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Evaluation of Engineering Properties of Black Cotton Soil Treated with Different Stabilizers

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Abstract: Lack of adequate road network to cater to the increased demand and increased distress in roads leading to frequent maintenance has always been a big problem in Karnataka state. Evolving new construction materials to suit various traffic and site conditions for economic and safe design is a challenging task in road construction. Effective utilization of local weak soils by imparting additional strength using stabilization materials enable reduction in construction cost and improved performance for roads. Exploring the feasibility of such materials for subgrade and embankment stabilization will help the road building sector to evolve a stronger, durable and economic design. Soil layers below embankments need to provide structural stability to support traffic-loads imposed upon them. Soil subgrade when found weak and unsuitable to carry loads from pavement layers, soil subgrade need to be stabilised. Use of stabilizers such as coir fiber may improve load carrying capacity of subgrade soil, which also acts as reinforcing material. The test results indicated that the inclusion of fiber reinforcement with black cotton soil, cemented black cotton soil caused an increase in the unconfined compressive strength (UCS), increases axial strain at failure, decreased the stiffness, and changed the soil's brittle behaviour to a more ductile one. The bond strength and friction at the interface may be the dominant mechanism controlling the reinforcement benefit.

1.0 INTRODUCTION:

In India, soils are classified into six groups mainly alluvial soil, marine soil, laterite and lateritic deposits, expansive soils, sand dunes and boulder deposits. On an average 1 lakh sq km area is covered by lateritic soil deposits,3 lakh sq km area is covered by Black cotton soil, and 5 lakh sq km area is covered by sand dunes.Marine soils are available in the coastal belts,laterite and lateritic soil deposits are available in Maharashtra, Karnataka, and parts of Kerala. Black cotton soil is available in
Maharashtra, Gujarat, Madhya Pradesh, North Karnataka, parts of Andhra Pradesh and Tamilnadu.
Alluvial soils are available in indo-gangetic plains, and sand dunes in Rajasthan and boulder deposits are available in the Himalayan regions. Black cotton soil contains a clay mineral called montmorillonite which is having a peculiar behavior of swelling in the presence of moisture and developing shrinkage cracks in dry season. Because of volumetric change in behavior the structure constructed on such soils will undergo differential settlements, cracks in buildings or total destruction of the structure however the structures can be constructed on such a soil by treating the expansive soil with a non-expansive material. This can be done by using ground improvement technique like mechanical stabilization, chemical stabilization, freezing and heating, reinforcing earth technique etc.

1.2 Objectives of the present study:
To determine optimum fiber content using coir fiber, this was used as a reinforcing material in Black cotton soil.
To determine gain in strength with the use of coir fiber as a reinforcing material by conducting Unconfined compression test (UCC) and California Bearing ratio test (CBR).
To compare the strength achieved by black cotton soil with their respective optimum fiber content (OFC).

2.0:LiteratureReview:
GOPALRANJAN,et.al.,(I996) conducted series of triaxial compression tests on cohesionless soils reinforced with discrete, randomly distributed fibers, both synthetic and natural, to study the influence of fiber characteristics, soil characteristics and its density, and confining stress on shear strength of reinforced soils.

J.T.HUANG and D.W.AIREY{1998) Naturally cemented materials often have inherent variabilities in density and degree of cementation. The influence of this variability on the properties of cemented materials is investigated by producing artificially cemented specimens at dry unit weights ranging from 12 to 19 kN/m^3 and gypsum cement contents ranging from 0% to 20%. Tests have been performed to investigate the index strengths, the behavior in isotropic and K_o compression, and the responses from standard triaxial compression tests over a wide range of confining pressures.

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3.0: Experimental Studies: Black cotton soil, coir fiber and cement were used in the present investigation; the experimental work was carried out in three stages. In the first stage basic tests like Wet Sieve analysis and Atterberg limits tests and Hydrometer analysis test were conducted on soil obtained for investigation. Second stage consists of determining Optimum fiber content of Black cotton soil by Jodhpur mini compaction method. In the third stage Unconfined Compressive tests were conducted with varying percentages of coir fiber and cement

Table-1: Physical Properties of Black Cotton Soil.

