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Behaviour of Randomly Distributed Fibre Soil in consolidated undrained condition

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ABSTRACT: The advantages of fiber-reinforcement in soils have gained attention in the last couple of decades. This study presents data from laboratory undrained triaxial tests on reinforced and unreinforced samples Soils. The standard specimen size was 38mm x 76mm. The undrained shearing behaviour of the reinforced and non-reinforced soil is also analysed and conclusions drawn. The addition of fiber in soil sample enhanced the peak strength of RDFS.

KEYWORDS: Fiber, Triaxial Tests, Undrained, Shearing, Peak Strength

I. INTRODUCTION

Soil mass reinforced with randomly distributed discrete fibres (RDFS) resembles the conventional earth reinforcement in many of its properties. The preparation is quite similar to that of admixture stabilization. Mostly the discrete fibers are simply added and mixed with the soil, much the same as cement, lime or any other additives. The Polypropylene fibre is added in concrete and soil to enhance their properties (Saman et. al., Shashank et. al., and Roohul et. al. 2015). It has been established that strength and deformations characteristics of soil can be improved by fibre inclusions (Charan H.D., 1995). The mechanical interlock effect of the fibers provides increased tensile strength and cohesion to the soil matrix. Laboratory tests measured and increase in the post-peak strength response; and an increase in the modulus of the soil. This reinforcement mechanism has potential in the construction of highways and slopes (Natural and McManis, 2002).
Fibers reinforced soil exhibits greater extensibility and small loss of post peak strength i.e. greater ductility in the composite materials as compared to unreinforced soil. (Singh, 1995). One of the primary advantages of randomly distributed fibres in the absence of potential planes of weakness that can develop parallel to oriented reinforcement and the maintenance of strength isotropy (Prabhakar and Sridhar, 2002). The technique of reinforcing the soil increases the stiffness and load carrying capacity of the soil though frictional interaction between the soil and the reinforcement.

II. METHODS AND METHODOLOGY

The main objective of the triaxial tests on the RDFS were to study the stress strain behaviour of RDFS and influence of fibre content, fibre length and confining pressure on the strength of the fibre reinforced clay. All tests were conducted in consolidated undrained condition. All consolidated undrained triaxial tests were conducted as per IS2720 (part 12):1981.

A) Test Equipment

The strength of the RDFS was measured using conventional triaxial testing machine. It consists of a circular base that has a central pedestal has two holes which were used for the drainage of the specimen in a drained test and for pore pressure measurement in an undrained test. A triaxial cell was fitted to top of the base plate with the help of three wing nits. The triaxial cell was Perspex cylinder which is permanently fixed to the cap and the bottom brass collar. There

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were three tie rods which support the cell. The top cap was a bronze casting with its central boss forming a bush through which a stainless steel ram can slide.

The ram was so designed that it has minimum friction and at the same time did not permit any leakage. There was an air release valve in the top cap which was kept open when the cell was filled with water for applying the confining pressure. The deviator stress was applied to the specimen from a strain controlled loading machine through the ram. The loading system consists of a screw jack operated by an electric motor and a gear box.

1) Sample Preparation

The sample preparation for triaxial test was same as for unconfined compression test. The first step was to determine the mixing proportions of the soil and fibres to fill the compaction mould of 1000cc to achieve maximum dry unit weight and fibre content. As the maximum dry unit weight of the soil was 16.95kN/m^3 and OMC was 19%, the soil taken for sample preparation was 1730 gm. And according weight of soil, the weight fibre content was decided.

The second step was mixing of fibres in the clayey soil. Like unconfined compression test in triaxial test also, the fibres were mixed by hand. The third step of the sample preparation was mixing of water (OMC=19%) in the soil thoroughly. The prepared wet soil was compacted in the compaction mould with the rammer in three equal layers as it was done in light compaction test. In the next step, sample tubes were inserted in the compacted soil of compaction mould. Then samples were extracted from the tubes through sample extractor and split mould. The standard specimen size was 38mm X 76mm. The specimens were carried out from the split mould having same dimensions as the standard specimen size.

