Comparative Study of Soil Reinforced with Natural Fiber, Synthetic Fiber and Waste Material

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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.It is one of the most popular techniques used for the improvement of poor soils. Further, soil reinforcement causes significant improvement in tensile strength, shear strength, bearing capacity, as well as economy. The use of coconut fibre, which is now most often considered as waste, as a resources to produce farm building material to substitute wood product, offers many advantages. They are moth-proof, resistance to fungi and rot, provide excellent insulation against temperature and sound, not easily combustible, flame-retardant, unaffected by moisture and dampness, tough and durable, resilient, springs back to shape even after constant use, totally static free and easy to clean. 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 fibers in soil have only started recently. Considering these, a series of tests were performed with red loam soil using coconut coir, glass fiber and cement bag 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. The main objective of this project is to find the variance and the conclusion by comparing the initial properties and the final properties after use of waste coconut coir fiber, glass fiber and cement bag.

Keywords: Soil Reinforcement, Red Soil, Glass Fiber, Coconut Fiber, Cement Bag Waste, Geosynthetics, 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. Soil reinforcement is defined as a technique to improve the engineering characteristics of soil. The process of soil reinforcement helps to achieve the required properties in a soil needed for the construction work.Reinforcing soils using tension resisting elements is an attractive means of improving the performance of soil in a cost effective manner. Soil reinforcement by fiber material is considered an effective ground improvement method because of its cost effectiveness, easy adaptability and reproducibility. The use of random discrete flexible fibers mimics the behaviour of plant roots and gives the possibility of improving the strength and the stability of near surface soil layers. This technique is employed for the stabilization of thin layers of soil, repairing failed slopes, soil strengthening around footings and earth retaining structures.Also the use of biodegradable natural fibers as soil reinforcement materials is gaining popularity. There are many general advantages of coconut fibers. They are moth proof, resistant to fungi and rot, provide excellent insulation against temperature and sound, not easily combustible, unaffected by moisture and dampness, tough and durable, totally static free and easy to clean. Coconut fibre finds application in slope stabilization in railway cuttings and

embankment, protection of water courses, providing a sub base layer in road pavements, land reclamation highway cut and fill slopes.

II. LITERATURE REVIEW

Hejazi et.al (2012) have made a brief review on the applications and benefits of natural and synthetic fibers. On the basis of the review he has commented that natural and synthetic fibers in geotechnical engineering is feasible in six fields including pavement layers, retaining walls, railway embankments, protection of slopes, earthquake and soil-foundation engineering.

Siham Ibrahim et.al (2006) did a study on compressive strength and swelling properties of randomly distributed fiber-reinforced clayey soil and concluded that the UCS of the clay fiber mixture has increased with increasing the fiber content.

Sung-Sik Park (2009) did a study on the Effect of fiber reinforcement and distribution on unconfined compressive strength of fiber-reinforced cemented sand and made an observation that the UCS of the fiber-reinforced cemented specimens gradually increases as the number of fiber inclusion layers increases.

Laskar and Pal (2013) investigated the effect of waste plastic fibers on the on the compaction and consolidation behaviours of reinforced soil

III. MATERIALS

- 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. The soil used in this study was collected from a s ite near Khanapara in Assam. The properties of the red soil are given in Table 1.

Table 1

Property	Values
Specific Gravity	2.81
Liquid limit (%)	58.2
Plastic limit (%)	30.6
Plasticity index (%)	27.6
Optimum moisture content (%)	19.5
Maximum dry density (gm/cc)	1.60

- Natural fiber (coconut coir)- Coir is a natural fiber extracted from the husk of coconut and used in products such as floor mats, doormats, brushes, mattresses etc. Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut.

- Synthetic fiber (Glassfiber) - Glass fiber also called fiber glass is made from extremely fine fibers of glass. Fiber glass is a light weight, extremely strong and robust material. Glass fibers are among the most versatile industrial material known today. They are readily produced from raw materials derived from composition containing silica. They exhibit useful bulk properties such as hardness, transparency, resistance to chemical attack, stability and inertness, as well as desirable fiber properties such as strength, flexibility, stiffness and durability.

- Waste material (Cement bag) - It is made from high strength polypropylene woven fabrics. The use of plastic products such as cement bag, plastic bags, plastic bottles, containers is increasing can be used effectively to increase the various properties of the soil. One such type of waste is the cement bag that is added to the soil to increase the shear strength, tensile strength and California bearing ratio of the soil

IV. METHODOLOGY

Sample preparation: The soil sample was cleaned and then the various index properties of the soil were found out as per Indian Standards codes. The various percentages of fibers that were used were taken by dry weight of the soil sample and mixed with water. The unconfined compression tests were done by compacting the soil at optimum moisture content and maximum dry density.

