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Consolidation characteristics of clayey soils improved with rice husk ash

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Abstract

Rice husk is a by-product of the rice milling process. About one hundred million tons of rice husk per year are produced worldwide. In order to reduce the volume of waste, rice husk is burned as a fuel in ovens for rice drying, the burning effect volatilizes the organic compounds and water of the rice husk, and about 20% of the mass remains as rice husk ash. Rice hush ash has pozzolonic effect and can be used as an additive in concrete. Besides, the improvement of soils through addition of rice husk ash and lime was studied in several researches. In the current study, consolidation characteristics of soils improved with rice husk ash, an organic pozzolanic waste product, were investigated through laboratory studies.

Introduction

One of the consequences of increasing urbanization is the increase in building loads. The stresses caused by the structural loads on the soils cause compression. As a result of the compression and displacement of soil particles under load, settlement occurs in the ground. Time dependent settlements due to decrease in volume of water in the voids is called consolidation settlement [1].

Depending on soil type, various amounts of deformations are likely to develop in building foundations. These deformations cause the stress conditions of the soil under the structure to change. Due to the increase in stress conditions, settlements occur in the ground under the structure. Contrarily, swelling can also be observed as a result of the decrease in the stresses in the soil mass for any reason or the changes that may occur in the water levels. Engineering structures built on soils with high potential for settlement and swelling are exposed to forces arising from the swelling properties of soils. This affects the load bearing elements of the buildings while causing further deformations in the structure. Changes in the volume of the soil mass due to settlement and swelling properties are one of the most influential factors in geotechnical design [2].

In this study, the use of rice husk ash obtained by burning rice hulls, which is an organic waste product, in soil improvement works will be studied. Rice husk is an organic waste product resulting from the removal of the grains of rice. About one hundred million tons of rice husk per year are produced worldwide. In order to reduce the volume of waste, rice husk is burned as a fuel in ovens for rice drying, the burning effect volatilizes the organic compounds and water of the rice husk, and about 20% of the mass remains as rice husk ash. Rice husk ash, one of the pozzolanic additives, is obtained by burning rice husks. Clayey soils have significant potential of consolidation settlements and swelling problem depending of the type of clay minerals dominant in the soil mass. It is well known that clayey soils do not respond the immediate compactive activities but exhibits time dependent settlement [2]. When the clayey soils with low water permeability are subjected to vertical loads, the porosity decreases due to water escaping out of the soil voids. There are many studies in the literature concentrating on the consolidation characteristics of clayey soils [3-6]. The aim of this study is to investigate the consolidation characteristics of low plasticity clays after mixing with rice husk ash as an additive material.

Material and Method

The phenomenon of compaction of soils under constant stresses by removing the water in their bodies, depending on time, is called consolidation. Over a period of time, the gradual increase in effective stress in the soil layer will cause settlement. This event is referred to as consolidation. This process continues until the excess pore water pressure caused by an increase in total stress is completely dissipated. The simplest consolidation case is one-way consolidation under the condition of zero lateral deformation. The swelling process, which is the opposite of consolidation, is a slow increase in the volume of a soil under negative excess pore water pressure [7]. The consolidation coefficient (C_c) is determined by a test apparatus called as oedometer.

The consolidation test begins by placing the soil samples in the consolidation ring with sufficient compression. The surfaces of the samples placed in the consolidation rings are smoothed and weighed with the help of a balance. Then, the soil sample placed in the ring is placed in the consolidation cell, bounded by porous stones from the bottom and top, and the cell is filled with water. The cells filled with water are placed in the consolidation instrument and a reading clock is placed on it to read the vertical deformations. Then, the necessary loads are placed on the lever arm of the consolidation tool and the loading process is started and the deformations are read at regular intervals for 24 hours. At the end of 24 hours, the next load is placed on the lever arm of the consolidation tool and the loading is started again and the readings are taken again for 24 hours. In our experiment, appropriate weight loadings were made corresponding to 25, 100, 400 and 1600 KPa pressures and the necessary readings were taken.

After the loading tests are completed, the soil samples removed from the consolidation tool are weighed with the help of scales and left to dry in the drying oven for 24 hours. As a result of all these experiments, the desired value is obtained by drawing the vertical stress versus void ratio graphs.

In this study, the effect of rice husk ash on the consolidation settlement and swelling characteristics of low plasticity clayey soils was investigated by adding 5% and 10% by weight rice husk ash to the natural soil sample, respectively. The soil samples we used in the experiment were cured for 3 days by keeping the humidity constant in the desiccator. None of the samples were mixed with lime or cement within the scope of this study.

