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Effect Of Random Inclusion Of Sisal Fibre On Strength Behavior Of Black Cotton Soil

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ABSTRACT

Soil is a naturally occurring material that are used for the construction of all except the surface layers of pavements (i.e., concrete and asphalt) and that are subject to classification tests to provide a general concept of their engineering characteristics.

Stabilization is the process for modifying the properties of a soil to improve its engineering performance. Stabilization is being used for a variety of engineering works, the most common application being in the construction of road and air-field pavements, where the main objective is to increase the strength or stability of soil and to reduce the construction cost by making best use of the locally available materials.

A large part of Central India and a portion of South India are covered with Black Cotton soils. These soils have high swelling and shrinkage characteristics and extremely low CBR value and shear strength. Hence, there is need for improvement of these properties. The practice of using reinforced earth has been well established in soil engineering profession. The concept of reinforcing soil masses with sisal fibre is a relatively new development to improve the properties of soil. The use of natural and artificial fibres is a suitable method for homogeneous soil reinforcing. The present study attempts to investigate the effect of inclusion of sisal fibres on the compaction characteristics and unconfined compressive strength of expansive soil treated with lime and to determine the plasticity characteristics of soil treated with lime.

The present study is to determine the behavior of Black Cotton soil reinforced with Sisal fibre and Lime in a random manner. The black cotton soil for the present study is collected from Vidya nagar, Harihara, Davanagere district.

1. INTRODUCTION

Expansive soil is a term generally applied to any soil that has a potential for shrinking or swelling under changing moisture conditions. Expansiveness is a phenomenon that affects many clay soils, particularly those that contain significant quantities of smectite clay minerals. The primary problem that arises with expansive soils is that deformations are significantly greater than elastic deformations and they cannot be predicted by classical elastic or plastic theory. Movement is usually in an uneven pattern and of such a magnitude as to cause extensive damage to the structures and pavements resting on them. Expansive soils can cause more damage to structures, particularly light buildings and pavements, than any other natural hazard, including earth quakes and floods.

Expansive soils cover large area in several countries of the world and in India these deposits are known by the name “black cotton soil” and it occupies 20% of its area. They are predominant in the states of Gujarat, Maharashtra, Madhya Pradesh, Andhra Pradesh, Karnataka and Tamil Nadu. These soils undergo volumetric changes with the increase in moisture content. This is due to the presence of the mineral montmorillonate. They are of great challenge to civil engineers for the construction of building structures and roads over it. Expansive soils are not suitable for civil engineering applications owing to the difficulties experienced with their high swelling and shrinkage nature. Expansive soils are poor material for foundation as well as construction. They possess high plasticity and compressibility, small shear strength when saturated and exhibit very high volume changes during drying wetting. Due to ingress of water, soil exerts swelling pressure, which may damage the floor slab. Walls may be pushing outwards, leading to cracks even in single storied buildings. Pavements constructed on such soils may get cracked and damaged. The flexible pavement constructed over expansive soils are suffer from the problems of distorted pavement surfaces, longitudinal cracking of pavement along wheel tracks and loss of effective pavement thickness over a period of time. The failures are resulting from intrusion of sub grade soil into overlying structural layers of pavement and subsequent penetration of sub base material into softened sub grade during rainy seasons. In factory buildings, the swelling pressure exerted by expansive soils may disturb the alignment of machinery. Swell pressure is taken as the design parameter for heavy structures where adequate superimposed loads are exerted on the foundation soil.

2. OBJECTIVES OF THE STUDY

- To determine the basic properties of the given Black Cotton soil.
- Know the amount of Sisal fibre and Lime to stabilize the black cotton soil.
- To increase the stability and strength of the black cotton soil.
- Reduce the construction cost by making best use of locally available materials

2.1 SCOPE OF THE STUDY

Previous studies have shown that coir fibre and banana fibre reinforcements increased the unconfined compressive strength, flexural strength and permeability characteristics of compacted soils. Short term durability of reinforced soil samples has also been checked. The shear strength and consolidation characteristics of coir and banana fibre reinforced soil have also been studied. The results have shown improvements in the value of cohesion, angle of internal friction, coefficient of compressibility and coefficient of consolidation. The penetration resistance of coir and banana fibre reinforced soil has also been studied. The results have shown improvements in CBR value. This study is intended to find out the effect of sisal fibre on the compaction characteristics, California Bearing Ratio and unconfined compressive strength of soil.

