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EXTENDED ABSTRACT

Effect of Crude Oil on the Physical and Mechanical Properties of Fine-Grained Soils of Arak Shazand Refinery Zone

Roghayeh Hasani[a], Ebrahim Asghari-Kaljahi[a, b,*], Sina Majidian[a,c]

[a] *Department of Civil Engineering, Arak Branch, Islamic Azad University, Arak, Iran*
[b] *Department of Earth Sciences, University of Tabriz, Iran*
[c] *Department of Civil Engineering, University of Science and Technology of Mazandaran, Iran*

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1. Introduction

Each soil mass is composed of particles with different sizes and connected voids. The voids between the soil particles allows a fluid to flow from a higher hydraulic gradient point to a lower hydraulic gradient point. The flow and transmission of fluid in the soil depends on several factors, including fluid potential energy, internal and external mechanisms, temperature, osmotic driving force, hydraulic gradient, fluid viscosity, density, etc. Horgan and Ball (1994) showed that the amount of void space and porosity affects fluid flow in soil. The type of soil is effective in the preservation and stability of oil pollution, as there is usually a direct relationship between the clay content and aromatic hydrocarbons. With the increase of clay minerals in soil, the ion exchange capacity increases, so the effect of oil pollution on clay soils is greater. Kaolinite and bentonite clay minerals contaminated with organic fluid causes an increase in initial swelling of the soil and also lubrication of soil particles. Due to the presence of petroleum fluid, it will increase the compressibility of the soil. The effect of oil contamination on the parameters of strength, settlement and compressibility of sand has been studied by Sedghyani and Jiriaee Sharahi, (2004). Khamehchiyan et al. (2007) showed that in clay soils, increasing the crude oil content causes a significant decrease in cohesion. Lekmine (1991) showed that for active clays such as montmorionite, the compressibility as time increases, the penetration of petroleum hydrocarbons increases. In this paper the effect of crude oil on the physical and mechanical properties of fine-grained soils of Arak Shazand refinery zone is investigated.

2. Materials and methods

The materials used are soil samples from Shazand Refinery area and crude oil sample from Shazand Refinery feed. Shazand refinery is located 25 km west of Arak. In the area of this refinery, 70 boreholes with a depth of 50 to 60 meters have been drilled by Pazhohesh Omran Rahvar Company (2019), with the aim of investigating groundwater pollution. Drilling of some boreholes was as continues coring. Soil samples were taken from boreholes drilled in Shazand Refinery and transferred to the laboratory. The soil of several different depths from 5 boreholes was mixed together and the base soil sample was obtained and used in the experiments to investigate the effect of crude oil on the fine-grained soil. The particle size if base soil is illustrated in the Fig. 1.

For preparation of samples, about 30 kg of the desired base soil was dried and passed through sieve No. 10 (size 2mm). Then, the soil sample was divided into 5 parts and 0-5-10-15-20 percent by weight of dry soil,

* Corresponding Author
E-mail addresses: royahasani22764@gmail.com (Roghayeh Hasani), e-asghari@tabrizu.ac.ir (Ebrahim Asghari-Kaljahi), sina.majidian@mazust.ac.ir (Sina Majidian).

crude oil was added to each part in the form of a spray and mixed until it became homogeneous. Immediately, each part was put in the plastic bags and were closed to prevent the evaporation of crude oil. These samples were kept in this condition for at least 7 days so that the oil is absorbed by the soil particles.

