

Stabilisation of Black Cotton Soil by Random Inclusion of Sisal Fibre

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ABSTRACT: Soil stabilization is the process for altering the engineering properties of a soil. The main motto of stabilization is to increase the strength of soil and also to make the project economical by making the best use of the locally available materials. India is covered with large amount of expansive soil which is also known as Black Cotton soil, which covers about 20% of total land area. These soils have less compressive strength, high swelling, high shrinkage characteristics and low in CBR value. Hence, in the present study sisal fiber which is a naturally occurring fiber is made use of in stabilizing the black cotton soil. The strength behavior such as compaction characteristics, swelling behaviour and unconfined compressive strength of sisal fibre reinforced black cotton soil has been studied.

KEYWORDS: Black cotton soil, Sisal fiber, Stabilization, Swell index, Unconfined compressive strength.

I. INTRODUCTION

The term soil is defined as an unconsolidated material, which consists of solid particles produced by disintegration of rocks. The voids space which is present between the soil particles may contain air, water or both. The term expansive soil is generally referred to that soil that has a potential for large swelling or shrinking under changing moisture conditions. The minerals which are responsible for expansiveness in soil are montmorillonite and bentonite. The structures built over expansive soil face various problems due to the expansive nature of the soil. To overcome this problem, soil reinforcement with high tensile materials is going on from past two decades. Materials like metal strips, plastic grids and fabrics have all been used to increase the shear resistance, tensile strength, and stiffness of soils. In the sub grade soil of multilayer pavements under heavy traffic loads tensile stresses are induced.

The behaviour of soil due to the introduction of coir fibre and banana fiber has already been studied on a type of red soil collected from Thiruvallam in Trivandrum District. The practice of building houses on soil reinforced with natural fibers and constructing earth walls with different types of reinforcing inclusions are age old arts to the villagers in tropical Africa and Southern Asia. Rope fibers and bamboo strips were used to strengthen rural road bases. In order to increase the resistance to crack propagation vertically arranged rectangle grids of bamboo strips and stalks of palm branches could be used as a central core for mud walls.

Soil stabilization is the process of altering some soil properties by different methods in order to produce an improved soil material which has all the desired engineering properties. Stabilization of soil is done to increase their strength and durability or to prevent erosion of soils. The main aim of stabilization is the creation of a soil material or system that will hold under the design use conditions and for the designed life of the engineering project. The properties of soil vary greatly at different places. Various methods like mechanical or chemical are employed to stabilize the soil and the method should be verified in the lab with the soil material before applying it on the field.

II. LITERATURE REVIEW

Santhi Krishna K. and Sayidam K.C (2009) aimed at determining the behavior of black cotton soil reinforced with sisal fiber in a random manner. The fibers were cut to different lengths (1.5cm, 2.0cm, 2.5cm and 3.0cm) and mixed randomly with soil in varying percentages (0.25%, 0.50%, 0.75% and 1.00%) by dry weight of soil and compacted to maximum

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dry density at optimum moisture content. The results obtained from the test indicate a reduction in the maximum dry density and the optimum moisture content of soil due to the addition of sisal fiber. It also indicated an improvement in the California bearing ratio value and Unconfined compressive strength of soil due to the addition of sisal fiber.

Manjunath K. R and Venugopal G (2013) aimed to determine the effect of random inclusion of sisal fibre on strength behavior of black cotton soil. The fibers were cut to pieces of 10mm length and are randomly mixed with soil in varying percentages (0.25%, 0.5%, 0.75% and 1%) by dry weight of soil. Lime also added in varying percentages (1% to 5%). They observed increase in the value of the unconfined compressive strength of BC soil when reinforced with sisal and lime.

