Effect of Oil Contamination on Geotechnical Properties of Clayey Soil

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***Abstract*—Soil pollution by different oil products is a serious geo-environmental problem that adversely affects the quality of soil, groundwater and atmosphere. Oil spillage on land accounts for the majority of hydrocarbon contamination of our planet. When oil products accidentally spill over the ground surface, it infiltrates through the unsaturated zone where part of it is retained in this zone, while the other part reaches the water table causing ground water pollution. Evaporation of the retained part to the atmosphere pollutes the air, vegetation, and has a deleterious effect on human beings. The common sources of oil contaminants are oil exploration, transportation, production and processing. Soil contamination by oil not only affects the environment but also has negative affects on the safety of civil engineering structures. Oil contamination reduces the permeability, strength and Atterberg limits by increasing oil contamination. There is lack of information concerning the effect of contamination duration of oil pollution on the geotechnical properties on different type of soil. The objective of this study is to analyse different laboratory testing program to study the effect of motor oil contamination together with the effect of contamination duration on geotechnical properties of different soils .The studied properties include Atterberg limits, unconfined compressive strength, and permeability and compressibility characteristics.**

Keywords*— *Kaolinite; Thonakkal clay; oil contamination;

I. INTRODUCTION

Rapid increase in the population all over the world is directly proportional to the development programmers in housing and construction for industrial enhancement. Nowadays it can be shown that geotechnical work and earning are directly related to the industrialization that in turn brings pollution effect to the surrounding. The rapid growth of industrialization has created several problems in all parts of the world. In the present situation, if industrial development for the benefit of humanity is not properly planned then environment is being adversely affected at a great speed. Increasing of industrialization and changes in land use pattern have resulted in general degradation of the soil i.e. pollution of soil, water and air which affect the technology of the environment area and vice versa.

Oil contaminated soil is defined as any earthen material or artificial fill that has human or natural alteration in its physical, chemical, biological or radiological integrity resulting from the introduction of crude oil, any fraction or derivative there of (such as gasoline, diesel, or Motor oil) or oil based product.

Oil contamination of soils may occur through a variety of sources such as oil leakage from damaged pipelines, tanker accidents, and discharge from coastal facilities or natural seepage. Despite the best efforts of both, petroleum industry and regulatory community releases, leakages and spills of petroleum products occurs frequently.. Once a spill or leakage occurs, the hydrocarbon liquid under gravity moves down to the groundwater partially and upon reaching the ground water table, this liquid may spread horizontally by migration within the capillary zone, thereby further saturating the soil. Clay particles are chemically active soil particles. Their behaviour is always affected by the environment to variable degree depending on the clay particles mineralogy. The particular environment includes the pore fluids, their properties and type of ions present therein. Their behaviour can be altered substantially by the presence or permeation of different pore fluids. Nowadays castor oil is also used in industries like in the manufacturing of soaps, plastics, synthetic resins, fibers, paints, varnishes, lubricants, dyes, leather treatments, grease, hydraulic fluids, machining oils, rubbers and as bio fuel. Due to these all uses, it may contaminate soil. Due to soil contamination by various liquids from different sources, clay behavior may change.

II. MATERIAL AND METHODS

The oil used for analysis is used motor oil, which is a waste product from automobiles and other machineries. The oil is collected for a local workshop near Nellimood in Thiruvananthapuram district. The properties of oil is shown in table 1. The soil sample is collected from Thonakkal quarry of English Indian ClayPvt.Ltd.The Geotechnical Properties of the soils are shown in table 2.

TABLE 1.PROPERTIES OF OIL

Properties	Value
Colour	Black
Density	1.1368 kg/m^3

TABLE 2. THE GEOTECHNICAL PROPERTIES OF THE SOILS

Properties	Value obtained
Natural water content (%)	22.5
Liquid limit (%)	56.5
Plastic limit (%)	28.89
Shrinkage limit (%)	27.8
Plasticity index (%)	27.61
Specific gravity	2.496
Optimum moisture content (%)	31.1
Maximum dry density (g/cc)	1.384
Unconfined compressive strength (kN/m^2)	144.3
Percentage sand (%)	21.5
Percentage silt (%)	20.5
Percentage clay (%)	58
Unified Soil Classification	CH

III. RESULTS AND DISCUSSION

The results as obtained from the above test programme are presented as follows.

