EFFECT OF GLASS FIBERS ON RED SOIL

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ABSTRACT

Soil reinforcement has been introduced into the field of geotechnical engineering for many years in order to improve the properties of ground soil in specific engineering projects. Traditional geosynthetics such as geotextile, geogrid etc. have been proved to be efficient, and they are being increasingly used in geotechnical engineering but the use of glass fibres in soil have only started recently. Though some research have been done with a few types of soil, still the volume of study is rather scanty compared to other soil reinforcing materials. Moreover, the effect of randomly distributed glass fibers acting as reinforcement material seems to be an interesting concept due to the absence of potential planes of weakness that can develop parallel to oriented reinforcement. Considering these, a series of tests were performed with red loam soil with glass fibre as reinforcement at various percentage content to find out its effects on the soil and to find whether the particular soil – reinforcement combination is useful.

Keywords: Glass Fibers, Optimum Moisture Content, Plasticity Index, Red Soil, Unconfined Compressive Strength

I. INTRODUCTION

Soil stability is one of the most important topics in geotechnical engineering practices. With frequent failures of soil mass, whether it is on a slope or level ground, have proved to be costly in terms of both life and property. Various soil stabilization techniques including fibre reinforcement have been in use for a while and the results in some of them has been quite satisfactory. Reinforcing soils using tension resisting elements is an attractive means of improving the performance of soil in a cost effective manner. The use of random discrete flexible fibres mimics the behaviour of plant roots and gives the possibility of improving the strength and the stability of near surface soil layers. Practicing engineers are employing this technique for the stabilisation of thin layers of soil, repairing failed slopes, soil strengthening around footings and earth retaining structures. However, more research is needed to further understand the potential benefits and limitations and to allow its application to more complex geotechnical structures (Yetimoglu et al., 2005). Direct shear tests, unconfined compression tests and conventional triaxial compression tests have demonstrated that shear strength is increased and post-peak strength loss is reduced when discrete fibres are mixed with the soil (Al Refeai, 1991; Maher and Ho, 1994; Yetimoglu and Salbas, 2003; Tang et al., 2007 among others). Red Loam Soil being a major type of soil in Assam, the aim of this project is to find the effects of glass fibers on the properties of Red Loam soil extracted from a particular site in Assam. The properties include liquid limit, plastic limit, plasticity index, maximum dry density, optimum moisture content and unconfined compressive strength of the soil. Glass fibre is one such fibre having a durable, inert nature possessing high tensile and compressive strength. However its use is still in an infant stage.

II. LITERATURE REVIEW

A lot of research has been done on fiber reinforced soil. Hejazi et al. (2011) have made a brief review on the applications and benefits of natural and synthetic fibers and concluded that the enhancement in strength and stiffness of the soil matrix can be attributed to fiber characteristics such as aspect ratio, skin friction, weight fraction and modulus of elasticity, on the soil characteristics and also on the test condition such as confining stress. The application of polypropylene fiber showed an improvement in mechanical behaviour of the silty clay as described by O. Plé and T.N.H. Lê (2011). Miller and Rifai (2004) reported that fiber reinforcement reduces the development of desiccation cracks in compacted clay samples, increased the hydraulic conductivity with increase in fiber content, and reduces workability after a particular amount of dose and an increase in dry density of the reinforced soil and a variation of 4.6% value of the optimum water content with the unreinforced soil. They suggested an optimum fiber content of 0.8% as applicable for maximum results. Akbulat et al. (2007**)** have investigated the influence of randomly oriented fiber inclusion on the geotechnical behaviour of clayey soil. They used waste fiber materials such as scrap tire rubber, polyethylene and polypropylene fiber for the modification of clayey soils. Sung-Sik Park (2008) has studied the effect of fiber reinforcement and distribution on the unconfined compressive strength of fiber reinforced cemented sand and concluded that the strength of fiber reinforced cemented soils not only depends on the degree of fiber reinforcement but also on the uniform distribution of fibers within the soil matrix. Puppala and Musenda (2007) investigated the effects of fiber reinforcement on the stabilization of expansive soils and reported that the undrained shear strength of the clay samples increased on inclusion of the fibers as reinforcement. The increase in shear strength was attributed to the tensile strength of fibers in the soil-fiber matrix.

