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Natural Hazards and Earth System Sciences

Liquefaction severity map for Aksaray city center (Central Anatolia, Turkey)

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Abstract. Turkey having a long history of large earthquakes have been subjected to progressive adjacent earthquakes. Starting in 1939, the North Anatolian Fault Zone (NAFZ) produced a sequence of major earthquakes, of which the Mw 7.4 earthquake that struck western Turkey on 17 August 1999. Following the Erzincan earthquake in 1992, the soil liquefaction has been crucial important in the agenda of Turkey. Soil liquefaction was also observed widely during the Marmara and the Düzce Earthquake in 1999 (Sönmez, 2003). Aksaray city center locates in the central part of Turkey and the Tuzgolu Fault Zone passes through near the city center. The fault zone has been generated to moderate magnitude earthquakes. The geology of the Aksaray province basin contains Quaternary alluvial deposits formed by gravel, sand, silt, and clay layers in different thickness. The Tuzgolu Fault Zone (TFZ) came into being after the sedimetation of alluvial deposits. Thus, the fault is younger from lithological units and it is active. In addition, the ground water level is very shallow, within approximately 3 m from the surface. In this study, the liquefaction potential of the Aksaray province is investigated by recent procedure suggested by Sonmez and Gokceoglu (2005). For this purpose, the liquefaction susceptibility map of the Aksaray city center for liquefaction is presented. In the analysis, the input parameters such as the depth of the upper and lower boundaries of soil layer, SPT-N values, fine content, clay content and the liquid limit were used for all layers within 20 m from the surface. As a result, the category of very high susceptibility liquefaction class was not observed for the earthquake scenario of Ms=5.2, 4.9% of the study area has high liquefaction susceptibility. The percentage of the moderately, low, and very low liquefied areas are 28.2%, 30.2%, and 36.3%, respectively. The rank of non-liquefied susceptibility area is less than 1%.

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1 Introduction

Turkey has a long history of large earthquakes along the North Anatolian Fault Zone (NAFZ). The Anatolian Block is moving westward by lateral extrusion as a consequence of north-south convergence between Africa-Arabia and Eurasia Plates (Sengor et al., 1985). The compression of the Anatolian Block is responsible for complex deformation of the North Anatolian Fault Zone (NAFZ) that causes major earthquakes along the fault (Fig. 1). The Tuzgolu (Salt Lake) Fault Zone is one of the main tectonic elements of the Central Anatolia. It extends from the Tuzgolu to the Aksaray city center. The associations between the Tuzgolu Fault Zone and the alluvial deposits have been threaten to the Aksaray city center. Aksaray city is an place that growing up 400% exponential in last twenty years (Turkish Statistical Institute, 2007). However, geotechnical assessment has been got behind in the new residential areas. There is a liquefaction potential in the place due to appropriate materials, high level ground water, and earthquake hazard. For this reason, suitable site selection and planning for settlement areas and other engineering construction, assessment of liquefaction potential of a liquefaction-prone area is one of the important missions in geotechnical engineering as in the Aksaray city center (Fig. 2). Several methods were recommended to evaluate the liquefaction potential of sandy soils due to earthquakes (Iwasaki et al., 1982). The experimental criterion based on SPT-N values has been most popular or commonly preferred for evaluating the liquefaction assessments in most countries and in Turkey.

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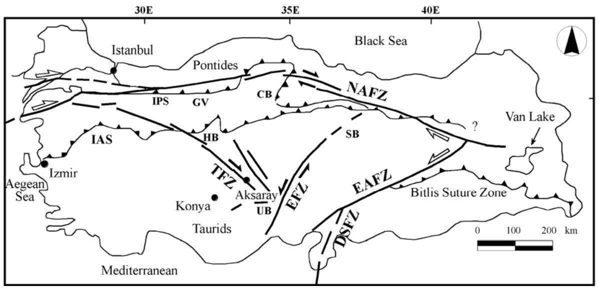

Fig. 1. The major basins and tectonic elements of the Central Anatolia (NAFZ- the North Anatolian Fault Zone, EAFZ- the East Anatolian Fault Zone, TFZ- the Tuzgolu Fault Zone, EFZ- the Ecemis Fault Zone, DSFZ- the Dead Sea Fault Zone, IAS- the Izmir-Ankara Structure Zone, IPS- the Intrapontide Structure Zone, GV- the Galatian Volcanics, CB- the Cankiri Basin, SB- the Sivas Basin, UB- the Ulukisla Basin) (after Cemen et al., 1999).

