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Shear Strength Properties of Organic Soil with Sand Column

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ABSTRACT

This paper discusses the results of a series of direct shear test that were undertaken to investigate the behaviour of organic soil with granular soil column. The tests focused on effect of diameter of granular column in organic soil. Water content of the organic soil was kept constant for all tests. It was 125% that is liquid limit value. Four different column diameters were used. Sand used in the test is poorly graded and passing the No. 5 sieve and retaining on sieve No. 40 sieve. Shear strength properties of the samples were determined from direct shear test. Loading was performed under undrained condition. Test results showed that ratio of sand column area to organic soil (S/O) are an important factor effecting shear strength properties of improved organic soil.

INTRODUCTION

Organic soils are occurred by mixture of fragmented organic material formed in wetlands under suitable climatic and topographic conditions and they are formed from vegetation that has been chemically changed and fossilized. This types of soil generally formed in thick layers in limited areas, is geotechnicaly problematic due to their very high compressibility and very low shear strength. Because it includes huge amount of organic content represent the extreme form of soft soil. The physical properties of organic soils are dependent on the four major components which make up the organic soil system; the organic material, the mineral material, water and air. Andriesse [1] highlighted difficulties in characterization of the physical properties of organic soils caused by the changes in the proportions of the four components upon reclamation or drainage for utilization. The presentation of the results of analysis for the physical properties of organic soils has been largely questioned especially in the context of reporting in volume or weight basis. The parameters commonly used to describe the physical properties of organic soil are those related to texture, loss on ignition, bulk density, porosity, wetting and drying process, and moisture relationships. Organic soils contain less water in comparison to mineral soil when both are compared at volume basis using the same amount of water. Fabric materials were also found to contain less water compared to sapric materials. The bearing capacity of organic soils varies considerably with moisture content and generally improves with decreasing moisture content. Therefore, the bearing capacity is indirectly linked to the water table level in the soil.

It is one of the important issues for geotechnical engineers to be able to obtain suitable design parameters, as well as to find suitable construction techniques on soft problematic organic soils. Various ground improvement techniques have been employed in order to improve these types of soils. Sand column is one of the improvement methods that are extensively used to improve the bearing capacity and settlement properties of poor ground.

Sand column that consist of granular material compacted in cylindrical holes is used as a technique for improving the strength and consolidation characteristics of soft soils. Load

carrying capacity of a sand column is attributed to frictional properties of the stone mass and frictional properties of soils surrounding the column, flexibility or rigidity characteristics of the foundation transmitting stresses to the improved ground and the magnitude of lateral pressure developed in the surrounding soil mass. The sand column derives its axial capacity from the passive earth pressure developed due to the bulging effect of the column and increased resistance to lateral deformation under superimposed surcharge load. The theory of load transfer, estimation of ultimate bearing capacity and prediction of settlement of sand columns was studied by many researchers [2-9].

It is discussed in this paper that the results of a series of direct shear test that were undertaken to investigate the behaviour of organic soil with granular soil columns having different diameters.

MATERIAL AND METHOD

The main objective of this research was to find out the effect of sand column diameter on shear strength parameters of organic soil. The 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 [10] (Figure 1). Engineering properties of the organic soil is listed in Table.1. Organic content was estimated by firing process at 440 ^{0}C in an oven for 24 hours according to ASTM D-2974. Sieve analysis was carried out on ash and it was found that soil contains 15% silt and clay, 25% sand, and 60% organic materials. Liquid limit of the organic soil was estimated by fall cone test according to BS1377 and found to be 125%. The sand used for the test is poorly graded passing the No. 5 sieve and retaining the sieve No. 40. Figure 2 shows organic soil and Figure 3 shows sand used in the test.

In this study cylindrical thin tubes having four different diameters 2 cm, 3 cm, 4 cm, and 5 cm, were used to make sand columns in organic soil. Table 2 shows test programs performed in this study. Figure 4 shows test samples and shear box apparatus used for the tests. Shear strength properties of the improved soil was determined using direct shear test apparatus.

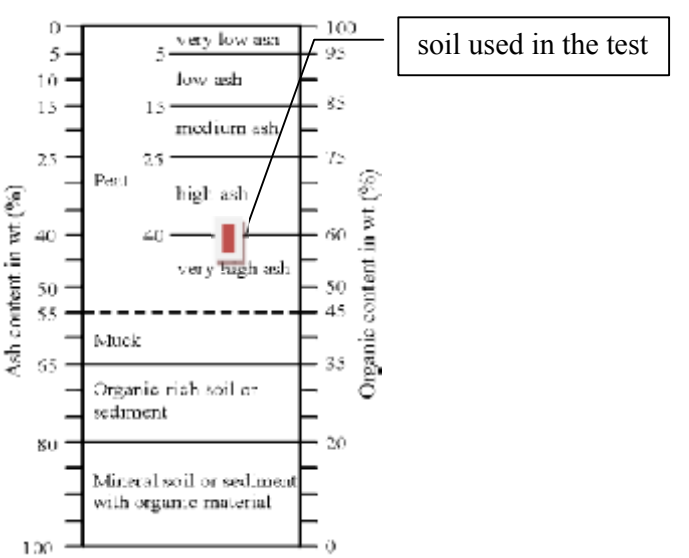

Figure 1 Classification system for peat deposits [10]

Test samples were prepared in the following order. First, the sand was loosely filled in the predetermined thin tube located at the center of the shear box apparatus. Then, the organic soil was placed loosely around the tube to fill the shear box apparatus. Finally the thin tube holding sand was pulled out. Figure 5 shows 5 cm diameter sand column incorporated in organic soil in the direct shear box.

