INTERNATIONAL
EARTHQUAKE SYMPOSIUM KOCAELI 2007
22-26 OCTOBER 2007

LIQUEFACTION ANALYSIS of YOUNG SEDIMENTS in WESTERN PART of İZMİT BASIN

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Key Words: İzmit Basin; Liquefaction; Liquefaction Analyses

ABSTRACT *The İzmit Basin has developed under the control of North Anatolian Fault Zone (NAFZ). The basin is morphologically located in a plain between the Kocaeli Peneplane in the north and the Samanlıdağ Highlands in the south. NAFZ covering the study area in east west direction affects the region. Layers of sand and silty sand deposits are widespread in the alluvial basin. The groundwater level is considerably shallow. Soil liquefaction and settlements due to seismic shaking were assessed by this study. Necessary borings, field and laboratory tests are densely existent in the western part of the basin. Thus, liquefaction studies were mainly performed in the western part of the basin at Saraybahçe, Kullar and Kosekoy areas. Two evaluation methods were carried out for soil liquefaction analyses based on soil and seismic properties. A computer program assessed soil liquefaction potential of coarse grained soils based on Seed and Idriss approach originated in 1971. SPT N_{30} values of coarse grained soils were used in the liquefaction analyses and settlements due to liquefaction and seismic shaking were also determined. This method which is called Standard Liquefaction Analysis indicated that 36 out of 61 borings had liquefaction potential in different sand and gravelly sand levels. Calculated total average settlements varied from 7.83 to 13.27 cm. The lowest average settlement was observed in Saraybahçe area. The results obtained from standard liquefaction analyses were imported to Geographical Information System (GIS) to map the liquefaction potential and seismic settlements. The second method, Modified Chinese Criteria (MCC), was performed for liquefaction susceptibility of fine grained soil layers. This method which takes into account consistency and index properties of soils identified two boring areas that are susceptible to liquefaction. LL versus W_n graphs displayed the results of this method.*

INTRODUCTION

Dynamic loads generated by an earthquake may cause different soil behaviors depending on the nature of the soil and morphology. Liquefaction is defined as temporary strength loss of saturated coarse grained soils under dynamic loads. The study area, İzmit Basin, is located in the first degree earthquake zone according to General Directory of Disaster Management Earthquake Research Office map (DAD, 1996). The earthquake hazard by the north strand of NAF can initiate liquefaction for the İzmit Basin soils sustaining liquefaction conditions. This study investigates the liquefaction potential and susceptibility of the young sediments of western part of the İzmit Basin. A similar study was performed by Monsoor et al. (2004) for Aqaba (Jordan) city.

The study area is located in the Kocaeli Province in northwestern part of Turkey (Figure 1). The basin extends from Sapanca Lake to İzmit Bay in east-west direction and is bounded by higher elevations in north and south. Geotechnical investigations were densely performed for Saraybahçe (Geos, 2000), Kullar (Megason, 2000) and Köseköy

(Seta, 2000) settlements located in the western part of the basin. The data gathered from these three main settlement areas were used in the analyses and evaluation (Figure 1). Geology of the study area and the region consists of two tectonic units brought together by the NAF. The tectonic unit in north composed of sedimentary lithologies from Paleozoic to Quaternary, while the south tectonic units start with the metamorphic bedrocks overlain by Tertiary volcanic rocks and Pleistocene terrestrial sedimentary units. The basin located in between these two tectonic units consists of Quaternary alluvial and fluvial sediments covering the tectonic units in the middle of the basin and Pleistocene terrestrial sedimentary units deposited along the edges of the basin. Coruk et al. (1997) defined the topmost 70 meters soil zone of the basin in the middle section as clayey-silt (0-10 m) underlined by sand-gravelly sand (10-40 m) and impermeable blue-green clay between 40 and 70 meters.

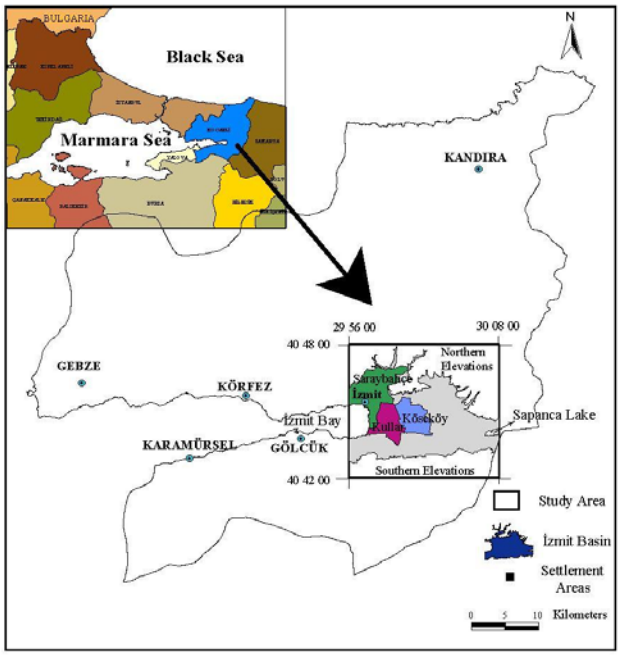

Figure-1. Study area location map.

METHODOLOGY

The liquefaction potential of young sediments deposited in western part of İzmit Basin was performed by the standard and Modified Chinese Criteria (MCC) liquefaction assessment methods (Karakaş, 2005). Field, laboratory and seismological data were gathered from several sources for accomplishing the assessments. Boring logs and soil laboratory data were obtained from previously performed engineering geology and geotechnical investigations. Basic data sources for this study are 169 boring logs and laboratory test results of soil samples taken at different depths. Boring logs define detailed lithological descriptions, SPT N_{30} blow counts, groundwater depth, and extraction type and depth of soil samples. Laboratory test results indicate engineering and index parameters of the soils. Table 1 displays the number, location, minimum, maximum and average depths of the borings used and total settlement values obtained in this study.

