Experimental Study on Shear Strength Parameters of Soil Mixed with Glass Fiber

Mohammad Farouk Abdelmagied

Abstract—Determining the shear strength properties of the soil is a vital step in investigating its stress-strain behavior. Moreover, suction plays a vital role in the shear strength of the unsaturated soil. This paper investigates the influence of the fiber glass on the shear strength parameters of (c-phis) soil with different ratios. To achieve this purpose, the samples of (c-phis) soil from El-Fardos gardens housing compound, Benha city, Egypt, were prepared at their maximum dry densities with corresponding optimum moisture content. Direct shear box test of 60 x 60 mm under a relentless rate of 1 mm/min was employed with the proposed range of ASTM D 3080. Different fiber glass ratios of 0.1, 0.50 and 1.00 % of soil sample weight were used. The results confirmed that the peak shear strength parameters increased with increasing the fiber ratio.

Index Terms—Direct Shear Box, Fiber Glass, Shear Strength Parameters.

I. INTRODUCTION

In many geotechnical problems, the direct shear tests are used to evaluate the shear strength parameters of geomaterials to define design parameters. Several labs execute direct shear test on sand, clay and (c-phis) soil to compute the cohesion and angle of internal friction for engineering design purpose.

Reviewing literature revealed that different types of fiber glass are frequently used to improve concrete behavior, but a few studies used it to enhance the soil shear strength parameters.

Szypcio (2019) applied the frictional state theory, he believed that the stress-dilatancy relationship for the large shear box was different from that for the small one conventionally used in direct shear tests, and recommended higher non-homogeneity deformation within the shear band during a large shear hold in comparison with that in a small one. Ajay et al. (2018) investigated rheological properties of typical vibrated concrete employing a simple direct shear box. The concrete mixes were proportioned supported on absolute volume construct. Olujide et al. (2017) studied the direct shear experiments to research the interaction between a preponderantly cohesion less soil and uncharged concrete and therefore the validation of the tangent of two-third of the angle of internal friction angle, unremarkably they assumed in style involving stability of structures with relation to friction. Mohapatra et al. (2016) introduced a shot to investigate the dilative behavior of dense sand at 2 different sizes of the direct shear box, i.e. small (60 x 60 x 30) mm and large (305 x 305 x 140) mm. A three-dimensional numerical model was additionally developed victimization the FLAC3D computer program. Moayed et al. (2016) investigated the impact of the dimension issue on the shear strength of sands with different silt contents. Stark et al. (2014) reviewed the suitable instrumentality and check the procedure for ballast shear strength testing victimization the direct shear methodology and that they give some typical results. Xiao et al. (2013) given a large-scale direct shear testing of tire-derived aggregate (TDA) of large sizes (25-75) mm to get and compare the shear resistances of large-sized TDA and TDA in-turned with sand, concrete and geosynthetics.

Kim et al. (2012) explored the impact of the gap between the shear boxes on the shear behavior within the direct shear box test (H=20 x D=60) mm underneath a relentless vertical stress victimization seven styles of granular material. Hamidi et al. (2011) given a completely unique direct shear device and that they mentioned that using osmotic methodology to execute the specified suction for a variety of medium to comparatively high suction. A polyethylene Glycol (PEG) solution was circulated beneath the soil sample to use the specified solution. Liu (2009) studied the DST with more valid by performed tests on samples with an equivalent gradation, instead of on samples with parallel gradations, under normal stresses up to 880 kPa. The DST was performed inside fills in two applications. Qiang et al. (2009) introduced a series of two-dimensional numerical direct shear tests to check the scaling influence. Liu (2006) showed some ways to reduce the interface frictional force. Distinct part simulation was performed for direct shear box tests on dense and a loose two-dimensional sample, attention was attracted to the effect of the resistance force between the inside surface of the upper shear box and therefore the sample had on the measured shear strength. Cerato and Lutengger (2006) tested five sand samples with different properties in three square shear boxes of variable sizes, every three relative densities and that they offered an outline of the test methods and results.