Normal load applied to samples during direct shear tests were 5 kg,10 kg, and 20 kg. Loading rate used for all tests was chosen 1 mm/min for undrained loading condition. All tests were done at liquid limit value of the organic soil that is 125 %.

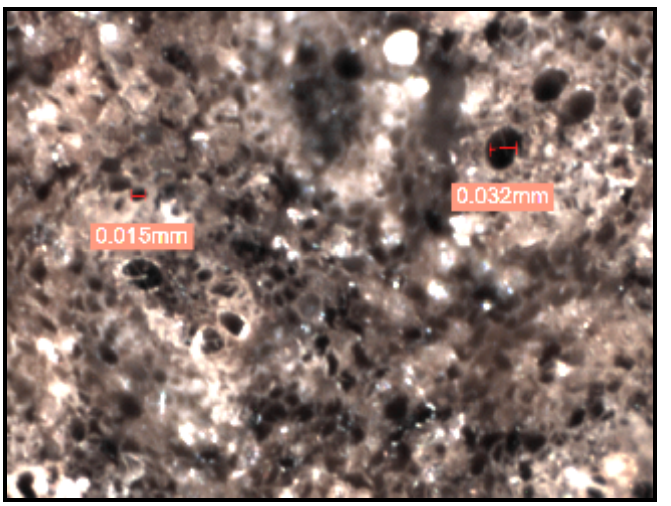

Figure 2 Close up view of organic soil

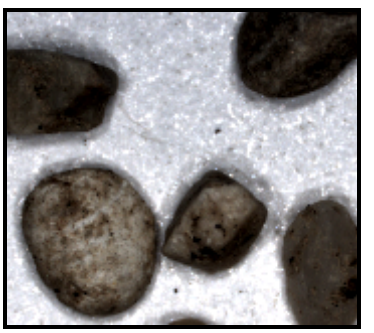

Figure 3 River sand particles used in the testing program

Table 1 Properties of organic soil

Soil properties	values
Organic content (%)	50-70
PH	4,5-6,5
Organic carbon (%)	20-30
Water keeping capacity (in volume %)	85-95
Air capacity (in volume %)	15-25
Liquid limit (%)	125

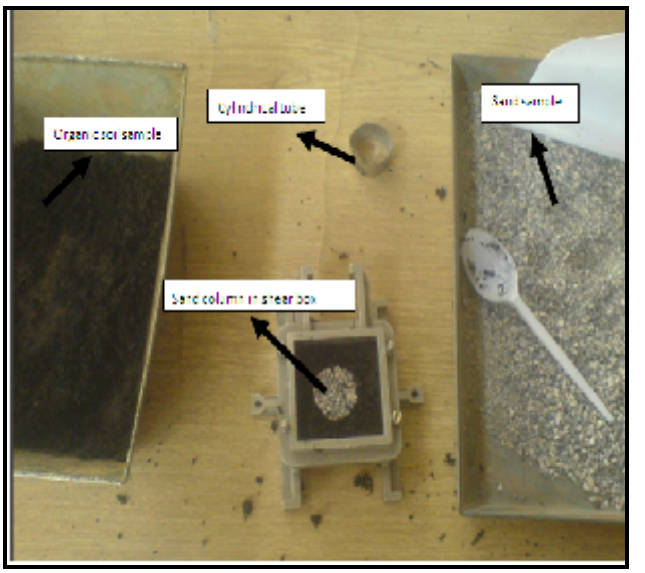

Figure 4 Test samples and shear test apparatus

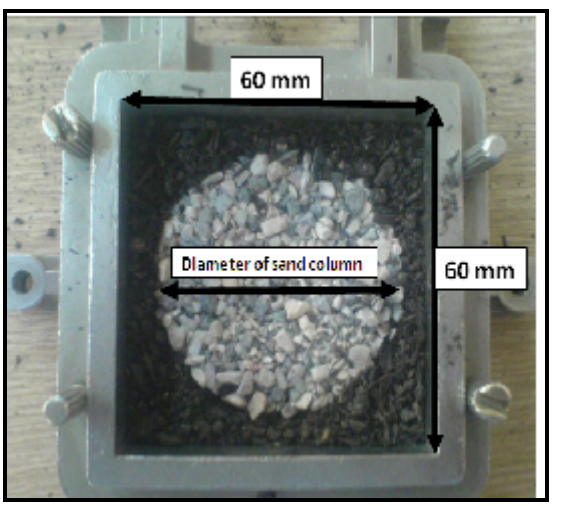

Figure 5 Organic soil with 5 cm diameter sand column

Table 2. Sand column diameter and area orientations

Test No	Sand column Diameter (cm)	S/O ratio (%)
1	-	-
2	2	8,72
3	3	19,64
4	4	34,92
5	5	54,56

