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Influence of Contamination on Geotechnical Properties of Clayey Sand Soil

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ABSTRACT

Generating large quantities of contaminated soil annually in all parts of the world poses a great threat to the environment and humans. In recent times there have been multiple sources of soil contamination. One of the most famous of these contaminants is the used engine oil. In this research, the effect of waste engine oilon some geotechnical properties of soil were studied. Laboratory tests including compaction and California bearing ratio (CBR tests were conducted on clean and contaminated soil. Contaminated soil samples were prepared by adding the waste engine oilat ratios of 4%, 8%, 12% and 16% of the dry weight of the samples. The results revealed a positive effect of the waste engine oilon the maximum dry density (MDD) and CBR values, but this improvement continued until the contaminant ratio of 8%. These values were decreased with further increase in the contaminant ratio to 16%.

Keywords: *contaminated soil, used engine oil, clayey sand soil, geotechnical properties.*

1. INTRODUCTION

Waste engine oilis one of the most famous contaminants in recent times because of dependence on different means of transportation that play a great role in economic growth and facilitating daily life. Number of different cars and vehicles has increased in all countries of the world, and consequently the usage of engine oil has increased. The disposal of waste engine oilcauses great problems to the environment and human being. The effect of various contaminants on the soil behavior and soil properties has become one of the most important topics that have attracted the attention of a large number of researchers recently. In this study, the influence of waste engine oilon some geotechnical properties of soil has been studied.

Most of the research studies concerned with studying the effect of different contaminants on the geotechnical properties of soils showed wide variation in their results. Akinwumi et al.(2014), Oluwapelumi et al. (2012), Rasheed et al. (2014) and many other researchers have been concerned with studying the influence of various contaminants on the geotechnical properties of clayey soils.

Akinwumi et al. (2014) studied the influence of waste engine oil contamination on the compaction and California bearing ratio (CBR) of lateritic clay soil. As the waste engine oil content increased, the maximum dry unit weight and OWC decreased in the contaminated soil.

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Soaked and unsoaked CBR values of the contaminated soil increased up to 8% of waste engine oil then they decreased. Rasheed et al. (2014) investigated the effects of crude oil products such as gasoline and kerosene on the geotechnical properties of soil and concluded that as the percent of contamination increased, the MDD and OWC slightly decreased. . Similar behavior was also observed on CBR values of soil. For shear strength, with increase in contaminant percent, the cohesion between soil particles decreased, although the angle of internal friction increased.

Many other researchers have been concerned with studying the influence of different contaminants on sandy soil behavior. Geotechnical properties of sandy soil contaminated by engine oil were investigated by George et al. (2014). Results concluded that the oil contamination decreased the MDD values whereas the value of OWC increased with the increase in amount of engine oil added into the soil. Results showed that the UCS increased when diesel engine oil was added. The un-soaked CBR value of soil increased from 10.7% to 13.1% as the percentage of oil increased from 0 to 4% then it decreased with increasing oil content to 12%.

Most of these researches were concerned with studying the behavior of clayey or sandy soils. Unfortunately, there are insufficient researches to study the behavior of contaminated clayey sand soils. Because of the presence of clayey sand soil on a large scale in most countries, especially in Egypt, this soil was chosen to be the subject of study in this research.

2. EXPERIMENTAL METHODOLOGY

2.1 SOIL PROPERTIES

In this study, a soil mixture of sand and kaolin was used. Sand was obtained from Rashid, Egypt. Sieve analysis was conducted on sand and the grain size distribution curve is shown in Figure 1. Rashid sand classified as poorly graded fine sand (SP), According to the Unified Soil Classification System. The physical properties of the sand used are listed in Table 1. The modified Proctor compaction test (ASTM D-698) gave an OWC of 7.86% and a maximum dry density of 18.56 kN/m^3. The angle of internal friction (Ø) of sand was equal to 41.608° at maximum dry density.

