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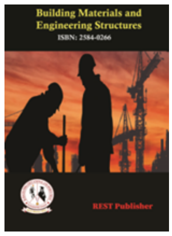

Stabilization Of Black Cotton Soil By Using Type-C Glass Fiber

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Abstract: *One method for rehabilitation of weak and problematic soil properties is rehabilitation by using physical added material such as fibres. Black cotton soils, widely used in construction, often exhibit limitations in strength and stability, particularly under changing moisture conditions. Type C class fibres, known for their high tensile strength and durability, are introduced as a reinforcement material to enhance the soil's performance. In this project, effect of glass fiber on rehabilitation of Black cotton soil mechanical properties are studied. The main goal of this project is evaluation of how added glass fiber to black cotton soil can affect engineering properties of soil, particularly unconfined shear strength of reinforced soil. In this project different composition of soil and glass fiber (0.5 to 2.5) percent with 12, 14 and 16 percent water content are used. In order to study the effect of water contain and glass fiber, unconfined compression tests have been done on Black cotton soil reinforced by fiber glass and unreinforced Black cotton soil. The results will reveals that the inclusion of glass fibers significantly improves the unconfined shear strength and mechanical properties particularly at higher water contents, where soil tends to weaken.*

Keywords: *Type-C Glass Fiber, Unconfined Shear Strength, Black Cotton Soil, Water Content.*

1. INTRODUCTION

Black cotton soil is found to be one of the most unreliable soil in any construction project since it depicts excessive volume change with varying moisture content. Because these types of soils have a low shear strength and high compressibility, building on weak and soft soils poses a significant risk. Which, if improperly handled, can result in significant harm to structures such as runways, spread footings, airport, roads, earth dams and high ways. Because Black cotton soils volume change behaviour is so sensitive to moisture content, expansive soils are used difficult in Engineering applications. Expansive soils are the soils which expand when the moisture content of the soils is increased. The clay mineral montmorillonite is mainly responsible for expansive characteristics of the soil. The expansive soils are also called swelling soils or black cotton soils. Expansive soils are generally residual soils left at the place of their formation after chemical decomposition of the rocks such as basalt and trap. The soils and generally dry because the water table there is quite deep. During rainy season, they become wet. The soils expand as the water content is increased. Severe movements of the soil mass may occur. Structures built on such soils may experience cracking and damage due to differential heave. When the area to be treated is limited, reinforcements are especially trustworthy and successful at strengthening weak soil. Here we study the effect of glass fiber inclusion on Engineering properties of BC soil. Type C glass fiber, known for its exceptional strength is widely used in Civil engineering to enhance the mechanical properties of soil, concrete and other construction materials. When added to soil or concrete, Type C glass fiber significantly improves the unconfined shear strength (UCS), shear strength, and ductility of the material. In soil stabilization applications, adding 0.5% to 2.5% of fiber increases UCS by 15% to 50%, depending on the fiber content, while also boosting cohesion and internal friction angle, enhancing the soil's shear resistance. The fiber reinforcement reduces the brittleness of soil, making it more ductile and capable of withstanding greater loads without cracking. It's moisture resistance ensures that it retains its strength properties even in humid or wet conditions. It improves the load-bearing capacity of pavements, embankments, and retaining walls, preventing settlement and reducing deformation.

2. LITERATURE REVIEW

The study by Masoud Amelsakhi et al. [1] investigates the impact of adding Glass fiber (0.5% to 2.5%) on the mechanical properties of clay soil, focusing on unconfined compressive strength (UCS) and elasticity modulus under varying moisture levels (11%,13%, and 15%). Unconfined compression test revealed that glass fibre significantly enhances ucs and elasticity modulus. However, while increased fiber and moisture content improves ductility and failure strain, they tend to reduce UCS and elasticity. The optimal fiber content for maximum UCS was 1% by weight, achieving UCS values of 1543 kPa (11% moisture), 1128 kPa (13%), and 573 kPa (15%). UCS decreased with rising moisture, with the lowest value (273 kPa) in unreinforced to clay at 15% moisture.