III. MATERIALS AND METHODS

3.1 Red soil

Red soil is a type of soil that has a red to reddish yellow tinge due to presence of iron compounds mainly iron oxide. This soil can form from iron-rich sediments or the compounds may develop in the soil as it weathers. On account of heavy rainfall there is an excessive leaching of soil colloids and silica hence the soils are porous. The soil used in this study was collected from a site near Jalukbari in Assam. The properties of the red soil are given in Table 1.

Table 1

Property	Values
Specific Gravity	2.66
Liquid limit (%)	40.2
Plastic limit (%)	18.24
Plasticity index (%)	21.96
Optimum moisture content (%)	15.7
Maximum dry density (kN/m^3)	17.85

3.2 Glass Fibers

Fiberglass is a lightweight, extremely strong, and robust material. Glass fibers are among the most versatile industrial materials known today. The glass fibers used in this study was locally available, found in the form of mesh. The properties of the fibers are shown in Table 2. Fig. shows a picture of the glass fibers used in the study.

Table 2

TENSILE STRENGTH as per ASTM D2256(IS 235) at 1.8% elongation at break	1.53 GN/ mm^2
Young's Modulus (Priyadarshee 2013) as per ASTM D2256	112.3 GN/ mm^2
Specific Gravity	2.57
Diameter	0.15 mm
Length	~10 mm

Figure 1- Glass Fibers Cut Into 10mm Length

3.3 Methods

The procedure used for this project is as follows:

- At first the soil sample obtained from the site is cleaned from any visible unwanted matter like leaves, plastic etc.
- Then the various index properties of the soil like sieve analysis, liquid limit, plastic limit and moisture content are found out as per IS: 2720 respectively.
- The maximum dry density and optimum moisture content is found out using the Standard proctor test.

- Using the O.M.C found in proctor test, the test sample for the Unconfined Compressive Test is prepared and the related strength parameters are found.
- Now using 0.5%, 1% and 1.5% fibre content by dry weight of the soil, the same tests are performed for each fiber content.

IV. RESULTS AND DISCUSSIONS

4.1 Liquid Limit and Plastic Limit

The liquid limit and plastic limit was determined as per IS: 2720 part 5. The effect of reinforcement on the liquid limit and plastic limit of the soil has been shown in Table 3 and Table 4. It is observed that as the fiber content was increased from 0% to 1.5%, the liquid limit and plastic limit of the soil sample increased. This can attributed to the fact that glass fibers have a tendency to absorb water. Table 5 shows the variation of plasticity index. The plasticity index reduced as the fiber content increased. This indicated that the soil became less compressible when the fibers are added to the soil.

Table 3

FIBRE (%)	LIQUID LIMIT (%)
NO FIBRE	40.2
0.5%	41.6
1 %	45.2
1.5%	46.9

Table 4

FIBRE (%)	PLASTIC LIMIT (%)
0	18.24
0.5	23.02
1	27.86
1.5	31.25

Table 5

FIBRE (%)	PLASTICITY INDEX (%)
0	21.96
0.5	18.58
1	17.34
1.5	15.65

4.2 Optimum Moisture Content and Maximum Dry Density

Compaction tests were conducted as per IS: 2720 Part 7, to determine the optimum moisture content and maximum dry density of the virgin soil and also in presence of reinforcing elements. Fig.2 shows the comparison of the compaction curves for both the virgin and reinforced soil. It is clear from the figure that as the fiber content increased from 0.5% to 1.5%, the maximum dry density reduced and the optimum moisture content increased.