2) Mounting of Sample

In this step, free flow of water was allowed through drainage line by opening drainage valve for de-aeration. Then it was stopped. Next, porous stone was kept of the Triaxial base. A filter paper was placed on the porous stone. Then sample was mounted on the porous stone with the help of stretcher. Suction was applied to the tube of the membrane stretcher, and filter paper along with porous stone was at the top of specimen. Membrane was unrolled from the stretcher after releasing suction. Then pedestal end of the membrane was sealed by O-Ring and membrane stretcher was removed. A drainage cap i.e. plastic pad was inserted on top of the porous stone. Finally, two O-Rings was placed around top cap. Triaxial cell was then positioned over the base and tightened to it with the help of bolts.

3) Testing procedure

Triaxial tests were conducted in consolidated undrained condition. So each test was performed under three stages viz. saturation, consolidation, and actual shearing test. To perform the test, ram was lowered just
sufficient to make contact with the top platen cap and desired water was filled in the cell keeping the air release valve opened. When the water started flowing through the air release valve, the valve was closed.

The first stage of test was saturation stage. In this stage drainage was closed and saturation valve was opened. For saturation of sample a back pressure of 0.8% of applied cell pressure was applied to the sample. As soil was clay it took at least 24 hours for saturation. When an increase in cell pressure shows equal increase in back pressure saturation stage was completed.

The second stage of consolidation was started after the completion of saturation stage. In this stage, back pressure was down to zero while saturation valve was closed. The drainage valve was opened. The drainage valve was attached to the burette to measure the change in volume of sample during the consolidation stage. When the reading in the burette was constant the consolidation of specimen was completed.

Third stage was actual shearing of specimen sample. In this stage, drainage valve was closed while pore water pressure valve was opened to measure the pore water pressure developed during the shearing. The loading machine was run at a speed of 0.38 mm/min. the sample was sheared by applying deviator stress by the loading machine. Deviator load, deformation, and pore water pressure were recorded in digital data logger. The failure was indicated when the deviator load reading recede after having reached the maximum or when an axial strain of 20% was reached.

After completion of test, the loading was shut off. All additional axial stress was removed. The cell pressure was the removed to zero, and cell was emptied. The Triaxial cell was unscrewed and removed from the base. O-Rings, loading cap and porous stones were taken out and membrane was removed. Then sample was kept in the oven from water content determination.

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III. RESULT AND DISCUSSION

The shear strength of soil can be denoted in terms of c-φ parameters or stress ratio or major principle stress at failure (Charan, 1995). In the present investigation with CU triaxial tests also shear strength of fibre reinforced clay has been defined in terms of c- $_{\varphi}$ parameters.

It is seen that both the length of fibre and percentage of fibre content played an important role in the development of shear strength parameters c- φ of the fibre reinforced soil. The shear strength parameters values obtained from Mohr Circle diagrams (Figure 1 to Figure 7) of the unreinforced and reinforced clay are presented in the Table.

Effect of Fibre Length and Fibre Content on the c- $_{\varphi \text{ Values}}$ of the RDFS under CU Triaxial Tests

Fibre Length (mm)	Fibre Content (%)	c Values (kg/cm^2)	ϕ Values
0mm	0.0	0.451	35.72
6mm	0.1	0.654	33.77
	0.2	0.615	34.73
	0.3	0.921	34.09
12mm	0.1	0.834	33.36
	0.2	0.870	33.86
	0.3	1.063	31.40

Figure 1 Mohr's Circle For Triaxial Test (Soil=100%,FC=0%,FL=0mm)

