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Increase of Shear Strength of Soft Soil Using Fibre in a Random Manner

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***Abstract*—For any land-based structure the foundation is very important and has to be strong to support the entire structure. In order for the foundation to be strong, the soil around, it plays a very critical role. So to work with soil, we need to have proper knowledge about their properties and factors which affect their behaviour. The process of soil stabilization helps to achieve the required properties in a soil needed for the construction work.In India, the modern era of soil stabilization began in early 1970's, with a general shortage of petroleum and aggregates, it became necessary for the engineers to look at means to improve soil other than replacing the poor soil at the building site. With the availability of better research, and materials and equipment, soil stabilization is emerging as a popular and effective method of soil improvement. Here in this project, soil stabilization has been done with the help of randomly distributed polypropylene fibers which is a geosynthetic form available as geotextile, hence a comparative study is made on the basic properties of plain soft soil with that of the modified properties of the same and thereby knowing the importance of geosynthetics in assisting the construction over soft soil.**

***Index Term*—Stabilization, Polypropylene Fibers, Random Manner, Unconfined Compressive Strength, Stress-Strain Curve.**

I. INTRODUCTION

Soil stabilization is the process of altering some soil properties by different methods, mechanical or chemical in order to produce an improved soil material which has all the desired engineering properties.Construction across soft soils creates a dilemma for the engineer. The construction proceeds at a slow pace because much time is spent recovering equipment mired in muck(Fig. 1) and hauling large quantities of fill to provide adequate bearing strength.

Fig. 1 Equipment mired in Muck

By inclusion of fibre in the soft soil leads to stabilization [2]. The process is very fast and cost effective too [9], there is no need to bring good soil for the foundation or replace entire foundation soil which is soft. In low lying areas or areas where good soil is scarcely available, the methodof stabilization using geosynthetic is very effective.

The main objectives of this study are (i) review of the effect of various fibre parameters on strength of soil [6]; this includes the identification of the optimum fiber reinforcement condition in terms of fiber length and fiber content, (ii) to study the effect of various fiber parameters on strength of soil, (iii) to quantify the improvement in shear strength parameters caused bythe inclusion of fibers from experimental results and (iv) to perform a comparative study of shear strength parameters of unreinforced and fibre reinforced soil.

II. MATERIALS AND METHODS

A. Methodology

The detailed methodology for this study is presented in Fig. 2.

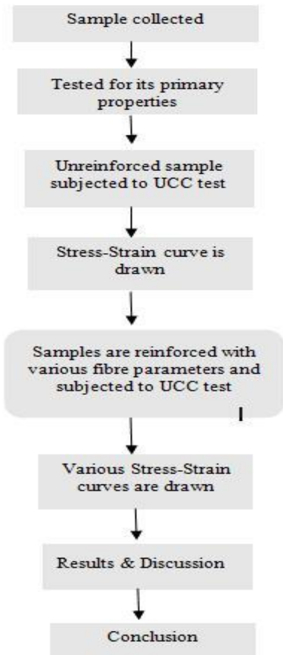

Fig. 2 Flow chart of methodology

B. Experimental Investigation

Sample collection

Soil: Sample is collected from Avadi (Fig. 2), Chennai.

Visual identification: The soil from its physical appearance is identified as soft clayey soil, coffee brown in colour, with a little silt content.

Short Polypropylene(PP) Fibres: The collected Short Polypropylene(PP) Fibres are represented in Fig. 3.

(a)

(b)

Fig. 2 (a, b) Sample Collection

Fig. 3Short Polypropylene(PP) Fibres

C. Basic Properties of Soil Sample

The Basic Properties of Soil Sample are presented in Table 1.

TABLE 1 THE BASIC PROPERTIES OF SOIL SAMPLE

Properties	Values
Specific gravity	2.85
Liquid limit	30%
Plastic limit	16.67
Plasticity Index	13.53
Liquidity Index	1.23
Toughness Index	1.69
Shrinkage Index	1.16
Uniformity coefficient	2.47
Percentage of mineral fraction	Sand-39.72 Silt-52.75 Clay-7.53
Optimum moisture content	14.5%
Optimum dry density	1.79 g/cc

D. Reinforcing Fibre

Index and strength parameters of fiber are presented in Table 2.

TABLE 2 INDEX AND STRENGTH PARAMETERS OF FIBER

Behaviour Parameters	Values
Fibre type	Multi filament
Unit weight	0.85-0.95 g/cc
Average diameter	2mm
Average length	Varying (12mm, 15mm, and 20mm.)
Modulus of Elasticity	1650MPa
Burning point	>300^{0}C
Dispersibility	Insoluble
Breaking tensile strength	34MPa

E. UCC Test for Unreinforced Sample

The effect of fiber inclusion on the unconfined compressive strength (UCS) and stress–strain relationship of soil specimens was determined as a function of fiber content and length. Primarily, the tests were performed on un-reinforced soil to establish base UCS so that the relative gain in UCS due to addition of polypropylene fibers could be estimated. Fig.4 shows the stress strain response of soil specimens without polypropylene fibers.