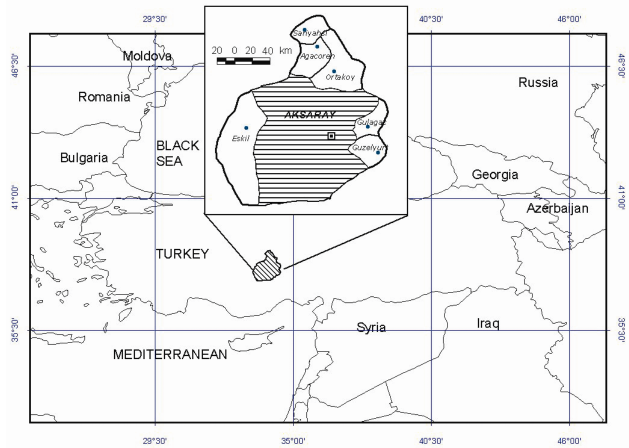

Fig. 2. Location map of the study area.

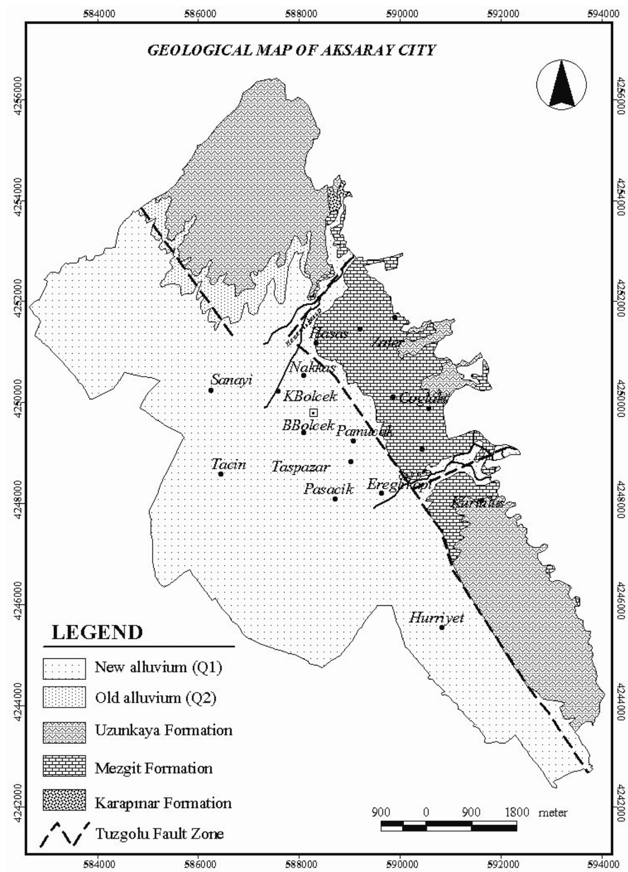

Fig. 3. The geological map of the study area (after Gullu, 2003).

Seed and Idriss (1971) proposed a simplified procedure based on SPT-N values for the assessment of liquefaction resistance of soils after two large and catastrophic earthquakes occurred in Alaska and in Niigata (Japan) in 1964. The original simplified procedure based on empirical rules has been modified and improved over the years (Seed, 1983; Seed et al., 1985; Seed and DeAlba, 1986; Seed and Handler, 1990). The factor of safety against liquefaction (F_L) on the basis of the SPT is designated by the ratio of the cyclic resistance ratio (CRR) to cyclic stress ratio (CSR). While a soil layer with a factor of safety (F_L) greater than 1.2 and between 1.0 and 1.2 are defined as non-liquefied and marginally liquefiable, respectively, soil with an F_L less than 1.0 is considered liquefiable (Ulusay and Kuru, 2003). Determining the F_L for a soil layer gives some information of liquefaction but it is a not adequate appliance for evaluation of liquefaction severity. In addition, F_L is not a functional parameter to arrange liquefaction severity maps for liquefaction-prone areas. In this study, factor of safety (F_L), probability of liquefaction (P_L), and liquefaction severity index (L_S) relations were explicated and a liquefaction susceptibility map for liquefaction-prone areas in Aksaray, Turkey is prepared by considering the liquefaction severity categories.

