International Balkans Conference on Challenges of Civil Engineering, BCCCE,
19-21 May 2011, EPOKA University, Tirana, ALBANIA.

Interface Friction Between Organic Soil and Construction Materials

Hanifi Çanakcı[1] H.Erdem Yavuz[1] Fatih Çelik[1] Hamza Güllü[1]

[1]*Department of Civil Engineering, University of Gaziantep, Turkey*

ABSTRACT

In this study, interface frictional resistance between organic soil and some of construction material was investigated. Construction materials used in this work are concrete, metal, and wood. Interface friction angle were determined for three different water contents values of organic soil dry, 25%, 50%, and 75% respectively. Different face roughnesses were tested for different water content. All tests were carried out using direct shear test device. Three different normal forces were used and shear stress at 10% strain rate was taken as maximum shear stress. Test results showed that water content of the organic soil, material type, and surface roughness should be considered while selecting interface friction angle between organic soil and construction materials.

INTRODUCTION

Organic soil is a mixture of fragmented organic material formed in wetlands under appropriate climatic and topographic conditions and it is derived from vegetation that has been chemically changed and fossilized. This type of soils has low shear strength and high compressive deformation which often result in difficulties when construction work is undertaken on the deposit. Bearing capacity and settlement problems are generally solved using pile foundations or different improvement methods. Pile foundation used in this type of soil is generally friction piles where loads transferred to soil through interface friction between soil and pile material. One of the important parameter for frictional resistance is friction coefficient between pile material and soil.

Many geotechnical problems involve estimation of stresses transferred along the interface between soils and solid surfaces. Pile foundations and earth reinforcements involve the estimation of interfacial friction between soils and such structures. It is essential to determine the interface friction angle between soil and pile material in order to make a good estimation of the axial capacity of the pile. Also, knowledge of the interface friction angle in the determination of the magnitude and line of action of the wall reaction is significant.

Various studies on interfacial friction between soil and other materials were carried out in the past. Different kinds of apparatus were used in the literature to determine interface friction angle between soil and solid construction material such as direct shear test apparatus [1-6], simple shear apparatus [7-8], ring torsion apparatus [9], dual shear apparatus [10], miniature pile test apparatus [11], and soil-pile slip tests apparatus [6].

Previous researchers found that several factors affecting the value of the interface friction angle. Among those factors are: (i) soil properties such as mineralogical composition, density, grain shape, grain size and gradation; and (ii) the properties of the material surface such as hardness and surface roughness.

In this study, interfacial friction between organic soil and some of construction material was investigated using direct shear box apparatus. Construction materials used in this work are rough and smooth concrete, smooth, rough, and painted metal, and wood. Four different water contents values of organic soil were used for testing program. These are dry, %25, %50 and 75%. Interface friction angle was measured using direct shear test device. Tests were performed with locating construction material at lower part of the shear box and filling the upper part with organic soil.

MATERAILS AND METHODS

Organic soil used in this experiment was obtained from Sakarya region, Turkey. A relatively uniformly graded organic soil is used in the study. This organic soil is classified as OH by Unified Soil Classification System (USCS) and peat by classification system suggested by Wüst, [12]. Engineering properties of the organic soil is listed in Table.1. Organic content was estimated according to ASTM D-2974. Sieve analysis was carried out on ash and it was found that ash contains 15% silt and clay and 25% sand. Liquid limit of the organic soil was estimated by fall cone test according to BS1377 and found to be 125%.

Table 1 Engineering properties of the organic soil used in the study

Soil properties	Values
Organic Content (%)	50-70
PH	4,5-6,5
Organic Carbon(%)	20-30
Water keeping capacity, (in volume %)	85-95

The quality of the steel was that of common commercial mild steel, which is widely used for pipe piles and sheet piles. For practical purposes, three different kinds of surface finish were used in this investigation. These are original manufactured surface, rough surface that was obtained by making deep groove on the surface, and painted surface with three layers of anti-corrosive paint (Figure 1).

