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EFFECT OF BAMBOO REINFORCMENT IN STABILIZATION OF BLACK-COTTON SOILS

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ABSTRACT

Soil is a minute particle having different properties, which are responsible for various civil engineering constructions. Soil is classified into cohesive and cohesive-less and cohesion less soils has more shear strength and bearing capacity than cohesive soils. Black cotton soil is a type of cohesive soil having less shear strength and bearing capacity. Hence the soils not suitable to construct structures like highways, sky scrapers marine structures and machine foundations. Stabilization of black cotton soil by chemical methods is very expensive compare to natural methods. . Bamboo is a naturally available material from bamboo tree and it has high tensile strength, shear strength and compression strength. Laboratory tests were conducted on black cottons soils by introducing bamboo as a reinforcement to know the strength of reinforced soil at optimum moisture content, natural moisture content, plastic limit and the fifty percent of plastic limit. The test results are analyzed with and without bamboo reinforcement and found considerable increase in soil bearing capacity and settlements.

Keyword: *Black cotton soils, Bamboo reinforcement, Soil stabilization*.

I. INTRODUCTION

For design and construction of any major structures, the soil conditions are important. Type of soil present at the site and its properties are great importance for design of foundations of structures. Black cotton (BC) soil is one of the major soil deposit in India and is spread over a wide area of 3,00,000 sq. km., (Fig. 1) they are found in regions having low to medium slopes and poor drainage conditions. BC soil is expansive in nature due to the presence of montmorillonite and illite clay minerals and exhibits low bearing capacity. Stabilization of black cotton soil is to improve shear strength and bearing capacity. The soil behavior depends upon the type material used for stabilization.

Alemu D.G., et al. (2017) report stabilization of soil is performed by using Industrial waste materials and Admixtures [1]. The materials used are fly ash, marble dust, lime, cement, waste paper sludge, crushed glass and expanded polystyrene. The optimum ratio of fly ash, marble dust is 15% of weight of Soil. Kavish Mehta et al. (2014): report Lime stabilization of black cotton soil increases the strength and decreases the material plastic properties. The stabilization method [2] can be preferred for large constructions and for the construction of roads. By adding lime the swelling properties also decreases and the strength of soil increased by getting high C.B.R values. Vishnu et al. (2016) Stabilization carried out by adding rice husk ash and jute fiber. The combination of 6% Lime and 6% Rice husk ash was obtained as the optimum percentage for getting more strength to the soil [3]. Among various combinations of jute, 2% jute of aspect ratio 25 proves to be more effective as compared to lower percentages.

Pavani and Mangamma (2017) report stabilization of black cotton soil is done by adding fly ash and egg shell powder. When fly ash is added to the soil as increment of 5% the properties of the soil are altered and maximum dry density is 2.63 gm/cc and Optimum moisture content is 12.5% [4]. When Egg shell powder is used for stabilization, the Optimum moisture content of soil is 6.67% and the Maximum dry density is 1.79 gm/cc."

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Aazokhiwaruwu (2014) report on use of Bamboo grid reinforcement under the foundation could increase the bearing capacity of peat soil. The plate load test has been conducted to obtain relationship between load and settlement [5]. Bearing capacity increased by 140% for one layer of bamboo reinforcement, 224% for two-layer of bamboo reinforcement and 279% for 3 layers of bamboo reinforcement.

Manjunath et al. (2012) Experimental investigations are done to know the effect of ground granulated blast furnace slag (GGBS) on black cotton soil [6]. UCC strength of Ordinary Black Cotton Soil which was found out to be 188.5 kN/m^2, increased to 3429.37 kPa. Finally, this study concluded that for the proportion of (BC soil + 30% slag) + 4% lime @ OMC on 28th day with proper curing. UCC strength has increased up to 18 times that of ordinary Black Cotton Soil.