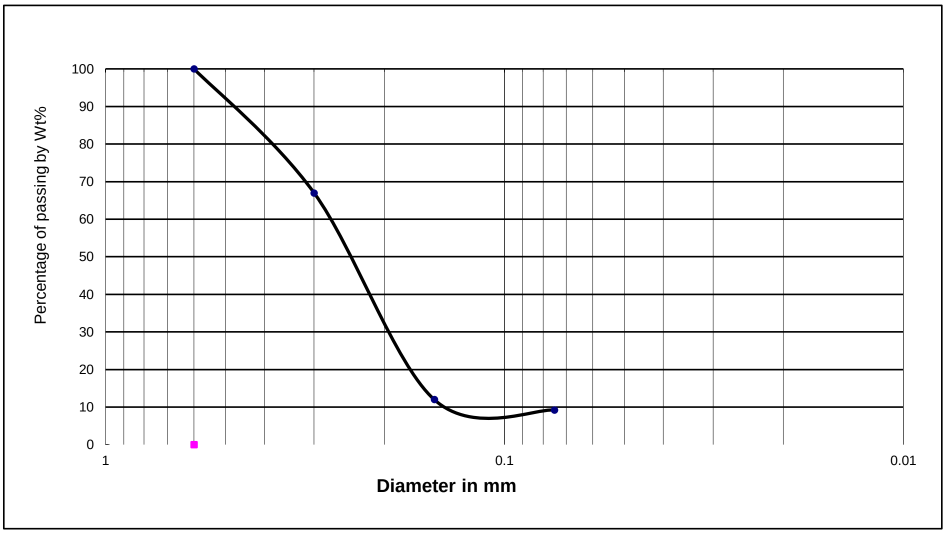

Figure 1: Grain-size distribution curve for Rashid sand.

Table 1: Properties of Rashid sand used in this study.

Physical properties	Quantity
Fines content (< 0.075 mm)	10.0
Effective particle size, D10 (mm)	0.16
Coefficient of Uniformity, Cu	1.75
Coefficient of curvature, Cc	0.90
Soil classification(USCS)	SP
Specific gravity, Gs	2.62
Maximum dry unit weight, Ɣd max (kN/m3)	16.2
Optimum moisture content (%)	17.93
The angle of internal friction at MDD (°)	41.608

2.2 Kaolin Properties

Kaolin was obtained from El basatin for Industry Company. Hydrometer test (D-422) was conducted on kaolin and the grain size distribution curve is plotted in Figure 2. According to the Casagrande plasticity chart, kaolin can be classified as clay with low plasticity. The liquid limit and plastic limit of kaolin are 27.8% and 19.4%.

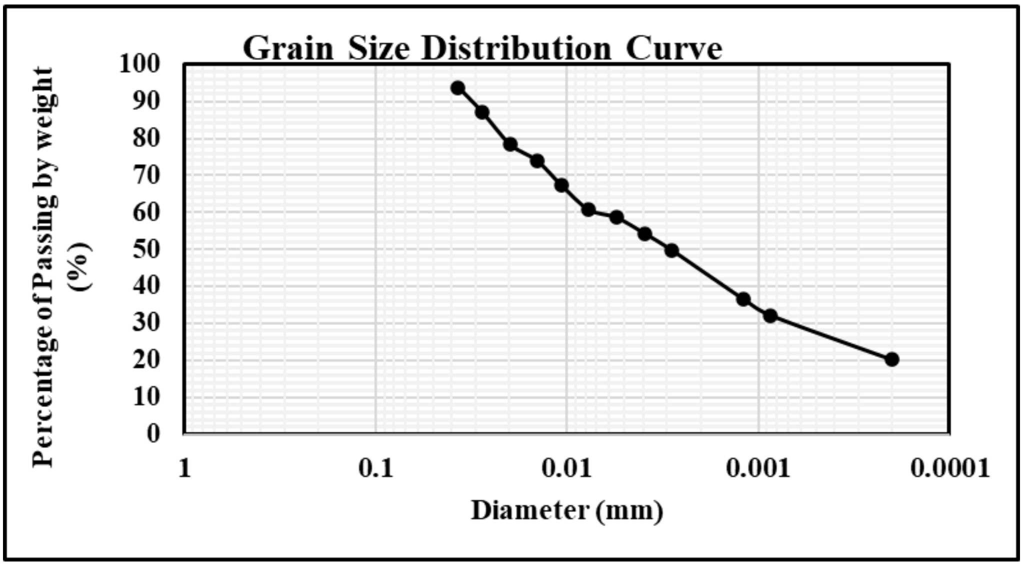

Figure 2: Grain-size distribution curve for tested kaolin.

