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Effects of Coir Fibre on the Strength of Black Cotton Soil

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Abstract*— Black cotton soil is expansive in nature and possesses the property of shrinking when it is dry and swelling as it absorbs water. It has poor bearing capacity and shear strength, so notable awareness of its stabilization process is needed to make it more suitable for all kinds of construction purposes. We can improve the properties of black cotton soil by stabilising it with various natural fibres such as coir fibre, rice husk, jute, fly ash etc. This paper presents the results of the lab experiments on black cotton soil using coir fibre as a stabilizer to compare the test results. The tests performed are liquid limit, plastic limit, specific gravity, oven drying and proctor test. The standard proctor compaction test performed on the black cotton soil is mixed with different percentages of coir fibre ranging from 1%, 2%, 3%, and 4%.

Keywords- Black cotton soil, Coir fibre, proctor test, Shear strength.

I. INTRODUCTION

Black cotton soil is clay-rich soil which is grey and brown in colour and it's formed from weathering of lava rocks. It is found in Maharashtra, Madhya Pradesh, Gujarat, parts of Karnataka, Andhra Pradesh, and Tamil Nadu, and contains montmorillonite mineral which is accountable for excessive swelling and shrinking characteristics of the soil. Black cotton experiences change in volume when it absorbs water hence it expands during the rainy season due to absorption of water and shrinks during the dry season, it is so strong in its dry state and becomes completely weak in hardness and strength as it absorbs water. Construction of structures like houses, roads etc. on Black Cotton causes differential settlement due to low shear strength. Excessive compressibility properties and degradation lead to damage to highway pavements. Black cotton soil can be stabilized to resist heavy loads as a substructure, high developing countries like India focuses a lot on infrastructural development like roads, railways etc. which require stabilized soil so as to provide better road and railway network. Stabilization of Black cotton soil leads to the change in the properties of its volume change due to water absorption, Shear strength, Atterberg's limits and its stability properties. In order to enhance the performance of black cotton soil, several literature studies have shown various methods of stabilization such as the effects of coir fibre and curing time on both the tensile and compressive strength of soft soil treated with lime so as to be used on land-based structures[4], effects of cement and fly Ash based geopolymer on the behaviour of expensive soil which shows an increase on unconfined compressive strength (UCS) of expensive soil on the increase of concentration of Fly ash based geopolymer[5], stabilization of clay soil with jute and fly ash which showed an increase in the mechanical properties of the soil after several tests were conducted such as standard proctored test[1] has been used. The reason for any stabilization method used is to improve the strength and stiffness of black cotton soil, improve the buildability of soil and reduce the plasticity index. In this Research paper, we look at how the use of coir fibre influences the strength of Black Cotton soil. Black cotton soil was mixed with varying percentages of coir fibre (1%,2%,3%, and 4% by dry weight of soil) to improve the strength properties of Black Cotton soil and a standard proctored test was conducted. The impact of coir fibre on Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) as per IS 2720 was studied, and the addition of coir fibre in Black cotton soil reduces its volume-changing behaviour.

Coir fibre

Coir fibre is a natural fibre got from the outermost shell of coconut; the main advantage of coir fibre is that it is readily available with minimal cost. Coir fibre has very high rupture strength and can hold this strength even in moisture or wet condition, it also has a disadvantage i.e., it is biodegradable with time due to over-absorption of water which reduces the interfacial bond between the soil and the fibre. Coir fibre adds bulk to the soil and reduces its settlement Coir fibre should not be confused with coir pith since coir pith is the powdery and spongy material got from the processing of the coir fibre, Coir fibre can be classified into white and brown. Brown coir extracted from ripened coconuts is thick, strong and has high abrasion resistance. White coir fibre is harvested from immature coconut, are smoother and finer. Coir fibre can be used for making mats, and ropes and can also be used for reinforcement in low-cost concrete structures because of its property of toughness and sturdiness.

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II. MATERIALS

2.1 Black cotton soil

The clay soil sample used in this project is taken from Rajkot, Gujarat.

