Soil Stabilization Using Waste Thermosetting Plastic material

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Abstract- Soil stabilisation is the process of enhancing the strength properties of soil by using materials such as lime, NaOH, polyethylene, rice husk, slag, brick dust, and so on. The amount of waste thermosetting fibre materials is rapidly increasing; these wastes Because thermosetting fibres are non-biodegradable and non recyclable fibre materials, they are commonly dumped or thrown, endangering the ecology and ecosystem. Thermosetting fibre materials are one of the waste fibre materials among these. Thermosetting fibre (charger, cooker handles) was employed as an element in this study to improve the qualities of natural soil. Thermosetting fibre has been treated by 10% OPC cement and used to replace soil in a given percentage, and tests have been conducted. To determine the optimal amount of Thermosetting fibre, the soil was replaced with varied quantities of thermosetting fibre. Based on the findings of the experiments, it was discovered that replacing various soil qualities with 3.0 percent thermosetting fibre by weight of soil produces the best results. Unconfined Compressive Strength has increased from 3.24 kg/cm2 to 4.92 kg/cm2, indicating that it can now withstand higher loads. MDD has also grown in value from 1.56 g/cm3 to 1.72 g/cm3, equal to 3% thermosetting fibre. However, due to the low density and inert behaviour of thermosetting fibre, the percentage of increase is minimal. In addition, the value of Soaked CBR rises from 1.92 to 2.63, corresponding to 3% thermosetting fibre which shows that it can be utilised for pavement in locations with a high ground water table. And at 3% thermosetting fibre, the value of Unsoaked CBR increases from 4.09 to 5.46, indicating that we can reduce pavement thickness in pavement design, lowering construction costs in highway and railway construction, and therefore increasing the slope of the slope of the pavement for slope stability.

Keywords: Thermosetting fiber, soil, Sodium hydroxide, maximum dry density, optimum moisture content, unconfined compressive strength, California bearing ratio value.

INTRODUCTION

Soil stabilization is the term in which chemical or physical treatments are given to soil which increase or maintain the stability of a soil or improve its engineering properties. Need of soil stabilization is because structures need a stable foundation for their proper construction and lifelong durability but if weak soil base is used for construction, with passage of time it compacts and consolidates, which results in differential settlement of structure it may result in cracks in structure which can have caster phobic effect too, and it would be very costly to transport the soils from one place to another so to avoid these future problems stabilized soil should be considered. Soil stabilization techniques can be classified in mainly three categories-

MECHANICAL STABILIZATION: In this process we use compacting or tamping machineries like rollers or rammers. The mechanical soil stabilization is also done by removing or adding different soil particles to obtain effective distribution of soil particles. This technique is generally used for subbase and base courses to obtain stabilization of soil.

CHEMICAL STABILIZATION: This stabilization is achieved using traditional and nontraditional chemicals. Traditional chemical stabilization includes lime, cement, bitumen and calcium-based fly ash materials and nontraditional method soil stabilizers include sulfonated oils, ammonium chloride, enzymes, polymers, and potassium compounds.

POLYMER STABILIZATION: polymers are added to improve the physical properties of soil. Some time at very small concentration within soils, various polymers have been shown to increase water retention and reduce erosion, increase shear strength of soil and structure of soil.

THERMOSETS: They strengthen when heated up they make up nearly 20 percent of total global production of plastic and problem is they are mostly non-recyclable but the advantage with them are presence of covalent intermolecular chemical cross link that increases strength and stiffness and reduce the succeptiblity to creep as compared to their thermoplastic counterparts. They become less succeptible to damage by thermal and chemical impulses from nearby environment which makes them highly suitable for use in structural and protective application. Examples Vulcanized Rubber, Bakelite, Duroplast, Urea formaldehyde Resin, Melamine formaldehyde Resin, Epoxy Resins, etc.

Fig. 1 Thermosetting plastics

LITERATURE REVIEW

V Bansal and B K Shukla in [2022] investigated effects of adding Urea formaldehyde in soil. Study was done by varying contents of urea formaldehyde by 1%, 3% and 5% and they found out that enormous increase in the cohesion of the soil and 30gm (by weight) of Urea for every 1Kg of soil is the most optimum.

