Effects of Oil Contamination on Geotechnical Properties of Alluvial Soil Naini, Allahabad

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Abstract*—Soil contamination by engine oil basically takes place due to spilling from vehicles or discarding of used engine oil in areas near garages or service stations. This contamination causes huge damage to the environment. The hydrocarbons present in the oil influences the quality and physical properties of oil contaminated soil. These hydrocarbons infiltrate into the soil through pore spaces and collect at the top of the ground level. A fraction of this hydrocarbon gets trapped and clog within pore space, which is cumbersome to remove and costly to clean .Some major tasks need to be performed for remediation and reclamation of contaminated area .Also, in connection with the clean-up works, and for any possible application of contaminated soil, a knowledge of the geotechnical properties and behavior of contaminated soils is required. This study aimed to investigate the compaction characteristics of engine oil-contaminated alluvial soil. The amount of oil added to soil was varied at 0%,4%,8% and 12% of the dried weight of samples. Results showed that the oil contamination decreased the liquid limit , plastic limit and shrinkage limits. The compaction characteristics were also affected to a great extent. The MDD value was found to be decreasing as a result of increasing amount of added engine oil into the soil. A similar behavior was observed with the value of OMC with increasing engine oil content, which means that the addition of oil has adverse effects to the geotechnical properties of the studied soil. Contaminated residual soils might be used for geotechnical purposes and these results will be used for geotechnical purposes and will benefit engineers or researchers in recycling or re-using of contaminated soils

***Index Terms*— Hydrocarbons, oil contaminated soil, petroleum products, remediation, reclamation.**

I. INTRODUCTION

Soil contamination by various oil products is a serious geo-environmental issue that adversely hampers the quality of soil,undergroundwater and atmosphere. Oil spillage on land is responsible for the majority of hydrocarbons contamination of earth [1].Oil products when spill over the ground surface,it percolates through the unsaturated zone where some part of it is retained in this zone, while the rest of the portion reaches the water table causing ground water pollution.Evaporation of the retained part to the atmosphere pollutes the air, vegetation etc. [2,3]

Engine oil contamination of soil is very common in areas in the vicinity motor mechanic workshops. It has been reported that the engineering properties of such soil are drastically changed and made unsuitable for supporting engineering structures.

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Sulphur compounds found in contaminated soils attacks the concrete and hydrocarbons from oil adversely affect the hydration of fresh concrete. At the sites with excessive oil contamination, vertical settlement of tanks, cracking of pipelines etc are usually expected to occur [4]. Not only highways, but garages, petrol stations, oil storage sites etc are common sites contaminated with oil, especially engine oil.

The extent of contamination has a lot to do with the chemical composition of contaminant and properties of the soil [5].Unfortunately the reclamation of oil polluted soil is not sufficiently and deeply studied at many places. Various methods have been proposed by researchers which can be applied to treat oil contaminated soil, out of which bio-remediation and chemical oxidation are the most widely used ones [6].In connection with the cleanup works, for any possible application of contaminated soil, knowledge of geotechnical properties and behavior of contaminated soil is necessary. This paper presents the result of laboratory testing program carried out to determine the effects of engine oil contamination on index properties(which are indicative of other important geotechnical properties)[7] and compaction characteristics on alluvial soil type CL of Naini, Allahabad.

II. PROCEDURE FOR PAPER SUBMISSION

A.Site review

The study area was selected as SHIATS, Naini, Allahabad. This area is situated at $20^0$27’0’’N (Latitude) & $81^0$51’0”E (Longitude). The soil samples used in this study were collected from a site situated in the SHIATS, University, Naini, Allahabad, and Uttar Pradesh. The soil samples were taken from parking area in the Shepherd School of Engineering and Technology, University campus of S.H.I.A.T.S. The site was cleared for construction of parking purpose and is located close to the civil Engg. Department.The litho logy of this area predominantly consists of alluvial soil which is deposited by Yamuna and its tributaries and owes its origin to the basaltic rock of central Indian hills. The alluvial soil has developed from Yamuna alluvium and is dark to very dark grey, fine textured, calcareous soil showing remarkable swelling and shrinkage on wetting & drying [8].

B.Sample Preparation

The engine oil was used in this study. The degree of contamination is defined as percentage of weight of oil with respect to dry weight of soil. Each portion of soil foe sampling was mixed thoroughly with engine oil at different percentage of 0, 4, 8 and 12 to the dry weight of soil. The samples were kept in air tight container. For two weeks to attain a stage of homogeneous mixture. These samples then

were used to determine the engineering properties of soil. The tests were generally carried out on the soil samples in accordance with the procedure outlined by Indian standards.