3. LITERATURE REVIEW

Martin Jacob and K. Pandeu (2001) conducted a series of lab tests and evaluated the effects of hydrated lime on the engineering behaviour of highly plastic clay soil. Tests were performed with different percentages of hydrated lime. On the basis of all tests and their results they concluded: Effects of lime (6 % addition of lime) on Atterberg Limits: The plasticity index values of the clay soil are substantially and immediately decreased with increasing lime content; no significant effect of curing time is noted; the large increase in the plastic limit thus increasing the granular nature of the clay with lime. Effect of lime surface areas obtained by the methylene lime method (8 % addition of lime): Increasing the lime content and curing time decreases the surface areas of the treated soil; 20 % added lime decreases 40 % in surface area. Effect of lime on swelling potential and swelling pressure: A significant decrease in the swelling potential and pressure values was obtained with an increase of lime up to 4 %. Further addition of 10 % to 20 % lime swelling potential quickly dropped to zero. The addition of lime below 6 % has practically a non-significant effect on the swelling potential of this highly clay soil. Effect of lime on the mineralogical structure: The reaction of lime and clay minerals leads to the formation of a new crystalline phase identified as CAH; identified by the X – ray diffraction tests. This new phase appears when lime is added above 6 %.

Ilamparuthi. K et. al., (2008) investigated the effect of expansive black cotton soil was treated with lime content of 3%, 5% and 7% by weight to assess whether curing temperature influences the progress of lime-soil reactions. Compacted specimens of natural and various lime treated soils are cured at 5°, 30°, and 50°C. The unconfined compressive strength of these specimens was obtained immediately after the preparation of samples and after the curing periods of 7, 14 and 28 days. Experimental results revealed that the temperature of 5°C retards the soil-lime reactions and lime content as high as 7% is unable to improve the strength of soil in spite of curing for the period of 28 days.

Arvind Kumar (2007) An experimental program was undertaken to study the effects of polyester fiber inclusions and lime stabilization on the geotechnical characteristics of fly ash-soil mixtures. An Indian fly ash was mixed with expansive soil in different proportions. The geotechnical characteristics of fly ash-soil specimens, lime-soil specimens and lime-fly ash-soil specimens mixed with different proportions of randomly oriented fibers were investigated. Lime and fly ash were added to an expansive soil at ranges of 1–10% and 1–20%, respectively. Test specimens were subjected to compaction tests, unconfined compression tests and split tensile strength tests. Specimens were cured for 7, 14, and 28 days after which they were tested for unconfined compression tests and split tensile tests. Based on optimum values obtained for lime and fly ash, tests were conducted on test specimens prepared from fly ash-expansive soil- lime-fiber mixture after 28 days of curing. Samples were tested with 0, 0.5, 1.0, 1.5, and 2% plain and crimped polyester fibers by dry weight. Based on the favorable results obtained, it can be concluded that the expansive soil can be successfully stabilized by the combined action of fibers, lime, and fly ash.

J.Giridhar(1985), A comparative study was made between the moisture absorption behaviours of sisal and jute fibre composites in an epoxy matrix under immersion conditions. Sisal fibres in spite of possessing more compact structure than jute fibres exhibited higher moisture absorption levels in their composite form; contrary to expectations. This tendency was attributed to the high cellulose content and a possible interfacial effect in the former.

H. N. Ramesh (2011), Coir fiber made of natural fibers is increasingly finding a place as erosion control, but not for soil reinforcement. This is in spite of the fact that strong fibers like coir which have a very high lignin content can be effectively made use of as a reinforcing material , provided they are given suitable treatment. This paper describes Water absorption of uncoated and coated coir fibers in 100% submerged condition. In this test coir fibers are submerged in water chambers and at suitable time intervals their weights were taken and compared with the unsoaked weights of the uncoated or coated coir fibers. It is concluded that kerosene coated coir fibers reduces the water absorption by 4.7 times the uncoated coir fiber at 365 days of submergence in water. From water absorption test kerosene coated fibers are taken for further analysis because of lower water absorption capacity. Both uncoated and kerosene coated coir fibers were used in the Black cotton Soil (BC soil) as a reinforcing materials for BC soil. From compaction and unconfined compressive strength it is found that 0.5% of randomly distributed uncoated coir fiber (by weight of soil) in BC soil is found to be optimum. Further it is observed that 60% (by weight of coir fiber) kerosene coated, 0.5% coir fiber in BC soil increases unconfined compressive strength by 55 % compared to uncoated coir fiber in BC soil at 60 days curing.

