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A Study on Shear Strength of Sand Reinforced with Glass Fibers

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Abstract - *Scarcity of suitable land and unavailability of good quality construction soil lead to the implementation of various ground reinforcement techniques. Among the various reinforcement techniques fiber reinforcement is achieving more attention in geotechnical engineering. Soils can be reinforced either by incorporating continuous reinforcement inclusions within the soil mass in a defined pattern or by mixing discrete fibers randomly with the soil. The influence of various types of fibers on the shear strength of soils has been investigated by several researchers through triaxial tests and direct shear tests. In the present study, a series of direct shear tests have been carried out to investigate the shear strength behavior of a fine sand reinforced with glass fibers. In this study the improvement of shear strength of sand by adding different percentage of glass fiber such as 1.0%,1.5% and 2.0% also at different normal stress values are tested and compared with normal values. The test results show an increase in the shear strength. Sand reinforced with glass fiber having good shear strength at different normal stress comparing to unreinforced sand. The tests result also show that with change in relative density, both the shear strength and stiffness of the reinforced sand have increased.*

1.INTRODUCTION

It is a general technique to modify the soil properties by mixing with different materials such as lime, cement and fly ash or by reinforcing the soil. So, the primary purpose of reinforcing soil mass is to develop the parameters such as shear strength, to improve its stability, to increase its bearing capacity, to reduce settlements and lateral deformation. Compared to conventional geosynthetics, there are some advantages in using randomly distributed fiber as reinforcement. First, randomly distributed fibers limit potential planes of weakness that can develop parallel to oriented reinforcement. Second, discrete fibers are simply added and mixed with the soil, much like cement, lime, or other additives. Finally, soil reinforced with fibers has good environmental protection effect, it is easy to be constructed, and facilitates to take borrow materials in place with cost effective constructions. Mechanical behavior of fiber reinforced sand has been studied by a number of researchers. Their research has demonstrated that shear strength of composite is increased and post-peak strength loss is reduced when discrete fibers are mixed with the soil. Fiber-reinforced soil can be advantageously employed in improvement of the structural behavior of soils. In this study the effectiveness of glass fiber added sand is studied.

1.1 Objectives of the Study

This study was undertaken to investigate the shear strength parameters of treated sands reinforced with randomly distributed glass fibers by carrying out direct shear test. For validating and future reference this study is conducted. Determination of index properties and shear strength characteristics of sand is done first after that shear strength of glass fiber added sand were studied to check shear strength of sand at various normal stress. Finally results of both were compared to know the trend in values

1.2 Scope of the Study

This project is meant to have more knowledge about the soil stabilisation techniques. Project aims at improving the properties of locally available cohesion less soil using glass fiber. In the present study, a series of direct shear tests have been carried out to investigate the shear strength behavior of a fine sand reinforced with glass fibers. Inclusion of fibers decreases the brittleness and increases the energy absorption capacity of sand specimens and makes them ductile. So the use of fiber reinforced sand in different areas of application such as embankment, subgrade, etc is validated in this study.

2. MATERIALS USED

The materials used were locally available river sand and reinforcing material such as glass fiber.

2.1 Sand

The sand chosen for the study was a river sand obtained from Kadalundi river side near Malappuram. The sand was air dried for conducting all the laboratory tests. The grain size distribution was found using IS: 2720-part 4. For conducting direct shear test the sand was sieved through 4.75 mm IS sieve

Fig -1: Sand collected from river side

2.2 Glass Fiber

Glass fiber (or glass fiber) is a material consisting of numerous extremely fine fibers of glass. Glass fiber has roughly comparable mechanical properties to other fibers such as polymers and carbon fiber. Although not as rigid as carbon fiber, it is much cheaper and significantly less brittle when used in composites. Glass fibers are therefore used as a reinforcing agent for many polymer products; to form a very strong and relatively lightweight fiber-reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), also popularly known as "fiberglass". This material contains little or no air or gas, is denser, and is a much poorer thermal insulator than is glass wool. Glass fiber is collected from a construction material supplier at Calicut.

Fig -2: Glass fiber

3. METHODOLOGY

First step was collection of materials. The materials used for the study is collected from native places. Then the index properties of sand were found out to know the characteristics. Tests conducted are Specific gravity, Determination Relative density, Sieve analysis, Direct shear test and Permeability of sand. Then 1% of glass fiber is added into sand and direct shear test were done. To know the trend in shear strength, amount of glass fiber is increased and tests were repeated.

