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Comparative Study On Effect Of Soft Soil Stabilization Using Coir Fibres And Polypropylene Fibres

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Abstract: *The loads coming on the structures are transferred directly to the earth. The stability of the structure depends upon the strength of the soil on which it is constructed. In case of soft soils, i.e. clay, the properties have to be improved for better performance under the action of loads. Geosynthetics have been widely used in soil reinforcement. The main aim of the study is to investigate and evaluate the effects of polypropylene fibres and coir fibres on various properties of soil. The results obtained are compared and inferences are drawn towards the usability and effectiveness of fibre reinforcement in soft soil. It is essentially an eco-friendly approach.*
Keywords - *Coir, Geosynthetics, Polypropylene, Shear Parameters, Soft soil, UCC.*

I. Introduction

The concept of earth reinforcement is not new; the basic principles are demonstrated abundantly in nature by animals and birds and by the action of tree roots. Ground improvement is the field in which the engineer forces the ground to adapt to the project's requirement instead of altering the design to suit the natural limitation of the ground. Development of major ground improvement techniques has been one of the major challenges of geotechnical engineers. As a result of this challenge, several methods have been developed which can be mainly grouped as mechanical modification, hydraulic modification, chemical stabilization and modification by inclusion and confinement.

Of the various ground improvement techniques, the technique of soil reinforcement is being widely used now-a-days and is fast replacing the conventional ground improvement techniques. The advantages of reinforced earth technique that make them most suitable are: First, they are economical with about 30 to 50% savings in cost; second, they are amenable to rapid installation and therefore involve considerable saving in time and third, they are able to withstand deformations and foundation settlement problems in a better way compared to rigid structures.

A more recent development in stabilization of weak sub-grades is to provide confinement of soil. The use of thin planar geo-grids cannot provide this confinement effect due their limited depth. Thus a better option in this regard is to use geo-cells which can provide a three dimensional confinement to the soil. A geo-cell foundation mattress consists of a series of interlocking cells, which contains and confines granular soil. Geocells are manufactured from a wide variety of synthetic materials like polyester, polyamide etc.

II. Literature Review

In his study, H P Singh et al. (2013) found that the CBR value of the soil increased with increase in fibre content. The increase in length and diameter also increased the CBR value. Parag M. Chaple et al. (2013), focused on the effect on coir on the bearing capacity and settlement of footing with parameters such as thickness of reinforced layer (B, B/2, B/4) with 0.25%, 0.5%, 0.75% and 1.0% of coir using laboratory model tests on square footings supported on highly compressible clayey soil reinforced with randomly distributed coir fibre. J.R. Oluremi et al. (2012), found that coconut husk ash can be effectively used to improve lateritic soils with low CBR values but not suitable for improving soils with high liquid limit. Rakesh Kumar Dutta et al. (2012), studied the effective use of treated coir fibres on unconfined compressive strength of clay. The results indicate that the fibre reinforced clay was able to bear higher strains and increase in the unconfined compressive strength was higher with CCl_4 treatment. Abhinav Nangia, et al.(2015), found that addition of randomly distributed polypropylene fibres enhance the properties of soil. Mousa F. Attom et al. (2010), compared the shear strength parameters of sandy soil with two different types of polypropylene fibres. Test result showed that shear strength increased with increase in fibre content and with increase in aspect ratio.

From these literature surveys conducted, it was clear that studies have been conducted on the variation in properties of soil mixed with treated and untreated coir fibres and polypropylene fibres. The work focuses on the comparative study of use of coir fibres and polypropylene fibres in soft soil stabilization, i.e. clayey soil from the rice fields in Ernakulam, India. The study aims at investigating the variation in soil properties by the addition of coir fibres and polypropylene fibres and finding the optimum percentage of fibres required to get the desired changes in properties of soil.

III. Methodology

3.1 Data Collection

The physical properties of coir fibre were collected from Jayasree Coir Mills, Cherthala, are listed below in TABLE 1:

Table 1: Properties of coir fibres

Physical Properties	Values
Ultimate Length	0.6mm
Diameter/ width	16 micron
Fibre Type	Single fibre
Tensile Strength	175 MPa
Young’s modulus	4-6 GPa
Water absorption	130-180%

The physical properties of polypropylene fibre were collected from Ahana Enterprises, Bangalore, are listed below in TABLE 2:

Table 2: Properties of polypropylene fibres

Physical Properties	Values
Average Length	12 mm
Average Diameter	0.034 mm
Fibre Type	Single fibre
Tensile Strength	350 MPa
Young’s modulus	3500 MPa
Acid & Alkali resistance	Very Good

3.2 Experimental Study

The following tests were conducted for the soil sample collected from the field.

