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Effect of Gradation on the Interface Shear Parameters between Geo Grid and Sand

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Abstract: Reinforced soil is being extensively used for various Ground Improvement applications due to its effectiveness and durability. The load-settlement behaviour of Reinforced Soil depends upon the interaction between the reinforcement and surrounding granular soil. This paper investigates the effect of gradation of surrounding soil on the interface shear parameters, by carrying out a series of large scale direct shear tests using a shear box of dimensions 300 x 300 x 200mm.Tests were conducted on five no coarse aggregate (CA) and sand (S) with varying mix ratio of 1:0.5, 1:1, 1:1.5 and 1:2and separately for coarse aggregate and sand also. It is observed that gradation of soil, shear parameters and aperture of Geogrid considerably influences the interface shear parameters between the Geogrid and surrounding soil.

Keywords: Reinforced Soil, Load-Settlement Behaviour, Gradation, Interface Shear Parameters.

I. INTRODUCTION

The uses of reinforced soil technique are widely used in the construction of retaining walls, roads, embankments, and foundation soil improvements. When a geosynthetic sheet, it may be geogrids orgeotextiles, are placed in the soil to get the enhanced properties of soil, then the soil is reinforced [1].The selection and gradation of the range grain size of soil available at nearby the construction site, to be used for the reinforcing the soil, is a question of special importance to the researchers, designers and contractors working in the field of reinforcing of weak soil. Depending upon the grain size, the selection of the proper and suitable grid for the available soil is also very important. Hence the efficient particle size is determined for which tests are conducted and particle size distribution is to be determined. The influence of particle size on the shear strength and the size of particle diameter was known to have insignificant differences in the case of sand whereas, in the case of coarse-grained soils with big particle diameters, there have been many different opinions arising among the researchers [2]. Interaction between soils and geosynthetics is of utmost importance in applications of these materials as reinforcement in geotechnical engineering. That is also the case for some applications of geosynthetics in environmental protection works. The mechanisms of soil–geosynthetic interaction can be very complex, depending on the type and properties of the geosynthetic and the soil [3].The soil reinforcement interaction is of high importance for the design and the performance of reinforced soil structures. The interaction behaviour depends on the geometry and the mechanical properties of the reinforcement and the surrounding soil. Different types of laboratory tests but also theoretical work have been developed, in order to improve the understanding of the soil geosynthetic interaction mechanism. The discrete interaction between the transverse members of the geogrid and the surrounding soil has been made visible by performed photo-elastic studies [4]. Different failure mechanisms occurring in specific zones due to different interactions between the backfill material and the reinforcement were indicated.These results show that by reducing the distance between the transverse members discrete non-uniformities in the distribution of bearing loads among transverse members might occur. This no uniform load distribution is a result of the highly discrete behaviour between granular soil and the reinforcements [5]. The shear strength parameters, such as interface friction angle and adhesion, for no reinforcement, reinforcement with soft geogrid, and reinforcement with stiff geogrid were studied [6]. In the case of no reinforcement, as the maximum particle diameter became larger, the more the internal friction angle was increased, but the internal friction angle in the case of reinforcement with geogrid turned out to be smaller than that in the case of no reinforcement. The tendency of decrease in the interface friction angle due to reinforcement with geogrid is similar to the results of tests in his previous research.The influenceof soil particle size on soil-geosynthetic interaction is important, but its significance dependson several factors. With geogrids, the relative sizes of soil particles and geogridapertures, and the thickness of the geogrid bearing members, and soil-geogridinterface shear resistance. Tests, on geogrids in which the bearing members had been cut, show a significant decrease in soil-geogrid interface shear resistance. The influence of soilparticle size is less important for geotextiles and geocomposites. Although the structureof geotextiles and geocomposites has an effect on soil-reinforcement interface behaviour,

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mobilisedpull-out resistance is also affected by the axial tensile stiffness of geotextiles and geocomposites [7]. The load–displacement curve obtained in pull-out tests are not sufficient for an accurate investigation of soil–grid interaction and bearing force degradation mechanisms must be incorporated in the analysis of grid pull-out response if accurate predictions of pull-out strength and grid deformations are to be made[8].

The correlation between certain physical properties of granular material such as the friction angle and the grain size distribution were studied[9]. In the laboratory, the determination of friction angle requires hard and expensive testing. Prediction of this parameter from the grading curve proves to be very interesting. Direct shear tests were performed on actual marine sand of Tergha (Algeria) and on seventeen different samples arranged from the same sand with various particle size ranges. Results showed that the friction angle of sand is a result of contribution of various constituent granular classes. The results show a direct relation between particles size and peak friction angle. It is noted that there is an increase in peak friction angle with the increase of particles size. So if we know the size of particles of marine sand we can deduce directly the value of peak friction angle. On the other hand the line of variation of internal friction angle, according to di is almost horizontal, which shows that there is no influence of the particles size on the internal friction angle.