Results

Based on the data obtained from the tests performed, the vertical stress versus void ratio graphs of the natural sample and the samples with 5% rice husk ash and 10% rice husk ash added, respectively, are depicted in Figs 1, 2 and 3. The compression (C_c) and swell (C_s) indices calculated from the graphs are shown in Table 1.

Table 1. Test results to compare the compression and swell indices for the tested samples

Test Name	Compression coefficient (C_c)	Swelling coefficient (C_s)	Water Contents (%)
Natural soil sample	7.152E-05	1.542E-05	13.15
%5 rice husk ash added sample	8.553E-05	1.497E-05	15.94
%10 rice husk ash added sample	9.637E-05	1.507E-05	18.55

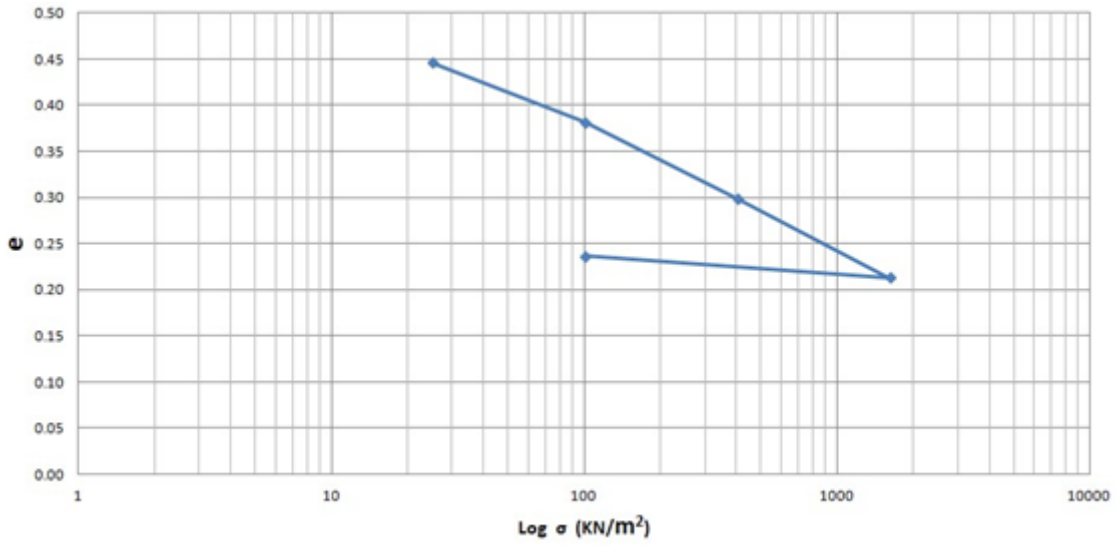

Figure 1. The vertical stress versus void ratio graph for the natural soil sample

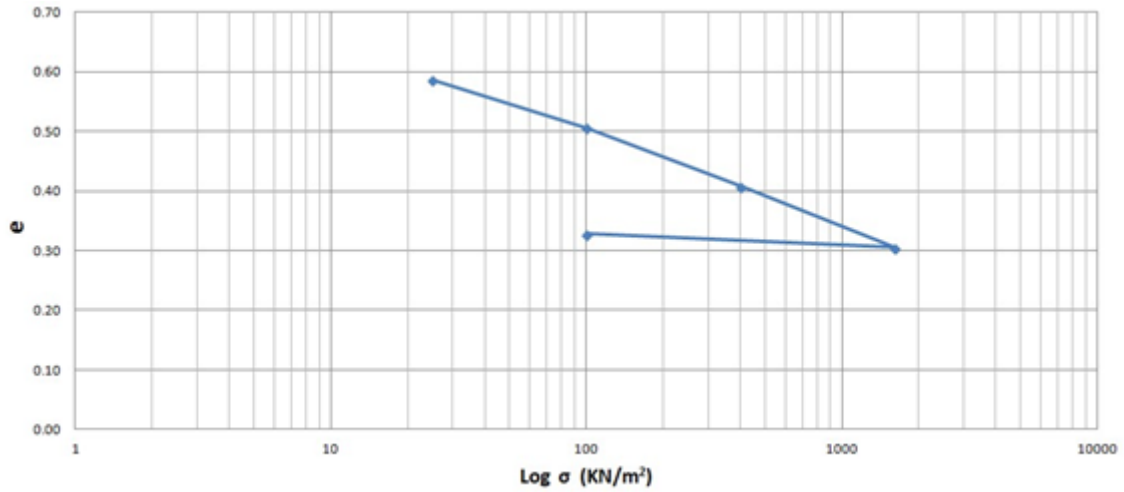

Figure 2. The vertical stress versus void ratio graph for the %5 rice husk ash added clayey soil

