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Effect of Diesel Spill from the Boat on the Geotechnical Properties of Cohesive Soil: An Overview

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Abstract: ***Soil pollution by diesel is a serious geo - environmental problem that adversely affects the quality of soil, groundwater and atmosphere. Soil infection by means of diesel not most effective influences the surroundings but additionally has negative influences at the safety of civil engineering structures. Diesel contamination reduces the permeability, strength and Atterberg limits by increasing oil contamination. Clay particles are soil particles that are chemically active. Their behavior is always affected by the environment to variable degree depending on the clay particles mineralogy. The goal of this study is to examine impact of diesel that's spilled from boats to the soil with the impact of infection duration on geotechnical properties on cohesive soil.***

Keywords: Diesel oil, contamination, cohesive soil

1. Introduction

Land contamination is not only harmful for the subsurface water aquifers but such actions are a detriment to the buildings and structures standing on it. Any change in the engineering qualities and behavior of the soil strata can result in a loss of bearing capacity, as well as an increase in total or differential settlements of the buildings' foundation systems. As a result, structures may fail functionally or structurally. Diesel oil contamination of soils may occur through a variety of sources such as oil leakage from boats, damaged pipelines, tanker accidents, discharge from coastal facilities, offshore petroleum production facilities, and natural seepage. Due to soil contamination by various liquids from different sources, clay behavior may change. The permanence of hydrocarbons in the unsaturated zone depends on different factors, such as the solubility, volatility, toxicity, biodegradation rate, and sorption of the hydrocarbons; the nature and permeability of the soil. Geotechnical behavior of the soil changes due to the physicochemical processes that occur between the contaminant and the soil. This can change soil behavior and reduce its bearing capacity. Therefore, the stability of the structures will be compromised and the soil will be polluted.

2. Materials Used

a) Cohesive Soil

Cohesive soils are fine - grained, low - strength, and easily deformable soils that have a tendency for particles to adhere. The soil is classified as cohesive if the amount of fines (silt and clay - sized material) exceeds 50% by weight. The soil selected for this study was collected from the Alappuzha region of Kerala. In order to prepare soil specimens, the soil is oven dried for 24 hours to remove moisture from the soil and the dried sample passing through 4.75 mm sieve was used for the study.

b) Diesel

Diesel fuel, also called diesel oil, combustible liquid used as fuel for diesel engines, ordinarily obtained from fractions of crude oil that are less volatile than the fractions used in gasoline. It is produced from various sources, the most common being petroleum and the other sources include biomass, animal fat, biogas, natural gas, and coal liquefaction. The diesel oil has taken from a petrol pump in Trivandrum, Kerala. Diesel oil used has light brown color.

3. Literature Review of Diesel in Cohesive Soil

Christian Hernandez - Mendoza et al. (2021) and Sofia Rodriguez et al. (2018) have discussed about effect of diesel in cohesive soil. *Christian Hernandez - Mendoza et al. (2021)* determined the maximum diesel retention by an unsaturated clayey soil and evaluated the impact of diesel contamination on its geotechnical properties. The results showed that the soil could only retain 12.6% of the added diesel and the excess was expulsed. At such a diesel concentration, the saturation rate of the soil was lower than 80%. Diesel contamination increased the plasticity and the internal friction angle of the soil, while its cohesion was considerably decreased. It should be noted that the matric suction of contaminated soil was lower than the one obtained for natural soil. However, its osmotic suction was considerably higher. This indicates that osmotic suction must be considered to evaluate the shear strength of contaminated soils. The experiment was performed in two phases: natural soil characterization and soil contamination and characterization. In the first phase, the extraction of disturbed natural (uncontaminated) soil samples was done. In the second phase of this work, the remaining soil sample was contaminated with diesel for its geotechnical characterization. Diesel contamination of soil reduced its calcium content and caused a decrease in the pH of the soil. Diesel promoted the agglomeration of fine - grain - sized particles of the soil and changed the particle size distribution of the contaminated soil.

*Sofia Rodriguez et al. (*2018) presented the interaction between clay soil with moisture content of 30% and diesel content of 1%, 3% and 6% of dry mass. The soil is taken from Colombia to know the effect of diesel on the index properties (moisture content, specific gravity of solids, Atterberg limits), cation - exchange capacity, mineralogy composition and unconfined compression strength; moreover, the samples are tested at different temperatures considering if it is known the presence of diesel or not in the soil because the presence of diesel increases organic components, then if there is known the presence the temperature is 50 ± 5 °C but 110 ± 5 °C. The difractograms showed that diesel did not affect the mineralogical composition in the exposure period of 7 days, but in real cases the hydrocarbon may be for prolonged periods, months or even years. Independent of the test temperature, there was an increase in moisture content and decrease in specific gravity of solids as diesel content increased. The Atterberg limits had an uncertain behavior by the presence of diesel and change in the test temperature. The cation - exchange capacity was increased by the presence of diesel independent of the test temperature. The parameters of unconfined compression strength decreased as diesel content increased. The research concludes that diesel effects over geotechnical parameters of the soil generates negative impact, and projects that have soils with diesel need special attention, so it is important to keep doing research where diesel has more time of exposition in the soil.

