INTERFACE BEHAVIOUR BETWEEN CONCRETE AND BFRP WRAPPED CONCRETE WITH SANDY SOILS

M. SHALLY ALICE
UG Student, Department of Civil Engineering, VV College of Engineering,
Tisaiyanvilai, Tamil Nadu, India.

M. MURUGAN
Associate Professor, Department of Civil Engineering, VV College of Engineering,
Tisaiyanvilai, Tamil Nadu, India.

V. JEYANTHI VINEETHA
Assistant Professor, Department of Civil Engineering, Mahakavi Bharathiyar College of Engineering and Technology, Vasudevanallur, Tamil Nadu, India.

ABSTRACT

Shearing resistance between soil and foundation materials is major importance to make a good estimation of friction between soil and substructures. In this paper the interface strength between concrete and Basalt Fiber Reinforced Polymer (BFRP) wrapped concrete specimens with soil is studied since load transfer between soil and solids takes place at their interfaces. The interface strength is based on surface roughness of material, composition of soil, relative density of soil, grain size distribution and shape of soil particles, moisture content of soil, magnitude of normal stress and rate of shearing. Direct shear tests were conducted to examine the interface friction angle between concrete and BFRP wrapped concrete specimens with sandy soils. The tests were performed under four values of normal stress 0.05 N/mm^2, 0.10 N/mm^2, 0.15 N/mm^2 and 0.20 N/mm^2. Examining the data obtained from direct shear test, it could be seen that in general, there was a decrease in the angle of interface friction with BFRP wrapping. The experimental results show that soil gradation and surface roughness of specimens significantly changes the interface friction angle.

Key words: Direct shear test, Sand, Internal friction angle, Interface friction angle, BFRP.

INTRODUCTION

Soil-structure interaction studies have proven to be an effective tool for the analysis and design of geotechnical structures. Soil-structure interfaces have a great impact on the bearing capacity and load-deformation response of geotechnical structures such as retaining walls, buried culverts, piles, mechanically stabilized structures and etc. Hence it is necessary to determine the interface strength between soil and geotechnical structures to make a good estimation of load transfer between structures and soils. The purpose of soil-solid interface behavior is to study the strength and stability of geotechnical structures. Many researchers have

ISSN 2229-5518

considered application of fibre reinforced polymer sheets/strips as an effective strengthening and rehabilitation material. FRP has limited use in geotechnical engineering applications to date, due to lack of information regarding the behaviour of systems that include these materials. So it is necessary to investigate the interface behaviour between FRP and soil. Uesugi and Kishida (1986) performed an experimental study of frictional resistance at yield between dry sand and mild steel. The results show that the shearing resistance at the interface depends on the normal stress; surface roughness and sand type. Tsubakihara et al. (1993) conducted laboratory tests on friction between cohesive soils and mild steel; experimental results indicate that the friction is dependent on the roughness of steel. Tan et al. (1998) studied the sand-geotextile interface shear strength by torsional ring shear tests. The experimental results show that the peak friction angle measured by the direct shear apparatus is larger than that measured by the ring shear apparatus and the peak friction occurs earlier in the direct shear test than in the ring shear test. Hammoud and Boumekik (2006) studied the interfacial shearing between cohesive soils and solid materials. The results show that the shearing resistance at the interface depends on the interface roughness, as well as on the properties of soils. Ling and Youg (2012) carried out laboratory tests to determine the interface shear strength of Palm biodiesel contaminated sand with smooth and rough steel surfaces. The experimental results show that the contribution of palm biodiesel content to interface shear strength is significant. Interface shear strength increases with the increase of palm biodiesel content. Applied normal stress and surface roughness have remarkable influence on the interface shear strength. The decrease in interface shear strength due to an increase in palm biodiesel content.

SOIL CHARACTERISTICS

Well and poorly graded sandy soils were used in the study. Engineering properties of the sandy soils is listed in Table.1. The sandy soils were classified as well and poorly graded according to IS: 1498 – 1970.

