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STUDYING THE EFFECT OF THE ADDITIONS ON EXPANSIVE SOILS

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ABSTRACT

Expansive soils cause damages to civil engineering structures in various parts of the world, because they swell when absorb water and shrink when they dry out. Additional stresses applied to the structures due to the swell pressures are important in explaining some of the damages to the structures in expansive soils. Therefore the prediction of the swell pressures and taking them into consideration in the design of structures is needed. In this study, the relationship between the index properties and swelling characteristic of expansive soils is examined. The earlier studies showed that an increase in dry density and plasticity index of the soil cause an increase in swell pressure, while a decrease in natural moisture content cause an increase in swell pressure. In this paper, **ALmarj** soil will be used because of their properties to compare the swelling before and after adding the additions, that will be:- 1. Fine aggregate 2. Burned oil**.**

These additions are choosing because they are cheap and recyclable available materials. The experimental study results show that, the soil properties after adding these additions have been changed with different ratio.

INTRODUCTION

Expansive soils include clays and very fine silts which shrink as their moisture content decreases and swell as their moisture content increases

Engineering geological properties of expansive soil including the swelling, shrinkage, and mechanical properties are closely related to their origin, geological time, geological process, material source and composition, and microstructure type. The geological times of the expansive soil is an important factor influencing the engineering properties. (Miao et al. 2007).

Swelling in expansive clays is complex and a result of changes in the soil water system. When water is introduced in the environment, clay soils adsorb water more than sandy and gravelly soils causing extensive damage to civil engineering structures. Chen (1975) estimated that the annual cost to repair buildings, roads and other structures built on expansive soils were expected to be more than $10 billion in 1975. In 2004, the annual cost of expansive soil damage in the U.S. was estimated to be more than $25 billion (Wray and Meyer 2004).

The main objective of this study is to investigate the effect of some additions on expansive soils (Al Marge clay), to calculate swell pressures for this soil, and the relations between some variables.

TEST DATA TO STUDY SOIL

The sample was taken from AL.merj soil. The used soil was passing NO200 sieve. Some laboratory tests were performed on the soil before and after the additions(with different ratios) included soil classification, specific gravity (Gs), liquid limit(LL), plastic limit(PL), consolidation test, and swell pressure were considered for the analysis of this study.

Classification of Soil Samples

Based on the Unified Soil Classification System (USCS), the sample analyzed were classified as fine-grained soils. The soil sample used for this study is plotted on the plasticity chart as shown in Figure 1.
Figure 1 shows that the majority of the samples were low-plasticity clays (USCS classification of CL).

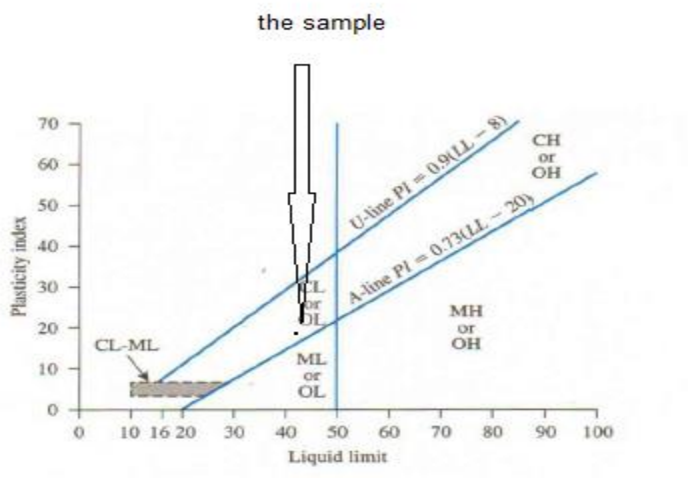

Figure 1. Soil data on plasticity chart (Das 2007)

Swell pressure

Evaluation of swelling characteristics of expansive soils, namely, swell potential and swell pressure, is important for the design of foundations. Previous investigations have indicated that some factors influence swell potential and swell pressure, such as type and amount of clay, nature of pore fluid, temperature, initial condition of soil in terms of dry density and moisture content, and time (Day 1994)