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Black cotton soil after sieving

Coir fibre after cutting

The physical properties of the black cotton soil are given in Table (i) below:

Table 1

Part (A)

Sl. No	Parameters	Properties	IS Code
1	Natural moisture content	12.487%	IS 2720 Part 2
2	Specific gravity	1.62	IS 2720 Part 3

Part (B)

3	Liquid Limit	40	IS 2720 Part 2
4	Plastic Limit	31.34	IS 2720 Part 5
5	Maximum dry density	1.67	IS 2720 Part 8
6	Optimum moisture content	18.29	IS 2720 Part 8

2.2 Coir fibre

The coir fibre used in this project is collected from Phagwara, Punjab. It was cut into lengths ranging from 1mm – 4mm and mixed with black cotton soil in different proportions (1% - 4%).

Table (ii) shows the physical properties of the coir fibre:

Table 2

SL No	Parameters	Properties
1	Length	1mm-4mm
2	Diameter	0.1mm – 4mm

III. METHODOLOGY

The experimental steps performed on this project are as follows-

- determination of natural moisture content of the black cotton soil by oven drying method
- determination of specific gravity of the black cotton soil by Pycnometer method – The soil sample was passed through a 4.75 mm sieve as per IS: 2720 (Part 3) 1980
- determination of Liquid Limit by the Casagrande method
- determination of Plastic Limit
- determination of maximum dry density and corresponding optimum moisture content of the black cotton soil by standard proctor test as per IS: 2720 (part 7) 1980
- Determination of maximum dry density and the corresponding optimum moisture content of the Black cotton soil stabilised with coir fibre (1%, 2%, 3% and 4%)
- Comparing the test results of the stabilised Black cotton soil with natural black cotton soil.

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IV. RESULTS AND DISCUSSION

Graph 1, 2, 3, 4, and 5 shows the values of MDD and OMC for different percentages of coir fibre added to the soil.

