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Geotechnical examination of Ermenek District in the Province of Karaman

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Abstract

In recent years, as a result of the increasing interest in construction in our country, the demand for construction areas has also increased. Regarding the buildings we plan to build, we should examine whether the ground being the surface on which the structure will sit or be adjacent, can respond to us positively in terms of strength. As a result, if the soil strength is poor, either the ground must be improved or the property of the structure to be built must be changed. Hence, the building and the ground can not be considered separately. They need to be considered as a whole. In our country, there are not many geotechnical studies which deal with the structure-soil relationship and explain the ground infrastructure of the region, especially in settlements with medium and small populations. Due to this reason, in this study, it is aimed to address the Ermenek district of Karaman from this respect and to eliminate this deficiency of the district. In accordance with this, ground structure of district, various ground survey reports and geophysical reports prepared in recent years were examined. Furthermore, structure class of building planned to be made on that parcel, as well as ground settlement area, number and height of floors, approximate building and foundation loads were calculated with respect to architectural aspects and static and dynamic loads that were formed were brought together and their suitability for the structure, amount of seating that may occur on the ground, and liquefaction situations were examined with respect to bearing capacity of ground. In this way, an infrastructure information bank was created with regards to geotechnical aspects of district.

1. Introduction

Natural disasters occur almost every year in our country and in different parts of the world. These disasters cause situations of loss of life and property. Earthquake, which is one of these disasters, is the most damaging ground movement. About 500,000 earthquakes occur annually in the world whereas 80% of these earthquakes are palpable, and nearly 100 of them are destructive. Unfortunately, earthquakes in urban areas cause physical and socio-economic losses. As an example of this, we are a country that experienced earthquakes in 1999 in Gölcük and Düzce, in 2003 in Bingöl, in 2011 in Van, and in 2020 in Elazığ and İzmir. As a result of these earthquakes, tens of thousands of our citizens lost their lives and were injured, and thousands of families were left homeless and unemployed.

Although it is not possible to prevent the occurrence of earthquakes or to determine when they will occur by using today's technology, it is possible to minimize the damage they will cause. Especially in the settlement areas established on problematic, low-strength floors, the high population increases the danger even more.

Besides, incidents such as "Building-Soil Incompatibility", that is, the construction of a structure on a ground with unsuitable strength for the structure, are often confronted with. This event does not only cause settlement or

swelling in the buildings built over time, but also damages and even collapses the structures situated on the adjacent parcels.

Even though it is not possible to prevent the occurrence of earthquakes or to determine when they will occur with today's technology, it is possible to minimize the damage they will cause, and it is possible to prevent the dangers and damages that will occur by improving the soils with unsuitable strength and by choosing the appropriate construction/manufacturing method.

Ermenek District of Karaman Province, which has been examined regarding this issue, is one of the safest regions in our country in terms of seismicity. No large earthquakes occurred in the mentioned region. Considering the earthquake events of the last 15 years in the region, it is seen that the largest earthquake had a Magnitude of 3. Maybe due to these reasons, no geotechnical studies and investigations covering Ermenek and its surroundings that can be taken as a reference in general terms have been carried out. However, the recent major construction attack in the district, in addition to this, the Ermenek Dam with a crest height of 274 meters that is built on the Ermenek Stream, which passes through the south of the district and feeds the Göksu River, the presence of many regulators on the same brook and the construction of Tekeçatı Regulator on Tekeçatı Stream, which passes through the north of the district constitute the evidence that more interest must be shown on the region with regards to geotechnical aspects.

In the study, geological and geophysical reports previously prepared in province of Ermenek were evaluated, and structures built or planned to be built as per zoning plan were evaluated and required numerical values were calculated and accordingly, bearing capacity of ground, amount of floor seating, liquefaction situation were examined parcel by parcel with certain geotechnical programs. By means of this study, ground status of province has been revealed.

If we would give some other studies similar to this study being conducted as an example;

Alkaya [1] has prepared an excel program to make the preparation of geotechnical reporting in an error-free and fast way. Formulae, tables and figures that were required in this program were revealed in an explanatory manner. In the package programs which are known in the market, either limited calculations are made or the necessary arrangements are not made for the calculation outputs, so a new software has been developed that brings together geotechnical calculations.

