Effects of glass fibres on the shear strength of sandy soil

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ABSTRACT: This paper presents the effects of glass fibres on the shear strength parameters of coarse sand. To study the effect, sand was mixed with three different glass fibre contents (0.5%, 1.0% and 1.5%) with three aspect ratios of 30.45 and 60. Series of direct shear test was carried out at in loosest density to study the behaviour of unreinforced and reinforced sand. After studying the results, it clearly showed that the shear stress at failure and angle of internal friction of sand increased with increased in fibres contents.

Keywords: Direct shear test, L/D ratio, angle of internal friction, Shear strength, Relative density, Glass fibre content.

1 INTRODUCTION

Reinforced soil is the latest technique used for ground improvement, the concept of reinforced soil was first given by Vidal of France in 1966. The main function of reinforcing the soil matrix is to increase the strength (shearing strength) and reduce its deformation. The primary advantages of randomly distributed fibres are the absence of potential planes of weakness that can develop parallel to oriented reinforcement (Maher and Gray 1990).

Large number of investigator have worked on fibre-reinforced soil using synthetic as well as natural fibres. Some of them are Rosa L. Santoni, Jeb S. Tingle and Steve L. Webster (2001), Kameshwar Rao Tallapragada, Anuj Kumar Sharma and Tarulata Meshram (2009), Mousa F. Attom and Adil K. Al-Tamimi (2010), Amin Chegenizadeh and Hamid Nikraz (2012), Shivanand Mali and Baleshwar Singh (2013), H. P. Singh and M. Bagra (2013), Rabindra kumar kar, Pradip Kumar Pradhan and Ashutosh Naik (2014), S. Yari, A. Bagheri and M. Yousefi Rad (2014), Shivanand Mali and Baleshwar Singh (2014), Himadri Baruah (2015), Dinesh Kumar, R. Shanmuga and G. Kalyan Kumar (2015), Dimpa Moni Kalita, Indrani Mili, Himadri Baruah and Injamamul Islam (2016). The technique of soil reinforcement using glass fibre is being widely used at present in a civil engineering projects and is fast replacing the conventional ground improvement techniques. Glass fibre has generally had long life as compared with natural fibre and it is non biological degradation. The authors have made an attempt to study the strength behaviour of randomly distributed glass fibre reinforced soil.

2 MATERIALS USED

2.1 *Sand*

The coarse sand was obtained from Ghaggar river in Patiala, Punjab. The physical properties of coarse sand are tabulated in Table 1. According to Indian Soil Classification System, coarse sand is classified as poorly graded sand (SP). The glass fibre of lengths 10mm, 15mm and 20mm were obtained from a local supplier.

Table 1. Properties of sand

S. No.	Description	Values
1	Fines (%)	0
2	Sand (%)	100
3	Effective size, D_{10} (mm)	0.18
4	D_{30} (mm)	0.32
5	D_{60} (mm)	0.52
6	Uniformity coefficient, C_u	2.8
7	Coefficient of curvature, C_c	1.09
8	Classification	Coarse Sand

2.2 *Glass fibre*

Glass fibre has been procured from Science market Ambala cantt. Haryana, India and were divided into basis of three different lengths 10mm, 15mm and 20mm for its inclusion in various percentages (0.5, 1.0 and 1.5 by dry weight) to both reinforced fine sand. The physical properties of glass fibre are given in Table 2.

Table 2. Properties of glass fibres

Description	Glass fibre
Length (mm)	10,15,20
Diameter (mm)	0.35
Tensile strength (GPa)	2.30
Tensile modulus (GPa)	76
Ultimate strain	0.018

Figure 1. Glass fibre

3 EXPERIMENTAL PROGRAMME

For preparing test specimens, first the required amount of sand which was calculated from dry density (Υ_d) and fibres were mixed together in a dry state. All the sand and fibre were mixed by hand and proper care was taken to prepare a homogeneous mix. The compacted specimen was of 30mm in height and 60mm in plan area. Three fibre contents (0.5%, 1.0%, and 1.5%) by weight of sand of lengths 10mm, 15mm and 20mm were used at loosest density of sand. The direct shear test was conducted on number of specimens as per IS: 2720 Part 13.