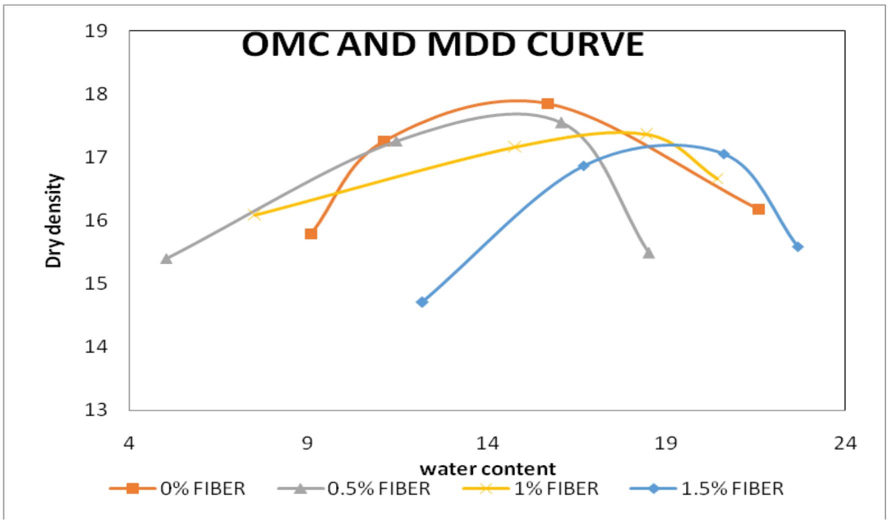

Fig 2: Optimum Moisture Content and Maximum Dry Density Curve

4.3 Unconfined Compressive Strength

The unconfined compressive strength (UCS) of the soil samples were found by conducting unconfined compression tests as per IS: 2720 Part 10. The tests were performed on cylindrical specimens 38mm in diameter and of length 76mm. The soil was compacted at OMC and MDD for the virgin and reinforced soil with varying fiber contents. From Fig.3, it is observed that the unconfined compressive strength of the soil sample increased as the fiber content increased. The unconfined compressive strength of the sample with no reinforcement is around 146 kPa. The value of unconfined compressive strength increased from 146 Kpa to 171 kPa for the sample with 0.5% fiber content, to 180 Kpa for 1% fiber content and 204 kPa for the sample reinforced with 1.5% Kpa. Though the dry density decreased with the increase in fiber content, the unconfined compressive strength increased at all percentages of fiber content. The fibers being strong in tension enhance the bond strength between its surface and the soil particles. Randomly distributed discrete fibers form a coherent matrix with the soil grains and restrict displacement. The the tensile stresses are resisted and the tensile strength of the soil fiber matrix increases.

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ISSN 2348 - 7550

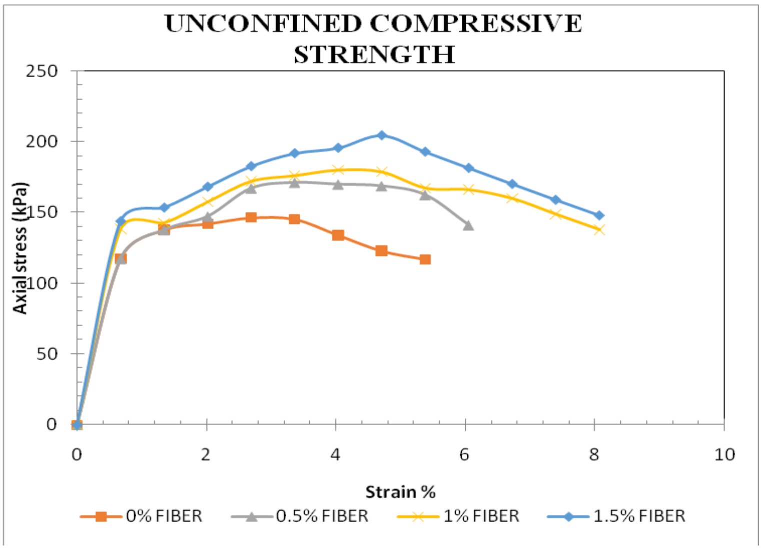

Fig.3: Comparison of Stress Strain Curve for Different Percentage of Fibers

V. CONCLUSION

In this study, an attempt has been made to study the benefits of glass fibers as a reinforcing element in red loamy soil of Assam. Various tests were conducted to determine the effects of glass fibers on the liquid limit, plastic limit, plasticity index, optimum moisture content and maximum dry density and the unconfined compressive strength of the red soil.

From the various results obtained we can see that though the liquid limit and plastic limit of the soil increased on addition of fibers, the plasticity index reduced, which indicated the reduction in the compressible nature of the soil. The optimum moisture content increased and maximum dry density reduced on addition of fibers but the unconfined compressive strength of the soil increased. This indicated that glass fibers can be used as reinforcing materials to help soil retain their strength. But the increase in strength of the soil will be limited only up to optimum fiber content. In this study, the maximum fiber content used was 1.5% by dry weight of the soil. Further studies can be made to see the optimum fiber content and also the orientation of the fibers. Different length of fibers can be used to see the effect on soil properties. As the unconfined compressive strength of the soil increased and plasticity index of the soil was reduced, red loamy soil, reinforced with glass fibers can be used in sub grade formation for road construction, slope stability, ground improvement techniques etc.

VI. ACKNOWLEDGEMENT

This research was carried out in Royal School of Engineering and Technology, Assam and the author would like to express her gratitude to the Civil Department and Bachelor students Neeldip Barman, Neelkamal Kalita, Sourav Boruah, Punit and Mriganka.

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