Strengthening of Diesel Contaminated Soil Using Surfactant

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Abstract- *The study was designed to investigate the effect of surfactants on diesel contaminated soil. The growing energy demand led to the increasing use of petroleum products. The leakages of these oils from storage tanks has led to contamination of soil. The contamination of these product alters the geotechnical properties of soils such as lowering of pH, shear strength, immobilization of soil nutrients. Reduction in shear strength causes low bearing capacity of the soil. This paper aims to study the geotechnical properties of diesel contaminated laterite soil with various percentage of diesel. For this standard proctor test, unconfined compressive strength, Atterberg limits test were performed. The study reveals that increase in contamination leads to increase in the liquid limit, plastic limit and shrinkage limit of laterite soil. Also, the compaction characteristics and unconfined compressive strength decreases as a result of increasing oil content. Remediation method by using surfacetant sodium dodecyl sulphate (SDS)with different percentage are added in the diesel contaminated soil. From the test the maximum dry density and water content increase by 16% with addition of surfactant in the contaminated soil. Also, there is an increase in the compressive strength of contaminated soil by 85% from the worst strength obtained in the diesel content. the worst strength condition of contaminated soil was achieved at 7.5% of diesel content.SDS with0.5 %, 1%, 1.5%, 2%, 2.5 % of soil were added to the soil at the worst condition. The soil strength increases by 75% with increase in SDS content up to 2.5%.*

Keywords- laterites oil, sodium dodecylsulphate, stabilization

I. INTRODUCTION

The oil contamination of land has arisen due to human activity and is essentially a legacy of our recent industrial history. Petroleum products can be released into the soil by spill, leakages, transport, pipelines. Soil contamination due to these products destroys the soil structure, moisture content, hydraulic conductivity, and shear strength of the soil. Thus, oil contamination is a major problem which effects the soil as well as the ecosystem. Hence there is a need to encompass such situation by suitable remedial methods.

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. Soil contamination by various oil products is a serious geo-environmental issue that adversely hampers the quality of soil, underground water and atmosphere. Oil contamination is not only harmful for subsurface water aquifers but is also a detriment to the buildings and structures on it. The changes in shear strength of soil may tends to settlement of structures built over it. Thus, in order to minimize potential environmental impact of this contamination, it must undergo an efficient chemical treatment or stabilization. Various Studies are carried out to determine characteristics of contaminated soil and its effects on change in properties of soil. Studies were carried on contaminated soils with different percentage of oil and its remedial measures are implemented with stabilizing agents like fly ash, bagasseash. The crude oil contaminated soil requires stabilization or remediation before using it as a construction material. The aim of this experimental investigation is to contaminate a laterite soil with 0 % 1.5%, 3%, 4.5%, 6%,7.5 % of crude oil and determine the effects of such contamination on the plasticity, strength and compaction characteristics of the soil. Then it is stabilized with 0.5 %, 1%, 1.5%, 2%, 2.5 %percentage of SDS

II. OBJECTIVES

The aim of the study was to evaluate the geotechnical properties of both oil contaminated laterite soil and contaminated soil stabilized with surfactant. The particular objectives were to investigate the effect of oil contamination on, Atterberg limits (liquid limit and plastic limit), compaction, and strength characteristics of oil contaminated soil.

III. MATERIALS AND METHODOLOGY

A. Materials

1) Soil

The soil used for this study was locally available laterite soil which is collected from Thrissur at a depth of 1m from the ground surface. It was reddish in colour. The soil used in the particular study is shown in figure 1.

Fig.1.Laterite Soil

2) Diesel

Oil used in this study was diesel purchased from Bharath petroleum, Thrissur. Diesel oil used has a light yellow colour. It has a specific gravity of 0.84and kinematic viscosity at 40 ˚C to be 3.912.

Figure 2 shows the diesel used for the study.

Fig.2.Diesel

The physical properties of diesel are shown in table 1.

Table 1. Physicochemical properties of diesel

PHYSICOCHEMICAL PROPERTIES	
Volatility	Low volatility
Specific Gravity	0.82-0.95 at 15°C
Odour	Characteristic odour
Upper explosive limit	6.5%
Lower explosive limit	0.6%

3) Sodium dodecyl sulphate (SDS)

SDS, a form of surfactant also known as sodium dodecyl sulphate was used in this study. It was purchased from Ozone chemicals and is white in colour (Figure 3).

