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Evaluation of impact of oil contamination on geotechnical properties of clay soil

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Abstract: *Oil Pollution is the resultant contamination of environment due to the presence of oil in excessive quantity. Oil contamination is a genuine danger to our environment and biological community and should be controlled with urgency. The oil contamination is influencing the geotechnical properties of soil. So, it's a need to study the effect of diesel oil on geotechnical properties of soils. In this study, the variation of geotechnical properties like Atterberg limits and unconfined compressive strength with the addition of diesel oil in clay was considered. For Removal of Contaminated oil adding EDTA at thrice the oil content. After removal of oil content further adding glass fiber for the strength characteristics. The results showed that increase in the amount of diesel oil decreases the Atterberg limits and unconfined compressive strength. Increasing diesel oil content will leads to decrease in strength and settlement. For that EDTA was best remedial measures for removing oil content*

Key Word : *Oil pollution, geotechnical properties, Atterberg limits, unconfined compressive strength, diesel oil. EDTA, Glass fiber.*

I.INTRODUCTION

Every kind of pollution is harmful to nature. Oil does not break up in water and hence oil normally floats on the surface of water. Oil Pollution is the resultant contamination of environment due to the presence of oil in unreasonable amount. Oil pollution is most common in expansive water bodies like oceans and seas. Oil spills include any spill of raw petroleum or oil refined items e.g., gasoline, diesel fuels, jet fuels, kerosene, hydraulic oils, lubricating oils that can contaminate the surface of the land, air, and water environments. Oil spills occur due to the release of a liquid petroleum hydrocarbon in to the environment particularly the marine eco system. Marine water is particularly influenced by this type of contamination. Oil contamination is basically a man-made contamination and is a result of human reckless exercises. Ships and tankers conveying crude oil over theoce 2.5ans may cause deadly oil spills in marine water due to different causes, leakage being the most widely recognized one. The amount of oil spills matter when it comes to the significance of oil and water pollution. During marine accidents, the oil spills amount is enormous. Oil contamination is a serious risk to our environment and eco system and should be controlled with urgency.

II.MATERIAL

In this study the soil was artificially contaminated with diesel oil and variations in geotechnical properties was studied.

2.1. Soil

The study was conducted on clay, collected from near Chittur, Palakkad and it was high plastic clay. The geotechnical properties of marine clay are given in table I.

Fig.1.Soil sample

Table-1: Properties of Soil

PROPERTIES	RESULTS
Specific Gravity (%)	2.6
Percentage of Clay (%)	58

Percentage of Sand (%)	30
Percentage of Silt (%)	12
IS Classification	CH
Liquid Limit (%)	58
Plastic Limit (%)	28
Shrinkage Limit (%)	18
Plastic Index	30
Optimum Moisture content (%)	28
Maximum dry density(g/cc)	1.6
Free swell	37
Unconfined Compressive Strength (kpa)	81

2.2. Diesel Oil

The diesel oil was taken from a petrol pump in Thrissur. Diesel oil used has light brown color

Fig.2.Diesel Oil

Table2**:** Basic properties of Diesel oil

Specific Gravity	0.86
Viscosity	20.52
API gravity	32.75
Pour point(˚C)	-18

2.3. EDTA

Ethylene di amine tetra acetic acid. It is Industrial Cleaning Chemical. It has 0.1 normality EDTA and collected from Chemind Chemical shop Thrissur. Ethylene di amine tetra acetic acid (EDTA) is an amino poly carb oxylic acid with the formula $[CH_2N(CH_2CO_2H)_2]_2$. This white, water-insoluble solid is widely used to bind to iron (Fe^{2+}/Fe^{3+}) and calciumions (Ca^{2+}), forming water-soluble complex seven at neutral PH.

Fig.3.EDTA

2.4. Glass Fiber

It is used as reinforcement of polymers in various field in civil engineering construction. The 12 mm glass fiber was taken from online. The aspect ratio – 0.571. For the common composite material reinforced with glass fibers, see Fiber glass.

