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The behavior of Oil-Contaminated Sands in CBR Test

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ABSTRACT: Several factors affect the bearing of a load of natural and engineered embankments and slopes including the crude oil leakage, leading to a severe decrease in resistance. This is especially important for oil-rich countries, such as Iran, which have several crude oil resources. The main purpose of this study is to investigate the load-bearing (i.e., load versus settlement) and strain-stress behavior of crude oil contaminated sandy soils using the California bearing ratio (CBR) test. In this paper, 10 different types of sand with different characteristics were used. At first, a series of CBR experiments were performed for natural sands (i.e. clean sands) and then contaminated sands with 6% crude oil tested under similar conditions and densities to obtain the reduction in bearing a load of crude oil-contaminated sands quantitatively. Experimental results showed that bearing the load of sand containing 6% of crude oil decreased at least 50% compared to clean sands and the stress-strain diagram of these contaminated soils would decrease significantly. Based on the results of the investigation, it can be stated that particle shape (sharpness or roundness), coarse particle ratio, and finally the type of aggregation influences the resistance of crude oil contaminated sands. It was also found that standard Ottawa sand had an 83% reduction in strength and sand with a coarse particle had a 57% decrease in strength. Sand contaminated with crude oil experienced a severe loss of bearing capacity, so in designing foundations and engineering structures, greater safety factors should be considered, where there is a risk of crude oil leakage.

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1. INTRODUCTION

Load bearing is one of the classic concepts of foundation engineering, which is subject to several conditions. Increasing the bearing tolerance with the help of technical methods has always been of interest to geotechnical researchers. If the soil of the site is reduced for any reason, the bearing capacity of that area will be reduced, which will result in a serious threat to the safety of the structures. Crude oil leakage is a major threat in areas near oil wells. Accordingly, awareness and knowledge about the importance of reducing the load tolerance of these areas are more important.

Mohammadi *et al.* [1] used three types of pollutants (diesel, crude, and engine oil) to investigate the effect of oil contamination on the interaction between sandstone piles. The results of their research showed that the presence of oil between the sand particles would have significant negative effects on reducing the pile's load-bearing capacity. AL Adly *et al.* [2] research revealed that sand pollution with crude oil changes the load-settlement curve and drastically reduces the load-bearing capacity. They also indicated that the failure mode changes from local to punching failure. Joekar and Hajiani Bushehrian [3], by numerically examining the bearing load tolerance of the strip footing on the sandy slope contaminated with crude oil, concluded that by increasing the thickness of the contaminated layer and increasing the number of pollutants, the bearing tolerance decreases. Nasr [4] showed that the CBR of contaminated sand using heavy engine oil dropped sharply. If such contaminated sand is stabilized with cement, the CBR value will increase dramatically, indicating the importance of stabilizing contaminated sands.

Despite numerous studies on bearing tolerance and CBR testing, there is a dearth of literature about the reduction in load-bearing tolerance of crude oil-contaminated sandy soils. Therefore, in the presented paper, an attempt has been made to answer this question by performing a series of CBR experiments on different types of sand in a clean (non-contaminated) state and contaminated conditions with 6% crude oil. At the end of this study, the basic questions of how the shape of particles, the size of particles, and the type of grain size distribution play role in reducing the bearing tolerance of crude oil-contaminated sands can be answered.

2. MATERIAL CHARACTERISTICS

In this research, 10 different types of sand have been used; the specifications of each sand are given in Table 1. Preliminary experiments were performed on each of the sands to obtain the parameters and characteristics of each type of soil. The sands used are Ottawa standard sand, Firoozkooh 161 and 171 grains of sand, Bushehr sand, two

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Table 1. Sand characteristics

Sand Type	USCS	Cu	Cc	D50	Gs
Ottawa	SW	7.231	1.010	0.971	2.660
Bushehr Sand	SP	2.876	0.909	0.197	2.696
FiroozKooh#161 Sand	SP	2.065	1.072	0.230	2.644
FiroozKooh#171 Sand	SP	1.990	1.192	0.184	2.592
KRSS#1	SP	4.701	0.489	0.963	2.660
KRSS#2	SP	6.866	0.968	1.487	2.786
KRSS#1A	SP	-	-	-	2.720
KRSS#1B	SP	-	-	-	2.614
KRSS#2A	SP	-	-	-	2.747
KRSS#2B	SP	-	-	-	2.711

models of Kermanshah river sand (KRSS#1 & KRSS#2), and Kermanshah river sands with specific grading, one passing from sieve No. #4 and blocked on sieve No. #10 (KRSS#1A & KRSS#2A) and the other passing through sieve No. #10 and blocked on sieve 60 (KRSS#1B & KRSS#2B).