III. OBJECTIVES

- i. Determination of the natural properties of the black cotton soil.
- ii. Evaluation of the index properties of the black cotton soil, when stabilized with sisal fibre by varying the percentage of sisal fibre from 0.2% to 0.8% by dry weight of the soil at the interval of 0.2% and also varying the lengths from 2.2 cm to 2.8 cm at the interval of 0.2cm.
- iii. To study the strength behaviour in BC soil using for sisal fiber by varying the percentage of sisal fiber from 0.2% to 0.8% by dry weight of the soil at the interval of 0.2% and also varying the lengths from 2.2 to 2.8 cm at the interval of 0.2cm.
- iv. To make the stabilization process economical by using the naturally available fibers

IV. MATERIALS

A BLACK COTTON SOIL



Fig-1 Black cotton soil

For the present research work, the black cotton soil was collected from Kadur taluk of Chikmagalur District, Karnataka state, India, at a depth of 2m from the natural ground level. The soil obtained from the site was air dried and then pulverized manually. All the tests were conducted as per IS-2720 Standards.

The following tests were conducted on the black cotton soil which was obtained from field and the results obtained are as mentioned in Table-1

- 1) Specific gravity
- 2) Atterberg limits such as
 - a) Liquid limit
 - b) Plastic limit
 - c) Plasticity Index
- 3) Standard compaction test
- 4) Unconfined compression test and
- 5) Free swell index

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TABLE.1
GEOTECHNICAL PROPERTIES OF THE BLACK COTTON SOIL USED FOR THE PRESENT STUDY

Soil properties	Values
Field moisture Content (%)	20.77
Liquid Limit (%)	67
Plastic Limit (%)	44.22
Plasticity index (%)	22.78
Field density(gm/cc)	1.5
Specific gravity	2.64
Maximum dry density(gm/cc)	0.59
Optimum moisture content (%)	31.02
Unconfined compressive strength(kN/m ²)	209.19
Swell index	180

B SISAL FIBER



Fig 2 Sisal plant

Sisal is a natural fiber (scientific name is *Agave sisalana*) of Agavaceae (agave) family yields a stiff fiber traditionally used in making twine and rope. Sisal is fully biodegradable and highly renewable resource of energy. Treated sisal fiber is exceptionally durable and a low maintenance with minimum wear and tear. Required sisal fiber is extracted by a process known as decortications, where leaves are crushed and beaten by rotating wheel set with blunt knives, so that only fibers will remain.



Fig 3 Uncut Sisal fiber used for the present investigation

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Fig 3 shows the uncut fibre obtained from sisal plant. For the present study, sisal fibre was obtained from Dharmapuri, Tamilnadu.



Fig 4 Sisal fiber cut into length for experiment

The fibers were cut into pieces of lengths 2.2cm, 2.4cm, 2.6cm and 2.8cm and are randomly mixed with soil in varying percentages (0.2%, 0.4%, 0.6% and 0.8%) by dry weight of soil. The properties of sisal fiber are shown in Table 4.2 and Fig-4 shows the appearance of Sisal fiber.

TABLE-2
PROPERTIES OF SISAL FIBRES

Property Of Fiber	Value
Colour	White
Average Diameter(mm)	0.25
Average Tensile Strength(N/mm ²)	407.4
Density(g/cc)	1.47
Unit Weight(Kg/m ³)	964
Specific Gravity	0.964

V. RESULTS

Various tests were carried out with the reference of IS 2720 to determine the compaction characteristics, swelling behaviour and unconfined compressive strength behavior of sisal fibre reinforced soil. The test results are as follows.

A COMPACTION CHARACTERISTICS OF FIBRE REINFORCED SOIL

The variation of maximum dry density (MDD) and optimum moisture content (OMC) with respect to the variation in fiber content and fiber lengths are as shown in Table-2 and Fig-5. It can be observed that the maximum dry density has been obtained for 0.4% sisal fiber content of 2.4 cm length.

