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Evaluation of the soil conditions in Alikahya Region (İzmit)

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ABSTRACT

In this study, the soil conditions of Alikahya region (İzmit) were investigated by the results of geological, geophysical and geotechnical survey results. Alikahya region is almost entirely located on sub-mid-upper Eocene aged rocks and Quaternary aged sediments. The alluvium thickness is nearly 300 m. According to seismic studies, P-wave velocities are between 277-2562 m / sec, and S-wave velocities are between 110-1427 m / sec in the study area. The local soil classes were found Z-3 on the clay stones and Z-4 on the Quaternary aged alluvium, respectively. The ground water level varies between 1-2 m depths in the alluvium. Alikahya region located on first degree earthquake risk zone. Liquefaction analysis results indicated that the region has liquefaction potential.

Introduction

Since our country is located on an active tectonic belt, it has a suitable topography for natural disasters such as earthquakes and landslides. This reveals the necessity of determining safe and risky areas in terms of soil properties in the planning of residential areas. Especially the losses and damages experienced in the Izmit and Düzce earthquakes in 1999 have contributed to the development of earthquake awareness and sensitivity about the precautions to be taken against possible earthquakes in our country.

Local ground conditions also play an important role in the assessment of earthquake risk for residential areas, as well as features such as the probability of an earthquake, its magnitude and distance from the study area. While seismic waves pass through the soil layers, their properties can change according to the local soil conditions and can decrease or increase the earthquake forces acting on the structures located on the ground surface [1]. Likewise, during the propagation of earthquake waves, the properties of the soil layers can also change. For this reason, detailed investigation of local soil conditions in areas with high earthquake risk is of great importance in terms of developing earthquake resistant structure design and minimizing the damages that may occur.

In this study, the soil properties of the Alikahya region of Izmit province were examined with the research results of geological, geophysical and geotechnical methods and the suitability of the region for settlement was investigated. In this direction, field studies such as drilling, seismic refraction, and laboratory results on soil samples were examined in detail. Considering the earthquake hazard of the region, the liquefaction risk of the soils was also investigated.

Geology and Tectonics

Alikahya Region is located in the eastern part of Izmit province. According to the geological data, the Izmit Basin extending from Izmit Bay to Sapanca consists of Quaternary and Pliocene aged sediments, and a transition towards older and solid soils is observed towards the north and south of the Izmit Basin. In the parts close to Izmit Bay, transitions to Lower-Middle Eocene aged sandstone, conglomerate, shale and mudstone are observed. In the Alikahya Region, Quaternary aged alluvium is generally formed by consecutive clay-sand-silt. The unit observed in the northern parts of the study area has a medium-hard rock quality in terms of engineering. The unit is may

described as cracked and fractured. The waters seeping into these cracks and fractures decomposed the rock. Alteration is observed in the surface sections of the unit where it comes into contact with water.

The study area is located on the North Anatolian Fault (NAF). The North Anatolian Fault (NAF) is approximately 1500 km long and is one of the most active faults in Turkey and the world. The NAF splits into two branches from the Mudurnu Stream valley in the west of Izmit Bay. The northern branch forms the Izmit-Sapanca segment, and the southern branch forms the Geyve-Iznik branch. Different structural models have been proposed for this branch of the NAF. The first of these is the right-sided strike-slip system model with a vertical slip component of the NAF in the Gulf of Izmit and the Sea of Marmara [2]. In another model, in which seismological data are also used, it is suggested that the trough areas in the Gulf of Izmit and the Sea of Marmara are grabens developed due to gravitational forces [3]. In the third model, it is assumed that the northern branch of the NAF zone is represented by many fault segments and that there are pull-apart basin structures between these stepped segments [4-5].

Geophysical Research

Field study results of 18 seismic refraction measurements were used to determine the geophysical properties of the soils in the study area. Based on these measurements, layer thicknesses, underground velocity structure, dynamic-elastic engineering parameters of the soils were determined. Table 1 contains the information about the seismic refraction measurement results taken in the first 4 profiles. In the seismic refraction measurements performed along 18 profiles, the longitudinal wave velocities of the soils Vp were measured between 277 – 2562 m/sec and shear wave velocities Vs between 110 – 1427 m/sec.