4. MATERIALS

4.1 Black Cotton Soil:

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

Table 4.1 Geotechnical Properties of the Soil used

Properties	**Black Cotton Soil**
Colour	Black
Specific Gravity	2.46
GRAIN SIZE DISTRIBUTION	2.4
Fine sand fraction (%)	22.5
Silt size (%)	75.0
Clay size (%)	
ATTERBERG'S LIMIT	
Liquid Limit (%)	62.13
Plastic Limit (%)	29.44
Plasticity Index (%)	32.69
Shrinkage Limit (%)	15.58
Unified Classification	MH-OH
COMPACTION CHARACTERISTICS	
Maximum Dry Density (kN/m3)	15.16
Optimum Moisture Content (%)	21.96
Unconfined Compressive Strength(KN/m^2)	84.92
CALIFORNIA BEARING RATIO	
Soaked	2.11
Unsoaked	1.40

Table 4.2 Chemical Properties of Black Cotton soil

Chemical composition	**Percentage**
Silicon Dioxide	52.85
Alumina	12.24
Iron Oxide	8.04
Titanium Dioxide	0.24
Calcium Oxide	6.01
Magnesium Oxide	2.94
Potassium Oxide	0.48
Loss On Ignition	16.18
Sodium Oxide	0.26

4.2 Sisal Fibres

For the present study, sisal fibre was obtained from Srinivasapura, Kolar. The fibres are 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. The properties of sisal fibre are shown in Table 4.3. Photograph of sisal fibre is shown in Fig 4.1.

Fig 4.1: sisal fibre used in present investigation

Table 4.3 Properties of Sisal Fibres

Properties	**Values**
Color	White
Average diameter, mm	0.25
Average length, mm	10
Average tensile strength (N/mm2)	405.9
Density (g/cc)	1.45

4.3 Lime

Chemically pure hydrated lime is obtained from nice chemicals private limited, Kerala, India has been used in this investigation. The chemical properties of lime are shown in the Table 4.4. Photograph of lime is shown in fig 4.2

Table 4.4 Chemical Properties of Lime - Ca(OH)2 (As supplied by the manufacturer)

Constituent	**Quantity**
Assay	Min 95
Chloride (Cl)	Max 0.01
Sulphate (SO_4)	Max 0.2
Arsenic (As)	Max 0.0004
Lead (Pb)	Max 0.001
Insoluble Matter	Max 1

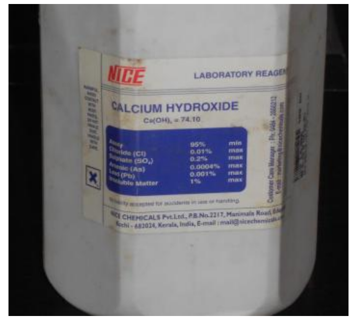

Fig 4.2 Lime used in the present investigation

5.0 METHODOLOGY

5.1 Moisture-Density Relationships

The maximum dry density and optimum moisture content of the unreinforced and reinforced soils were determined by standard proctor compaction tests. About 3kg of dry soil passing through 20mm IS sieve was taken. For compaction of soil-lime-fibre mix, the required amount of fibre was mixed with the dry soil-lime mix before adding water. Water is then added and thoroughly mixed before compacting in the mould. Standard proctor compaction tests were done to determine the Maximum Dry Density (MDD) and the Optimum Moisture Content (OMC) in each case.

5.2 Unconfined compression tests

Unconfined confined compression tests were carried out on cylindrical specimens of 38mm diameter and 76mm height. the soil with required water content was prepared first, and then the 3% percentage of lime were added to the soil before the test samples were to be compacted. If fibre reinforcement was used alone, the prescribed content of fibres (0.25, 0.5, 0.75 and 1% by weight of soil) was first mixed into the air-dried soil in small increments by hand, making sure all the fibres were mixed thoroughly to achieve a fairly uniform mixture, and then the required water was added. If both lime and fibre were used, a moist fibre soil mixture was prepared as explained above and then the moist mixture was mixed with optimum percentage of lime. All mixing were done manually and proper care was taken to prepare homogeneous mixtures at each stage of mixing. After the compaction, the samples treated with lime were wrapped with plastic membrane in the curing box for 0, 7, and 30 days, respectively until tested. These specimens were of maximum dry unit weight at optimum moisture content prepared by static compaction.

