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A study on potential of liquefaction of sediments in Astaneh Ashrafieh using microscopic and dynamic properties and its effect on the sustainability of the city and the urban crisis

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Abstract

Study of natural hazards can be a useful tool in decision-making, planning and prioritization of measures to manage the crisis. In this research, the details of this approach in Astaneh Ashrafieh district in northern Iran in Gilan Province were evaluated and described given the history of liquefaction in the earthquake in Rudbar and Manjil in 1990. According to GSI maps of Sefidrud delta sediments in which Astaneh Ashrafieh area is located, the area from Paykouh to the beach mostly belongs to the Quaternary. At the delta level, there are three stratigraphic units related to the Pleistocene and five units related to the Holocene. In this study, more than 50 boreholes were drilled and a borehole for analysis was analyzed at the most critical parts of the region. Type of drilling in the study was machine-rotating and continuous sampling was conducted to a depth of 18 meters at a depth. Underground water level for this purpose was 3 meters and using experiments, research work began on the sand of the area, sand of the area was tested by field and laboratory studies such as on-site testing, grading test, and chemical and mineralogical tests. Based on the tests, sediments were mainly made of plagioclase, clinopyroxene and epidote minerals, a little quartz and carbonate debris and contained circular and semi-circular particulars and a small amount of clay and in some areas, silt in the surface layers.

Key words: *liquefaction, evaluation, dynamic properties, microscopy, sediments*

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Introduction

Liquefaction is a phenomenon in granular sandy-silty soil in saturated condition. The dynamic loads imposed on the saturated masses are prone to liquefaction; increasedpore water pressure and decreased soil shear strength, as far as the soil finds fluid behavior and becomes liquefied. It finally cause collapse and can lead to failure of soil mass (International Institute of Earthquake, 1999). Destruction that the earthquake caused in Niigata, Alaska, Astaneh Ashrafieh in Iran in the recent earthquake occurred in Turkey and Japan, are an example of liquefaction. Liquefaction can cause different types of devastation in one site. Full assessment of liquefaction risks requires an examination of the potential deformation caused by it. When faced with such a problem, potential liquefaction risks due to the potential for liquefaction of soil structure as well as being susceptible to soil liquefaction probability are studied. Several methods have been developed to assess the potential liquefaction, most of them have been developed on simple method Sid and Idris (Sid and Idriss). In the SM and Idris, presented in 1971, N Standard Penetration Tests were used to determine the density of the soil (Lenz and Baise, 2007). Simplified procedures estimateliquefaction potential at certain depth of soil and place; So techniques have been developed in such a way that the liquefaction potential in all boreholes are investigated. For this purpose, liquefaction Index (LPI) was developed to provide and integrate liquefaction throughout speculation by Iwasakiet al. (Iwasaki et al., 1982, Cited by Lenz and Baise, 2007). LPI combines depth, thickness and reliability of soil prone to liquefaction in a parameter (Toprak and Holzer, 2003).

Geography and geology of the study area

Astaneh Ashrafieh area with an area of 24 square kilometers is located 30 kilometers from the city of Rasht in northern Iran (Figure 1). In the region, during the earthquake of Manjil-Rudbar in 1990, liquefaction occurred and caused many losses, which led to study and do research on the sand area, and in this regard, sand of Astaneh Ashrafieh studied in conventional field and laboratory tests.

According to 1:250,000 and 1:100,000 maps of National Cartographic Center (NCC) (1985 and 2006) Sefidrud delta sediments where Astaneh Ashrafieh area is located belong in the foothills of the range to beach mostly to the Quaternary period.

Quaternary tectonic: passage of overall Alborz fault below sediment ofdeltaand end bed of Sefidrud and crossing of Sefidrud fault in its bed show sensitivity to the tectonic movementin study area. In the citation reports and resources (Paluska 1992 - Translation - Shahrabi M.), Alborz Mountains comes up about 8 mm per year. Depression in the areas of Bandar Anzali and formations in Anzali Wetland, Sefidrud al-