2 Geological and hydrogeological characteristics of the study area

The geology of the Aksaray province is dominated by Quaternary alluvial sediments. Figure 3 shows the simplified geological map of the Aksaray city. The rock units in Aksaray region belong to Paleocene-Eocene, Oligo-Miocene, Pliocene, and Quaternary periods. The rock units of the Paleocene-Eocene are found in the north of the centrum, namely, in Yunuskent, Ciftlik, and Hamambogazi regions. They show a volcano-sedimentary stratigraphy and consist of yellow, yellow-green sandstone and evaporite. The Oligo-Miocene series trending NW-SE are characterized by conglomerate, sandstone, mudstone, and claystone which are known as Mezgit Formation (Tromp, 1942), crop out in the Zafer, Kurtulus, and Bedirmuhtar regions. Sandstone, siltstone, marl and mudstone of Pliocene known as Uzunkaya

Formation (Beekman, 1966) are observed in the north and east of the region. The formation overly the most expansive area after Quaternary units.

The Quaternary deposits are described by the new and old alluvial soils. Old alluvium soils are found as a narrow strip in the north of the Aksaray city, namely, in Yenimahalle, Somuncubaba, and Ciftlik regions. It is overlain by the new alluvial soils in the city center towards south and south east. The Aksaray city is a broad, flat, Tuzgolu Fault bounded plain traversed by two main rivers, the Ulu River in the east and the Hamambogazi River in the northeast. The Ulu River comes from the east to the plain, the slope decreases from a rather steep descent in the mountains to the about flat surface of the basin floor. This abrupt change of slope causes rapid deposition of sediment. The deposition and redistribution of the Quaternary sediments carried into the basin by these rivers has led to the gathering of thick unconsolidated alluvial plain deposits composed of intercalated gravel, sand silt and clay layers. Because of the rapid and dynamic sedimentation process, the deposits vary from well to poorly graded and are generally loosely compacted.

Considering the quality of the data required for liquefaction analysis, seventy-seven boreholes were selected from the boreholes drilled by Orta Anadolu Jeoloji Muh. Company in the Aksaray city for geotechnical purposes. The ground water table in the drill holes was measured and the groundwater level generally ranges between 3 and 9.5 m below the ground surface. The existence of a groundwater table within 10 m from surface and loose granular alluvial deposits increases the susceptibility of liquefaction potential of the soils.

3 Tectonic setting

The major tectonic plates in the eastern Mediterranean region are shown in Fig. 1. The Anatolian block has been moving to the west along the North Anatolian Fault Zone (NAFZ) since the Pliocene (Barka, 1997). The important tectonic features within the area are the Tuzgolu Fault Zone, the Yeniceoba Fault Zone, the Cihanbeyli Fault Zone (Fig. 4) and in the south-east, the Ecemis Fault Zone (Fig. 1). In addition, the Central Anatolian Volcanic Province (CAVP) (Fig. 4) is situated between Kirsehir and Nigde massifs that collectively constitute the Central Anatolian crystallen complex, and CAVP of Neogene-Quaternary age extendes as a volcanic axis of about 300 km in NE-SW direction in the Central Anatolia, Turkey. The formation and evaluation of the CAVP has been usually attributed to the convergence between Afro-Arabian and Eurasian plates (Ercan et al., 1990, Goncuoglu and Toprak, 1992). The major Tuzgolu Fault cuts across the CAVP with a NW-SE direction. The Tuzgolu Fault Zone is a NW-SE trending intracontinental fracture zone, approximately 190 to 200 km long and 5 to 25 km wide, extending from north of Tuzgolu to south-east of Aksaray (Dirik and Goncuoglu, 1996). In the north-western part of

