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Experimental Investigation on Expansive Soil Stabilized Using Coir Fibre

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Abstract: **Expansive soils are highly problematic because of the susceptibility of these soils to undergo large changes in volume due to variation in the moisture content. Generally black cotton soil falls under this case, which has poor bearing capacity and shearing strength. Special attention is required on stabilization process to make it more suitable for all construction purposes. This experimental study deals on the stabilization of black cotton soil using coir fibre as this natural fiber is a cost effective and eco-friendly material which is used to improve properties of black cotton soil. The basic properties of virgin soil like specific gravity, grain size distribution, Atterberg's limits, compaction characteristics and unconfined compressive strength tests were conducted. Further the black cotton soil is mixed with varying percentage of coir fibre by dry weight of soil such as 0.25 %, 0.5 %, 0.75 % and 0.1 %. The change in properties such as liquid limit, plastic limit and shrinkage limit of stabilized black cotton soil is studied. Comparisons are drawn for change in maximum dry density, optimum dry density and unconfined compression test values for both stabilized soil and untreated soil.**

Keywords: **Black Cotton Soil, Coir Fibre, Atterberg's limits and Unconfined Compressive Strength.**

I. INTRODUCTION

Black Cotton soils are highly clayey soils, greyish to blackish in colour. Black cotton soils have been formed from blast or trap. Black cotton soils contain the clay mineral 'Montmorillonite', which is responsible for the excessive swelling and shrinkage characteristics of soil. Black cotton soil undergoes change in volume when it comes in contact with water; it expands during rainy season due to intake of water and shrinks during summer season. Coir or coconut Fibre belongs to the group of hard structural fibres. It is an important commercial product obtained from the husk of coconut. The coir Fibre is elastic enough to twist without breaking and it holds a curl as though permanently waved. Shorter mattress fibres are separated from the long bristle fibres which are in turn a waste in the coir Fibre industry. The stabilization is done using locally available coir fibre. [1]Used coir fibre reinforcement to improve the strength properties of black cotton soil subgrade stabilized with cement kiln dust (CKD) was investigated. Black cotton soil was mixed with optimum of CKD along with different proportions of discrete coir fibres (0 %, 0.25 %, 0.5 %, 0.75 % and 1.0 % by dry weight of soil cut to 25mm size). Compaction properties and unconfined compressive strength (UCS) values were determined for soil mixtures compacted using British Standard Light (BSL) effort. Test results indicated that the inclusion of fibre in stabilized specimen resulted in reduced maximum dry unit weight, higher optimum moistures as well as UCS and therefore enhanced load carrying capacity of the subgrade. [3]The percentage of Coconut coir fibre by dry weight of soil is taken as 0.25 %, 0.50 %, 0.75 % and 1% and corresponding to each Coconut coir fibre content un-soaked and soaked CBR tests are conducted in the laboratory. Tests result indicates that both unsoaked and soaked CBR value of soil increases with the increase in Coconut coir fibre content. Soaked CBR value increases from 3.9 % to 8.6 % and un-soaked CBR value increases from 8.1 % to 13.2 % of soil mixed with 1% Coconut coir fibre. [16] In this paper author made an attempt to study the effectiveness of coconut fibre (coir) to control swelling properties of black cotton soil along with an impact on its strength characteristics and dry density. The test results show that in presence of 2% coir fibre, the shrinkage limit is increases from 7.52 % to 12.62 %. Increase in compressive strength was observed from1.09 kg/cm^2 to1.32 kg/cm^2. [17] BC Soil was tested using three different stabilizing agents, firstly, Cement waste dust collected from the cement plant, secondly, Cement Dust + Lime Powder, lastly, Lime Powder. The cement waste dust was found best agent as a

stabilizer to improve the Atterbergs' Limit and hence Plasticity Index of BC Soil as well as the compressive strength of the same. Laboratory tests were performed with different percentages of three stages, each of them ranging from 1 % to 9 %. Cylindrical Samples of BC Soil with all three combinations were prepared to check the compressive strength of stabilized soil. Moisture content taken was the optimum percentage of plastic limit in each combination. The cylinders of size 50 mm in diameter and 60 mm height were tested after 3, 5, 7, 14, 21, 28 days. The relations for these periods were established among the use of all three different agents. Compressive strength of Cement dust stabilized BC Soil found to be more reliable.

A. Objectives

The following are the objectives of the present work.

1. To find the properties of black cotton soil for treated (Stabilized) condition and untreated condition.
2. To find the shear strength parameters of black cotton soil using UCS test for treated and untreated soil.