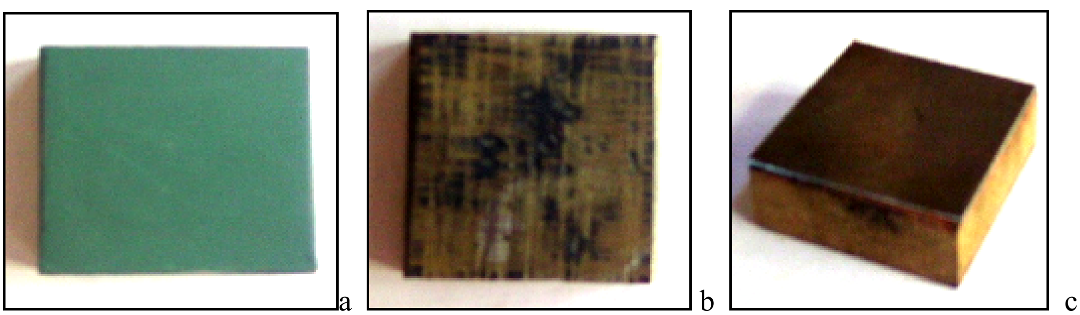
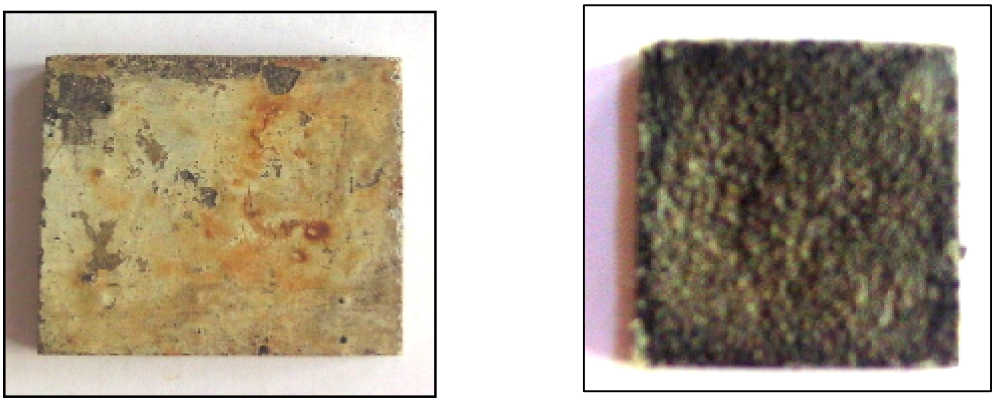


Figure 1 Metal used in the experimental work a) Painted b) Rough c) Original

Concrete was prepared so that the strength value is a practical value, at the same time it can be sheared with organic soil repeatedly with minimum wear on the surface. The concrete was prepared by first mixing the sand and cement, adding water and mixing gradually, subsequently filling the prepared boxes with concrete. For concrete specimens, smooth surface was obtained by location the one side of the box on clean and smooth tile surface, and rough surface was obtained by poring 1 mm sand particles on fresh concrete then the surface was leveled (Figure 2).



a. b.

Figure 2 Concrete used in this study a) Smooth b) Rough

Wood used for the test was sound pine. It was cleaned from any unnatural surface irregularities and defects (Figure 3). Each test piece was shaped by planning to minimize the effect of roughness attributed by other than the natural texture of the wood. The tests were carried out in parallel directions to the grain of the wood.