Fig.4.Glass fiber 12mm

Table3: Basic properties of Glass Fiber

SL.NO	Glass fiber properties		Values
1.	Specific gravity		2.67
2.	Elastic Modulus (Gpa)	Tensile Compression Flexural	20.2 16.9 17.1
3.	Strength (Mpa)	Tensile	**384**
		Compression	**201**
		Flexural	**481**

III.METHODOLOGY

The study was conducted to determine the effects of diesel oil on clay, high plastic clay. For this the contaminants are mixed in various proportions and the variations in geotechnical properties like liquid limit, plastic limit, Shrinkage Limits and unconfined compressive strength are analyzed. The contaminants are mixed in 2%, 4%, 6% and 8% by weight of the dry soil samples. And Second study was Conducted to determine the effect of EDTA at contaminated Soil at the thrice the oil content i.e, 6%, 12%, 18%, 24%. The third study was conducted to determine the effect of Diesel oil +EDTA+ Glass fiber at various percentage.

3.1. Variation of various percentage of diesel oil in clayey soil

Table 4.Variation of diesel contamination

Diesel oil (%)	LL (%)	PL (%)	SL (%)	UCS (Kn/m2)
0	58	28	18	81
2	53	24	16	76
4	47	22	13	70
6	39	21	11	62
8	30	19	6	51

3.1.1. Variation of Atterberg Limits.

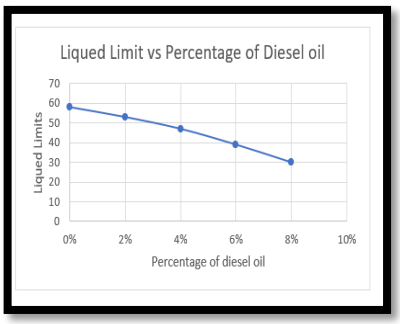

Chart-1: Variation of Liquid Limit

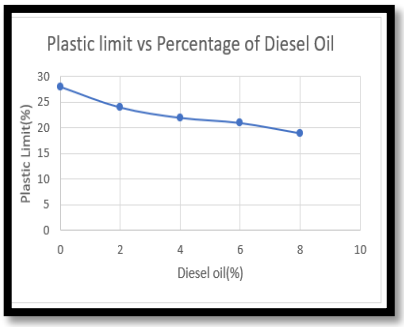

Chart-2: Variation of Plastic Limit

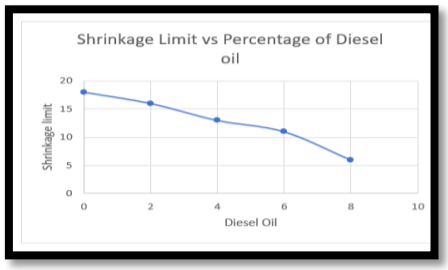

Chart-3: Variation of Shrinkage Limit

Chart 1, chart 2 and Chart 3 shows variation in liquid limit, plastic limit and Shrinkage Limits with diesel oil. It observed that liquid limit, plastic limit and shrinkage limits decreases with the increase in diesel oil content. It is because of the oil is mixed with soil, it surrounds the soil particles, and then the water reaction with soil particle reduces. The thickness of double-layer reduces and decrease in Atterberg limits a soil is added to as oil.

3.1.2. Variation of Unconfined Compressive Strength

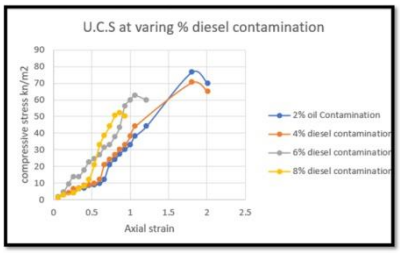

Chart-4: Variation of UCS with Diesel Oil

Chart 4 shows the variation of UCS with the addition of diesel oil. On this sample, there is an inverse correlation between qu and oilcontent.UCS decreases drastically with the increase in diesel oil contamination in the soil .It leads to the weakness of soil and decreases the strength.