II. METHODOLOGY

1. To conduct basic experiments to Identify soil properties (Untreated condition).
2. To find shear strength of soil using UCS test (Untreated condition).
3. Addition of Coir fibre (0.25 %, 0.5 %, 0.75 % & 1.0 %) soil in varying percentage by weight of soil (Stabilized condition).
4. To find shear strength of stabilized soil using UCS test (Stabilized condition).
5. To find change in properties of stabilized soil by conducting basic experiments (Stabilized condition).
6. Comparing the test results of Stabilized soil with untreated black cotton soil.

A. Scope of the Work

The experimental work consists of the following steps:

1. Specific gravity of soil and Nature Moisture content of the soil.
2. Determination of soil index properties (Atterberg's Limits)

i. Liquid limit by Cone Penetration method

ii. Plastic limit

iii. Shrinkage limit

iv. Particle size distribution by sieve analysis.

3. Determination of the Maximum Dry Density (MDD) and the corresponding Optimum Moisture Content (OMC) of the soil by Proctor compaction test.
4. Preparation of reinforced soil samples.
5. Determination of the shear strength by unconfined compression test (UCS).

B. Materials

1. Black Cotton Soil (B.C.)

This soil was collected from Beekanahalli village, Chikkmagaluru District (Karnataka) at a depth of 1m below from the ground level .The test results are given in the table-1.

Table 1: Physical Properties of Black cotton soil sample

Sl.No.	Parameters	Properties B.C. Soil
1	Natural moisture content (%)	13
2	Specific gravity	2.58
3	Sieve analysis • Percentage Gravel	 14.2

	• Percentage Sand • Percentage Silt and clay	83.9 1.9
4	Liquid limit (%)	48.5
5	Plastic limit (%)	38.22
6	Shrinkage limit (%)	12.39
7	Soil Classification	CH
8	Maximum dry density (g/cc)	1.6
9	Optimum moisture content (%)	27.74
10	UCS (N/mm^2)	0.318

2. Coir Fibre

The coir fibre was collected from Arsikere town, Hassan District (Karnataka); the table-2 specifies some of the physical properties of the coir fibre supplied by industry.

Table 2: Physical Properties of Coir Fibre

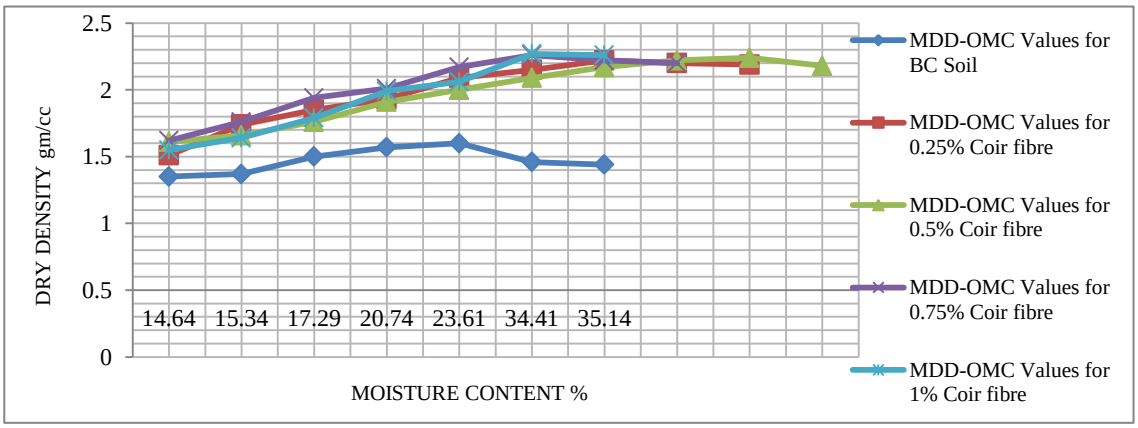
Sl.No.	Parameters	Material Properties
1	Length (inches)	6 to 8
2	Density (g/cc)	1.4
3	Tenacity (g/Tex)	10
4	Breaking elongation (%)	30
5	Diameter (mm)	0.1 to 1.5
6	Rigidity of Modulus (dyne/cm^2)	1.8924
7	Moisture at 65% RH (%)	5
8	Swelling in water, diameter wise (%)	10.50

III. RESULTS AND DISCUSSION

The graph-1 shows the variation of MDD and OMC values against various dosage of coir fibre added to black cotton soil. Numerical values of the same are also quoted in the table-3. Addition of coir fibre results in increase in the dry density of the soil. Soil with higher dry density tend to sustain better during the application of loading compared with the ones of low dry density soil.

