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Stabilization of a Subgrade Composed by Low Plasticity Clay with Rice Husk Ash

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Abstract. The construction of road works in the world has always been a challenge for engineering, especially in areas where the conditions and types of soil are not adequate for the execution of this type of projects. The present investigation has as main objective to determine the influence that has the rice husk ash (RHA) to stabilize the subgrade layer of a pavement, composed of a low resistance clayey soil. RHA is a waste and pollutant material for the environment; therefore that its use can be considered as an economic and ecological alternative. Thus, several tests were carried out where it proved the value of CBR increased from 4.30% to 20.70%, by adding a 20% RHA dosage, achieving its optimum value to be considered a very good subgrade. In this way, it is possible to affirm that the addition of RHA improves the geotechnical properties of the soil.

1. Introduction

The paving of a road allows easy access, communication and transport within a country. Depending on their structural composition, pavements can be classified as rigid or flexible [1]. For the effectiveness of a pavement, it must have the ideal dimensions to support the applied loads, provide a suitable surface for comfortable driving, minimal deformation, long service life, among other conditions [2]. The durability and quality of a pavement depend on the strength and mechanical properties of its subgrade, because this layer of the soil fulfills the role of foundation. Thus, in the case of clay subgrade, which does not have adequate resistance, these must be stabilized or improved by means of methods that are economical and that favor environmental care. The most common techniques are based on the addition of cementitious materials to the soil in order to improve their resistance.

In 1992, in Malaysia, Haji et al. [3] studied the geotechnical properties of a clayey soil stabilized with rice husk ash (RHA). The authors classified the soil as a sandy clay (SC), A-7-5 according to the AASHTO standard, with a liquid limit of 73%, a plastic limit of 36% and a CBR value of 2% for saturated samples; also, the rice husk was obtained as a by-product of the rice milling and an ash was obtained with an amount of silica of 90.73%. After the respective laboratory tests, it was determined that at a higher amount of RHA the maximum dry density decreases and the optimum humidity content increases. On the other hand, in 2016, Rukenya et. Al [4] performs CBR tests on an expansive clay in Nairobi, where it is sought to solve the problems of soil resistance. Through the use of RHA with 78.9% silica, dosages of RHA and lime are performed that result in an 800% improvement in the CBR value and a 70% decrease in soil swelling, both in comparison to the soil sample natural. Likewise, rice production in Peru has increased by 19.2% in November 2018 compared to the same month in 2017, with total production of 171,207 tons [5]. Rice husk ash represents approximately 25% of the husk when burned and the latter, in turn, is equivalent to 22% of the total grain [6].

In summary, the research seeks to quantitatively determine the improvement of the geotechnical properties of a soil with poor support capacity against the addition of rice husk ash as a stabilizing agent. This soil is used as a subgrade of an unpaved low traffic road, where the optimum CBR value is 20% according to the manual of the Ministry of Transportation and Communications of Peru. Thus, due to the poor development and investment in innovative methods, in this country, there is not enough information from similar studies to generate standard civilizations. Therefore, laboratory tests are carried out to determine the physical, chemical and mechanical properties of natural and dosed soil at different proportions of rice husk ash to determine an optimal mixture that meets the required CBR value.

2. Experimental program

2.1 Materials

The materials that have been used in the investigation are the clay extracted from the Callampampa farmhouse in the province of Chota, Cajamarca and the rice husk ash, obtained in a mill in the city of Guadalupe, Lambayeque. Both components were taken to various preliminary tests to know their physical, chemical and mechanical properties.

In the first place, a granulometric analysis was carried out on the clay, in its natural state, where 75.06% of material was reached through the # 200 mesh without the presence of gravels. Also, the main physical properties were determined, which are shown in Table 1.

Table 1. Physical properties of the soil.

Soil properies	Tests results
Humidity content (%)	19.00
Liquid limit (%)	26.00
Plastic limit (%)	19.00
Plasticity index (%)	7.00
SUCS Classification	Low Plasticity Clay (CL)
Maximum dry density (kN/m3)	16.61
Optimun humidity content (%)	18.60
Soaked CBR (%)	4.50

In second place, through X-ray fluorescence test was obtained the chemical composition of low plasticity clay and rice husk ash. Through the results obtained in Table 2, we can highlight that RHA is an excellent pozzolan having 90.81% silica (SiO2) in its chemical composition. This characteristic is very important for the stabilization of the clay since, the RHA, when combined in various dosages with the CL, will form a cementitious compound of greater stability.