- Particle size distribution using sieve analysis
- Water content by oven drying method
- Density of the soil, which includes its dry density and bulk density
- Consistency limits or Atterberg's limits

The following tests were conducted in the soil by varying the percentage of coir fibres and polypropylene fibres:

- Unconfined Compressive Strength using UCC testing machine
- Compaction characteristics and determination of optimum moisture content
- California Bearing Ratio from CBR testing apparatus

IV. Results And Discussions

4.1 Index Properties of Soft Soil

The specific gravity of the soil sample using Pycnometer method is obtained as 2.2. The dry density of the soil sample is obtained as 1.09 g/cc and bulk density as 1.60 g/cc. The water absorption of the soil sample is found out to be 52.17% using oven drying method.

4.2 Particle Size Distribution

From Figure 1, the effective size D_{10} is obtained as 0.12 mm and D_{30} and D_{60} are obtained as 0.22mm and 0.49mm for the percentage finer 30% and 60% respectively.

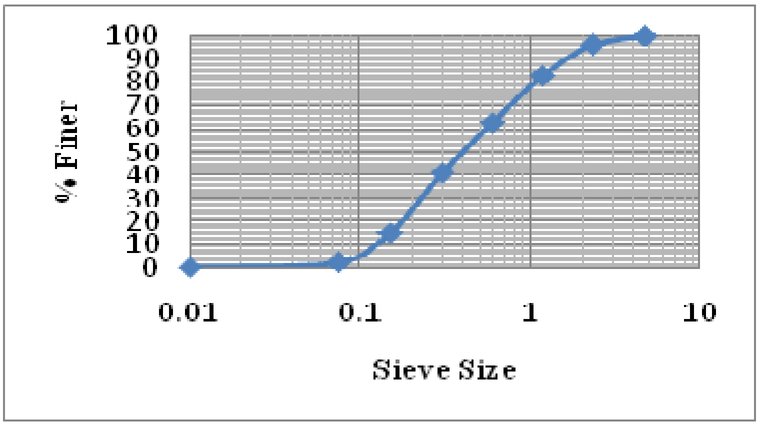

Figure 1: Gradation Curve

4.2 Liquid Limit

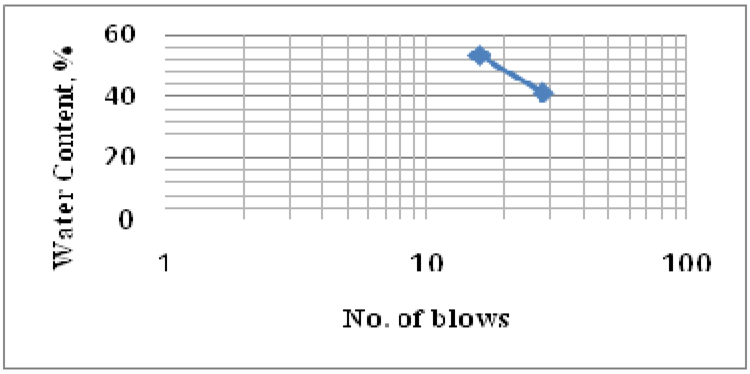

Figure 2: Flow Curve

From Fig. 2, the liquid limit i.e. the water content corresponding to 25 number of blows is obtained as 44.44%. The plastic limit is obtained as 33.33%. The plasticity index i.e. the difference between the liquid limit and the plastic limit is found to be 10.67%. The flow index is obtained as 49.99% and thus the toughness index i.e. the ratio of plasticity index to the flow index is found to be 0.213.

4.3 Standard Proctor Test

From the Fig. 3, the optimum moisture content is obtained as 36% which gives the peak value of dry density.

