ISBN 978-967-2110-70-5

CHAPTER 4

EFECT OF CONTAMINATION ON THE SHEAR STRENGTH PARAMETER OF SAND

4.1 INTRODUCTION

Oil spills is one type of contaminant that in most cases are accidental and present in the sand. It can happened during transportation on land, as leakage from storage tanks. It percolates steadily into subsurface environments and contaminates the soil and water system. This will lead to geotechnical problems related to construction or foundation structure on this oil-contaminated site.

In general, oil contamination reduces the permeability, strength and geotechnical properties of the sand. Thus, affecting the quality of the soil and altering the physical properties of oil-contaminated soil. A number of related studies were carried out in order to investigate the geotechnical behaviours of oil contaminated soil.

The objectives of this study are, to determine the basic properties in two different type of soil, to determine the maximum shear strength and friction angle in the contaminated and uncontaminated sands, and to compare both type of soil in term of its shear strength parameter of friction angle.

This study was conducted at Research Centre for Soft Soil (RECESS) that located at University of Tun Hussein Onn Malaysia (UTHM). In this study, engine oil is used to act as contaminant. Laboratory testing involved are sieve analysis and direct shear test.

Sieve analysis was conducted to produce grain size distribution curve in order to determine the basic properties of soil samples. Direct shear test was done to examine the effect of contamination on sand under normal load of 50 kPa, 100 kPa and 200 kPa. Through this test, the maximum shear strength and friction angle for clean and contaminated soil in two different type of soil were obtained.

4.2 LITERATURE REVIEW

For any possible application of contaminated soils, knowledge of the geotechnical properties and behavior of contaminated soil is required. Furthermore, it is necessary to determine the effect of oil contamination on the existing structures. Unfortunately, there is

ISBN 978-967-2110-70-5

very few from past studies that deals with the geotechnical properties of contaminated soils are available in the literature.

Hassan, et. al., [1] had carried out a laboratory testing program to determine the influence of oil contamination and aging on geotechnical properties of Kuwaiti sand. Based on their result, oil contamination leads to decrease permeability and strength. The friction angle also generally decrease with increase oil contamination. The maximum reduction of friction angle occurred with heavy crude oil. Their test result also concluded that the use of contaminated sand for road construction is possible from the engineering view.

Hassan, et. al., [1] also carried out direct shear test on clean and oil-contaminated soil samples to determine the effect of crude oil contamination on geotechnical properties of clayey and sandy soils. They found that the shear strength of all soil samples reduces with increase of oil contamination. There is also a extreme reduction in cohesion with increasing oil content in CL, while does not have any distinct path in SM. SP samples show a slow cohesion due to oil contamination that can be result of viscosity and inherent cohesion of oil.

Triaxial tests was carried out on clean and oil-contaminated quartz sand. They found that full saturation with motor oil caused a significant reduction in the friction angle of both loose and dense sands and a drastic increase of volumetric strains.

Last but not least, Hassan, et. al., [1] studied the bearing capacity of unsaturated oil-contaminated sand. The oil content in their test samples varied from zero to 6%. Based on their test results, oil contamination drastically reduces the bearing capacity of sand.

4.3 BASIC PROPERTIES OF SOIL SAMPLES

Sieve analysis was conducted on the soil samples according to BS1377: 1990. Figure 4.1 (a) and (b) shows the grain size distribution of all the selected soil samples. Two sieve analysis test were conducted. According to Unified Soil Classification System, Soil A is classified as SW (well graded sand) while Soil B is classified as SP (poorly graded sand).

