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EFFECT OF SURFACTANTS ON CONSOLIDATION CHARACTERISTICS OF DIESEL CONTAMINATED COMPACTED SOIL

P. VASUDEVA RAO*, R. K. SRIVASTAVA ** , R. P. TIWARI ** , B. SUDHAKARARAO*, K. SIVARAMAKRISHNA* AND P.V.V. SATYANARAYANA***

* Civil Engineering Department, GITAM Institute of Technology, GITAM University, Visakhapatnam, India,
** Civil Engineering Department, Motilal Nehru National Institute of Technology, Allahabad 211004, India,
*** Civil Engineering Department, Andhra University, Visakhapatnam, India

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ABSTRACT

A study was performed to understand the consolidation behavior of diesel contaminated soils with surfactants in the laboratory. In this research locally available soil in Allahabad, U.P. (India) has been collected for testing. Sodiumlauryl sulphate and liquid organic cleaner were used as a surfactants in remediation of diesel contaminated soils. The soil was contaminated with different percentages of diesel i.e. 20 mL/kg, 40 mL/kg and 60 mL/kg by weight of dried soil, to simulate the effect of contaminant on the virgin soil. The increasing trend in compression index and coefficient of consolidation, where as decreasing trend in permeability have been observed on contamination with diesel as compared to the virgin soil. In order to decontaminate the diesel contaminated soil by soil washing technique, 4 gm/kg soil SDS and 4ml LOC in one litre of water has been used separately. After decontamination it was observed that the Max. dry density, compression index and coefficient of consolidation increases, where as permeability and optimum moisture content of soil decrease and the value of the geotechnical properties were found near to the properties of virgin soil. To compare the results an alternative method of Fourier transform infra red (FTIR) spectroscopy was carried out on laboratory virgin, contaminated and decontaminated soil samples. These results show that maximum contaminants were removed by surfactants at optimum dose.

INTRODUCTION

Most of the industrialized nations have a legacy of land that is contaminated with industrial chemicals from previous use. This can results in soil and groundwater pollution with consequent potential risks to human health and the environment. In recent years efforts have been made to overcome this situation. The locations where land contamination is usually encountered are important and costly. The objective of site investigation of such contaminated lands is to reclaim economically these well located lands. In recent years the awareness of land contamination has tremendously increased for two

***Address for correspondence - Email :** vasudevarao_9@yahoo.com; rkcivilgitam@yahoo.co.in

reasons. First the risk involved and second the cost of abandoning land could be more than reclaiming and using the land for different purposes.

If land is contaminated, it can have serious effects on the health of people and the environment. These effects can occur now and in years to come. It is therefore important that land is relatively free from contamination so that we can live safely and the environment we enjoy today could be enjoyed by future generations.

Lee *et al.* (1996) studied the effect of organic fluids on the permeability of montmorillonite and kaolinite and concluded that presence of organic pore fluid cause a decrease in permeability of soil. Salas and Serratosa (1953) had not found any appreciable differences in the compression index with respect to nature of cations present in the pore fluid in the case of kaolinite because of its low ion exchange capacity. An experimental study was performed by Meegoda and Ratnaweera (1994) to investigate factors that control the compression index of contaminated kaolin soils with different organic pore fluids. Experimental result indicated that pore fluid viscosity influenced the compressibility behaviour in the case of non expanding lattice of kaolin clay.

There are many in-situ/on-site/off-site treatment and disposal options for the decontamination of soils. The most cost effective option is selected based on engineering factors such as soil characteristics (which are a function of soil type, void ratio and degree of saturation), site geology, lateral extent of contamination, depth of contamination, topography, location, climate, land usage, surface and groundwater conditions, accessibility, and type and amount of chemicals. Depending on the above factors, the best option(or combination of options) is selected as the treatment/disposal method. For this discussion, the currently available technologies can be broadly categorized as biological, physical, chemical, or other methods (ERPI, 1987; Ellis, 1985; USEPA, 1985, 1989).

Meegoda and Ratnaweera (1995) In this study, four virgin soils were first identified and classified. All four virgin soils were contaminated with 3% motor oil and treated by low temperature desorption, solvent extraction and treatment with surfactants. Test results showed that treatment with surfactant produced near virgin soils for all four soils comparatively other methods.

