University of Tabriz

Journal of Civil and Environmental Engineering
Volume 52 (2022), Issue 1 (Spring), 217-226

EXTENDED ABSTRACT

Influence of Gas Oil Contamination on Geotechnical Properties of Clayey Sand

Milad Shahidi [a], Farhad Asemi [b], Farhang Farrokhi [a,*]

[a] *Faculty of Civil Engineering, University of Zanjan, Zanjan, Iran*
[b] *Faculty of Engineering, Department of Civil Engineering, Kharazmi University, Tehran, Iran*

Received: 31 January 2019; **Accepted:** 29 September 2020

Keywords:
Contaminated Soil, Clayey Sand, Gas Oil, Scanning Electron Microscope (SEM), Uniaxial Compression Strength (UCS).

1. Introduction

Contamination of soils with petroleum products, in addition to being an environmental problem, also makes it difficult from the point of view of geotechnical engineering and doubts the use of this soil following structures, road pavements, and other constructed structures. Sridharan et al. (1981) reported an increase in soil settlement due to contamination of the region's soil with hydrocarbons, resulting in damage to industrial buildings. In recent decades, due to the importance of studying the geotechnical behavior of contaminated soils with petroleum products, many studies have been conducted on the physical and chemical properties of these soils. Much research has been done on the geotechnical properties of fine-grained and coarse-grained soils contaminated with petroleum products (Shin and Das, 2001; Ratnaweera and Meegoda, 2006; Rahman et al., 2010; Al-Aghbari, 2011; Kermani and Ebadi, 2012; Karpuzcu et al., 2018). In this study, the emphasis is on the evaluation of the polluting effect of gas oil as a pollutant with a specific gravity less than water on the fine-grained and coarse-grained behavior of soil. For this aim, a set of geochemical (including XRD and XRF analyzes), geotechnical tests (including grain size distribution, gas evaporation, Atterberg limits, and unconfined compression strength), as well as observation by scanning electron microscopy on contaminated Clayey Sand by gas oil was done.

2. Methodology

In this study, Clayey Sand soil containing 56% coarse-grained and 44% fine-grained was used. Gas-oil with a specific weight of 0.84 kg/lit was selected as a contaminant at 2, 4, 6, 8, 12, and 16 percent. To prepare the samples, the soil was compressed into five layers (sample length 70.1 mm and diameter 33.3 mm) using 16 blows per layer of a special hammer for the Harvard compaction apparatus; the maximum dry weight was obtained from the standard Proctor density test. Grading modulus (GM), standard compaction, Atterberg limits the percentage of gas-oil evaporation, uniaxial compressive strength (UCS), and scanning electron microscopy imaging (SEM) tests were performed on the soil in uncontaminated and contaminated modes with different percentages of gas-oil.

* Corresponding Author
E-mail addresses: milad.shahidi@znu.ac.ir (Milad Shahidi), farhad.asemi@znu.ac.ir (Farhad Asemi), farrokhi@znu.ac.ir (Farhang Farrokhi).

3. Results and discussion

3.1. Grading modulus (GM)

In order to investigate the contaminated soil, the grading modulus was used to confirm the reduction of fine grains in contaminated soils. The grading modulus, according to Eq. 1 is defined as the ratio of the total percentage of soil particles remaining on sieve 2, 0.425, and 0.075 mm per 100.

$$GM=(P_2+P_{0.425}+P_{0.075})/10 \quad (1)$$

The results show that the grading modulus varies from 0.064 for uncontaminated soil to 0.214 for soil with the highest amount of gas-oil (16%).

3.2. Atterberg limits

The results show that with increasing gas-oil, the liquid limit decreases, and for contaminated soil containing 16% gas-oil was observed 28.9% decrease. In addition, according to the results, the difference between the plastic limit and the liquid limit (plastic index) for gas-oil quantities up to 8% has an increasing trend and for the values of 12 and 16% gasoil takes a downward trend (Fig. 1). This can be attributed to the high viscosity of the gas-oil and the different emulsion formations in each of the ascending and descending trends.