The grain size distribution of these sands is shown in Fig. 1. In this Figure, the diagram of the first six grains of sand is given. The other four types of sand that are not shown in this diagram have specific grains, stated previously.

Since one of the parameters studied in this paper is the shape of the particles, Fig. 2 shows the sand samples under an optical microscope to better and further understand the shape of the particles in each soil. The CBR test performed in this study is based on the ASTM D1883 standard. The internal dimensions of the mold have a diameter of 150 mm and a height of 120 mm.

3. SAMPLE PREPARATION

In this study, the amount of crude oil contamination with the clean soils was 6% of the dry soil weight. According to previous research on oil-contaminated soils [4-6], the highest percentage of pollution was selected for sandy soils is 6%. Because at higher percentages, the efficiency of the soil is practically lost and it is not possible to test it. In addition, in fewer percentages, the effect of pollution will not be visible. Fig. 3 shows how Firoozkooh 171 sand contaminated with 6% crude oil was prepared.

4.CBR EXPERIMENTS

All 10 types of soil were tested in conditions contaminated with crude oil. Fig. 4 shows the results from the CBR test on 6% crude oil-contaminated sands.

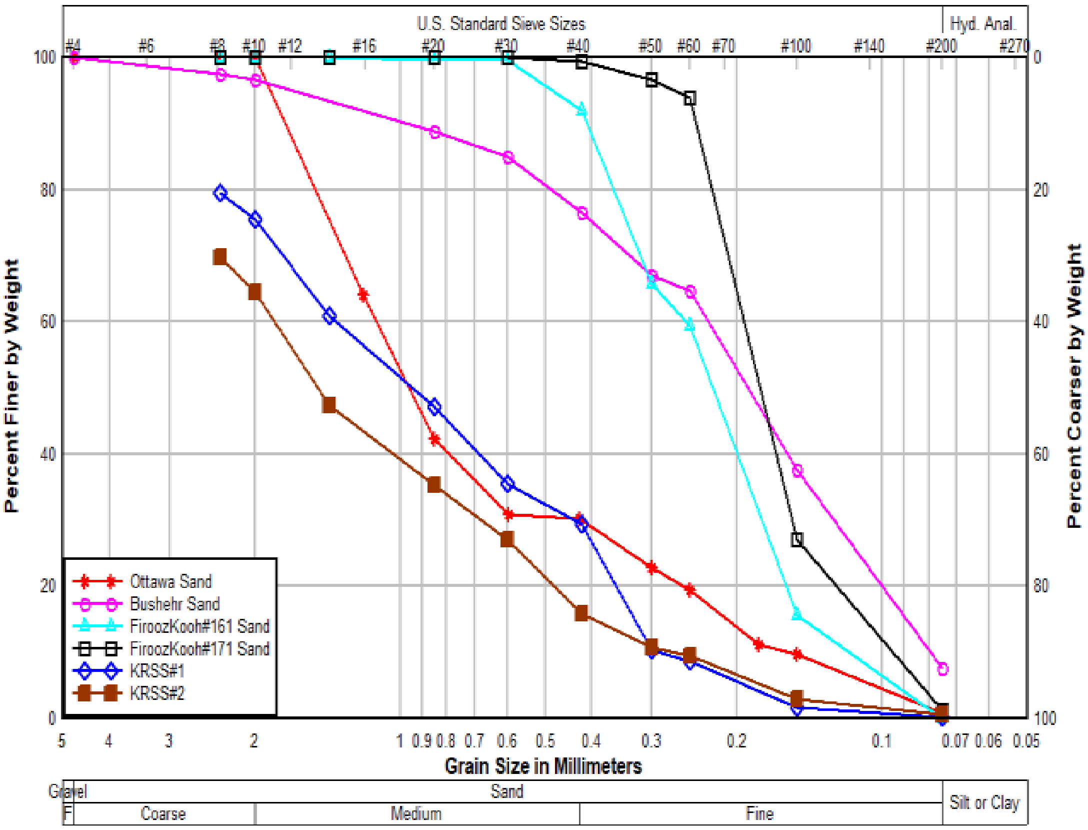

Fig. 1. Sands grain size distribution

Fig. 2. Sand particles under an optical microscope

Fig. 3. FiroozKooh#171 contaminated sand preparation

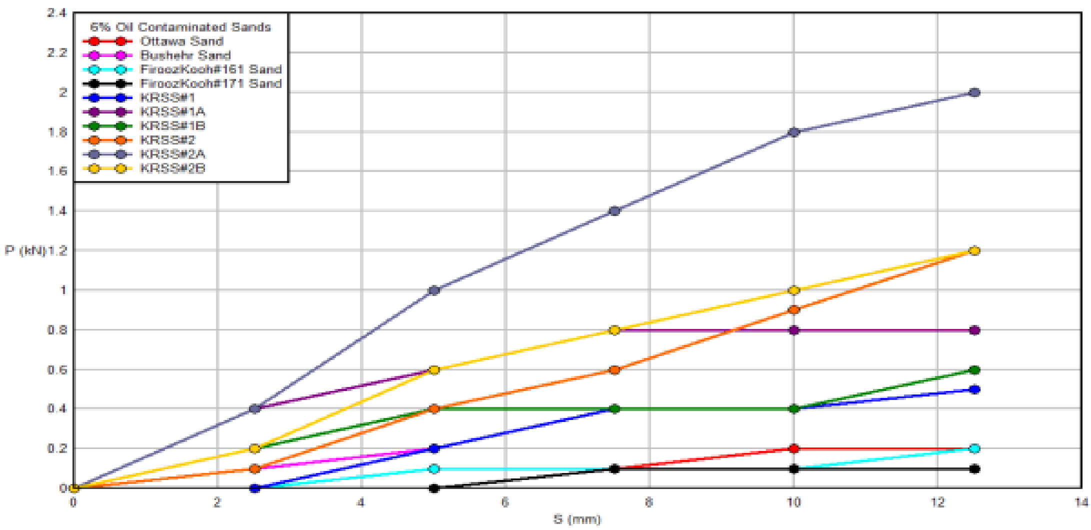

Fig. 4. CBR Test results on 6% oil-contaminated sands

5. RESULTS

Based on the data from the experiments, the drop in load tolerance and the reduction of the resistance of sandy soils contaminated with 6% crude oil is quite evident. In all tested soils, the reduction in CBR of contaminated samples was more than 50%. Firoozkooh 171 sand (which is fine-grained sand) has the largest decrease with a drop of 91%, indicating that this type of sand is much more sensitive to oil contamination than other soils. However, since KRSS #2A has a CBR drop of about 58%, it performs better than other soil samples, which the shape of its grains can explain the reason for this phenomenon.

