Improving Stability of Soil Using Natural Fiber's (Coconut Coir)

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Abstract: Soil having poor bearing and shearing strength need stabilization to make it suitable for construction purpose. In this study coir (extracted from coconut) is used as natural fiber for stabilization of soil. Stabilization using natural fiber is a cost-effective and ecofriendly approach to improve properties of soil. Chemical-based or synthetic fibers harm our environment so; the use of natural fiber is an initiative to maintain balance in nature. This study reveals around the reinforcement of soil by coir fiber and the comparison between engineering properties before and after stabilization. The study is carried out to evaluate the effects of coir fiber on shear strength of soil by carrying out direct shear test and unconfined compression test on two different soils samples. Disturbed samples are collected from two different construction sites at Najafgarh and Noida respectively. In laboratory, testing of liquid limit, specific gravity along with grain size distribution is carried out for the classification of soil. For different percentage of coir fiber, the Proctor Compaction test was carried out. Further at optimum moisture content (OMC), direct shear test and unconfined compression test are carried out for different fractions of coir fiber. The experimental results with and without coir fiber reinforcement are compared to obtain optimum quantity of fiber reinforcement (% of soil sample) required to stabilize a weak soil along with the inference about effect on bearing capacity and shear strength.

Keywords — Black Cotton Soil, California Bearing Ratio (CBR), Coconut Coir fibre, Unconfined Compressive Strength (UCS,) Atterberg's limit, proctor compaction test.

I. INTRODUCTION

Black cotton soils found in many parts of India. Their color varies from dark grey to black. It is easy to recognize these soils in the field during either dry or wet seasons. Soil stabilization has become a major issue in construction engineering and the researches regarding the effectiveness of using natural wastes are rapidly increasing.

Use of waste material and natural fibre for improving soil property is advantageous because they are cheap, locally available and eco-friendly. In this study, the stabilizing effect of Natural fibre (coconut coir) on soil properties has been studied. Soil samples for unconfined compression strength (UCS) and California bearing ratio (CBR) tests are prepared at its maximum dry density corresponding to its optimum moisture content in the CBR mould without and with Coir fibre. Keeping the percentage of coir fibre by dry weight of soil is taken as 0.25%, 0.50%, 0.75%, 1% to each Coir fibre content by varying percentages of admixtures are added and CBR test is conducted in the laboratory. CBR value increases from 3.91 to 8.6% of soil mixed with varying percentages of coir fibre. Adding of coconut coir fibre results in less thickness of pavement due to increase in CBR of mix and reduce the cost of construction and hence economy of the construction of highway will be achieved This is because of composite effect of natural fibre changes the brittle behaviour of the soil to ductile behaviour.

II. MATERIALS USED

BLACK COTTON SOIL: - Black cotton soils are highly clayey soils, greyish to blackish in color found in several states in India. The black cotton soil taken for the present study is obtained from Herur lake, Gubbi.

COIR OR COCONUT FIBRE: - Coir fibre is an environmentally friendly belongs to the group of hard structural fibrous. The coir fibre is elastic enough to twist without breaking and it holds a curl as through permanently waved.

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III. METHODOLOGY

THE EXPERIMENTAL WORK CONSISTS OF THE FOLLOWING STEPS,

1. MOISTURE CONTENT
2. SPECIFIC GRAVITY OF THE SOIL
3. DETERMINATION OF SOIL INDEX PROPERTIES (ATTERBERG LIMITS),
4. CALIFORNIA BEARING TEST (CBR)
5. LIQUID LIMIT BY CASAGRANDE'S APPARATUS,
6. PLASTIC LIMIT,
7. PARTICLE SIZE DISTRIBUTION BY SIEVE ANALYSIS
8. OMC TEST (OPTIMUM MOISTURE CONTENT)

IV. RESULTS *AND CONCLUSIONS:*

EXPERIMENTAL RESULTS OF BLACK COTTON SOIL

SL NO	PROPERTIES	RESULTS
1	Specific gravity	2.65
2	Liquid limits	28.90%
3	Plastic limit	22.58%
4	Plasticity index	6.5%
5	CBR value	3.91%
6	Optimum moisture content	10.60%
7	Maximum dry density	1.93g/cc
8	Unconfined compression strength	0.159kpa

Table 1: Properties of black cotton soil

PROCTOR COMPACTION TEST RESULT

SOIL SAMPLE	MASS OF SOIL	FIBRE CONTENT (%) OF SOIL MASS	OPTIMUM MOISTURE CONTENT (%)	MAXIMUM DRY DENSITY (g/cc)
Soil Sample	Without Fibre	0.0	10.6	1.93
	With Fiber	0.25	11.0	1.90
		0.5	11.4	1.89
		0.75	11.6	1.87
		1	12.6	1.83

Table 2: Proctor Compaction results (g/cc)

The maximum dry density for the BC soil is 1.93 g/cc, as the coconut coir fiber percentage increases and the maximum dry density decreases up to 1.83 g/cm3. The reason for decreases in MDD is the less specific gravity of fiber as compare to soil particles. These fibers also do not let the soil particles to come near each other and hence density decreases.