C. Soil Characteristics

Particle size analysis showed that the sample consisted of 40.30% sand, 27.78% silt and 31.92% clay. It is clearly seen in Figure 1, in the soil sample. The proportions of gravel and sand in soil samples showed the high % of the sand, soil samples showed moderate amount5 of clay proportion. The particle size distribution of soil samples is shown in Figure 1.

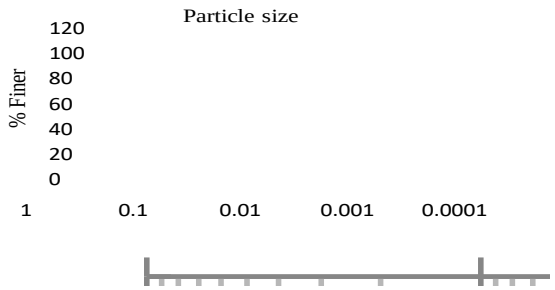

Figure1:Particle size distribution curve for virgin soil.

On the basis of Indian standard classification, the soil can be classified as. CL type (i.e., clay of low plasticity, lean clay)[9]. The field water content was 20-25% and field density was found by core cutter method to be 1.64gm/cc.

III. RESULT DISCUSSION

A.Atterberg Limits

The results from the liquid limit, plastic limit and shrinkage limit tests for the soil samples have been shown in Figure 2,3 and 4.

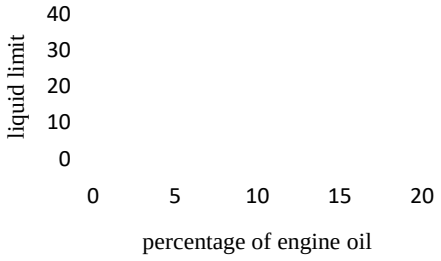

Figure 2: Liquid Limit results for contaminated soils.

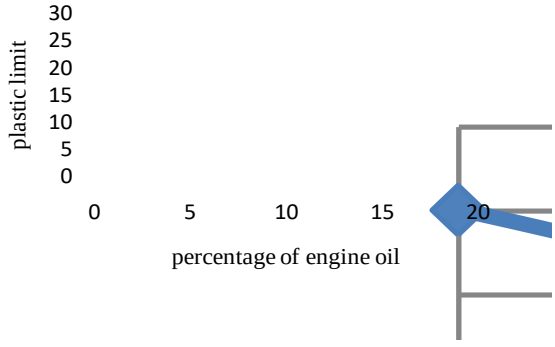

Figure 3: Plastic Limit results for contaminated soils.

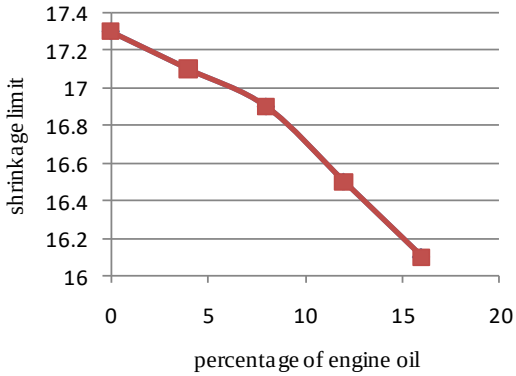

Figure 4 : Shrinkage Limit results for contaminated soils.

The results of the addition of engine oil into the alluvial soil has clearly affected the index properties of the contaminated soils. The increase in oil content in soils caused the reduction of water content in the liquid and plastic limit, A similar trend was observed on the same tests performed on basaltic soils [10] and sandy soils [11].The presence of hydrocarbons in engine oil, which is non-polarizing liquid has caused reduction in thickness of water film around the clay minerals. Hydrocarbons relatively makes first contact with clay minerals instead of water. Since, water is a binding agent between clay minerals and its orientation around the clay minerals provides the clay minerals provides the plastic characteristics [12].

B.Compaction Characteristics.

Standard proctor compaction test (ASTM-D698,method) [13]was performed on uncontaminated virgin and artificially contaminated samples. Compaction curve for virgin soil is shown in Figure 5.

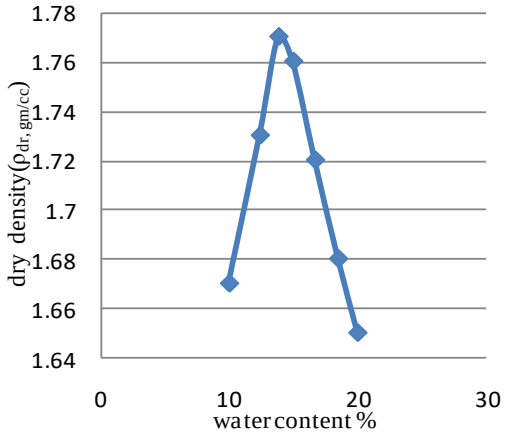

Figure 5: Compaction curve for virgin soil

The compaction curve for 4%,8% and 12% contamination are also shown in Figure6,Figure7 and Figure8 respectively.