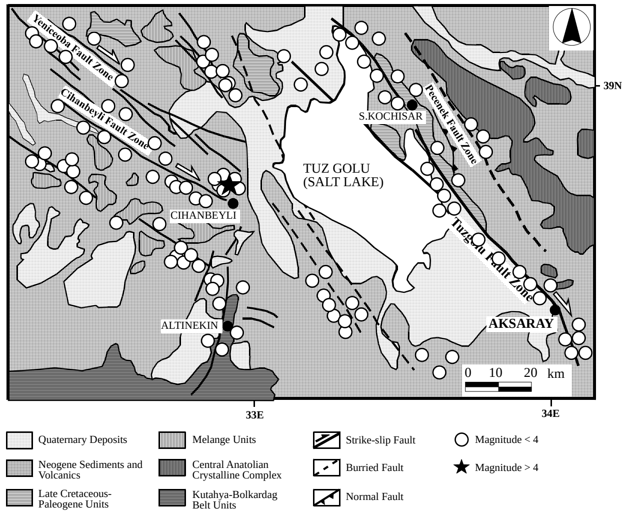

Fig. 4. The seismogeological map of the Tuzgolu basin and its close vicinity (after Cemen et al., 1999).

the Tuzgolu, two parallel fault zones extend from Yeniceoba and Cihanbeyli northwestward, namely, the Yeniceoba Fault Zone and the Cihanbeyli Fault Zone. These faults bring Paleozoic basement rocks and overlying sedimentary succession to the surface (Cemen at al., 1999). The Ecemis Fault Zone is one of the major structures of Turkey and a NE-SW trending normal-oblique left-lateral strike-slip characteristic is shown. Approximately 2 to 15 km wide, extending from north of Mersin to south-west to Sivas-Refahiye (Dirik and Goncuoglu, 1996). These fault zones have been generated to earthquake different magnitude. Besides, Fig. 4 shows the earthquake in Tuzgolu basin at the last one year, at the same time in the Tuzgolu, the Yeniceoba, the Cihanbeyli, and the Ecemis Fault zones.

4 Liquefaction assessment

Liquefaction occurs in saturated loose soils, that is, soil layers within 20 m from ground surface with the F_L values less than 1.0 are appraised as liquefiable. The condition $F_L>1$ indicate that the soil is classified as non-liquefiable, if $F_L<1$ show that the unit is categorized liquefiable. However still, these limits are theoretical assets and don't adduce to absolute results. For realistic liquefaction assessments, detailed geological and seismological data sets are required, such as SPT-N values, clay content (CC), fines content (FC), liquid limits for soils etc. In addition, liquefaction potential index (L_I) and its severity categories were suggested by Iwasaki et al. (1982) for resolving restriction of F_L. In this research, Iwasaki et al. (1982) proposed a liquefaction index (L_I) is

Table 1. Liquefaction potential categories suggested by Iwasaki et al. (1982).

Liquefaction index (L_I)	Liquefaction potential
0	Very low
$0 < L_I \leq 5$	Low
$5 < L_I \leq 15$	High
$15 > L_I$	Very high

Table 2. Liquefaction severity categories based on L_S (Sonmez and Gokceoglu, 2005).

Liquefaction index (L_I)	Liquefaction potential
0	Non-liquefiable (based on $F_L \geq 1.411$)
$0 < L_I \leq 2$	Low
$2 < L_I \leq 5$	Moderate
$5 < L_I \leq 15$	High
$15 > L_I$	Very high

explained by the succeeding equations.

$$L_I = \int_0^{20} F(z) W(z) dz \tag{1}$$

$$F(z) = 1 - F_L \text{ for } F_L < 1.0 \tag{2a}$$

$$F(z) = 0 \text{ for } F_L \geq 1.0 \tag{2b}$$

$$F(z) = 10 - 0.5z \text{ for } z < 1.0 \tag{2c}$$

$$W(z) = 0 for z > 20\,\mathrm{m} \tag{2d}$$

where z is the depth from the ground surface in meters. Iwasaki et al. (1982) proposed four classes termed as *very low*, *low*, *high*, and *very high* for liquefaction severity (Table 1). Non-liquefiable group could not be discriminated by Iwasaki et al. (1982), to bring expansion these issue, Sonmez (2003) modified $F(z)$ term appearing the equation of L_I by considering the threshold value of 1.2 between the non-liquefiable and marginally liquefied categories as follow:

$$F(z) = 0 for F_L \geq 1.2 \tag{3a}$$

$$F(z) = 2 \times 10^6 e_L^{-18.427F} \text{ for } 1.2 > F_L > 0.95 \tag{3b}$$

$$F(z) = 1 - F_L \text{ for } F_L < 0.95 \tag{3c}$$

As a result of evaluations, Sonmez (2003) proposed new classification categories called as *non-liquefiable*, *low*, *moderate*, *high*, and *very high* for liquefaction potential (Table 2).