Figure 3 Wood used in this study

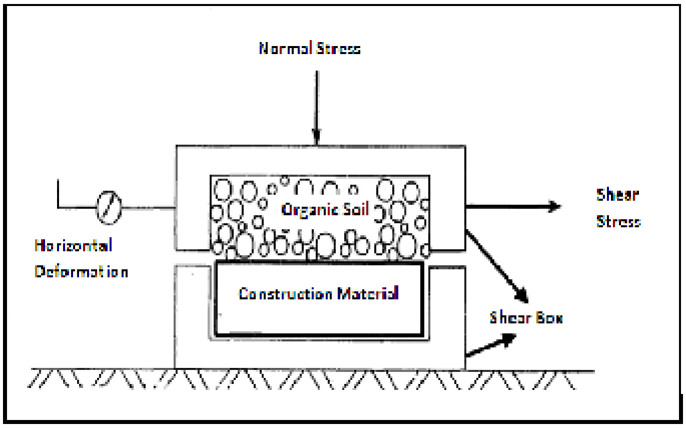


Figure 4 Test set up for interface friction measurement

The conventional direct shear test apparatus with dimensions of 60 mm x 60 mm was used in this study (Figure 4). For the interface tests, construction material was placed in the lower half of the direct shear box and the upper half of the shear box was filled with organic soil at predetermined density. The organic soil was in disturbed condition and prepared in a cup for different water content and was kept in desiccation container for 24 hours for uniform saturation. Tests were conducted with a deformation-controlled direct shear machine connected to a variable speed motor in series with a gear reduction box, which made it possible to maintain the rate of shearing at a desirable constant level. Test speed can be controlled by choosing the appropriate gear wheel from the gear box. Samples were sheared at 1.0 mm/min. For each tests three normal stress 30 kPa, 60 kPa, and 120 kPa were used.

TEST RESULTS AND DISCUSSIONS

Figure 5 and Figure 6 shows the values of interface friction angle between organic soil and construction materials at dry and 75% water content. It can be seen that, the highest interface friction angle was obtained between timber and organic soil for dry condition that was 45°. However, the highest interface friction angle was observed between organic soil and rough concrete at 75% water content that was 41°. Same Figures also shows that frictional resistance between organic soil and the metal has the lowest value compared to other construction materials for both dry and saturated condition. In dry condition, rough concrete has higher friction angle than smooth concrete surface. For the metal with rough steel gave higher friction angle compare to painted and plain one for dry and saturated case. Interface friction angle increases when the metal is painted in both dry and saturated condition.