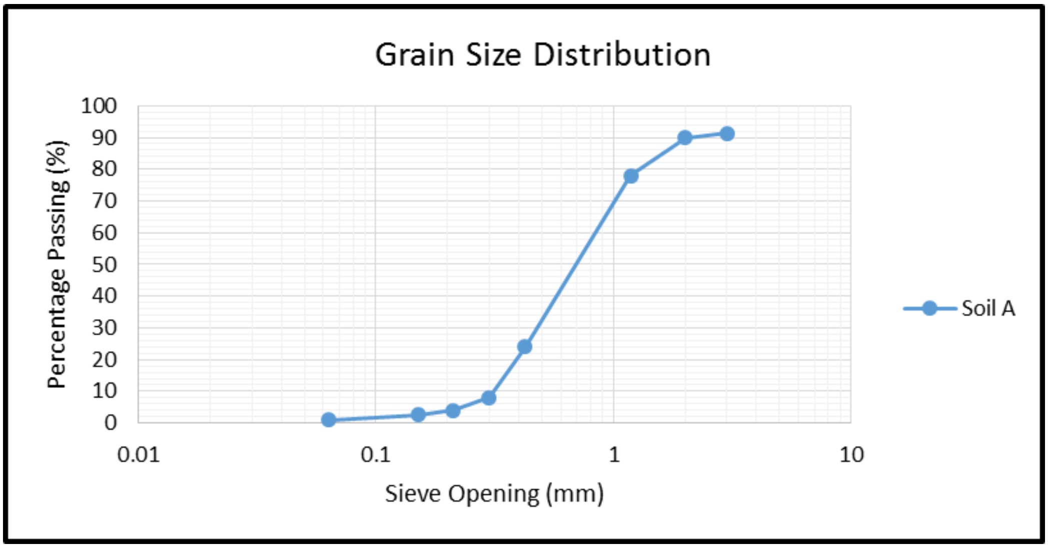

Figure 1 (a): Grain size distribution for soil A

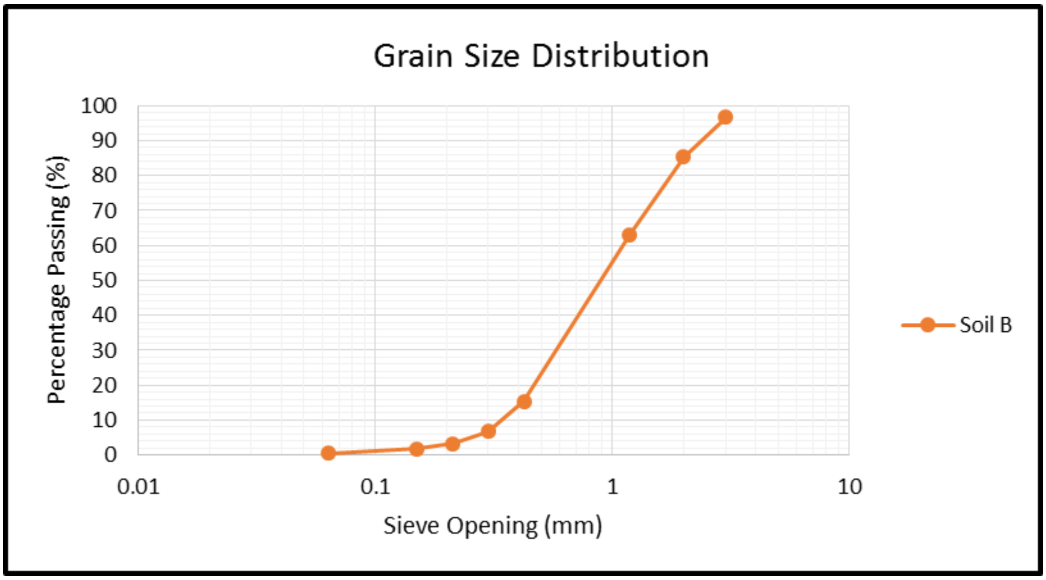

Figure 1 (b): Grain size distribution for soil B

4.4 SAMPLE PREPARATION

After grain size distribution, each soil sample were divided into four parts. In the case of contaminated samples, the amount of oil was calculated as a percent by mass of the dry sand. The percentage by mass of oil were 0%, 5%, 10% and 20%. The eight mixed and equilibrated soil samples were prepared as shown in Table 4.1.

ISBN 978-967-2110-70-5

Table 4.1: The names of artificially oil-contaminated soil samples

Sample name		Percentage of oil (%)
SW	SP	
SW0	SP0	0
SW5	SP5	5
SW10	SP10	10
SW20	SP20	20

4.5 SAMPLE PREPARATION

Direct shear test (ASTM-D3080-72) was carried out by using ShearTrac-II machine to find the effect of contamination on the shear strength parameter of sand. The test was performed in a square shear box (60 mm x 60 mm x 25 mm) with a rate of shear equal to 0.5 mm/min at normal load of 50 kPa, 100 kPa and 200 kPa.

Selected test results based on shear strength parameters are plotted in Figure 4.2 (a), (b), Figure 4.3 and Figure 4.4 as shown as below.

