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Friction characteristics of organic soil with construction materials

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Abstract

Understanding the basic phenomena controlling the mobilization of friction at the soil-solid surface contact is essential for such traditional foundation structures such as piles, micropiles and anchors. In this study, the interface frictional characteristics of organic soil and a variety solid construction materials, including concrete, steel, and wood, were investigated. The interface friction angles of organic soil-solid surfaces were determined for different water content and granular soil content. In addition, the relationship between surface roughnesses and interface friction was investigated. All tests in this study were performed using a direct shear test device under different normal stresses. The test results showed that the frictional resistance between construction material and organic soil is affected by the water and granular soil content of the organic soil, the type of material, and the surface roughness.

Keywords: Organic soil; Construction materials; Interface friction angle; Surface roughness

1. Introduction

Organic soil is a mixture of fragmented organic material formed in wetlands under appropriate climatic and topographic conditions, derived from vegetation that has been chemically changed and fossilized (Dhowian and Edil, 1980). This type of soil has low shear strength and high compressive deformation (Anggraini, 2006). Though there are a variety of improvement methods which can be adopeted, problems with bearing capacity and settlement are generally solved by using pile foundations. Friction piles tend to be the pile foundations of choice in this type of soil: they transfer the load to the soil through interface friction between soil and pile material. One of the important parameters for frictional resistance is the friction coefficient between the pile material and the soil. The majority of the design interface friction values are based on empirical correlations. They are related to soil shear strength parameters. In current geotechnical engineering practices, the soil–structure friction values recommended by the Naval Facilities Engineering Command (NAVFAC) Design Manual (DM) 7.02 (US Department of Navy, 1986) are widely adopted.

An extensive series of investigations on this topic has already been performed by several authors both in laboratory and in situ (Potyondy, 1961; Coyle and Sulaiman, 1967; Kulhaway and Peterson, 1979; Evgin and Fakharian, 1996; Hryciw and Irsyam, 1993; Uesugi et al., 1988; Hu and Pu, 2004; Canakci et al., 2011; Celik and Canakci, 2014; Nasir and Fall, 2008). Potyondy (1961) measured the ratio of skin friction and adhesion with soil friction and cohesion, respectively. He performed direct shear tests on the interface of concrete, steel, and wood with sand, sandy silt, cohesive soil,

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rock flour, and clay. The tests were conducted for certain preset moisture contents as well as for dry specimens. The results showed that the frictional resistance of a soil depends on the amount of mixed sand it possesses.

Coyle and Sulaiman (1967) investigated the frictional resistance between sand and the steel pile, and Kulhaway and Peterson (1979) measured the frictional resistance between sand and concrete. Several other researchers such as Evgin and Fakharian (1996), Hryciw and Irsyam (1993), Uesugi et al. (1988) and Hu and Pu (2004) conducted direct shear tests on the interface between steel or concrete and sand to measure the interface frictional resistance. As an alternative to the direct shear device, Paikowsky et al. (1995) developed a dual interface apparatus. In addition, Yoshimi and Kishida (1981) developed a ring shear device to measure interface frictional resistance for large deformations.

The previous studies showed that several factors affect the value of the interface friction angle. These factors are their mineralogical composition, density, grain shape, grain size and gradation, as well as the roughness of the material surface (Uesugi and Kishid, 1986; Lambe and Whitman, 1979; Yoshimi and Kishida, 1981).

A survey of existing literature showed that limited information is available for practicing engineers about interfacial friction between organic soil and various construction materials. In this study, an intensive investigation was carried out to determine interface friction values. For this purpose, concrete, smooth and rough steel, and wood were selected as structural materials. Tests were done at different water contents and different granular soil content in the organic soil. All tests were performed using the direct shear test device.

