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Stabilization of clayey soil for subgrade using rice husk ash (RHA) and sugarcane bagasse ash (SCBA)

F. Hidalgo[1], J Saavedra[1], C Fernandez[2] y G Duran[2]

1 Bachelor, Civil Engineering Program, Universidad Peruana de Ciencias Aplicadas, Lima, Peru
2 Full Professor, Civil Engineering Program, Universidad Peruana de Ciencias Aplicadas, Lima, Peru. Email: gary.duran@upc.edu.pe

Abstract. This document studies the stabilization of the soil used as a subgrade, by adding locally available materials such as rice husk ash (RHA) and sugarcane bagasse ash (SCBA). These aggregates were added to the soil in substitution by weight between 5%, 7.5% and 10%. By adding these, the expansiveness is reduced while the maximum dry density increases, in addition the tendency of CBR is increasing and then tends to decrease proportionally to the addition of the aforementioned aggregates. This indicates a peak in CBR and expandability. The best result obtained from CBR was 33.75% with the 5% replacement mixtures.

1. Introduction

One of Peru's first economic activities is agriculture, about 3 million tons of rice cultivation is produced each year, which provides about 900 thousand tons of rice husk. For every 1000 kg of ground rice crops, about 300 kg (30%) of rice husk is produced, and when it is burned, about 45 kg (15%) of rice husk ash (RHA) is generated. On the other hand, sugar production is estimated at 9.4 million tons per year, La Libertad-Peru, is the department with the highest production around 4.5 million tons, representing almost 50% of the country's annual production.

Kumar Yadab et al. [1] conducted various studies by adding RHA to evaluate the physical and mechanical properties of clayey soils. This author proposed replacement percentages that vary from 2.5% to 12.5%. Through this replacement it was observed that the optimum humidity content and CBR increase proportionally to the addition of ash, while the maximum dry density decreases.

Delgado López et al. [2] evaluated the effect of adding alkaline activated sugarcane bagasse ash (SCBA) to a clayey soil. Performed tests with additions that varied from 10 to 20% of addition with respect to the weight of the soil, resulting in an optimal mixture of 15% where the soil improved by 20% in compression with respect to the unaltered sample.

Castro (2017) [3] conducted trials by mixing RHA, lime and clayey soil. The RHA additions proposed by the author varied between 10 and 40% and 3% lime. The mixture with 20% RHA showed a CBR improvement of 5% to 38.5%. Finally, Castro (2017) concludes that this mixture can be used as a subgrade of pavements.

2. Materials and methods

Mixtures with different percentages of each ash and natural soil (S100 + A0 + B0) were prepared, the addition was 5% (S90 + A5 + B5), 7.5% (S85 + A7.5 + B7.5) and 10 % (S80 + A10 + B10). At the time of immersion for 96 hours of the mixtures the reaction of the silica with the calcium of the soil is activated resulting in the formation of calcium silicates, subsequently the crystallization of these components is generated, giving greater resistance to the soil in its quality as subgrade.

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2.1. Physical and chemical properties of stabilizing agents

Rice husk ash was obtained at the "El Rey" mill, located in the department of San Martin-Peru. The rice husk was burned at temperatures between 600-700 ° C in open fire. In this part of the process silica is amorphous. The sugarcane bagasse burned in a temperature range of 800-1000 ° C.

2.1.1. Stabilization through the use of RHA

Rice husk ash contains silica, an element that with the usual characteristics in clayey soils such as calcium generates calcium silicates that harden the mixture and allows the increase of the soil density and its resistance characteristics.

2.1.2. Stabilization through the use of SCBA

Additionally, the SCBA contains a high percentage of silica that borders 57% of its entire composition, this contributes to its ability to be a pozzolanic material. Similarly, other compounds such as calcium oxide and ferric oxide that together with silica comprise more than 70% of SCBA are large pozzolana enhancers.

2.2. Laboratory Investigations

The soil was classified as clay of low plasticity CL. The natural soil particle distribution test was carried out by granulometric analysis as shown in Figure 1.