Generally two types of surfactants are used as washing fluid for diesel contaminated soil. One is an anionic surfactant (SDS) and other is non ionic liquid (LOC). Surfactant is a surface-active substance such as detergent. Surfactants are organic molecules with positive and or negative charges. Surfactants act by the lowering of the surface tension of the cleaning solutions there by enabling a better wetting of the surfaces to be cleaned (Rosen, 1989).

The aims of this study were to investigate the effect of diesel contamination on geotechnical properties of soil and washing the diesel contaminated soil with SDS and LOC separately in the remediation process. Also confirming the remediation process the Fourier transform infra red spectroscopy analysis was conducted.

MATERIAL AND METHODS

The soil samples from MNNIT campus were collected from 1.0m below the existing ground level with the aim of getting true sample of actual soil strata, as the top layer is quite often affected by human activities. After collected the soil from the site, roots of the plants, debris and stones were removed. Sufficient quantity of soil according to the requirement has collected and put it in oven for drying at the temperature of 105°C. For contamination diesel fuel was obtained from a Bharat Petroleum outlet of Allahabad city.

Contamination Procedure

Soil samples were mixed with varying percentages of diesel fuel by dry weights of soils and matured over for a period of time for proper mixing. For this purpose soil was mixed with 20 mL/kg , 40 mL/kg and 60 mL/kg by dry weight of the soil and the mixture was kept in a plastic covered container for 7 days.

Surfactant Washing Procedure

The term washing refers to the mechanized processing of contaminated soil in aqueous medium in order to physically separate the contaminants away from original soil. Surfactants SDS by 4 gm/kg soil and LOC by 4mL/L water were used to wash/ clean the diesel contaminated soil in the laboratory controlled condition. SDS and LOC solution was prepared separately in a plastic container. Gentle stirring was done for about 10 minutes for getting proper contact of surfactant with the soil and kept the mixture for 12 hr for detachment of diesel from soil. After that water was removed and soil was again washed twice with 15 liters of deionized water (twice). Finally soil was kept in oven at 60°C to make it completely dried sample for carrying out further experiments. It was assumed that after washing of contaminated soil with deionized water twice, there was no residue of surfactant left on to the soil.

For each sample of virgin soil, diesel was used as contaminant in varying concentration of 20 mL/kg, 40 mL/kg and 60 mL/kg. To asses the effect of contaminant on soil, the changes in engineering properties of contaminated soil has been evaluated. For decontamination of diesel contaminated soil SDS as 4 gm/kg soil and LOC as 4mL/L water were used. Geotechnical properties like optimum moisture content and maximum dry density permeability, compression index and coefficient of consolidation were investigated. After that at a particular OMC and Max. dry density, samples were remoulded for permeability, compression index and coefficient of consolidation test. The mix designations for various combinations are shown in Table 2.

Fourier transform infra red (FTIR) spectroscopy was carried out on laboratory virgin, contaminated and decontaminated soil samples. The utility of FTIR is that a relatively high degree of specificity for certain structural features of hydrocarbons can be obtained. EPA method measures the transmittance/absorbance of petroleum extract at the frequency of maximum absorbance of the stretching of C-H bond at 2930 cm^{-1}.

RESULTS AND DISCUSSIONS

The collected virgin soil was classified CI, i.e. clay with medium compressibility, based on the unified soil classification system. Based on the test results, treatment with a combined anionic/nonionic surfactant appears to be the best method to decontaminate the contaminated soils in the laboratory.

To decontaminate the soil, surfactants of SDS LOC were used. All the experiments were performed in laboratory controlled conditions. Surfactant solutions were prepared in deionized water and the soil to solution ratio was kept 1:4 for decontamination process.

For contamination of soil with diesel, decreasing trends have been observed in Max. Dry density and

Table 1. Geotechnical Properties of Virgin, Contaminated and Decontaminated soil.