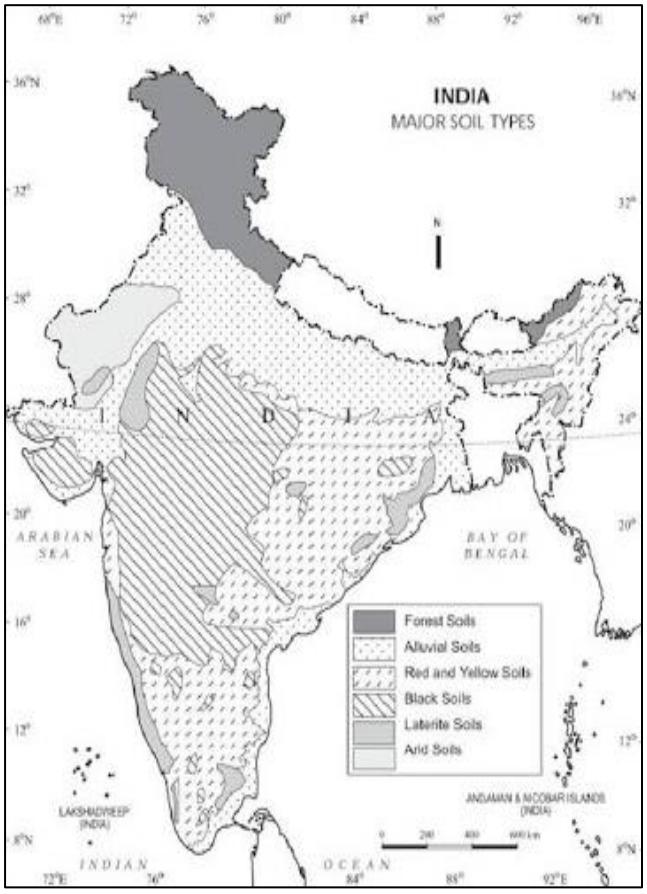

Fig.1 Soil distribution in India

II. MATERIAL PROPERTIES

Bamboo is a naturally available material and is used for soil stabilization and construction purpose. It is easily available, cost effective and the separation of bamboo from the soil is easy compare another material it is an eco-friendly material and strength depends upon its diameter or cross section and length of bamboo used in construction. Mechanical properties of bamboo are tested as per ISO22157 [07- 09] and results are:

Table1. Mechanical properties of bamboo

Property	**Range**
Compressive strength:	40-80 N/mm2
Tensile strength:	160 N/mm2
Shear strength:	4 to 8 N/mm2
Bending strength:	50-150 N/mm2.

Tests are conducted on black cotton soil and the results are as follows:

Table2. Properties of Black Cotton Soil

Specific Gravity (G):	2.68
Water Content	27.82%
Liquid limit	58.30%
Plastic Limit Test	26.20%.
Plasticity Index I_P	32.10%
Wet Sieve Analysis	
Gravel (%)	0
Sand (%)	26
Hydrometer Analysis	
Silt (%)	28
Clay (%)	46
Unconfined compression strength. (kg/mm^2)	6.90
Optimum moisture content (%)	21.70%
Maximum dry density (g/cc)	2.156

III. TEST PROCEDURE

Making of Bamboo reinforcement

A well-seasoned bamboo wood procured from the market. The wood cut into to a size of 3mm to 5mm thickness and of 15 cm lengths and the sizes may vary $\pm$ 2 mm (Fig. 2). The stabilization of soil, bamboo reinforcement is placed at bottom soil to study the settlement criteria.

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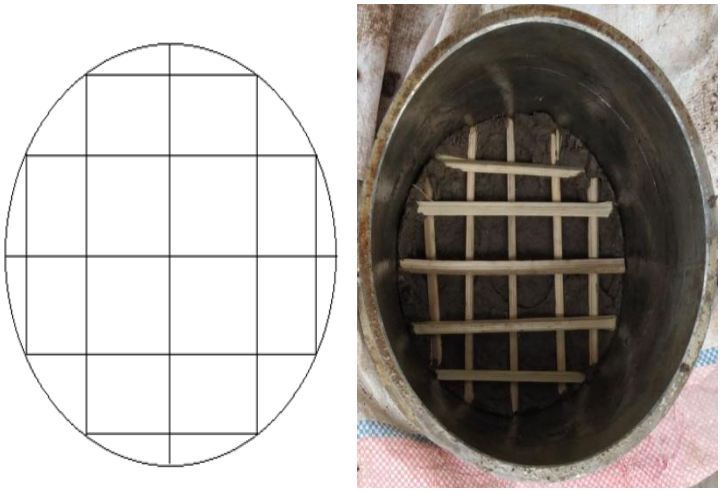