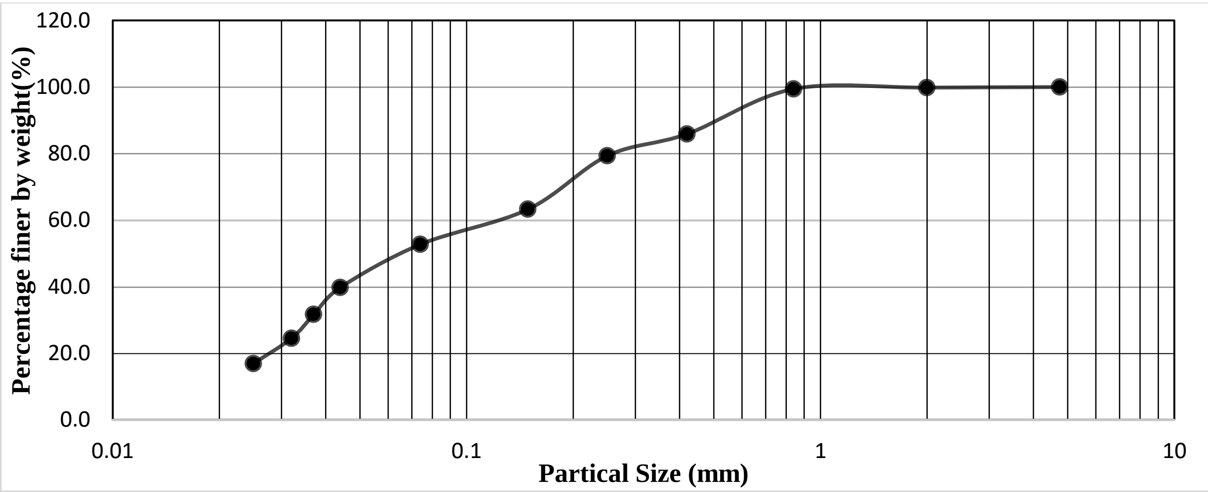

Figure 1: Particle size distribution for natural soil.

2.2.1. Results of the Atterberg Limits

The liquid, plastic and plasticity index limits of the clayey soil and mixtures were obtained. There is an influence of the presence of ash in the values of the Atterberg Limits, especially in the decrease of the plasticity index with the increase in the presence of ash.

Table 1: Atterberg Limits.

Name	Mixture Soil: RHA: SCBA	LL	LP	IP
S100+A0+B0	100: 0:0	30.69	18.75	11.94
S90+A5+B5	90: 5:5	35.10	24.48	10.62
S85+A7.5+B7.5	85: 7.5:7.5	34.59	27.76	6.83
S80+A10+B10	80: 10:10	34.10	27.87	6.23

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2.2.2. Compaction Results
The Proctor Standard test was performed according to ASTM-D-1557 to determine the optimum humidity content and maximum dry density of clayey soil and mixtures.

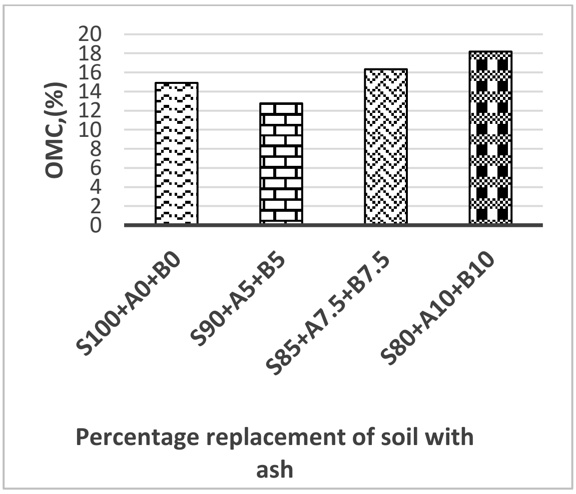

Figure 2: Effect of ash on OMC.

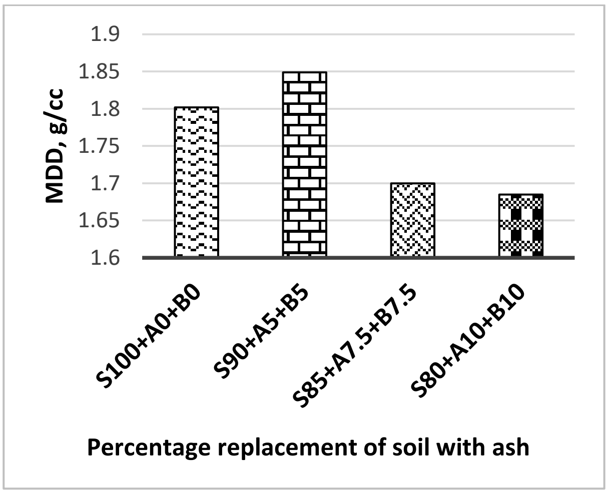

Figure 3: Effect of ash on MDD.

Figure 2 shows that increasing the presence of ash in the mixture increases the optimum humidity content, except for the S90 + A5 + B5 mixture, this is consistent with the increase of the liquid limit and plastic limit. In Figure 3 it can be seen that the maximum dry density of the S90 + A5 + B5 mixture is greater than that of the clayey soil, then for the mixtures with greater ash presence the maximum dry density decreases.

2.2.3 CBR Results
The CBR test for natural soil and stabilized soil was performed according to ASTM-D-1883 in immersed conditions to assess its carrying capacity. The results are shown in Figure 4.