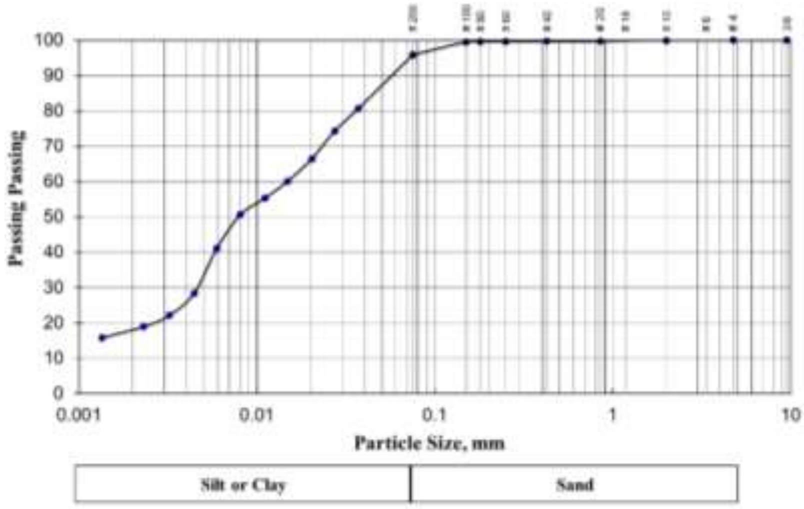

Fig. 1. The particle-size distribution curve of base soil sample

3. Test results and discussion

About 300 grams of each sample was passed through sieve No. 40 and Atterberg limit tests were conducted according to ASTM D4318. As it can be seen in the Fig. 2, at first, with an increase in the oil content up to 10%, the liquid limit of the soil decreases, and then with an increase of oil up to 15%, the liquid limit increases and in the amount of 20%, the liquid limit increases.

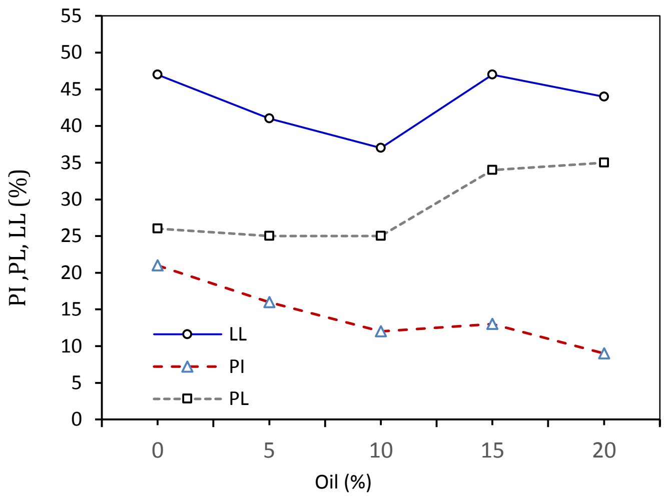

Fig. 2. The effect of oil on the plasticity properties of soil

Proctor compaction test has been done on the soil sample with 0-5-10-15-20 percent crude oil content. This test has been done according to ASTM D698. As shown in Fig. 3, with the addition of 15 and 20% of crude oil, the maximum dry density increased by 5 and 6%, respectively, and the optimum moisture content decreased by 18% with the addition of 10% of oil, and then with the addition of 15 and 20 percent of oil, the optimal moisture increases.

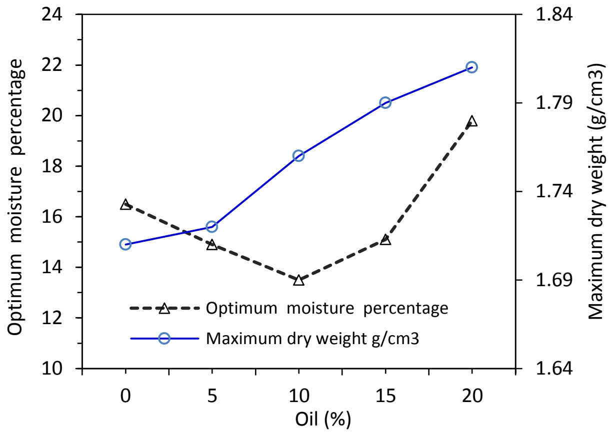

Fig. 3. Changes of dry density and optimum moisture content of soil vs oil content in Proctor compaction tests

The permeability test was performed by the falling head method on the soil sample with oil content of 0-5-10-15-20%. As seen in the Figure 4, the permeability coefficient of the base soil is 5.8-e4 cm/s and the permeability decreases with increasing of the oil content.

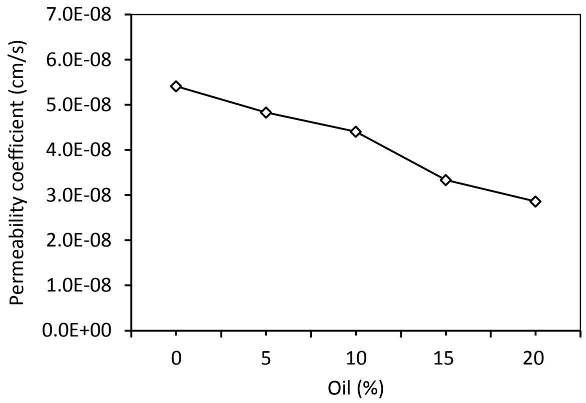

Fig. 4. Variation of permeability coefficient of the soil vs oil content

Uniaxial compressive strength tests were performed according to ASTM D2166 on samples with 0-5-10-15-20% oil. The results of the tests are illustrated in the Fig. 5. It can be seen that the uniaxial compressive strength of the soil decreases with the increase of oil content.