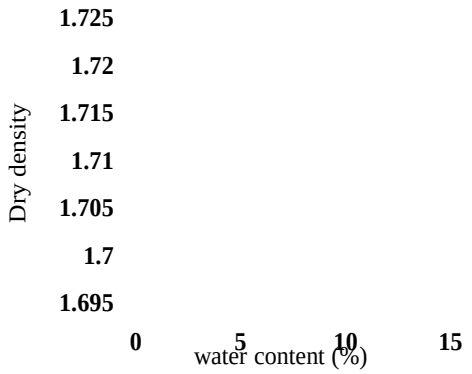

Figure 6: Compaction curve for 4% contamination

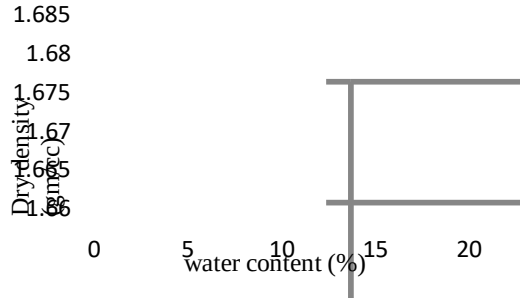

Figure 7: Compaction curve for 8% contamination

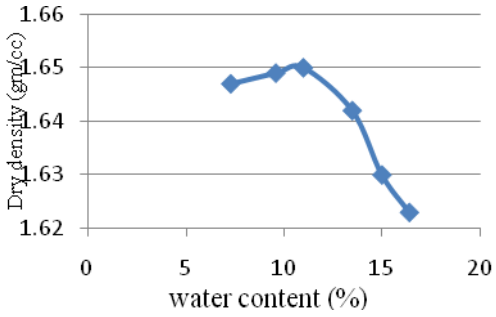

Figure 8: Compaction curve for 12% contamination.

The maximum dry density and optimum moisture content (OMC)values at different percentage of engine oil are shown in Figure 9 and Figure 10.

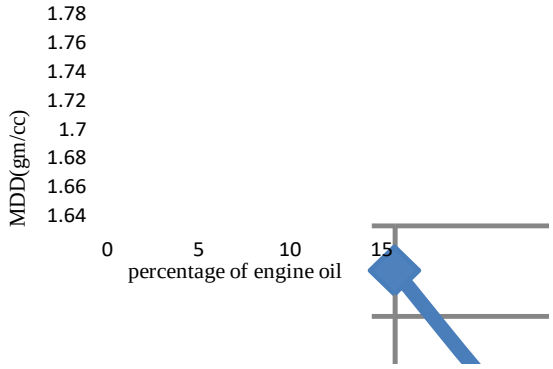

Figure 9: Curve for MDD for contaminated soil.

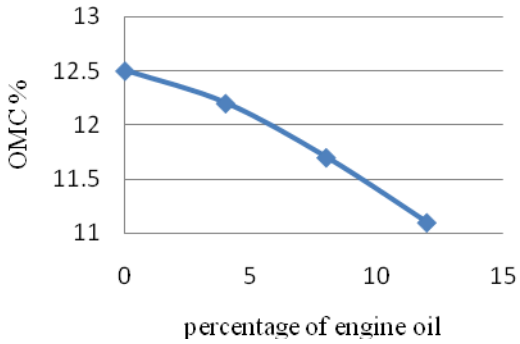

Figure 10: Curve showing variation of OMC for contaminated soil

It can be clearly seen in curves that there is reduction in maximum dry density with increasing oil contents. This reflects the effect of lubrication imparted by the soil due to the presence of engine oil in it, which facilitates compaction due to slippage of soil particles in empty voids and hence reduces the amount of water needed to reach maximum dry density.

IV. CONCLUSIONS

In this study, the effects of oil contamination on the geotechnical properties are clearly observed on alluvial soils. The atterberg limits of contaminated soils were lower than that of uncontaminated soils. The role of oil is quite similar to water, it increases the chance of inter-particle slippage, thus reduce the shear strength of the contaminated soils. The maximum dry density and moisture contents dropped due to the increased content of engine oil. The increased inter-slippage of soil particles reduces the shear strength of soil [7]. The results clearly showed that the oil contamination on soil system has negatively influenced the geotechnical properties of the soil. Contaminated soils might be used for geotechnical purposes and these results will benefit to the engineers or decision makers in recycling or re-using of contaminated soils.

V. ACKNOWLEDGMENT

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