Table 1. Engineering properties of the sandy soils used in the study

Soil Property	Well Graded Sand	Poorly Graded Sand
Grain size analysis:		
Effective size, D10	0.36 mm	0.29 mm
Coefficient of uniformity, C_u	6.46	2.14
Coefficient of curvature, C_c	2.08	0.94
Classification (unified)	SW	SP
Specific gravity, G_s	2.65	2.62
Dry unit weight:		
Maximum, γ_d(max)	17.12 kN/m^3	16.81 kN/m^3
Minimum, γ_d(min)	15.72 kN/m^3	15.25 kN/m^3
Test, γ_d(test)	16.54 kN/m^3	16.16 kN/m^3

TESTING APPARATUS

The apparatus for the direct application of shear force for this entire study were carried out in shear box. The apparatus consists of a square brass box of 60 mm x 60 mm in cross-section split horizontally at the level of the centre of the soil sample. The lower half of the box is mounted on rollers and is pushed forward at a uniform rate by a motorized gearing arrangement. The gearbox with its motor is used with the step less speed control box. The speed control of the shear box is calibrated in mm/min. Test speed could be controlled by choosing the appropriate gear wheel from the gear box. The lower half of the shear box is rigidly held in position in a container and the upper half of the box bears against a steel proving ring. The normal stress to the specimen is by a vertical load hanger which rests on the yoke above the soil specimen, and hangs vertically downwards permitting selected weights to be held on its loading pan. The deformation produced by proven ring indicating the shearing force. The horizontal displacement of the soil specimen was measured with the help of a dial gauge.

TESTING METHODOLOGY

For the interface frictional test, four concrete specimens of size 6cm x 6cm x 1.4 cm were prepared. The concrete specimens were prepared by first mixing the sand and cement, adding water and mixing gradually, subsequently filling the prepared boxes with concrete. Three different surface of concrete (smooth, medium and rough) were suitably obtained by travelling. Next day, the specimens were remoulded and immersed in water for curing. After sufficient curing, specimens were taken out and one specimen was wrapped with BFRP mat. Direct shear test was conducted between these specimens with sandy soils. Four different concrete specimens are shown in figure 1.The specimens were placed in the lower half of the direct shear box and the upper half of the shear box was filled with sandy soils at predetermined density. The modified direct shear test setup is shown in figure 2. When a shearing force is applied to the lower box through the geared jack, the movement of the lower part of the box is transmitted through the specimen to the upper part of the box and hence on the proving ring. The deformation in proving ring indicates the shear force. The horizontal displacement during the shearing process is measured by mounting a dial gauge at the top of the box. Samples were sheared at 1.25 mm/min. For each tests four normal stress 0.05 N/mm^2, 0.10 N/mm^2, 0.15 N/mm^2 and 0.20 N/mm^2 were used.