Table 1. Dynamic parameters

Profile No Layer No	Vp m/sn	Vs m/s	Pre. period sn	Thickness m	Bulk M. kg/cm²	Density gr/cm³	ElasticityM. kg/cm²	Poisson Rate	Shear M. kg/cm²
P-1/L1	384	129	0.70	2.09	1719	1.37	656	0.43	228
P-1/L2	963	401	"	7.79	12312	1.73	7748	0.73	2776
P-1/L3	1593	782	"		33730	1.96	32127	1.96	11976
P-2/L1	376	150	0.48	2.12	1520	1.37	863	0.40	307
P-2/L2	1323	627	"	9.10	22924	1.87	19920	0.35	7349
P-2/L3	1894	961	"		48179	2.05	50111	0.32	18886
P-3/L1	351	130	0.68	1.92	1350	1.34	644	0.42	226
P-3/L2	873	410	"	8.71	9065	1.69	7696	0.35	2832
P-3/L3	1688	910	"		34677	1.99	42622	0.29	16454
P-4/L1	339	120	0.66	1.81	1273	1.33	547	0.42	191
P-4/L2	956	452	"	7.10	11058	1.72	9551	0.35	3521
P-4/L3	1859	977	"		44439	2.04	50875	0.30	19429

Geotechnical Research

14 drilling studies and laboratory test results of the samples obtained from the drillings were used in determining the geotechnical properties of the soils in the study area. According to the drilling data, the groundwater level in the study area varies between 1 and 3 m. The average of the number of SPT blows determined during drilling is 16 for the study area. According to the unified soil classification (USCS), there are predominantly ML and CH group soils in the region. Average cohesion values (c) vary between 0.22 – 0.56 kg/cm^2, and internal friction angle (Ø) vary between 5.20° and 33.4°, according to the results of the triaxial pressure test performed especially for loose soil zones in the study area. The soils in the study area were also classified according to the Regulation on the Structures to be Built in Disaster Areas, which was issued by [6]. According to this; In the sections with rock units, the soil class is Z-3 soil group B, and in the alluvial region with low slope, the soil class Z-4 soil group is D.

Liquefaction Risk

The liquefaction susceptibility of soils is evaluated by the calculated liquefaction safety number using simplified procedures. In this approach, the cyclic shear stresses caused by the earthquake and the cyclic resistance of the soil to liquefaction are compared. The most common field test used to evaluate the resistance of soils to liquefaction is the standard penetration test (SPT). SPT, which is a dynamic penetration test, is one of the most frequently used tests in soil investigations in our country. SPT results are used in liquefaction analysis as well as successfully predicting the firmness and shear resistance properties of especially granular soils. SPT-based liquefaction analysis was first proposed by [7] and has been improved over time. Today, especially with the

procedure proposed by [8], it has become a widely used method to determine the liquefaction sensitivity of sands in Turkey as well as in many countries of the world.

In determining the liquefaction potential of the soils in the study area, liquefaction analyzes based on SPT results were carried out in accordance with the purpose of the study with the obtained drilling information. In this context, using the simplified procedure proposed by [7], the safety coefficients (FS) were calculated for all sandy levels. Considering the earthquake hazard of the region and previous studies, the maximum horizontal ground acceleration was evaluated as a_{max} = 0.40g and the earthquake magnitude as Mw = 7.5, in the study. The safety coefficients obtained as a result of the calculations were used to determine the levels with and without liquefaction potential. Levels with a factor of safety less than 1 are considered liquefiable, while levels greater than 1 are considered non-liquefiable. Some liquefaction analysis results of the soils in the study area are given in Table 2.

Table 2. Some liquefaction analysis results in the study area

SK No	Z (m)	Water Level (m)	FC (%)	Unit Weight kN/m³	$N1_{60}$	CSR	CRR	FS
SK1	3,00	2,44	45,08	19,57	16,50	0,281	0,176	0,63
SK3	3,00	1,9	35,18	19,75	36,00	0,311	0,374	1,20
SK3	4,50	1,9	24,15	19,99	19,50	0,353	0,209	0,59
SK4	3,00	2,2	46,36	19,56	18,50	0,294	0,197	0,67
SK8	3,00	2,8	45	20,10	32,20	0,265	0,318	1,20

Conclusion

In this study, geological, geophysical and geotechnical data were used together to determine the soil properties and liquefaction potential of Izmit province Alikahya region. While there are sandstone, conglomerate, shale and mudstone units in the north of the study area, the remaining areas are represented by Quaternary aged alluvium. Seismic velocities and SPT impact numbers were found to be low, especially at near-surface depths throughout the study area. According to the liquefaction analyzes made considering the earthquake hazard and loose soil structure of the region, it has been determined that some local areas in the study area are at risk of liquefaction (Table 2). It will be beneficial to use the necessary soil improvement methods for new constructions to be made in areas with liquefaction risk in the region.

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