Table 3: MDD-OMC values for B.C. Soil and varying percentages of Coir fibre

Sl.No.	Materials	Dry Density (g/cc)	OMC (%)
1	BC Soil	1.60	27.74
2	BC Soil + 0.25 % Coir fibre	2.21	27.14
3	BC Soil + 0.5 % Coir fibre	2.24	32.04
4	BC Soil + 0.75 % Coir fibre	2.26	31.65
5	BC Soil + 1 % Coir fibre	2.27	34.41

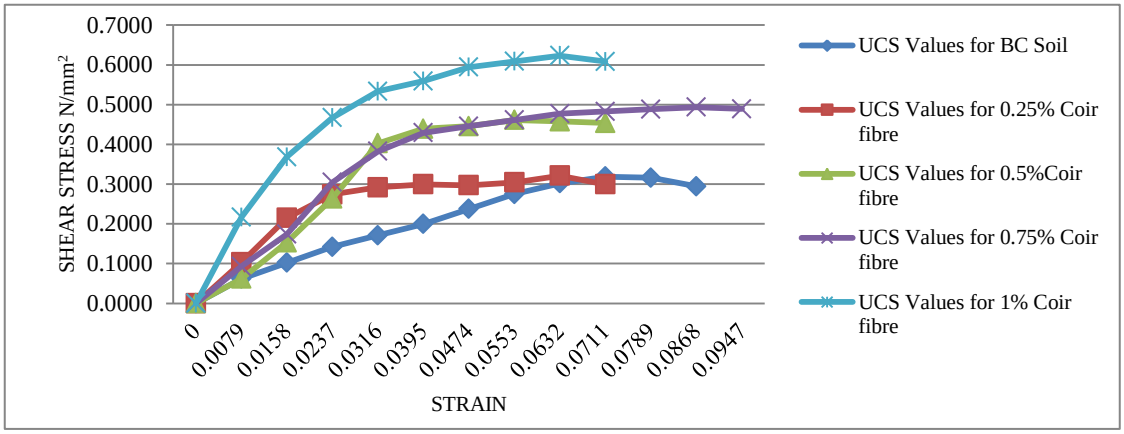


Graph 1: Comparison of MDD-OMC for B.C. Soil with varying percentages of coir fibre

The graph-2 shows the variation of shear stress to strain values against various dosage of coir fibre added to black cotton soil. Numerical values of the same are also quoted in the table-4. Addition of coir fibre results in increase in shear stress values there by reducing the strain parameter of the soil.

Table 4: UCS Values for B.C. Soil and for varying percentage of Coir fibre

Sl.No.	Materials	Shear Stress (N/mm^2)
1	BC Soil	0.3186
2	BC Soil + 0.25 % Coir fibre	0.3213
3	BC Soil + 0.5 % Coir fibre	0.4771
4	BC Soil + 0.75 % Coir fibre	0.4935
5	BC Soil + 1 % Coir fibre	0.6232

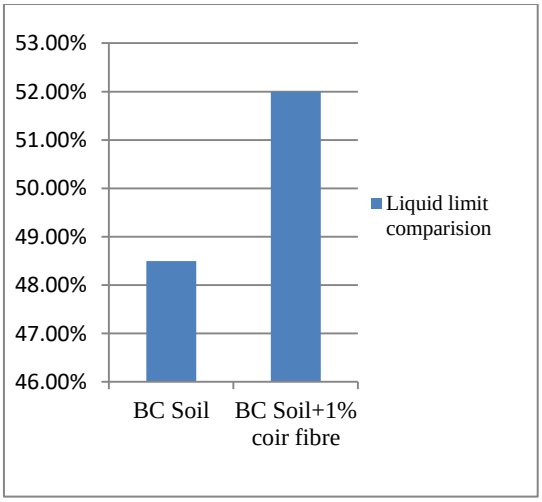


Graph 2: Comparison of UCS for B.C. Soil with varying percentages of coir fibre

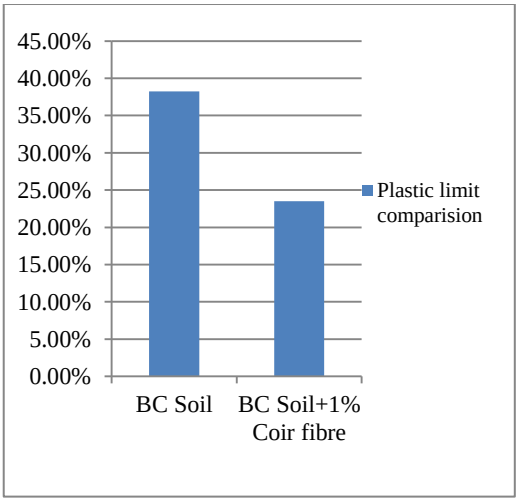
The graph-3 shows the comparison of liquid limit and plastic limit of virgin soil and with 1 % addition of coir fibre to black cotton soil. The results in table-5 helped in judging the plasticity index of the soil. The graph-4 shows the comparison of shrinkage limit and volumetric shrinkage of source soil and with 1 % addition of coir fibre to black cotton soil.