A. Atterberg limits

Atterberg limits or consistency limits are characterized by plastic and liquid limits and plasticity index. The liquid limit represents the minimum water content at which soil particles flow under its own weight. The plastic limit is the minimum water content at which a soil is moulded without breaking. These limits control the consistency of the soils as wetting conditions change. Atterberg limits have a very extensive use in geotechnical engineering for identification, description and classification of soils, and as a basis for preliminary assessment of their mechanical properties. Although these limits are easily determined and their qualitative correlations with soil composition and physical properties are well established, the fundamental interpretations of the limits and quantitative relationships between their values and compositional factors are more complex.

1) Liquid limit

The liquid limit depends on physico-chemical factors. If water is used as pore fluid, the influence of mechanical factors would remain the same. However, if an organic fluid is used instead of water, then the physical properties of the fluid such as viscosity would influence the liquid limit. The physiochemical factors due to low dielectric constant value would cause the clay to behave more like granular material, in the presence of oil contamination, thus lowering the liquid limits. The contaminated clay behaves more like a cohesionless material, owing to the formation of agglomerates. Variation of liquid limit with oil contamination is shown in fig.1.

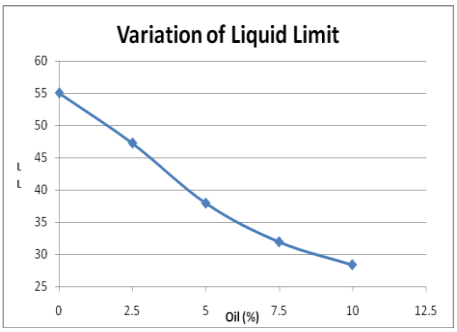

Fig.1. Variation of liquid limit with oil contamination

2) Plastic Limit

Due to the presence of oil the plastic limit of the soil decreases. The plastic limit decreases with increase in concentration of oil. The Variation of plastic limit with oil contamination is shown in fig.2.

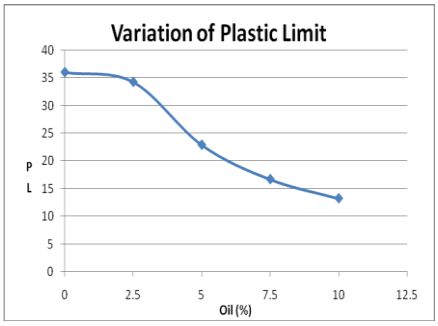

Fig.2. Variation of plastic limit with oil contamination

3) Shrinkage Limit

The Variation of shrinkage limit with oil contamination is shown in fig.3. The shrinkage limit decreases with increase in oil concentration.

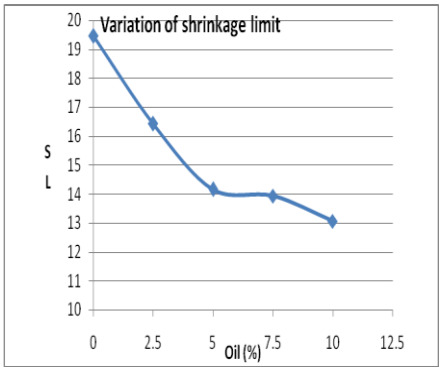

Fig.3. Variation of shrinkage limit with oil contamination

B. Specific gravity

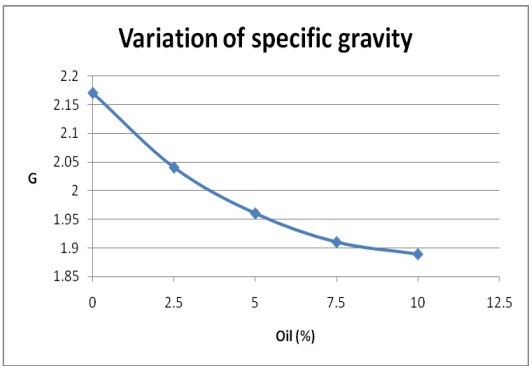

Fig.4. Variation of specific gravity with oil contamination

The variation of specific gravity with oil concentration is shown in fig.4.The specific gravity decreases with increase in oil concentration.