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TABLE-2
STANDARD PROCTOR TEST OF BLACK COTTON (BC) SOIL WITH VARYING LENGTH AND PERCENTAGES OF SISAL FIBER (SF)

Materials	Moisture content	Dry density (kN/m ³)
BC soil+0.2% SF+2.2 cm	31.274	1.466
BC soil+0.4% SF+2.2 cm	35.287	1.889
BC soil+0.6% SF+2.2 cm	19.786	2.187
BC soil+0.8% SF+2.2 cm	21.59	1.760
BC soil+0.2% SF+2.4 cm	22.485	1.488
BC soil+0.4% SF+2.4 cm	47.094	1.586
BC soil+0.6% SF+2.4 cm	23.701	1.789
BC soil+0.8% SF+2.4 cm	12.96	1.574
BC soil+0.2% SF+2.6 cm	40	1.833
BC soil+0.4% SF+2.6 cm	22.99	2.386
BC soil+0.6% SF+2.6 cm	18.183	2.389
BC soil+0.8% SF+2.6 cm	14.27	1.74
BC soil+0.2% SF+2.8 cm	18.06	1.41
BC soil+0.4% SF+2.8 cm	18.81	1.39
BC soil+0.6% SF+2.8 cm	30.15	1.719
BC soil+0.8% SF+2.8 cm	21.93	1.53

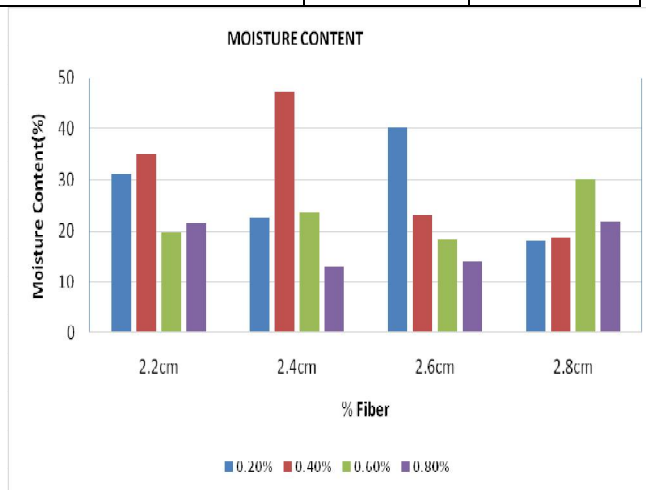


Fig 5 Variation of OMC of stabilized black cotton soil with respect to fibre content and length

Soil-fibre content and variations in length also showed a huge difference in the maximum dry density which is as shown in Fig-6

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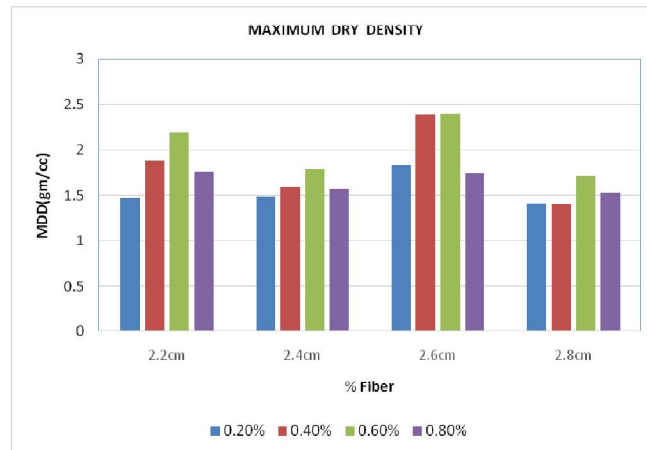


Fig 6 Variation of MDD with respect to soil- fibre content and length

B UNCONFINED COMPRESSIVE STRENGTH (UCS) TEST

Unconfined compressive strength (UCS) of the soil samples with different percentages of sisal fibre (0.2, 0.4, 0.6 and 0.8%) and lengths (2.2cm, 2.4cm, 2.6cm and 2.8cm) is shown in Table-3 and Fig-7.