2. Materials and methods

2.1. Organic soil

The organic soil used in this study was obtained from the Sakarya region of Turkey. This peat was bought from a commercial firm as packed peat. Once the peat was delivered to the laboratory, all of it was dried in an oven. Its moisture content was determined before testing. Since it is quite difficult to prepare organic soil samples with high water content for the tests proposed, peat of four different moisture contents as selected for this work. The properties of peat soils, including their natural water content, acidity, degree of humification, fiber content, shear strength, and compressibility, are affected by the formation of peat deposit (Ajlouni, 2000). This indicates that in terms of content, fibrous peat is different from one location to another (Berry and Poskitt, 1972; Ajlouni, 2000; Robinson, 2003).

Sakarya peat (natural soil) has herbaceous characteristics, and can absorb 3–4 times its weight of water with respect to its decomposition rate. Its initial density ranges from 0,121 to 0,217 g/ cm^3. Remoulded soil has a dry density of 6,44 kN/m^3 and an optimum moisture content of 58%. The fibrous peat used for all tests was passed through a 2 mm sieve size and retained on a 100 (0.15 mm) sieve. Organic soil is classified as

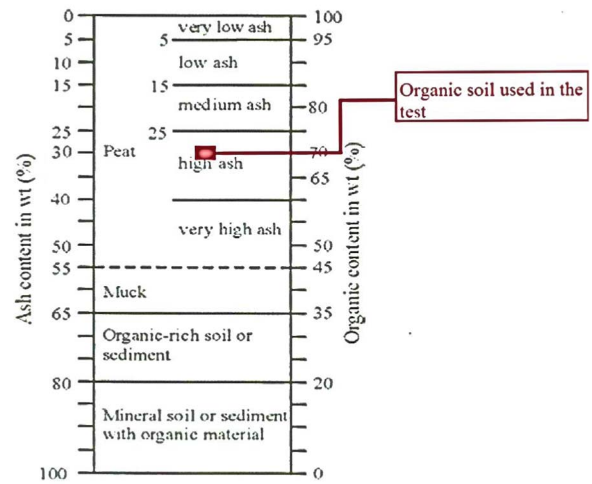

Fig. 1. Classification system for peat deposits (Wüst et al., 2003).

Table 1
Engineering properties of the organic soil.

Properties of organic soil	
Organic content (%)	70
pH	5.0
Natural water content (%)	256
Liquid limit (%)	125
Plasticity index (%)	None plastic
Specific gravity	1.97

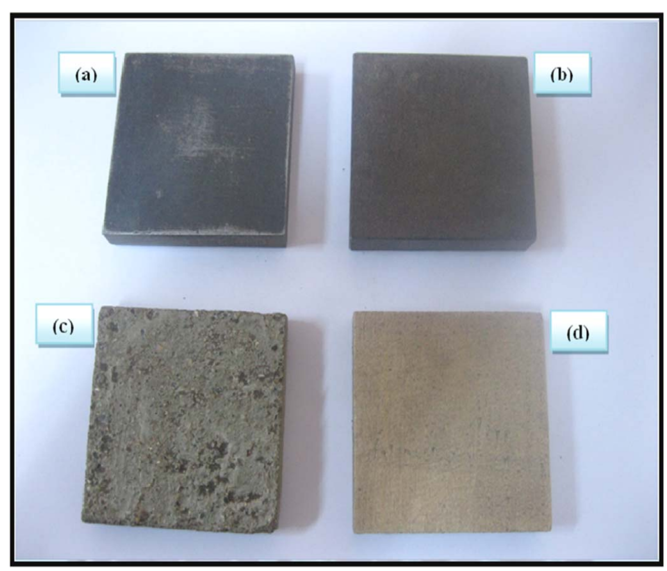

Fig. 2. Construction materials used in the test; (a) smooth steel (b) rough steel (c) concrete and (d) wood.

peat by both the Unified Soil Classification System (USCS) and the Wüst et al. (2003) classification chart shown in Fig. 1. It is also classified as fibric according ASTM D 1997, high ash according to ASTM D 2974, and moderately acidic according to ASTM D 2976. Organic soil can also be classified according to its decomposition rate. According to the Von Post (1922) scale, the decomposition rate changes from H1 to H10. In this

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