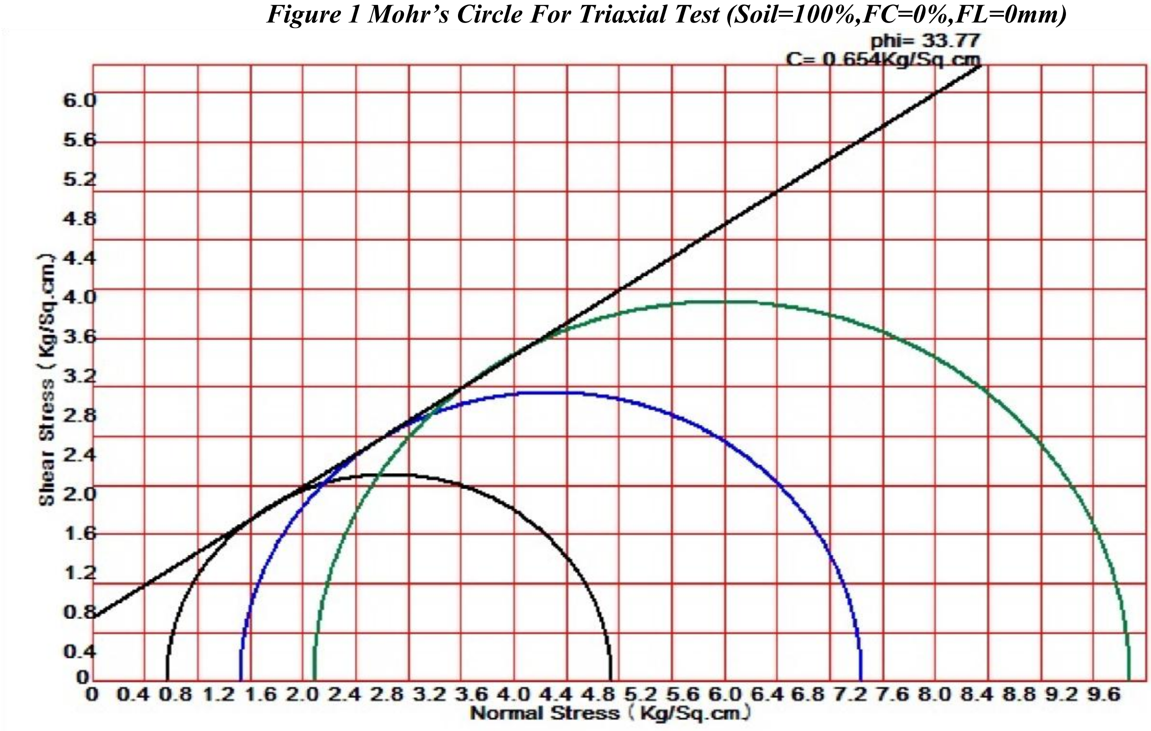

Figure 2 Mohr's Circle For Triaxial Test (Soil=100%,FC=0.1%,FL=6mm)

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Figure 3 Mohr's Circle For Triaxial Test (Soil=100%,FC=0.2%,FL=6mm)