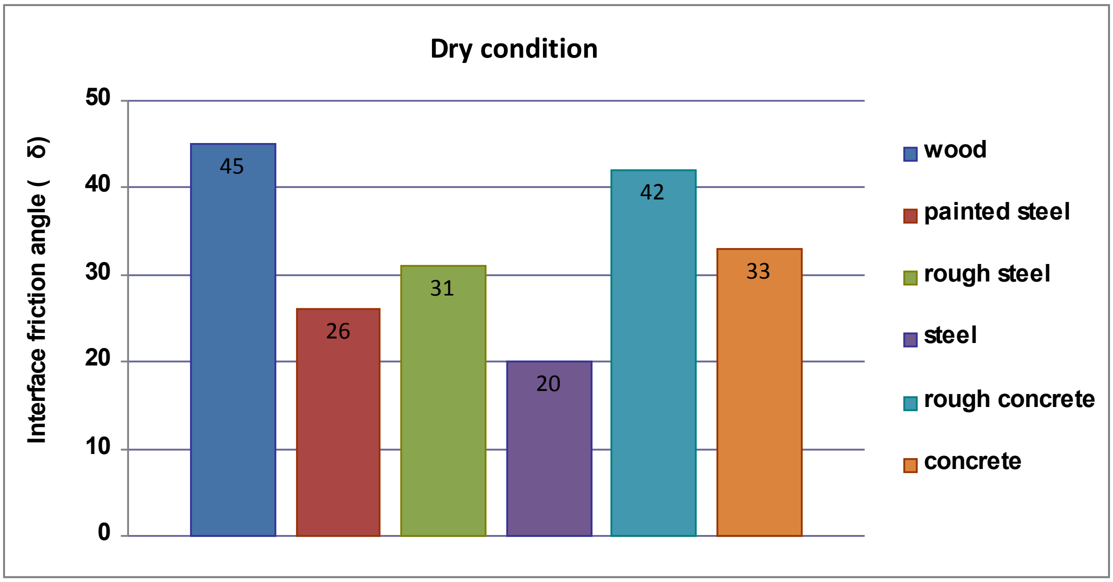


Figure 5 Variation in interface friction angle for dry condition

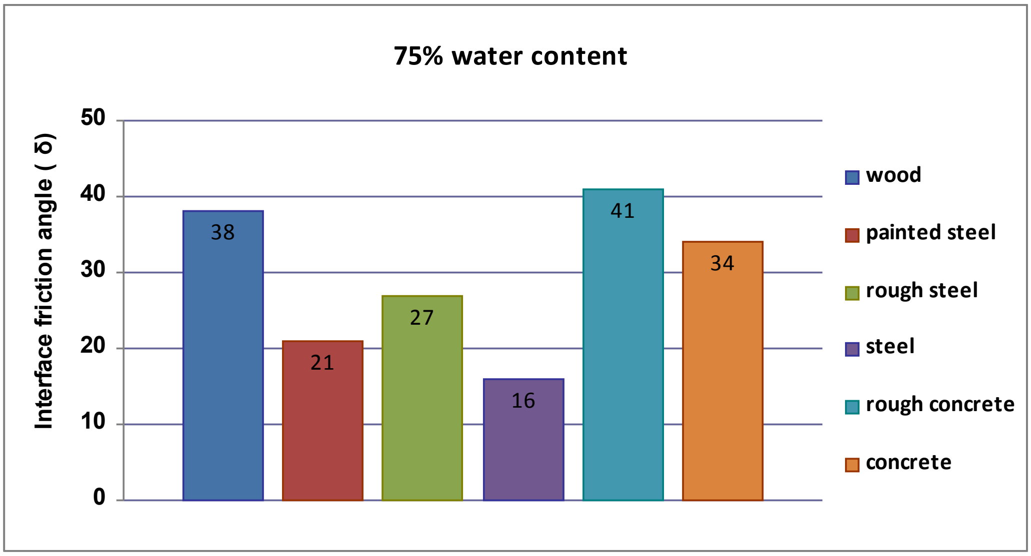


Figure 6 Variation in interface friction angle for 75% water content

Figure 7 shows varition in interface friction angle between organic soil and different construction material for varios water content. Study was carried out on four diffrent water content values and three material. These are dry, 25%, 50% and 75% by weight and wood, smooth concrete, and steel respectively. It can be seen from the figure that when the water content of the organic soil is incresed from dry contion to 75% interface friction angle decreases from 45° to 38° for wood, and it decreses from 20° to 16° for steel. Whereas, there is a minor change in interface friction angle between smooth concrete and organic soil with change in water content.