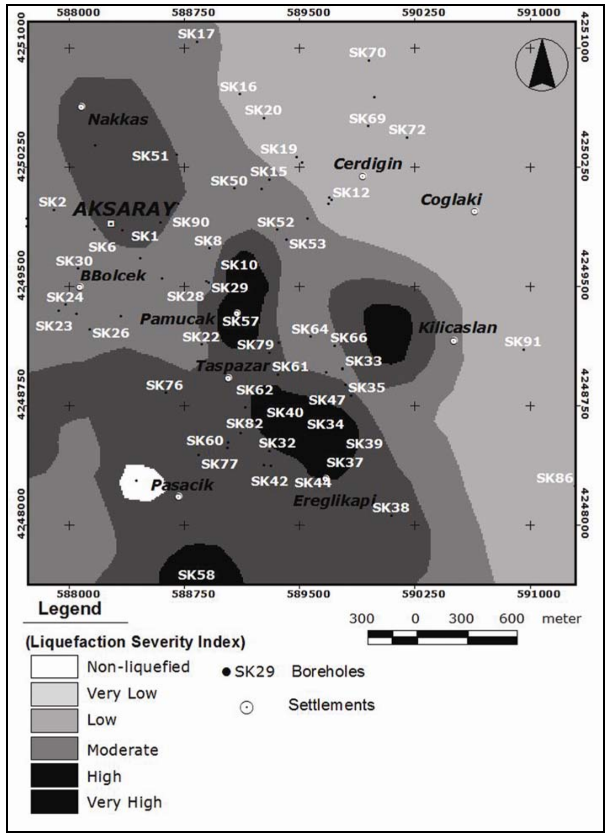

Fig. 5. The liquefaction severity map of Aksaray city center.

The probabilities of soil liquefaction are related to the value of F_L (Chen and Juang, 2000). The probability of liquefaction has been calculated by P_L equation (Juang et al., 2003). This value strolls from zero to one as a function of F_L.

$$P_L = \frac{1}{1 + (F_L/0.96)^{4.5}} \tag{4}$$

Chen and Juang (2000) suggested to the classification of probability of liquefaction (Table 3). Juang et al. (2003) substituted the $F(z)$ illustrate of the L_I index suggested by Iwasaki et al. (1982) with P_L and also renamed L_I as liquefaction risk index (I_R).

$$I_R = \int_0^{20} P_L(z) W(z) dz \tag{5}$$

Iwasaki et al. (1982), Sonmez (2003), and Lee et al. (2003) were suggested to the liquefaction indices using for the preparation of liquefaction susceptibility maps. Therefore, to bring new perspective in this issue, Sonmez and Gokceoglu (2005), the term *liquefaction severity index* (L_S) is preferred instead of *liquefaction risk index* (L_R) suggested by Lee et al. (2003).

Table 3. The classification of the liquefaction probability based on P_L (Chen and Juang, 2000).

Probability (P_L) ranges	Description	Factor of safety (F_L) ranges calculated from Eq. 4
$0.85 \leq P_L < 1.00$	Almost certain that it will liquefy	$0.653 \geq F_L > 0.000$
$0.65 \leq P_L < 0.85$	Very likely	$0.837 \geq F_L > 0.653$
$0.35 \leq P_L < 0.65$	Liquefaction/non-liquefaction is equally likely	$1.102 \geq F_L > 0.837$
$0.15 \leq P_L < 0.35$	Unlikely	$1.411 \geq F_L > 1.102$
$0.00 \leq P_L < 0.15$	Almost certain that it will not liquefy	$\infty \geq F_L > 1.411$

Table 4. Liquefaction severity categories based on L_S (Sonmez and Gokceoglu, 2005).