II. TEST APPARATUS

The schematic diagram of the modified shear box is shown in Figure 1.The test apparatus includes upper and lower boxes. The dimensions internally is 300mm x 300mm x 100mm and that of lower box is 300mm x 300mm x 100mm .The box is made of MS plates having a thickness of 4mm.The whole set up is mounted on a MS testing bench with facilities to apply vertical and horizontal loads. Also, the horizontal applied id through a 2 KN proving ring fitted with a dial gauge to measure the load applied. Another dial gauge is fitted on the other side to measure the horizontal displacement.

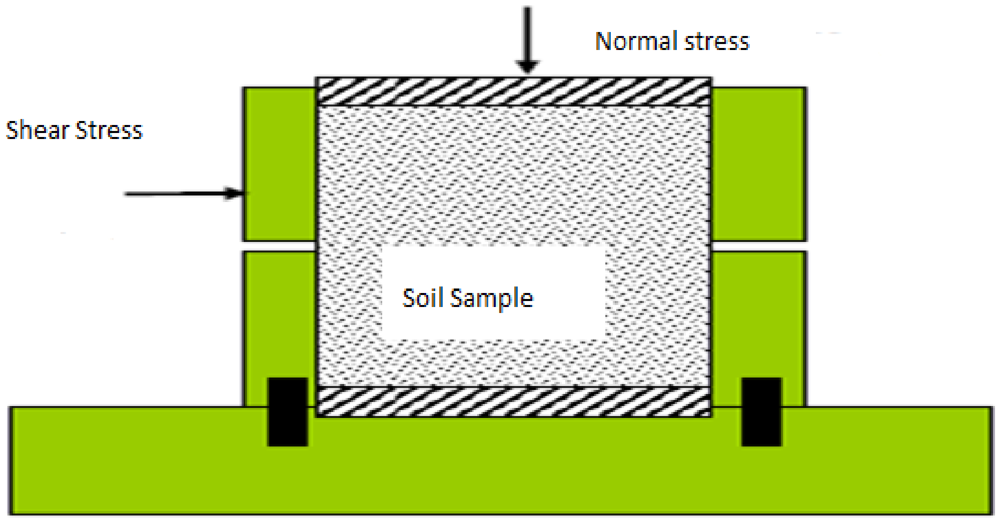

Figure 1: Test Apparatus

III. TEST MATERIALS

The test soil consists of two parts. Coarse aggregate (CA) and sand(S).The tests are conducted for different mix ratios of CA and S and tested separately. The mix ratio of CA and S are: 1:0.5, 1:1, 1:1.5 and 1:2. The aperture size of the Geogrid used is27mm x 18mm and is made of PP.

TABLE 1: PROPERTIES OF SOIL

SOIL	D10	D30	D50	D60	Cu	Cc
CA 1:0.5	0.36	2	4.95	5.9	16.4	1.9
CA 1:1	0.22	0.65	2.1	4	18.2	0.48
CA 1:1.5	0.2	0.41	1.1	1.8	9	0.47
CA 1:2	0.2	0.42	1.3	1.9	9.5	0.46
S	0.32	0.6	0.92	1.2	3.75	0.94
CA	1.95	3.3	6.8	6.45	3.3	0.87

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IV. TEST PROCEDURE

The CA and S mix is prepared for each mix ratios. The samples are well mixed and the sieve analysis is carried out. The soil sample is filled in the lower box in equal layers of 5 cm and each layer is compacted using a 1 Kg weight by tamping the surface. The dry density is also measured. The upper box is placed over the lower box and soil is filled as before. The rigid bearing plate was horizontally placed on the surface of the soil and the required vertical loads of 1.95, 3.9 and 5.85 KPa were applied. While doing the test with the Geogrid, 280mm x 280mm size Geogrid is used. The horizontal load applied is through a proving ring (PR) and is measured using a dial gauge fitted to the PR. The horizontal displacement is measures using a dial gauge fixed on the other side of the PR. The readings of horizontal displacements and horizontal load applied were measured against each vertical load.

The test is carried out for the CS: S mix ratio of 1:0.5 for vertical stress of 1.95, 3.9 and 5.85 KPa each with and without Geogrid. The test is repeated for all the mix ratios as well for Cs and S alone.
The interface shear stress $\tau_p$of the modified shear test can be defined as
$\tau_p = T_p/A_p$

whereAp is the area of geogrid buried in the soil sample and T_p is the horizontal force applied through the PR [10].
The sand –Geogrid interface under direct shear mode is featured to shear resistance between sand and the surface of the ribs of Geogrid and internal shear resistance of the soil in the openings of Geogrid. An expression for this had proposed to predict the shear strength in sand – Geogrid interface mobilized under the direct shear mode is
$\tau_{sand\text{-}Geogrid} = \sigma n \; [(1-\rho) \tan\phi_{sg} + \rho\tan\phi_s]$

whereσn is the normal stress, ρ is the per cent of open area of geogrid;$\phi_{sg}$is the interface friction angle between sand and the Geogrid and ϕs internal friction of sand obtained from direct shear test [11].

