International Journal of Current Engineering and Technology
ISSN 2277 - 4106

Available at http://inpressco.com/category/ijcet

Research Article

Effects of Cotton Fiber on CBR Value of Itnagar Soil

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Accepted 05 August 2013, Available online 10 August 2013, **Vol.3, No.3 (August 2013)**

Abstract

Use of natural fiber in civil engineering for improving soil properties is advantageous because they are cheap, locally available, biodegradable and eco-friendly. The natural fiber reinforcement causes significant improvement in tensile strength, shear strength, and other engineering properties of the soil. Over the last decade the use of randomly distributed natural and synthetic fiber has recorded a tremendous increase. Keeping this in view the present study was taken up. In this study a number of experiments were conducted on locally available (Doimukh, Itanagar, Arunachal Pradesh, India) soil reinforced with cotton fiber. Soil samples for CBR value tests were prepared at its maximum dry density corresponding to its optimum moisture content in the CBR mould with and without reinforcement. The percentage of cotton fiber by dry weight of soil was taken as 0.25%, 0.5%, 0.75% and 1% and corresponding to each fiber content unsoaked and soaked CBR tests were conducted in the laboratory. Tests result indicates that unsoaked and soaked CBR value of soil increases with the increase in fiber content. It was also observed that increase in CBR value of reinforced soil is substantial at fiber content of 1 %. Thus the significant increase in CBR value of soil due to cotton fiber will substantially reduce the thickness of pavement subgrade.

Keywords: *CBR value, Soil, Cotton fiber, Random Length, Random Diameter*

1. Introduction

Soil has been used as a construction material from time immortal. Being poor in mechanical properties, it has been putting challenges to civil engineers to improve its properties depending upon the requirement which varies from site to site. During last 25 years, much work has been done on strength deformation behaviour of fiber reinforced soil and it has been established beyond doubt that addition of fiber in soil improves the overall engineering performance of soil. Among the notable properties that improved are greater extensibility, small loss of post peak strength, isotropy in strength and absence of planes of weakness. Fiber reinforced soil has been used in many countries in the recent past and further research is in progress for many hidden aspects of it. Fiber reinforced soil is effective in all types of soils (i.e. sand, silt and clay). Use of natural material such as Jute, coir, sisal and bamboo, as reinforcing materials in soil is prevalent for a long time and they are abundantly used in many countries like India, Philippines, Bangladesh etc. The main advantages of these materials are they are locally available and are very cheap. They are biodegradable and hence do not create disposal problem in environment. Processing of these materials into a usable form is an employment generation activity in rural areas of these countries. If these materials are used effectively, the rural economy can get uplift and also the cost of construction can be reduced, if the material use leads to beneficial effects in engineering construction. Of all the natural fiber Jute has highest tensile strength and withstand rotting and heat (Sen and Reddy, 2011). Studies have also shown that durability of natural fiber can be improved using coating of fiber with Phenol and Bitumen which is easily available in these areas (Sivakumar Babu and Vasudevan 2008). Many studies have been conducted relating to the behaviour of soil reinforced with randomly distributed fiber. Gray and Ohashi (1983) conducted a series of direct shear tests on dry sand reinforced with different synthetic, natural and metallic fiber to evaluate the effects of parameters such as fiber orientation, fiber content, fiber area ratios, and fiber stiffness on contribution to shear strength. Based on the test results they concluded that an increase in shear strength is directly proportional to the fiber area ratios and shear strength envelopes for fiber-reinforced sand clearly shows the existence of a threshold confining stress below which the fiber tries to slip or pull out. Various types of randomly distributed elements such as polymeric mesh elements (Andrews et.al, 1986), synthetic fiber (Gray and Al Refeai 1986, Mahar and Gray 1990, Ranjan et. al, 1996, Charan 1995, Consoli et al., 2002, Michalowski and Cermak, 2003, Gosavi et al., 2004, Yetimoglu and Inanir 2005, Rao et al., 2006, Chandra et al. 2008 and Singh 2011) metallic fiber (Fatani et al.1999) and discontinuous multioriented polypropylene elements (Lawton et.al, 1993)