6. CONCLUSION

The purpose of this study is to a better understanding of the behavior of sands contaminated with crude oil. In this study, 6% of crude oil was used to contaminate 10 types of sands. With the help of CBR experiments on non-contaminated sands and contaminated sands, the following results were obtained. However, in the case of load-bearing in non-contaminated conditions, the type of sand grain distribution has a significant effect. Nevertheless, in the case of sand contaminated with crude oil, the most important factor is the shape of the particles, and the granular particles perform better than the rounded particles so that the least reduction in load tolerance or stress tolerance in stress-strain graphs belong to these type of soils.

REFERENCES

[1] Mohammadi, A., et al. (2018). "Axial compressive bearing capacity of piles in oil-contaminated sandy soil using FCV." Marine Georesources & Geotechnology 37(2): 164-179.

[2] Al-Adly, A. I. F., et al. (2019). "Bearing capacity of isolated square footing resting on contaminated sandy soil with crude oil." Egyptian Journal of Petroleum Article in Press.

[3] Joekar, A., A. Hajiani Bushehri (2020). "Studying the behavior of strip foundation rested on the kerosene oil contaminated sand slopes." Sharif Journal of Civil Engineering Article in Press.

[4] Nasr, A. M. A. (2014). "Utilisation of oil-contaminated sand stabilized with cement kiln dust in the construction of rural roads." International Journal of Pavement Engineering 15(10): 889-905.

[5] Al-Sanad, H. A., et al. (1995). "Geotechnical properties of oil-contaminated Kuwaiti sand." Journal of Geotechnical Engineering 121: 407-412.

[6] Nasr, A. M. A. and S. V. Krishna Rao (2016). "Behaviour of laterally loaded pile groups embedded in oil-contaminated sand." Géotechnique 66(1): 58-70.

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