(a) *(b)*

Fig. 2 Bamboo Reinforcement placed in Soil sample

The Bamboo Reinforcement is placed at a depth of 45mm and 95mm from the bottom of the test mould for single and double reinforcement (Fig. 2).

Experiment is carried out in a circular MS mould of 15 cm diameter and 17.5 cm height. The mould has a circular plate of 15cm diameter and 4 cm thickness which is used at bottom to support the sample soil. The experiments are conducted on circular mould, hence only vertical compression loading is possible. The Bamboo Reinforcement of size is placed at depths 45 mm and 95 mm from the bottom of the mould. Tests are carried out to measure the settlements for different moisture content and single and double layer bamboo reinforcement by applying load under CBR equipment.

Soil samples are prepared at optimum moisture content (OMC) and Natural moisture content (NMC) and is placed in mould for testing. The samples are reinforced with bamboos in single and double layers and kept under CBR machine for recording the settlements by applying load. On top of the soil sample circular MS plate is placed and load applied gradually. Dial gauges are arranged to measure settlements and proving reading gives the applied load on to the sample.

The tests are limited to 3mm settlements and corresponding loads are recorded. Also unconfined compressive strength of black cotton soil tested at OMC, NMC, Plastic limit moisture content and 50% plastic limit water content.

IV. RESULTS AND DISCUSSIONS

Black cotton soil samples are prepared to conduct unconfined compressive strength (UCC) test to know the ultimate stress of soil and shear strength of soil. The samples are prepared at OMC, NMC; at plastic limit moisture and 50% plastic limit moisture content (Fig.4).

FUCC test results of black cotton soil

The soil sample exhibits maximum compressive strength at OMC and compressive stress 1.70 kg/cm^2. The graph shows that the strength is less at NMC, plastic limit and 50% moisture contents. Test results for black cotton soil at OMC are carried out for no reinforcement, single layer reinforcement and double reinforcement (Fig. 2). The reinforcement has been placed at 45 mm from bottom of the sample. Lods are applied gradually and load vs. settlements are recorded (Table.3). It was observed that for 4.5% increase in moisture content from OMC to Plastic limit moisture content i.e. 26.2%, there is decrease of about 65.3% in strength.

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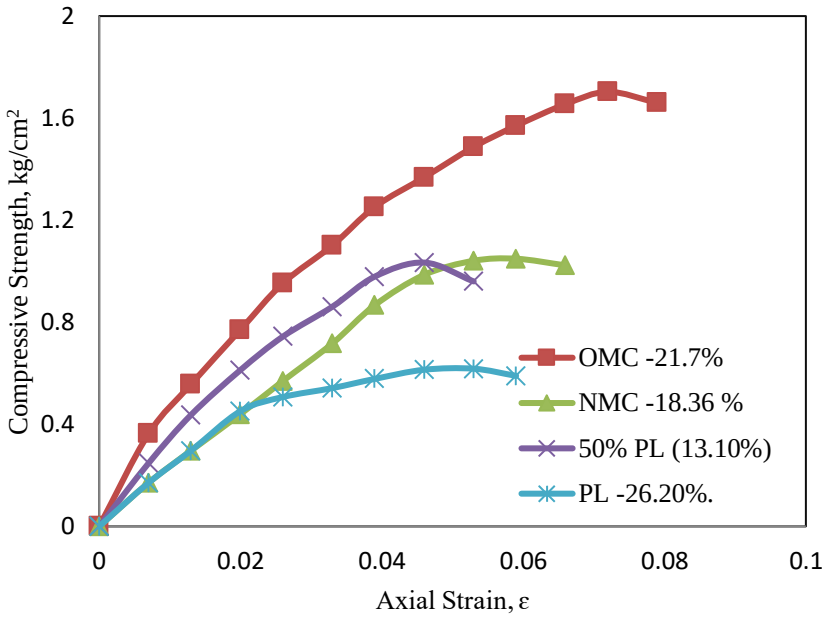