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5.3 California bearing ratio (CBR) tests

CBR tests were carried out by taking heavy compaction mould, which will be having internal diameter of 150mm and height of 175mm with coller of 50mm length. Before conducting test the soil and fibre are mixed in dry form for different percentage (0.25, 0.5, 0.75 and 1.0), then obtained moisture is added for test and test is carried. Similarly for the addition of 3%lime with fibre and soil the tests were conducted. Soaked condition of CBR is carried by soaking the soil for 72hrs of soaking condition. The test results are shown in fig.

6.0 RESULTS

Various tests were carried out in accordance with the standard procedure to determine the compaction characteristics and unconfined compressive strength behavior of fibre reinforced lime treated soil and to determine the plasticity characteristics of soil treated with lime. The test results are as follows.

6.1 Compaction Characteristics of Fibre Reinforced Lime Treated Soil

The variation of MDD and OMC with respect to the lime and fibre content is plotted in Fig

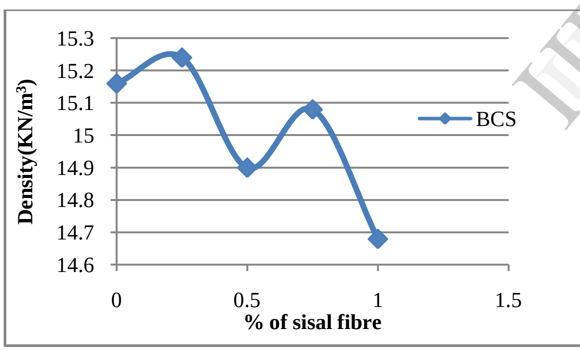

Fig.6.1: Variation of OMC with respect to soil-fibre content

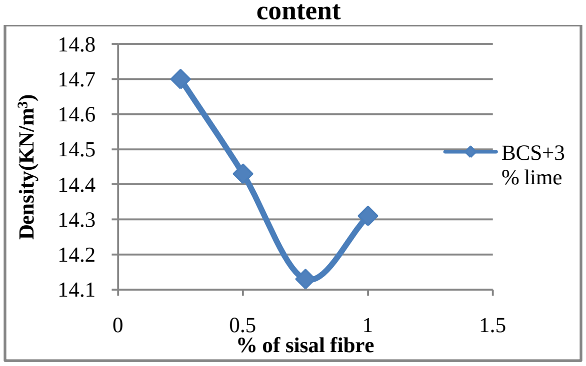

Fig 6.2: Variation of OMC with respect to soil-lime-fibre content

6.2 Unconfined Compressive Strength (UCS) Test

Unconfined compressive strength (UCS) of the soil samples with different percentages of sisal fibre (0.25, 0.5, 0.75 and 1%) and 3% lime is shown in fig for various curing periods.

