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Evaluation of Black Cotton Soil Stabilized with Sisal Fibres: A Sustainable Approach to Soil Improvement

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Abstract - *In this work, the stabilizing properties of sisal fibre for expansive black cotton soil are assessed in a controlled laboratory setting. Numerous tests were carried out using Sisal Fibre additions of 0%, 0.25%, 0.5%, 0.75%, and 1%, including Heavy Compaction, California Bearing Ratio (CBR), Unconfined Compressive Strength (UCS), and Consolidation. The fibers were 10–15 mm long. The CBR tests in both drenched and un soaked circumstances were conducted after the modified Proctor test was used to determine the Optimum Moisture Content (OMC), with the greatest value recorded at 0.75% fibre. For extended curing times, 0.5% fibre had the highest strength in UCS tests, which were carried out at 0, 3, 7, 14, and 28 days. According to consolidation experiments, sisal fibre enhanced the soil's consolidation properties.*

Key Words: Black-Cotton Soil, Soil stabilization, Expansive Soil, Sisal Fibre, Engineering Properties, Compressibility, Bearing Capacity.

1.INTRODUCTION

A cohesive soil, black cotton soil is usually dark Grey or black in hue. It causes structural problems since it swells during the rainy season and contracts during the summer[1]&[2]. While shrinkage causes cracks in walls, slabs, and floors, swelling causes uplift pressure that affects plinth beams, foundations, and road surfaces. Even for constructions with light loads, its extreme compressibility and low bearing capacity make construction challenging[3]. Nonetheless, particularly in central and southern India, it is extremely fertile and produces crops like cotton, paddy, and sugarcane. Construction on Black Cotton Soil need mat foundations, deep foundations, or under-reamed piles for stability because of its limited bearing capacity[4].

2.LITERATURE SURVEY

S.Bharathi [1]:-This study examines how Black Cotton Soil can be enhanced by the addition of polypropylene fibre in varying concentrations (0%, 0.25%, 0.5%, 0.75%, and 1%). Significant soil properties were measured and compared to a control sample, including the California Bearing Ratio (CBR) and Unconfined Compressive Strength (UCS). The results indicated stronger soil since a higher fiber concentration raised UCS. The results show that stabilizing Black Cotton Soil with polypropylene fiber is a good way to enhance its engineering properties.

Kiran Kumar M.S [2]:- According to research, adding jute fibers to soil gradually improves its California Bearing Ratio (CBR) and unconfined compressive strength (UCS). Jute fibers have been added to soil in different amounts, improving properties including maximum dry density and ideal moisture content. According to experimental findings, adding jute fibers significantly increases the soil's strength, making it more appropriate for building. According to our research, the ideal percentage of jute fiber content to get the optimum strength and stability outcomes was 4%.

S. Andavan [3]:-Fibers are essential for stabilizing soil because they increase the soil's compressive and shear strengths. The purpose of this study was to assess the impact of fibers on stability and strength by adding them to the soil in varying amounts (0%, 5%, 10%, 15%, and 20%). The purpose of adding fibers to red soil was to increase its load-bearing capacity and structural integrity. The results show that fiber reinforcing greatly increases the strength of the soil, which makes it more appropriate for building.

R. Gopala Krishna [4]:-This study explores the improvement of expansive soil characteristics by adding different amounts of coir pith. The study focuses on adding coir pith to expansive soil to chemically stabilize it. The addition of coir pith improves the soil's strength and boosts its bearing capacity, making it more appropriate for foundation applications.

Rajashekhar Rathod [5]**:-** This project's goal is to improve the qualities of black cotton soil by figuring out the right amount of lime and how to combine it with bamboo fiber. It has been determined that stabilizing black

cotton soil with 6% lime is an effective way to make it suitable for road construction. In this study, different amounts of bamboo fiber (2%, 4%, 6%, and 8%) are combined with black cotton soil and 6% lime to evaluate the impact on soil parameters.

Gopu Ganesh Naidu [6]:-By adding stabilizing materials, this study seeks to improve the strength properties of weak soil, making it more appropriate for sustaining tall buildings. The study focuses on using soil stabilization techniques to improve key technical attributes like strength, compressibility, and bearing capacity. It specifically investigates how well glass fibers and lime work to fortify black cotton soil. In order to improve stability and load-bearing capability, the effects of varying ratios of lime and glass fibers on soil parameters are examined.