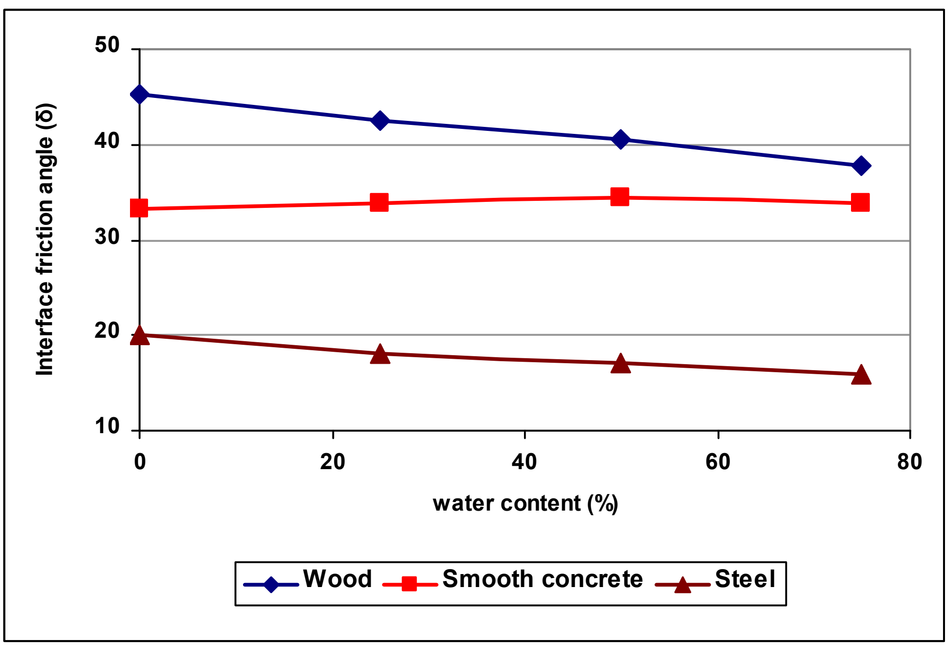


Figure 7 Effect of water content on interface friction angle

CONCLUSION

It may be concluded from this study that moisture content and the surface roughness of material effects interface friction angle between organic soil and construction material. The wood gives the highest interface friction angle for all water content value, and the lowest interface friction angle was obtained from the steel for dry and saturated condition. Interface friction angle reduces with increase in water content for wood and steel. Water content has little effect interface friction angle between organic soil and smooth concrete.

REFERENCES

[1] Potyondy, J. G., (1961). Skin Friction between Various Soils and Construction Materials. Geotechnique, Vol. 11, No. 4, pp. 339-353

[2] Acar, Y. B., Durgunoglu, H. T. and Tumay, M. T. , (1982). Interface Properties of Sand. J. of Geotechnical Engineering, ASCE, , Vol. 108, No. 4, pp. 648-654.

[3] Bosscher, P. J. and Ortiz, C.,(1987). Frictional Properties between Sand and Various Construction Materials. J of Geotechnical Engineering, ASCE, Vol. 113, No. 9, pp. 1035-1039

[4] O'Rourke, T. D., Drushel, S. J. and Netravali, A. N. , (1990). Shear Strength Characteristics of Sand-polymer Interfaces. J. of Geotechnical Engineering, ASCE, Vol. 116, No. 3, pp. 451-469

[5] Subba, Rao, K.S., Allam, M.M. and Robinson, R.G, (1988). Interfacial Friction between Sand and Solid Surfaces. Proceedings of the Institution of Civil Engineers, *Geotechnical Engineering,* Vol. 131, pp. 75-82.

[6] Reddy, E.S., Chapman, D.N. and O Reilly,M.P., (1998). Design and Performance of Soil-Pile-Slip Test Apparatus for Tension Piles. *Geotechnical Testing J.,* Vol. 21, No.2, pp. 132-139

[7] Uesugi, M. and Kishida, H, (1986). Influential Factors of Friction between Steel and Dry Sands. Soils and Foundation, Vol. 26, No.2, pp. 33-46.

[8] Kishida, H., and Uesugi, M. (1987). "Tests of the interface between sand and steel in the simple shear apparatus," Géotechnique 37(1), 45-52

[9] Yoshimi Y and Kishida T (1981). A ring Torsion apparatus for evaluating friction between soil and metal surface. Geotechnical testing journal, GTJODJ, Vol. 4, No.4.

[10] Paikowsky, S. G., Player, C. M., and Connors, P. J., (1995), "A Dual Interface Apparatus for Testing Unrestricted Friction of Soil along Solid Surfaces," Geotechnical Testing Journal, Vol. 18, No. 2, pp. 168–193.

[11] Coyle, H. M. and Sulaiman, I.H., (1967). Skin Friction for Steel Piles in Sand. Journal of Soil Mechanics and Foundation Engineering, ASCE,Vol.93, No.SM6, pp. 261-278.

[12] Wüst, R. Bustin, RM. and Lavkulich, LM. (2003). New classification systems for tropical organic-rich deposits based on studies of the Tasek Bera Basin, Malaysia. Catena 53:133–163