Liquefaction severity (L_S)	Description
$85 \leq L_S < 100$	Very high
$65 \leq L_S < 85$	High
$35 \leq L_S < 65$	Moderate
$15 \leq L_S < 35$	Low
$0 < L_S < 15$	Very low
$L_S = 0$	Non-liquefiable

Sonmez and Gokceoglu (2005) was explained in the following stages for construction of the liquefaction severity classification:

Stage 1: *W(z)=10-0.5z* is put into the Eq. 5 and it was rewritten.

$$L_S = \int_0^{20} P_L(z)(10 - 0.5z)dz \tag{6a}$$

Stage 2: F_L value appearing in $P_L(z)$ equation is assumed as a constant from the ground surface to a depth of 20 m, and Eq. 6a was solved.

$$L_S = P_L(z)\left(10z - \frac{z^2}{4}\right)\Big|_0^{20} \tag{6b}$$

$$L_S = 100 P_L(z) \tag{6c}$$

Stage 3: Boundary values of L_S are derived from Eq. 6c for each P_L value given in Table 3, and tabulated in Table 4 with liquefaction susceptibility descriptions.

As a result of these evaluation, Sonmez (2003) proposed as non-liquefiable soil layer if $F_L > 1.2$ and but, as non-liquefiable limit was suggested by Sonmez and Gokceoglu (2005) to much more meaningful values (F_L=1.411) considering the function the probability of liquefaction given in Eq. 4. The $P_L(z)$ term of L_S is assumed as equal to zero for the layer with $F_L > 1.411$. Youd et al. (2001) pointed out if the corrected SPT-N value ($N_{1(60)cs}$) is greater than 30 in the SPT-based method, F_L couldn't be designated, and the predicted the cyclic resistance ratio (CRR) for the soil layer involving more than 35% fines content may be protective. For that reason, Youd et al. (2001) suggest that the rectifications based on fines content should be used with engineering decision and concern. Similarly, soil layer with $F_L < 1.0$ can be assessed as non-liquefiable based on some criteria such as offered by Finn et al. (1994), and Andrews and Martin (2000), which consider Clay Content and Liquid Limit. Therefore, if the soil layer is appraised as non-liquefiable based on the futures of fines, the P_L(z) term is assumed as equal to zero to distinguish non-liquefiable area (Table 5) (Sonmez and Gokceoglu, 2005).

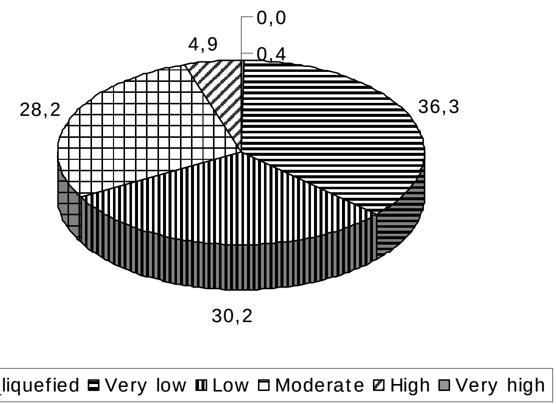

Fig. 6. Pie charts showing the areas of the severity zones.

The equations to be used for the designation of L_S are given below.

$$L_S = \int_0^{20} P(z)W(z)dz \tag{7}$$

$$P_L(z) = \frac{1}{1 + (F_L/0.96)^{4.5}} \text{ for} F_L \leq 1.411 \tag{8}$$

$$P_L(z) = 0 \text{ for } F_L > 1.411 \tag{9}$$

or the soil layer with $F_L \leq 1.411$ can be considered as non-liquefiable layer considering Clay Content and Liquid limit.

In Eq. 6, the term of $W(z)$ is as same as in Eq. 2c and d.

Table 5. Liquefaction severity index values for Aksaray city.