4. RESULT AND DISCUSSION

The soil was tested for determining the index properties and engineering properties. Results of these tests are discussed below. For determining type of sand and its properties these tests are conducted and results are tabulated. Further study on improvement of glass fiber added sand are done by direct shear test only. Results obtained from direct shear test are plotted and compared below

Table -1: Index properties of sand

Index properties of Sand			
Specific gravity	2.67	Relative density	1.58g/cc
Sieve analysis		Permeability	9.17x10^ -4
Co.efficient of uniformity	2.57<6	Direct shear test	
Co. efficient of curvature	0.71<1	Shear strength	15.6kpa

Direct shear test conducted for sand with different percentage of fiber, normal stress and different compaction conditions. Graph plotted based on test results are shown below Shear Stress Vs Shear strain graphs are first plotted. Reason for the change in shear stress is is due to the increase in the interfacial friction of sand and fiber. The increase in fiber content reduces the tendency for dilation in reinforced sand.

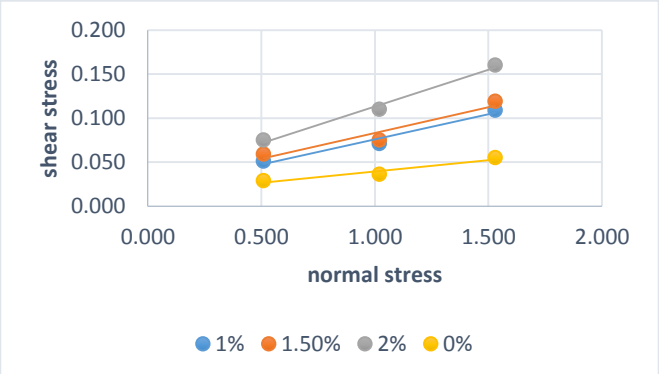

Chart -1: Shear stress Vs Normal stress graph for loose sand

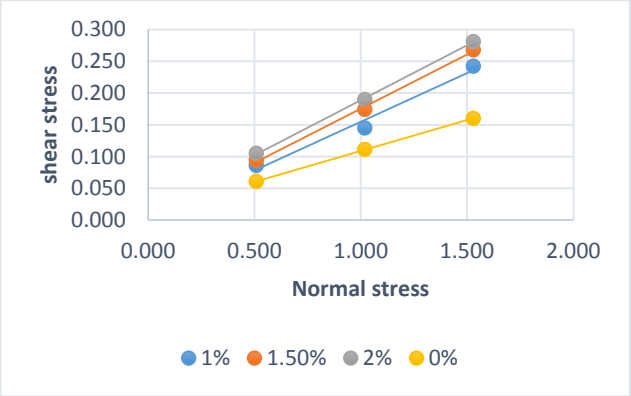

Chart -2: Shear stress Vs Normal stress graph for Medium sand

Chart 1 shows the Shear Stress Vs Normal stress graph for loosely compacted sand. The percentage of fiber content increased in each test and studied. By drawing this chart, it shows an increase in shear strength with increase in percentage of glass fiber. When the normal stress is increased up to 150kpa the increase in shear stress is due to the increase in the interfacial friction of sand and fiber. The increase in fiber content reduces the tendency for dilation in reinforced sand. In chart 2 the test results of medium compacted sand are shown.

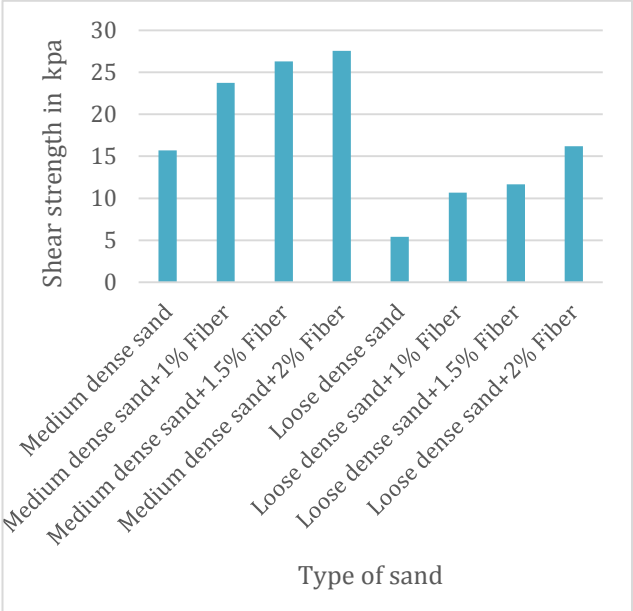

Chart -3: Trend in increase of shear strength

In chart 3 the comparison of all the result is shown. By increase in density and fiber percentage the shear strength is getting increased.