2.2 The study of Dharmendra Singh [2] explores the use of glass fibre to improve the strength properties of black cotton soil (BCS), which is problematic for construction due to its high shrink-swell behaviour from montmorillonite clay. Glass fiber (2% to 8% by weight) was mixed with oven dried BCS, and various tests, including UCS, were conducted over curing periods up to 56 days. Results showed that while UCS decreased due to the water retention of glass fiber, optimum moisture content (OMC) and California bearing ratio (CBR) increased. Conversely, maximum dry density (MDD) and expansion ratio declined. XRD analysis also showed changes in microstructure and mineral composition with more fiber and longer curing. The study concludes that glass fiber can moderately enhance BCS properties but only within certain limits.

3. MATERIALS USED

3.1 Black Cotton Soil

A large part of the central India and a part of the South India is covered with expansive soils. Although these soils are good for growing cotton, they are treacherous for foundations of structures. Heavy damages may occur to buildings, roads, runways, pipe lines and other structures built on such soils if proper preventive measures are not adopted. The damages can be prevented to a large extent if the characteristics of the expansive soils are properly assessed and suitable measures are taken in the design, construction and maintenance of structures built on expansive soil. When the water content of the expansive soil is increased, it expands. When the water content is reduced, it shrinks and cracks develop.

FIGURE 1. Black Cotton Soil

Black Cotton soil sample was collected from Kamalapuram, Kadapa district, Andhra Pradesh, India. Coordinates of the soil sample collection site location is reported as 14.5833°N 78.6500°E.

3.2 Glass fiber

The fiber length, diameter, and content significantly influence the reinforcement performance, with longer and thicker fibers providing greater strength enhancement. In direct shear tests, fiber-reinforced soil exhibits increased cohesion and friction angle, while UCS test demonstrate substantial gains in compression strength. In geotechnical applications, type-C glass fibre strengthens weak soils, preventing slope failures and improving foundation stability. It's fatigue resistance makes it suitable for structures exposed to repeated loading. The low density and high strength-to-weight ratio of type C glass fibre make it ideal for lightweight yet robust construction applications. The thermal stability of the fiber allows it to maintain its mechanical properties under temperature variations.

FIGURE 2. Type C Glass Fiber

Glass fiber (GF) was purchased from fiber source, anbu nagar ,8th street, Alwarthirunagar, Chennai (600087), India. Glass fibre is a lightweight material. Length of glass fibre is 12mm. Nowadays, it is widely adaptable industrial material.

4. METHODOLOGY

4.1 1standard Proctor Compaction Test

Standard proctor test was performed to determine the moisture content-dry unit weight relationship. The soil was mixed with varying amounts of water and then compacted in three equal layers by a hammer that delivers 25 blows to each layer using an automatic dynamic compacter with a hammer is dropping from a height that produce a compactive effort. The compaction test has been performed on soil with different fiber contents (0.5,1.0,1.5,2.0,2.5%).

FIGURE 3. Standard proctor apparatus

4.2 California Bearing Ratio Test

The CBR is a measure of resistance of a material to penetration of standard plunger under controlled density and moisture conditions. The test is performed on a disturbed soil or undisturbed soil of soaked and unsoaked soil. It is measured by the pressure required to penetrate as oil sample with a plunger of standard area which is then divided by the pressure required to achieve an equal amount of penetration on a standard crushed rock material. For the test, mix proportions used for the compaction test were used again, dry soil was mixed thoroughly with calculated quantity of water to obtain moist soil as per the required moisture percentage obtained from the compaction test. The soil was compacted in a CBR moulds, each in 3 layers and of 56 blows at each layer using the standard rammer. The top surface was scraped and levelled after compacting the third layer. The loading was applied at the rate of 1.25 mm/min. 0.5,1.0,1.5,2.0,2.5,3.0,4.0,5.0,7.5,10.0 and 12.5. The CBR test has been performed on soils with different fiber contents (0.5,1.0,1.5,2.0,2.5%).

FIGURE 4. CBR Apparatus

4.3 Unconfined Compression Test

The unconfined compression test is a special type of tri-axial test where the confining pressure is zero, and it is conducted only on clayey soil that can stand without confinement. This test, generally performed on intact and standard clay specimens, follows is:9143-1979 standards, which recommend a specimen diameter of 45 mm, with a minimum limit of 35mm. The load is applied continuously at a stress rate of 0.5 to 1.0 MPa per second. The procedure involves applying a thin layer of oil to the mould, collar, and base plate, preparing a clay sample at optimum moisture content, and compacting it in three layers using 56 blows per layer with a standard rammer. The sample is then trimmed, extracted, and placed in the loading unit, where a load is applied at a rate of 1.25mm/min. Load readings are taken at regular strain intervals, and the data is used to plot a load-deformation graph.