Two methods evaluated the young deposits for liquefaction. The first method is the standard liquefaction method applied to the coarse grained soils (sand, gravelly sand, silty or clayey sand) based on soil strength calculated by SPT N_{30} values versus the earthquake load. An earthquake magnitude of 7.4 and acceleration value of 0.4 g were considered in this method. The standard liquefaction analyses performed by a computer program LiquefyPro (CivilTech, 2002) assessing the soil liquefaction potential of coarse grained soils based on Seed and Idriss approach originated in 1971. LiquefyPro is

software that evaluates liquefaction potential and calculates the settlement of soil deposits due to seismic loads based on NCEER (1997) guidelines. The second method, Modified Chinese Criteria (MCC), evaluated the fine grained soils (silt and silty soils) for liquefaction susceptibility in the study area based on soil index properties. Wang (1979) developed the Chinese Criteria Method to define the liquefaction susceptibility of fine grained soils. Perlea et al. (1999) modified this method based on the ASTM standards. Obtained results from both methods were evaluated and displayed in GIS and on the graphs. Figure 2 shows the steps followed for this study.

Table-1. General information for the boring logs.

Boring Area	**# of Total Borings**	**# of Borings Used in the 1st Method**	**# of Borings Used in the 2nd Method**	**Boring Depth (m)**			**Total Settlement (cm)**		
				Min.	**Max.**	**Avg.**	**Min.**	**Max.**	**Avg.**
Saraybahçe	92	20	18	5.55	40.95	16.35	4.96	38.05	10.10
Kullar	18	18	11	9	18	14.92	2.27	23.92	13.27
Köseköy	59	23	43	15	30	17.29	0.18	39.29	7.83

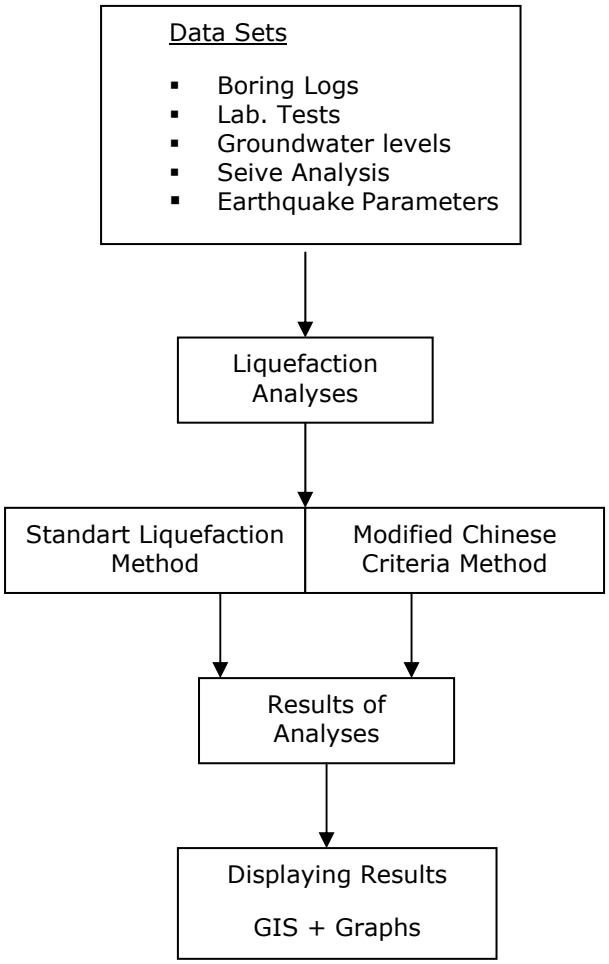

Figure-2. Methodology flow chart of liquefaction assessment followed in this study.

CONCLUSIONS

Soil liquefaction, one of the ground behaviors during the earthquakes, was studied in this study for western part of the İzmit Basin. Different soil behaviors resulted based on soil type, physical parameters of these soils and the groundwater levels. First, LiquefyPro program (CivilTech, 2002) evaluated the liquefaction potential of coarse grained soils. This program evaluates each boring individually and calculates liquefaction potential and liquefaction related total settlements. This method which is called Standard Liquefaction Analysis indicated that 36 out of 61 borings had liquefaction potential in different sand and gravelly sand levels. Calculated total average settlements varied from 7.83 to 13.27 cm. The lowest average settlement was observed in Saraybahçe area. The maximum settlement value was noticed in Köseköy area. Minimum and maximum total settlement values varied from 4.96 cm to 38.05 cm for Saraybahçe, from 2.27 cm to 23.92 cm for Kullar and 0.18 cm to 39.29 cm for Köseköy. Soil levels with liquefaction potential were mainly located in south of Saraybahçe, north, north-west and –east of Kullar and north, northwest, southeast of Köseköy areas. The results obtained from standard liquefaction analyses were imported to Geographical Information System (GIS) to map the liquefaction potential and seismic settlements in İzmit Basin.

Liquefaction susceptibility of fine grained soils (silts, clayey silts) was analyzed by modified Chinese Criteria Method. This method uses geotechnical parameters of soil samples taken from the different levels of the borings (LL, w_n, PI, % fine content). Data of Liquid limit (LL) and water content (W_n) parameters were plotted on the graphs to determine liquefaction susceptibility of soils. This method taking into account consistency and index properties of soils identified two boring areas that are susceptible to liquefaction. Thus, liquefaction susceptibility of fine grained soils of the western part is very low.

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