Table3. Terminology used

Abbreviation	Designation
CS	Coarse sand
F	Fibre
CS+F	Coarse sand-Fibre mix
1%F	1% fibre content
RD	Relative density
L/d	Aspect ratio

4 RESULTS AND DISCUSSION

The number of direct shear tests was carried out in accordance with Indian standard procedure. A shear box of 60 mm x 60 mm in plan and 30 mm in depth was used in the tests. The test was performed at vertical normal stresses of 5, 10 and 15 N/cm^2 and in order to completely define the shear strength parameters. The tests were carried out at a constant displacement rate of 1.20mm/min. The tests were continued up to 20% strain. Each test was repeated at least twice to ensure reproducibility.

4.1 *Effect of percentages of fibres of varying length on the shear stress at failure*

It can be seen from figure 2 that the addition of glass fibre of aspect ratio of 30 from 0.0% to 1.5% resulted in increasing the shear stress at failure of sand from 3.71 N/cm^2 to 5.82 N/cm^2 (increase of about 57%) respectively under normal stress equal to 5 N/cm^2. The shear stress at failure of the sand increases about 32% when glass fibre increased to 1.5% under normal stress of 10 N/cm^2. The shear stress at failure of the coarse sand increases from 10.12 N/cm^2 to 12.66 N/cm^2 when glass fibre increased from 0.0% to 1.5% under normal stress is 15 N/cm^2 i.e. an increase of 25%.

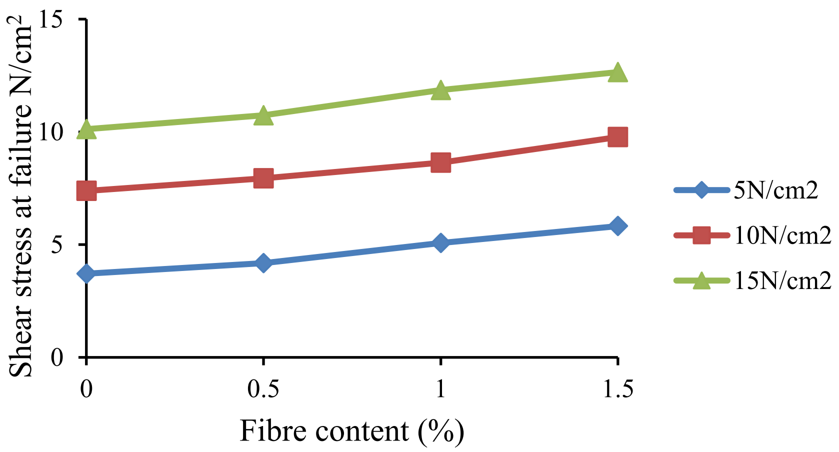

Figure 2. Fibre content vs shear stress at failure under varying normal stress at RD=0% and L/d=30.

Similarly addition of glass fibre of aspect ratio 45 from 0% to 1.5% resulted in increasing the shear stress of sand from 3.71N/cm^2 to 6.53N/cm^2 (76% increase) respectively under normal stress equal to 5N/cm^2. Similarly the shear stress of the coarse sand increases up to 48% when glass fibre increased from 0.0% to 1.5% under normal stress equal to 10N/cm^2.On the similar lines there is a increase of 36% in shear stress when glass fibre is increased to 1.5% under a normal stress of 15N/cm^2 as shown in figure 3.