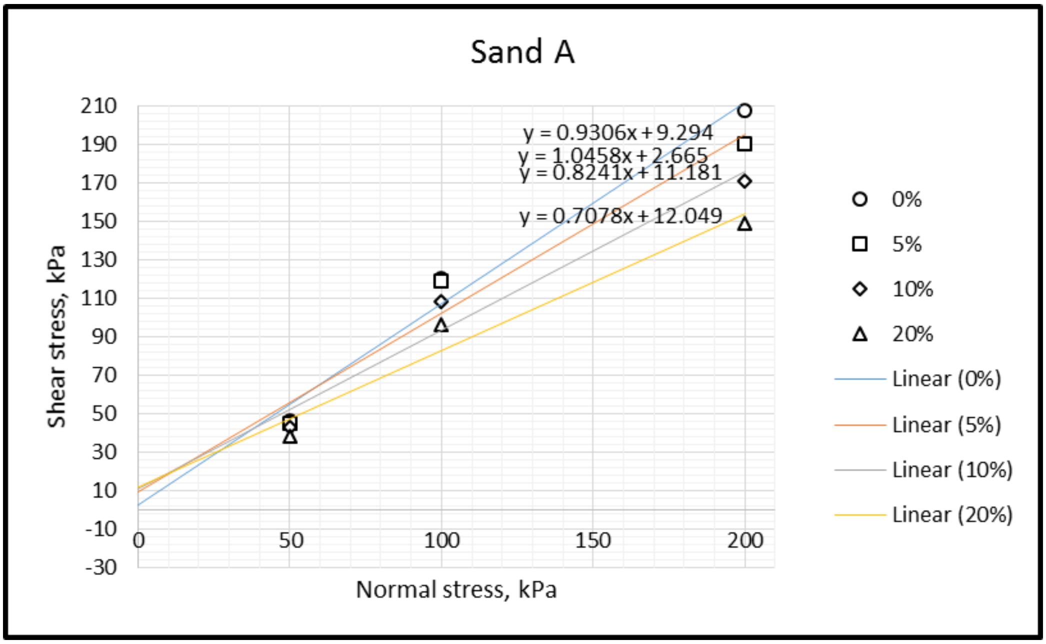

Figure 4.2 (a): Graph envelopes for clean and oil-contaminated samples for sand A

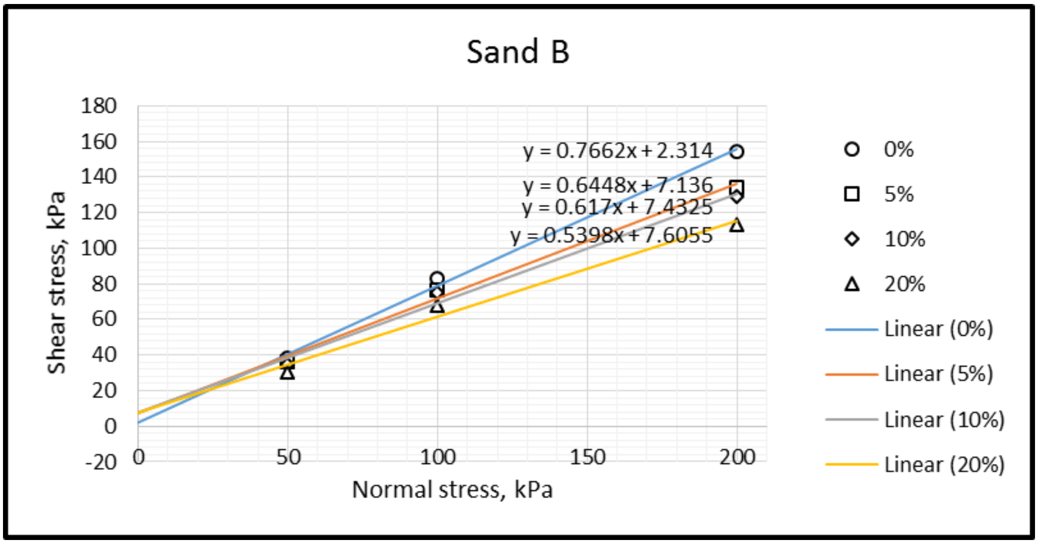

Figure 4.2 (b): Graph envelopes for clean and oil-contaminated samples for sand B

From both Figure 4.2 (a) and 4.2(b), the shear strength in both sand A and sand B decreased with increasing percentage of oil. This proved that increasing percentage of oil contamination in soil sample did caused an effect in the shear strength of sand. The figures also shown that SP samples can achieved higher shear stress than SW samples. From both figures, the graph produced value for friction angle (ϕ) and cohesion (c) of the clean and oil-contaminated soil samples A and B.

