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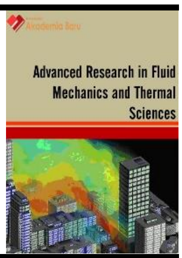

Improving Expansive Soil Properties by Adding Fuel Oil

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ABSTRACT

Expansive soils are the an un constant volume soil, because, they distend or swell when wetting & shrink when they are dried, therefore they affect the stability of the structures that are rested on it, such as light weight buildings & pavements and, then, damages appear because of the developments of heave and swelling which depend, mainly, on the clay content (less than 0.002mm particles size) which the soil has. The problem discussed her on an expansive soil area at the Iraqi west desert that the new [Wild Hajj] road passes over it, named AL-Bussita area. Stability tests such as maximum dry density, CBR, unconfined and triaxial shear test besides other tests such as swelling tests, (one dimensional oedometer tests), were performed on soil shales taken from this area. The study was continued with a sample from a same soil mixed with the fuel oil. The simulation and experimental results demonstrate that the (8% by weight) was the optimum percent of the fuel oil to minimize the swelling potential, and to get a good engineering soil property and the mixed soil became acceptable to use in earth works of roads.

1. Introduction

The common problem of the swelling soil is the volume changes due to the variation of moisture and then the resulting damage of foundations and pavements movements due to this property [1-2]. Expansive soils are a major engineering problem and their identification and mapping is an important undertaking in the building industry [3]. The potential volume change (PVC) is dependent on several physical and chemical properties, among them are clay content, clay mineral type and environmental factors such as the moisture conditions of a site [4]. Soils that exhibit greatest volume changes from dry to wet state usually possess a considerable percentage of montmorillonite. Since expansive soils have a tendency to change their volume to a large extent, they cause heavy distress to engineering constructions [5]. Volume change and associated soil movement is a common problem for structures buried in expansive soil [6]. The generated swelling pressure will then result in the soil microstructure

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changes, in spite of the constant total volume condition [7]. In the recent decades, a number of field observations proved that in most cases, regardless of soil texture, when water infiltrates through the vadosezone of soil, preferential flow occurs [8]. The swelling soils are commonly known by the name of Black Cotton Soils. For swelling to occur, these soils must be initially unsaturated at some water content. If the unsaturated soil gains water content, it swells [9-10].

An important relation between the laboratory measurements of swelling pressure and the inset stress state studied by Ramello [11]. The swelling mechanisms and causes of heaves and their relations with the temperature was described by Mitchel [12]. The causes of foundation damages and pavements movements were mentioned by Robert [13], in this study the author explained how these soils can expand to over 100% of their origin size and then affect concrete slabs and drive ways. Joseph [14] and Yamus *et al.,* [15] advised to use atrial mix procedure to get an optimum percent of additives to improve soil properties. Expansive soils spread over wide area in Iraq, especially at north (Kurdistan) Galawezh *et al.,* [16] but it is found over a little area at west and east. The AL-Bussita area is an expansive soil shale which have an area of about 2000 [40*50] km² near the common borders of Saudi Arabia west desert of Iraq at a 200 km distance west AL-Najaf town as shown in Figure1.

Fig. 1. Map of Iraq

1.1 Research Significance

The fuel oil is a distillation tower product of petroleum. It was choosing to stabilize the swelling soil in this paper, because of its ability of bending, as well as, it delays the attachment of water and soil which is the main reason of soil volume changes. The investigation discussed her on an expansive soil area at the Iraqi west desert that the new [Wild Hajj] road passes over it, named AL-Bussita area.

2. Experimental Work

An experimental program was devoted in this work to investigate the natural expansive soil shales. Firstly, the soil was tested and its properties are shown in Table 1. Secondly, same soil was mixed with fuel oil and strength tests were performed to recognized the effect of fuel oil on the expansive soils which must be used in earth works of roads and embankments according to (ASTM) [17] tests specifications.