Fig. 1. Concrete specimens used in this study

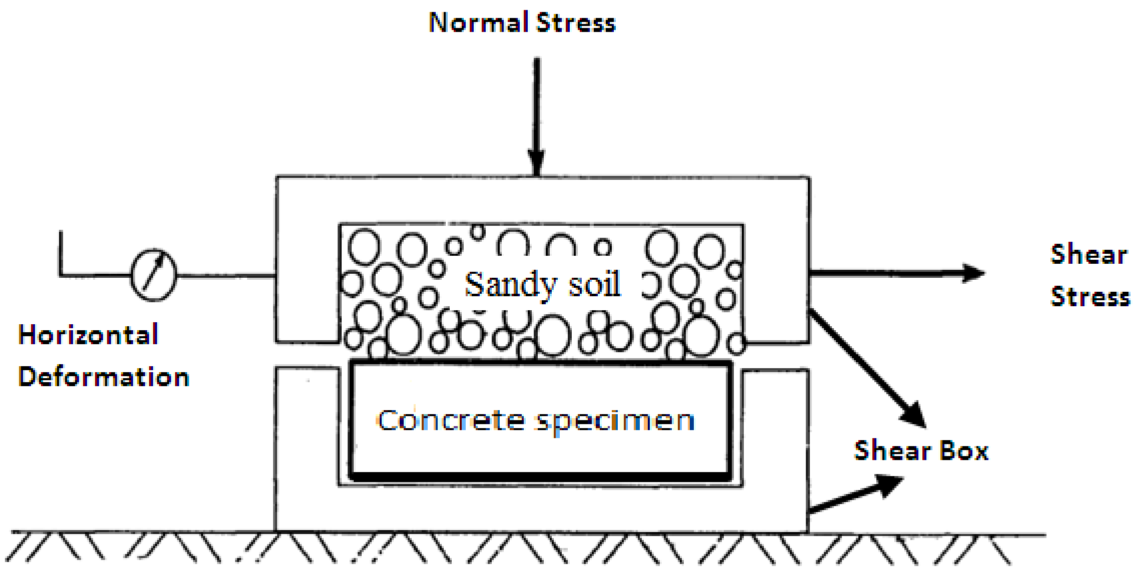

Figure 2: Test set up for interface friction measurement

TEST RESULTS AND DISCUSSIONS

Effect of surface roughness on interface friction

The factor that influences the shear strength parameters is Surface roughness of the geotechnical structures. Generally, Absolute roughness (R_a) is considered for calculating interface friction between two different materials. It is a measure of the surface roughness of a material. This roughness is generally expressed in units of length as the absolute roughness of the material. Surface roughness of concrete specimens used in the study is given in the table 2. The results obtained for the well and poorly graded sandy soils under different normal stresses were analysed to obtain the required shear strength parameters. The obtained shear strength parameters are presented in table 3. Interface friction angle against surface roughness of concrete specimens with well and poorly graded sandy soils are shown in figure 3 and 4 respectively. It indicates that interface friction angle of the soil proportional to the surface roughness of the concrete specimens used in this study. The highest peak shear strength is achieved when the surface is rough.

Table 2. Surface roughness

Concrete specimens	Surface roughness, R_a (µm)
Smooth surface concrete	0.62
Medium surface concrete	0.88
Rough surface concrete	1.82
BFRP wrapped concrete	0.72

ISSN 2229-5518

Table 3: shear strength parameters

Type of interaction	Angle of internal/interface friction	
	Well graded sand	Poorly graded sand
Sand – Sand	38.21°	36.48°
Sand – Smooth surface concrete	34.68°	32.44°
Sand – Medium surface concrete	36.92°	34.94°
Sand – Rough surface concrete	42.46^0	40.52^0
Sand – BFRP wrapped concrete	35.41^0	33.22^0

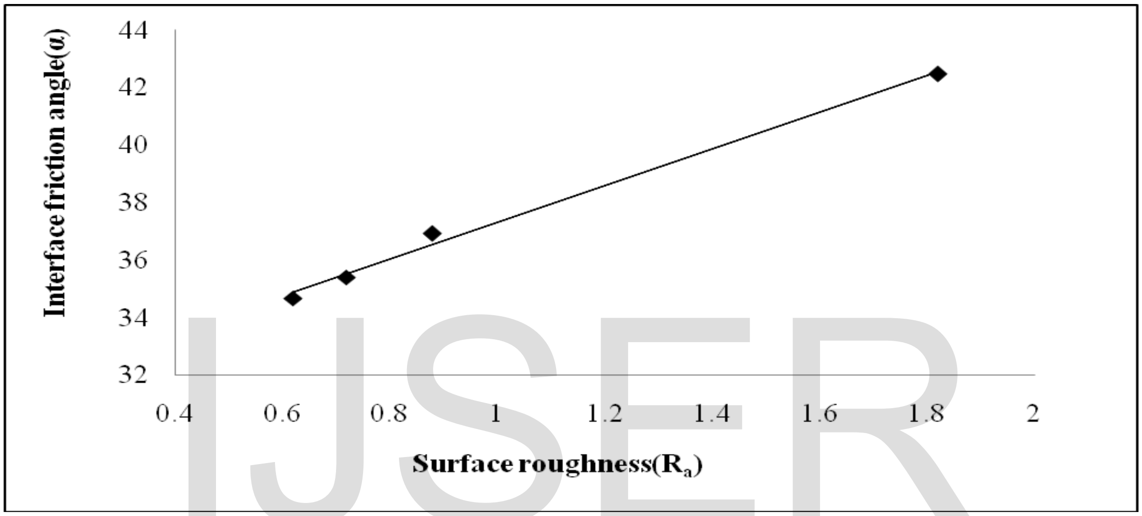

Fig. 3. Interface friction angle against surface roughness of concrete specimens with well graded sandy soil

