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Moisture Content Effect on Sliding Shear Test Parameters in Woven Geotextile Reinforced Pilani Soil

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ABSTRACT: *Woven geotextile is widely used as reinforcing material in soil. Adhesion and interface friction are the primary parameters affecting reinforced soil performance under these conditions. They are determined using sliding shear test in the laboratory. Soil gradation, plasticity, in-situ dry density, moisture content and surface characteristics of the geotextile are important parameters affecting them. In the present experimental study, effect of moisture content on adhesion and on interface friction has been studied for local soil reinforced with woven geotextile. Trend of variation has been explained. Practical significance of the study has also been discussed.*

KEYWORDS: *Adhesion, Interface friction, Local soil, Moisture content, Sliding shear test, Woven Geotextile.*

I. INTRODUCTION

The term “Geosynthetics” essentially includes family of materials. These materials are used in conjunction with soil to improve its geotechnical performance in a specific geotechnical context. These materials include geotextiles, geomembranes as well as host of other products such as geogrids, geonets, geocomposites, geosynthetic clay liners, geopipes, geobags etc. While in soil, geosynthetics perform functions, such as reinforcement, separator, filtration, drainage and moisture barrier.

Use of geosynthetics as reinforcing material in soil is one of its primary applications. While functioning as reinforcing material in soil, geosynthetics ensures improved response of soil to loading. It also reduces disturbing shear forces. Consequently, steep slopes can be constructed or an embankment of increased height can be built on soft soil. In pavements, geosynthetics, owing to their membrane action induces tensile forces, which controls deformation and significantly improves pavement performance.

While being used as reinforcing material in soil, the interface friction angle as well as adhesion between geosynthetic and soil are the primary and most contentious variables used. The tensile stress-strain behavior of geotextile is also significant. An understanding of soil/geosynthetic interface’s shear strength is essential to the design and stability analysis of geosynthetically reinforced soil structures. An interface with a stronger shearing resistance in a geosynthetically lined slope can reduce the tensile forces mobilized in the geosynthetics, as well as increase the safe slope inclination [1], [2]. The shear strength of the soil/geosynthetic interface is also essential to understand the behavior of the sub-grade and base layers of roads.

Sliding shear testing is one of the techniques used in laboratory to determine interface friction angle as well as adhesion between geotextile and soil. In sliding shear test, sliding of soil mass over a stationary reinforcement takes place. From the mechanics point of view the sliding test is akin to kinetic or rolling friction condition. In sliding shear tests, the soil movement is minimum at the interface, since the movement of soil is restrained by reinforcement, and increases with distance away from it (Figure 1) [3].

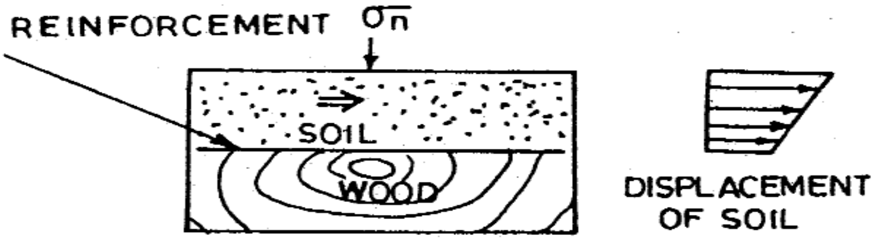

Figure 1: Sliding shear test [3]

The above relative movement induces constant normal stress condition for sliding shear test. Adhesion and interface friction angle values obtained from sliding shear tests can be used for designing a footing resting on dense sand reinforced with stiff reinforcement, where soil slides over the stationary reinforcement (Figure

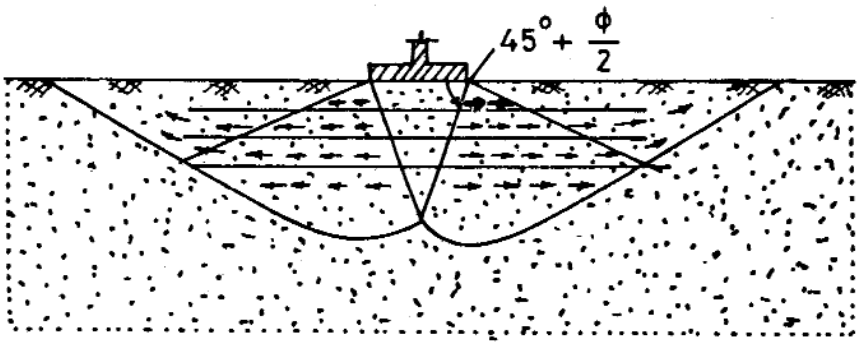

Figure 2: Sliding resistance (dense sand) [3]