Md. Shah Azam et. al. in [2020] investigated effects of adding scrap rubber in clayey soil. They treated soil with 0, 5, 10, 15 and 20% by weight of rubber tyre scrap and they found out that the optimum moisture content (OMC) varies from 17% to 20% due to addition of scrap rubber tyre as form of shredded rubber content .The shear strength increased with the increasing amount of rubber up to 20 percentage by its weight. The percentage reduction in liquid limit and plasticity index was about 50% & 54% when 4% CRP was added. For soil treated with 20% of scrap rubber tyre (Retained - 425 µ – scrap rubber tyre passing through 600µ and retained on 425µ IS sieve), and the highest unconfined compressive strength (UCS) value of 68KN/m2 has been observed.

Jeerapan Donrak et. al. in [2020] used melamine debris to stablise laterite soil. Marginal lateritic soil (LS) samples were obtained from a borrow pit in Maung district, Sakonnakhon province, Thailand at 1.5 metre depth. This investigation is about the density, unconfined compression strength (UCS) and durability against wetting and drying (w-d) cycles of cement stabilised LS/MD blends, at various cement contents and MD replacement ratios. The density and UCS of stabilised LS/MD blends decreases significantly with the MD replacement ratio. Even with the decrease in UCS, the soaked CBR and durability against w-d cycles are improved by MD replacement. The optimum MD replacement ratio was found to be 20%, which corresponds with the highest soaked CBR and w-d cycled UCS.The 3% cement LS/MD blend at 20% MD can be used as a stabilised subgrade material, while 5% cement LS/MD blends at 40% MD and 20% MD can be used as stabilised subbase and base materials, respectively based on the specification of Department of Highways, Thailand.

Salaheddin Hamidi et. al. in [2018] taken two samples of clay soils with different clay minerals and added epoxy resin to them. Clay soil samples that tested experimentally were bentonite and kaolinite. A series of microstructure and macrostructure experiments were conducted on the samples. The results show that using epoxy resin increases strength parameters about 100 to 1000 times while UCS reaches to more than 50 MPa in some samples based on the clay mineral types in the soils. Unlike the cement concrete, as the strength increases the failure strain and material toughness will increase simultaneously as well. In addition, the important and prominent result of stabilization by epoxy resin is the best efficiency in the weakest and the most sensitive soils.

Mangesh et. al. in [2017] observed the use of e-waste in different proportions (i.e. 2%, 5% & 8%) in the stabilization of black cotton soil as an effective solution for the disposal problem of this waste. In their study, the soil sample was collected from the Ravet city of Pune District in Maharashtra state (India). The sample was classified as clay of low compressibility (CL) as per Indian Standard Soil Classification System (ISSCS). In their study, the peak values of UCS and CBR tests were found on the addition of 5% e-waste with the soil. Hence, it was concluded from their study, that the 5% doses of e waste with soil could be an economical and productive method for soil stabilization.

PT Ravichandran et. al. in [2016] investigated effects of adding crumb rubber in a weak soil. Two types of problematic clay soils are stabilised with the various percentages of crumb rubber (5, 10, 15 and 20%). The strength properties of stabilized soils were improved by increasing percentages of crumb rubber up to 10% is studied by the CBR tests. In addition to strength development t, the influences of this stabilizer type and different quantities on drainage characteristics are also studied. Addition of crumb rubber in both the soils shows desirable changes in permeability. With the addition of crumb rubber of 10% shows the improvement in CBR value of soil is 161% and 130% in soil A1 and A2. The results obtained shows that both strength and permeability modification results in the better stabilization for clayey soil.

MATERIALS AND METHODOLOGY

The following materials used in this study-

Name of material	Source of material
Clayey soil	Obtained from BIT Sindri campus
Thermosetting plastic	Obtained from BIT Sindri campus
OPC cement grade-33	Shop

Treatment of Thermosetting fiber

As thermosetting fibres are hydrophobic in nature and do not absorb any moisture, they do not disperse well in water, this is why cement of 10 % solution is used to ensure total dispersion.

Following steps to be carried out for the treatment of thermosetting fiber

- Make the solution of 10 % cement
- Weight the thermosetting fibre and is fully dispersed for 24 hours
- Take out thermosetting fiber from solution
- Wash the thermosetting fiber by distilled water

Weight the fibre again to check that there is no weight gain in the fibre, and that the fibre has been dispersed and is ready for use as soil reinforcement

Dosing and Mixing

Different % of thermosetting fiber i.e., 0.5%,1%,1.5%,2.0%,2.5%3.0%,3.5% and 4.0% of thermosetting fiber by weight of soil are used. Treated thermosetting fiber are then mixed with soil by hand properly to get uniform mix and add water as per requirement.