A study done by *Huie Chen et al.* (2018) also showed the influence of diesel contamination on engineering properties of soil and its mechanism. A series of laboratory experiments were conducted to study the change in the engineering geological properties of diesel - contaminated soil. Soil samples with different contaminant concentrations were manually prepared via mixing and static compaction methods. The influence of diesel contamination on engineering properties of the soil was analyzed from the perspective of granulometric composition, Atterberg limits and indices, mechanical properties and microstructural features, and its mechanism of action was discussed. The results showed that contaminated soil contained more fine particles, and a sample with 8% diesel had the highest clay content. With increasing contamination, the plastic limit decreased slightly; the liquid limit increased initially and reached its peak value at 8% diesel content and thereafter decreased slightly. The sample with 4% diesel content had a higher unconfined compression strength than the uncontaminated sample and other contaminated samples. The microstructure changed from an aggregated fabric into a dispersed fabric after the addition of diesel, decreasing the strength of soil. High compressibility clayey soil (CH) contaminated with diesel to evaluate its impact on the limits of consistency and the compressibility index of the soil was also done by *Cabello Suarez and Hernandez - Mendoza* (2017). It has been found that the liquid limit decreased when the soil was contaminated with diesel. The results showed that in the consolidation process in the contaminated soil a decrease in the compressibility index of 19% compared to the soil with water.

4. Literature Review of Diesel in Soil Added Component Mixture

Contamination of diesel occurred in different soil mixture or with extra added component mix was also considered under investigation. *Edyta Hewelke et al. (2018)* studied the impact of soil moisture on CO_2 efflux from diesel - contaminated albicpodzol soils. Two contamination treatments (3000 and 9000 mg of diesel oil per kg of soil) were prepared for four horizons from two forest study sites with different initial levels of soil water repellency. CO_2 emissions were measured using a portable infrared gas analyzer while the soil samples were drying under laboratory conditions (from saturation to air - dry). The assessment of soil water repellency was performed using the water drop penetration time test. An analysis of variance (ANVOA) was conducted for the CO_2 efflux data. The obtained results show that CO_2 efflux from diesel - contaminated soils is higher than efflux from uncontaminated soils. The initially water - repellent soils were found to have a bigger CO_2 efflux. The non - linear relationship between soil moisture content and CO_2 efflux only existed for the upper soil horizons, while for deeper soil horizons; the efflux is practically independent of soil moisture content. The contamination of soil by diesel leads to increased soil water repellency.

SepidehTaheri et al. (2018) dealt with a sand - bentonite mixture that was exposed to different concentrations of diesel and lead simultaneously in order to address the effects of these contaminants on some of the physical and mechanical variations in the sand - bentonite mixture. To accomplish the stated objectives, an extensive series of tests including compaction, direct shear, and permeability, was performed. Furthermore, the characterization experiments focused on in this study included the determination of changes in the pH, EC and microstructure characteristics of the samples with regard to different concentrations of the aforementioned contaminants. The results indicated that in the samples with different concentrations of lead (II), the presence of diesel caused an approximately 6% increase and 45–50% decrease in the maximum dry density and optimum moisture content, respectively. Although the effects of the lead and diesel were in the same direction in the compaction test, they had an adverse effect on the direct shear and permeability tests. The thickness of the diffused double layer was seen as a contributing factor in the performance of the clay part. Also, the pH decreased while the EC increased due to the lead contaminant. These parameters did not change significantly with the addition of diesel to the samples. Moreover, the scanning electron microscope (SEM) images showed an aggregate structure with more macro pores due to lead contamination. Diesel enlarged the size of the particles by flocculation as well. As a result, by adding diesel to the lead - contaminated samples, the number of voids decreased as they became filled with diesel. Similar study was also done by *Sayed Alireza Nasehi et al. (2015)* considered the effect of gas oil contamination on the geotechnical properties of some soil specimens such as poorly graded sand (SP), low plasticity clay and silt (CL, ML). The uncontaminated specimens have undergone some basic laboratory tests such as plasticity, compaction, unconfined compression strength (UCS) and direct shear tests. The samples artificially contaminated with 3, 6 and 9 % of gas oil in relative to their dry weight. Results indicate a decrease in the friction angle and an increase in the cohesion of the soils with the increase of gas oil content. In addition, a reduction in the maximum dry density and optimum moisture content observed during the conduction of compaction test. The increase of gas oil percentage also showed a direct effect on the increases of liquid and plastic limits of clay and silt soils. . On the other hands, the increase of gas oil percent reversely effect on the UCS of silt soil. According to the field emission scanning electron microscopy study, it can be stated that the increase of clay particles extends the rate of fabric flocculation is a key factor for increasing the unconfined compression strength in clayey soil.