In sliding shear test involving geotextiles as reinforcing material, an wooden block of appropriate dimensions is selected. The dimension of wooden block is such that it just fits in the lower half of standard shear box used in direct shear testing. The geotextile material which is to be used as reinforcing material is glued on the top surface of the aforementioned wooden block using appropriate adhesive. Experimental soil at required dry density (which is usually close to in-situ dry density) is compacted only in the upper half of shear box. Experiment similar to direct shear testing is then conducted at different normal stresses to obtain corresponding failure shear stresses. Using the results of the aforementioned experiment, adhesion as well as interface friction angle between geotextile and soil is determined. Technique is same as cohesion and angle of internal friction determination in direct shear testing. Testing is conducted under fully drained conditions. Usefulness of experiment is limited to freely draining soils. Soil gradation, plasticity, in-situ dry density, moisture content and surface characteristics of the geotextile are important parameters affecting adhesion as well as interface friction angle between geotextile and soil. It was concluded that the test using a large solid block as the lower shear box is the best at replicating the testing results of the soil/geotextile interface [4]. It has been stated that the geotextile and geomembrane can be tested with a solid block or soil in the lower part of the shear box, while the geogrid must be tested by a device in which both parts of the shear test device have to be filled with soil [5].

Geotextile is one of the geosynthetics commonly used as reinforcing agent in soil. It could be woven, non-woven or knitted type. In the present study woven geotextile has been used as reinforcing material in the soil. Large numbers of geotextiles are of woven type. They can be sub-divided into several categories based upon their method of manufacture. They were the first to be developed from synthetic fibers. Woven geotextiles are manufactured by adopting techniques which are similar to weaving usual clothing textiles. This type has the characteristic appearance of two sets of parallel threads or yarns. The yarn running along the length is called warp and the one which is perpendicular is called weft. The majority of low to medium strength woven geotextile is manufactured from polypropylene fiber. This can be in the extruded tape, silt film, monofilament or multifilament form. Usually a combination of yarn types is used in the warp and weft directions. Objective is to optimize performance as well as cost [6]. Higher permeability is obtained when monofilament and multifilament form of polypropylene fiber is used in woven geotextile manufacture.

Experimental soil has been collected from Birla Institute of Technology & Science, Pilani campus. Sliding shear testing of woven geotextile reinforced experimental soil has been conducted at four different moisture contents. Variation of adhesion and interface friction angle with moisture content has been thus investigated. Practical significane of the study has also been discussed.

II. MATERIALS USED

The materials used in this study were local soil, woven geotextile and ordinary tap water. Woven geotextile was glued on wooden block which was having 6cm x 6cm plan area. Dimensions of the wooden block was such that it just fitted into the lower half of standard shear box. This shear box was used in present study and its inner plan area was also 6cm x 6cm.

Local soil used in the study was collected from Birla Institute of Technology & Science, Pilani campus. Soil was collected from ground surface using core cutter technique. Standard core cutter was used for this purpose. The collected soil had in-situ water content 10%, in-situ bulk density 1.922 gm/cc and in-situ dry density 1.747 gm/cc. Specific gravity of this experimental soil using pycnometer was found to be 2.577. Particle size distribution of experimental soil is shown in Table 1. Its particle size distribution curve is also shown in Figure 3. All the experimental soil used in sieve analysis was found to pass through 4.75mm sieve and only 2.4% was found to be finer than 75µ sieve indicating that the soil was sand type. From particle size distribution curve of Figure 3, it was found that uniformity coefficient of the experimental soil was 2.89 & its coefficient of curvature was 0.96 indicating it to be poorly graded sand & is of freely draining type.

Table 1: Particle size distribution of experimental soil

Particle Size	2.36mm	1.18mm	600µ	300µ	150µ	75µ	Pan
% Finer	97.4	92.8	91.6	67.2	34.0	2.4	0