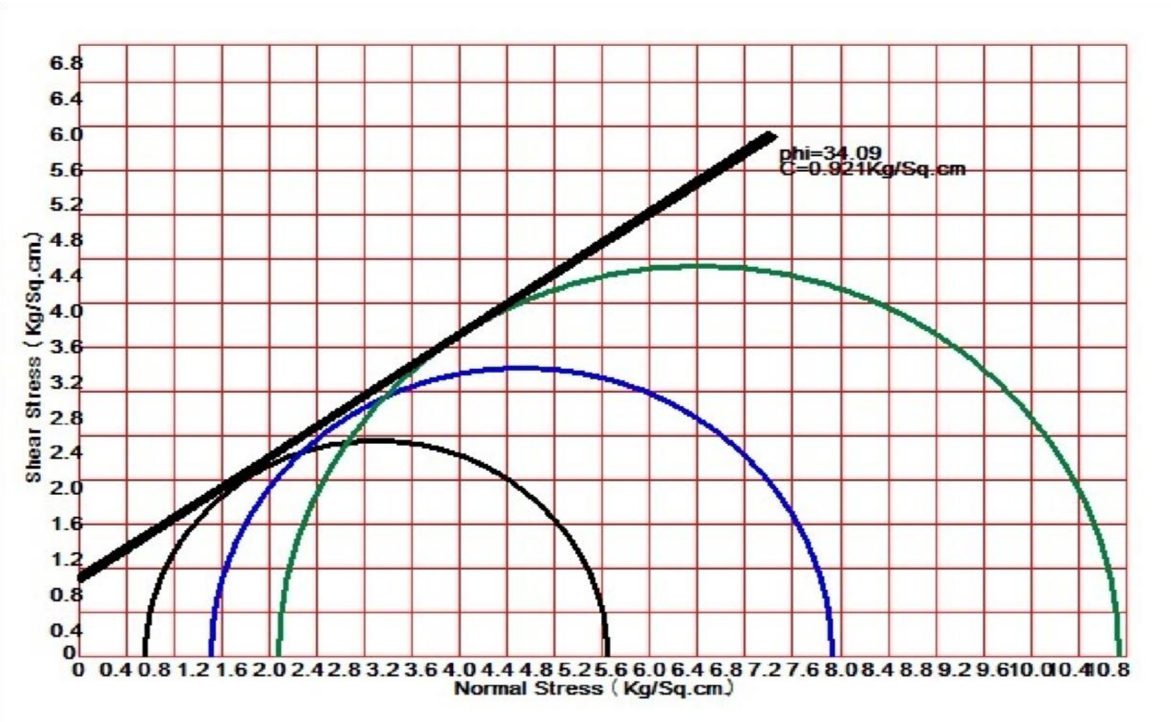

Figure 4 Mohr's Circle For Triaxial Test (Soil=100%,FC=0.3%,FL=6mm)

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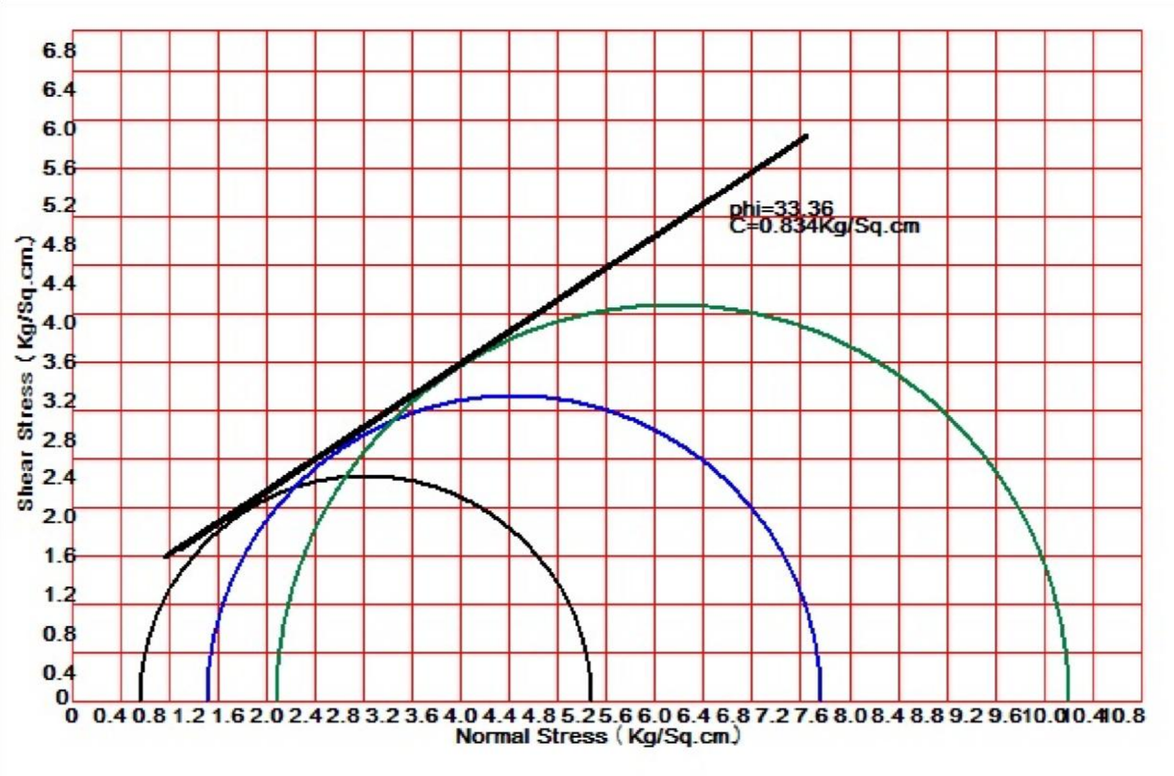