Color	Black
Grain size distribution	
Gravel, %	2.00
Sand, %	38.20
Silt and Clay, %	59.80
Atterberg's limits:	
Liquid limit, %	46.6
Plastic limit, %	24.81
Plasticity index, %	21.79
Shrinkage limit, %	16.97
Compaction characteristics:	
Maximum dry density (g/cc)	1.67
Optimum moisture content, %	20.08
CBR,%	3.70
Unconfined compressive strength kN/m^2 at MDD & OMC	101.00

Table-2: OMC and MDD Values for BC Soil with Varying Coir Fibers:

Particulars	MDD	OMC
BC Soil Alone	1.67	20.08
BC Soil Alone+0.2% Coir Fibers	1.74	18.42
BC Soil Alone+0.3% Coir Fibers	1.77	18.83
BC Soil Alone+0.4% Coir Fibers	1.70	18.93
BC Soil Alone+0.5% Coir Fibers	1.69	19.75

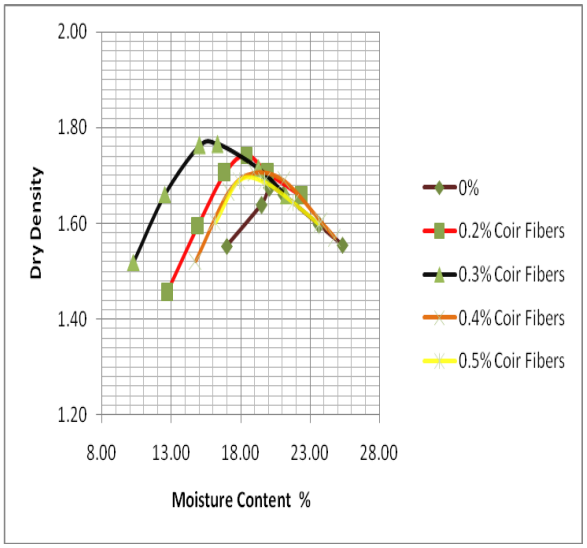


Table 3: Unconfined compressive test on black cotton soil with varying coir fiber content

Particulars	UCS Test Values(KPa)
BC SOIL	101.00
BC SOIL + 0.2% COIR FIBERS	164.21
BC SOIL + 0.3% COIR FIBERS	198.44
BC SOIL + 0.4% COIR FIBERS	103.61
BC SOIL + 0.5% COIR FIBERS	118.00

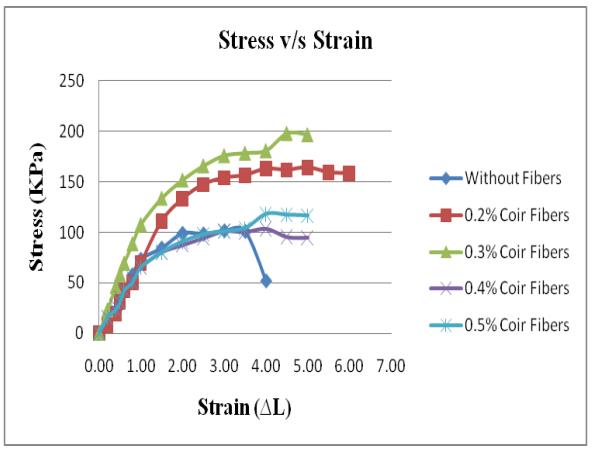


Fig 1: Unconfined Compressive Strength of Black Cotton Soil Treated With Various Percentages of Coir Fibers

Table-4: Unconfined Compressive test results for black cotton soil treated with varying percentage

Particulars	UCS Test Values(KPa)
BC SOIL	101
BC SOIL + 2% Cement	210
BC SOIL + 4% Cement	335
BC SOIL + 6% Cement	465
BC SOIL + 8% Cement	410