CBR TEST RESULT

SL NO.	PROPERTIES	COCONUT COIR FIBRE				
		0%	0.25%	0.50%	0.75%	1%
1	CBR (%)	3.91	5.0	6.2	7.1	8.6

Table 3: CBR Test results

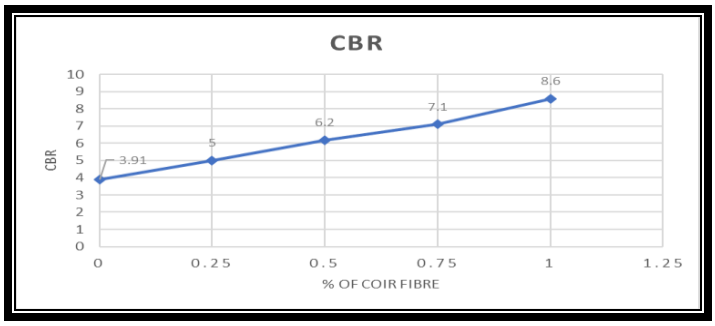

Fig 1: CBR V/S Percentage of coif fiber

The value of CBR is found to be 3.91% and effectively increases with increase in percentage of coconut coir fiber. The increase in strength is observed up to 120 % compared to the initial soil.

UNCONFINED COMPRESSIVE STRENGTH TEST RESULT

COIR FIBRE	UNCONFINED COMPRESSIVE STRENGTH kPa		
	3 days	7days	28 days
0%	0.159	0.35	0.425
0.25%	0.329	0.403	0.45
0.50%	0.361	0.444	0.490
0.75%	0.458	0.460	0.765
1%	0.298	0.420	0.426

Table 4: Unconfined Compressive Strength Results

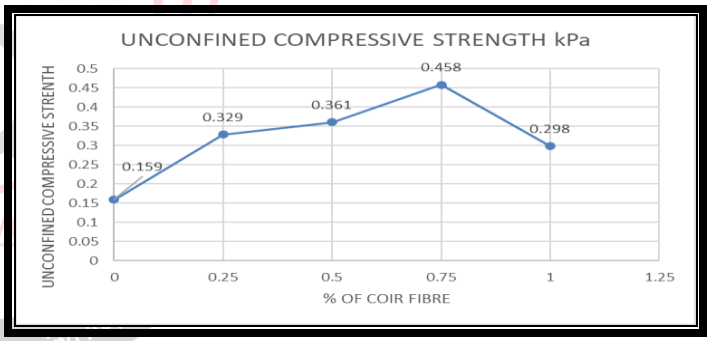

Fig 2: UCS (3Days) kg/cm2 V/S % of Coir fiber

The UCS value of BC soil for 3 days curing period is found to be 0.159kg/cm2. When the coir fiber is added increase in strength is more. An increase in compressive strength from with increase in percentage of coir fiber and compressive strength is maximum at 0.75% of coir fiber.

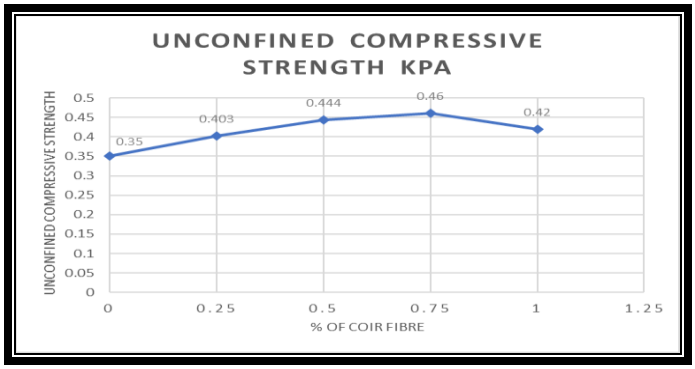

Fig 3: UCS (7Days) kg/cm2 V/S % of Coir fiber

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The UCS value of BC soil for 7 days curing period is found to be 0.350 kg/cm2. When the coir fiber is added increase in strength is more. An increase in compressive strength from with increase in percentage of coir fiber and compressive strength is maximum at 0.75% of coir fiber.

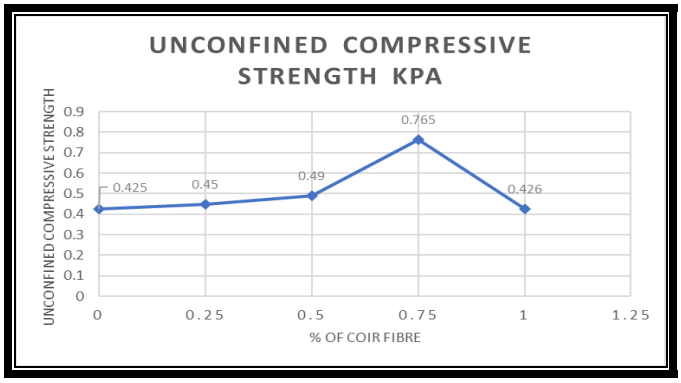

Fig 4: UCS (28ays) kg/cm2 V/S % of Coir fiber

The UCS value of BC soil for 28 days curing is found to be 0.425 kg/cm2 . When the coir fiber is added increase in strength is more. An increase in compressive strength from with increase in percentage of coir fiber and compressive strength is maximum at 0.75% of coir fiber.

CONCLUSION

1. An increase in OMC from 10.6% to 12.6%, decrease in MDD 1.93g/cc to 1.83g/cc was observed.
2. The reason for decreases in MDD is the less specific gravity of fiber as compare to soil particles. These fibers also do not let the soil particles to come near each other and hence density decreases.
3. The reason for increases in OMC is the water absorbing capacity of fibers which is greater as compared to soil particles.
4. CBR values of soil-coir Fiber mix increases with increasing percentage of Fiber.
5. The strength of soil-coir mix increases with increasing the percentage of coir Fiber.
6. An increase in compressive strength from with increase in percentage of coir fiber and compressive strength is maximum at 0.75% of coir fiber.

SCOPE FOR FUTURE STUDY:

1. Following studies can be carried out to improve the characteristics of Black cotton soil.
2. The combinations of coconut coir fibre can be added to the Black Cotton Soil and its performance can be evaluated.
3. The effect of coconut coir fibre on the strength characteristics of expansive soils can also be investigated.

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