Tests conducted

1. Proctor test
2. Unconfined compressive strength test
3. CBR test

A. Soaked CBR

B. Unsoaked CBR

RESULT AND DISCUSSION

Table 1 Properties of the Natural soil

S. No.	Parameters	Values
1.	Specific Gravity	2.57
2.	Liquid limit	38.80%
3.	Plastic limit	22.04%
4.	Plasticity index	16.76%
5.	OMC	15.40%
6.	MDD	1.560 g/cc
7.	UCS	3.42 kg/cm^2
8.	Soaked CBR	2.04%
9.	Un-soaked CBR	4.17%
10.	Percentage finerthan 75 micron (clay+silt)	58.8 %
11.	Percentage ofclay	15.32%

1. Variation of soil properties with addition of treated thermosetting plastic waste

Table 2

Cement treated thermosetting (%)	MDD (g/cc)	OMC (%)
0	1.56	16.83
0.50	1.59	16.41
1.00	1.62	15.98
1.50	1.63	15.67
2.00	1.65	15.43
2.50	1.67	15.19
3.00	1.72	14.93
3.50	1.66	15.62
4.00	1.63	15.98

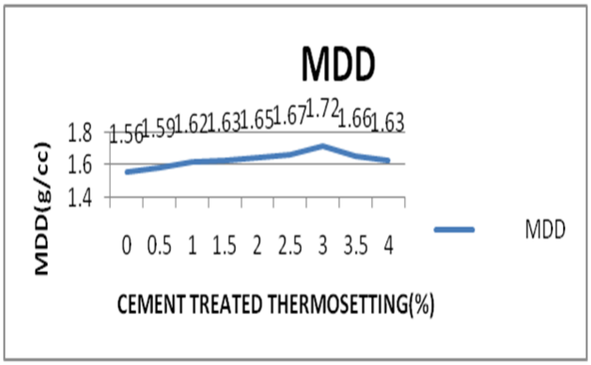

Fig.2 MDD vs cement treated thermosetting

The maximum dry density of fibre reinforced soil at optimum moisture content increased as the amount of thermosetting fibre increased, and the maximum dry density – percentage of thermosetting fibre relationship shows that increasing the fibre content up to 3.0 percent by dry weight of soil has a significant effect on the magnitude of maximum dry density with thermosetting fibre, as shown in figure. The maximum dry density of soil increases with increases in thermosetting fibre up to 3.0 percent and subsequently drops, but the increment in MDD is not much greater due to the low density of thermosetting fibres, as seen in the graph above.

(3) .CBR Value-

Table 3-Comparison between Soaked CBR and Unsoaked CBR

S.N.	Soil(%)	%cement treated thermosetting fiber	SoakedCBR (%)	Unsoaked CBR(%)
1	100	0	1.92	4.09
2	99.50	0.50	1.99	4.31
3	99.00	1.00	2.12	4.57
4	98.50	1.50	2.25	4.86
5	98.00	2.00	2.41	5.06
6	97.50	2.50	2.59	5.21
7	97.00	3.00	2.88	5.46
8	96.50	3.50	2.63	5.28
9	96.00	4.00	2.47	5.13

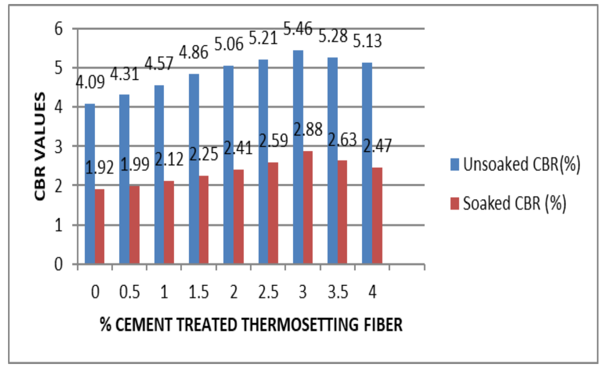

Fig. 3 CBR vs % CEMENT TREATED THERMOSETTING FIBER

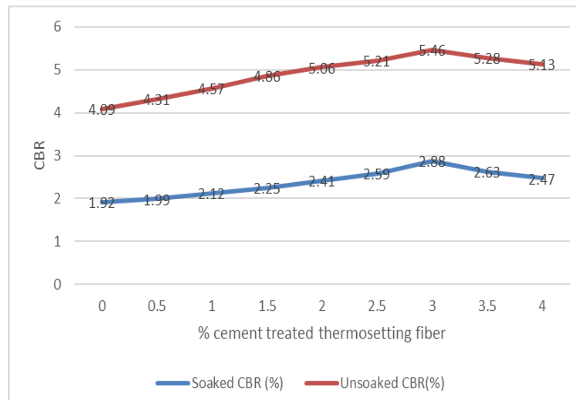

Fig. 4 CBR vs % cement treated thermosetting fiber

From Unsoaked CBR test results , it was observed that the Unsoaked CBR of natural soil is 4.09% and the CBR value is increased to 5.46% at 3.0% treated thermosetting fiber and then decreases because more than 3.0% of cement treatedthermosetting fiber causes voids in soil due to improper mixing and from Soaked CBR test results, it was observed that the Soaked CBR of natural soil is 1.92% and the CBR value is increased to 2.88% at 3.0% of cement treated thermosetting fiber.