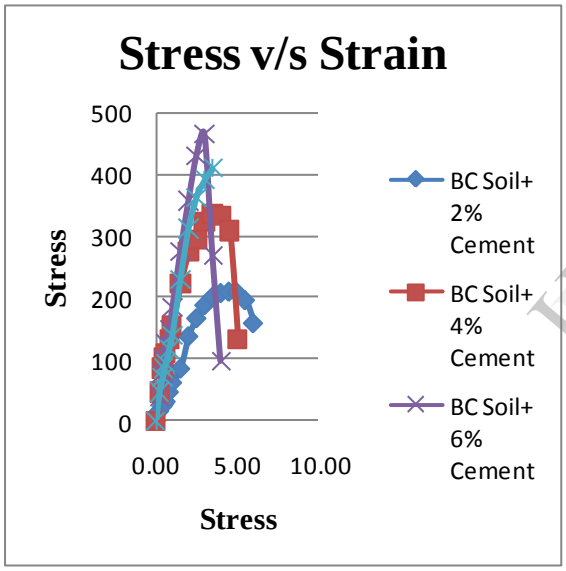


Table-5: Unconfined Compressive test results for black cotton soil treated with varying percentage of cement content at 3 days curing

	UCS Test Values(KPa)
BC SOIL + 2% Cement	368
BC SOIL + 4% Cement	1012
BC SOIL + 6% Cement	1561
BC SOIL + 8% Cement	1087

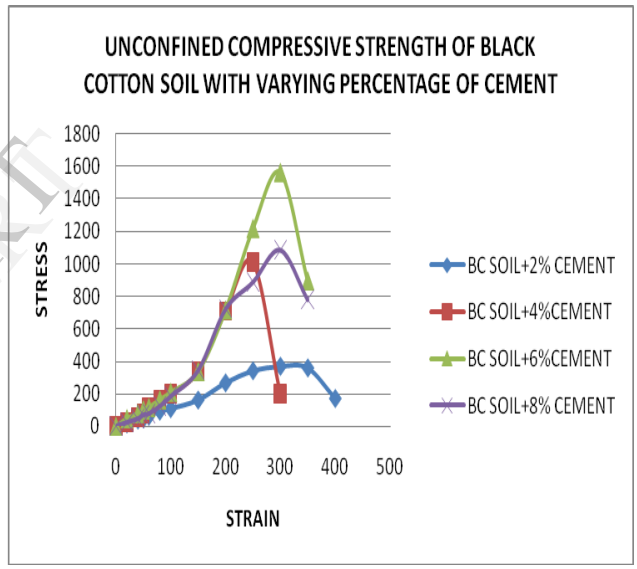
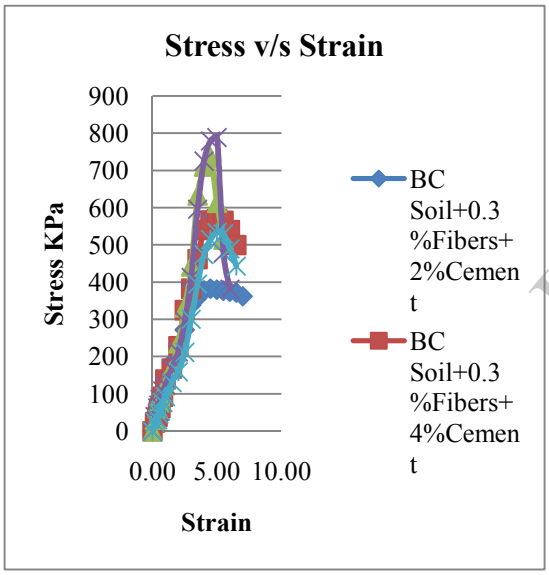


Table-6: Unconfined Compressive test results for black cotton soil treated with optimum fiber content and varying percentage of cement content at zero days curing

Particulars	UCS Test Values(KPa)
BC SOIL +0.3% Fibers+2% Cement	382
BC SOIL +0.3% Fibers+4% Cement	569
BC SOIL +0.3% Fibers+6% Cement	735
BC SOIL +0.3% Fibers+8% Cement	788
BC SOIL +0.3% Fibers+10% Cement	533



Unconfined compressive strength test on black cotton soil treated with optimum coir fiber content of 0.3% and with varying percentage of cement

Table-7: Unconfined Compressive test results for black cotton soil treated with optimum fiber content and varying percentage of cement content at 3 days curing.

