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Stabilization Of Black Cotton Soil By Using Lime And Recron Fibers

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ABSTRACT

Geotechnical engineers face various problems while designing the foundations on highly compressible clayey soil due to poor bearing capacity and excessive settlement. Most of the soil available are such that they have good compressive strength adequate shear strength but weak in tension / poor tensile strength. To overcome the same, many researchers have concentrated their studies on soil improvement techniques by developing new such materials, through the elaboration of composites. The main objective of this study is to investigate the effect of fibers in geotechnical applications and to evaluate the strength of unsaturated soil by carrying out compaction tests and CBR tests on two different soil samples. The fibers are cut in lengths of 6mm and mixed randomly with lime-soil mixture in varying percentages (0.50%, 1.00%, 1.5%, 2.0% 2.5% and 3.0%) by dry weight of soil and compacted to maximum dry density at optimum moisture content. The test results indicate a reduction in the maximum dry density and the optimum moisture content of soil due to the addition of Recron fiber. It also indicates an improvement in the CBR value.

Keywords *- Black cotton soil, Reinforcement, Compaction, Formulation, California Bearing Ratio (CBR).*

1. Introduction

In India, the modern era of soil stabilization began in early 1970's, with a general shortage of petroleum and aggregates, it became necessary for the engineers to look at means to improve soil other than replacing the poor soil at the building site. Soil stabilization was used but due to the use of obsolete methods and also due to the absence of proper technique, soil stabilization lost favour. In recent times, with the increase in the demand for infrastructure, raw materials and fuel, soil stabilization has started to take a new shape. With the availability of better research, materials and equipment, it is emerging as a popular and cost-effective method for soil improvement.

1.1 **Principles of Soil Stabilization**:-

- Evaluating the soil properties of the area under consideration.
- Deciding the property of soil which needs to be altered to get the design value and choose the effective and economical method for stabilization.
- Designing the Stabilized soil mix sample and testing it in the lab for intended stability and durability values.

2 Materials

2.1 Black cotton soil

Black cotton soil is also called as Black cotton soil or swelling soil. This soil is found in extensive regions of the Deccan. The name 'Black cotton' has an agricultural origin. Most of the soils are black in colour and are good for growing cotton. Some of these soils have reddish brown and grey colour. The soils are usually found near surface, with the layers thickness varying from 0.5mts to more than 10mts. Black cotton soils are highly Black cotton, sticky, plastic clays formed from residual weathering of deposits derived from volcanic rocks. These soils have great affinity towards moisture and are characterized by their high swelling and shrinkage.

2.2 Lime

The source rock for the production of lime is *Limestone* - (Calcium Carbonate $CaCO_3$) which occurs naturally as a sedimentary rock. Lime can be used to treat soils in order to improve their workability and load-bearing characteristics in a number of situations. Lime Stabilization has the potential to reduce initial construction costs through improved sub grade stability and reductions in pavement structure. Types of lime:- The two types of lime used on construction are hydrated lime and quicklime.

Figure 1 Lime

Table 1 : Lime Properties

Property	Value (%)
Calcium hydroxide	90
Silica	1.5
Ferric oxide	0.5
Magnesium oxide	1.0
Alumina	0.2
Carbon dioxide	3.0

2.3 Polyester (Recron) fiber

The primary purpose of reinforcing a soil mass is to improve its stability by increasing its bearing capacity, and by reducing settlement and lateral deformation. Conventional reinforcing methods make use of continuous inclusions of strips, fabrics, and grids into the soil mass. These fibers were made from polymerization of pure teraphthalic acid and Mono Ethylene Glycol using a catalyst. These fibers were found to be widely used in concrete technology. Fig.3.2.4 shows a view of fibers used in this study. Which has a special triangular cross-section and equivalent diameter of fiber was about 32 μm– 55 μm.