Sr. No.	Property	Virgin soil	Soil contaminated with			Decontamination with SDS for			Decontamination with 4ml/L LOC for		
			2% Diesel	4% Diesel	6% Diesel	2% Diesel	4% Diesel	6% Diesel	2% Diesel	4% Diesel	6% Diesel
1.	Compaction										
	a) O.M.C (%)	15.93	16.37	16.93	17.75	16.06	16.41	16.78	16.13	16.52	16.67
	b) M.D.D (kN/m^3)	18.26	17.95	17.76	17.52	17.97	17.89	17.95	18.02	17.99	18.08
2.	Triaxial Shear Test										
	C (kN/m^2)	74.0	60.0	47.0	25.0	63.0	51.0	34.0	68.0	60.0	50.0
	F (Degrees)	11	12.5	14.5	14	12	13	13.5	11.5	14	12
3.	U.C.S Test qu										
	(kN/m^2)	184.0	138.4	92.8	58.6	142.3	105.8	73.3	159.8	136.8	123.8
4.	Direct Shear Test										
	C (kN/m^2)	50.0	40.0	34.0	26.0	42.0	38.0	34.0	46.0	42.0	40.0
	F (Degrees)	12	13.5	14.5	15	12.5	13.5	14	13	13	13.5

Table 2. mix desiganation

Notation	Mix designation
V	Virgin soil
C2:	Soil contaminated with diesel of 20mL/kg soil
C4:	Soil contaminated with diesel of 40mL/kg soil
C6:	Soil contaminated with diesel of 60 mL/kg soil
C2DSDS:	Decontamination of diesel of 20mL/kg contaminated soil with sodiumlauryl sulphate
C4DSDS	Decontamination of diesel of 40mL/kg contaminated soil with sodiumlauryl sulphate
C6DSDS	Decontamination of diesel of 60mL/kg contaminated soil with sodiumlauryl sulphate
C2D4LOC	Decontamination of diesel of 20mL/kg contaminated soil with 4ml LOC in one litre of water
C4D4LOC	Decontamination of diesel of 40mL/kg contaminated soil with 4mlLOC in one litre of water
C6D4LOC	Decontamination of diesel of 60mL/kg contaminated soil with 4ml LOC in one litre of water

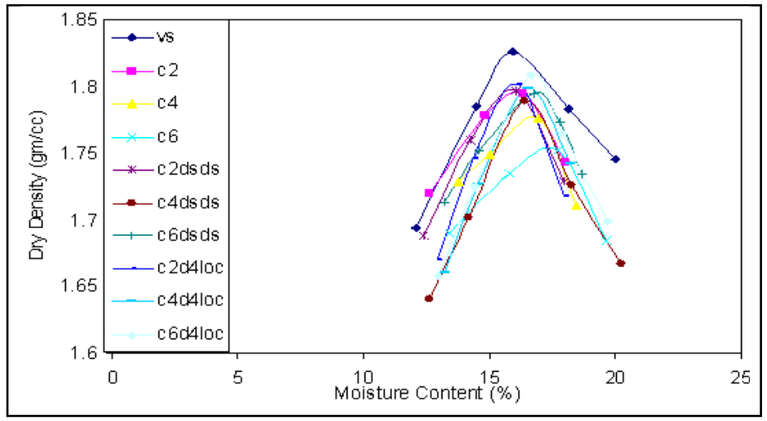

Fig. 1 Compaction Curve for virgin, contaminated and decontaminated soils

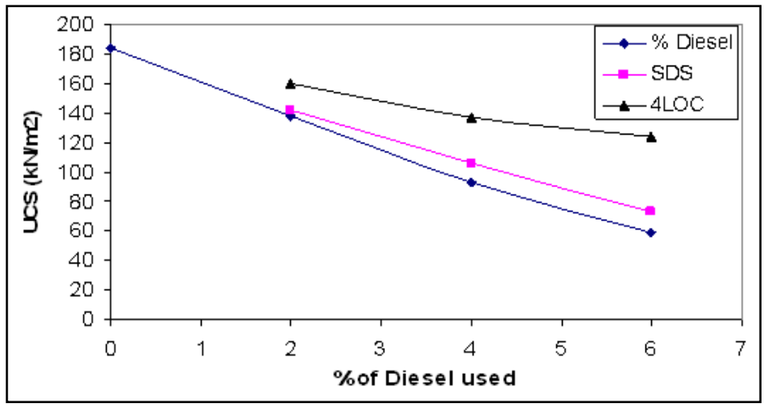

Fig. 2 Variation of Permeability for virgin, contaminated and decontaminated soils

permeability, where as compression index, coefficient of consolidation and optimum moisture content increases compared to virgin soil. Decontamination with anionic surfactant SDS with the concentration of 4 gm/kg soil and 4mL/L LOC showed that Max. Dry density and permeability ,compression index and coefficient of consolidation have been increased as compared to contaminated soil.