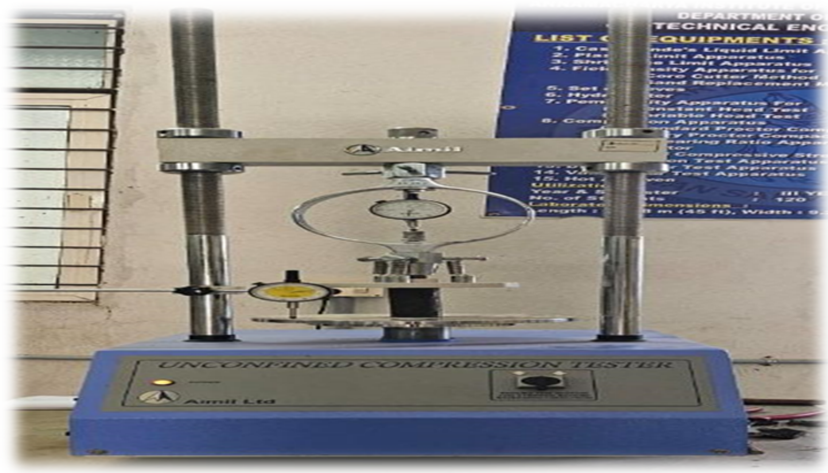


FIGURE 5. UCS Apparatus

5. RESULTS AND DISCUSSIONS

5.1 Atterberg Limits

TABLE 1. Atterberg Limits of BC Soil with Glass Fiber

% of Glass Fiber	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
0	78.57	33.33	45.24
0.5	78.12	35.24	42.88
1	76.5	36.72	39.78
1.5	74.6	38.46	36.14
2	71.26	39.13	32.13
2.5	68.14	41.27	26.87

5.2 OMC & MDD values

TABLE 2. OMC & MDD values with GF

% of Glass Fiber	OMC(%)	MDD(g/cc)
0	17.39	1.67
0.5	19.44	1.61
1	21.31	1.51
1.5	22.72	1.46
2	20.71	1.39
2.5	18.75	1.322

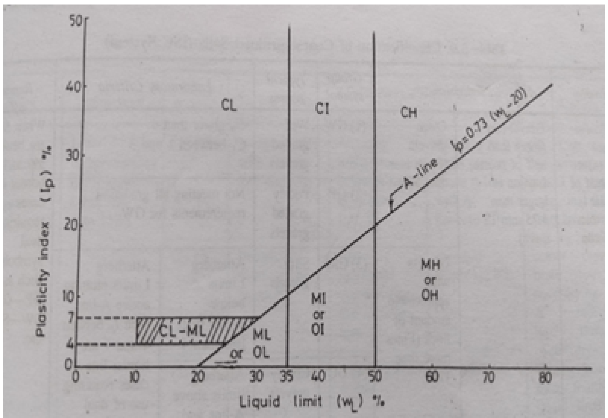
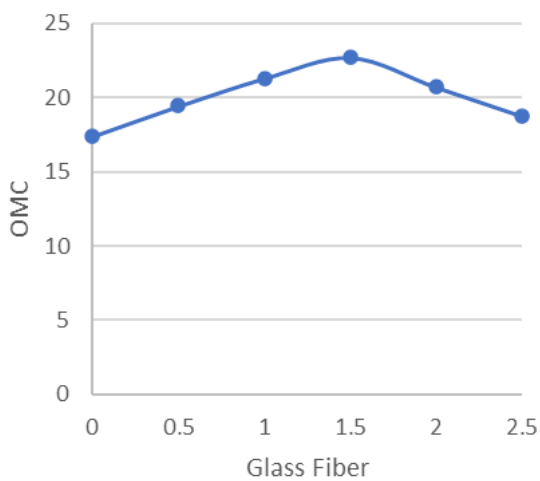
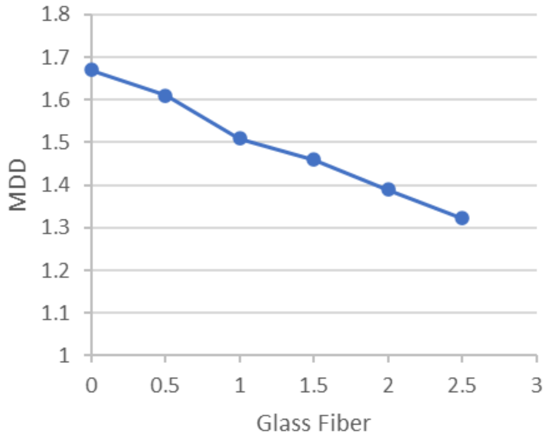