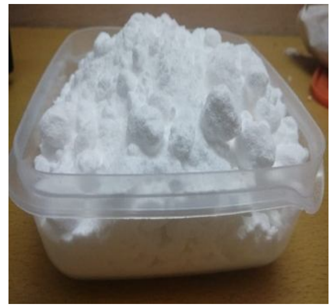

Fig.3. SDS

B. Methodology

The soil used for this study are collected from field. Prior to testing soil was oven dried and hand sorted to remove the pebbles. The soil was then contaminated by diesel in varying percentage by weights of laterite soil and allowed to cure for 24-hour period before testing and then tested to determine their geotechnical properties. Diesel of0%, 1.5%, 3%, 4.5%, 6%,7.5% by weight of the dry soil samples was mixed with the soil samples. The mixed samples (soil-diesel) were put in containers and allowed to cure. These samples are tested to determine the Atterberg indices, moisture content, maximum dry density, shear strength of soil.These were achieved by conducting Atterberg limit test, standard proctor test, unconfined compressive strength test.After determining the worst strength, stabilizing agents are added with 0.5%, 1%, 1.5%, 2%, 2.5 % to the contaminated soil.

IV. RESULTS AND DISCUSSIONS

The basic properties of uncontaminated soil are given in table 2. According to the Unified soil classification (USC) system soil is classified as Clay of low plasticity (CL).

Table2. Properties of laterite soil

PROPERTY	VALUES
Specific gravity	2.66
Liquid Limit	37%
Plastic limit	25%
Shrinkage limit	8.3%
Plasticity index	8.37%
Soil type	CL
Dry unit Weight (g/cc)	1.97
Optimum moisture content	18.5%
Unconfined compressive strength	47.9kN/m^2

A. Effect of diesel contamination on plasticity of clay

The liquid limit, plastic limit, and plasticity index of the soil increases with increase in diesel content.Fig.4 shows the variation of Atterberg limits of soil with different percentage of diesel content

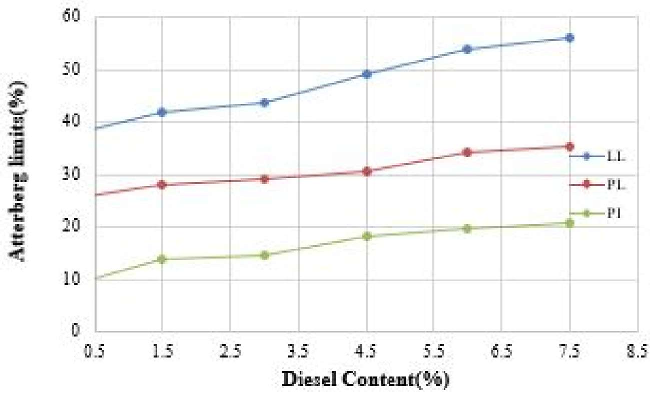

Fig.4. Variation of Atterberg limits with diesel content

In fig.4, it shows the variation of atterberg limits with varying percentage of diesel. The liquid limit and plastic limit of the uncontaminated soil was found to be 37% and 25%. Thus, there is an increase in the value of liquid limit and plastic to 51.3% and 40 %. This may be due to formation of double diffused layer around the soil particles.

Plasticity index of uncontaminated soil was found to be 8.37% while that of contaminated soil is 20.67%.Thus, it indicates that there is a decrease in shear strength of soil.

Table 3 shows the values obtained by addition of diesel to the soil.

Table 3. Plasticity properties of soil for different percentage of diesel

Percentage of diesel (%)	Liquid limit (%)	Plastic limit (%)	Plasticity index (%)
0	37	25	8.37
1.5	42	28.2	13.8
3	43.5	29	14.5
4.5	49	30.71	18.29
6	54	34.19	19.81
7.5	56	35.33	20.67

B. Compaction characteristics of diesel contaminated soil

With increasing oil content, the dry density and OMC of contaminated soil is found to be decreased. Table 4 shows the variation of water content with varying diesel percentage.

Table 4.Max.dry density and OMC for different percentages of diesel

Percentage of diesel (%)	OMC (%)	Maximum dry unit weight (g/cc)
0	18.5	1.97
1.5	17.5	1.94
3	16.7	1.93
4.5	16.1	1.91
6	15.8	1.87
7.5	15	1.75

Figure 5 shows the variation of maximum dry unit weight and OMC with diesel content.

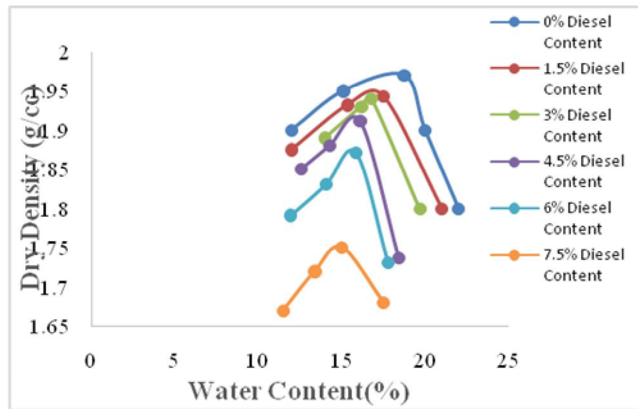

Fig.5.Compaction curve for contaminated soil

As diesel contamination increases both maximum dry density and maximum water content decreases 12% and 25% respectively. The diesel is hydrophobic and it binds itself around individual particles and prevent entry of water which interacts with clay particles, so it reduces the amount of water needed by the soil to reach it maximum dry unit weights. Therefore, optimum moisture content decreases with increasing oil content.