Geotechnical properties of soil contaminated with diesel and decontaminated with SDS 4 gm/kg and LOC 4mL/L are presented in Table 1. Typical curves for moisture content vs. dry density and permeability ,compression index and coefficient of consolidation under various experimental conditions are presented in Fig.1, 2 and 3 respectively.

After conducted the FTIR analysis a peak at 2930 cm^{-1} was found in the contaminated soil while it was nearer to virgin peak in decontaminated soil. This result shows that maximum contaminants were removed by surfactants at optimum dose. Typical curves for virgin, contaminated and decontaminated with LOC were presented in Fig. 4, 5,6 and 7 respectively.

CONCLUSION

This study focuses on the remediation of soil, contaminated with diesel, by applying a surfactant enhance desorption technique with SDS and LOC. Following observations have been drawn, based on the results of the experimental study.

- Maximum dry density decreases and optimum moisture content increases with increase in percentage of contamination. After decontamination with surfactants LOC and SDS the optimum moisture content decreases and maximum dry density increases towards virgin soil.
- Permeability value is minimum for 6% contamination and the value was decreased by 16%. The same increased to 49% after decontamination.
- Compression index increases with increase in percentage of contamination.
- Coefficient of consolidation decreases with increases of contaminant percentage. The value decreased to 27% at 6% contamination. After decontamination with LOC value increased to 87%.
- It is also concluded that the FTIR spectroscopy results show that maximum contaminants were removed by using optimum dose of surfactants (4 gm/kg soil SDS and 4 mL/L of water LOC).

It is concluded according to the results, that both SDS and LOC are effective for the remediation of soil contaminated with diesel. Hence this technique can be effectively and economically used in-situ for

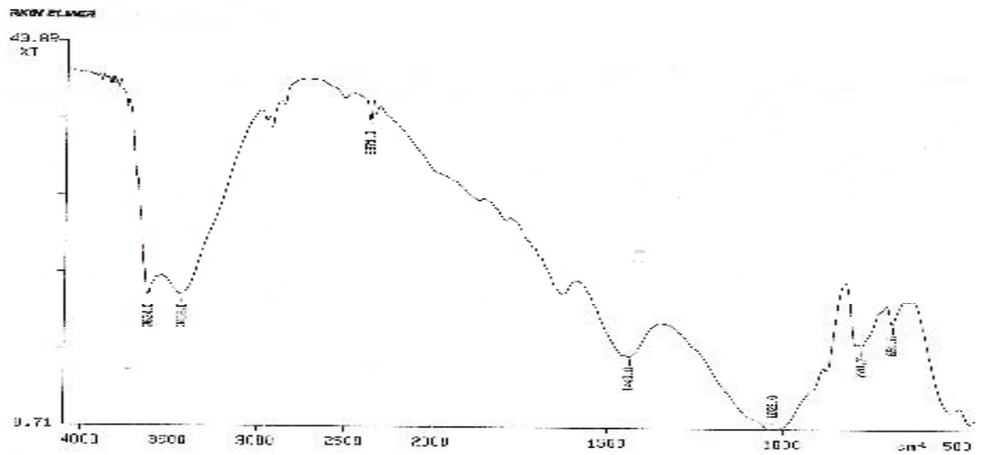

Fig. 3 Variation of Coefficient of consolidation for virgin contaminated and decontaminated soils