Erzin and Erol (2007) investigated the effect of different empirical equations in a wide range of expansive soil properties to calculate the swell pressure and compared these equations with the measured swell pressures by oedometer tests. They also indicate that soil suction is the most relevant soil parameter for the characterization of swell behavior of expansive soils. They found that the following equations have strong correlations between the logarithms swell pressure and the soil properties, R =0.96 and 0.97, respectively. Also these equations have a good agreement between the measured and predicted swell pressures.

$$\text{Log } P_s = - 16.31 + 0.0330 \text{ PI} + 8.253 \gamma_d + 0.829 \log s$$

If the suction measurements are not available, then the equation for the correlation between the soil suction, s, and the soil properties given in the following:

$$\text{Log } s = 2.02 + 0.00603 \text{ PI} – 0.0769 w$$

Where P_s in kN/m^2; PI and w in percent; γ_d in kN/m^3; s in bar.

γ_d = dry unit weight of the material, and they assumed the values between 15 to 18 kN/m^3

Erzin and Erol concluded that the swell pressure can be predicted by the initial soil suction and the two soil properties, plasticity index and dry density, using simpler techniques than the oedometer tests in shorter time.

The definition of swell pressure for undisturbed soils is that the pressure required keeping the volume of a soil as constant at its natural dry density. For remolded soils, the swell pressure is the pressure that is required to keep the volume of a soil at its maximum proctor density constant (Fadol and Ke-xu 2004). The definition of swell potential introduced by Seed et al. (1962), is the percentage of swell of a laterally confined sample on soaking under 1 psi surcharge, after being compacted to maximum density at optimum water content in the standard AASHO compaction test.

The degree of swell potential of expansive soils can be classified by the soil's liquid limit, *LL*, or plasticity index, *PI*. As the liquid limit or plasticity index increases, the swell potential of the soil increases. Mansour(2011) concluded based on previous studies, the classification as shown in table 1

Table 1: Classification of expansive soils based on previous studies (Mansour 2011)

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Classification	Plasticity index (%)	Liquid limit (%)
Non-expansive	0-6	0-25
Low	< 25	25-50
Marginal	25-35	50-60
High	> 35	> 60

ANALYSIS AND RESULTS

The analyses were performed for sample was taken from AL.merj soil, which was passing NO.200 sieve. Then some laboratory tests were performed on the soil before and after adding the additions which were(fine aggregate and burned oil with ratio1%, 2%, and 4%) and comparing the results for water content, plasticity index, the suction, unit weight, swell pressure, and consolidation test

The analysis results are shown in table2 through table10,

Table 2: Sample without additions

W%	PI	Log S	γd	P_S
21.08%	18.05%	2.004	15	109.74
			16.5	122.12
			18	134.5

Table 3: Sample with 1% Fine aggregate additions

W%	PI	Log S	γd	P_S
20%	35.13%	2.006	15	110.3
			16.5	122.68
			18	135.06

Table 4: Sample with 2% Fine aggregate additions

W%	PI	Log S	γd	P_S
27.04%	16.24%	2	15	109.67

			16.5	122.06
			18	134.43

Table 5: Sample with 4% Fine aggregate additions

W%	PI	Log S	γd	P_S
27.6%	14.4%	1.99	15	109.6
			16.5	121.98
			18	134.37

Table 6: Sample with 1% oil additions

W%	PI	Log S	γd	P_S
29%	7.72%	1.99	15	109.39
			16.5	121.76
			18	134.15

Table 7: Sample with2% Oil additions

W%	PI	Log S	γd	P_S
30%	24.48%	1.99	15	109.94
			16.5	122.32
			18	134.7

Table 8: Sample with 4% oil additions

W%	PI	Log S	γd	P_S
31%	20.93%	1.99	15	109.825

			16.5	122.2
			18	134.58

where:

P_s= Swell pressure (kn/m$^{2)}$

S = Soil suction

γd= Dry unit weight (kn/m$^{3)}$

PI=Plastic index

ω %=water content

Table 10.a: Consolidation test results

coefficient	Before addition	After loading					
		After oil addition			After agragget addition		
		1%	2%	4%	1%	2%	4%
e	0.936	0.968	1.001	1.193	0.922	0.927	0.939
Cc	0.119	0.123	0.149	0.132	0.109	0.166	0.113
Cs	0.023	0.0133	0.0199	0.00332	0.083	0.0033	0.0199
ΔH	0.728	0.773	0.929	0.779	0.733	0.723	0.739
Ht av	18.531	18.443	18.075	18.56	18.514	18.435	18.45

Table 10.b: Consolidation test results

coefficient	Before addition	After unloading					
		After oil addition			After agragget addition		
		1%	2%	4%	1%	2%	4%
e	0.829	0.85	0.858	1.0688	0.838	0.828	0.834
Cc	0.119	0.123	0.149	0.132	0.109	0.166	0.113
Cs	0.023	0.0133		0.00332	0.083	0.0033	0.0199
ΔH	0.036	0.0275	0.0305	0.027	0.733	0.022	0.739
Ht av	17.174	16.968	16.358	16.933	18.514	17.141	18.45

Distribution of Plasticity Index and the Additions

The distribution of the plasticity and different ratios of fine aggregate is given in figure 2, the test result shows the plasticity indexes decrease with increasing the ratio of fine aggregate.

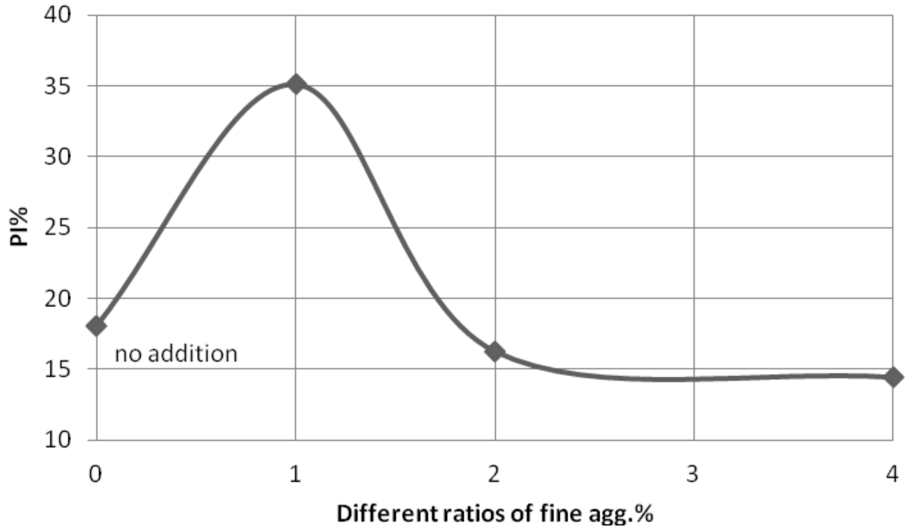

Fig.2 Different ratios of fine aggergate vs. plasticity index

For diferent raios of burned oil in figure 3, there is increasing in plasticity indexes with increasing the ratio of burned oil