C .Unconfined compressive strength

The results of unconfined compressive strength for clay samples were performed for control and contaminated specimens. The Variation of load displacement curve with oil contamination is shown in the fig.5. Oil contamination causes a significant reduction in the unconfined compressive stress. Fig.6. shows the variation of shear strength with oil contamination. In pollution of clay with diesel oil entailed substantial microstructure change: relatively loose packing of clay particles and their detachment from grain surface in cohesion with increasing of oil content. Variation of UCC strength with oil contamination is shown in the fig.7. The UCC strength value decreases with the increase in the concentration of oil.

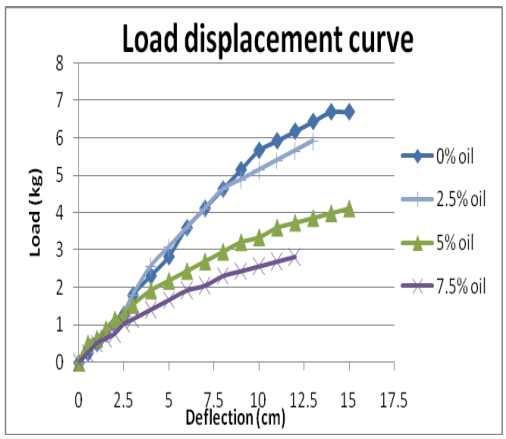

Fig.5. Variation of load displacement curve with oil contamination

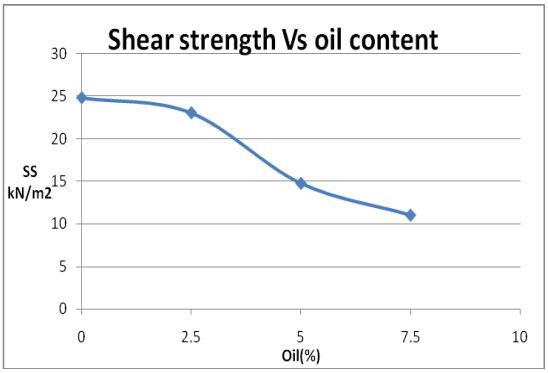

Fig.6. Variation of shear strength with oil contamination

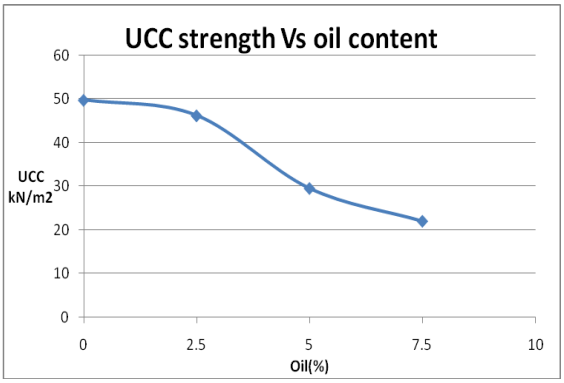

Fig.7. Variation of UCC strength with oil contamination

IV. CONCLUSION

The geotechnical properties of soil is found to be greatly affected by increase in concentration of oil among the various percentage of contaminant. Oil contamination causes a significant reduction in the unconfined compressive stress. As a result of oil presence, soil properties including physical, chemical and geotechnical properties were affected negatively. Significant decrease in both liquid and plastic limits is detected with the increase of the increase in concentration of oil contamination. Shrinkage limit and specific gravity decreases for soil samples with the increase in concentration of oil contamination.

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