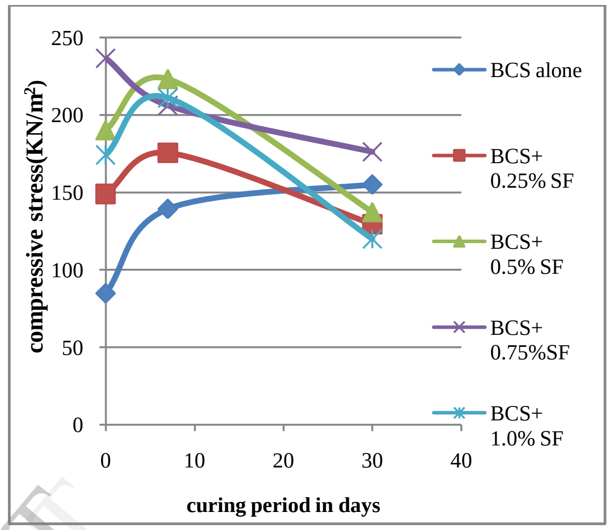

Fig 6.3: variation of UCCS for BCS with addition of sisal fibre

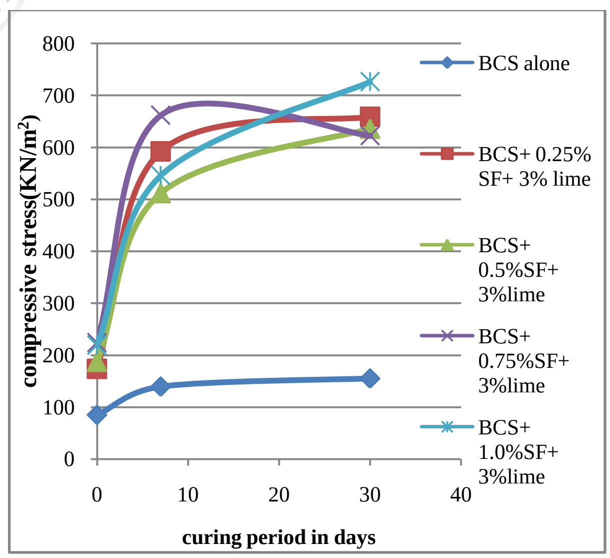

Fig 6.4: variation in UCCS for BCS with addition of sisal fibre and 3% lime

6.3 California bearing ratio (CBR) Test

California bearing ratio (CBR) of the soil samples with different percentages of sisal fibre (0.25, 0.5, 0.75 and 1%) and 3% lime with soaked and unsoaked condition is shown in fig.

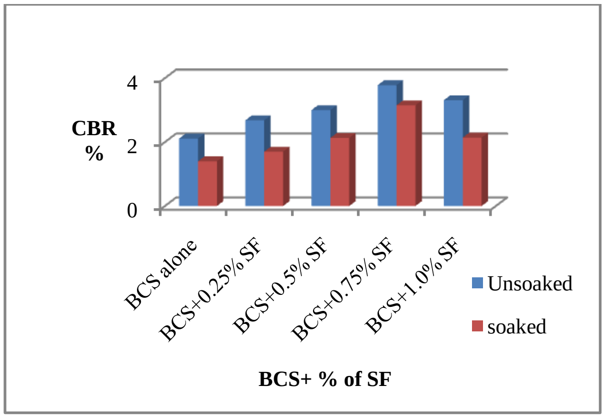

Fig 6.5: variation on CBR value with addition of sisal fibre

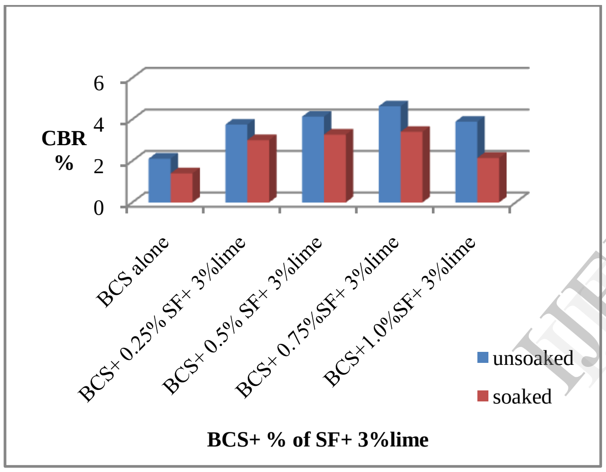

Fig 6.6: Variation in CBR value with addition of Sisal fibre and 3% lime

7.0 CONCLUSIONS

This paper evaluated the effect of sisal fibre on the strength and compaction characteristics of lime treated black cotton soil. A series of tests were performed to study the effects of lime on strength characteristics of black cotton soil.

For a given fibre percentage contents in the compaction tests, the maximum dry density of stabilized soil increased and optimum moisture content decreased. The maximum dry density of sisal fibre reinforced with 3%lime treated soil increased the density value and OMC value

Addition of various percentages of lime to black cotton soil gives increased value in the unconfined compressive strength upto 3% and addition of lime with sisal fibre also gave increase in compressive strength upto 0.75% sisal fibre. The curing period with addition of lime and sisal fibre gave higher strength values. Hence, 3% of lime content and 0.75% of sisal fibre is considered as optimum percentages for black cotton soil.

Addition of various percentages of lime to black cotton soil gave increased value in the CBR upto 3% as we can observe in bar graph. Then the addition of sisal fibre gave increased value of CBR for 0.75% sisal fibre. The combination of 3% lime and 0.75% sisal fibre gives more increased value than addition of lime and sisal fibre. Hence, 3% of lime content and 0.75% of sisal fibre can be considered as optimum percentages for black cotton soil to increase the CBR value.

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