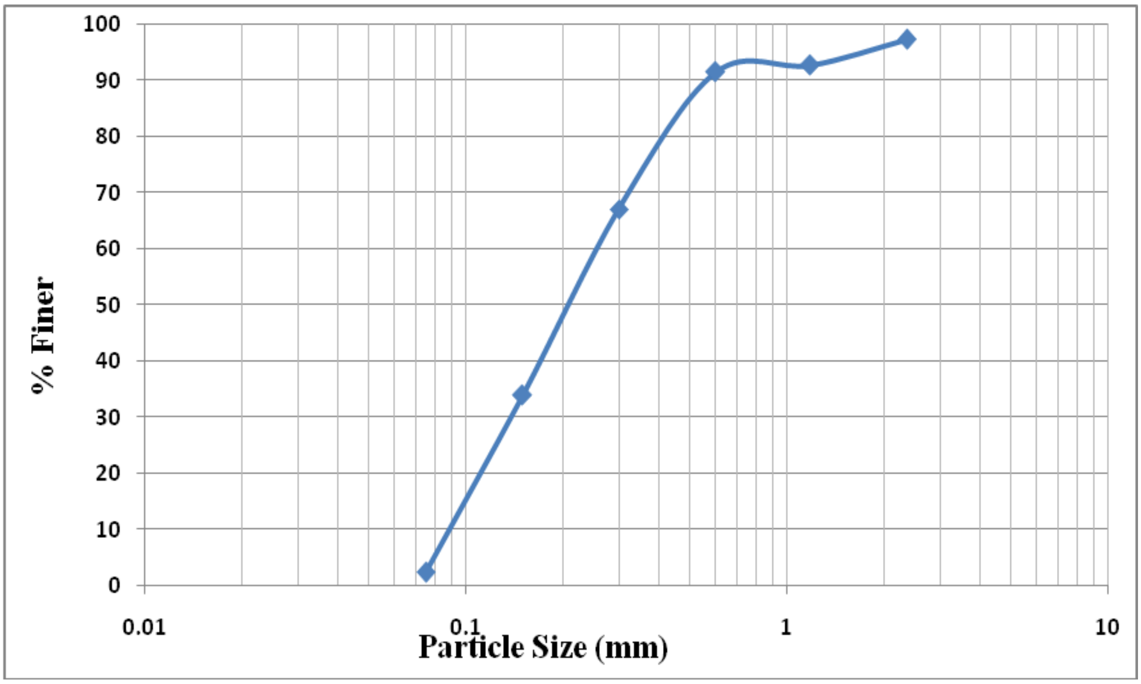

Figure 3: Particle size distribution curve of experimental soil

III. EXPERIMENTAL DETAILS

Sliding shear testing of experimental soil was conducted at in-situ dry density of 1.747 gm/cc. First sliding shear testing was conducted at in-situ water content, which was 10%. Soil which was collected from field using core cutter was used for this purpos e. Volume of the upper half of shear box (after fitting woven geotextile glued wooden block in the lower half) was found to be 99cm^3. Hence, in order to get 1.747 gm/cc dry density, bulk weight of in-situ soil compacted in upper half of shear box was 190.2gm. Water present in soil at this 10% water content was in-situ water.

Experimental soil collected from field was then oven dried for 24 hours. The dry soil at 0% water content was also subjected to sliding shear testing at 1.747 gm/cc dry density. Weight of dry soil thus compacted in upper half of shear box was thus 172.9gm.

Results of aforementioned two sliding shear testing experiments have been summarized in Table 2. It is also plotted in Figure 4.

Table 2: Sliding shear test results (In-situ & dry soil sample)

Normal stress (kg/cm^2)	Failure shear stress (kg/cm^2) (In-situ soil sample)	Failure shear stress (kg/cm^2) (Dry soil sample)
0.0491	0.0982	0.0675
0.0694	0.1166	0.0920
0.0986	0.1289	0.1105
0.1388	0.1596	0.1350

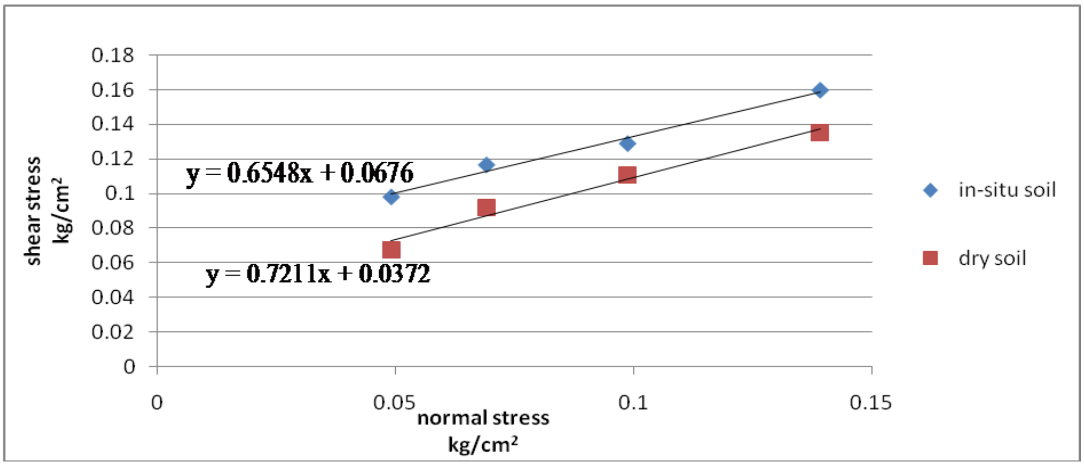

Figure 4: Sliding shear test results (In-situ & dry soil sample)

