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Optimization of Cost and Fibre Quantity in Stabilization of Soil

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***Abstract*— Once there is a change in a place, type of soil also get changes. Along with soil type the properties of soil also changes. For any kind out of construction we require stable foundation in the form of firm strata. This can be available naturally if hard rock encountered below the soil. But this condition can not be possible at every site. Hence stability of foundation soil is the major work in front of construction industry. Research shows lot of interest and many methods were found out for the stabilization of soil. Soil Stabilization by using cement and lime was the most ancient method which was commonly adopted all over the world. But it is found out that this will prove costly and time consuming. In this study the effect of inclusion of various types of fibres on unconfined compressive strength of clayey soil was studied. The fibres used were natural fibre, plastic fibre, polypropylene with different fibre contents and length. The fibre percentages were varied from 0% to 2%. The fibre length and fibre content are found to play important roles in the strength of fibre reinforced soil. Furthermore, it was observed that the unconfined compressive strength of soil sample taken for study increased by inclusion of fibres. Conclusions were obtained from this investigation that the inclusion of randomly distributed fibres significantly improved the unconfined compressive strength of clayey soil. Increase in fibre content decreases MDD and increases OMC. Optimum percentage of fibres was identified from the carried out study. Use of optimum quantity of fibre will reduce the cost of project. Results shows that soil stabilization by fibres will effects on the life cycle of the project ultimately project deration reduces.**

Keywords*— Soils; Unconfined Compressive Strength; Optimum fibre quantity; Cost optimization.

I. INTRODUCTION

Soils and their related behaviour has always been the subject of many studies. Recent researches show some interests in investigation of inclusion of randomly distributed fibre in soil. This study focuses on effect of fibre inclusion on the strength and other parameters of clayey sand composite material. This study is related to effective parameters on strength of the clayey sand composite with using natural fibre, plastic fibre, polypropylene, polyester with different fibre contents and length. UCS test were carried out to investigate behaviour of the composite under different condition. The fibre percentage varied from 0% (for unreinforced samples) to 2%.

The aim of the present work is to study the effect of fibres in stabilization of soil and to optimize the required percentage of fibre at which soil sub-grade can give maximum unconfined compressive strength at least cost.

Objectives of the study:

- To study the influence of types of fibre on unconfined compressive strength.
- To find the optimum percentage of fibre at which maximum unconfined compressive strength can be obtained.
- To check the suitable type of fibre for stabilization of clayey soil.
- To minimise the cost of soil stabilisation by using optimum quantity of fibre.

II. LITERATURE REVIEW

1. T. Subramani, D. Udayakumar, (May 2016), Experimental Study on Stabilization of Clay Soil Using Coir Fibre

The authors found that 0.5% coir fibre proportion in a soil is optimum percentage for maximum soaked California Bearing Ratio (CBR) value. They concluded that this proportion may be economically used in stabilization of clay soil.

2. Parag M. Chaple, A I. Dhatrak, (May 2013), Performance of Coir fibre Reinforced Clayey Soil

In this study coir were used in varying percentage as 0.25%, 0.5%, 0.75% & 1.0% and effect of coir on bearing capacity were determined. Provision of coir reinforced layer increases bearing capacity ratio up to 1.5 to 2.66.

III. MATERIAL USED

A. Soil

Local soil was collected from nearby place of Dr. BATU campus, Lonere. After conducting the tests on collected soil sample the soil was classified as clayey soil of low plasticity which was coarse and inorganic in nature (ML). The index properties of soil were determined as per Indian Standard test procedure (IS: 2720 Part 5 1970 and IS: 2720 Part 3 Sect 2 1981). The following table represents the physical properties of soil:

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Table 1. Engineering and Geotechnical properties of soil

S.N.	Test Properties	Result
1.	Specific gravity	2.411
2.	Natural Water Content (%)	27.50
3.	Sieve Analysis % of Gravel % of Sand % of Fines	 10.577 84.153 5.27
4.	Cc Coefficient of Curvature	1.28
5.	Cu (Uniformity Coefficient)	10.52
6.	Optimum moisture content (%)	13
7.	Maximum dry density (g/cc)	1.89
8.	Unconfined Compressive Strength (kg/cm^2)	1.7071

B. Coir

Image 1: Coir coated with black oil paint

Coir industry is one of the oldest industries in India, and coir has been traditionally used for packaging. However, its versatility is coming to light after the world had started looking for natural options to save the environment. Coir fibre is a coarser in nature. Coir fibre used for the study was purchased from local market. The diameter of the individual fibre varied between 2 mm to 10 mm. These fibers are generally available in the threaded form. Table 2 represents the basic properties of coir used in this study.

