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A Study on Cotton Fiber Stabilize Soil and its Effect on CBR Value

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Abstract: ***For improvement of soil properties natural fibers can be used with great advantage because they are locally/ readily available, biodegradable, economical and eco-friendly as well. Soil reinforced with natural fiber is responsible for noteworthy improvement in its shear strength, tensile strength and other engineering properties. The use of randomly distributed synthetic and natural fibers over last two decades have gained remarkable popularity and success. In this study samples of locally available soil reinforced with cotton fibers were considered for experimental investigations. California bearing ratio (CBR) test was performed on samples with and without reinforcement for obtaining CBR values of soil by preparing samples at its maximum dry density (MDD) corresponding to its optimum moisture content(OMC). The cotton fiber content by dry weight of soil was taken as 0.3%, 0.6%, 0.9%, 1.2% and 1.5%. Unsoaked and soaked CBR value corresponding to each cotton fiber content was determined in the laboratory as per specified procedure. From the test results it was observed that unsoaked and soaked CBR value of soil increases with fiber content up to 1.2% and then a slight decrease was marked. It was also noticed that the increase in CBR value of reinforced soil was appreciable at cotton fiber content of 1.2%. This increase is responsible for reduction in the pavement crust thickness and ultimately economy in the cost of construction.***

Keywords: CBR value, Cotton fiber, Maximum dry density (MDD), Optimum moisture content (OMC).

1. Introduction

From the very beginning the soil has been used as a construction material and as a support for foundation of various structures. Due to its poor mechanical properties it was always a challenge to engineers to improve its properties as per requirement of site conditions, type of structure and nature of loadings. Various studies have revealed that due to inclusion of reinforcement in the form of fibers in the soil has improved the engineering properties of soil. Fiber reinforced soil has a better resistance towards deformation under applied loadings. The properties which were improved are remarkable i.e. greater extensibility, small loss of post peak strength, isotropy in strength and absence of plane of weakness. Fiber reinforced is effective for all types of soils i.e. sand, silt and clays. Many countries have adopted the fiber reinforcement technique to stabilize soil for improvement of its engineering behavior. Many countries including India have used the natural materials like jute, coir and bamboo as reinforcement in soil. These materials are in abundance in country like India and other adjoining countries. These materials are locally available and hence they are cheaper. These materials are biodegradable in nature so they do not create any disposal problem and are eco-friendly. The use of these materials in rural construction activities is a boon for India as the cost of construction can be reduced. The effective utilization of these materials will result in uplift of rural economy as well. In 2011 Sen and Reddy have shown that natural fiber of jute possess highest tensile strength, can withstand decaying and effect of heat. Researchers Sivkumaar Babu and Vasudevan have shown that by coating fiber with Phenol and Bitumen, the durability of natural fiber can be increased. To calculate the effect of parameters like fiber orientation, fiber content , fiber area ratios and fiber stiffness Gray and Ohashi in 1983 have conducted several direct shear tests on dry sand reinforced with randomly distributed synthetic, natural and metallic fibers and gave following conclusions-

- An increase in shear strength is directly proportional to fiber area ratios.
- Shear strength envelopes for fiber- reinforced sand shows the existence of a threshold confining stress below which the fiber tries to slip or pull out.

Many researchers in past have used various types of randomly distributed fibers for reinforcing the soil to improve its performance. The prominent researchers who have utilized different fibers are listed below in the Table.1 .

Table 1: Researchers and utilized fibers

Name of Researchers	Fiber Utilized
Andrews et.al,1986	Polymeric mesh elements
Gray and Al Refeai,1986, Mahar and Gray,1990, Consoli et. al,2002, Rao et al, 2006, Chandra et al, 2008, Singh 2011	Synthetic fiber
Fatani et al, 1999	Metallic fiber
Lawton et al, 1993	Multi-oriented Polypropylene elements
Lekha,2004 and Vishnudas et al, 2006	Coir geotextile
Sivkumaar Babu and Vasudevan, 2008	Coir fiber
Singh and Yachang ,2012	Jute geotextile sheet