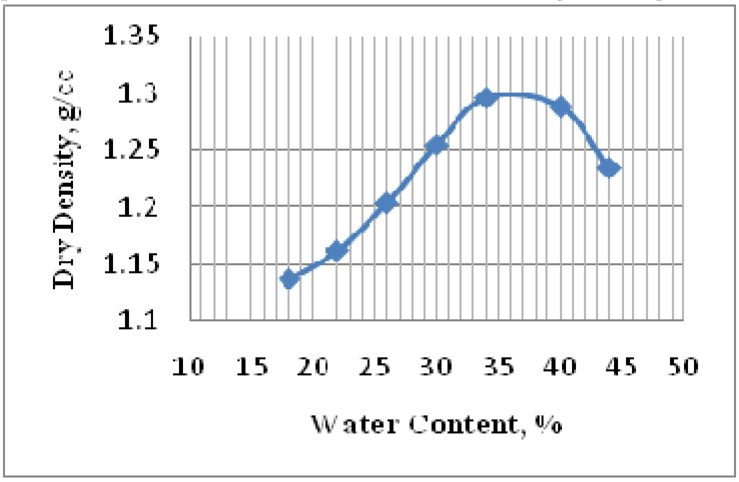

Figure3: Compaction Curve

4.5 Unconfined Compression Test Results

UCC was performed with coir fibres of lengths 30mm at various percentages to fix the optimum percentage of coir fibres to be added.

For 30 mm length of fibers, the maximum unconfined compressive strength obtained at 0.5%, 1%, 1.5% & 2% fiber content is noted.

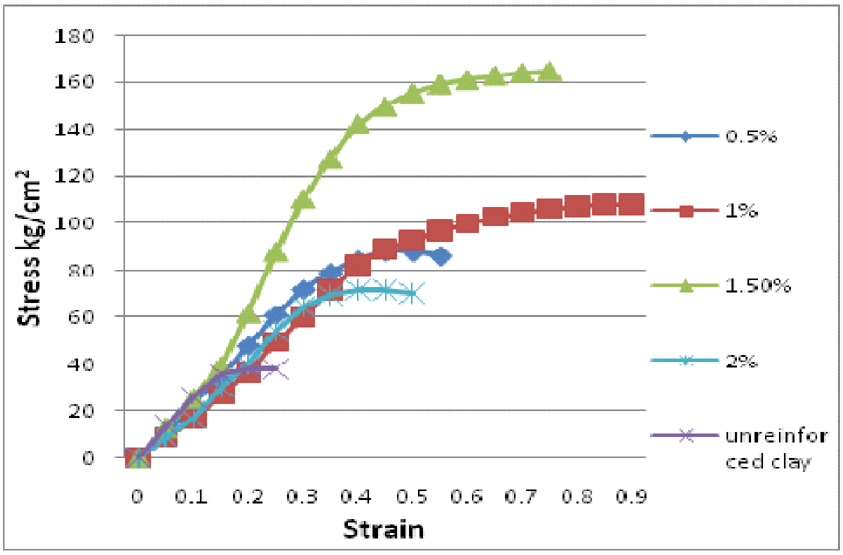

Figure 4: Results of Unconfined Compression Tests – Coir Fibre

From Fig. 4, it is clear that the soil when added with coir fibres of length 30 mm at 1.5% gives the maximum compressive strength.

UCC was performed with polypropylene fibres of lengths 30mm at various percentages to fix the optimum percentage of polypropylene fibres to be added.

For 30 mm length of polypropylene fibers, the maximum unconfined compressive strength obtained at 0.5%, 1%, 1.5% & 2% fiber content is noted.

