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Evaluation of the Effect of Anionic Surfactant of Sodium Dodecyl Sulfate on Undrained Shear Strength Parameters of Crude Oil Contaminated Loose Sand

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ABSTRACT: Contamination of soil with petroleum products due to leakage from oil tanks and pipelines causes damages to the environment and human life and in addition to severe environmental damages, depended on soil type, causes changes in its strength characteristics. One of the most important methods for crude oil remediation is the soil washing technique which can affect on strength of contaminated and also natural soil in addition to their effects on the degradation process. This study aims to investigate the effect of using soil washing technique using anionic surfactant of sodium dodecyl sulfate (SDS) at different concentrations on the degradation process of crude oil contamination and also, undrained shear strength parameters of loose sand contaminated by various concentrations of light crude oil. The results indicate that, under all confining pressures, by an increase of crude oil content up to around 5%, the shear strength of sandy soil decreases and then increases for crude oil content more than 5%. Also, reduction in internal friction angle and increase of cohesion by an increase of crude oil concentration are the results of this study. Soil washing by using different concentrations of SDS solution increases the shear strength of crude oil contaminated sandy soil, but the rate of this increase is lower at crude oil contents greater than 5% and high confining pressures. As a general remark, it can be said that the shear strength of both crude oil-contaminated sand and contaminated sand washed by a surfactant is less than the same for clean sand.

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1- Introduction

Recently, few studies have been conducted on the behavior of sandy soils contaminated with crude oil and its derivatives in which reduction in shear strength and friction angle of sandy soils and depending on the type and percentage of fines in the soil, increase or decrease of cohesion have been reported [1-4]. In recent years, several studies have been conducted on the effect of using surfactants on the removal of oil pollution from soils which show a significant increase in the efficiency of the removal of petroleum hydrocarbons. Few studies have investigated the geotechnical properties of washed contaminated soils. The results of these studies showed that mixing contaminated soils with surfactants brings the number of properties of contaminated soil closer to the state of clean soil [5-6].

The review of previous researches shows the lack of studies about shear strength parameters of loose sandy soils contaminated by petroleum hydrocarbons and also, the effect of using surfactants on the behavior of such soils. On the other hand, in all researches on the effect of using surfactants to eliminate crude oil contaminants, the laboratory mixing method has been used, which can't be practical. Accordingly, in this study the effect of different concentrations of light crude oil on shear strength parameters of loose sand as well as the effect of soil degradation on the behavior of the studied soil is done by injecting an anionic surfactant solution of sodium dodecyl sulfate (SDS) at different concentrations have been investigated.

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2- Materials and Methods

The soil used in this study is 131 Firuzkooh sand with an average grain size of 0.67 mm. The type of this soil is SP according to the unified soil classification system (USCS). The Khuzestan light crude oil provided from the Tehran oil refinery has been used as a pollutant. Also, an anionic surfactant of SDS has been used for washing contaminated soil.

In this paper, the under-compaction method has been used to make homogeneous loose specimens with a 5 cm diameter and height of 10 cm and relative density in the range of 30 to 32%. For preparing contaminated samples, crude oil was mixed with clean soil at concentrations of 1, 3, 5, 7, and 9% and kept in sealed plastic bags for 7 days. In the case of washed specimens, SDS solution in three concentrations of 10000, 30000, and 50000 ppm was injected into the contaminated specimen. The process of injecting and washing the soil was kept on until the volume of the output solution reaches 10 times the volume of specimen pores (P.V). Then, the washed specimen was subjected to CU triaxial test under 50, 100, and 200 kPa confining pressures at a loading rate of 0.5 mm/min.

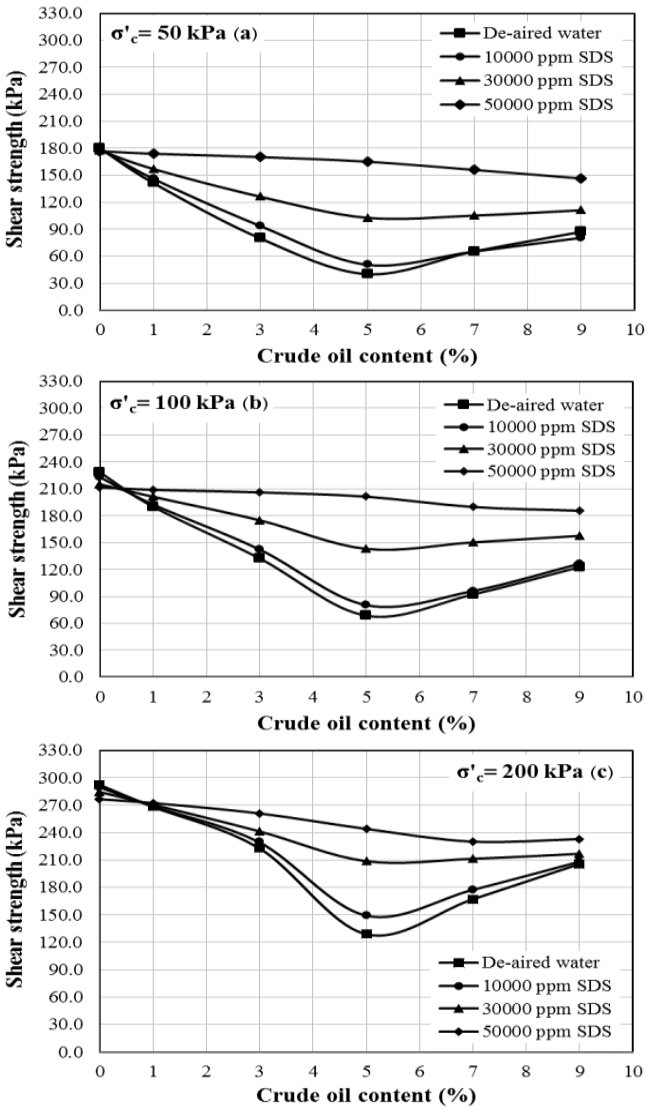

Fig. 1. Variation of shear strength by crude oil concentration for different SDS solutions and confining pressures.