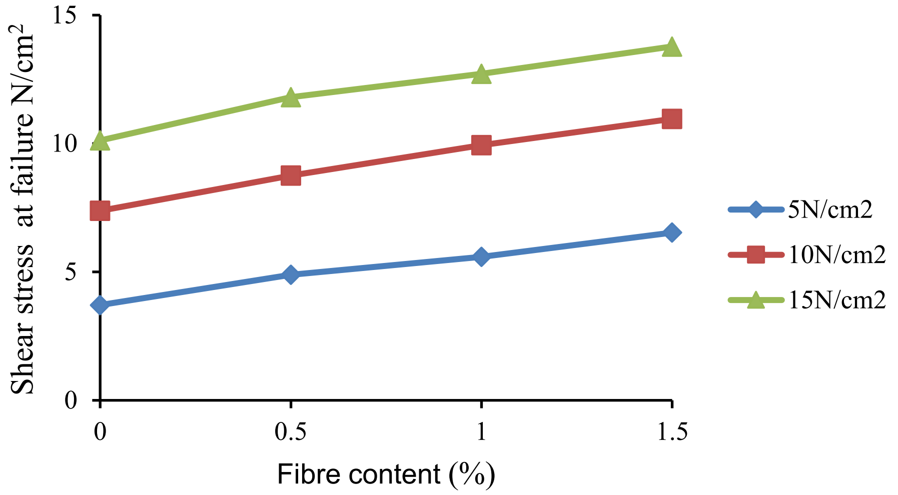

Figure 3. Fibre content vs shear stress at failure under varying normal stress at RD=0% and L/d=45.

The addition of glass fibre of aspect ratio 60 from 0.0% to 1.5% resulted an increase of 36% in value of shear stress under normal stress equal to 5N/cm^2. While there is increase of 26% at normal stress of 15N/cm^2 as shown in figure 4.

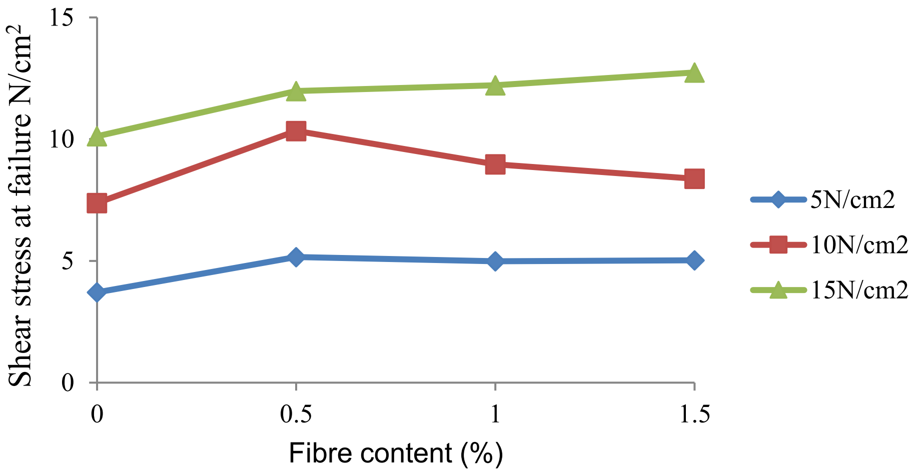

Figure 4. Fibre content vs shear stress at failure under varying normal stress at RD=0% and L/d=60.

After comparing the results at all three different aspect ratio the shear stress at failure of glass fibre reinforced sand increases . But the best results are at aspect ratio 45 where the highest increases in shear stress were noticed.

4.2 *Shear strength parameters of sand at varying aspect ratio*

Table 4 shows the angle of internal friction values of glass reinforced sand at various aspect ratios in loosest state. It can be seen that the angle of internal friction values is increased when sand is reinforced with glass fibre. Also as the aspect ratio i.e. L/d is increased from 30 to 60 the shear strength parameter increases.

Table 4: Shear parameter of fibre reinforced sand

RD	MIXES	L/d =30	L/d = 45	L/d = 60
		Φ^0		
0%	CS	32.65	32.65	32.65
	CS+0.5%F	33.22	34.68	34.29
	CS+1.0%F	34.17	34.99	35.90
	CS+1.5%F	34.37	35.94	37.63

5 CONCLUSIONS

Based on the experimental results of this study the following conclusions are drawn:-

1. In sandy soil, glass fibre can be used as a reinforcing material resulting an increase in shear strength of soil when glass fibres are randomly mixed.
2. The effect of length and increase in fibre content increases the shear strength at failure .Increase in strength/stiffness of weak and soft soils will performed better as compared with unreinforced soil.
3. Inclusion of glass fibres also increases the angle of internal friction.
4. Use of glass fibre provided stiff surface for construction and randomly mix glass fibre can lead to a lot of saving in money and becomes construction economical. Because it is long life due to its unique property of non-biodegradable in nature.

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