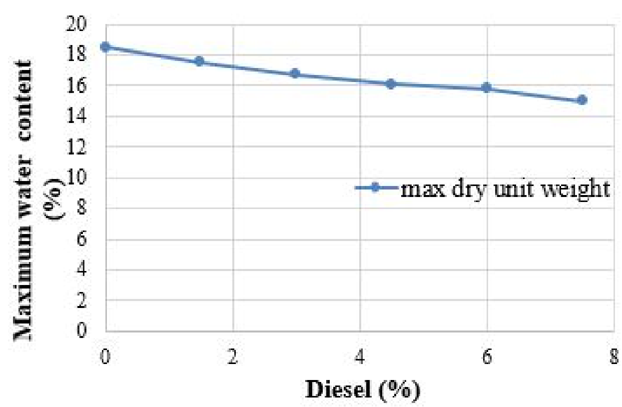

Fig.6.Max. water content with varying diesel content

Graph 6 shows the decrease in water content with different Percentage of diesel. Due to increase in contamination drydensity also decreases The dry density decreases from1.97g/cc to 1.75g/cc.

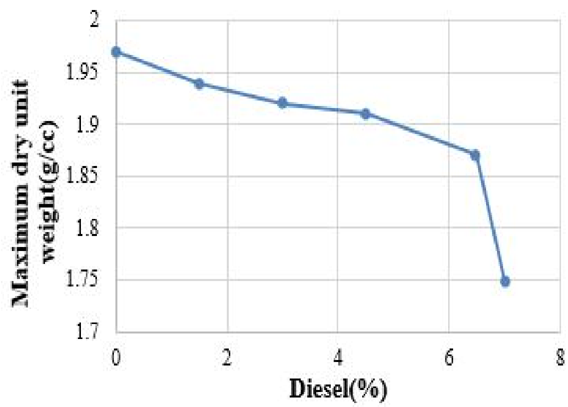

Fig.7. Maximum dry unit weight with varying diesel content

From the fig.7 it can be seen that dry density decrease with diesel content. Formation of double diffused layer leads to decrease in water content and dry density of soil.

C. Shear strength characteristics of contaminated soil

Effect of diesel contamination on unconfined compressive strength of contaminated soil was conducted at maximum dry density and optimum moisture content obtained from compaction test. Unconfined compressive strength decreases with increase in oil contamination of the soil. The diesel content tends to decrease the soil density and loses the soil structure, which leads to decrease in strength. The graph below shows he variation of strength of diesel contaminated soil.

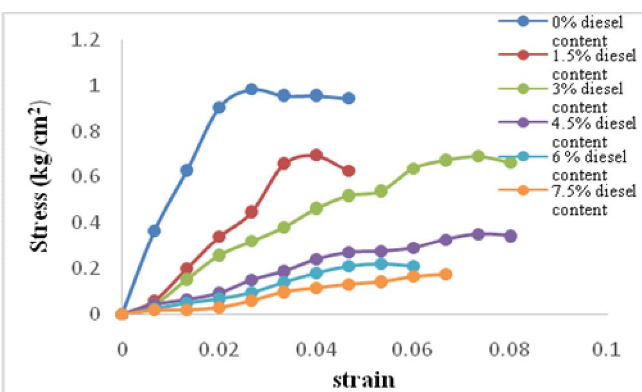

Fig.8. Stress –Strain curves of soil with different percentage of oil content

Fig.8 shows the variation of shear strength with diesel content. There is a decrease in the strength from 47.9kN/m^{2}to 17.9 kN/m^2.

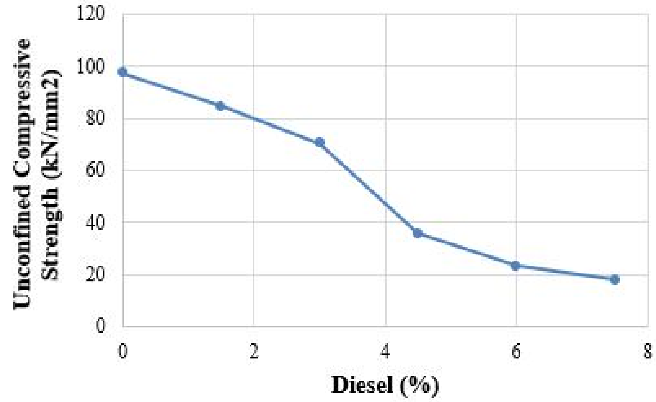

Fig.9. Variation of Unconfined strength of soil with diesel content

It is clear from fig.9 which shows the shear strength reduction of contaminated soil with diesel content.