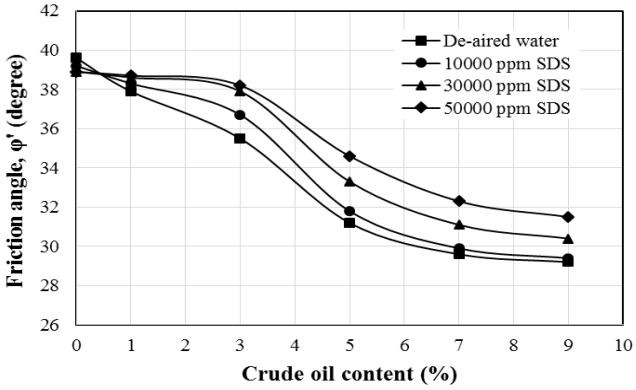

Fig. 2. Variation of internal friction angle by crude oil concentration for different SDS solutions.

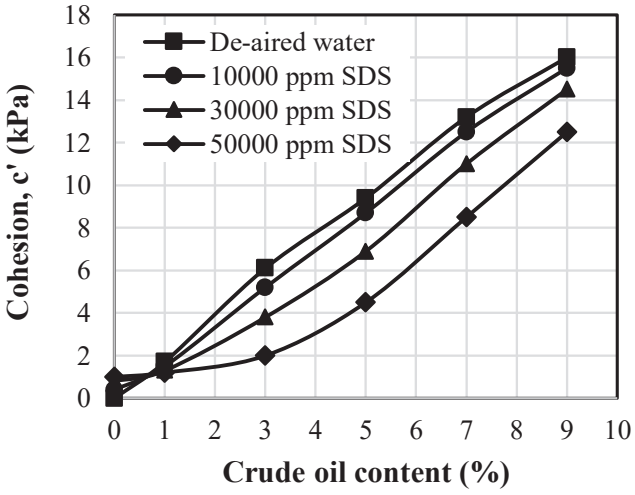

Fig. 3. Variation of cohesion by crude oil concentration for different SDS solutions.

3- Results and Discussion

As shown in Fig. 1, at all confining pressures, increase of crude oil concentration up to around 5% causes reduction in shear strength of contaminated sand, and for crude concentrations more than 5%, shear strength of contaminated sand increases by an increase of crude oil concentration. Whereas, at all crude oil concentrations and confining pressures, the shear strength of contaminated sand is lower than the same for clean sand. As shown in Figs. 2 and 3, contamination of sand with crude oil significantly decreases the internal friction angle and increases its cohesion. An increase of crude oil concentration up to 5% causes a significant decrease of internal friction angle, due to lubricating properties of the crude oil between soil particles and increase of soil cohesion because of the high viscosity of crude oil and the presence of polymer derivatives in it and consequently increase of surface tension between soil particles and crude oil. However, for crude oil concentrations of more than 5%, the whole surface of the sand particles is covered with crude oil, and as a result, the rate of change of the internal friction angle is drastically reduced. Meanwhile, the cohesion resulted from the presence of crude oil at concentrations greater than 5% increases at an approximately constant rate. Since the cohesion increases and the internal friction angle is somewhat fixed, the shear strength of the contaminated specimens at concentrations of more than 5% increases.

Also, at all confining pressures, washing crude oil contaminated soil by injecting SDS solution increases the shear strength of contaminated soil, but in general, the shear strength of washed soil is less than the same for clean soil. Removal of crude oil from the soil by washing with SDS solution reduces the lubrication between sand particles and thus increases friction angle, as is evident in Fig. 2. The use of SDS solution, as shown in Fig. 3, decreases the cohesion of contaminated sand, but since the shear behavior of

granular soils is more affected by friction angle and inter-granular contacts, the shear strength of the washed specimen increases.

4- Conclusion

The main results obtained in this study are as followed.

-At all confining pressures, by an increase of crude oil content up to 5%, the shear strength of sand decreases and increases at concentrations more than 5%, but in general, the shear strength of contaminated soil is less than clean soil.

-Pollution of sandy soil by crude oil up to 5% significantly decreases the internal friction angle and increases its cohesion. At crude oil concentrations of more than 5%, the rate of reduction in internal friction angle decreases sharply. While the cohesion resulting from the presence of crude oil increases at an almost constant rate.

-Removal of crude oil from contaminated specimens by washing them with SDS solution causes an increase of internal friction angle and reduction in cohesion, but since the shear behavior of granular soils is more affected by internal friction angle and inter-granular contacts, the shear strength of washed specimens' increases.

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