Fig. 5.6. Plasticity Chart (ISC)

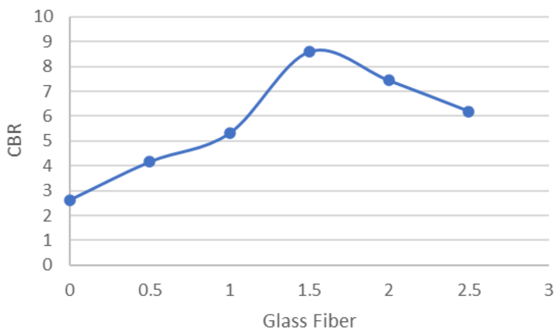




5.3 CBR Value

TABLE 3. OMC & MDD values with GF

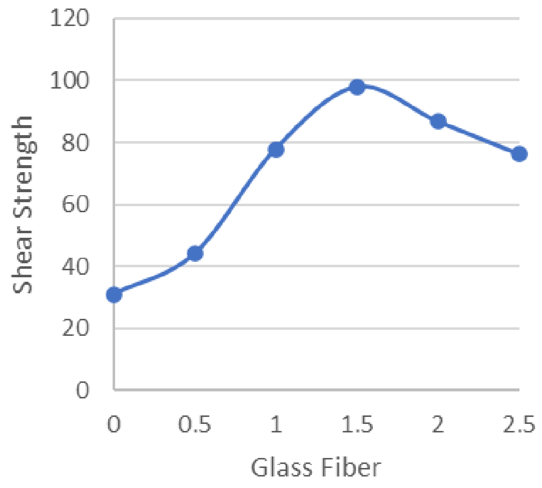
% of Glass Fiber	CBR value (%)
0	2.62
0.5	4.16
1	5.32
1.5	8.61
2	7.44
2.5	6.20



5.4 Shear Strength Value

TABLE 4. Shear Strength Value

% of Glass Fiber	Shear Strength(kPa)
0	31.04
0.5	44.03
1	77.8
1.5	97.85
2	86.7
2.5	76.2



5.5 SBC Value

TABLE 5. SBC Value

% of Glass Fiber	SBC (kPa)
0	11.32
0.5	23.45
1	15.56
1.5	18.24
2	16.7
2.5	15.19

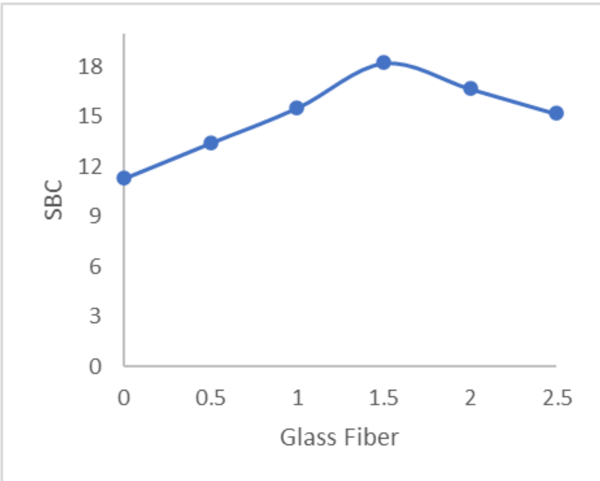


FIGURE 6. SBC Value

6. CONCLUSION

Use of glass fiber may slightly enhance the properties of expensive soils. Glass fiber can be used as a reinforcement up to certain limit. The improved geotechnical properties of Black cotton soil are as follows:

1. Liquid limit values were found to be decreased and plastic limit values were found to be increased with the increasing Glass fibre percentage. This tests helps to classify the type of soil.
2. OMC values were found to be increased up to 1.5% of Glass fibre and then it decreases.
3. CBR and shear strength values increased progressively with the addition of glass fiber up to an optimum content of 1.5%, beyond which a decline in strength was observed.
4. The SBC increased gradually with the addition of fiber up to 1.5%, due to enhanced cohesion and internal friction.

5.

Overall, the use of Type C glass fiber can be considered an effective method for stabilizing expansive soils when used at optimal dosages.

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