2.3 OIL PROPERTIES

The waste engine oilwas collected from the mechanic workshop. It is black and feels greasy on the palm. The waste engine oilhad the following properties; viscosity (at 30°C) = 2.89 Poises, density = 0.87 gm/cm3 and specific gravity @15.6° = 0.84.

2.4 SOIL SPECIMEN'S PREPARATION

Soil samples were prepared by mixing sand with kaolin by 90 to 10%, respectively. The sand and kaolin were first oven-dried at 1058C. Then, the waste engine oil was added to samples at ratios 4, 8, 12, 16 % by dry weight of soil.

3. LABORATORY TESTS AND EXPERIMENTAL PROGRAM

Laboratory tests were conducted on clean and contaminated soil samples. Tests included Modified proctor compaction and California Bearing Ratio (CBR). All the tests in this study were conducted according to ASTM procedures. In some cases, the test was repeated on another sample to check if the result will repeat or not. In general, the results were close. For compaction test, modified Proctor tests according to ASTM D-1557 method were conducted on contaminated soil samples at different oil content. Unsoaked and soaked California bearing ratio (CBR) tests were carried on clayey sand specimens with and without waste engine oilwere performed as shown in ASTM D-1883. All samples in different oil ratios were equipped at their maximum dry density and optimum water content.

4. ANALYSIS OF TEST RESULTS AND DISCUSSION

A set of experiments were conducted on clean soils first and their properties were determined, and then the same properties were assigned to the soil at different proportions of the contaminant, but in short, the results of the clean soil were combined with the results of the contaminated soil.

4.1 INFLUENCE OF WASTE ENGINE OILON COMPACTION

Modified proctor tests were carried out on clayey sand samples (90% sand+10% kaolin) with a waste engine oilcontent of 0%, 4%, 8%, 12% and 16% by dry weight of soil. The results are showed in Figure 3 in the form of water content versus dry density curves. The results show that the maximum dry density of clayey sand soil without contaminant is 1.75 gm cm3 at the optimum water content of 10.6%. By adding the used engine oil, compaction characteristics were improved. With adding 4% of WEO the maximum dry density reached 1.85 gm/cm3 at a water content of 5.8%. At 8% WEO, compaction characteristics were better 0and the MDD and optimum water content were 1.925 gm/cm3 and 2.94% respectively. At 12% and 16% WEO, the maximum dry density value began to decrease to 1.919 gm/cm3 and 1.77 gm/cm3 respectively, while the optimum water content became 0%. The increase in MDD values reflects the lubricating effect resulting from the presence of oil that Facilitates compaction and decreases the optimum water content. When WEO ratio exceeds 8% the samples became on the wet side of the compaction curve without adding water so the optimum water content became 0%. The maximum dry density and optimum water content (OWC) values at different ratios of waste engine oilare shown in Figure 4 and Figure 5.

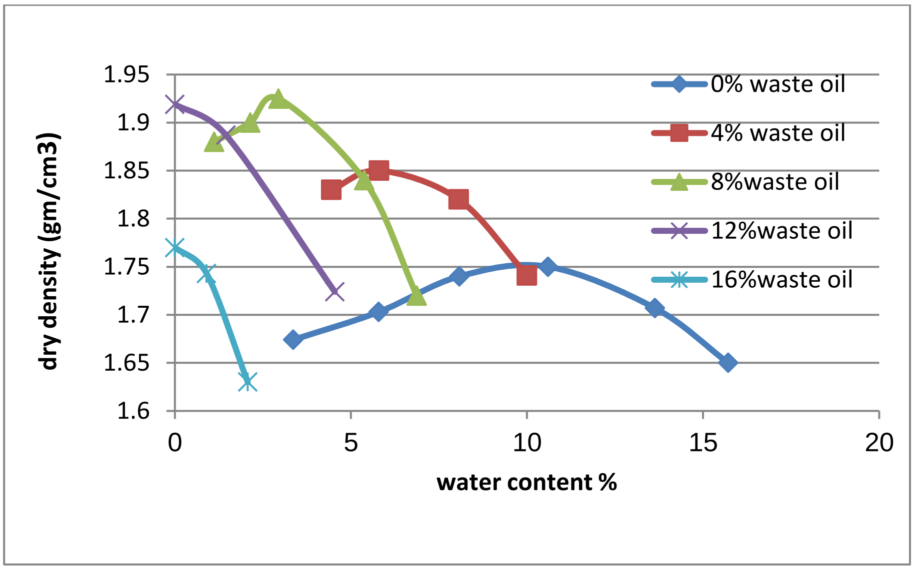

Figure 3: Variation of OWC and maximum dry density at different contaminant ratios.

