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Oil Contamination Effect on the Dispersivity Potential and Shear Strength of Dispersive Clay Soils

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ABSTRACT: Dispersive clay soils are soils that have high percentage of sodium ions. The soils prone to be washed when placed under water seepage and erosion. In this research, the impact of crude oil as a side effect of pollution (possibly positive) on the dispersion capability of a clay soil is discussed. Therefore, soil were first dispersed artificially by adding a solution of sodium hexametaphosphate, then some pinhole tests performed on the soil samples with different contents of crude oil (as 1, 3, 5 and 7% by unit weight). In addition, the effect of crude oil pollutant on the shear strength was studied using unconfined compression tests. Pinhole test results showed that presence of oil and increasing of its content and time passing, dispersivity of soil is decreased. Also, unconfined compression tests results showed that samples strength increases at first up to 3% oil content and more oil quantities reduces the resistance of the soil. Also adding of oil content reduces soil compression strength up to 7 days aging time and after that increases it.

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1- Introduction

Dispersive soils are related to clays particles that can be easily washed by waters with low salt contents. Such clays usually contain high content of sodium ions in their absorptive ions. Dispersion is a progressive phenomenon beginning from a point with high water concentration which gradually develops. Cracks from condensation, differential settlements and hydraulic gradient could result in dispersion. Dispersive phenomena knowledge is very important in the projects involving earth dams, water canals design and construction. Dispersive soils are abundant in different climates and regions through the world, such as Australia, Brazil, Iran and USA [1]. The dispersive soils may not be recognized by regular soil classification tests. Therefore it is usually recommended to simultaneously use four tests to recognize them, including Pinhole, Kramb, chemical and double hydrometric tests [2]. Environmental pollution due to oil contaminations have been one of the recent important challenges for human life. Usually a large amount of oil products are yearly outspread in nature. In this paper, the impact of crude oil as a side effect of pollution (possibly positive) on the amount of divergence and strength of the soil is studied using some pinhole and unconfined compression tests.

2- Soil and the performed tests

The soil used in this research was a clay soil. Particle size distribution of soil is shown in Figure 1. Physical properties of soil included specific gravity of particles, liquid limit, plastic limit, plastic index, dry unit weight and optimum moisture content are presented in Table 1. The selected soil was classified CL based on unified soil classification system. The soil itself was not dispersive at first, and it was disperse artificially by adding of 12 % meta-phosphate sodium solution. The soil was polluted by 1, 3, 5 and 7 percent of petroleum and consequently samples were constructed. Samples were remained inside of plastics membrane up to 1, 7 and 28 days. Then, pinhole tests were performed on the samples. The contaminated soil shear strengths were also studied using unconfined compressive test.

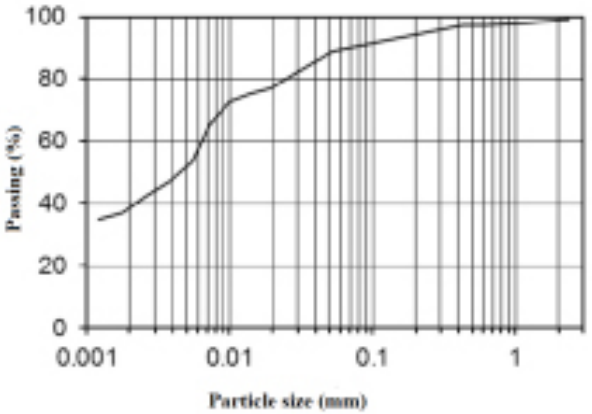

Figure 1. Particle size distribution of the used soil

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Table 1. Physical properties of the used soil

property	Value
Specific gravity of particles	2.657
Liquid limit (%)	46
Plastic limit (%)	20
Plastic Index (%)	16
Optimum moisture content (%)	14.9
Dry unite weight (gr/cm^3)	1.82

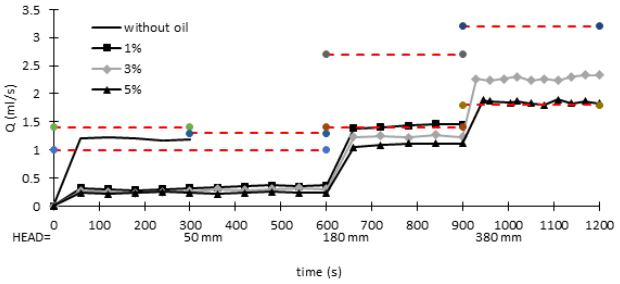

Figure 2. Discharged water inside of sample versus cumulative time of test for 28 days aging time

3- Results and Discussion

Pinhole test results are shown in Figure 2 as discharged water inside of sample versus cumulative time of test for 28 days aging time as an instance. As shown in Figure 2, the sample without oil has been failed and washed rapidly. On the other hand the soil itself has been dispersed very soon under water head of 50 mm. Adding of oil to soil, increases the soil strength against water seepage and reduces the soil dispersivity potential. Totally pinhole tests results performed on the polluted samples is summarized in Table 2. Based on this table adding of both the petroleum content and aging time reduce the dispersivity potential of clay soil. Figure 2 shows that all the samples will be non-disperse with 7 % oil content. Unconfined compressive strength of contaminated samples is illustrated in Figure 3. This figure shows that adding of oil to soil reduces the uniaxial strength at first up to 7 days aging. After that the uniaxial strength of samples has been increased for 14 and 28 days aging time. Based on Figure 3, unconfined compressive strength is increased from 134 kPa (for uncontaminated soil) to 185 kPa (for contaminated sample with 3% oil) at aging time of 28 days.

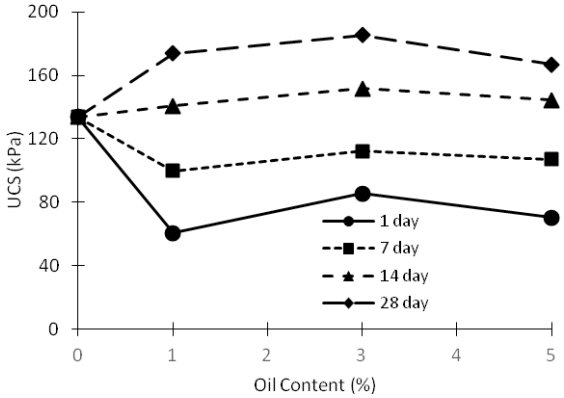

Figure 3. Unconfined compressive strength of contaminated samples

Table 2. Pinhole tests results on the dispersivity potential of polluted samples based on ASTM standard

Oil content (%) / Aging time (days)	1	3	5	7
1	Very disperse (D1)	Low to medium (ND3)	Low (ND4)	Non-disperse (ND2)
7	Disperse (D2)	Low to medium (ND3)	Low (ND4)	Non-disperse (ND2)
14	Low to medium (ND3)	Low to medium (ND3)	Low (ND4)	Non-disperse (ND2)
28	Low to medium (ND3)	Low (ND4)	Low (ND4)	Non-disperse (ND2)

4- Conclusion

Briefly the following results were obtained based on the pinhole and unconfined compression tests about the effect of crude oil on the dispersivity and strength of a clay soil:

1. The soil itself was not disperse at first and dispersed by adding of 12 % meta-phosphate sodium solution.
2. Adding of oil to disperse soil and passing of aging time reduces its dispersivity potential, so that all the samples will be non-disperse with 7 % oil content.
3. Unconfined compression tests results showed that samples resistance increase at first up to 3% oil content and more oil quantities reduces the soil strength. Adding of oil to clay soil reduces its unconfined compressive strength up to 7 days aging time and after that increases it.

References

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