Using free swell method (oedometer test method) to calculate the vertical swell value in millimeters and the percentage of vertical swell as follows:

$$P_s = \frac{\Delta H}{H} \times 100 \quad (1)$$

where
P_s = The percentage vertical free swell
ΔH = Increasing in the oedometer sample thickness due to swelling
H = The original thickness of the oedometer sample (19mm)

The applied swelling pressure was calculated by testing soil spacemen in the oedometer laboratory test and applying a vertical effective pressure equal to (7KPa) [17], then saturating this specimen. After 24hrs, a small increments of pressure were applied to get swelling cancellation of the soil specimen. This was continued till the final pressure which made a stable zero swelling of the specimen. Then the total effective zero swelling pressure value was calculated by using the following equation.

$$б_z = б0 + бf \quad (2)$$

where
$б_z$ = Total vertical effective zero swelling pressure (KPa)
$б0$ = Vertical constant effective pressure = (7KPa)
$бf$ = The final added effective zero pressure.

3. Results and Discussion

All test results of the natural soil are present in Table 1. The results show the soil activity and its classification besides other physical tests results. After that the fuel oil, was added and mixed as a percentage of soil weight. Using modified Procter procedure to prepare samples Galawezh *et al.,* [16] different percentages of the fuel oil was mixed with soil (instead of water), to achieve the optimum percent according to the results tests values of density, CBR, unconfined and triaxial shear tests, Table 2 show the properties of the fuel oil properties.

Figure 2 to 6 show the effect of the added percent of fuel oil on the values of mixed soil density, CBR, unconfined and triaxiale shear results. It can be seen that the percent equal to (8%) of added fuel oil, was the optimum percent, because it is clearly shown that the results of previous tests were increasing until the (8%) of added fuel oil and decreasing after this percent. Consequently, the added fuel oil acts like the water when it is mixed with soil and lubricates the soil particles and then they become closer to appointed percent by weight (8%). Then, when the fuel oil percentage increase more than (8%), the soil particles were drifted away. Figure 2 show an enhancement was indicated in soil densities when adding fuel oil comparing to the natural soil even if the percent exceeded the (8%), this results can be attributed to the fact of the fuel oil has a more viscosity than water, Table 2, and the soil particles was more lubricated and become closer than the state when water was added.

Figure 3 shows an overview of the CBR results. The CBR values increases when adding fuel oil comparing to the natural soil even if the percent exceeded the (8%). The CBR increase due to the same reason of soil densities increased, besides, the fuel oil delayed the touch of water with the mixed soil during the (96) hours of the submerged sample period of this test. This relation is showing that the (8%) of fuel oil was still the optimum.

Table 1
Natural Soil Properties

Property test	Specification	Result
Specific gravity (G_S)	ASTMD854	2.78
Liquid Limit (L.L) %	ASTMD4318	63
Plastic Limit (P.L) %	ASTMD4318	29
Shrinkage Limit (S.L) %	ASTMD4318	14.0
Plasticity Index (P.I) %	ASTMD4318	34
Natural unit weight (KN/m³)		12.44
Natural moisture content %		8.7
Max. dry density (KN/m³)	ASTMD1557, D698	15.30
Optimum moisture content %	ASTMD2216	23.76
Percentage passing (0.075mm) sieve:	ASTMD422	98
-Sand %		2
-Silt %		37
-Clay %		61
Activity		0.608
*Unconfined compression strength (KPa)	ASTMD2166	85
*Cohesive strength(C) [(KPa)		20
*Angle of internal friction (φ˚)		2.6
*California Bearing Ratio (CBR)%	ASTMD1883-05	2.3
*Swell pressure (KPa)	ASTMD4546	1630
*Free swell(mm)	ASTMD 4829	4.333
*Expansion Index % [E.I]	ASTMD 4829	22.8
Classification:		
-Unified classification system	ASTMD2487	CH
- AASHTO classification system	ASTMD3282	A-7-6

*At Maximum Dry Density

Table 2
Fuel oil properties*

Test	Result
Density @15.0C˚	0.9607
API. Gravity @15.6˚C	15.7
Flash Point ˚C	> 100
Pour Point ˚C	+3
Vis.@50˚C (c.st)	171.46
Carbon Residue (wt.%	8.76
Sulfur Content (wt.%)	4.29