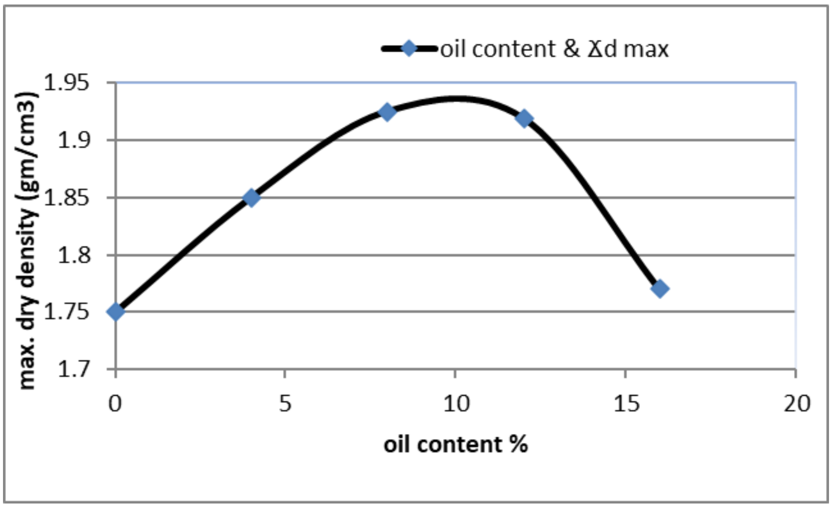

Figure 4: Variation of max dry density with different contaminant ratios for clayey sand soil.

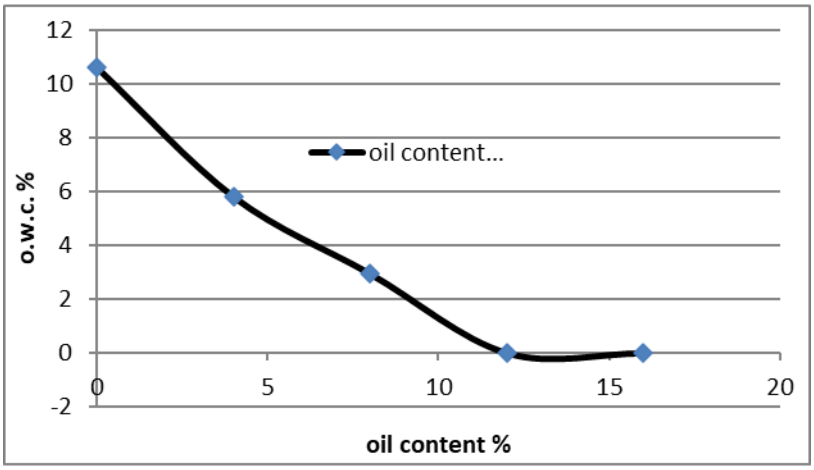

Figure 5: Variation of OWC with different contaminant ratios for clayey sand soil.

4.2 INFLUENCE OF WASTE ENGINE OILON CBR

Soaked and unsoaked California Bearing Ratio tests (CBR) were conducted on samples of clean soil and soil mixed with waste engine oilin an amount of 4%, 8%, 12% and 16% by dry weight. This is in line with the possibility of using contaminated clayey sand as a sub-base for road construction. The results are shown in table 4 and figure 6. As concluded, the CBR values increased with increasing WEO ratio up to 8%. With increasing the ratio of oil to 12% and 16% a significant drop in CBR values occurred. The CBR value increased by about 656% and 611% at 8% and 4%of WEO respectively for unsoaked samples. For soaked samples, the CBR values were slightly less than unsoaked because part of the oil floats on the surface of the water during immersion (table 2 and figure 6). At 12% and 16% WEO, the amount of oil is large and thus leads to a decrease in the maximum density of the mix. In general, we can observe that the results of CBR are in clear agreement with the results of the compaction test.

Table 2: CBR test results for unsoaked and soaked clayey sand soil sample.