Borehole no	Coordinates N	Coordinates E	Depth of GWT (m)	L_S	Liquefaction severity class
SK-1	588490.11	4249678.07	3.50	38.07	Moderate
SK-2	587946.89	4249986.41	3.50	20.14	Low
SK-3	587774.16	4249930.89	4.00	37.78	Moderate
SK-4	588458.99	4249808.82	4.50	32.70	Low
SK-5	588194.23	4250036.17	5.00	37.32	Moderate
SK-6	588379.71	4249854.81	4.00	27.30	Low
SK-7	588203.61	4249862.04	3.50	31.36	Low
SK-8	588926.52	4249742.81	6.50	20.14	Low
SK-9	587774.74	4249879.11	3.50	20.14	Low
SK-10	589120.91	4249589.49	4.50	70.02	High
SK-11	589675.12	4250025.33	9.00	30.81	Low
SK-12	589697.55	4250046.91	9.00	20.14	Low
SK-13	589507.82	4250282.49	7.50	28.21	Low
SK-14	589682.98	4250060.33	8.50	20.14	Low
SK-15	589305.81	4250174.89	6.50	30.37	Low
SK-16	589117.31	4250712.45	5.50	20.14	Low
SK-17	588850.87	4251041.86	7.50	26.41	Low
SK-19	589477.64	4250318.51	6.00	19.87	Low
SK-20	589272.41	4250563.74	7.00	20.74	Low
SK-21	589543.11	4249930.59	5.00	39.20	Moderate
SK-22	588880.46	4249135.04	4.50	19.87	Low
SK-23	587977.31	4249348.74	3.00	22.16	Low
SK-24	588021.75	4249383.57	3.00	18.77	Low
SK-25	588092.17	4249328.41	3.50	48.16	Moderate
SK-26	588170.88	4249232.37	3.50	34.39	Low
SK-27	588628.49	4249551.16	4.50	20.14	Low
SK-28	588906.93	4249533.71	4.50	19.40	Low
SK-29	588921.34	4249523.35	4.50	20.14	Low
SK-30	588101.28	4249615.58	3.50	49.28	Moderate
SK-31	588367.62	4249314.04	4.00	21.21	Low
SK-32	589498.05	4248539.05	4.50	40.96	Moderate
SK-33	589766.61	4248980.71	5.50	62.10	Moderate
SK-34	589663.44	4248585.49	4.00	83.64	High
SK-35	589817.53	4248814.81	6.50	20.14	Low
SK-36	589579.28	4248380.61	4.50	36.67	Moderate
SK-37	589786.37	4248345.64	4.00	35.51	Moderate
SK-38	590075.49	4248059.98	3.00	25.39	Low

5 Liquefaction severity map of the Aksaray city center

Following the 1999 Marmara earthquake, liquefaction falls over on the agenda of public opinion in Turkey, because, the most severe structural damages and loss of lives occurred during the 1999 Marmara Earthquake. There are several active tectonic sections in Turkey such as the North Anatolian Fault Zone, the East Anatolian Fault Zone, the West Anatolian Grabens, the Ecemis Fault Zone, the Tuzgolu Fault Zone, etc. The Aksaray city center locates near the Tuzgolu Fault Zone, a seismically active region in the Central Anatolian. In addition, loose granular alluvial deposits and close to surface groundwater table raise the liquefaction severity of the soils. For the analysis of liquefaction severity, a geological map of the Aksaray city was prepared and a total of 77 geotechnical boreholes performed by Orta Anadolu Jeoloji Muh. Company was assessed for the preparation of a liquefaction susceptibility map for the Aksaray city center. The SPT samples were implemented at depth intervals of 1.5 m from the first to the last boreholes, and the disturbed samples were used to describe grain-size distribution and Atterberg limits of the soils. The boundaries of the soil layer, SPT-N values, fines content, clay content and the liquid limit for all layers throughout boreholes were employed as input parame-

Table 5. Continued.

