ISSN : 0974 - 7451 Volume 5 Issue 6

Trade Science Inc.

Environmental Science
An Indian Journal

Current Research Papers

ESAIJ, 5(6), 2010 [375-377]

Influence of diesel contamination on geotechnical properties of black cotton soil

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Received: 13th October, 2010 ; Accepted: 23rd October, 2010

ABSTRACT

Petroleum and its refined products are major global resource used in industrial and transportation sectors for energy requirement throughout the world. The soil contamination is most common problem found in all over the world. The soil gets contaminated by petroleum product by various ways. Literatures suggest that the geotechnical properties of contaminated soil altered and result in detrimental effects. Here an attempt has been made to study the effect of Diesel contamination on geotechnical properties of black cotton soil. It was observed that various properties of black cotton soil are affected due to this contamination.

KEYWORDS

Soil pollution;
Black cotton soil;
Geotechnical properties;
Diesel.

INTRODUCTION

The petroleum products may be releases from a variety of activities including exploration, production storage, distribution, and accidental spillage of petroleum products. Most petroleum contamination in soil comes from leaking storage tanks, containers, pipes, and equipment; transportation accidents; and improper handling and disposal practices that lead to spills. The process by which the transportation and spread of contaminant in the soil mass is carried out is known as the soil contamination. Many other process that determine the fail of a contaminant within the soil mass includes physical, chemical and biological process such as leaching, precipitation into corporation into minerals, absorption photodecomposition, oxidation, hydrolysis and metabolism.

A contaminant is distributed in the soil in solid phase, liquid phase and vapor phase. The solid phase involves undissolved particles of the contaminant and dissolved particles, which is contaminant into a solid form the reaction between contaminant, other dissolved constitute and the soil matrix. The contaminants get dissolved in the soil water in the liquid phase. In the vapors phase, some contaminants are transferred from the solution phase to vapors phase by the chemical exist above the capillary zone where air voids normally occurs. The equilibrium condition between all these phases is depends upon the properties of the contaminant. Extend of contaminant partitioning which governs the impact of contaminant in the soil environment.

The petroleum products, including gasoline, diesel fuel, heating oil, jet fuel, lubricating oil, bunker oil, and tar - all of which are refined from crude oil contains many petroleum compounds and, sometimes, other additives that also can be of concern as contaminants. Depending on the petroleum product and how it is released into the environment, it may evaporate, attach to soil or sediment particles, be carried into surface waters, or be carried into ground.

Singh et al.[3] conducted an experimental studies on changes in the geotechnical properties of artificial expansive soil due to interaction with most widely used petroleum hydrocarbon based contaminants. Soil with high compressibility (CH) used for the study was fabricated by mixing kaolinite and montmorrilonite in the proportion 85:15 by weight. Laboratories studies were conducted on virgin (uncontaminated) soil samples and soil samples simulated to varying degrees of contamination (i.e. 3%, 6% and 9% expressed as a dry weight of soil w/w) to compare the geotechnical properties before and after contamination. The engineering properties vis-à-vis behavior of soils modified upon contamination. It was observed that geotechnical properties of the soil are get modified in the presence of petroleum products.

Rehman et al.[4] studied the oil contamination of the clay samples of active high plasticity clay obtained from the Al-Qatif area of the Eastern province of Saudi Arabia. The selected soil is considered to be highly expansive in nature. The crude oil of grade 35 was used as the source of contamination and mixed with the pulverized soil. The oil and soil was mixed in quantities to make the soil fully saturated at its natural dry density of 12 kN/m^3. A significant change in the engineering behavior of the clay was observed if it was contaminated by crude oil. The contaminated clay behaves more like a cohesionless material, owing to the formation of agglomerates. The coarse-grained soil-like behavior was obvious in the strength behavior of the oil-contaminated clay. The swelling pressure of the clay after contamination suffered three times reduction, while no change was observed in the percent swelling of the contaminated clay.