Figure 2 Recron fibers

Table 2 : Recron fiber Properties

Property	Values
Colour	White
Cut length	6mm,12mm
Denier (d)	1.5
Tensile Strength (MPa)	600
Specific Gravity	1.334
Equivalent diameter (μm)	32-55
Water absorption (%)	85.22
Acid resistance	Excellent
Alkali resistance	Good

3 Objectives of the study

The experimental work consists of the following steps:

a. Determination of soil index properties (Atterberg Limits) & Specific gravity of soil
b. To determine the reinforcing effect of randomly distributed recron fibers on the compaction characteristics, CBR Value of lime stabilized black cotton soil.
c. The study focuses on effect of change of percentage fiber content on the engineering properties of the soil.
d. Determination of dry density-water content of BCS and BCS with varied percentage of lime.
e. Dry density-water content for various percentages and different length of recron fibers in optimum BCS-lime mixture.

4 Methodology

Parameters considered in the present experimental work are length and percentage of recron fiber

a. Fiber reinforced soil samples are to be prepared at maximum dry density (MDD) and optimum moisture content (OMC).Optimum lime content to be determined by mixing black cotton soil with lime (1%, 2%, 3%, 4%, 5%).
b. The reinforced soil are to be prepared by adding recron fiber (0.5%, 1.0%, 1.5%, 2.0%, 2.5%, 3.0%) by varied length of 6mm and 12mm.
c. Fibers are to be randomly mixed with soil to form homogenous mixture.
d. Moist soil fiber mix are to be transferred to mould and compacted.
e. Compaction test should be conducted as per IS 2720-VII & CBR tests to be conducted for various combinations of soil sample compacted to their OMC-MDD as per IS 2720 part 16.

5 Formulations

Specific gravity (G):-

$$G = \gamma_S / \gamma_W$$

Where, γ_S - unit wt of soil solids, γ_W - unit wt of water

Moisture content:-

$$W = (W_W/W_S)*100$$

Where, Ww - Weight of water, Ws - Weight of soil solids

Atterberg limits: - The Atterberg limits are most use full for civil engineering, purposes they are Liquid limit, Plastic limit, Shrinkage limit.

Differential free swell:-

DFS= $[V_w - V_k] / V_k \times 100$

V_w = volume of soil specimen read from the graduated cylinder containing distilled water.

V_k = volume of soil specimen read from the graduated cylinder containing kerosene.

6 Result and discussion

Table 3 : Experimental results

Geotechnical properties	**Values obtained**
Specific gravity	2.49
Liquid limit	52.50%
Plastic limit	22.5%
Plasticity index	30%
Shrinkage limit	10.2%
Classification of soil	CH
Differential free swell	70 %
Optimum moisture content	16.0 %
Maximum dry density	15.90 KN/M^3

6.1 Dry density-moisture content of Bc soil with lime and recron fibers

Dry density-moisture content of lime treated BC soil at various percentage of recron fibers are shown in Fig-6.1. The OMC and MDD have been reduced for lime treated BC soil reinforced with recron fiber with different length. This is due to the disintegration of soil particles with the addition recron fibers.

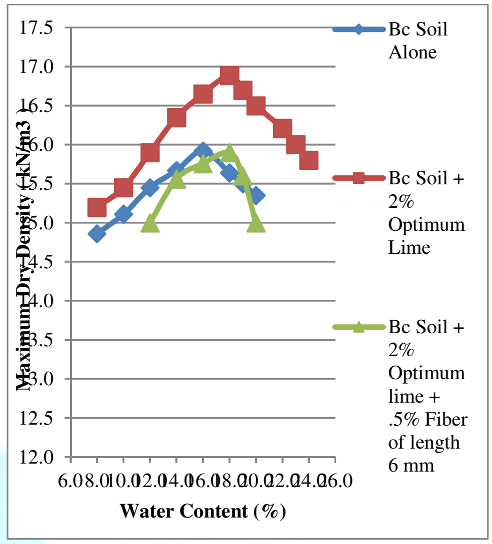

Figure 3 Dry density-water content for various percentage and length of Recron fibers in optimum Black Cotton Soil (BCS)-lime mixture

6.2 CBR Test Result

The Figure-6.2(a) and Figure-6.2(b) shows that load increases with addition of 2% optimum lime and different percentage of fibers of 6mm length up to certain limit beyond that load decreases. With corresponding penetration value also increases up to certain limit beyond that penetration value decreases.