5. Literature Review of Applications of Diesel Mixed Soil

Contaminated soils was not really acceptable for any other purposes, hence alternative applications was needed to be founded. *Suxi Wu et al. (2012)* studied the two - step preparation of Bio - diesel from the used bleaching clay. With the shortage of the raw material oil for producing bio - diesel in China, the oil, recovered from the used bleaching clay which often be discarded by vegetable oil factory, was used to prepare bio - diesel in this trial. Two - step catalyzed process was adopted to produce biodiesel from the oil. The effect of methanol - to - oil molar ratio, alkaline catalyst quantity, reaction temperature and reaction time on the pre - esterification and trans - esterification reaction was investigated through orthogonal experiments. Thus the optimal reaction condition came out. Firstly, the optimal pre - esterification condition, under which the end acid value of the product was minimum was to react for 40 h at 60°C, with a methanol - to - oil molar ratio of 12: 1, and by adding alkali catalyst 4% based on the oil weight. Secondly the optimal transesterification condition, under which the maximum yield of bio - diesel can reach up to 98.2%, was to react for 2.5 h at 60°C, with the methanol - to - oil molar ratio of 7: 1, and by adding catalyst 1.25% based on the oil weight. *Abidin Kaya et al. (2013)* studied the possibility of using dielectric constant and electrical conductivity to characterize and identify contaminated fine - grained soils. To investigate the usefulness of the preceding concept, the dielectric constant and electrical conductivity of kaolinite, bentonite, and a local soil are determined at various ion concentrations organic liquids, and moisture content. Results show that both dielectric constant and electrical conductivity of solid - fluid system are mainly controlled by those of pore fluid.

Obeta et al. (2015) presented the results of investigating the applicability of used engine oil at 3% contamination as a means of reuse in production of ordinary Portland cement stabilized soils. The soils which are classified as clayey gravel and clayey sand according to the unified soil classification system were subjected to classification tests, compaction tests, soaked and unsoaked CBR tests, X - ray fluorence and X - ray diffraction tests. The results shows that there is a general reduction in the optimum moisture content of the oil contaminated soils while the effect of oil contamination on maximum dry density varied for the two types of soils under consideration. Furthermore an increase of 130.45% and 240.37% were observed respectively in CBR values of the oil contaminated soils after curing it for six days and soaking for 24 hours in water content at 8% OPC content. *Paramkusam et al. (2010)* evaluated the efficacy of Cement Kiln Dust as stabilizing agent at different percentages 2%, 6%, and 14% on the geotechnical properties of diesel engine oil contaminated soil. The results show that the specific gravity of contaminated soil increased and the consistency limits were also affected marginally and the plasticity index is slightly increased due to contamination. CKD addition show increase in consistency limits of soil. The compaction characteristics of stabilized soils were observed to be decreasing trend of maximum dry unit weight and increasing trend of optimum moisture content with increase in CKD addition. The free swell index (FSI) of contaminated soil increased to 75% from 20% in uncontaminated soil. The free swell index of contaminated soil decreases with increase of CKD percentage. Unconfined compressive strength (UCS) of soil increased with increase of CKD addition and it showed regain of UCS. From the laboratory studies of the present research work CKD has potential to be used as an effective alternate stabilizing agent.

Hossam Hassan et al. (2005) presented the results of a study on the potential use of petroleum - contaminated soil (PCS) in construction applications including stabilizing the soil with cement, mixing it with crushed stone aggregate for use in road bases or sub bases, and using it as a fine aggregate replacement in hot mix asphalt concrete. PCS was obtained from Fahud asset area (northern Oman), where PCS is transported for treatment. PCS was subjected to the toxicity characteristic leaching procedure (TCLP). The chemical analysis of the extract indicated that the concentrations of metals and organic compounds did not exceed the maximum contaminant levels set for TCLP extracts. The unconfined compressive strength of the cement stabilized PCS increased with the addition of 5% cement and remained relatively constant with the addition of higher cement content. The oil presence in PCS had an adverse effect on cement hydration. The blend of PCS with crushed stone, as a road base or sub base, caused a reduction in CBR in comparison with 100% crushed stone. Blends of up to 10% PCS replacement can be used as a base material, while higher percentages of PCS substitution can be used for road sub bases. When PCS was used as an ingredient in the construction applications, the results indicated good potential for use in road construction.

6. Conclusion

From the above review of literature on effect of diesel on the geotechnical properties of cohesive soil, the following conclusions were drawn.

- The lubrication properties of oil have markedly increased the maximum dry density of the soil at very low optimum moisture content.
- During the strength testing, the contaminated soil has been found to behave like cohesion less material. This change in behavior is attributed to the formation of flocs due to the spherical agglomeration of oil coated clay particles.
- Contamination by diesel has shown varied changes in the geotechnical properties of the specified soil range.
- The removal of these components from the soil particles is not easy as it have to go through complicated procedures. This may include bioremediation processes or other physical processes which is time consuming and may not be so effective.

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