Figure 5 Mohr's Circle For Triaxial Test (Soil=100%,FC=0.1%,FL=12mm)

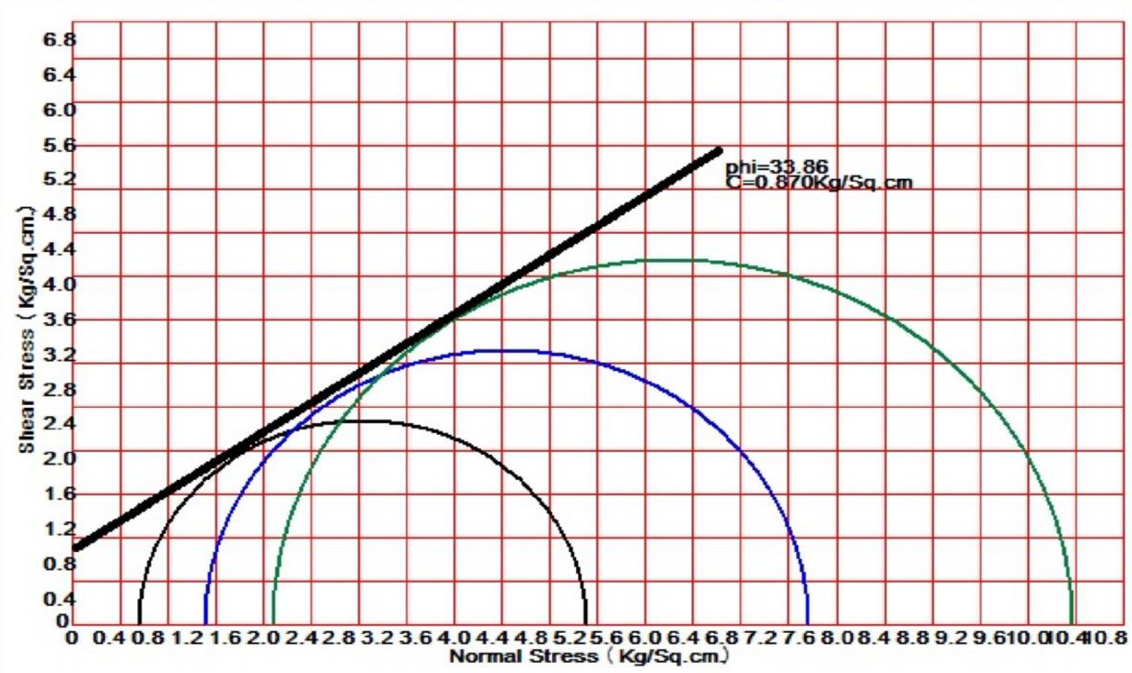

Figure 6 Mohr's Circle For Triaxial Test (Soil=100%,FC=0.2%,FL=12mm)