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have been used to reinforce soil and it has been shown that the addition of randomly distributed elements to soils contributes to the increase in strength and stiffness. Lekha (2004) and Vishnudas et al. (2006) have presented a few case studies of construction and performance monitoring of coir geotextile reinforced bunds and suggested that the use of coir is a cost effective ecohydrological measure compared to stone-pitching and other stabilization measures used in the protection of slopes and bunds in rural areas. Sivakumar Babu and Vasudevan (2008) and Singh et.al (2011) studied the strength and stiffness response of soil reinforced with coir-fiber. Singh and Yachang (2012) used the Jute Geotextile sheets to improve the laboratory CBR value of fly ash. Based on the experimental results they found that stress-strain behaviour of soil is improved by inclusion of coir-fiber into the soil and Jute Geotextile sheets improves the California Bearing Ratio (CBR) value of fly ash significantly. They further concluded that the deviator stress at failure is increased up to 3.5 times over the plain soil. They also observed that stiffness modulus of reinforced soil increases considerably which can reduce the immediate settlement of soil significantly.

Aggarwal and Sharma (2010) studied the application of Jute fiber in the improvement of subgrade characteristics. . The CBR value of the subgrade soil increases up to 250% with the inclusion of bitumen coated Jute fiber. Singh and Bagra (2013) also conducted the laboratory CBR tests on Itanagar, Arunachal Pradesh, India soil reinforced with Jute fiber having varying lengths and diameters of fiber and concluded that there is a significant increase (200 %) in CBR value of soil due to Jute fiber.

This paper presents the influence of cotton fiber on the CBR value of Itanagar, Arunachal Pradesh, India soil which is a typical soil and is normally used in the construction of embankments and pavement subgrade in tropical countries such as India. A number of unsoaked and soaked CBR value tests have been conducted on soil and soil reinforced with varying amount of cotton fiber The CBR values of reinforced soil have been compared eith that of unreinforced soil.

2. Materials

2.1 Soil

The soil used in this study was collected from the site of Doimukh RCC Bridge constructed on Dikrong River near Itanagar, Arunachal Pradesh, India. The various index properties and compaction properties (maximum dry density and optimum moisture content) of soil were determined in the laboratory which is given in Table 1. The grain size distribution curve of soil is shown in Fig. 1

2.2 Cotton Fiber

The synthetic cotton fiber was used as reinforcing material in this study and was purchased from the local market. The length and diameter of cotton fibers generally varies between 16 mm to 52 mm and 0.01 mm to 0.03 mm respectively. A typical view of cotton fiber is shown in Fig. 2

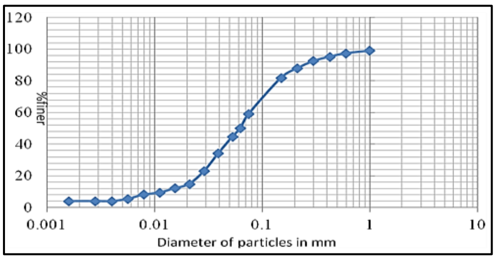

Fig. 1: Grain Size Distribution Curve of Itanagar Soil

Table 1 Index properties and compaction properties

S. No	Properties	Value
1.	Specific gravity (G)	2.65
2.	Liquid Limit	24%
3.	Plastic Limit	NP
4.	Gravel Size (> 4.75 mm)	0
5.	Sand Size (0.075-4.75)	44%
6.	Silt Size (0.002-0.075)	52%
7.	Clay Size (< 0.002 mm)	4%
8.	Coefficient of Uniformity (C_u)	6.72
9.	Coefficient of Curvature (C_c)	1.29
10.	Maximum Dry Density	17.20 kN/m^3
11.	Optimum Water Content	16.54 %