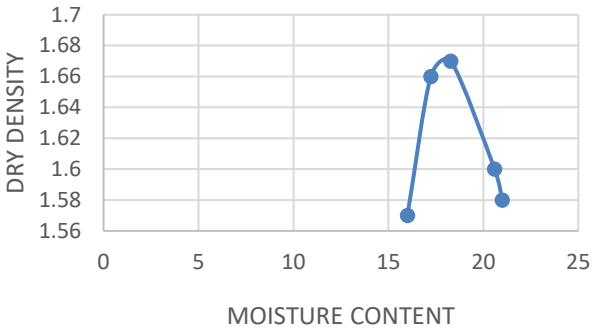

Figure 1: Dry density vs Moisture content for soil only

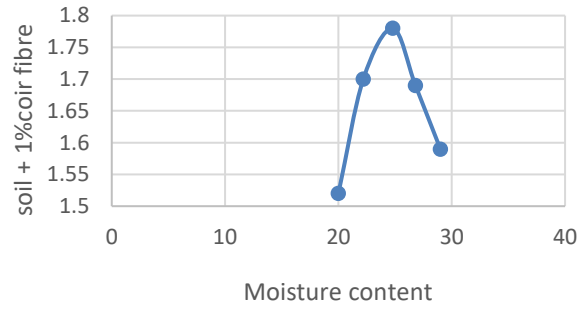

Figure 2: Dry density vs moisture content for soil + 1% coir fibre

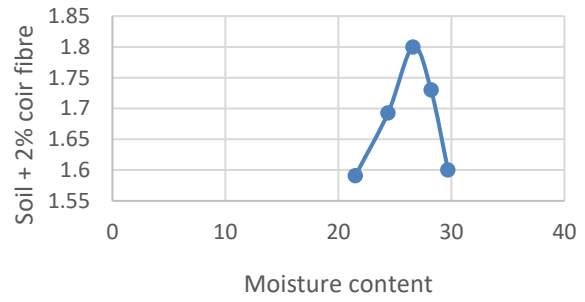

Figure 3: Dry density vs moisture content for soil + 2% coir fibre

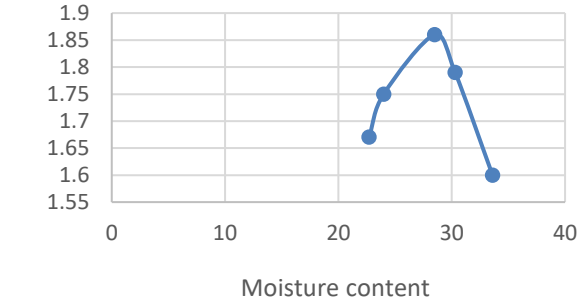

Figure 4: Dry density vs moisture content for soil + 3% coir fibre

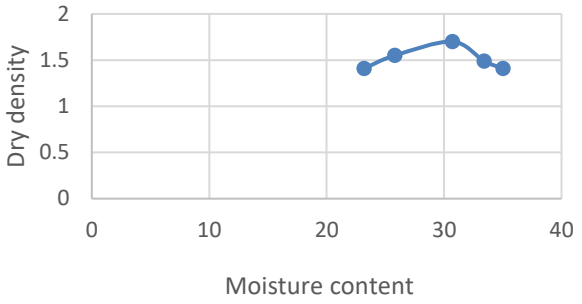

Figure 5: Dry density vs moisture content for soil + 4% coir fibre

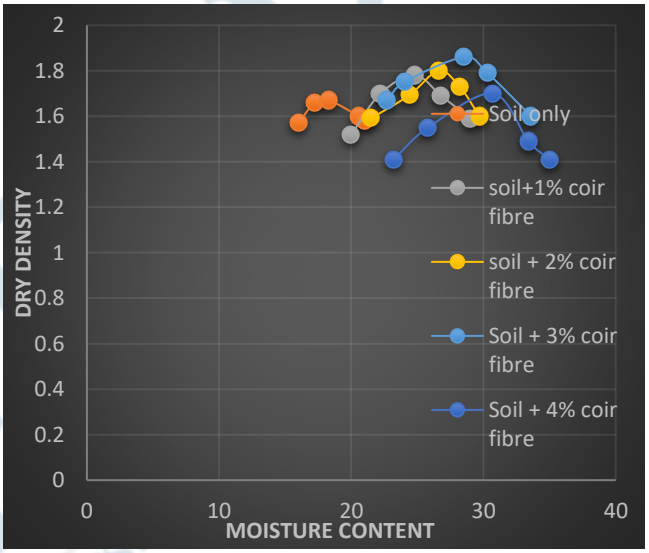

Figure 6: Comparison of MDD (Maximum dry density) - OMC (Optimum moisture content) for Black cotton soil with varying proportions of coir fibre (0%, 1%, 2%, 3%, 4%)

Table 3: MDD-OMC values of Black cotton soil for the varying percentage of coir fibre

Part (A)

Combined % of coir fibre	MDD	OMC
Soil only	1.67	18.29
Soil + 1% coir fibre	1.78	24.8
Soil + 2% coir fibre	1.8	26.6
Soil + 3% coir fibre	1.86	28.5
Soil + 4% coir fibre	1.7	30.7

Figure 6 shows the MDD vs OMC for varying percentages of coir fibre (1%,2%,3%,4%) added to Black cotton soil. The values are also tabulated in Table 3, the addition of coir fibre in the soil leads to an increase in the dry density of soil with 3% fibre having the highest dry density. Soil which has a very high dry density tends to withstand high loads compared to soil with low dry density. Atterberg's Limits such as Liquid limit, Plastic limit, Specific gravity, and standard proctored test were determined for Black Cotton soil by IS: 2720.

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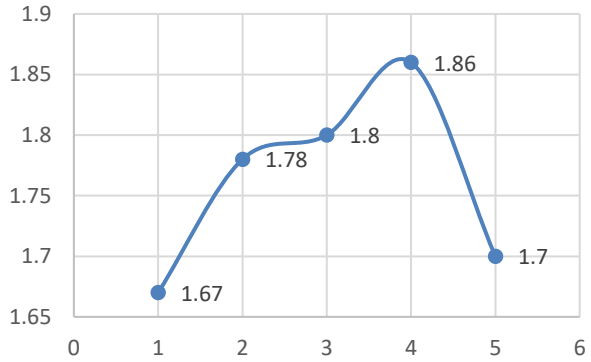

Figure 7: MDD of Black cotton soil for the varying percentage of coir fibre.

V. CONCLUSION

1. Various tests performed to study the nature of Black cotton soil in this project are specific gravity test, oven drying test, liquid limit, plastic limit, maximum dry density, optimum moisture content and standard proctor test.
2. The Maximum Dry Density of the black cotton soil is 1.67 g/cc at the optimum moisture content of 18.29%
3. Adding coir fibre at varying percentages (1%-3%) of the dry weight of the black cotton soil increases the MDD but adding 4% coir fibre reduces the MDD value. Therefore 3% is the optimum percentage of coir fibre
4. It is also observed that the OMC of the black cotton soil increases with the increase in the percentage of fibre because of the fibre's high absorption capability.

VI. ACKNOWLEDGEMENT

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