V. RESULT AND DISCUSSION

As narrated above, the vertical stress, shear stress, and displacements rate were measured from the experiments. The relations between the interface friction angle between sand and the Geogrid and internal friction of sand obtained from direct shear test these factors were investigated. These data were tried to correlate with the particle size, Cc and Cu of all the soil samples. The Cc values of different mixed CS and S is compared with the Interface friction angle between sand and the Geogrid and Internal friction angle of sand.

Table 2: Summary of test results

Soil	Interface friction angle between sand and the Geogrid $\phi_{sg}{}^0$	Internal friction angle of sand $\phi_s{}^0$
CA:S:: 1:0.5	17	9
CA:S:: 1:1	13.1	15.6
CA:S:: 1:1.5	12.7	17
CA:S:: 1:2	12.2	18.4
CA	8.75	11.6
S	8.75	11.6

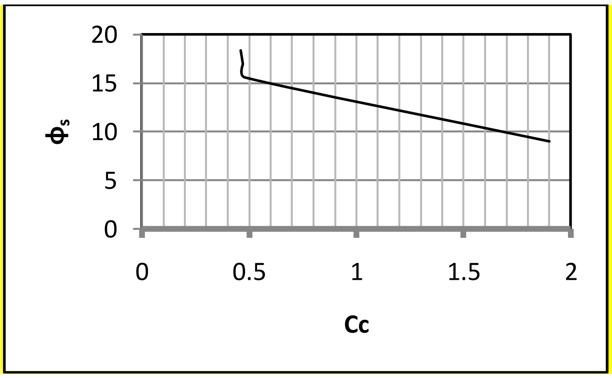

Figure 2: Cc - $\phi_s$relation ship

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In the different mix of CA and S, it can be seen that when the particle size D_{10} is decreasing, the $\phi_s$is increasing and $\phi_{sg}$is decreasing. The aperture size of the Geogrid used is 27mm x 18mm and the width of ribs in longitudinal direction is 5mm and it is 3.5mm in the other direction. The thicknesses of the ribs are 0.5mm.During the testing with geogrid, because of the passive pressure which has been developed in in on side i.e. upper side only.

The maximum particle size is 0.36 mm for CA: S for a mix ratio of 1:0.5.As this particle size is less than the thickness of the Geogrid ribs, the passive resistance pressure developed will not be sufficient to resist the applying horizontal force. The contact between the soil particles in side aperture area will be resisting the horizontal force.

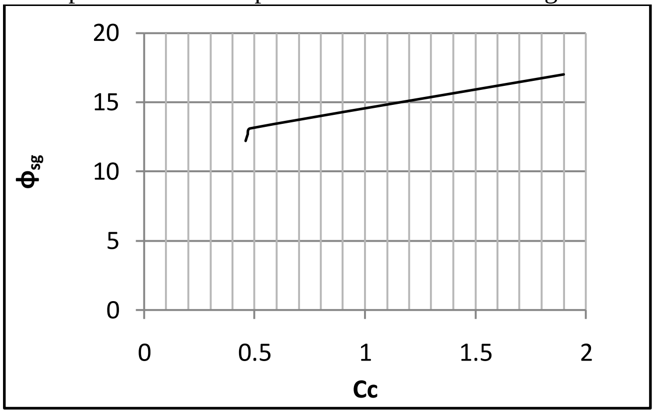

Figure 3: Cc - ϕ_{sg} relation ship

When the particle size is much less than the rib thickness, as in the case of CA: S for 1:1, 1:1.5 and 1:2, the D10 is 0.22 only, the $\phi_{sg}$is decreasing. So, when there is the presence of at least 15% of particles size less than or nearly equal the Geogrid rib thickness, the $\phi_{sg}$is having a high value compared to low particles size even if the presence is 15%.In general, it seen that ϕ_{sg} is in the decreasing trend when Geogrid is used for the increased contents of more sand. Also, the ϕs is in the increasing trend without Geogrid for the same conditions. Figure 2 shows the relationship between the Cc and ϕs. It can be seen that the when the Cc is decreasing,ϕs isincreasing. Similarly, Figure 3 shows the relationship between the Cc and ϕsg where the ϕsg is decreasing with decrease of Cc.

VI. CONCLUSIONS

The characteristic between the different mix of coarse aggregate and sand were studied by using modified shear box tests in this work. The tests were carried out with and without Geogrids. The following were concluded from the tests.

1) The Interface friction angle between sand and the Geogrid is seen decreasing with decrease of coefficient of gradation (Cc) of the soil samples tested.
2) The Internal friction angle of sand is seen increasing with decrease of coefficient of gradation (Cc) of the soil samples tested.
3) The Interface friction angle between sand and the Geogrid is more when the 10-25% particles are nearly equal to the thickness of the Geogrid rib thickness

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