*American Petroleum Institute

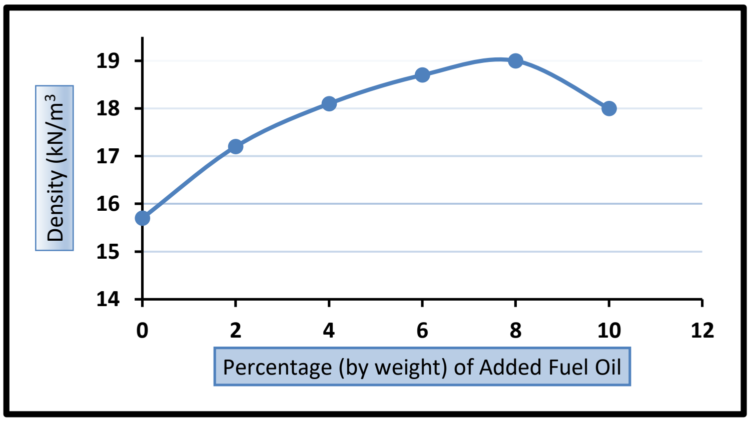

Fig. 2. The Effect of Fuel Oil on Dry Density

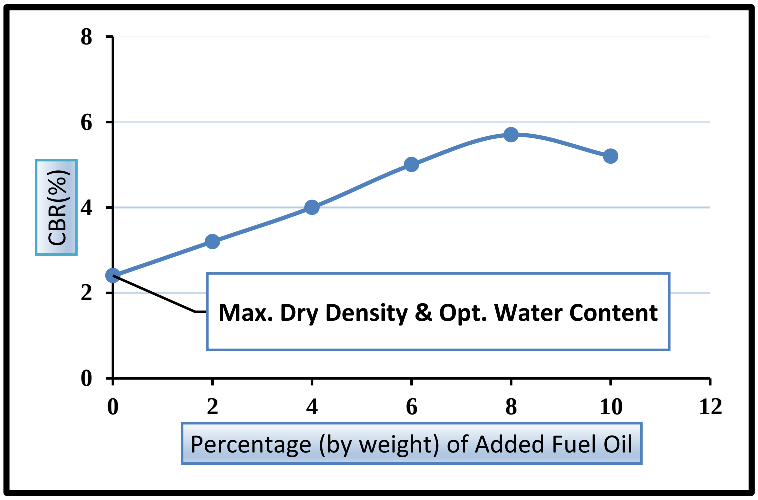

Fig. 3. The Effect of Fuel Oil on CBR

It was clarified in Figure 4 that the fuel oil increased the value of the unconfined compression strength with the increasing of the added percent until (8%) and then the value became less, also this result is related to the viscosity of the fuel oil which has a more value than it is for water leading to increase the mixed soil cohesion. This fuel oil did an opposite action after reaching the added (8%) because it was keeping the soil particles away from each other when the added percent was much more. Figure 5 also shows this behavior of the mixed soil cohesion values computed from triaxle tests. The mixed soil internal friction angle was little affected by adding fuel oil as it is shown in Figure 6, it was slightly raised from (2.6˚) for natural soil to (2.8˚) for (8%) fuel oil mixed with soil, but it was also becoming down after this percent because the fuel oil leads the soil particles far away from each other's as well as, they have a more surface area.