Prabakaran Ellappan [7]:-In order to improve the engineering qualities of black cotton soil, this study looks into stabilizing it using natural fibers. In different amounts—0.2%, 0.4%, and 0.6% by the dry weight of the soil—the study adds sisal, banana, and jute fibers. With the greatest California Bearing Ratio (CBR) of 21.55% obtained utilizing a mixture of 0.4% banana fiber, 0.6% sisal fiber, and 0.6% jute fiber, the results show a notable improvement in soil strength. With this combination, the Optimum Moisture Content (OMC) also rose to 20%. The results show that adding fibers that are dispersed at random improves the strength properties of black cotton soil.

3.MATERIALS AND METHODOLOGY

The characteristics of sisal fiber and black cotton soil, which are used in this study, are covered in the sections that follow.

3.1.Black Cotton Soil

The properties of soils can be classified into two categories:

Engineering Properties:

Permeability, compressibility, and shear strength—the three primary engineering characteristics of soils—are crucial for civil engineering projects, but they necessitate complex and drawn-out experiments involving undisturbed soil samples. Such samples are challenging to collect, which further increases the time needed. Indicative properties can be utilized for smaller projects to estimate soil behavior more quickly, but these tests are required for high-budget projects.

Index Properties:

Index properties are those aspects of soil that suggest engineering characteristics but are not of main importance to Geo technical engineers.

For testing, the Black Cotton Soil used in this investigation was air-dried after being collected from a depth of 1 to 1.5 meters. Preliminary testing revealed its characteristics, which are listed in Table 1.

Table -1: Characteristics of Black Cotton Soil

Properties	Values
Color	Black
Specific Gravity	2.65
Grain Size Analysis	0.043
Liquid limit(%)	41.70
Plastic Limit(%)	25.15
Compaction Test(%)	1.40
Differential Free Swell Index(%)	40
Permeability	0.00193
California Bearing Ratio	2.77

3.2.Sisal Fibre

The natural fiber known as sisal fiber is obtained from the sisal plant. A fiber producing facility in Cherakupalli village, Guntur district, Andhra Pradesh, India, called Sri Lakshmi Groups provided the sisal fiber used in this study. The firer's average length was between 10 and 15 mm, and its average diameter was 0.2 mm. In Fig. 1, the sisal fibre utilized in this investigation is depicted.

Fig. 1: Sisal Fibre

3.3.Methodology

Cotton in black During the two stages of the experiment, soil was allowed to air dry. Preliminary tests such as specific gravity, liquid limit, plastic limit, and differential free swell were part of phase 1. Sisal Fibre was added at 0%, 0.25%, 0.50%, 0.75%, and 1% in Phase 2, resulting in five samples, as indicated in Table 2. Sisal fiber's impact on the soil's engineering qualities was assessed using modified compaction, CBR, UCS, and consolidation tests. The types of samples and the notations used in the graphs are listed in Table -2.

Table-2: Types of Samples Prepared &Tested

S.No	Sample Prepared	Notation
1	Black Cotton Soil (BC)	S0
2	BC + 0.25% Sisal fibre	S0.25
3	BC + 0.50% Sisal fibre	S0.50
4	BC + 0.75% Sisal fibre	S0.75
5	BC + 1.00% Sisal fibre	S1.00

3.4.Laboratory Tests Conducted

The samples in Table 1 underwent several tests to evaluate the effect of sisal fiber on black cotton soil. The following sections provide a description of the testing techniques.

a. The following IS standards were used to test the index properties: DFS, Liquid Limit, Plastic Limit, and Specific Gravity: IS: 2720-Part 5 (1985) for limits, IS: 2720-Part 3 (1980) for specific gravity, and IS 2720-Part 11 (1977) for DFS.

b. The Modified Compaction technique (IS: 2720 – Part 8, 1983) was used to evaluate compaction properties, with an emphasis on the OMC and MDD connection for every sample.

c. In accordance with IS: 2720 – Part 16 (1979), CBR values were calculated using samples that were soaked for 96 hours.

d. Consolidation tests were performed at pressures between 0.1 and 1.6 kg/cm^2 in accordance with IS: 2720 – Part 15 (1986). The impact of Lime and Sisal Fiber on Black Cotton Soil was evaluated by calculating the Coefficient of Compressibility (av), Compression Index (cc), and Coefficient of Volume Change (mv).