The present result in Figure 4.3 shows a correlation between oil content and friction angle (ϕ) in both sand A and B. The direct shear test performed on oil-contaminated sands showed a reduction in ϕ in both soils.

In both soil samples, the friction angle decreased with increasing percentage of oil. The presence of oil acts as lubricant making particles attain a closer packing. Thus, there is a reduction in measured friction angles between clean and contaminated sample in sand A (SW) and sand B (SP) soil samples.

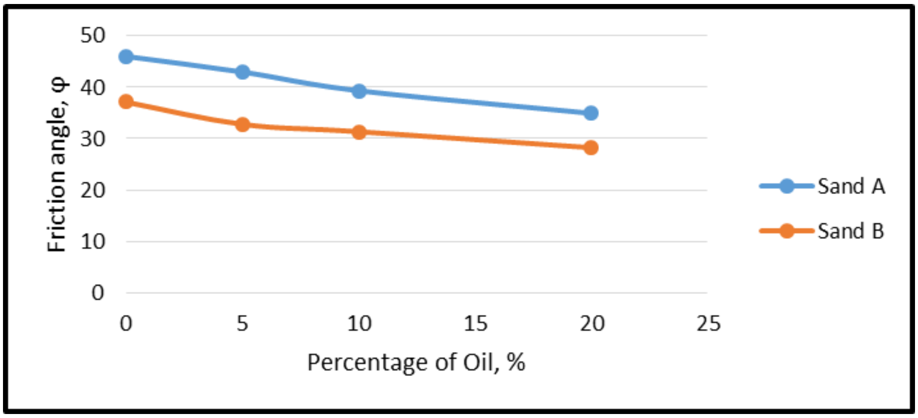

Figure 4.3: Influence of oil content on friction angle of soil samples

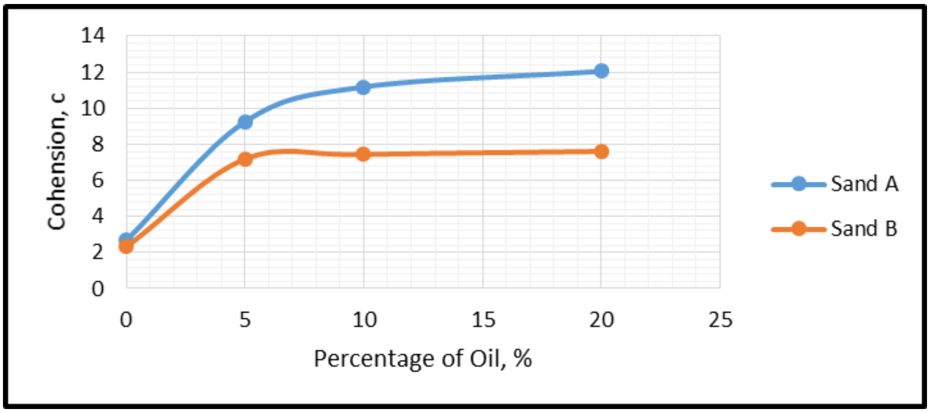

Figure 4.4: Influence of oil content on cohesion of soil samples

From Figure 4.4, there is a distinct path with decreasing order in both sands. However, sand B (SP) soil samples shows a low cohesion compared with sand A (SW) soil samples. This is due to oil contamination that it can be the result of viscosity and inherent cohesion of the oil. It must be noted that contaminated sands show a little apparent of cohesion due to surface tension force of existing oil in soil.

4.6 SUMMARY AND CONCLUSIONS

Sieve analysis and direct shear test was carried out to study the effect of contamination on shear strength parameters, i.e. shear strength, friction angle (ϕ) and cohesion (c) of SW and SP soil samples. The amount of 0%, 5%, 10% and 20% percentage of oil by mass was

ISBN 978-967-2110-70-5

selected for oil contamination level. The following conclusion are drawn based on these tests:

1. Based on Unified Soil Classification System, soil sample A is categorized as SW while soil sample B is categorized as SP.
2. Increasing percentage of oil content reduce the shear strength in sand A and B with a slight differences of value between the two sandy soil. The effect of oil contamination leads to a decreased peak shear strength in all the studied samples.
3. Increasing percentage of oil also reduce the friction angle in both sand A and B while increase in cohesion. This is due to the presence of the tension force of oil in soil.

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