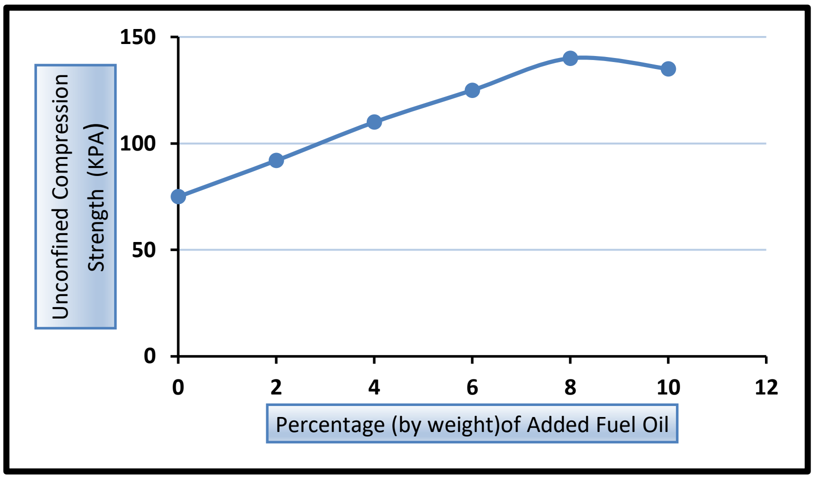

Fig. 4. The Effect of Fuel Oil on Unconfined Compression Strength

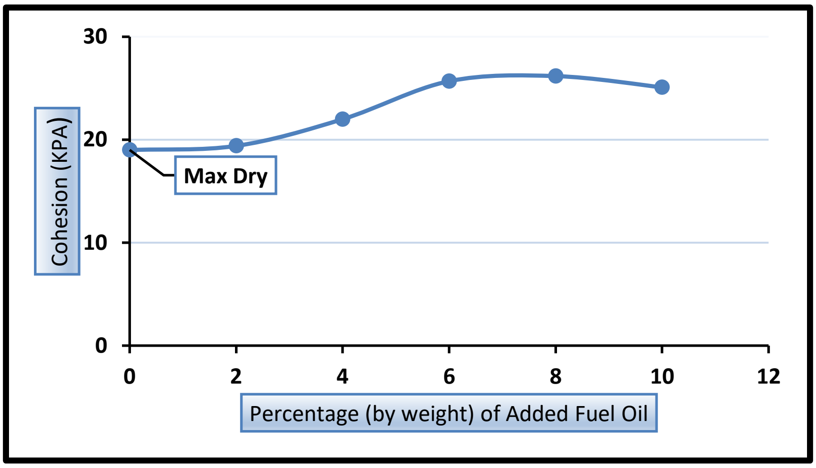

Fig. 5. The Effect of Fuel Oil on Cohesion

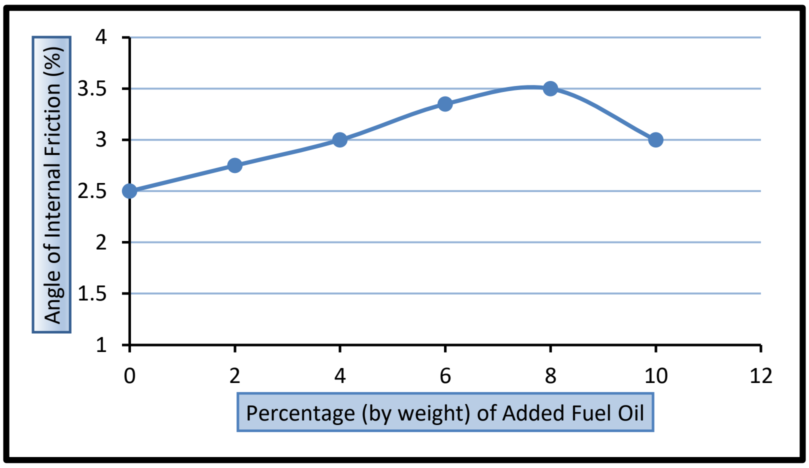

Fig. 6. The Effect of Fuel Oil on Angle of Internal Friction

As it is shown in Figure 7, the free swelling value of the oedometer natural soil specimen compacted to a maximum laboratory dry density was (4.33mm). The values reduced to (1.8) mm for tested soil mixed with (8%) of added fuel oil, this value slightly begun to rise after this percent, this result can be attributed to the fact that the fuel oil delayed the touch of water with the tested soil specimen. The effect of deletion ended by the gradually removing of the fuel oil by water (approximately 144 hrs.) because of the difference in their densities as it was discussed previously. Figure 8 shows the relation between the percentage of vertical free swelling and the total vertical effective zero swelling pressure ($б_z$) for both natural soil specimen and the mixed soil with the optimum percentage of fuel oil (8%). Two facts were noticed, first, the reduction of the percentage of vertical swell value from 22.8 to 9.6 percent for same applied pressure and, second, the decreasing of the total vertical effective zero swelling pressure($б_z$) from (1650) kPa to (530) kPa. These two facts were related to the raised density of mixed soil as comparison with it for natural soil and also because the added fuel oil restrained water from reaching the tasted soil specimen.