Table 5: Liquid limit, Plastic limit, Shrinkage limit and Volumetric Shrinkage values for BC Soil and 1% Coir fibre

Sl.No.	Materials	Liquid limit (%)	Plastic limit (%)	Shrinkage limit (%)	Volumetric Shrinkage (%)
1	BC Soil	48.5	38.23	12.39	56.05
2	BC Soil + 0.25% Coir fibre	52	23.49	18.74	36.98

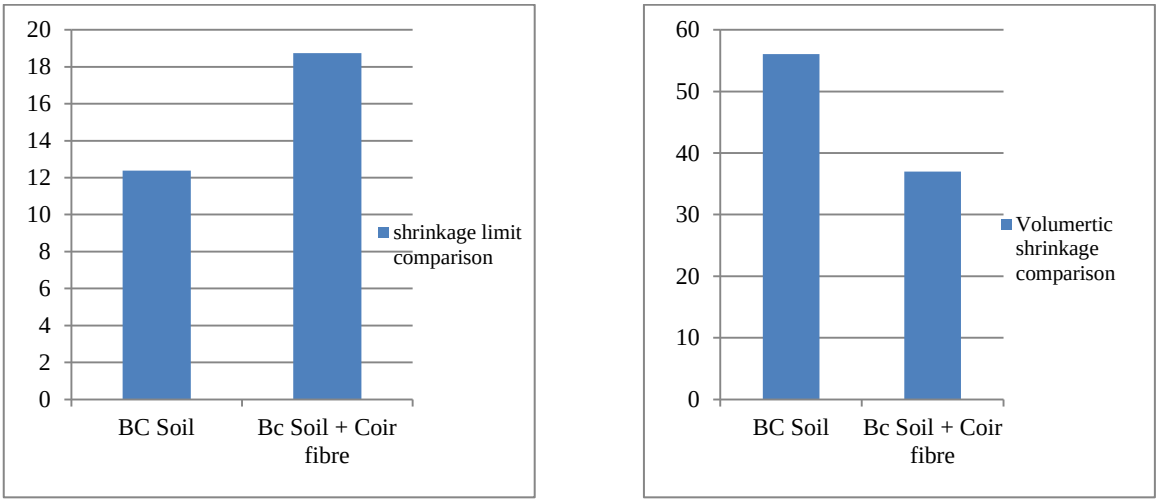


(a)



(b)

Graph 3(a) & (b): Liquid limit and Plastic limit comparison (B.C. soil and 1% coir fibre)



(a) **(b)**

Graph 4(a) & (b): Shrinkage limit and Volumetric Shrinkage comparison (B.C. soil and 1% coir fibre)

IV. CONCLUSION

1. The Maximum Dry Density (MDD) value of the black cotton soil is 1.6 g/cc at Optimum Moisture Content (OMC) of 27.74 %. The addition of coil fibre at various percentages to dry weight of black cotton soil leads to increase in MDD and OMC values.

2. It is observed from the test results that, the Unconfined Compression test (UCS) value of black cotton soil is 0.3186 N/mm^2 yielding the strain value of 0.0868. Addition of 0.75 % of coir fibre to black cotton soil leads to increase in the UCS value to 0.4935 N/mm^2, which is greater than the previous case. Further the UCS value at 1 % addition of coir fibre to soil gives better load carrying capacity with numerical value of 0.6232 N/mm^2 and also at this percentage the strain induced in the soil is 0.0711, which is lower compared to the virgin soil.

3. It is observed that, among all the percentage addition of coir fibre to black cotton soil from 0.25 % to 1 % at the interval of 0.25 %, coir fibre at 1 % of addition gives higher shearing strength capacity by UCS test results. Hence for these proportions the MDD, OMC, Liquid Limit, Plastic Limit and Shrinkage Limit tests were conducted to study the Index Properties of black cotton soil.

4. The liquid limit for black cotton soil is 48.5 % and for black cotton soil with 1 % addition of coir fibre is 52 %. There is considerable increase in the water content due to addition of coir fibre. The impression of increase in the water content is also reflected in MDD and OMC test, where OMC value of 34.14 % corresponds to the same percentage addition of coir fibre.

5. The plastic limit for black cotton soil is 38.23 % with plasticity Index of 10.27 which is considered to be low plasticity and for black cotton soil with 1 % addition of coir fibre is 23.49 % with plasticity Index of 28.51 which is considered to be medium plasticity. The source soil tend to have higher value of plastic limit may be because of soil particles size. The grain size distribution test results indicates that the black cotton soil contains 83.9 % of soil particles lies in between sieve sets of 4.75 mm to 75 micron.

6. It is seen that shrinkage limit of black cotton soil is 12.39 %, whereas for soil added with 1 % coir fibre has the value of 18.74 %. Addition of coir fibre to soil has increased the resistance of black cotton soil against shrinkage. It is also evident from the comparison table of volumetric shrinkage that there is reduction in values from 56.05 % to 36.98 % after additive added to the soil.

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