4.RESULTS AND DISCUSSIONS

A. Index Properties

The soil has been classified as CH based on its Liquid Limit of 52%, Plastic Limit of 25.15%, and Plasticity Index of 26.85%. With a Differential Free Swell of 50% and a specific gravity of 2.67, it is classified as High Expansive Soil.

B. Compaction Characteristics

According to the Modified Compaction test, untreated soil had a n OMC of 20% and an MDD of 1.50 g/cc. Fig. 2 illustrates how adding sisal fiber raised OMC and lowered MDD.

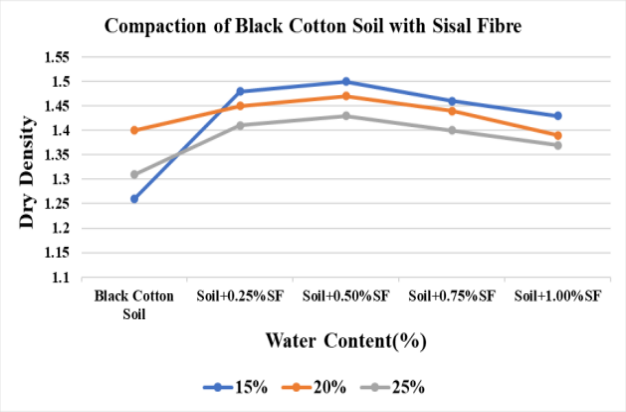

Chart -1: Compaction of Black Cotton Soil with Sisal Fibre

C.California Bearing Ratio

Black cotton soil load versus penetration figures are shown for both drenched and unsoaked circumstances with varying percentages of sisal fibre.

Table-3:CBR Test Results

S.NO	PROPERTIES	BLACK COTTON SOIL	SOIL +0.25 % OF SF	SOIL +0.50 % OF SF	SOIL +0.75 % OF SF	SOIL +1.00 % OF SF
1.	CBR@ 2.5mm	2.86	5.64	6.84	6.61	6.36
2.	CBR@ 5mm	2.68	5.77	6.81	6.56	6.32
3.	CBR Values	2.77	5.60	6.82	6.58	6.34

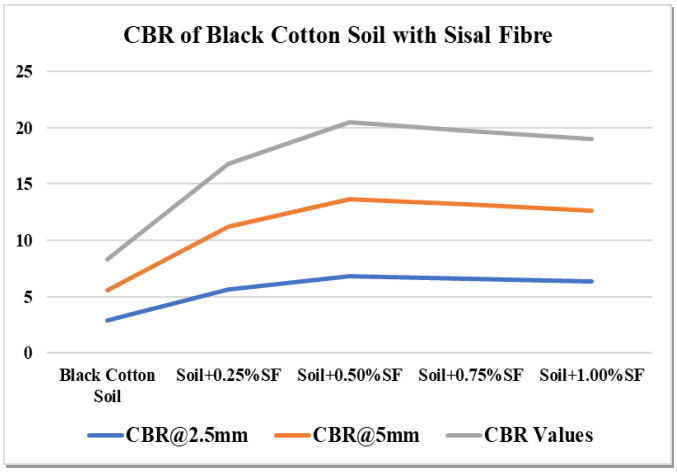

Chart -2:CBR of Black Cotton Soil with Sisal Fibre

5.CONCLUSIONS

The experimental study of the sisal fiber-reinforced black cotton soil's strength parameters produced a number of important findings. At 0.5% sisal fiber concentration, the soil's California Bearing Ratio (CBR) reached its highest value. The Maximum Dry Density (MDD) rose at 0.5% sisal fiber, however the Optimum Moisture Content (OMC) fell at the same amount. A lower specific gravity and a lower liquid limit were also observed in the sisal-fiber-reinforced soil as compared to the untreated Black Cotton Soil. These results demonstrate how sisal fiber improves the engineering qualities of black cotton soil.

6.FUTURE SCOPE

a. Different lengths of Sisal fibers are used.

b. Various types of fibers will be used as additives to the soil.

c. Different soil stabilization techniques will be applicable attain better strength.

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