Table 2. Chemical properties of CL and RHA

Item	Chemical Component	CL	RHA
1	Silicon dioxide (SiO_2)	69.00	90.81
2	Aluminum oxide (Al_2O_3)	14.94	0.21
3	Iron (III) oxide (Fe_2O_3)	3.99	0.61
4	Potassium oxide (K_2O)	1.96	4.62
5	Magnessium oxide (MgO)	0.90	0.59
6	Calcium oxide (CaO)	0.61	0.67
7	Others	9.60	2.49

2.2 Dosage

Through the tests of physical and chemical properties carried out on the samples of natural soil and ash, the dosage of this project was determined. In recent years, many researchers have stabilized clayey soils, of similar characteristics, with an average of 15% RHA as the optimal dosage. In this way, the research uses the dosages shown in Table 3.

Table 3. Dosage and denomination of samples.

Sample	Sample proportion (%)	
	CL	RHA
100CL0RHA	100	0
90CL10RHA	90	10
85CL15RHA	85	15
80CL20RHA	80	20
75CL25RHA	75	25

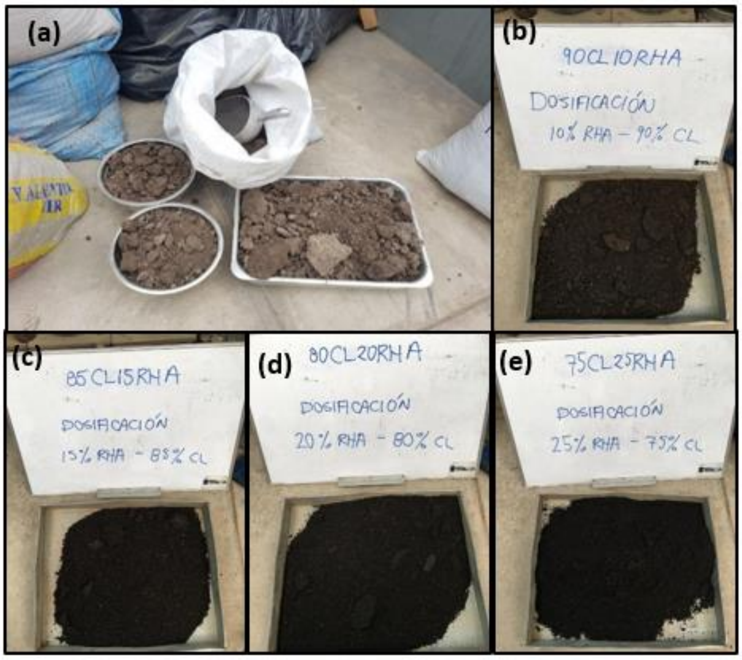

Figure 1. (a)100CL0RHA (b)90CL10RHA (c)85CL15RHA (d)80CL20RHA (e)75CL25RHA

3. Results and Analysis

3.1 Compaction

For this process, the modified proctor test was carried out in order of determining the optimum humidity content (OMC) and the maximum dry density (MDD). Figure 2 shows the variation that exists in (OMC) according to the dosage of RHA added. By increasing the percentage of ash and, therefore, by decreasing the proportion of soil, the OMC is increasing. This result means that more water will be needed to compact the CL-RHA mixture.

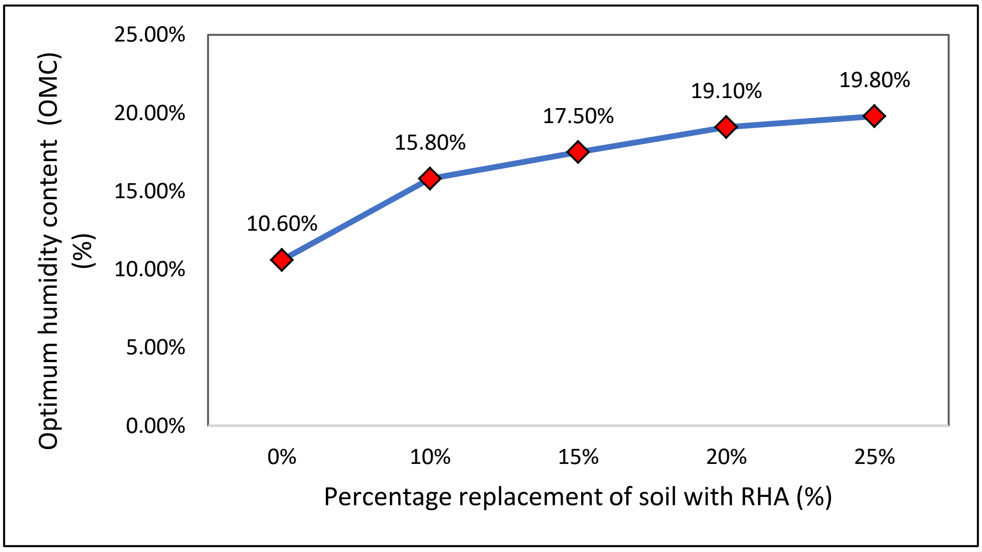

Figure 2. Effect of RHA on OMC.