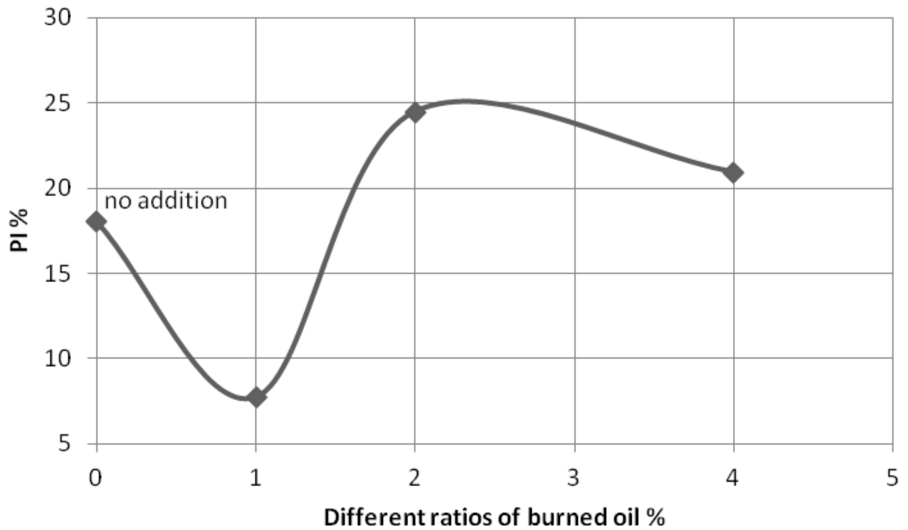

Fig 3. Different ratios of burned oil vs. plasticity index

Distribution of void ratio and the Additions

The distribution of the void ratio and different ratios of fine aggregate is given in figure 4, the test result shows the void ratios decrease 1%, 2% of fine aggregate.

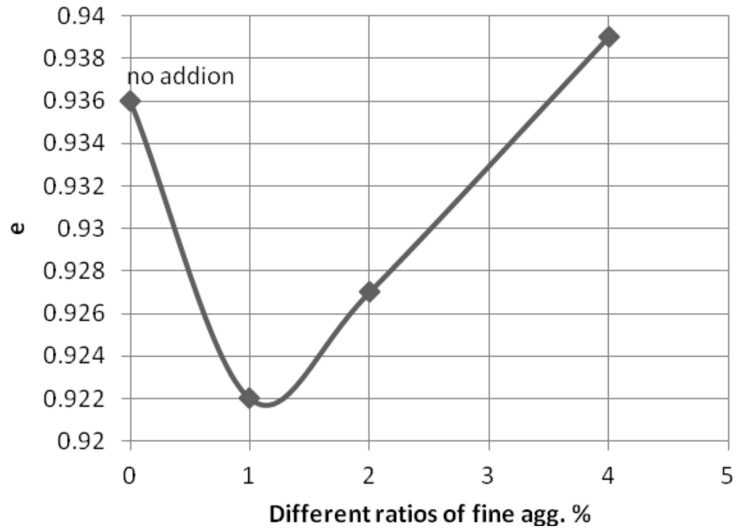

Fig.4 Different ratios of fine aggergate vs. void ratio

In figure 5, there is increasing in void ratio with increasing the ratio of burned oil

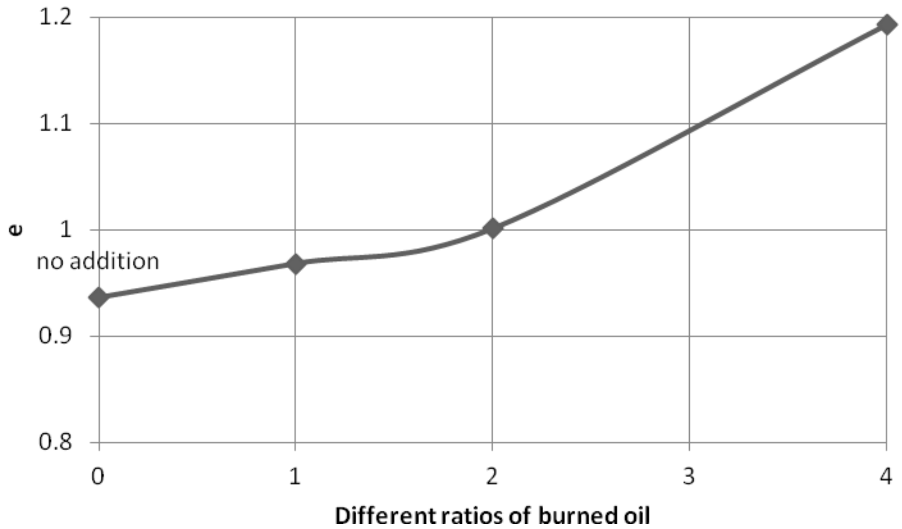

Fig.5 Different ratios of burned oil vs. void ratio

Distribution of swell pressure and the Additions

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The results showed that the swell pressure increasing with increasing in dry unit weight for different ratios of burned oil and fine aggregate as plotted in figure 6