TABLE-3
UNCONFINED COMPRESSIVE STRENGTH OF BLACK COTTON (BC) WITH VARYING LENGTH AND PERCENTAGES OF SISAL FIBER (SF)

%Fiber \ Length	0.2%	0.4%	0.6%	0.8%
2.2cm	140.54	220.98	228.89	179.89
2.4cm	77.86	88.54	111.41	97.77
2.6cm	120.04	155.58	256.00	129.87
2.8cm	104.39	185.62	205.10	104.46

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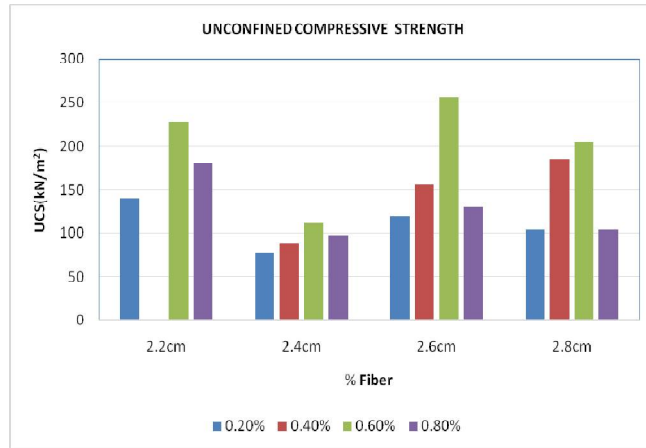


Fig 7 Variation of UCS for BCS with addition of sisal fibre

C SWELLING INDEX

The swelling behaviour of soil with different percentages of sisal fiber (0.2, 0.4, 0.6 and 0.8%) and lengths (2.2cm, 2.4cm, 2.6cm and 2.8cm) is shown in Table-4 and Fig-8.

TABLE-4
SWELLING TEST OF BLACK COTTON (BC) WITH VARYING LENGTH AND PERCENTAGES OF SISAL FIBER (SF)

% Fiber \ Length	0.2%	0.4%	0.6%	0.8%
2.2cm	65	50	55	40
2.4cm	40	40	50	40
2.6cm	30	30	10	25
2.8cm	30	30	25	40

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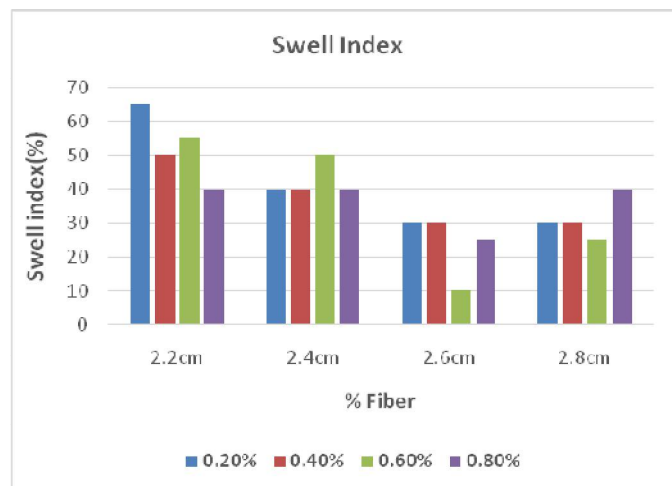


Fig 8 Swelling behaviour for BCS with addition of sisal fibre

VI. CONCLUSIONS

This paper evaluated the study on the behavior of black cotton soil reinforced with sisal fiber. A series of tests were performed to study the effects of sisal fiber on strength characteristics of black cotton soil. For a given fiber percentage and lengths contents in the compaction tests, the maximum dry density of stabilized soil increased and optimum moisture content decreased [1]. Addition of various percentages and lengths of sisal fiber to black cotton soil gives increased value in the unconfined compressive strength up to 22.38%, swelling of soil decreased by 38.89% [2].

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