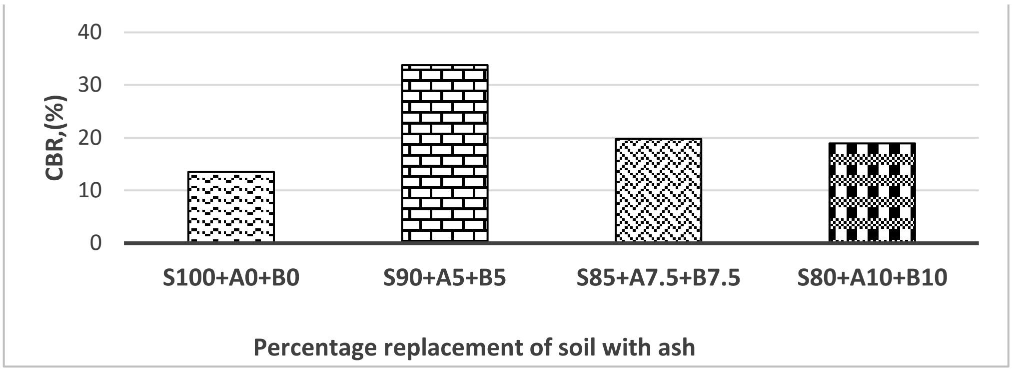

Figure 4: Effect of ash on CBR.

All mixtures achieved CBR values greater than that of clayey soil, being the mixture S90 + A5 + B5 the highest CBR value, 34.75%. The higher the presence of ash in the mixture, the CBR value decreases. The increase in CBR occurs due to the formation of calcium silicates after the reaction of silica from the ash and calcium of the soil that reacted during the 96-hour immersion. For the mixture S85 + A7.5 + B7.5 and S80 + A10 + B10 the CBR values were 19.73% and 18.90%, respectively.

Finally, with the S90 + A5 + B5 mixture, it manages to exceed the minimum value of CBR, 30%, a requirement for a subgrade to be considered as “excellent”, according to the materials manual of the Ministry of Transportation and Communications of Peru.

3. Discussion of the results:

- The S90 + A5 + B5 mixture manages to achieve an optimum humidity content lower than that of the clayey soil and a maximum dry density greater than the other mixtures. The greater presence of ash in the mixture, before the pozzolanic reaction, helps to reduce the density due to the lower specific weight of the ash and dramatically modifies the granulometric distribution, directly affecting the compaction results. On the other hand, the lower amount of ash in the mixture, before the pozzolanic reaction, could contribute to positively modify the granulometric distribution, so that during compaction, the fine grains of the ash settle between the grains of the natural soil, thus achieving a higher dry density in relation to mixtures with a higher percentage of ash.

- The CBR value stands at 33.75 for the 5% mixture and this produces the best result. In the same way, during the compaction test, the highest value (1,849 g / cm3) and the lowest optimum humidity content (12.78%) are obtained. For larger ash additions, the CBR decreases, this could be due to the amount of ash that fails to react and produce crystals. So instead of having soil grains, you have unreacted ash grains that do not contribute to soil resistance.

- The results obtained during this investigation showed that the soil stabilized with rice husk ash and sugarcane bagasse brings favorable changes that would make it possible to use it as a subgrade. Due to the high percentage of silica present in these ashes, it converts them into potential primary or secondary stabilizing agents.

- The proposal generates a possible solution to an environmental problem of the disposal of these wastes, mitigating the effects of pollution such as the generation of respiratory diseases, among others.

4. Conclusions

- The addition of rice husk ash (RHA) and sugarcane bagasse (SCBA) increases the value of CBR in a clay of low plasticity. The mixture with 5% RHA and 5% SCBA reaches a CBR value of 33.75%, being that of the clayey soil is about 12%.

- The mixtures compared to the natural soil sample show significant increases in the plastic limit value, this could be explained by the greater absorption of water from the ashes in relation to the natural soil.

- In comparison with the other mixtures, the mixture S90 + A5 + B5 obtained the highest value in CBR and MDD 33.75% and 12.78% respectively; and, the lowest value of OCH (12.78%).

- Finding new uses for RHA and SCBA, entails adding value to these wastes and reducing the negative impact on the environment and the generation of respiratory or other diseases.

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5. REFERENCES

[1] Anjani Kumar Yadav, Kumar Gaurav, Roop Kishor, S.K. Suman, (2017): “Stabilization of alluvial soil for subgrade using rice husk ash, sugarcane bagasse ash and cow dung ash for rural roads” International Journal of Pavement Research and Technology Vol 10, 27/02/2017, p254-261. 8p

[2] Delgado López, Carol Ashlly; Mendoza Meléndez, Ivette Anamile, (2018): "Influence of the percentage of alkaline-activated sugarcane bagasse ash on the effective tension in soils susceptible to liquefaction." (Undergraduate thesis). National University of Trujillo, Trujillo, Peru.

[3] Castro, Axel, (2017): “Stabilization of clay soils with rice husk ash for subgrade improvement”. (Undergraduate thesis). National University of Engineering, Lima, Peru.