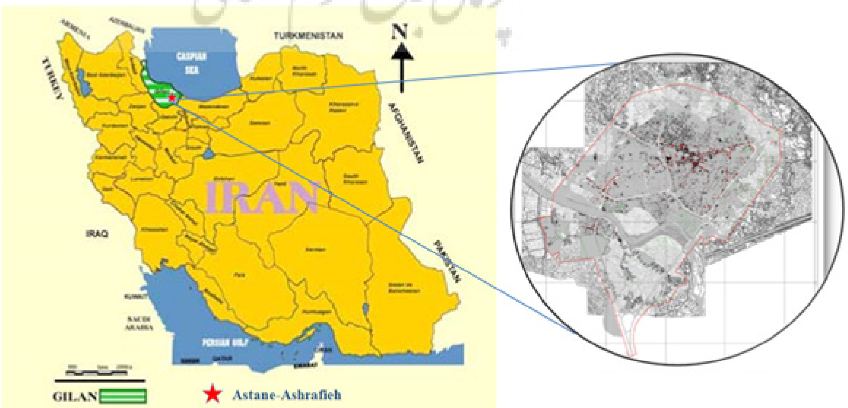
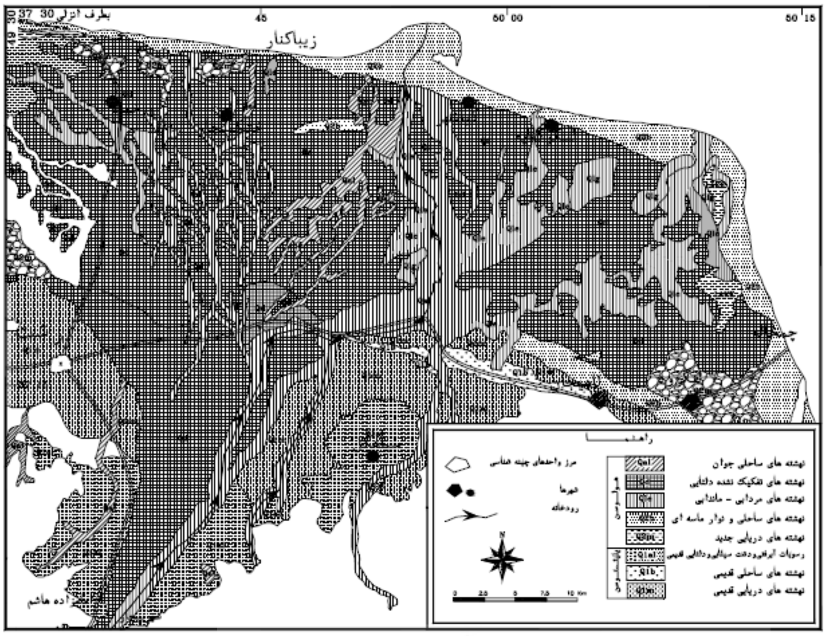


Figure 1. Geographical location of the study area



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▲ Figure 2. Geological map of the study area

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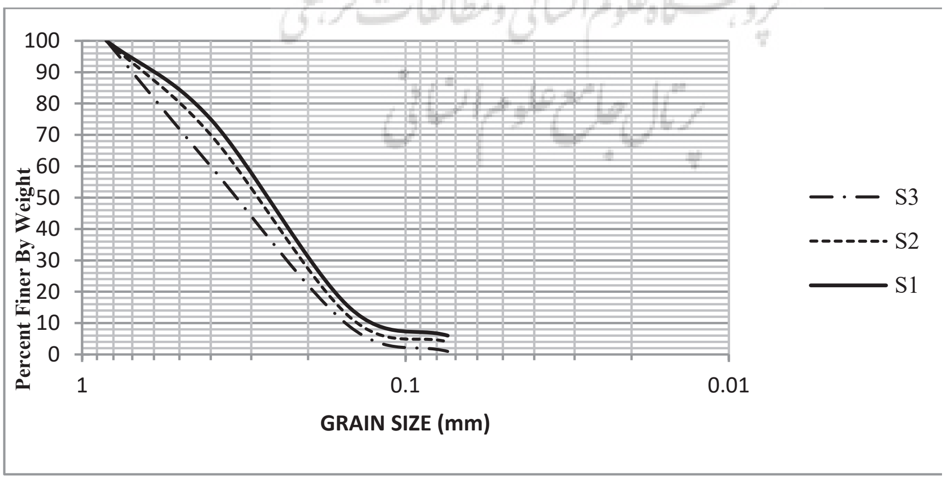
Soil Classification	Depth(m)	Sample	Sample Depth(m)	Cu	Cc	N_{SPT}
ML	1-3	-	-	-	-	-
SP-SM	3-7	S1	6.5	1.08	2.8	17
SP	7-10	S2	9	1.3	2.46	28
SP	10-18	S3	14.5	1.18	2.5	-