Fig.4 Unconfined compressive test on black cotton soils at various moisture content

Samples were tested under CBR equipment by applying the load and recorded settlements of sample. These results are tabulated and in table 3 and values plot in fig.4.

Table3. Soil settlements at OMC for no bamboo reinforcement and with reinforcement

Settlement (mm)	Without bamboo reinforcement	Single layer bamboo reinforcement	Double layer Bamboo Reinforcement
0	0.00	0.00	0.00
0.5	0.56	0.75	1.28
1	1.85	2.2	2.68
1.5	3.20	3.65	5.19
2	4.70	5.85	8.13
2.5	6.20	7.5	10.95
3	7.50	9.5	13.58

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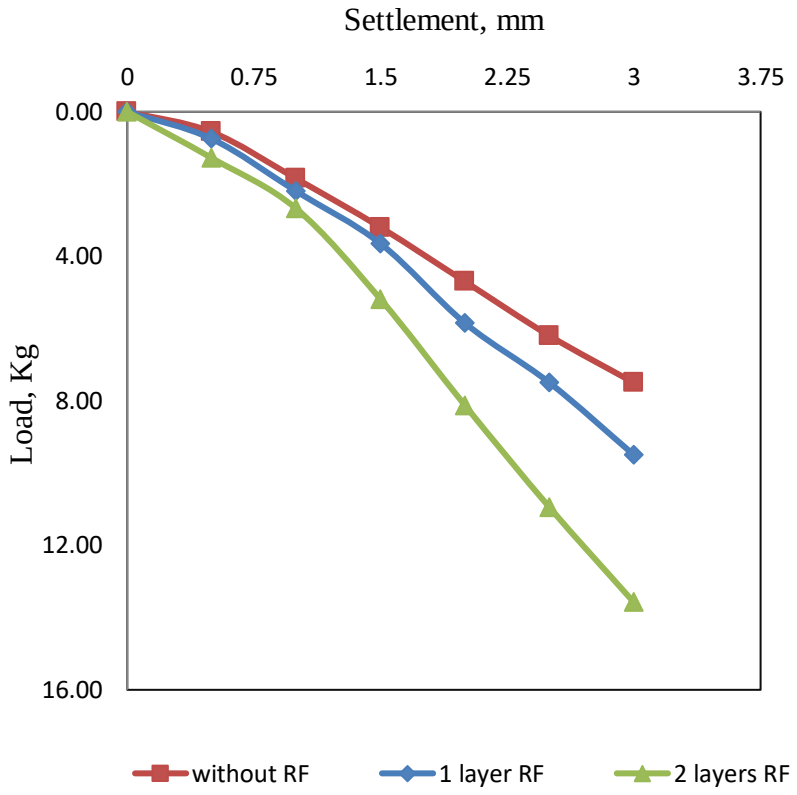

Fig. 5 Load Vs Settlements of black cotton sample at OMC

Settlements were recorded at OMC by varying the reinforcements (Fig. 5). It is observed that settlements are increases as 7.5 kg/cm^2, 9.5 kg/cm^2 and 13.58 kg/cm^2 for no reinforcement, single layer reinforcement and double layer reinforcement respectively (Table 3). There is soil strength increase of 8.5% for single layer and 12.58% double layer upon no reinforcement. There is considerable increase in the soil load bearing due to bamboo reinforcement.