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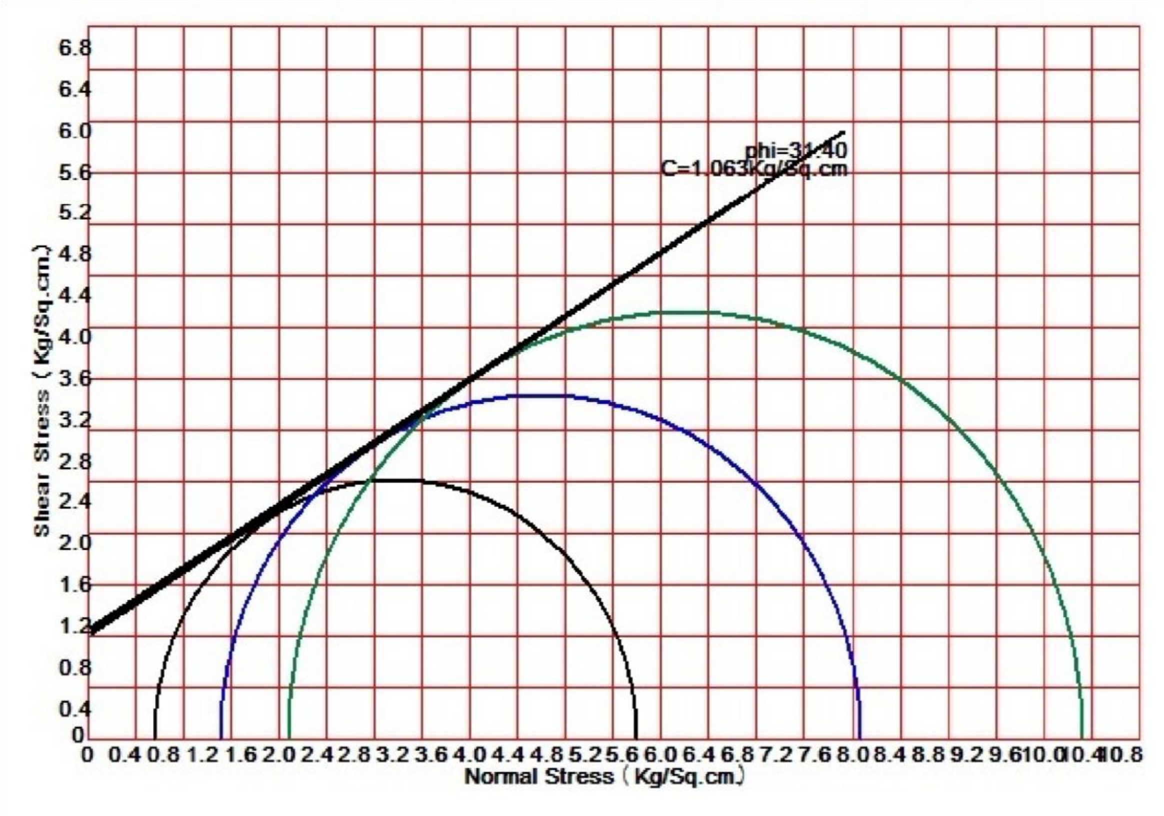

Figure 7 Mohr's Circle For Triaxial Test (Soil=100%,FC=0.3%,FL=12mm)

The table indicated that the c values of the reinforced clay is more than that of unreinforced clay, however there is no significant effect of reinforcement on angle of shearing resistance. It is generally agreed that reinforcement does not have a significant influence on the improvement of angle of shearing resistance.

The increase in cohesion of soil-fibre matrix may due to the increase in the confining pressure due to development of tension in the fibre and moisture in the fibre helps to form absorbed water layer to the clay particles, which enables the reinforced soil to act as a single coherent matrix of soil fibre mass. It is observed that, for 0.1%,0.2% and 0.3% fibre content c values are 0.654, 0.615, 0.912 kg/cm^2 while φ values are 33.77^o, 34.73^o and 34.09^o respectively for 6mm length fibre. Also, it can be observed that for 12mm length fibre, c values are 0.834, 0.870 and 1.063 kg/cm^2 while φ values are 33.36^o, 33.86^o, and 31.40^o with respect to 0.1%, 0.2% and 0.3% fibre content. So, it can be concluded that as fibre content as well as length of fibre increases cohesion of soil increases however there is no significant effect on angle of shearing resistance.

IV. CONCLUSION

- The peak strength of RDFS is more than that of the unreinforced clay. The peak stress increases with increase in fibre content with fibre length of 12mm upto 0.3% fibre content.
- As length of fibre increases, the effect of increasing the fibre content from 0.1% to 0.3% shows significant increase in shear strength of RDFS.
- The shear stress of reinforced soil also increases with increasing confining pressure. At 12mm fibre length with 0.3% fibre content gives maximum shear strength of RDFS.
- The value of cohesion (c) is increased due to inclusion of polypropylene fibres. Increase in length of fibres increases the value of cohesion and this variation is linear.
- Upto 0.3% FC, the cohesion is said to be improved linearly with increase in FC. But for the same fibre content of different length of fibre, the amount of increase in cohesion is quite less.
- There is no specific trend in the variation of friction angle (φ) with fibre length as well as fibre content. The increase in length of fibre as well as fibre content does not affect the φ value significantly.
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