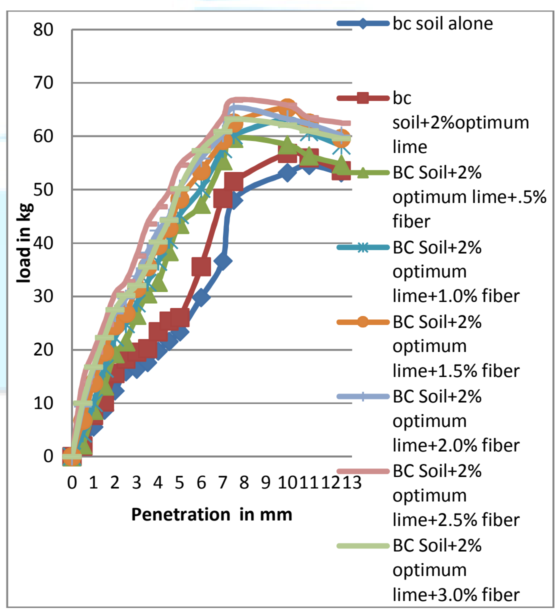

Figure 4 CBR Soaked

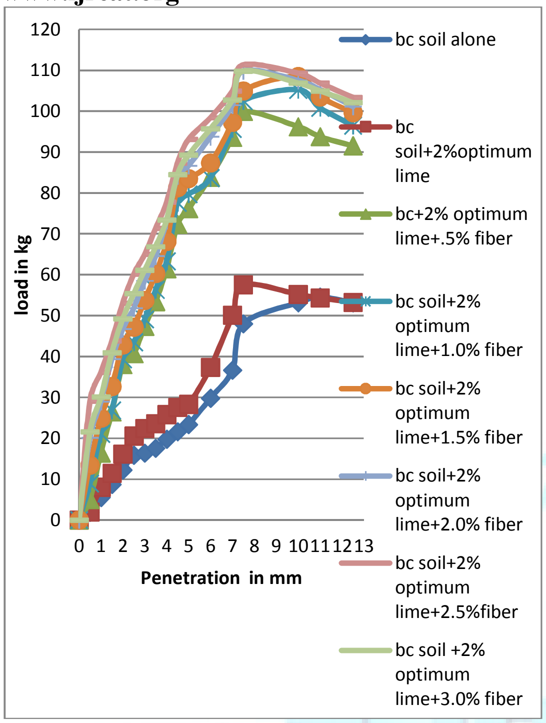

Figure 5 CBR UnSoaked

Table 4 : Black cotton Soil @ 2.5mm penetration.

Black cotton soil	Soaked(4 days)	Un-soaked
CBR in %	1.16	1.30

Table 5 : Black cotton Soil using lime @ 2.5mm penetration.

Black cotton soil	Soaked(4	Un-soaked
CBR in %	1.33	1.50

Table 6 : Black cotton Soil using lime and fiber @ 5mm penetration.

Black cotton soil using 2% lime and varied percentage fiber	Soaked (4 days) 6mm length of fiber	Unsoaked (4 days) 6mm length of fiber
0.5%	2.10	3.70
1.0%	2.20	3.74
1.5%	2.34	4.06
2.0%	2.44	4.22
2.5%	2.65	4.53
3.0%	2.40	4.33

7 Conclusions

- The MDD of BC soil increases with the addition of lime with corresponding increase in OMC. The adhesion between the water and soil particles increases with the increase in lime content up to 2%. With the further addition of lime beyond 2% MDD reduces and OMC increases.
- The addition of randomly distributed Recron fiber to BC soil with different percentages reduces MDD and increases OMC up to some extent. The BC soil mixed with optimum percentage of lime and 0.5% of fiber of 6mm length shows maximum value of MDD.
- The bearing resistance of specimens is found to increase with the fibre content. However, the rate of increase of strength with fibre content is not uniform. At low strain levels the bearing resistance is found to remain almost constant with fibre content.
- Randomly oriented discrete inclusions incorporated into granular materials improve its load – deformation behavior by interacting with the soil particles mechanically through surface friction and also by interlocking.
- The addition of varied percentage of fibers with lime content to BC soil showed that (6mm length fiber) the 2.5% fibers added gave higher CBR value.

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