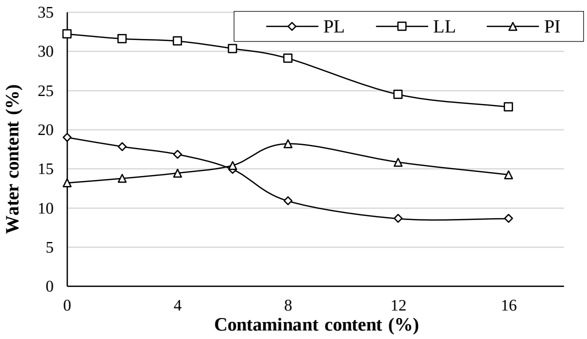

Fig. 1. The effect of gas-oil on the Atterberg limits of the Clayey Sand soil

3.3. Uniaxial compressive strength (UCS)

In order to evaluate the effect of curing time on the compressive strength of the contaminated soil samples, the testing was performed at three curing periods (7, 14, and 28 days). The results show that were reduced the compressive strength and the ultimate strain of the samples, for all three periods of curing, by increasing the percentage of contamination. Fig. 2 (a) shows that the highest uniaxial compressive strength at the 28-day curing period is observed for all cases of contamination percentage. Also, according to Fig. 2 (a), the slope of the reduction of strength with the increasing amount of contaminants in the soil for the 28-day compared to 7 and 14 days is the lowest value. Based on the stress-strain curve obtained from the compressive test, it was found that specimens with 6% or more contamination showed a different behavior than specimens without contamination or with less contamination. So that the behavior failure of the samples changes from strain-hardening to strain-softening.

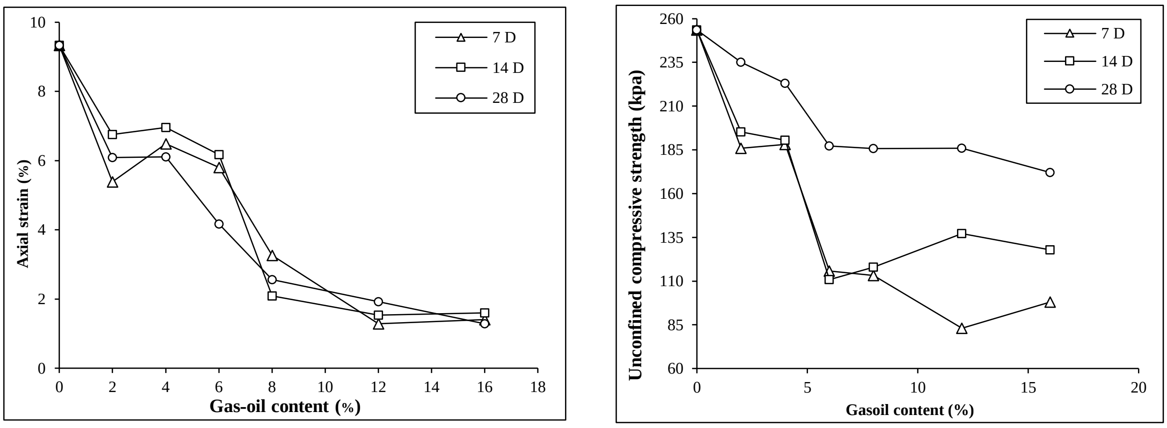

Fig. 2. Changes in: a) uniaxial compressive strength and, b) axial strain versus contaminant percentage for three curing periods

4. Conclusions

The results of the experiments performed in this study showed an increase in the grading modulus and particle size of the soil particles with an increase in the amount of pollutants. Also, the amount of evaporated gas-oil from the soil decreases as the amount of gas-oil increases. According to the results of Atterberg limits, the liquid limit and the plastic limit have a decreasing trend with increasing the amount of gas-oil. Maximum dry density has been declining to a minimum for the lower values contaminant but has increased in the following with the increasing amount of gas-oil. In addition, the optimum water content has decreased by increasing the percentage of diesel.

5. References

Al-Aghbari M, Dutta R, Mohamedzeini Y, “Effect of diesel and gasoline on the properties of sands a comparative study”, International Journal of Geotechnical Engineering, 2011, 5 (1), 61-68.

Karpuzcu M, Arbili MM, Ghaffoori F, Cabalar AF, “An assessment of the effects of light crude oil on the geotechnical properties of asoil”, International Journal of Advances in Mechanical and Civil Engineering, 2018, 5 (5).

Kermani M, Ebadi T, “The effect of oil contamination on the geotechnical properties of finegrained soils”, Soil and Sediment Contamination: An International Journal, 2012, 21, 655-671.

Rahman ZA, Hamzah U, Taha MR, Ithnain, NS, Ahmad N, “Influence of oil contamination on geotechnical properties of basaltic residual soil”, American Journal of Applied Sciences, 2010, 7 (7), 954-961.

Ratnaweera P, Meegoda J, “Shear strength and stress-strain behavior of contaminated soils”, Geotechnical Testing Journal, 2006, 29 (2), 133-140.

Shin EC, Das BM, “Bearing capacity of unsaturated oil-contaminated sand”, International Journal of Offshore and Polar Engineering, 2001, 11 (3).

Sridharan A, Nagaraj TS, Sivapullaiah PV, “Heaving of soil due to acid contamination”, Proc. 10th Int. Conf. on SM and FE, Stockholm, 1981, 6, 383-386.