3.2. Variation of Contaminated soil with EDTA

Table 4. Variation of diesel contamination with EDTA

Diesel oil (%)+EDTA(%)	LL (%)	PL(%)	SL (%)	UCS (Kn/m2)
0	58	28	18	81
2%+6%	54	26	17	78
4%+12%	51	23	15	72
6%+18%	41	22	16	64
8%+24%	37	21	14	56

3.1.1. Variation of Atterberg Limits and UCS with contaminated soil added by EDTA

Due to the presence of oil and EDTA the Atterberg limit of the soil increased compare with contaminated soil. The Consistency limits increase with increase in concentration of EDTA. The variation of Consistency limit with oil and EDTA shown in chart 5. From the above chart state that it was observed that diesel oil with EDTA affect the geotechnical properties of clay. Reducing oil content in soils.

Removal of Diesel Contamination from a soil matrix by the addition of ethylene di amine tetra acetic acid (EDTA) is an effective means of remediation.

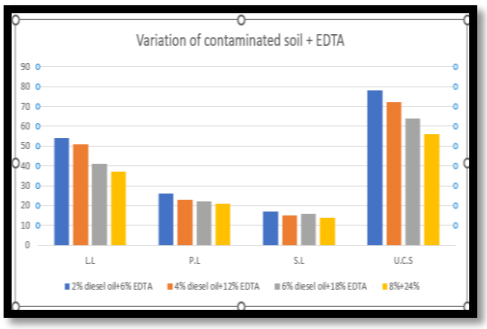

Chart-5: Variation of Diesel Oil + EDTA

The Liquid stream containing the metal and chelating agent is able to further treatment by electrolysis in which the Diesel can be separated from the chelating agent. This provides a separated Diesel that can be removed for reuse or treated for final disposal by conventional technologies and are claimed EDTA stream that can be used again for treatment of contaminated soil. Tests with EDTA demonstrated that over 95 percent recovery of Soil.

3.3. Variation of geotechnical properties of clayey soil with Glass Fiber

Table.5 Variation of geotechnical properties of clayey soil with Glass Fiber

Glass fiber (%)	L.L (%)	P.L (%)	P.I (%)	U.C.S (Kn/m2)
0.5%	59	30	29	84
0.75%	65	33	32	96
1%	63	32	31	92

From the table 5 shows the variation of clayey soil with glass fiber. Since the optimum ratio of glass fiber was found to be 0.75% for the clay sample so here used for the next experimental programs.

Liquid Limit and Plastic limit the liquid limit and plastic limit was determined as per IS: 2720 part 5. The effect of reinforcement on the liquid limit and plastic limit of the soil has been shown in Table4.7. It is observed that as the fiber content was increased from 0% to 1%, the liquid limit and plastic limit of the soil sample increased. This can be attributed to the fact that glass fibers have a tendency to absorb water.

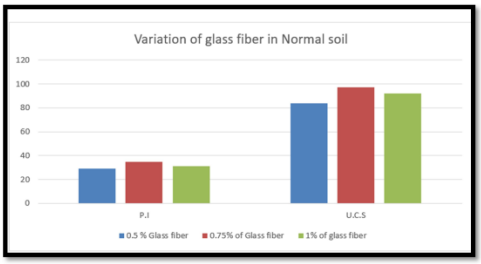

Chart-6: Variation of glass fiber in Normal soil

The unconfined compressive strength of the sample with no reinforcement is around 81 kPa. The value of unconfined compressive strength increased from 81 Kpa to 96 kPa for the sample with 0.5% fiber content, to 84 Kpa for 0.75% fiber content and 96 kPa for the sample reinforced with0.75% Kpa. Though the dry density decreased with the increase in fiber content, the unconfined compressive strength increased at all percentages of fiber content. The fibers being strong in tension enhance the bond strength between its surface and the soil particles. Randomly distributed discrete fibers form a coherent matrix with the soil grains and restrict displacement. The tensile stresses are resisted and the tensile strength of the soil fiber matrix increases.