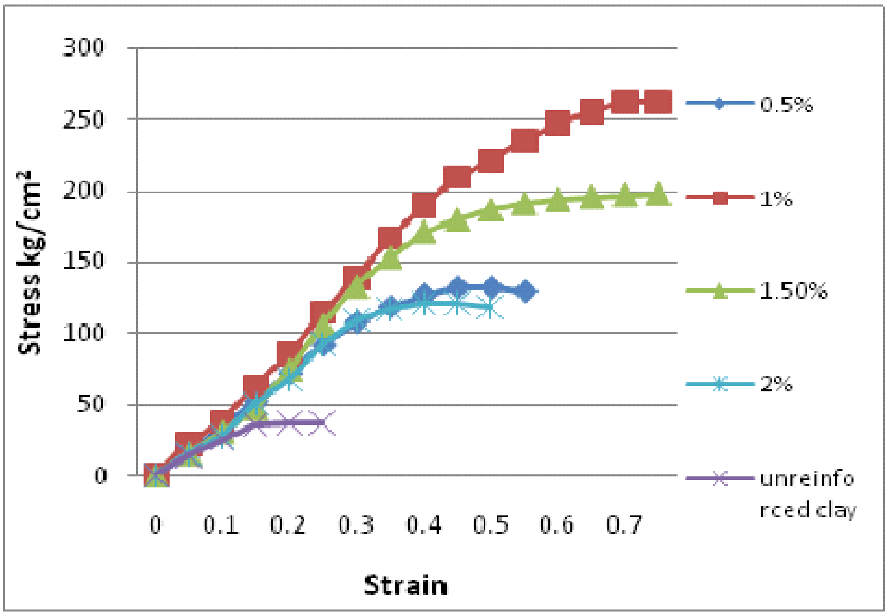

Figure 5: Results of Unconfined Compression Tests – Polypropylene Fibre

From Fig.5, it is clear that the soil when added with polypropylene fibres of length 30 mm at 1% gives the maximum compressive strength.

4.6 California Bearing Ratio

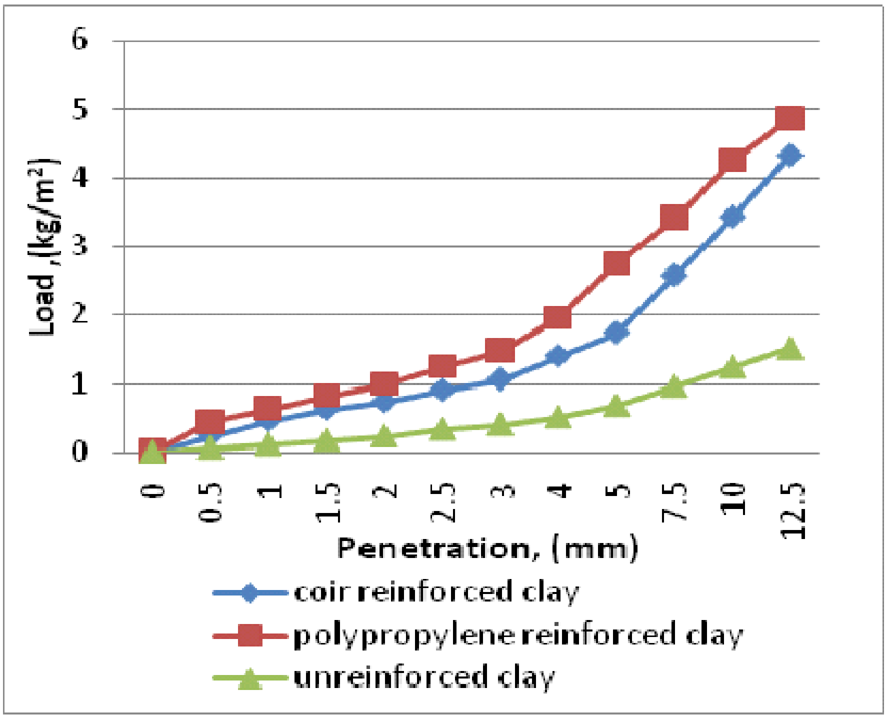

Figure 6: Load Penetration Curve

With reference to and Fig. 6, it is evident that the PP reinforced clay can bear higher loads compared to coir & unreinforced clay.

V. Conclusion

When the coir fibre content is varied, a fall in the unconfined compressive strength was observed at fibre content greater than 1.5% in case of coir fibre.. Hence, it is concluded that 30mm fibres at 1.5% yield a maximum value in terms of its unconfined compressive strength. The optimum percentage of polypropylene fibre was found to be 1% by weight of soil.

Soft soil was stabilized and made stiff. The Unconfined Compressive Strength of the PP reinforced clay was more than 5 times that of unreinforced clay. The Unconfined Compressive Strength of the coir reinforced clay was more than 4 times that of unreinforced clay. The results of polypropylene and coir fibres are comparable and therefore coir fibre can be used as an effective soil reinforcement. Also the California Bearing Ratio of coir reinforced clay was comparable with PP fibre.

The fact that coir fibre is economical and an organic material, makes it an effective reinforcement in soil.

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