Borehole no	Coordinates		Depth of GWT (m)	L_S	Liquefaction severity class
	N	E			
SK-39	589766.04	4248509.83	4.00	46.78	Moderate
SK-40	589400.98	4248658.59	5.00	49.16	Moderate
SK-41	589569.17	4248485.49	4.50	35.54	Moderate
SK-42	589313.36	4248372.76	5.50	27.45	Low
SK-43	589272.32	4248375.76	5.50	22.32	Low
SK-44	589582.85	4248365.92	4.50	37.19	Moderate
SK-47	589781.78	4248884.13	5.50	25.60	Low
SK-48	589302.25	4248465.97	4.00	45.77	Moderate
SK-49	588207.17	4250389.14	6.50	25.00	Low
SK-50	589085.87	4250120.48	5.00	45.70	Moderate
SK-51	588720.55	4250330.69	4.50	36.29	Moderate
SK-52	589351.26	4249860.15	6.50	20.14	Low
SK-53	589409.67	4249796.53	6.50	00.00	Non-liquefied
SK-54	589253.74	4250118.48	7.50	20.14	Low
SK-55	588728.72	4250022.79	5.00	27.39	Low
SK-57	589082.42	4249228.75	3.50	66.28	High
SK-58	588849.98	4247607.82	4.50	68.44	Moderate
SK-60	589039.13	4248483.07	3.00	36.30	Moderate
SK-61	589360.36	4248945.61	7.00	24.62	Low
SK-62	589265.89	4248799.12	5.50	62.26	Moderate
SK-63	589125.08	4248579.31	3.50	25.33	Low
SK-64	589563.44	4249183.54	8.00	20.14	Low
SK-65	589045.16	4248520.93	4.50	25.09	Low
SK-66	589713.55	4249129.32	6.00	35.94	Moderate
SK-68	588467.68	4248279.03	5.50	20.64	Low
SK-69	589926.98	4250511.33	9.50	20.14	Low
SK-70	589928.99	4250925.31	5.50	20.14	Low
SK-71	589973.46	4251222.36	9.00	20.14	Low
SK-72	590171.28	4250440.61	9.50	20.14	Low
SK-73	589965.03	4250692.45	9.50	20.14	Low
SK-76	588650.83	4248831.15	4.00	29.33	Low
SK-77	588857.81	4248439.09	4.50	30.73	Low
SK-78	589763.79	4248982.83	5.00	20.14	Low
SK-79	589301.91	4249085.08	5.50	20.14	Low
SK-81	589363.87	4249143.55	5.00	27.36	Low
SK-82	589151.46	4248739.21	4.00	30.13	Low
SK-86	591230.69	4248245.82	5.00	20.14	Low
SK-88	589661.24	4248958.29	6.00	20.14	Low
SK-90	588619.97	4249905.34	4.50	28.20	Low
SK-91	590905.79	4249102.36	6.00	20.14	Low

ters to determine the liquefaction severity index. In addition, for preparing the liquefaction severity map, the magnitude of the scenario earthquake and the maximum horizontal acceleration were used. The Tuzgolu Fault Zone and around zones have been generated to average as 5.2 magnitudes so far. Due to this reason, the magnitude of the earthquake scenario was considered at 5.2. One more input parameter in the liquefaction analysis, the maximum ground acceleration ($a_{\max}$), is introduced with great difficult. However, some researchers were proposed some equations for the maximum ground acceleration (Joyner and Boore, 1981; Fukushima et al., 1988; Inan et al., 1996; Aydan et al., 1996; Ulusay et al., 2004). Especially, Ulusay et al., (2004) displayed as comprehensive study related to iso-acceleration map of Turkey. In this study, the $a_{\max}$ values were calculated as approximately 300 gal for the Tuzgolu Fault Zone. The liquefaction severity indices for seventy-seven boreholes are calculated and given in Table 5. The liquefaction severity map of the Aksaray city center was generated by using triangulation with linear interpolation technique considering L_S values and coordinates of boreholes (Fig. 5). As can be seen from Fig. 5, a large horizon from NW to SE is represented by high to moderate-low liquefaction severity classes. Also, the distribution areas of all severity zones for the earthquake scenario are presented in Fig. 6 as pie chart.

6 Results and conclusion

The evaluation of the liquefaction potential of a liquefaction-prone area is one of the important issues in geotechnical earthquake engineering for assessment of site selection and planning studies. In this study, the concept of liquefaction severity index has been used for susceptibility mapping suggested by Sonmez and Gokceoglu (2005). For this aim, the Aksaray province, locating in the central part of Turkey and is passed through by the Tuzgolu Fault Zone, were evaluated for generation of the liquefaction severity map by considering for earthquake scenario Ms=5.2. Consequently, the category of very high susceptibility liquefaction was not observed for the earthquake scenario of Ms=5.2, however, 4.9% of the study area having high liquefaction susceptibility class. The percentage of the moderately liquefied took up too much area from the other class, 28.2%. The low and very low liquefied areas are 30.2% and 36.3%, respectively. The rank of non-liquefied susceptibility area is only less than 1%.

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