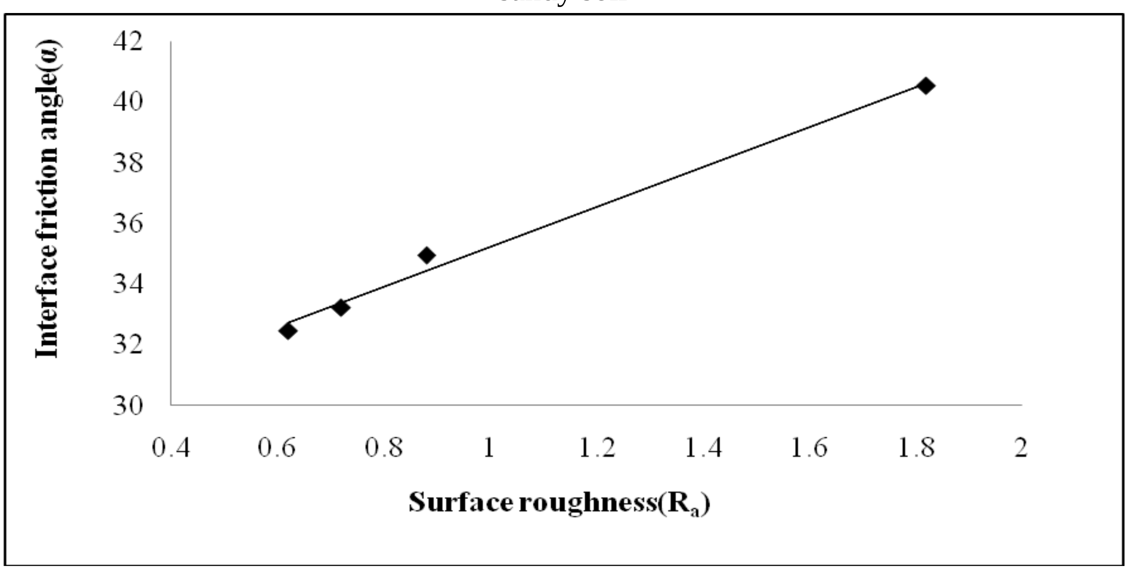

Fig. 4. Interface friction angle against surface roughness of concrete specimens with poorly graded sandy soil

CONCLUSION

Direct shear tests were conducted to investigate the interface friction angle between well and poorly graded sandy soils with concrete specimens. The tests were performed under four values of normal stress 0.05 N/mm^2, 0.10 N/mm^2, 0.15 N/mm^2 and 0.20 N/mm^2. Examining the data obtained from direct shear test, it could be seen that, the shear strength at the interface is directly proportional to the surface roughness of concrete specimens. The shear strength increases with increasing normal stress.

- When compared to medium surface concrete specimen, the smooth surface concrete specimen with well and poorly graded sandy soils shows lower values of angle of interface friction of 6.07 % and 7.16 %.
- When compared to medium surface concrete specimen, the rough surface concrete specimen with well and poorly graded sandy soils shows higher values of angle of interface friction of 15.01 % and 15.97 %.
- When compared to medium surface concrete specimen the BFRP wrapped concrete specimen with well and poorly graded sandy soils shows lower values of angle of interface friction of 4.09 % and 4.92 %.

REFERENCES

1. Uesugi, M., and Kishida, H. (1986). “Frictional resistance at yield between dry sand and mild steel.” Geotechnical Society, Soils and Foundations, 26(04), 139-149.
2. Tsubakihara, Y., Kishida, H., and Nishiyama, T. (1993). “Friction between cohesive soils and steel.” Geotechnical Society, Soils and Foundations, 33(02), 145-156.
3. Tan, S. A., Chew, S. H., and Wong, W. K. (1998). “Sand-geotextile interface shear strength by torsional ring shear tests.” Geotextiles and Geomembranes, 16, 161-174.
4. Hammoud, F., and Boumekik, A. (2006). “Experimental study of the behavior of interfacial shearing between cohesive soils and solid materials at large displacement.” Asian Journal of Civil Engineering (Building and Housing), 07(01), 63-80.
5. Ling, S. Y., and Youg, L. C. (2012). “Palm biodiesel contaminated sand-steel interface testing with direct simple shear apparatus.” International Journal of Civil and Structural Engineering, 03(01), 227-238.