Table 2: Basic Properties of Coir

Color	Yellowish brown
Specific Gravity	1.12
Diameter Used	2-8
Ash (%)	0.5-1.04
Wax (%)	0.4-0.81
Nitrogen (%)	0.4
Density	1825 kg/m^3

C. Human Hairs

Image 2: Human Hairs

Disposal of hairs is the major task in front of environmentalist as it has a non-biodegradable nature and solution over this is to use it for soil stabilization. The properties of these fibers are given in table:

Table 3: Properties of human hairs

S.N.	Property	Remark
1.	Cross-Section	Circular
2.	Diameter	10-100 µm
3.	Length	5-50 mm
4.	Elongation	1.5 times its dry weight
5.	Tensile strength	Equal to Copper wire

IV. TESTING METHODOLOGY

Index properties were first determined of soil sample to know the soil classification. Then to determine the proctor maximum dry density and optimum moisture content Modified proctor compaction test were carried out. Later on UCS test were carried out as per the procedures and guidelines laid down in Indian Standards Codes of practice. Four different types of fibres were used and each fibre type with different percentage (0.5%, 1%, and 2% of the total dry weight of the soil) was mixed with soil for each specimen.

V. RESULTS AND DISCUSSION

This work consists of 3 types of fibres and one type of soil. From each fibre 9 samples were prepared by varying proportion and later on they were tested for unconfined compressive strength.

Image 3: Original Sample Specimen

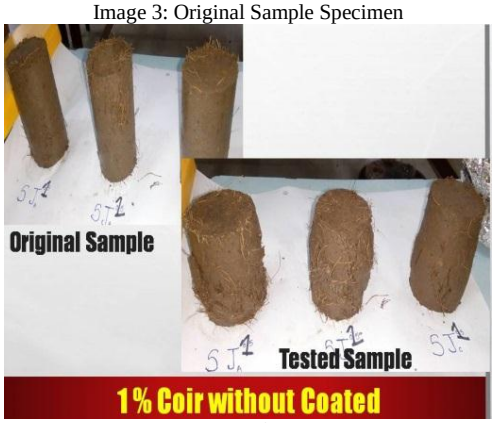

Image 4: Sample by mixing of 1% Coir (without coated)

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The values of each sample were tabulated below:

Table 4: Test results

S.N.	Sample Notation	Type of Sample	UCS values (kg/cm^2)
1	B	Natural Soil	1.7071
2	$^{0.5}H_1$	0.5% Hair mixed	2.4011
3	$^{1}H_3$	1% Hair mixed	3.8711
4	$^{2}H_3$	2% Hair mixed	3.5889
5	$^{0.5}NC_3$	0.5% Natural Coir	1.3548
6	$^{1}NC_2$	1% Natural Coir	1.8257
7	$^{2}NC_2$	2% Natural Coir	4.8909
8	$^{0.5}CC_3$	0.5% Coated Coir	1.3001
9	$^{1}CC_2$	1% Coated Coir	2.2121
10	$^{2}CC_1$	2% Coated Coir	2.747
11	$^{0.5}P_3$	0.5% Plastic fibre	2.3203
12	$^{1}P_1$	1% Plastic fibre	0.9303
13	^{2}P	2% Plastic fibre	0.7899

VI. COST BENEFIT ANALYSIS

As per IS 2720 Part X the required UCS value for black cotton soil was 2.69 Kg/cm2. Therefore the optimum percentage of fibre was so selected that which has UCS value nearer to the value specified by IS 2720 Part X. Initially the normal soil sample (without addition of any type of fibre) has 1.7071 kg/m2 UCS value which is less than the specified value of IS 2720 Part X. Hence there is necessity to add some percentage of fibre to increase UCS value. It was found that 1% addition of hairs will increase the UCS value up to 3.8711 kg/m2 and 2% addition of natural coir will increase the UCS value up to 3.6 kg/m2. Again,2% addition of Oil paint coated coir will increase the UCS value up to 2.747 kg/m2, 0.5% addition of Plastic fibre will increase the UCS value up to 2.3203 kg/m2 which is less than the required UCS value specified by IS 2720 Part X.

VII. CONCLUSION

1. Addition of 0.5% of uncoated and coated coir resulted in decrease in Unconfined Compressive Strength (UCS) compared to normal soil. This is due to insufficient bond of coir with soil and less quantity of coir available for sufficient anchorage.
2. Addition of 2% coir has shown maximum UCS.
3. The UCS increased at 1% of coated coir fibre compared to addition of same quantity of uncoated fibre.
4. Due to smooth surface of plastic fibres the bond between fibres and soil was poor which resulted in early failure of samples.

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