Rehman et al.[5] studied the residual soils originally developed from in situ weathering of granitic and metasedimentary rocks. The types of minerals present in granitic soil sample are quartz, kaolinite and gibbsite while metasedimentary soil consists of quartz and kaolinite. The engineering parameters for the contaminated and uncontaminated soils i.e. Atterberg limits, compaction and soil shear strength were studied. The amounts of hydrocarbon added to soil were varied at 0, 4, 8, 12 and 16% of dried weight of soil samples. The Atterberg limits value decreased as a result of increasing amount of added hydrocarbon into the soil. A similar behavior was observed with the values of maximum dry density and optimum water content with increasing hydrocarbon content. The maximum deviator stress, q_{max} for granitic and metasedimentary soils ranged between 6-28 kPa and 8-27 kPa, respectively. The overall unconsolidated undrained shear strength, Cu showed a decreasing trend with the increase in hydrocarbon content.

The literature indicates that soil contaminated with petroleum products greatly influenced various properties of uncontaminated soil. The black cotton soil is abundantly occurred in central India. Also major depot of petroleum products are stored and transported in the area. Therefore, an attempt has been made to study the influence of contamination of Diesel on geotechnical properties of black cotton soil.

EXPERIMENTAL WORK

The different geotechnical properties of black cotton soils were determined as per Indian Standard procedure (SP: 36). These tests includes sieve analysis, specific gravity, liquid limit, plastic limit, shrinkage limit, DFS test, standard Proctor test and direct shear test. The tests were also conducted on contaminated soil to evaluate the change in behaviors of expansive soils due to interaction with petroleum hydrocarbon based contaminants. The soil was contaminated at 2%, 4% and 8% degree of contamination by weight for further studies.

The black cotton soil was collected from local area. The contaminated soil samples were prepared by mixing the required amount of Diesel with black cotton soil and the contaminated samples were kept for 24 hours in airtight container to bring equilibrium. The soil contaminant mixture was pulverized with hands and thoroughly mixed. During this period, soils were mixed time to time. After one day of interaction between soil and contamination, geotechnical properties of contaminated soil were evaluated.

RESULTS AND DISCUSSION

The various tests are carried out on black cotton soil and contaminated soil for determining the different geotechnical properties. The soil was contaminated to 2%, 4% and 8% by weight with Diesel. The geotechnical properties obtained from experimental studies for the soil before and after contamination are tabulated in TABLE 1.

TABLE 1: Geotechnical properties of soil before and after diesel contamination

Properties	Units	Uncontaminated Black Cotton Soil	Contaminated Black Cotton Soil with Diesel		
			2%	4%	8%
Sieve analysis, Cc		0.89	0.59	0.59	0.43
Sieve analysis, Cu		5.61	21.8	21.1	21.1
Specific Gravity		2.93	2.5	2.38	2.48
Liquid limit	%	51	77.8	92.3	87.5
Plastic limit	%	32.33	25	33.3	33.3
Shrinkage limit	%	16.18	17.9	14.9	11.9
D.F.S.	%	92.85	50	72	70
γ_d-MDD	gm/cc	1.56	1.39	1.45	1.5
OMC	%	17.3	18.2	22.2	23
Direct Shear, C	KN/ m^2	22	24	35	22.5
Direct Shear, ϕ	Degree	8	15	10	10

The specific gravity, liquid limit, plastic limit and DFS decreases and then increases. The percentage of shrinkage limit increases initially and then decreases with the contamination. Maximum dry density and optimum moisture content obtained by standard Proctor test shows variations in it due to contamination of Diesel. The variation in MDD is not consistent with variation of contamination. The Diesel may be acting as a repellant material in during compaction, which may result in variation of MDD. The optimum moisture content of contaminate soil increases with percentage of contamination for all the three petroleum product contamination. The shear strength parameters such as cohesion and angle of friction shows variation with increase percentage of contamination.

CONCLUSIONS

The geotechnical properties of black cotton soil had been studied with various percentages of diesel contamination. It is observed that its behavior got modified due to the presence of petroleum products as contaminants. It can be concluded that the black cotton soil subjected to Diesel contamination will result in changes in a variation in geotechnical properties. Hence, a site contaminated with the petroleum products shall be investigated for affected area and geotechnical properties shall be properly investigated with respect to contamination.

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