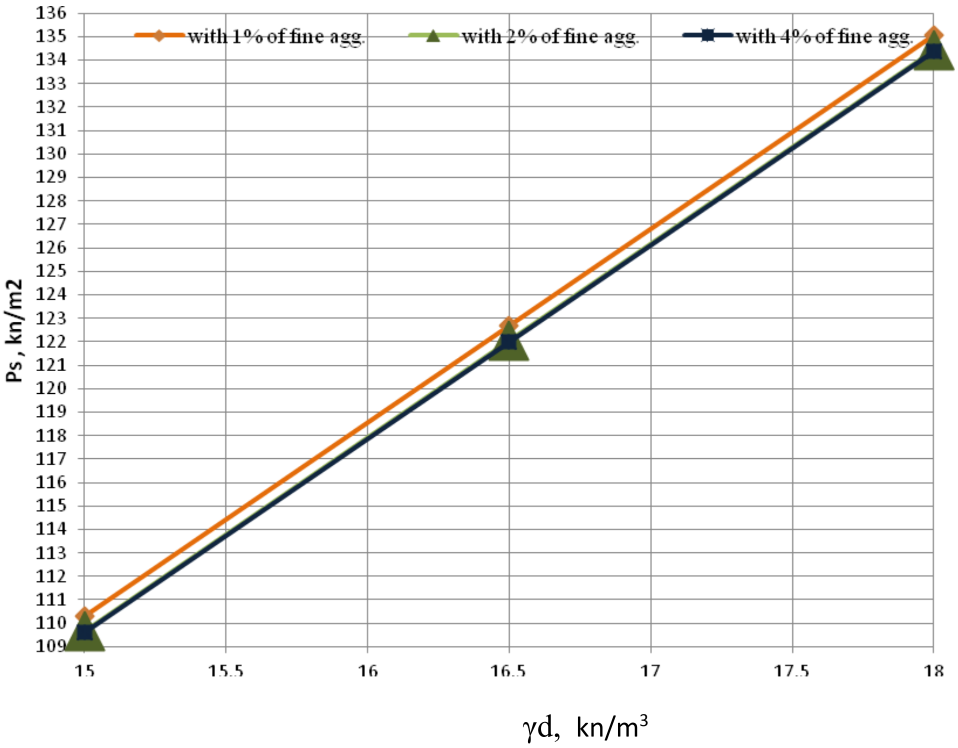

Fig.6 Dry unit weight of fine aggregate vs. swell pressure

SUMMARY AND CONCLUSION

In this study, Empirical equations were used to determine the expansive soil swell pressures. In addition, experimental studies were used to find soil properties before and after adding the additions. The conclusions and recommendations drawn from this study are given in the following sections.

1. It has been proven that the studied soil is an expansive soil based on table 1.

2. After adding the fine aggregate, it is showed that P.I decreasing with increasing the fine aggregate ratios 1, 2, and 4%.

3. After adding the burned oil, it is showed that P.I increasing with increasing the oil ratio.

4. For the fine aggregate, the ratio 1% and 2% showed that there is improvement in soil behavior [e, Ht(av)].

5. Expansive soil swell pressures depend on soil's dry unit weight and plasticity index. The swell pressures increase with increasing dry density and plasticity index.

6. The swell pressures also depend on the moisture content of the soil and the swell pressure increases with decreasing moisture content.

7. This study showed that the ratio of 1% and 2% fine aggregate is better than oil adding to improve the soil behavior.

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