For third sliding shear testing, required amount of tap water was added in oven dried experimental soil to get 5% water content in it. This testing was also conducted at 1.747gm/cc dry density. Bulk weight of tap water mixed compacted soil in upper half of shear box was thus 181.6gm. Sliding shear testing was also conducted at 15% water content in oven dried experimental soil by adding required amount of tap water in it. Like previous three sliding shear tests, this test was also conducted at 1.747gm/cc dry density. Bulk weight of tap water mixed compacted soil in upper half of shear box was thus 198.9gm. Results of these two sliding shear testing experiments have been summarized in Table 3. It is also plotted in Figure 5.

Table 3: Sliding shear test results (Soil sample at 5% & 15% water contents)

Normal stress (kg/cm^2)	Failure shear stress (kg/cm^2) (Soil sample at 5% water content)	Failure shear stress (kg/cm^2) (Soil sample at 15% water content)
0.0491	0.0982	0.0859
0.0694	0.1227	0.1105
0.0986	0.1473	0.1350
0.1388	0.1596	0.1596

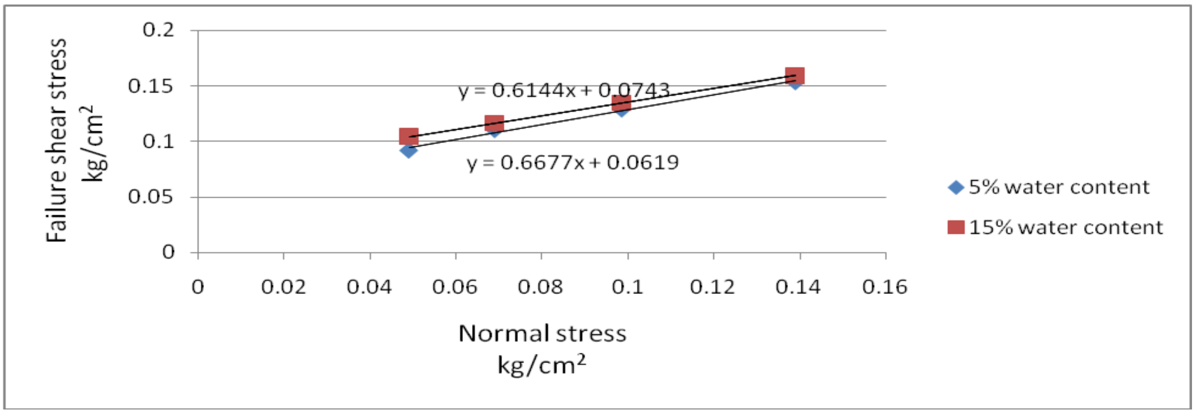

Figure 5: Sliding shear test results (Soil sample with 5% & 15% water content)

Adhesion and interface friction angle values between experimental soil and woven geotextile at tested water contents have been shown in Table 4. They have also been plotted in Figures 6 & 7 respectively.

Table 4: Adhesion & interface friction angle values at tested water contents

Tested water content	Adhesion (kg/cm^2)	Interface friction angle (deg.)
0%	0.0372	35.795
5%	0.0619	33.731
10% (In-situ)	0.0676	33.216
20%	0.0743	31.566

