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 environment and human life and in addition to sever environmental damages, depended on soil type, causes changes in its strength characteristics. One of the most important methods for crude oil remediation is soil washing technique which can affect on strength of contaminated and also natural soil in addition to their effects on degradation process. The aim of this study is to investigate the effect of using soil washing technique by means of anionic surfactant of Sodium Dodecyl Sulfate 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 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 increase of crude oil concentration are as results of this study. Soil washing by using different concentrations of Sodium Dodecyl Sulfate 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 shear strength of both crude oil contaminated sand and contaminated sand washed by surfactant are less than same for clean sand.

KEYWORDS

Anionic surfactant, Light crude oil, Undrained shear strength, Triaxial test, Loose 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 significant increase of the efficiency of 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 amount 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 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 oil degradation on behavior of the studied soil is done by injecting anionic surfactant solution of SDS at different concentrations have been investigated.

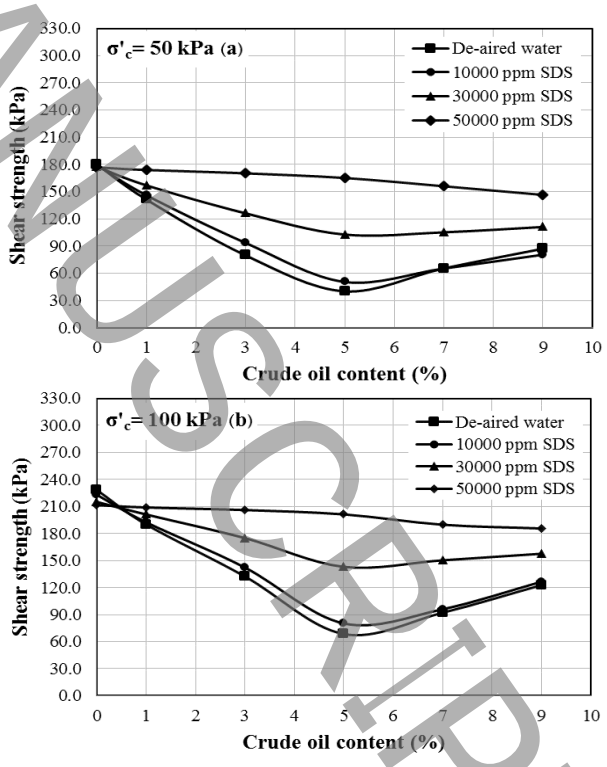
2. Materials and methods

The soil used in this study is 131 Firoozkooh sand with average grain size of 0.67 mm. The type of this soil is SP according to Unified Soil Classification System (USCS). The Khuzestan light crude oil provided from Tehran oil refinery has been used as pollutant. Also, anionic surfactant of Sodium dodecyl sulfate (SDS) has been used for washing contaminated soil.

In this paper, under-compaction method has been used to make homogeneous loose specimens with 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 is 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 is subjected to CU triaxial test under 50, 100 and 200 kPa confining pressures at loading rate of 0.5 mm/min.

3. Results and discussion

As shown in Figure 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 increase of crude oil concentration. Whereas, at all crude oil concentrations and confining pressures, shear strength of contaminated sand is lower than same for clean sand. As shown in Figures 2 and 3, contamination of sand with crude oil significantly decreases the internal friction angle and increases its cohesion. Increase of crude oil concentration up to 5% causes significant decrease of internal friction angle, due to lubricating properties of the crude oil between soil particles and increase of soil cohesion because of 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 more than 5%, 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 by 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 more than 5% increases.



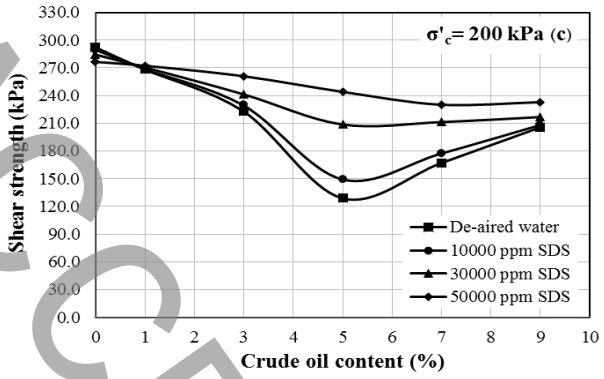


Figure 1. Variation of shear strength by crude oil concentration for different SDS solutions and confining pressures

Also, at all confining pressures, washing crude oil contaminated soil by injecting SDS solution increases shear strength of contaminated soil, but in general the shear strength of washed soil is less than 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 Figure 2. The use of SDS solution, as shown in Figure 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.

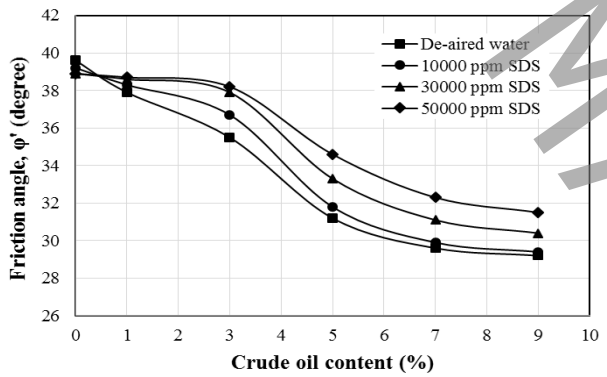


Figure 2. Variation of internal friction angle by crude oil concentration for different SDS solutions

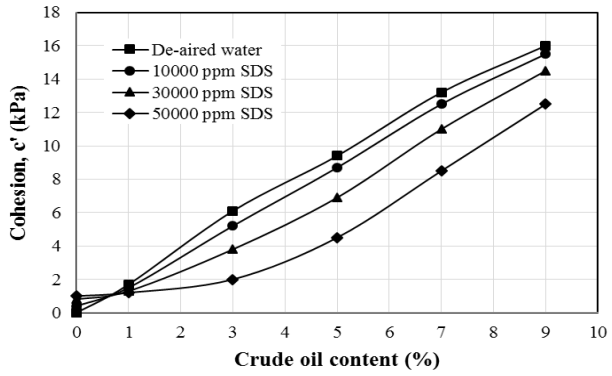


Figure 3. Variation of cohesion by crude oil concentration for different SDS solutions

4. Conclusions

The main results obtained in this study are as followed.

- At all confining pressures, by increase of crude oil content up to 5%, 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 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 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.

5. References

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