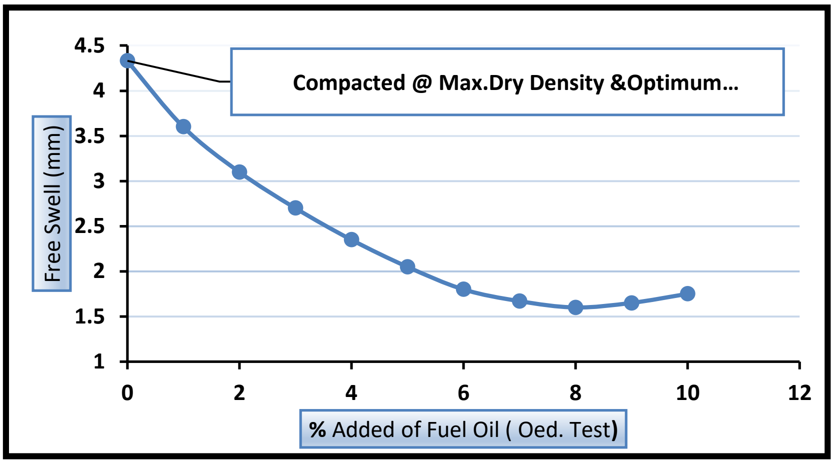

Fig. 7. Swelling amount(mm)- percentage by weight of fuel oil

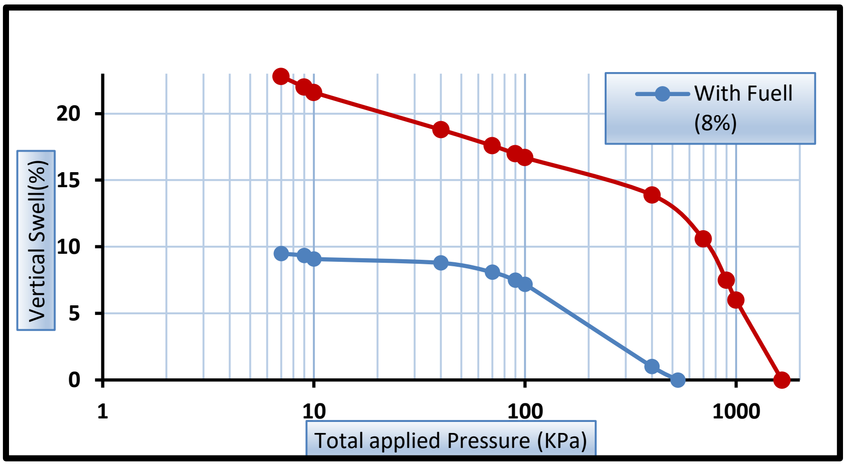

Fig. 8. The Effect of (8% by weight) Added Fuel Oil on the Relationship of Vertical Swell (%)- Applied Pressure

4. Conclusions

i. The fuel oil improved the properties of expansive soil and its strength because it reduced the soil volume changes resulting from wetting and drying and consequently reduced its ability of swelling and shrinking.
ii. The optimum percent of adding fuel oil is 8 percent by weight.
iii. Adding fuel oil raised the values of compacted density, CBR unconfined compression and shear strength parameters, (cohesion and angle of internal friction).
iv. Fuel oil restrained water from reaching or touching the expansive soil, for approximately 144 hrs., which is the main reason of expansive soil construction problems.
v. Expansive soil which mixed with fuel oil can be used at the earth works of road and high ways approaches.

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