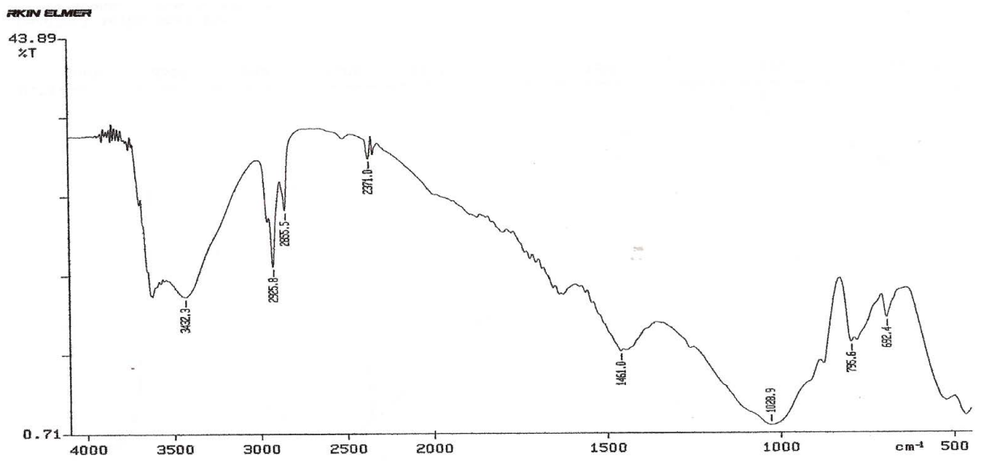

Fig. 4 FTIR curve for diesel contaminated soil

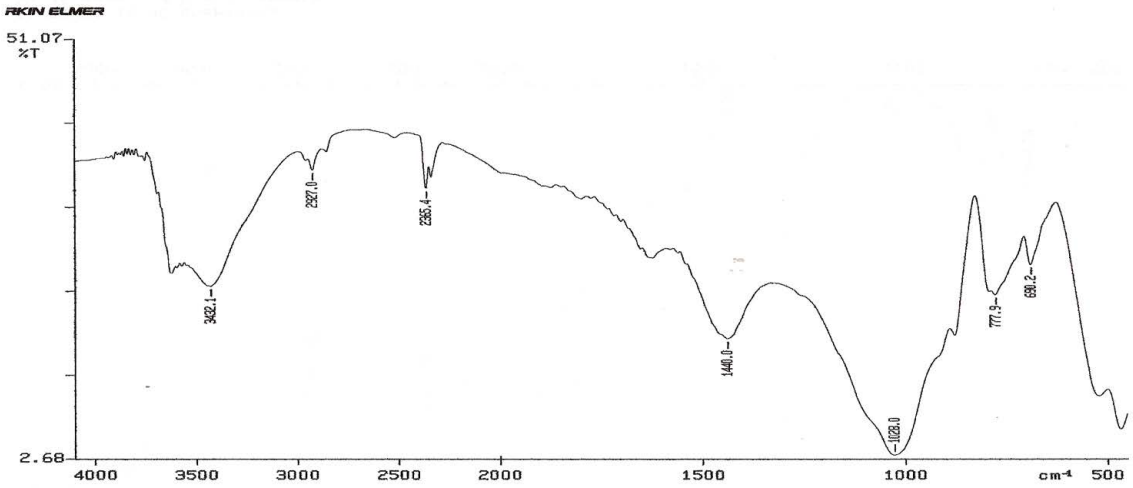

Fig. 5 FTIR curve for diesel contaminated soil

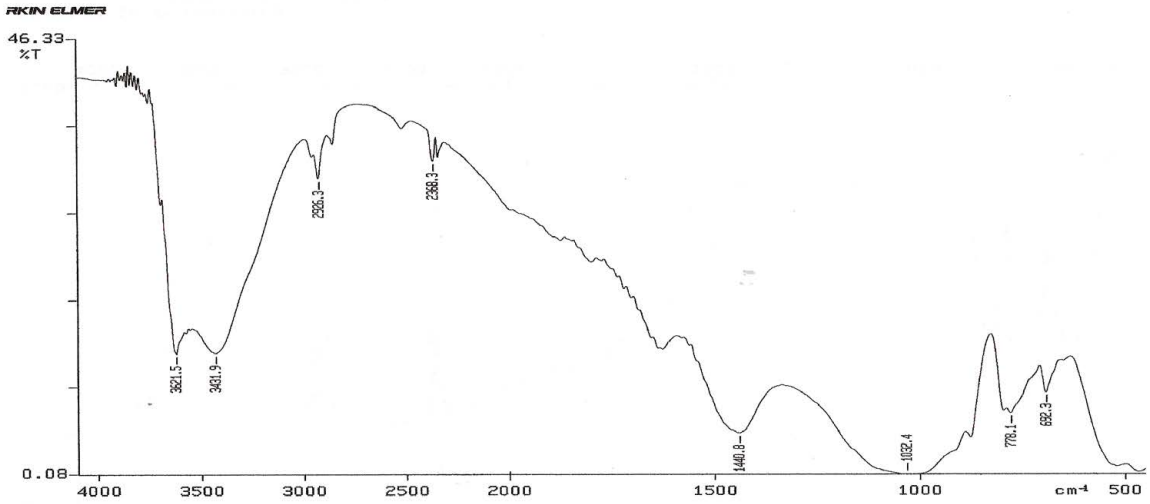

Fig. 6 FTIR curve for decontamination with SDS

decontaminating the soils affected by diesel.

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