D. Effect of surfactant on the compaction characteristics of diesel contaminated soil

Maximum dry density and optimum moisture content of diesel contaminated soil increases with increasing percentage of surfactant. The result of compaction test is shown in table 5.

Table 5. Max.dry density and OMC for different percentages of diesel

Percentage of SDS (%)	Max.dry unit weight (g/cc)	OMC (%)
0.5	1..69	15.4
1	1.75	15.38
1.5	1.82	16.8
2	1.84	17
2.5	1.86	17.4

Both OMC and maximum dry unit weight increases 16% and 16% respectively with increasing percentage of SDS.

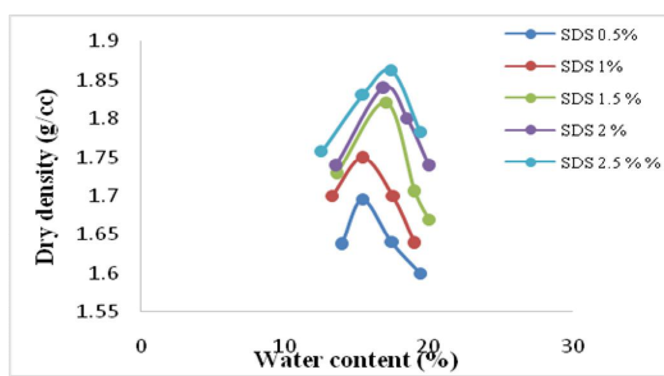

Fig.10.Compaction curve of contaminated soil stabilized with surfactant

It is clear from the fig.10 that, with increasing percentage of surfactant in diesel contaminated soil the shear strength has found to be increased .This is due to filling of SDS particles in the voids of soil.

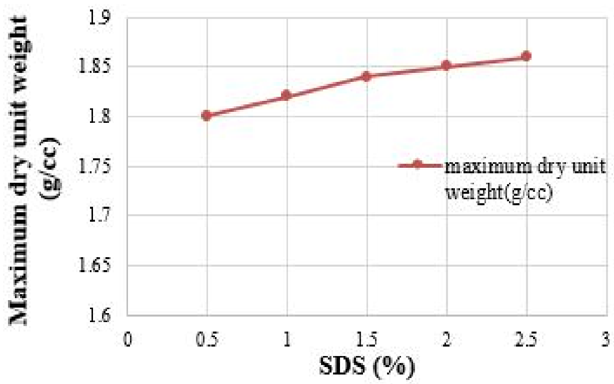

Fig. 11. Max. dry density of contaminated soil for different percentage of SDS

The fig.11 shows the increase in maximum dry density with increase in percentage of SDS

E. Effect of surfactant on unconfined compressive strength of contaminated soil

Unconfined compressive strength increases with the increase in surfactant content in contaminated soil up to 85 %. With increase in SDS percentage the strength is found to be increased by 75% from the lowest strength obtained in a diesel content of 7.5 %.

Fig.12 shows the variation of unconfined compressive strength with increase in diesel content.

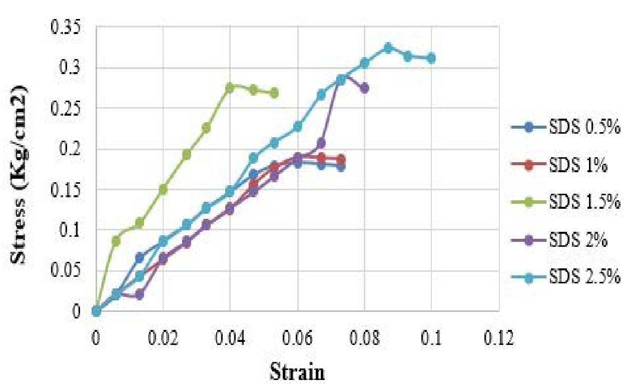

Fig.12.Variation of unconfined compressive strength of contaminated soil with SDS

The strength of contaminated soil increased with increase in percentage of SDS. Maximum strength is achieved for 2.5% of SDS.

V. CONCLUSIONS

- Moisture content decrease by 12 % with increasing diesel content and 7.5% of diesel gives the worst strength.
- Unconfined compressive strength decreases by 45% with increase in diesel content up to 7.5%
- There is an increase in liquid limit, plastic limit and plasticity index with increasing diesel content. Diesel more than 7.5 % cause loosening of particles
- Unconfined compressive strength increases by 85% with increase in SDS content up to 2.5%
- Both OMC and dry unit weight increases by 16% with the addition of SDS on contaminated soil.

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