Sert et al. [2] mentioned that one of the most important problems of the Sakarya region is the earthquake problem. They emphasized that the North Anatolian Fault Line passes through this region, and large magnetized earthquakes occur in the region for 10–30-year periods. Within scope of their studies, they conducted field and laboratory studies in Arifiye, Geyve and Güneşler locations in the region after the 1999 earthquake. Geotechnical evaluations of the data obtained as a result of these studies were carried out with the help of the Geographical Information System, and the causes of the damage after the earthquake were revealed.

Şahin [3] stated that there are many active fault lines in and around Bursa, where construction is extremely fast. It was stated that the soils in this region were exposed to volumetric changes as a result of earthquake movements. For this reason, he mentioned that if the structure of the soil is suitable, unfortunately, liquefaction may occur in the soils of the region. In the studies he conducted he determined that during the 1999 Kocaeli earthquake, there was liquefaction in fine-grained soils, in addition to sand. He stated that sand, silt, and clay content dominate the region. This situation has added even more importance to his work. In this study, he focused on two parameters for the region and examined the liquefaction potential and bearing capacities of the soils in the general soil evaluation. 140 liquefaction analyzes and 36 carrying capacity calculations were made. As a result of this study, critical values were found in 11 soils. In addition to cohesionless soils, it was observed that the liquefaction potential increased in cohesive soils with low plasticity and low fine grain ratio. It has been determined that soil improvement should be applied in such critical soils.

Kurtulus and Bozkurt [4] conducted geological and geotechnical investigations in the Cayirhan District of Ankara, due to the fact that some lands were opened for construction. In their field work, they had 12 drillings and conducted a SPT experiment at each distance of 1.5 m. UD and Core samples were taken at various depths from the drilling sites. In their studies, they determined the formation of the ground structure, and determined that it consists of vegetative soil in the range of 0.00-1.00 m, followed by silty clay and gravel. No faults were found in the study area. In the laboratory experiments, it was determined that the ground generally has plastic from low to medium value. Geotechnically, it has been determined that the soil has low and medium swelling properties.

Sevimli [5] mentioned in his study that seismic analysis is a field study used in geotechnical earthquake engineering. In his study, he stated that seismic analysis played an important role in the design of many structures. Within the scope of his study, the analysis of seismic movements occurring around the province of Batman from 1900 to the present has been made. The study area covers the region within the circular area with a radius of 100 km from the city center. The study also deals with deterministic and probabilistic methods. Suggestions have been proposed against damages that may occur as a result of seismic movement that can form as the conclusion of his study.

Bayrakcı and Baran [6] examined the geological and geotechnical structure of Osmaniye Province within the scope of their studies. In their study, they have divided the settlement area into regional systems having dimensions of 330 m x 330 m at areas where aluvion unit is observed on geological maps created by MTA and they

divided other observed areas into regional systems having dimensions of 400 m x 400 m. They drilled in the middle of each region. During this work, 15 boreholes were drilled. As a result of the analyzes they made by considering the data of the drilling wells in the regions, different earthquake accelerations and soil elastic spectra were processed on OKM maps.

Ateş et al. [7] revealed the geotechnical properties of the lands by using geological, geophysical and geotechnical methods in order to reveal the soil properties of the lands to be opened for construction in Kaynaşlı District in their study. He has mentioned that Duzce segment being one of the important segments of Kaynasli district Northern Anatolian Faulty zone diving into two branches is within Northern segment zone and that in the district till 1999 earthquake, disordered urbanization took place. Lateral and vertical thickness changes of coarse- and fine-grained alluvial deposition units of approximately 4-12 m thickness of the study area were determined. They drew attention to the fact that the region is close to both the alluvial structure and fault lines. Standard Penetration Test (SPT) and seismic refraction studies were performed at the study sites. They determined the physical-mechanical properties of soil samples with laboratory experiments. Geotechnical map of the region was prepared in line with the obtained geotechnical data.

Tutar [8] wanted to create a data bank for the northeastern region of Şanlıurfa. The geotechnical data of the field were digitized and collected in an environment. 30 ground survey reports have been digitized and the data obtained has been converted into a data bank with Delphi 7 programming language. As a result, he made necessary comments for the study area.

