameter of liquefaction is Vs velocity values. The different liquefaction parameter for the Gokpinar Damp area, Denizli city with Vs wave velocity values are shown in Fig. 4.

The water table depth, depth to bed rock details of the nearest bore well to the study locations along with computed Vs which is Vs < 350 m/s corresponds to soft soil, Vs350–450 m/s corresponds to stiff soil, Vs 450–550 m/s corresponds to very dense soils with soft rocks and Vs > 550 m/s corresponds to very hard soil. Soil classification is carried out and it is observed that most of the sites consist of very dense soils and soft rocks with velocity of 550 m/s. Most of the sites do not show the Vs > 600 m/s up to 10 m depth, which indicates deeper bed rock at the study locations.

The water table depth, depth to bed rock details of the nearest bore well to the study locations along with computed Vp which is Vp < 550 m/s corresponds to soft soil, Vp 550–750 m/s corresponds to stiff soil, Vp 750–950 m/s corresponds to very dense soils with soft rocks and Vp > 1200 m/s corresponds to very hard soil. Soil classification is carried out and it is observed that most of the sites consist of very dense soils and soft rocks with velocity of 750 m/s. Most of the sites do not show the Vs > 1200 m/s up to 10 m depth, which indicates deeper bed rock at the study locations. In Fig. 4, Liquefaction potential area is evaluated by purple color Vs6 and Vs 10 velocity surface map, below the 300 m/s. We can see the same effects on the Vp wave velocity map, with purple color under 600 m/s.

V. Conclusions

Seismic zonation studies in Quaternary alluvial deposits of the Gokpinar Damp area, Denizli city were implemented by the seismic wave methods. By this study, sediment conditions were determined and the variations of the velocity throughout the soil profiles were characterized by the seismic wave velocity method at 62 locations. The seismic wave method gave compatible results with each other especially in terms of surface velocity anomaly maps of Vp6, Vp10, Vs6, Vs10, Vs30, Vp/s6, Vp/s10, soil amplification for 6 and 10 meters. This allowed checking of the reliability of the seismic survey results and enabled to assign Vp and Vs velocity values to the corresponding layers. Therefore, the depositional environments and their products could be identified.

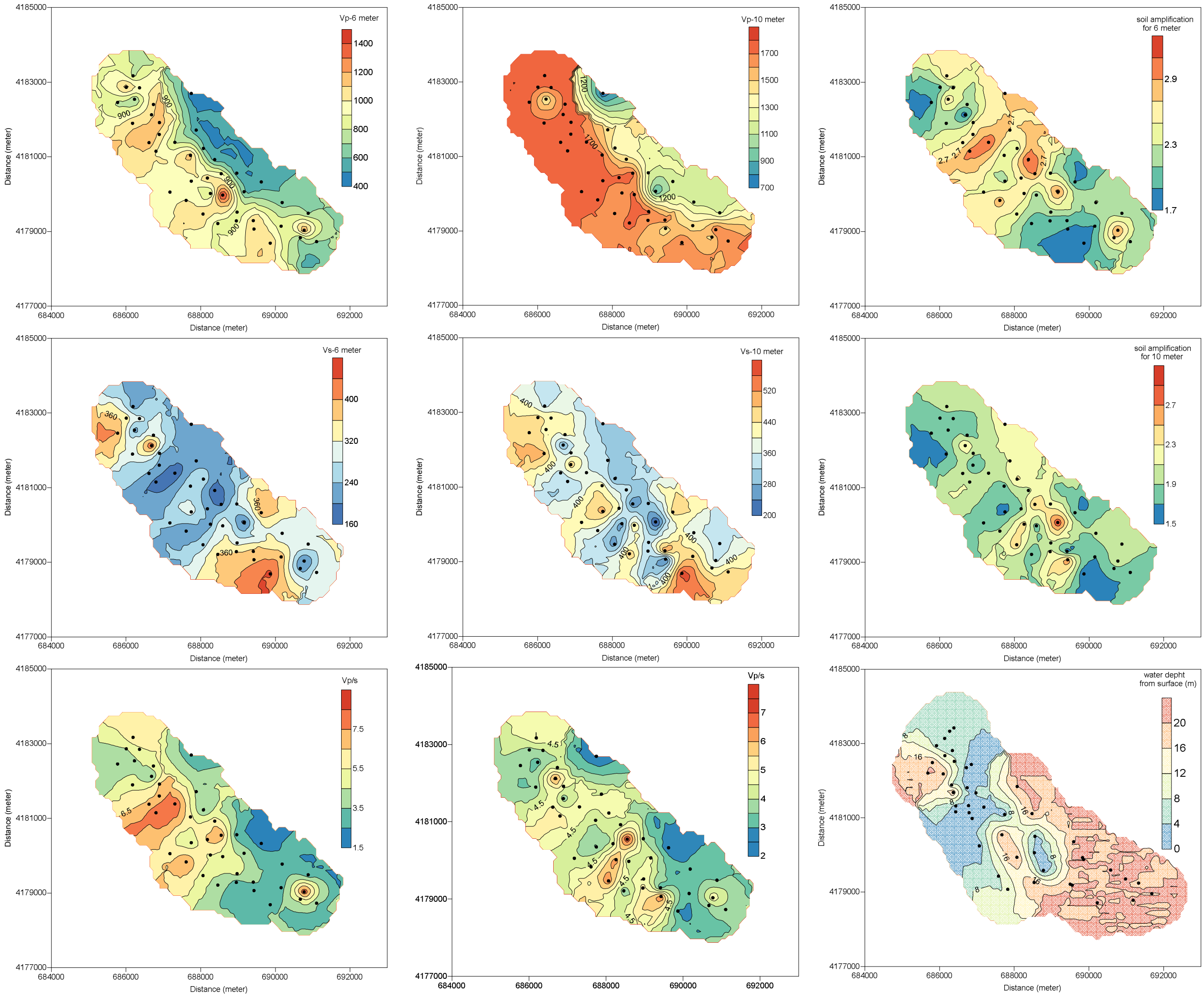

Fig. 4 Surface velocity anomaly maps of V_{p6}, V_{p10}, V_{s6}, V_{s10}, V_{s30}, $V_{p/s6}$, $Vp/_{s10}$, soil amplification for 6 and 10 meters and the water depth from surface

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