The following Engineering Tests were performed during the course of the study-

- Soil classification by sieve analysis as per Indian Standard of soil classification system (ISSCS)

- Determination of liquid limit
- Determination of plastic limit
- Unconfined compression test
- Standard proctor test
- Determination of moisture content by oven drying
- Determination of specific gravity

V. EXPERIMENTAL RESULTS AND DISCUSSIONS

The results obtained from the various engineering tests are shown here.

Fig 1 shows the curve for Moisture content density relationship obtained from the standard proctor test.

Hence from the graph,

MDD =1.60 g/cc and

OMC = 19.5%.

Fig 2, 3 and 4 shows the comparison of the Stess-Strain curves for different percentages of glass fibers, coconut coir fiber and cement bag waste respectively. It is clear from the figure that as the fiber content increased from 0.25% to 1%, the unconfined compressive strength also increased for all the types of fibers. The unconfined compressive strength of the soil with no reinforcement is 115kPa. For all the fibers, the maximum value of unconfined compressive strength was obtained on addition of 1% of the fiber content. For glass fibers maximum value of unconfined compressive strength was found to be 290.5 kPa, for coconut coir, 280 kPa and for waste cement bag, the maximum value of unconfined compressive strength was found to be 300 kPa. In Fig 5, a comparison of the axial stress versus strain for all the fiber types for the maximum fiber content is shown. It is clear from the figure that the maximum strength increase was found on addition of 1% of cement bag waste as reinforcing material. The increase in strength of the soil due to addition of fibers can be attributed to the high tensile strength of the fibers and hence can be used as reinforcing material.