Based on the experimental results they concluded that stress-strain behavior of soil is improved by introduction of coir-fiber into the soil and Jute Geotextile sheet was responsible for improvement in CBR value of fly ash appreciably. They also concluded that there was an increase in deviator stress at failure up to 3.5 times over the unreinforced soil. It was also observed by them that stiffness modulus of reinforced soil increases considerably which is responsible for significant reduction in immediate settlement of soil. Application of Jute fiber to improve subgrade characteristics was studied by Aggrawal and Sharma in 2010. They concluded that there was an increase in CBR value of subgrade up to 250% with introduction of bitumen coated jute fiber. Singh and Bagra in

2013 have shown that there was significant increase in CBR value of soil up to 200% with jute fiber having varying length and diameters of fiber.

2. Objectives

- To study the effect of inclusion of cotton fiber as a reinforcement in the soil and its effect on CBR value of soil.
- To carry out CBR test to evaluate the CBR value of unsoaked and soaked samples of soils with and without the cotton fiber reinforcement.
- To compare CBR values of cotton fiber reinforced soil with unreinforced soil and .
- To obtain optimum cotton fiber content to produce best results.

3. Materials and Methods

3.1. Materials: The materials used for the purpose of investigations and study are listed below-

3.1.1. Soil: The locally available soil collected from nearby locality of Lucknow district, Uttar Pradesh a state of India was used for preparation of sample with and without reinforcement.

3.1.2. Cotton Fiber: The reinforcing element in this study was synthetic cotton fiber which was collected from local shop. The physical properties of cotton fiber is as under-

Table.2 Properties of cotton fiber

Particulars	*Value*
Length (mm)	15 – 55
Diameter (mm)	0.01 –0.03
Color	Depends upon climatic conditions
Polymer system	Linear, cellulose polymer

A typical picture of cotton fiber is shown below in Fig.2.

Figure 2: Cotton Fiber

3.2 Method

The required samples were prepared in accordance with the provision of concerned code of practice and as per prescribed procedure. The various properties like Index properties, compaction parameters and CBR value were determined. The category wise details are described as under-

3.2.1. Index properties and compaction parameters

The index properties and compaction parameters (maximum dry density and optimum moisture content) of locally available soil sample were determined in the laboratory as per specified procedures and guidelines. The values of various parameters are laid shown in Table.3 below.

Table 3: Index properties and Compaction parameters

Properties	*Value*
Specific gravity(G)	2.68
Liquid Limit (LL%)	23
Plastic Limit (PL)	NP
Gravel size (>4.75mm)%	0
Sand size (0.075-4.75 mm) %	42
Silt size (0.002-0.075 mm)%	55
Clay size (<0.002 mm)%	3
Coefficient of Uniformity (Cu)	6.68
Coefficient of Curvature(Cc)	1.33
Maximum Dry Density(MDD) g/cm³	1.70
Optimum Moisture Content (OMC) %	15.86

The particle size distribution curve (PSD) was plotted as shown in Fig.2 below.

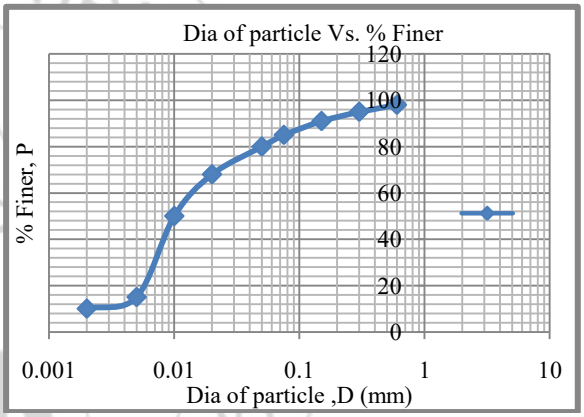

Figure 2: Particle size distribution curve (PSD) of Soil

3.2.2 California Bearing Ratio (CBR) Test

The soil samples for unreinforced and reinforced soil were prepared as per prescribed standard procedure and guidelines of IS codes and the CBR test was performed on both unsoaked