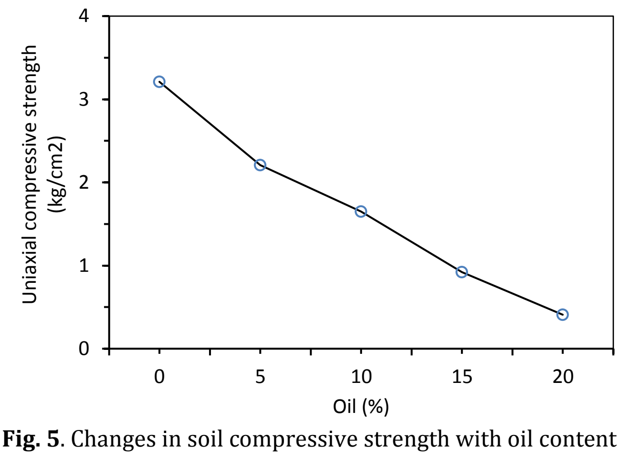

Fig. 5. Changes in soil compressive strength with oil content

Samples with different contents of oil with a compaction ratio of 90% (dry density of 1.54 g/cm^3) were made inside the ring of the oedometer consolidation device and were kept in the pool of the consolidation device for about 4 days for complete saturation. Then the test was performed by applying pressures of 0.5-1-2-4-8-16 kg/cm^2. The samples settlements are shown in the Fig. 6.

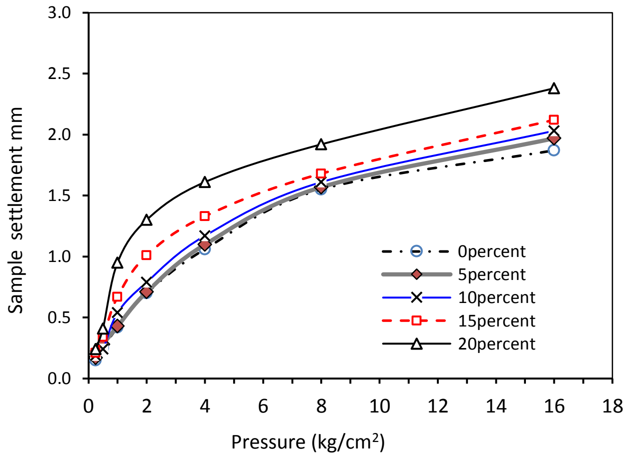

Fig. 6. The settlement curves of the soil samples with different amounts of oil at different pressures during consolidation tests

With the increase of overburden stress, the porosity of oil-containing soil decreases, and with the decrease of overburden stress during loading, these values increase. With the increase of oil amount, the consolidation diagram tends to decrease the values of specific volume. The porosity values of soil impregnated with oil are lower than those without oil, and with the increase of the density ratio, the soil will have lower specific volume values. The values of compression coefficient in samples with lower compression ratio are higher in soil with 15% crude oil than in soil with 20% crude oil. In general, with the increase of the amount of oil, the compression coefficient and as a result the potential of settlement increases.

4. Conclusions

The important results are as below:

1) With an increase in the crude oil content up to 10%, the liquid limit of the soil decreases, and then with an increase of oil up to 15%, the liquid limit increases and in the amount of 20%, the liquid limit increases.
2) With the addition of 15 and 20% of crude oil, the maximum dry density increased by 5 and 6%, respectively, and the optimum moisture content decreased by 18% with the addition of 10% of oil, and then with the addition of 15 and 20 percent of oil, the optimal moisture increases.
3) Crude oil reduces soil permeability. This is due to infilling of some soil voids by oil.
4) Due to the higher viscosity of crude oil compared to water, the compressibility of fine-grained soils increases with the increasing of oil content.
5) In the consolidation tests, with the increase of overburden stress, the porosity of oil-containing soil decreases, and with the decrease of overburden stress during loading, these values increase.
6) The soil consolidation coefficient increased with the increase of oil content, and the values of this coefficient in the soil with 15% oil are lower than the soil with 20% oil. With increasing density, soil consolidation coefficient increases.

5. Acknowledgments

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