II. MATERIALS AND METHODS

A. Studied material and sample preparation

The considered soil samples were assembled in an undisturbed state from El-Fardos gardens housing compound, Benha city, Egypt. Bulk samples were crushed by hammer to produce a homogenous media of soil particles. Sieve analysis, Atterberg limits, Water content and Specific gravity tests were performed and presented in Table 1. Fig. 1 shows a sample of the particle size distribution of the soil. Soil samples were prepared by adding an appropriate amount of water and the sample was

Published on June 28, 2019.

M. F. Abdelmagied is a Lecturer at Civil Engineering Department, Benha Faculty of Engineering, Benha University, Egypt.

DOI: http://dx.doi.org/10.24018/ejers.2019.4.6.1381
dried by an oven to achieve a water content of about 15.0%.

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$G_s$</td>
<td>2.59</td>
</tr>
<tr>
<td>LL (%)</td>
<td>31.27</td>
</tr>
<tr>
<td>SL (%)</td>
<td>24.93</td>
</tr>
<tr>
<td>PI (%)</td>
<td>13.12</td>
</tr>
<tr>
<td>$\gamma_d$</td>
<td>1.60 kg/cm$^2$</td>
</tr>
</tbody>
</table>

**TABLE I: INDEX PROPERTIES FOR SOIL SAMPLE**

B. Fiber Glass

In this study, one type named (E6-CR) with vinyl ester resin in size 18 mm lengths was utilized. The (E6-CR-18-M) was chopped from (E6-CR) glass fiber coated with saline-based sizing, and compatible with unsaturated polyester, vinyl ester, epoxy resin and systems and designed for compression molding process, Table II. The (E6-CR) is low static, low fuzz, good dispersion in results, low viscosity, and excellent flow ability of the prepared, good processing and excellent mechanical properties, Fig. 2.

**TABLE II: TECHNICAL PARAMETERS OF FIBERGLASS**

C. Direct shear test

Direct shear test was carried out considered at laboratory of Al Azhar university. The small-sized square shear box of dimension (60 x 60) mm was employed. The samples were sheared at a constant rate of 1 mm/min, which in the proposed range of ASTM D 3080, Fig. 3.

D. Experimental program

In the small size shear box of (60 x 60) mm, twelve tests were performed with different vertical seating stresses of 0.50, 1.00 and 2.00 kg/cm$^2$ using a dead weight system. The normal stress values were chosen based on the typical range of stress in practical projects and laboratory facilities specifications.

Samples were prepared in corresponding optimum moisture content, and they randomly mixed with different fiber ratios. In the shear box, the required amount of soil was compacted in three layers. Each layer was compacted with a constant compaction energy. After the compaction the sample surface was releveled and loaded. The forces transferred from the hydraulic system by a piston and plate on the sample. A sample without any fiber was tested as a reference case for comparison purposes. The fiber glass was considered with a percentage of 0.10, 0.50 and 1.00% of the weight of the soil sample, Fig. 4 and 5.
III. RESULTS AND DISCUSSION

The experimental results were validated. Horizontal shear stress versus horizontal displacement curves for clean soil sample and soil with fiber that have been tested are presented in Fig. from 6 to 9.

Shear stress versus normal stress curves revealed that a strain hardening behavior. The results indicate that the shear strength increases with increasing of normal stress and fiber ratios, Fig. from 10 to 13.
Comparison of Shear stress and Normal stress curve with Horizontal shear stress-horizontal displacement curve for clean soil sample and soil mixed with different fiber ratio, was graphically presented. Obtained result from soil mixed with 1.00% fiber ratio was approximately equal two times of other mixed ratios, Fig.14 and 15.

IV. CONCLUSIONS

A small direct shear apparatus was used for testing (c-\(\phi\)) soil mixed with fiber glass.

In this study, soil was randomly reinforced by different percentages of glass fiber and was evaluated. Based on the experimental results, using of certain percentage glass fiber was increased the shear strength parameters. Reinforcement soil by glass fiber produced higher values of strength than the fiber glass with percentage up to 1.00%. Whilst, the results of the clean soil were close to the fiber glass with a ratio up to 0.50%. The increase in shear strength parameters was obtained with a ratio of fiber more than 0.50% of sample weight.

REFERENCES