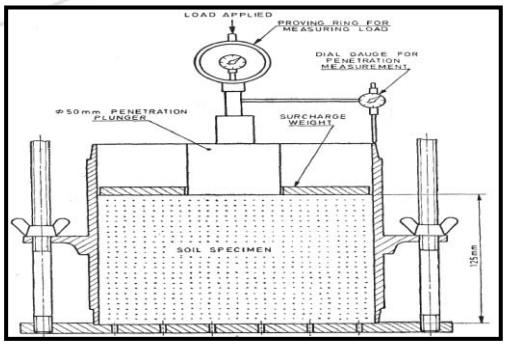

Figure 3: Set up for CBR Test

and soaked samples in accordance with the provision of IS:2720 Part 16-1987. The CBR values were determined accordingly. The set up for CBR test is shown in Fig. 3.

4. Results and Discussions

The unsoaked and soaked CBR values were determined for both plain soil and reinforced soil with varying percentages of cotton fiber i.e. 0.3%, 0.6%, 0.9%,1.2% and 1.5% by dry weight of soil. The results are tabled in Table. 4 as shown below-

Table 4: CBR value of Cotton fiber reinforced soil

Cotton fiber content(%)	CBR Value (%)	% increase in CBR Value
Unsoaked CBR value		
0	10	-
0.3	17.15	71.5
0.6	18.30	83
0.9	19.06	90.6
1.2	23.56	135.6
1.5	19.48	94.80
Soaked CBR value		
0	4.2	-
0.3	5.92	41
0.6	6.98	66.19
0.9	7.68	82.85
1.2	8.90	111.19
1.5	7.86	87.14

It was observed from the results as shown in Table.4 that there was an increase in both unsoaked and soaked CBR value of soil as the cotton fiber content is increased up to 1.2% after that there is a slight decrease in the CBR value at cotton fiber content of 1.5%. From the Table.4 it is clear that the maximum unsoaked CBR value is 23.56% at cotton fiber content of 1.2%, which is 2.35 times that of unreinforced soil. It indicates that there was an increase of 135.6% in CBR value at 1.2% fiber content. It was also observed from the Table.4 that the maximum soaked CBR value is 8.90% at cotton fiber content of 1.2%, which is 2.11 times that of unreinforced soil. It indicates that there was an increase of 111.19% in CBR value at 1.2% fiber content. However beyond 1.2% fiber content the value of CBR decreases and in case of soaked sample it is 7.86% at cotton fiber content of 1.5%.

The CBR value increases due introduction of randomly distributed cotton fiber because the introduced fiber is incorporated into soil mass and is responsible for improvement in its load deformation behavior by interacting with soil particles mechanically through surface friction and interlocking. The bond or interlock is responsible for transfer of stress from soil to discrete inclusion by mobilizing the tensile strength of fiber inducted. The fiber reinforcement acts as a frictional and tension resistant element. Further addition of fiber makes the soil a composite material resulting in greater strength and stiffness as compared to unreinforced soil. This may be the reason also that CBR value of reinforced soil was found greater than that of unreinforced soil. The optimum cotton fiber content corresponding to maximum value of CBR was found to be 1.2% by dry weight of soil.

5. Conclusions

Based on the experimental investigations and study the following conclusions can be drawn-

1) There was an increase in CBR value of soil with the introduction of cotton fiber for both unsoaked and soaked conditions up to cotton fiber content of 1.2% after that there is a slight decrease in the CBR value at cotton fiber content of 1.5% .
2) The maximum unsoaked CBR value is 23.56% at cotton fiber content of 1.2%, which is 2.35 times that of unreinforced soil. It indicates that there was an increase of 135.6% in CBR value at 1.2% fiber content.
3) The maximum soaked CBR value is 8.90% at cotton fiber content of 1.2%, which is 2.11 times that of unreinforced soil. It indicates that there was an increase of 111.19% in CBR value at 1.2% fiber content. However beyond 1.2% fiber content the value of CBR decreases and in case of soaked sample it is 7.86% at cotton fiber content of 1.5%.
4) The optimum cotton fiber content corresponding to maximum value of CBR was found to be 1.2% by dry weight of soil.

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Author Profile

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