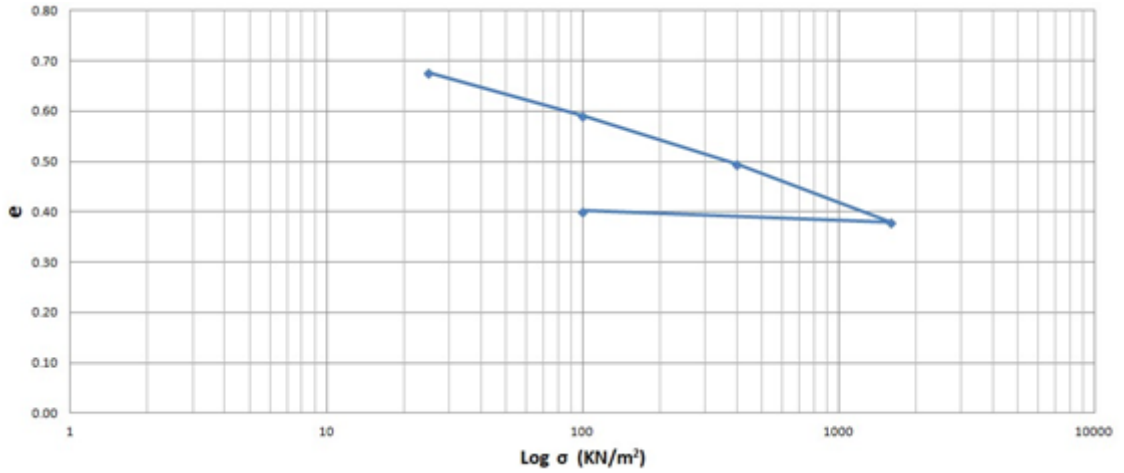

Figure 3. The vertical stress versus void ratio graph for the %10 rice husk ash added clayey soil

When the results of the consolidation test were investigated, it was observed that the smallest compression coefficient (C_c) was obtained in the natural sample and the highest compression coefficient was obtained in the 10% rice husk added sample. This can be explained with the high-water content of the %5 and %10 rice hush ash added soils. As the water content of the samples increases, the amount of dry mass decreases and the void ratio increases. Increasing void ratios cause an increase in the settlement coefficients in the experiments. In the consolidation test we have performed, it is observed that the settlement coefficients tend to increase because the water contents of the samples are different and higher than each other. In order to reduce this increase, it is necessary to keep the water contents constant or close to constant.

Conclusion

In the consolidation tests performed; it is seen that rice husk ash has some effect on the consolidation characteristics of low plasticity clayey soils. However, it is not realistic to come to solid conclusions regarding the effect of rice hush ask additive on the consolidation characteristics of the soils since there is a discrepancy in the water content of the samples in this study. However, it is clear that rice hush ash is modifying the consolidation indices of clayey soils due to its pozzolanic effect which can provide some amount of improvement in the soils.

The number of tests should be increased to get more realistic conclusion for this. As an anticipated future study, it is planned to carry out further consolidation tests on the samples with identical water content.

References

1. Aysu, Ş. (2020). Yüksek plastisiteli kil zeminlerde cam lifi katkısının zeminin mukavemet, permeabilite ve konsolidasyon özelliklerine etkisi. Konya teknik Üniversitesi Fen Bilimleri Enstitüsü.
2. Yılmaz, M., & Çelik, S. (2013). Kil zeminin şişme basıncı ve konsolidasyon özelliklerine öğütülmüş kumun etkisinin araştırılması. Kahramanmaraş Sütçü İmam Üniversitesi Mühendislik Bilimleri Dergisi, 15(2), 32-36.
3. Altundağ, Y. (2016). Siltli zeminlerin konsolidasyon karakteristikleri. Sakarya Üniversitesi Fen Bilimleri Enstitüsü.
4. Erşan, H., & Yıldırım, H. (2011). Tekrarlı yüklemeler etkisi altında zeminlerin konsolidasyonu. İTÜDERGİSİ/d, 5(3).
5. Dong, Y., Lu, N., & Fox, P. J. (2020). Drying-induced consolidation in soil. Journal of Geotechnical and Geoenvironmental Engineering, 146(9), 04020092.
6. Kar, R. K., Pradhan, P. K., & Naik, A. (2012). Consolidation characteristics of fiber reinforced cohesive soil. Electronic Journal of Geotechnical Engineering, 17, 3861-3874.
7. Yılmaz, I., Keskin, İ., & Yıldırım, M. (2014). Zemin mekaniği: laboratuvar deneyleri ve problemler. Seçkin Yayıncılık.