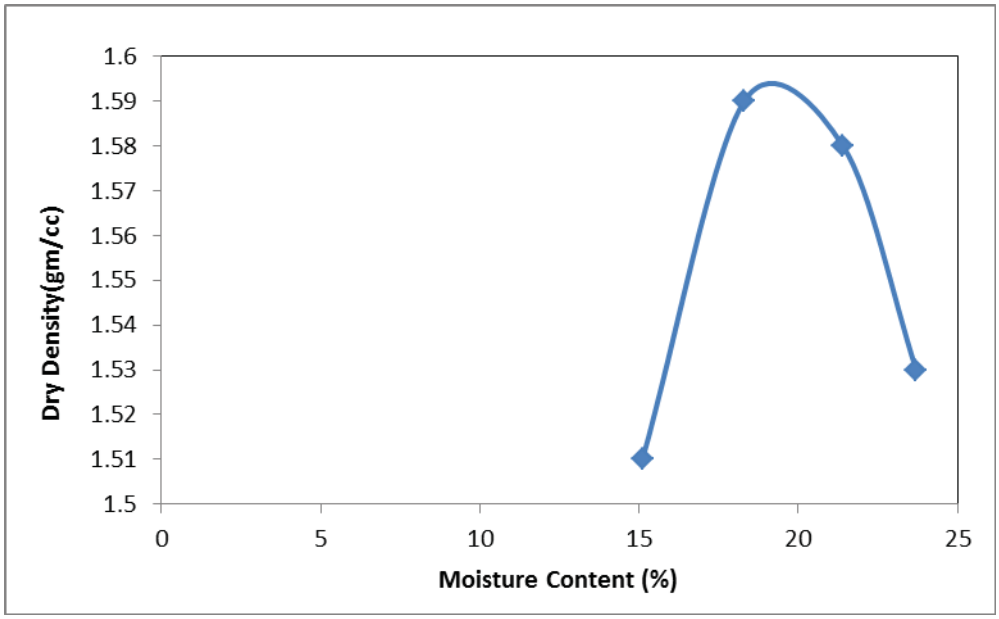

Fig 1: Compaction curve of pure soil

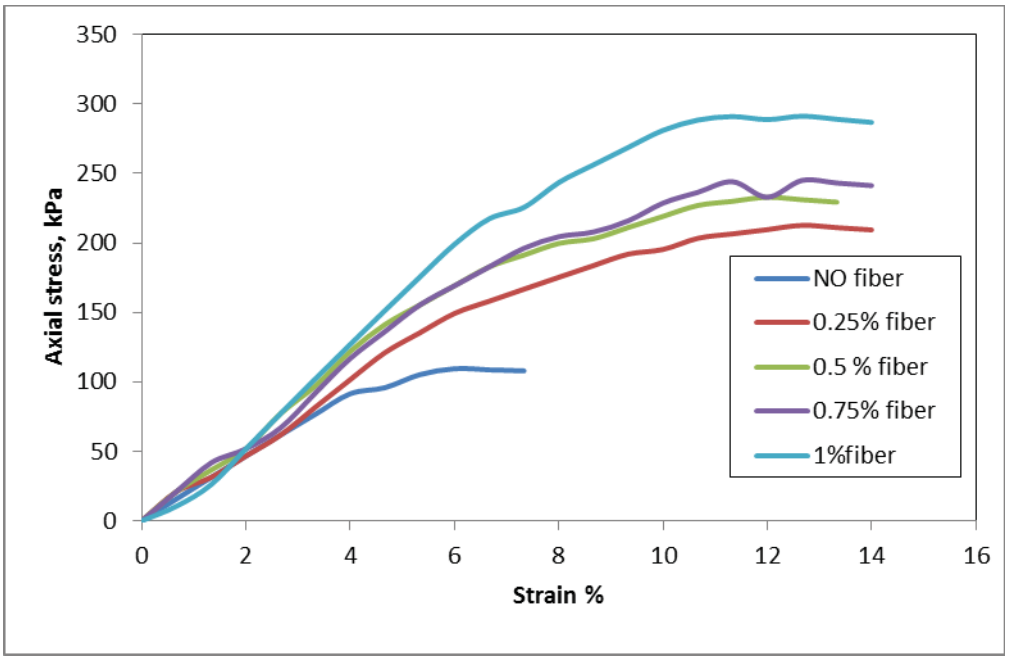

Fig 2: Axial stress versus strain % for different percentage of glass fiber

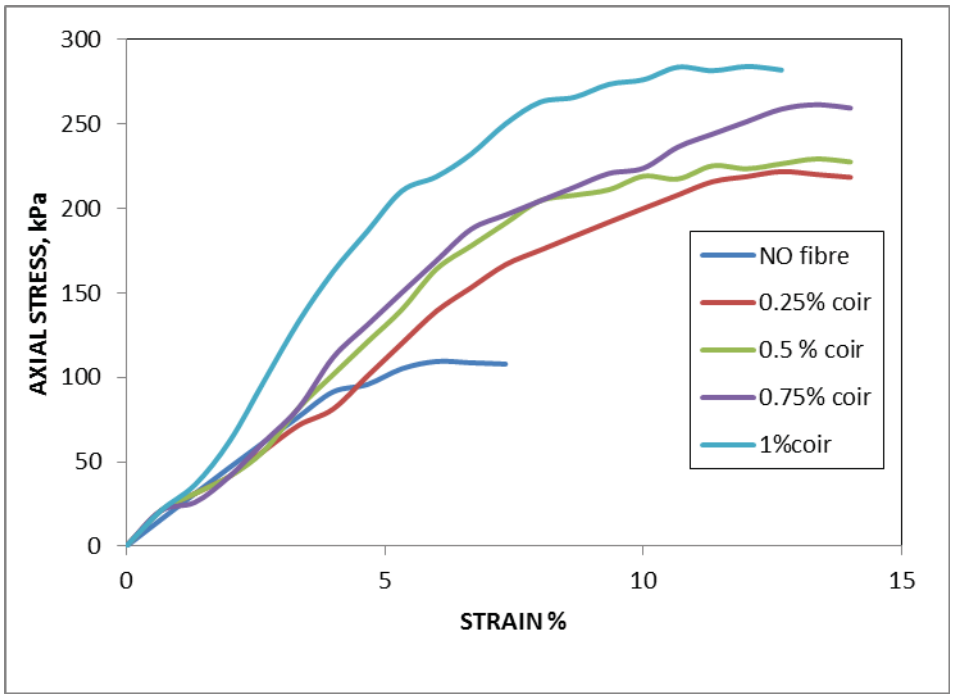

Fig 3: Axial stress vs. strain% for different percentage of coconut coir

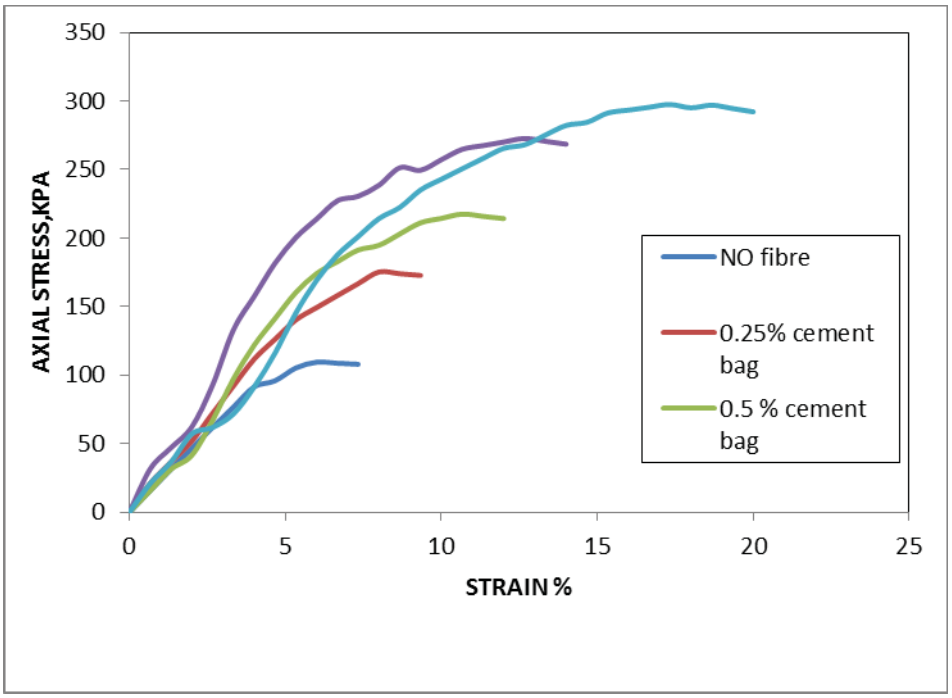

Fig 4 Axial stress versus strain% for different percentage of cement bag waste

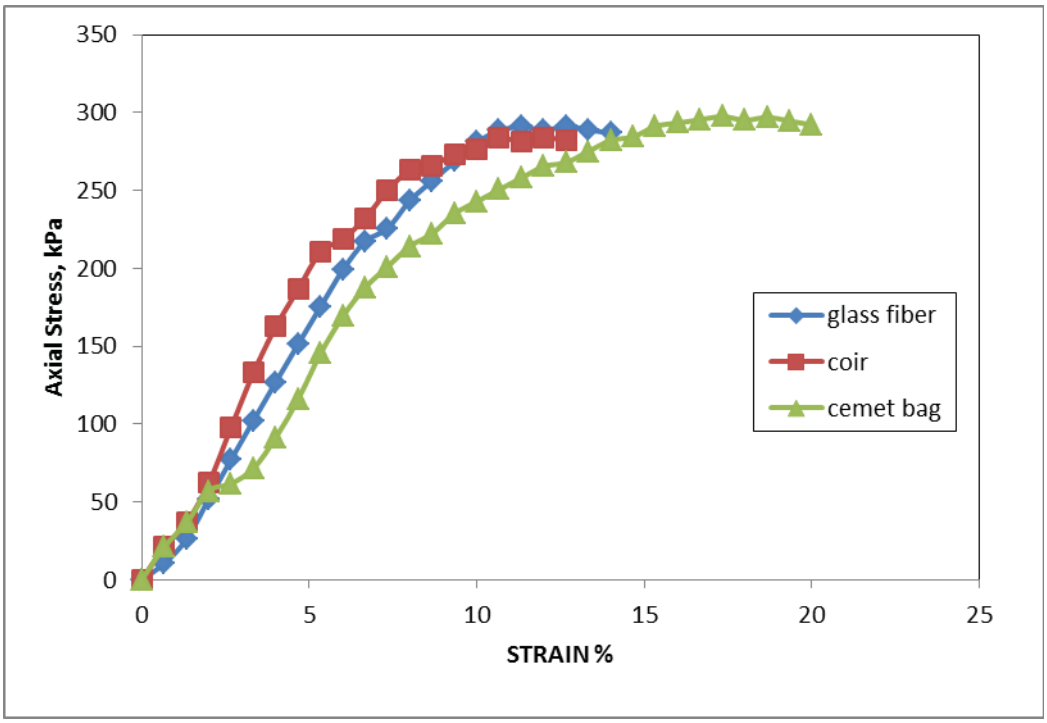

Fig 5 Comparison of stress-strain curve for highest fiber content and waste content

Table 2 Comparison of unconfined compressive strength and undrained shear strength for different fiber contents

Fiber content	Glass Fibers		Coconut Coir		Cement bag waster	
	UCS(kPa)	USS(kPa)	UCS(kPa)	USS(kPa)	UCS(kPa)	USS(kPa)
0%	115	57.5	115	57.5	115	57.5
0.25%	220	110	220	110	179.5	89.75
0.50%	230	115	230	115	220	110
0.75%	250	125	260	130	280	140
1%	290.5	142.25	280	140	300	150

In table 2, a brief comparison of the unconfined compressive strength and undrained shear strength of the soil sample reinforced with different fibers and at different fiber contents has been shown.

VI. CONCLUSION

It is seen that all the three types of reinforcement have effectively led to the increase in the strength of the soil with increase in the fiber content. From the literature review we have seen that glass fiber and coconut coir have been used as reinforcing elements in many engineering projects. Among all the three reinforcing element, the maximum strength was obtained when 1% of waste cement bag was used. This study has shown the effectiveness of waste cement bags as reinforcing material. Use of waste cement bags as reinforcing elements is done for the first time in this project work. In this way we can utilize waste materials in enhancing the strength of weak soils and also reduce landfill costs by utilizing waste bags in a cost effective manner.

VII. ACKNOWLEDGEMENT

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