Fig. 2: View of Cotton Fiber

3. Test Procedure

The soil samples of unreinforced and reinforced soil for CBR test were prepared as per standard procedure. The desired amount of oven dried (100-1050C) soil was taken and mixed thoroughly with water corresponding to its optimum moisture content (OMC) in the CBR mould having 150 mm diameter and 175 mm high with detachable perforated base plate (IS:2720-XVI). The soil was then compacted to its maximum dry density obtained by laboratory standard Proctor test. For the preparation of soil samples of reinforced soil the desired amount of fiber was mixed in dry state before the addition of water and then compacted to same Proctor density as per IS: 2720, Part VII- (1974). The top surface of the specimen in the CBR mould was made level and a filter paper and a perforated metallic disc were placed over the specimen. With spacer disc placed inside the mould, the effective height remains only 127.3 mm and the net capacity is 2250 cm^3. The CBR mould along with compacted soil and surcharge load of 5 kg was then transferred to a tank containing water for soaking of the sample. After 4 days (i.e. 96 hours) of soaking, the mould assembly was taken out from water and the top surface of sample was left exposed to air for half an hour. CBR mould along with soaked soil sample was brought to a motorized loading frame for testing. The CBR values of the test samples of unreinforced and reinforced soil were determined corresponding to plunger penetrations of 2.5 mm and 5 mm as per the standard procedure laid down in IS: 2720, Part XVI (1965). Unsoaked CBR values of unreinforced and reinforced soil samples were also determined for comparison of the test results.

4. Results and Discussion

The unsoaked and soaked CBR values determined in the laboratory for soil and soil reinforced with varying percentage of fiber content are shown in column 2 of Table 2 and Table 3 respectively.

It is clear from the tests results of Table 2 and Table 3 that both unsoaked and soaked CBR value of soil increases as the fiber content increases. Results from Table 2 show that maximum unsoaked CBR value of reinforced soil is 2.20 times (121 %) that of plain soil at a fiber content of 1 %. The minimum unsoaked CBR value of reinforced soil is observed as 1.83 times (83 %) that of plain soil at a fiber content of 0.25 %. In case of soaked test the maximum CBR value of reinforced soil (Table 3) is 2.12 time (112 %) that of plain soil at a fiber content of 1 %. The results of Table 3 also show that the minimum increase in CBR value of reinforced soil is 1.7 times (70 %) that of plain soil, at fiber content of 0.25 %.

Similar trend was observed by Singh et al. (2011), Singh (2011) and Singh (2012) with the natural and geosynthetic fiber reinforced soil and fly ash. This is due to reason that randomly oriented discrete inclusions incorporated into soil mass improves its load deformation behaviour by interacting with the soil particles mechanically through surface friction and also by interlocking. The function of bond or interlock is to transfer the stress from soil to the discrete inclusion by mobilizing the tensile strength of discrete inclusion. Thus, fiber reinforcement works as frictional and tension resistance element. Further, addition of Jute fiber makes the soil a composite material whose strength and stiffness is greater than that of unreinforced soil. The strength and stiffness of reinforced soil increases with the increase in fiber content and may be due to this reason also the CBR value of reinforced soil was observed to be greater than that of unreinforced soil. The optimum fiber content corresponding to maximum improvement in CBR value is found to be 1 %. It was difficult to prepare the identical samples (at constant dry density) of reinforced soil beyond 1 % of fiber content and hence in the present study the maximum cotton fiber content was considered to be 1 % by dry weight of soil.

Table 2 Unsoaked CBR Value of Cotton Fiber Reinforced Soil

Fiber Content (%)	CBR Value (%)	Increase in CBR Value	(%) Increase in CBR Value
0	11		
0.25	20.13	9.13	83
0.50	20.68	9.68	88
0.75	21.31	10.31	93
1	24.35	13.35	121

Table 3 Soaked CBR Value of Cotton Fiber Reinforced Soil

Fiber Content (%)	CBR Value (%)	Increase in CBR Value	(%) Increase in CBR Value
0	4		
0.25	6.8	2.8	70
0.50	7.16	3.16	79
0.75	7.80	3.80	95
1	8.50	4.50	112

Conclusions

Based on the test results of the present investigation it is concluded that CBR value of soil increases with the inclusion of cotton fiber for both soaked and unsoaked conditions. When the fiber content is increases, the CBR value of soil is further increases and this increase is substantial (112 %) at fiber content of 1 %.

It was also found that preparation of identical soil samples for CBR test beyond 1 % of fiber content is not possible and optimum fiber content was found to be 1 % by dry weight of soil. The maximum increase in CBR value was found to be more than 112 % over that of plain soil at fiber content of 1 % .

Acknowledgements

The authors are thankful to the Head of Civil Engineering Department of NERIST for providing laboratory facilities in conducting the tests. The help and support extended by Sri Rameshwer Bora, Laboratory Assistant of geotechnical engineering lab and of B.Tech. final year students Miss Hage Aruna, Miss Gyati Puming, Miss Tame Nini and Miss Awan Konyak are gratefully acknowledged.

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