▲ Table 1. Studied borehole geotechnical properties



▲ Figure 3. Granulationcurve of samples from boreholes

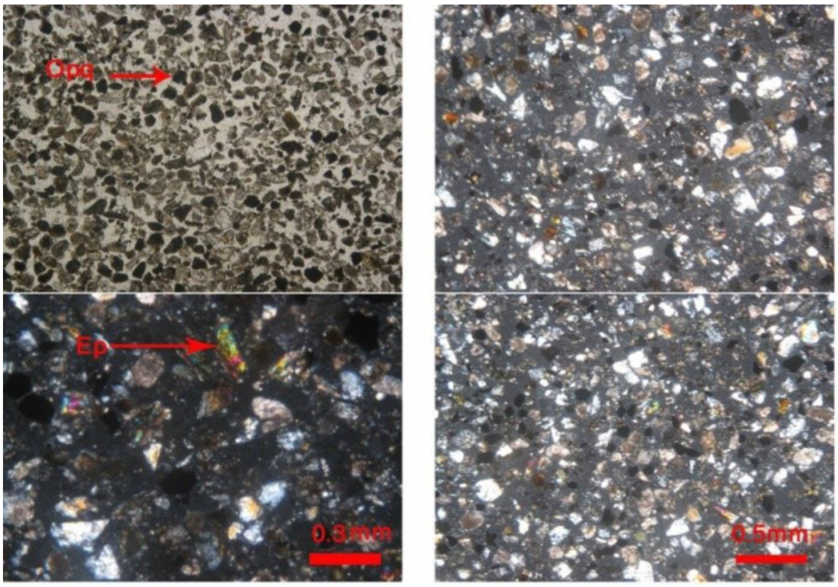


Figure 4. Astaneh Ashrafieh sediment samples under a microscope

luvial terraces, sandstone with dimensions of 80 cm in the bed of Sefidrood, and emerging oldmarine facies in the land are all evidence of New Quaternarytectonics. According zoned map of 2800 bylaw ofRoad, Housing and Urban Development Research Center (BHRC) (Fourth Edition), the risk of earthquakes in the study area is within relative high, and maximum design Acceleration of gravity in the areas is 0.3g.

Evaluation of physical properties of sand of Astaneh Ashrafieh:

In this project, more than 50 boreholes were drilled to analyze a borehole in the most critical part of the region. Drilling in this studied was done by rotary machine and sampling was done continuously to a depth of 18 m. The groundwater level was in depth of 3 meters and its results are presented in table 1 and gradation curves in Figure 3.

Study of the results of microscopic ecaluation of Astaneh Ashrafiehsand:

Impact of the form of sedimentary soils has an effective role in the physical parameters and hydrodynamic parameters, sedimentation history and response to seismicstimulation. Shape of particles is function of the lithology, particle size, type of static and dynamic loading, nature and extent of weathering, and time of sediment transport. In this section, we will examine the characteristics listed:

The sediment mainly composed from the mineral plagioclase, clinopyroxene, epidote, some quartz and carbonate. The frequency of each is as follows:

• Clinopyroxene: Most of the pyroxene in the sample was diopside and some augite, their frequency was 10% and their average size is 0.2 mm.

• Plagioclase: This mineral polysynthetic macle was most abundant minerals so that their frequency was 40% and their size was between 1.0 to 3.0 mm, and the average size was 0.2 mm.

• Epidote: This mineral is characterized with large bumps and high birefringence, their frequency was 5% and an average size of them 2.0 was millimeters.

• Carbonate particles: mainly consists of calcite and its frequency was 20% and its size varies between 0.1 and 0.3 mm.

• Quartz is rarely observed in this unit.