Table 4.Soil settlements at NMC for no bamboo reinforcement and with reinforcement

Settlement (mm)	Without bamboo reinforcement	Single layer bamboo reinforcement	Double layer Bamboo Reinforcement
0	0.00	0.00	0.00
0.5	0.35	0.57	1.34
1	0.95	1.5	2.23
1.5	2.09	2.55	3.06
2	3.50	3.81	4.43
2.5	5.12	5.95	6.92
3	6.50	8.25	10.59

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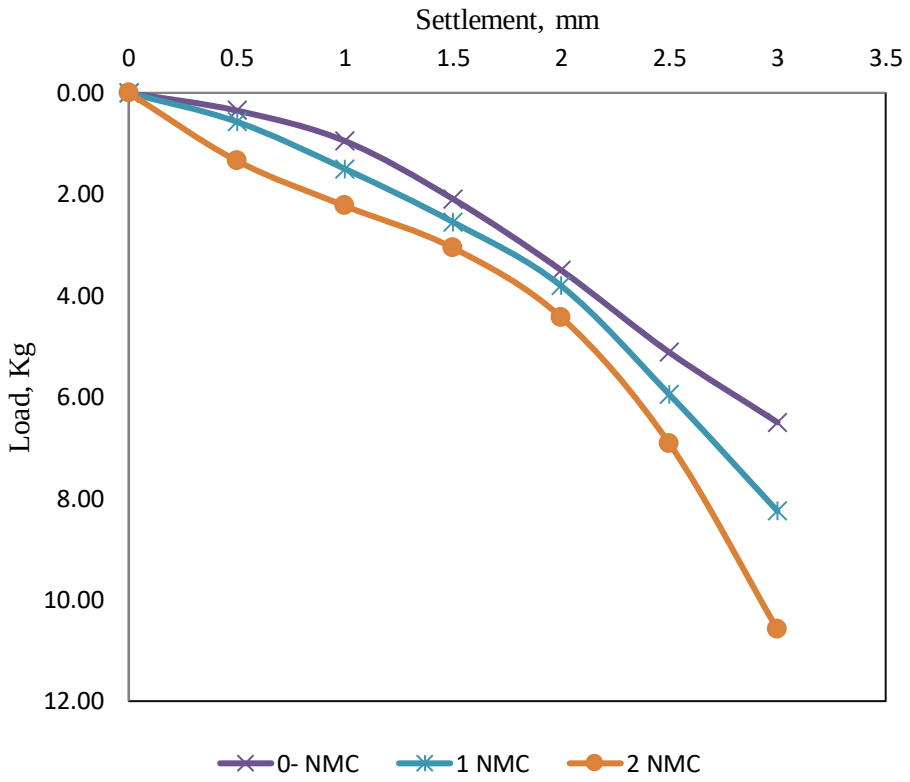

Fig. 6 Load – Settlement curve at Natural moisture content (NMC)

Load-settlement curve of black cotton soil at natural moisture content (NMC) shown in figure.6. The settlement increases gradually and nonlinearly on increase of load. It is observed that settlements are increases as 6.5 kg/cm^2, 8.25 kg/cm^2 and 10.59 kg/cm^2 for no reinforcement, single layer reinforcement and double layer reinforcement respectively (Table 4). There is soil strength increase of 7.25% for single layer and 9.59% double layer upon no reinforcement. There is considerable increase in the soil load bearing due to bamboo reinforcement.

V. CONCLUSIONS

- Unconfined compressive strength of black cotton soil sample has 1.7kg/cm^2 at OMC and the same has been reduced 65% strength upon increase in 4.5% moisture content.
- The load bearing capacity of soil at optimum moisture content are 1325 kg,1678 kg and 2400 kg at no reinforcement, single layer reinforcement and double layer reinforcement respectively.
- There is increase in stress of soil from 7.5 kg/cm^2 to 13.58 kg/cm^2 from no reinforcement to double reinforcement i.e. 12.58%.
- The stress values of soil at Optimum moisture content, natural moisture content are 1148 kg,1458 kg and 1871 kg at no reinforcement, single layer reinforcement and double layer reinforcement respectively.
- There is increase in stress of soil from 6.5 kg/cm^2 to 10.59 kg/cm^2 from no reinforcement to double reinforcement i.e. 9.59%.

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