Özaydın and Anlı [9] discussed the geological and geotechnical structure of the south of the Bosphorus and the Golden Horn. They have determined that young tectonic movements are effective in the region and that it has undergone significant morphological changes. They suggested that young sediments were formed in the region as a result of this change, and that these sediments were intertwined laterally and vertically. They mentioned that the movement caused two important topographical irregularities in the offshores of Karaköy and Sarayburnu, and that the sudden change in elevation caused by the fault offshore of Karaköy occurred, and that this fault gradually turned the Golden Horn into a hanging valley with the faults passing near Sarayburnu. They suggested that this caused the young sediments in the Golden Horn to be located deeper in the south of the Bosphorus. In this way, they produced a geotechnical map of the region.

Akdeniz et al. [10] stated that it is a study conducted for the purpose of ground survey and geotechnical survey, determination of the engineering properties of the ground, determination of the groundwater level, and evaluation of the structure to be built on the ground, both with the building ground and the surrounding structures. They mentioned that these surveys were determinant in deciding whether there is need for improvement or not at the ground where structure was based. They said that the survey work will be done in two branches as field and laboratory work. As a matter of fact, in line with these studies, 885 soil survey reports made in Eskişehir from 10 August 2005 until now were handled according to the "Soil and Foundation Study General Format" published by the Ministry of Public Works and Settlement on 10 August 2005. They revealed a general soil structure of the region.

Akyol et al. [11] revealed the effect of geotechnical and some seismic parameters of soils on construction in an area where business and residential buildings are concentrated in Denizli city center. During the study, they have used seismic breakage data of SPT value obtained from geological reports relating with the region. They revealed that the dynamic and geotechnical parameter values are low in the central parts and north of Denizli region, while they are higher in other regions. They have seen that the most common ground period distribution coincides with the 4-7 storey building period when they are based on the period depending on the number of floors in standard reinforced concrete structures. With this result, they revealed that most of the structures in the study area will resonate with the ground in a possible earthquake. As a result, they state that the period values of the ground and the structure should be made suitable for earthquake resistant structure design.

Similar studies have been carried out for different places such as.

As a result of this study, it is aimed to examine whether the structures suitable for the ground are built in this district, where almost no geotechnical studies have been carried out, whether any Soil Improvement is needed for the ground of the structures to be built, and to shed light on the future studies.

2. Material and Method

If we would mention about the district being examined, Ermenek District is located in Karaman province and it is 67 kilometers southeast of Karaman. There is Mut district in the east of the district, Anamur in the south and Balkusan Village in the west, 15.75 km north of the Antalya provincial border. While the land structure of the district varies from north to south, that is, from Tekeçatı Region to Ermenek Dam, between an altitude of 1400 and 700, there is no great difference in elevation from east to west. Geologically, the region is a structure that generally contains limestone, clay, marl, fossiliferous sandstone and even coal. At a distance of 40 km from the district, there are many small faults that are distributed within a zone of 17 km length and 3 km width. This region is named as Mut Fault Zone. The researchers state that the fault is strike-slip with vertical component and possibly alive due to the river valleys and parallel ridges following the faults.

The study was started by obtaining the Geological and Geophysical Report, which was prepared as a result of the Field and Laboratory Test results obtained from the Ermenek Municipality, from more than 40 parcels and more than 100 boreholes built by both state institutions and private companies, and by examining these reports in detail.

Experiments and results of the Geological Surveys on the land, the results of the laboratory experiments made on the samples taken, as well as the results obtained as a result of the Geophysical Surveys and seismic refraction tests carried out on the same plot, were presented in plots. Then, all data were transferred to a Geotechnical Analysis program known as Geotransportation, again separately. In the meantime, the building classes, number of floors, residence areas, estimated foundation models, foundation depths, Groundwater Levels and total building load of the structures built or planned to be built on the parcels were calculated and processed in the same analysis program. As seen below, 5 parcels selected from different regions and neighborhoods are presented in Tables 1-3.