WEO%	0	4	8	12	16
Unsoaked CBR%	2.46	17.5	18.6	1	0.83
Soaked CBR%	2.07	13.96	14.8	0.84	0.74

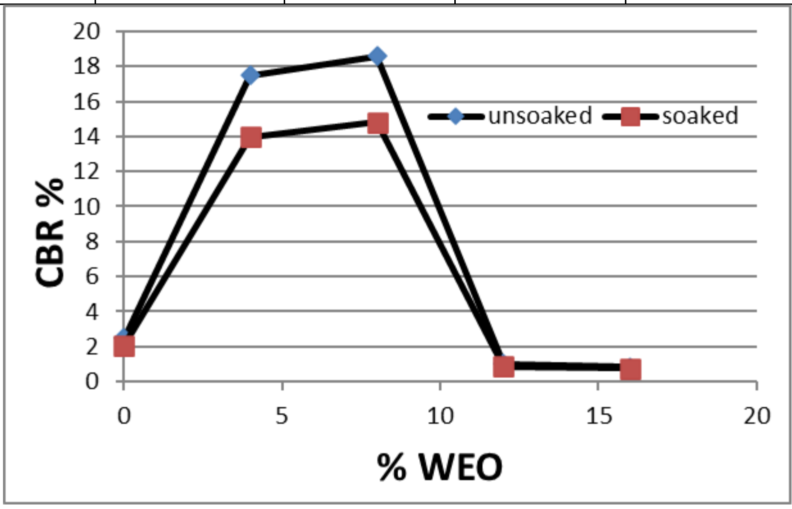

Figure 6: unsoaked and soaked CBR values at different WEO ratios for clayey sand soil samples.

5. CONCLUSION

In this paper, the effect of used motor oil on the geotechnical properties of sandy clay soils is studied. Based on these results, the possibility of using this contaminated soil is studied in various engineering applications, such as its use as a sub-base layer in rural roads. From this study, the following was easing concluded:

1. Compaction characteristics improve with the presence of waste engine oilup to 8% by weight for clayey sand soil 1 (90% sand +10% kaolin) and clayey sand soil 2 (60% sand +40% kaolin), then it decreased by a small percentage while increasing the WEO ratio to 16%. While there was a decrease in the value of optimum water content with increasing the amount of WEO.
2. Unsoaked and soaked CBR values of clayey sand soil increase significantly with the presence of the WEO to 8%. After that, a decrease in these values occurs at 12% and 16% WEO.
3. A decrease in the CBR value occurs with an increase in the duration of the samples submerging in the water at 8% WEO because part of the oil floats on the water surface and some properties of the contaminated soil change.
4. Significant improvement in most geotechnical soil properties occurs at 8% contamination and thus can be used in most engineering applications.
5. The large increase in the CBR values of 8% and the improvement in the compaction properties as well, and the decrease in compressibility enhance the opportunity to use this contaminated soil as a sub-base layer in roads.

6. REFERENCES

1. ASTM D-1883, 2007. Standard test method for CBR (California bearing ratio) of laboratory compacted soils. Annual Book of ASTM Standards. West Conshohocken, PA: ASTM International, Available from: www.astm.org.

2. ASTM D-698, 2007. Standard test method for laboratory compaction characteristics of soil using standard effort. Annual Book of ASTM Standards. West Conshohocken, PA: ASTM International, Available from: www.astm.org
3. George, s., Aswathy, E., Berlin Sabu, B., Krishnaprabha, N.and George, M. (2014). Study on geotechnical properties of diesel oil-contaminated soil. International Journal of Civil and Structural Engineering Research, Vol. 2, Issue 2, pp: (113-117).
4. Akinwumi, I., Uriel R. Maiyaki, U., Adubi, S., Daramola, S., Ekanem, B. (2014). effects of waste engine oil contamination on the plasticity, strength and permeability of lateritic clay. INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH VOLUME 3, ISSUE 9, ISSN 2277-8616.
5. Oluwapelumi, O. and Omotayo, O. (2012). Modeling waste engine oilimpact on the compaction and strength characteristics of a lateritic soil. Electronic journal of geotechnical engineering. Vol. 17.
6. Rasheed, Z., Ahmed, F. & Jassim, H. (2014). Effect of crude oil products on the geotechnical properties of soil. WIT Transactions on Ecology and The Environment, Vol 186, © 2014 WIT Press.