The un-reinforced soil sample was tested three times, each time slightly different value of shear strengths were obtained hence average value of the three trials was taken as the final shear strength value.

At first trial, the value of Unconfined Compressive strength as obtained from graph:

q_u= 0.7696*98.1 = 75.5 kN/m^2

In second trial, value of Unconfined Compressive strength as obtained from graph:

q_u= 0.7756*98.1 = 76.086 kN/m^2

In third trial, value of Unconfined Compressive strength as obtained from graph:

q_u= 0.774*98.1 = 75.938 kN/m^2

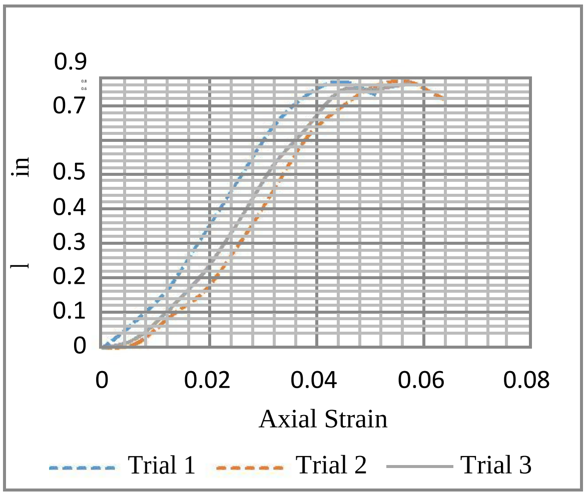

Fig. 4 Graph for unreinforced sample

Therefore the average value of unconfined compressive strength of unreinforced soil sample is obtained as

q_u=75.84 kN/m^2

Undrained shear strength,

$C_u = \tau_f = q_u/2$ = 37.92 kN/m^2

F. Randomly mixing fibers into the soil

This method consists of randomly mixing fibers into the soil to increase its shear strength (Fig. 5). The fibers increase the cohesion among the soil particles. In addition the interaction of the fibers among themselves and the fibers flexibility makes them behave as a structural mesh that holds the soil together increasing the soil structural integrity. When the fibers are randomly mixed with sample there won't be any distinct plane of failure. The Fibre reinforced soil specimen is shown in Fig. 6.

Fig. 5 Soil Specimen Randomly Mixed with Fibers

Fig. 6 Fibre reinforced soil specimen

G. UCC Test on Reinforced Sample

UCC tests were performed on the soil specimens with one type of fiber reinforcement (Polypropylene fibers) using varying permutations of length (12mm, 15mm, 20mm) and content (0.05%, 0.15%, 0.25%, 0.35%) of the fiber so as to obtain the optimum unconfined shear strength of the reinforced soil specimen (Figs. 7, 8 and 9). That is by keeping the fiber length constant UCC tests were conducted on varying percentages of fiber content on the soil specimen.

The comparison among the unconfined compressive strengths of different soil specimens having fibers of varying permutations of length and content are follows:

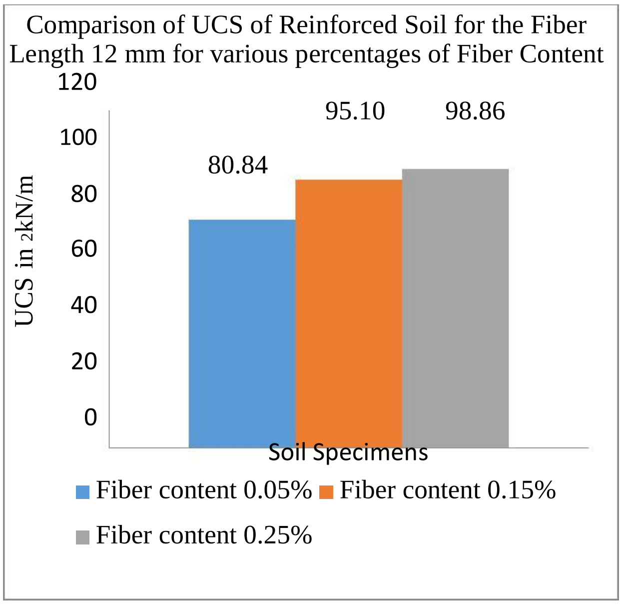

Fig. 7 UCS for the FL 12 mm for Various Percentages of FC

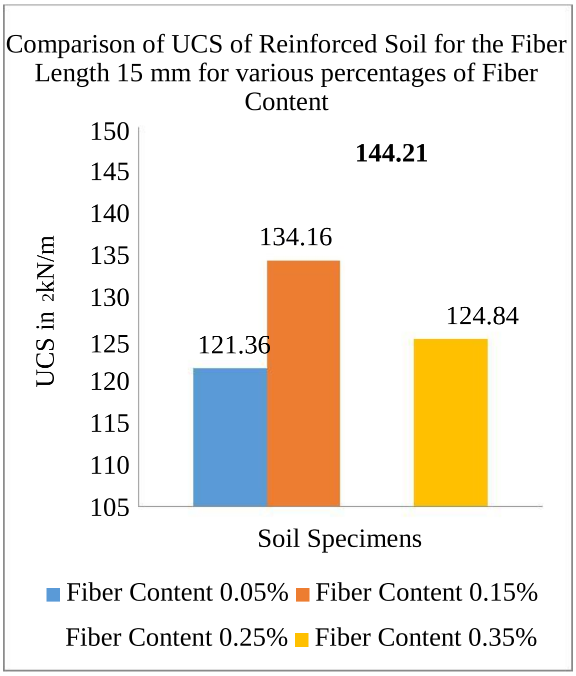

Fig. 8 UCS for the FL 15 mm for Various Percentages of FC

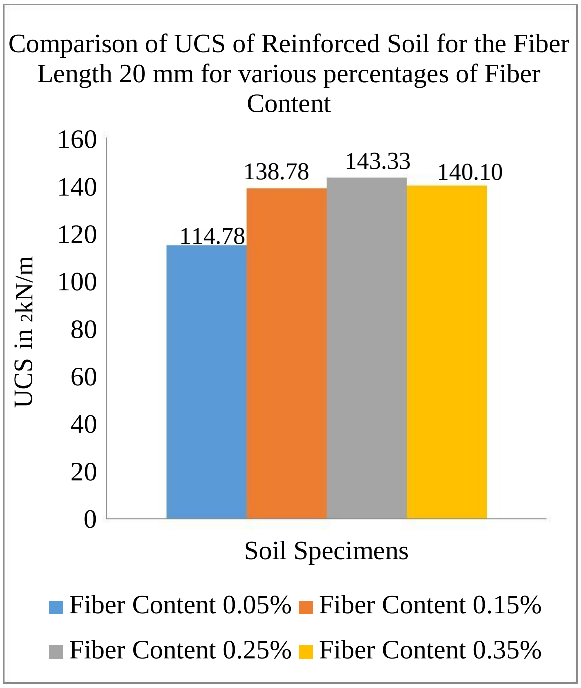

Fig. 9 UCS for the FL 20 mm for Various Percentages of FC

From the charts above it is clear that the UCS reached a maximum in particular fiber content for each fiber length.

Among the three fiber lengths, fiber length of 15 mm and 20 mm showed higher values of shear strengths than 12 mm. These two fiber lengths were performed in four percentages of fiber content as to obtain the optimum fiber content. Several trials were made to get accurate results. In both these lengths, shear strength increased as fiber content increased upto 0.25%, in soil specimens having 0.35% of fiber content, shear strength decreased.

For the length 15 mm fiber content of 0.25% showed maximum UCS of 144.21 kN/m^2. Further increase in the fiber content to 0.35% lead to the decrease in the UCS to 124.84 kN/m^2,that is UCS decreased up to 13%. A similar case occurred, when 20 mm fiber length was used. UCS of 143.33 kN/m^2 was obtained for the fiber content 0.25%, and for 0.35%, UCS showed a small decrease to 140.10 kN/m^2.

From the above discussion, we arrived at that the optimum fiber content for which the maximum UCS was obtained is for the fiber length 15mm in 0.25% of fiber content.

H. Comparison between Unreinforced and Reinforced Soil Sample

When compared with the UCS of unreinforced soil sample,Average value obtained for the unreinforced soil sample is 75.84 kN/m^2. For the soil specimen having optimum fiber content, UCS obtained is 144.21 kN/m^2. That is shear strength of the soil increased by 47.41%with the inclusion of fibers.The following chart (Fig. 10) shows the comparison:

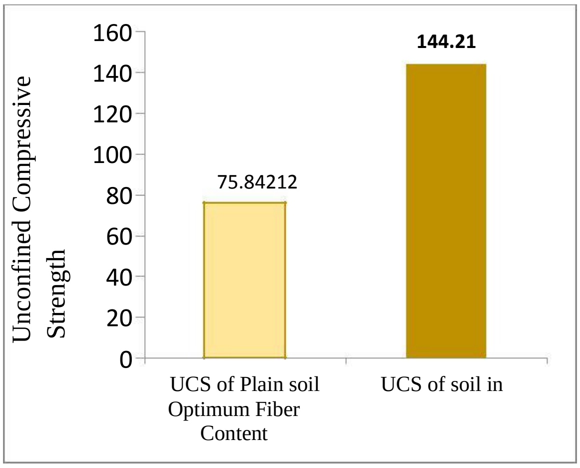

Fig. 10 UCS for Plain Soil and Soil with Optimum Fiber Content

IV. CONCLUSION

Soft soils are known to be highly deformable and have low shear strength. For the structure to be safe, it must not undergo excessive settlement and shear failure. Hence the shear strength of the soil has to be improved. The soil reinforced with fibers will have greater shear strength and the construction of pavements and structures will be easier. Further it can be said that the soil improved its consistency from medium to stiff. Considering the economy, geosynthetic fibers are easily available and cost effective. Overall it can be concluded that soil stabilization using Polypropylene fibers can be considered to be a good ground improvement technique especially in engineering projects on weak soils where it can act as a substitute to deep/raft foundations, reducing the cost as well as energy.

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