On the other hand, Figure 3 shows the variation presented by the maximum dry density with respect to the added RHA dosage. Second the graph shows that at a higher percentage of RHA, the MDD decreases. This is because the specific gravity of the ashes is less than that of the clay.

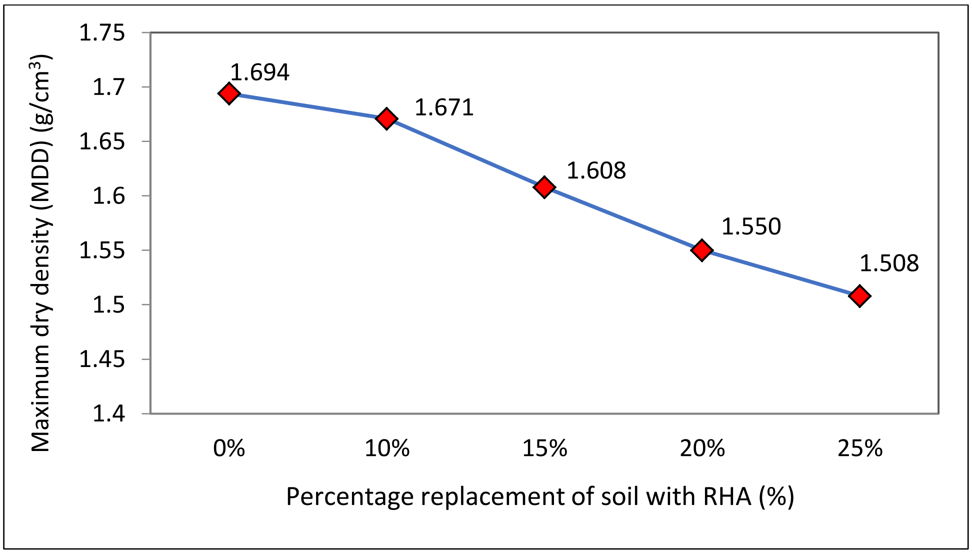

Figure 3. Effect of RHA on OMC.

3.2 CBR test

The CBR was the most important test that was carried out in the investigation since it allowed to know the resistance, both of the clay under study, and of the stabilized mixtures with various proportions of RHA. These analyzes were performed with their established humidity and density parameters, according to preliminary analyzes; as in its most critical condition, soaked.

Figure 4 indicates the effect that RHA has on the parameter of a saturated CBR. It can be determined that, while the RHA is added in greater quantity, the percentage of resistance increases. This is due to the formation of calcium silicates and calcium aluminates, which are very important parameters for the conformation of cementitious elements.

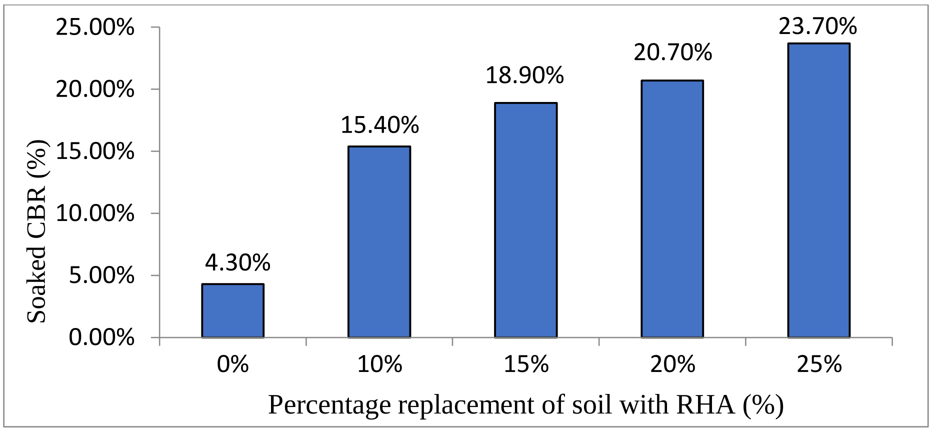

Figure 4. Effect of RHA on soaked CBR.

4. Conclusions

- When performing the X-ray Fluorescence test, the chemical components of rice husk ash and clay are determined. It is observed that the values of silica (SiO2), aluminum oxide (Al2O3) and iron oxide (Fe2O3) exceed 70% of the total components. Therefore, it is concluded that they are materials with a high pozzolanic behavior that can be used as a cement in soil stabilization.
- As the proportion of rice husk ash increases, the optimum humidity content (OMC) increases and the maximum dry density (MDD) decreases. In this way, we deduce that the addition of ash improves the soil and less energy is needed to perform its compaction.
- CBR values increase when more RHA is added. For this reason, to obtain a very good subgrade, a CBR value of 20% must be reached, this value being exceeded with the addition of 20% RHA, which gives a result of 20.70% CBR. Likewise, the different dosages provide various CBR values which could be used, referentially, for the conformation of retaining walls or as stabilizers for embankments.

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