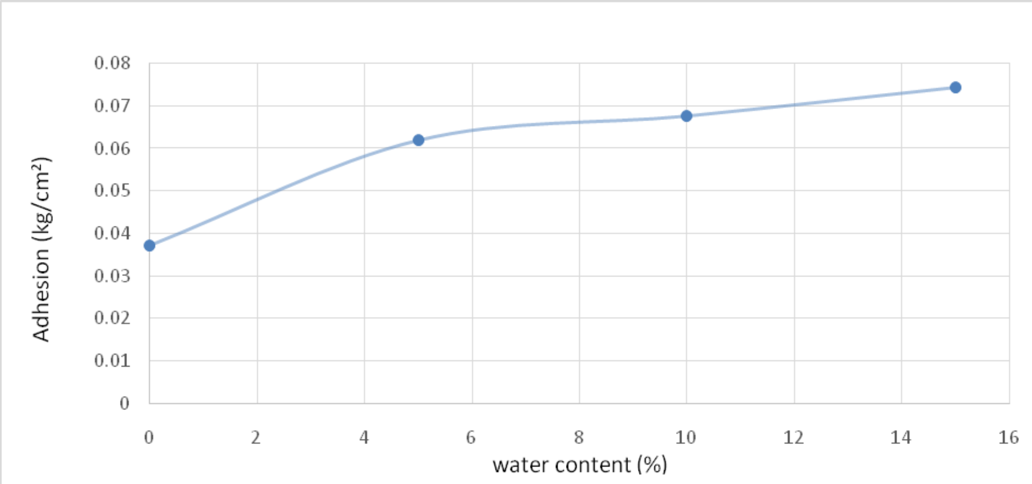

Figure 6: Variation of adhesion between tested soil & woven geotextile with water content

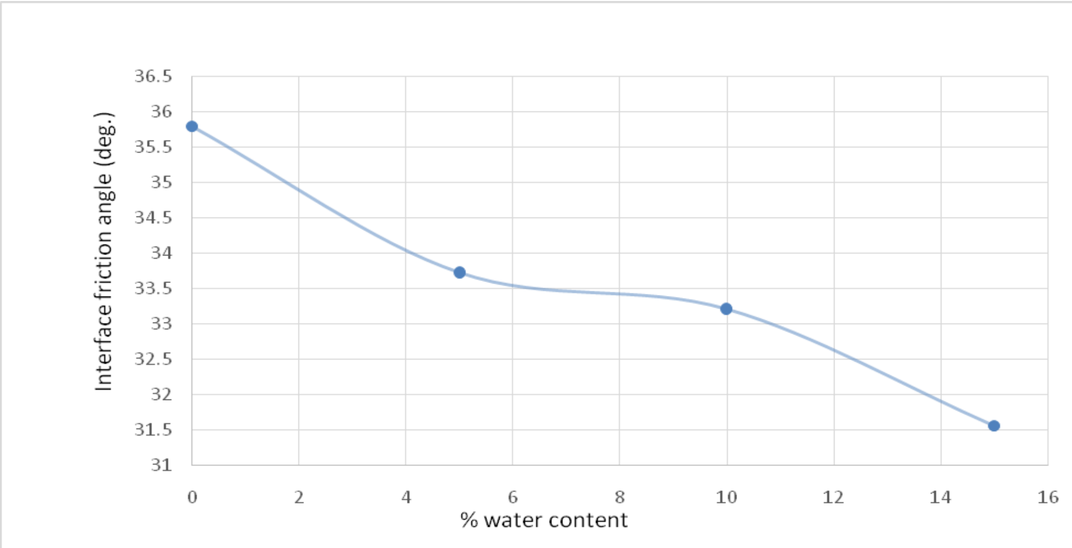

Figure 7: Variation of interface friction angle between tested soil & woven geotextile with water content

IV. DISCUSSION ON EXPERIMENTAL RESULTS

In-situ experimental soil of present study has negligible cohesion. Its angle of internal friction is around 28^0. These values are under similar conditions of direct shear testing as reported in present study. In the present study it was observed that this in-situ soil, when reinforced with woven geotextile gave adhesion value of 0.0676kg/cm^2 and interfacial friction angle value of 33.216^0 under sliding shear testing conditions. Hence there will be substantial shear strength increase if woven geotextile is used as reinforcing material in the tested soil under shallow footing conditions at appropriate place & location in the in-situ soil. From Figure 6 it is clear that adhesion between tested soil and woven geotextile increases as water content increases from 0% to 20% under sliding shear testing conditions. Adhesion is the tendency of dissimilar particles or surfaces to cling to one another. The intermolecular forces responsible for adhesion fall into the categories of chemical adhesion, dispersive adhesion, and diffusive adhesion [7]. These effects are enhanced as water content increases resulting in increased adhesion. From Figure 7 it is clear that interface friction angle between tested soil and woven geotextile decreases as water content increases from 0% to 20% under sliding shear testing conditions. If substantial water is present in soil sample, it has lubricating effect at the interface between soil and woven geotextile [8]. This leads to decrease in interface friction between soil and woven geotextile. As per geotechnical design requirement, if water content is altered from its in-situ value in the experimental soil, desired adhesion as well as interface friction angle can be obtained at the interface between experimental soil and woven geotextile. This also will have practical application when woven geotextile is used as reinforcing material in tested soil under shallow footing conditions.

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