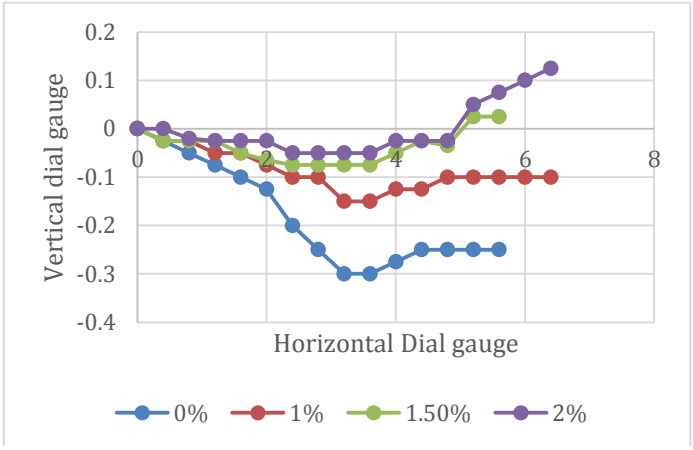

Chart -4: Vertical strain Vs Horizontal strain graph for Loose sand at 150kpa

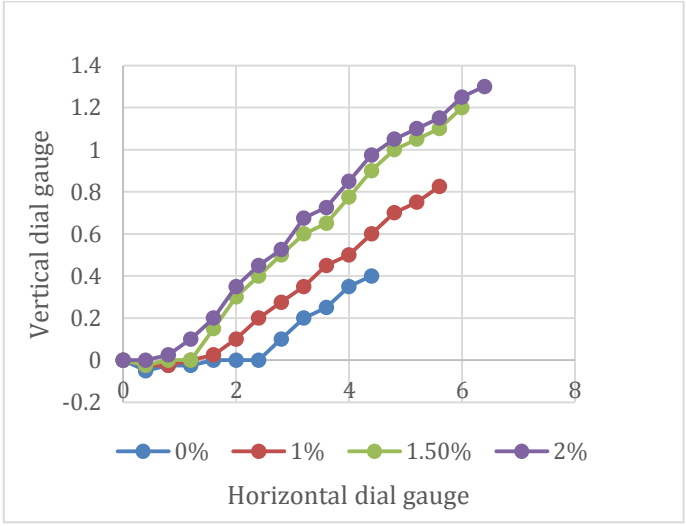

Chart -5: Vertical strain Vs Horizontal strain graph for Loose sand at 150kpa

To know the dilatancy effect of sand while adding glass fiber the vertical strain gauge readings are also taken along with horizontal dial gauge readings. To know whether it resist dilation at higher stress the normal stress s increased and tests was conducted and readings are noted. When the normal stress is increased up to 150kpa the increase in shear stress is due to the increase in the interfacial friction of sand and fiber. The increase in fiber content reduces the tendency for dilation in reinforced sand. Chart 4 and chart 5 shows graph drawn using test results obtained for 150kpa normal stress applied specimens at loose and medium condition.

From all these results we are arrived to some points such as shear strength of sand is increased by increasing the percentage of fiber and. Shear strength of sand at loose and medium condition is increased by adding fibers. The results indicate that for the same normal stress, the shear stress at failure increases with fiber content. The maximum shear strength of sand added with different

amount fiber are tested and by increase in the fiber content the shear strength sand also increasing. The improved behavior of reinforced sand is on account of sand-fiber interfacial friction and apparent cohesion.
The fiber content increases, the contribution of the interfacial friction becomes larger. The tests result also show that with change in relative density, both the shear strength and stiffness of the reinforced sand have increased. Which is known to denser packing and higher sand fiber interfacial friction. The tests also indicate that the presence of fibers consistently inhibits the tendency for dilation in fiber-reinforced sand at all normal stresses.

3. CONCLUSIONS

Fiber content is increased up to 2% of sand and tests are conducted the test results shows an increase in the shear strength. Sand reinforced with glass fiber having good shear strength at different normal stress comparing to unreinforced sand. The tests result also show that with change in relative density, both the shear strength and stiffness of the reinforced sand have increased. Which is known to denser packing and higher sand fiber interfacial friction. The tests also indicate that the presence of fibers consistently inhibits the tendency for dilation in fiber-reinforced sand at all normal stresses. Inclusion of fibers decreases the brittleness and increases the energy absorption capacity of sand specimens and makes them ductile. The findings of this study have practical significance as a ground improvement technique. Can be used in subgrade, embankment and other applications

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