Particulars	UCS Test Values(KPa)
BC SOIL +0.3% Fibers+2% Cement	551
BC SOIL +0.3% Fibers+4% Cement	1188
BC SOIL +0.3% Fibers+6% Cement	1898
BC SOIL +0.3% Fibers+8% Cement	2571

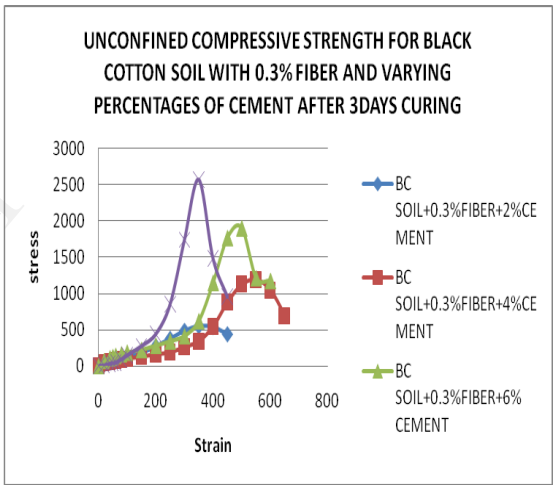
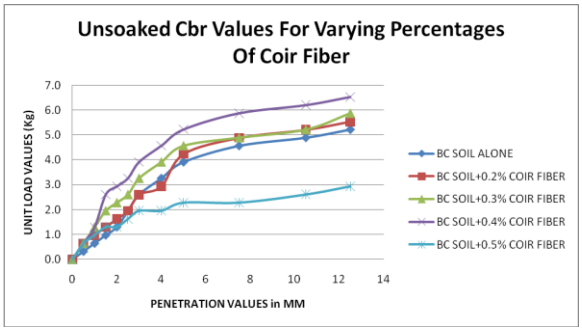


Table-8: California bearing ratio test results for black cotton soil treated with varying percentage of coir fiber content

Particulars	CBR Test Values
BC SOIL	3.70
BC SOIL +0.2% Fibers	4.00
BC SOIL +0.3% Fibers	4.34
BC SOIL +0.4% Fibers	4.96
BC SOIL +0.5% Fibers	2.32



DISCUSSIONS:

1. After conducting the physical properties test on Black cotton soil it is known that Liquid Limit of BC soil is 46.6 and Plastic Limit of Soil is 24.81. Hence the soil is classified as CI as per unified soil classification.
2. The MDD and OMC of BC Soil are 1.67 g/cc and 20.08%.
3. The above studies shows that the OMC and MDD of the soil increases with the percentage of increase in Coir Fibers.
4. It is also known that with the increase in MDD of soil, the UCS parameters of the soil increases with percentage of Coir Fibers.
5. It is also known that the OMC of BC Soil decreases with increased percentage of Coir Fibers because the fibers absorb the moisture to certain extent.
6. Cement was used as a chemical agent, 0.8% cement content with respect to weight of soil and 0.3% optimum Coir Fiber content was observed to give maximum compressive strength of 788 KPa.
7. When soil was combined only with Cement, without using Coir Fiber, 0.6% Cement Content was observed to give maximum compressive strength of 465 KPa.
8. With the use of Cement, it was observed that there is increase in the Compressive strength and mode of failure changes from brittle to ductile.

CONCLUSIONS:

The results of the laboratory investigation indicated that the inclusion of Coir fibers in the soils improved the unconfined compressive strength of the individual specimens.

- As the fiber percentage increases, the unconfined compressive strength increases to certain limit.
- While comparing the results of Black Cotton soil combined with Coir Fiber and Cement and with cement alone, it is found that Cement with coir fiber gives more unconfined compressive strength.
- The strain required to mobilize peak strength is more in case of reinforced specimen than when compared to unreinforced specimen.
- Black cotton soil with 6% cement gives optimun value with respect to unconfined compressive strength.
- Black cotton soil with 0.3% fibres with 8% cement gives optimum value with respect to unconfined compressive strength and also it can be seen from the sttress – strain curve the inclusion of fibres changes the behaviour from brittle to ductile.
- Black cotton soil with 0.4% fibres gives optimum value with respect to CBR values obtained for different fiber contents.
- Also it can be concluded with increase in aspect ratio and fiber content, the specimens are found to exhibit ductile behavior than when compared to unreinforced specimen.

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