Table 1. The working numbers of the examined parcels and underground water level

Work Number	Quarter	Plot	Parcel	Underground Water Level
1	Seyran	112	33	None
2	Taşbaşı	761	5	None
3	Meydan	460	36	None
4	Güllük	701	1	None
5	Değirmenlik	174	36	-3,00m

Table 2. Earthquake data of the examined parcels

Work Number	Vp Speed	Vs Speed	Vs30 Speed	To	Ss-Fs SDS	S1-F1 SD1	PGA PGV	TA-TB TL	TAD-TBD TLD
1	483	274	564	0,24	0,280-1,30	0,076-1,50	0,127	0,063-0,313	0,021-0,104
	2495	809			0,364	0,114	6,142	6,000	3,000
2	316	192	434	0,30	0,283-1,30	0,076-1,50	0,128	0,062-0,310	0,021-0,103
	1172	723			0,368	0,114	6,179	6,000	3,000
3	719	440	558	0,38	0,286-1,30	0,077-1,50	0,130	0,062-0,311	0,021-0,104
	1190	568			0,372	0,116	6,223	6,000	3,000
4	556	223	401	0,38	0,282-1,30	0,076-1,50	0,128	0,062-0,311	0,021-0,104
	1228	558			0,367	0,114	6,173	6,000	3,000
5	616	223	334	0,59	0,282-1,57	0,076-2,40	0,128	0,0082-0,411	0,027-0,137
	884	354			0,444	0,182	6,167	6,000	3,000

Table 3. Data on the buildings to be built on the examined parcels

Work Number	BF	BS (I)	EN	BHC	Bulding Foundation Depth (m)	Bulding Foundation Type	Bulding Foundation Area (m^2)	Bulding Total Weight (kN)
1	1	1,5	3a	6	-2,00	Raft	1097	104586
2	1	1,5	3a	6	-5,30	Raft	2950	103826
3	3	1	3a	5	-2,00	Continuous	175	34030
4	3	1	3a	6	-3,50	Continuous	1580	32282
5	3	1	3a	5	-2,00	Raft	280	29049

3. Geotechnical Analysis Results

After all the data were entered into the Geotransport Soil Analysis Program separately, the Controls for the Transport Forces, Settlement Amounts and Soil Liquefaction of all processed parcels were made as a result. Here again, the results of the 5 plots I mentioned above are presented in Tables 4-6.

Table 4. Analysis results of geotechnical bearing capacity of inspected parcels

Work Number	Bearing capacity analysis as per TBDY	Results
1	238,578>166	Sufficient
2	1252,286>200	Sufficient
3	2005,714>184	Sufficient
4	788,67>302	Sufficient
5	2331,429>151	Sufficient

Table 5. Analysis results Geotechnically Elastic fit amount and Consolidated fit amount of inspected parcels

Work Number	Elastic fit amount	Results	Consolidated fit amount and Results	Results
1	E.F.A. s=0,010m	Suitable	C.F.A. s=0,088m	Suitable
2	E.F.A. s=0,063m	Suitable	C.F.A. s=0,027m	Suitable
3	E.F.A. s=0,000m	Suitable	C.F.A. s=0,007m	Suitable
4	E.F.A. s=0,000m	Suitable	C.F.A. s=0,001m	Suitable
5	E.F.A. s=0,003m	Suitable	C.F.A. s=0,004m	Suitable

Table 6. Liquefaction Analysis results of inspected parcels

	Liquefaction Analysis	
Work number	Layer 1	Layer 2
1	Layer 1: 4,49>1,1 Suitable	Layer 2: 3,177>1,1 Suitable
2	Layer 1: 0,335<1,1 Suitable (Layer is above UWL)	Layer 2: 2,799>1,1 Suitable
3	Layer 1: 0,331<1,1 Suitable (Layer is above UWL)	Layer 2: 2,769>1,1 Suitable
4	Layer 1: 4,459>1,1 Suitable	Layer 2: 4,49>1,1 Suitable
5	Layer 1: 0,278<1,1 Suitable (Layer is above UWL)	Layer 2: 1,441>1,1 Suitable

4. Conclusion and Suggestions

The soil class determined in the district is mainly ZC class and has a structure mainly composed of limestones. In the analysis made in the examined parcels, it was seen that it has sufficient and suitable properties in terms of Bearing Power, Elastic and Consolidated Settlement Amounts and Liquefaction potential. It has been concluded that there is no need for any ground improvement for these structures planned to be built on the said parcels. In addition, the results of these geotechnical analyzes in higher building loads and multi-storey structures, can be examined and even examination can be made about how far the endpoints can be.

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Author contributions

Fevzi Sevimli: Conceptualization, Methodology, Data supply, Writing-Original draft preparation, **İsa Kul:** Writing-Reviewing and Editing.

Conflicts of interest

The authors declare no conflicts of interest.

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