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An investigation on the consistency limits of cohesive soils improved with rice husk ash

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Abstract

Superstructure loads are transferred to the ground via foundations. If the ground is not capable of supporting the high building loads, serious structural problems may arise. In order to overcome these problems, ground improvement works are considered as the first alternative before using deep foundations since deep foundation constructions cause significant additional cost to the project budgets. Soil improvement is a generalized definition for the applications-based targeting to increase the engineering properties of the soils. Consistency limits are the water content values of cohesive soils at which the behavior changes from liquid to plastic or plastic to solid. These values significantly affect the mechanical behavior of soils. For this reason, ground improvement methodologies specifically developed to alter the consistency behavior of soils can be an economic alternative in construction projects. Within the scope of this study, the consistency limits of the cohesive soils improved with rice husk ash, an organic waste product, were investigated by laboratory studies.

Introduction

Any structure transfers the superstructure loads to the ground through foundations. If the ground has sufficient bearing capacity, it will be able to meet the loads coming from the superstructure without any problems. However, in some cases, the foundation soils may not have enough strength to withstand these loads from the superstructure. In such cases, it is necessary to carry out a number of ground improvement to make the soils sufficient in terms of bearing capacity.

Rice husk is an organic waste product resulting from the removal of the grains of rice (Figure-1). Rice husk ash, one of the natural pozzolanic additives for concrete, is obtained by burning rice husks [1]. As can be seen in Table-1, rice husk ash contains high amount of silicon oxide [2]. In this study, the use of rice husk ash, which is an organic waste product having pozzolanic character, in soil improvement works will be examined.

Tablo 1. Content of rice husk ash

Constituents	Rice husk ash (%)
SiO_2	89.18
Al_2O_3	1.75
Fe_2O_3	0.78
CaO	1.29
MgO	0.64
K_2O	1.38
Weight loss after burning	2.05

Figure 1. Rice husk ash

There are studies in the literature regarding the use of rice husk ash in soils. Based on these studies, it can be told that there is an increase in CBR and unconfined compressive strength as well as the shear strength and cohesion values of the soils [1-4].

Material and Method

Consistency limits are the limits of water content used to describe soil behavior. If too much water is given to the cohesive soil, it behaves as liquid, in this case it has no shear resistance. If the soil is left to dry, it gains a certain shear resistance. The water content of the soil at this time of transition is called the liquid limit [5]. The liquid limit in this context is defined as the water content of the soil at the moment when it changes from a plastic consistency to a flowing form. The liquid limit can be estimated with two different laboratory tests namely Atterberg Limits Test (Casagrande test) or fall cone test. Within the scope of this study, liquid limit values were obtained by the Casagrande method.

In Casagrande test, firstly, cohesive soil samples are mixed with water and a homogeneous mixture is formed as shown in Figure-2. Sample is placed in the plate of the Casagrande instrument and its surface is leveled parallel to the base with the help (Figure-3). With the help of the flattened specimen grooving knife, a 2 mm wide cavity is opened from top to bottom as in Figure-4. The arm of the Casagrande tool is dropped from a height of 1 cm at a rate of 2 revolutions per second. As soon as the length of the opened cavity is closed by approximately 13 mm, the experiment is finished and the number of strokes is noted (Figure-5). A quantity of sample is taken into the aluminum container and the water content is determined. The test is repeated 5 more times using the same sample while increasing the water content. At the end of the test, a graph is drawn and the water content corresponding to 25 hits in the graphs is considered as the liquid limit of the sample used.

Figure 2. Soil sample

Figure 3. Placed soil sample

In this study, firstly, a liquid limit test was carried out on the soil sample formed by using 50% by weight of clay and sand. Then, 10% by weight of rice husk ash was added on the same sample and the experiment was repeated and the results were presented.

Figure 2. Soil sample to ready for test

Figure 3. Soil sample to end of test

Results

Based on the data obtained from the tests, liquid limit graph of the natural sample and the 10% by weight rice husk added sample are shown in Figs. 6 and 7.

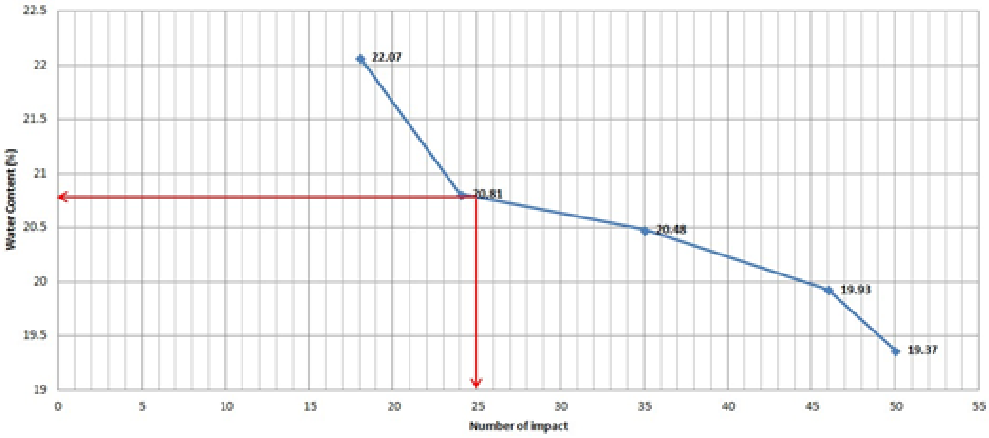

Figure 4. Casagrande test results for the soil without rice husk ash

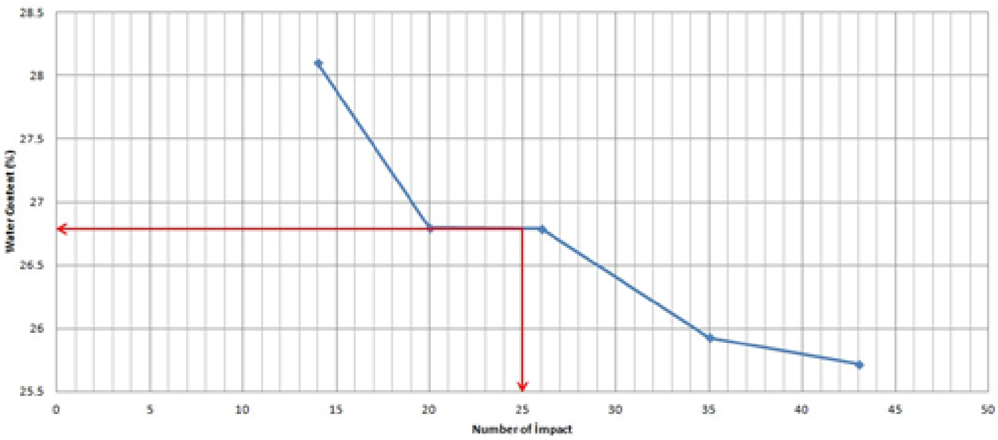

Figure 5. Casagrande test results for the soil with rice husk ash

As can be seen from these figures, liquid limit of the natural soil is found as approximately 20.8% whereas the liquid limit value of the soil sample with rice husk additive is obtained as 26.8%. Test results indicated that the plastic limit for the clayey soils with rice hush ash is higher compared to the unimproved soil. The water absorbtion capacity of the rice husk ash is significantly high causing the soil sample to behave liquid at relatively high-water content values. Plastic limit of the fine-grained soils is an important parameter defining how soils behave at different water contents. Therefore, this effect should be considered in ground improvement projects performed with using rice husk ash.

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