TEST RESULTS AND DISCUSSIONS

Test results showed that sand column has an effect on the shear strength of organic soil. When the surface area ratio of sand column to organic soil increases it was observed that internal friction angle of the mixed soil was also increases. As it is shown in Figure 6, increase in the frictional angle is small up to S/O ratio of 19 then it increases rapidly up to S/O ratio of 54. Internal friction angle of organic soil increases from 38° to 52° at S/O of 54. This corresponds to approximately 37% increase in internal friction angle.

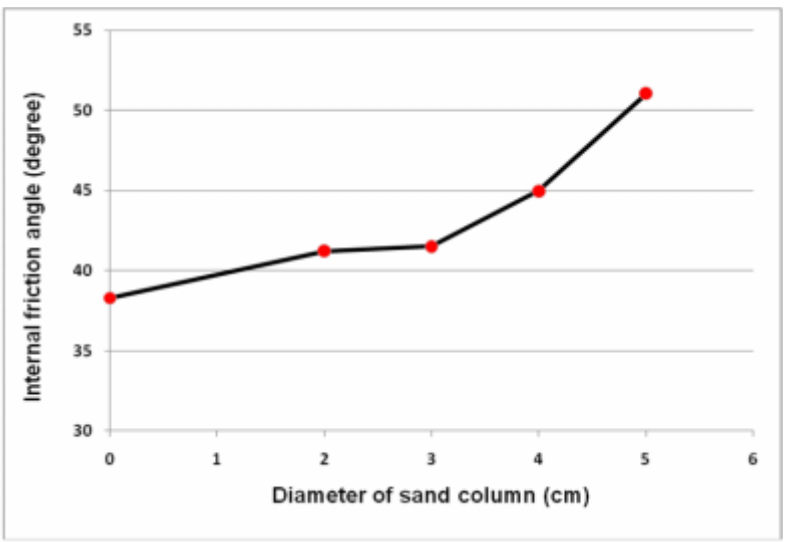

Figure 6 Relations between internal friction angle and diameter of sand column.

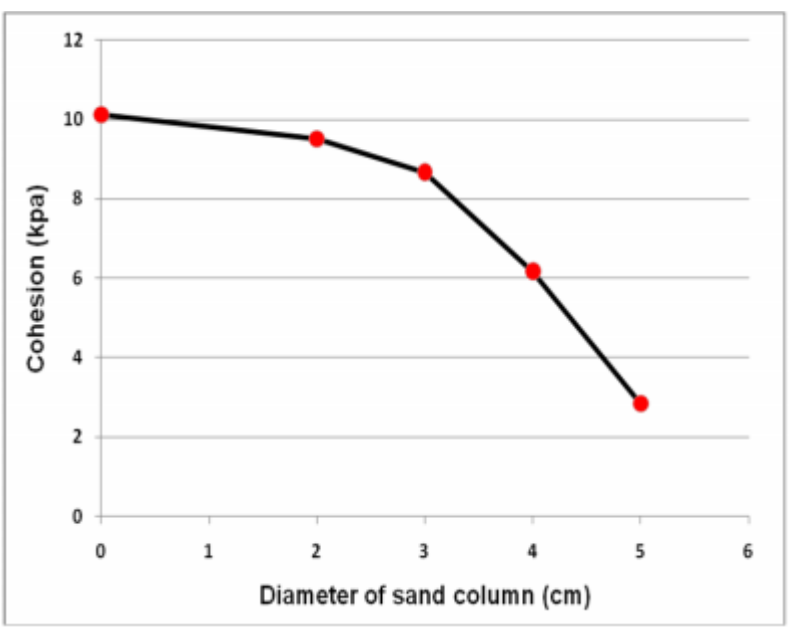

Figure 7 Relations between cohesion and diameter of sand column

Figure 7 shows change in apparent cohesion with change in diameter of the sand column. Cohesion of the organic soil at its liquit limit state (125%) was 11 kPa. As it can be seen on the figure when the diameter of the sand column increased in the organic soil cohesion of the mixture reduces rapidly. It is due to increase in non cohesive sand content in the mixture. Reduction in cohesion due to incorporation of sand column in organic soil is around 70%. Behaviour of the mixed soil changes from organic to granular non-cohesive soil.

CONCLUSIONS

This study showed that the incoparation of sand column in organic soil can be an effective way to increse shear strength of these soil. The main conclusions obtained from this study can be summarized as follows; when the ratio of sand column surface are to organic soil surface area (S/O) increases, internal friction angle of the mixture also increases, and cohesion of the mixed soil decreases with increasing sand column diameter or increase in S/O ratio.

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