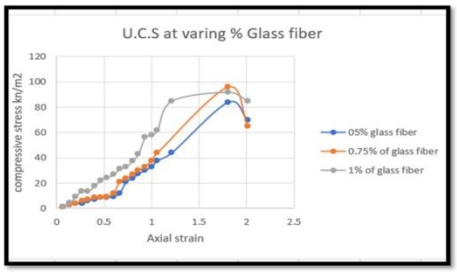

Chart-7: Variation of glass fiber in Normal soil

3.4. Experimental Program with after the removal of Diesel Contamination with Glass fiber

Table6. Variation of diesel contamination with EDTA and Glass fiber

Diesel oil(%)+EDTA(%)+Glass fiber	LL (%)	PL (%)	P.I (%)	UCS(Kn/m2)
0	58	28	30	81
2%+6%+0.75%	56	29	27	82
4%+12%+0.75%	55	27	28	78
6%+18%+0.75%	44	26	18	69
8%+24%+0.75%	41	24	17	67

It is observed that as the fiber content was increased 0.75%, the liquid limit and plastic limit of the soil sample increased. This can be attributed to the fact that glass fibers have a tendency to absorb water.

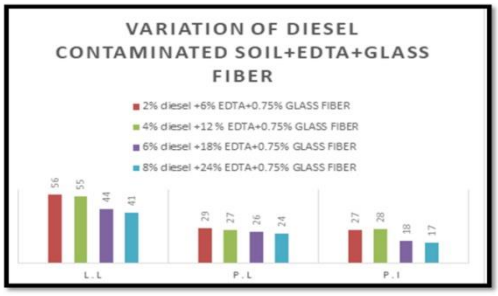

Chart 8 Variation of Diesel contaminated soil + edta + glass fiber

Chart 8 shows the variation of plasticity index. The plasticity index increased as the fiber content increased. This indicated that the soil became less compressible when the fibers are added to the soil.

(i) Unconfined Compressive Strength

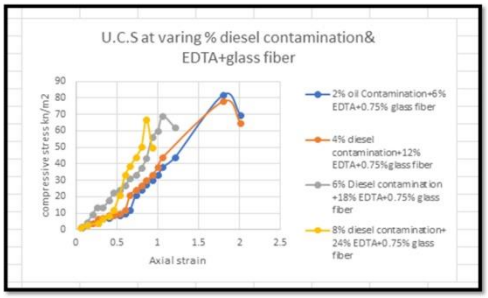

Chart 9 U.C.S (varying % Diesel + EDTA + Glass fiber)

Fiber addition on clay increase the UCS value. UCS value of soil reaches maximum during 02% Contaminated soil and 6% EDTA. Addition of fiber and then decreases. Therefore, the optimum percentage of Glass fiber on clay is found to be 0.75% and 2% contaminated soil with 6% EDTA.

IV.CONCLUSIONS

- From the results, it was observed that diesel oil affect the geotechnical properties of clay.
- Increasing of diesel oil content in soils causes a reduction of Atterberg limits
- The reduction in optimum water content is more in artificially oil-contaminated soil samples, indicating excess oil in the soil.
- Oil contamination induces a reduction in strength of the soil samples.
- UCS value decreases from 81 k N/m² to 51 k N/m² when it added with diesel oil.
- The strength of soil is decreased up to 1.5 times that of the uncontaminated soil is obtained.
- 8% of oil contamination gives the worst strength.
- This study demonstrates the feasibility of development of a system for the remediation of soil contaminated by Diesel with EDTA and subsequent recovery and reuse of the EDTA.
- Removal of Diesel Contamination from a soil matrix by the addition of ethylene di amine tetra acetic acid (EDTA) is an effective means of remediation.
- The unconfined compressive strength increases up to 0.75% addition of Glass fiber in clay and then decreases the optimum value of glass fiber on clay is 0.75%.
- From the fiber combinations used, the peak UCC strength is achieved with the clay is mixed with 0.75% of glass fiber
- The UCC strength increases from 81 kg/sq.cm to 96 kg/sq.cm
- Overall, it can be concluded that, clay with the combination of glass fiber can be effectively used as a soil stabilizer since it was able to produce considerable improvements in the strength of clay.

V.ACKNOWLEDGMENT

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