• Other minerals: Important minerals of this unit included metallic or opaque minerals whose frequency was between 15% and their size varied between to 0.1 and 0.2 mm. Because sediment composition mostly comprises mafic

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and ultramafic rocks, these minerals are with high probability opaque magnetiteminerals.

Sorting of particles was good but their roundedness was weak. Stones supplying these deposits often had a mafic composition and were also present in carbonate rocks route.

5. The dynamic properties of sandy area

To determine sand properties of the area, a sample of sand with grain size above a uniformity coefficient of 2.46 and curvature coefficient of 1.3 was used. eminexam value is equal to 0.45and emax is 0.80. To evaluate the liquefaction potential, first saturated sand of Astaneh Ashrafieh underwent triaxial cycles test at various overall pressure.

Triaxial tests

The results in Table 2 below. In this stage, after sampling and putting it in the device, stress ratio causing liquefaction $(\sigma d/2\sigma'_0)$ per a specified number of cycles was determined at different overallpressures.

If the graph of number of cycles versus stress ratios causing liquefaction (SRC) is drawn at different overall pressures, figure (5) is obtained. According to the figure, it can be said that increasing overall pressure reduces the stress ratios causing liquefaction.

For example, if for 6 cycles of loading, stress ratiocausing liquefaction is equal to 0.347 at an overall pressure of 0.5 kg per square meter, at overall pressure of 3 kilograms per square centimeter, it will be equal to 0.165.

Conclusion

Given identified minerals of area and soil behavior in dynamic conditions, there is a risk of liquefaction in the region. Existence of a relationship between shear modulus and liquefaction provides a solution that can be used to determine the liquefaction potential. Many factors influence the shear modulus and cyclic

3	2.5	2	1.5	1	0.5	(Overall pressure kg / cm2)
cyclic stress ratio causing liquefaction $(\sigma d/2\sigma'_0)$						The number of cycles
0.2	0.22	0.24	0.28	0.34	0.38	3
0.16	0.18	0.21	0.25	0.31	0.36	5
0.148	0.17	0.19	0.23	0.27	0.31	10
0.141	0.16	0.18	0.205	0.26	0.28	15
0.13	0.15	0.17	0.196	0.24	0.26	25

Table 2. Values of liquefaction causing tension in different cycles

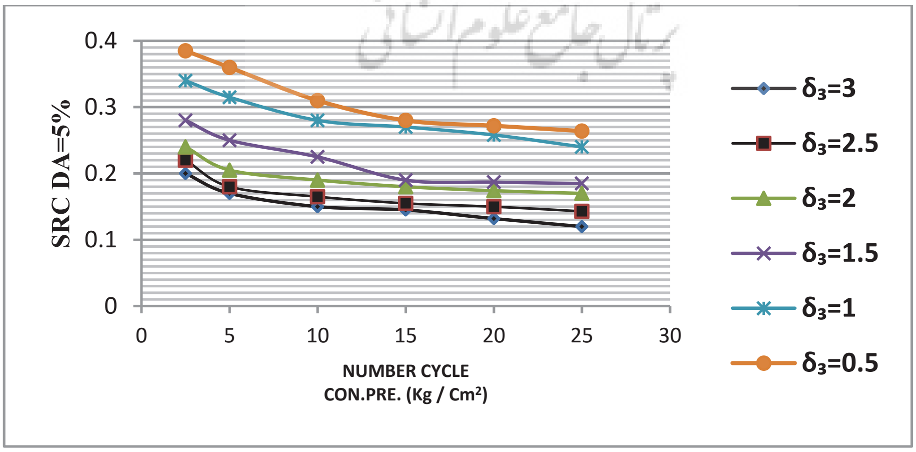

Figure 5. The stress ratios causing liquefaction versus the number of cycles in various multilateral pressure

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stress ratios causing liquefaction. Among these factors are all-round pressure, which greatly affects the shear modulus and cyclic stress ratios causing liquefaction in the given number of cycles. Increased pressure causes the shear modulus to increase. Overall pressure also reduces stress ratios causing liquefaction. Overall pressure also reduces stress ratios causing liquefaction. On the other hand, with increasing the density of the sand layer, the number of cycles required to cause liquefaction in the layer increased and on the other hand, the deformation of this layer decreases.

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