(4).Unconfined Compressive Strength Test Results

Values of UCS of the soil sample mixed with different percentage of thermosetting fiber and its variation with natural soil have been tabulated below:

Table 4UCS test results

S.No.	Soil (%)	%age cement treated thermosetting fiber	UCS(kg/cm^2)
1.	100.0	0	3.24
2.	99.50	0.50	3.43
3.	99.00	1.00	3.91

4.	98.50	1.50	4.15
5.	98.00	2.00	4.45
6.	97.50	2.50	4.72
7.	97.00	3.00	4.92
8.	96.50	3.50	4.60
9	96.00	4.00	4.35

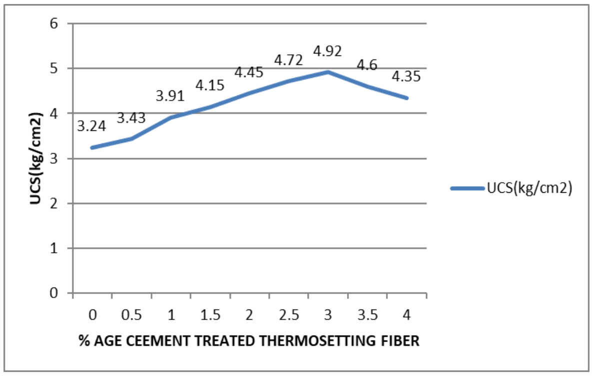

Fig. 5 UCS vs % AGE CEEMENT TREATED THERMOSETTING FIBER

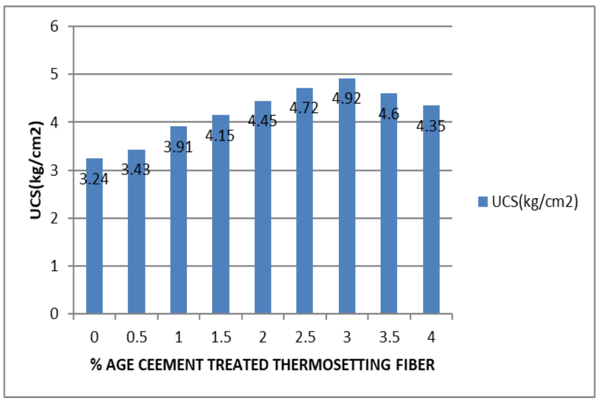

Fig. 5 Variation of UCS with %age cement treated thermosetting fiber

According to UCS test results, natural soil has an unconfined compressive strength of 3.24 kg/cm2, which climbs to 4.92 kg/cm2 with 3.0 percent cement treated thermosetting fibre concentration and then drops. There is a strength increase of roughly 51.86 percent at 3.0 percent cement treated fibre content. The accompanying table and graph demonstrate the fluctuation of UCS with respect to thermosetting fibre.

CONCLUSION

From the experimental results, it has been found the various properties of soil replaced with 3.0% of cement treated thermosetting fiber by weight of soil gives optimum results

- The UCS value goes on increasing from 3.24 kg/cm2 to 4.92 kg/cm2 upto 3.0 percent cement treated thermosetting fibre and after that decreases and 20.98 percent increase, indicating that it can support heavier loads.
- The MDD value goes on increasing from 1.56 g/cm3 to 1.72 g/cm3 upto 3.0%age cement treated thermosetting fibre and after that decreases, although due to the low density and inert nature of thermosetting fibre the percentage of increase is minimal.
- Soaked CBR's value goes on increasing from 1.92 percent to 2.63 percent upto 3.0 %age cement treated thermosetting fibre and after that decreases indicating that it can be utilised for pavement in places with a high ground water table.
- At 3.0 %age cement treated thermosetting fibre, the value of Unsoaked CBR goes on increasing from 4.09 to 5.46 percent, indicating that we can reduce pavement thickness for pavement design. We can increase the slope of the pavement to lower the cost of construction in highways and railways, as well as for slope stability.

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