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Research Article

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Improvement of Zogbedji (Togo) Clay Soil Characteristics by Adding Rice Husks Ashes (RHA)

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Abstract The construction of structures on clay soil without any particular arrangement is often a source of damage. To avoid this damage, it can, among other things, improve the characteristics of this soil by adding binder or other materials to reduce the phenomenon of shrinkage-swelling. In this paper it is envisaged the mixing of rice husks ashes (RHA) in various proportions and clay soil of Zogbedji in order to improve the characteristics of this soil including the CBR index and plasticity.

The results obtained show that the RHA added to the clay soil reduces the plasticity by more than 30% and thus reduces the shrinkage-swelling phenomenon and increases the soil CBR index up to 407%. This improvement makes it possible to envisage the mixture containing 15% of RHA as a sub-base course (CBR> 5).

Keywords CBR, clay soil, improvement, plasticity, rice husk ash

1. Introduction

Faced with a bad soil, it is sometimes necessary to treat it in order to make it usable by improving these characteristics. There are two types of soil treatments, namely improvement and stabilization [1-3]:

- The first corresponds to a simple improvement of the soil geotechnical characteristics (decrease of the water content, increase of the lift, decrease of the sensitivity to the water, etc.) without radically transforming the behavior which remains that of a soil. The improvement does not result in creating a semi-rigid type material, although there may be in the long term a significant increase of the modulus. The design criteria for a soil improved by treatment remain those applicable to untreated soil. The soil improvement is done by the adding different type of modifiers like (cement, lime, etc.) to a soil [3-5].

-The second called stabilization, gives the treated soil an elastic modulus of a level such that it behaves, in the long term, as a semi-rigid material where it is appropriate to apply the stages of implementation (preparation soil + cement mixture, humidification and compaction). The ways to stabilize the soil are compaction and admixtures usage. Commonly used stabilizers for altering soils properties are cement and lime [3].

Recent studies indicate solid waste materials use like rice husk ash for soil stabilization by means of or devoid of cement or lime [5].

Indeed, the high silica content of rice husks and rice husk ash allows the use of these agricultural by-products in various fields of construction: they are used to improve the properties of soils and bricks or concrete [4-18].

In this article, it is envisaged to study the effect of rice husk ash (RHA) on the characteristics (plasticity, swelling, CBR index) of Zogbedji soil in Lomé, Togo. This soil, which is plastic, is not suitable for construction because, like all clay soil, it is subject to shrinkage-swelling.

2. Materials and Method

RHA are obtained after incineration of rice husks coming from rice growing in Kovié, a village located about 27 km north of Lome, the capital of Togo. RHA are light and absorb a lot of water (Table 1).

The soil is taken from Zogbedji in the northeastern suburbs of Lome. It is a clay soil, little plastic and of type A2 (fine clay sands) according to GTR soil classification [19].

Table 1: Characteristics of the materials used

Characteristics	Clay soil	RHA
Apparent density (g/cm^3)	1.36	0.20
Liquidity limit (%)	32.11	-
Plasticity limit (%)	19.44	-
Plasticity Index (PI)	12.67	-
Consistency index	1.57	-
Absorption rate	-	300% (after deux hours of immersion)

The effect of RHA addition on Zogbedji soil characteristics is studied by varying RHA mass relative to that of the mixture in a range from 0 to 15%. Table 2 gives the different rates and quantities of materials used for each assay.

Table 2: Summary of the different dosages

RHA rates	RHA mass (g)	Clay soil mass (g)
0%	0	6500
2%	130	6370
5%	325	6175
8%	520	5980
10%	650	5850
15%	975	5525

The tests carried out on each mixture are:

- determination of particle size distribution according to standard NF EN ISO 17892-4 [20];
- apparent density according to standard NF EN ISO 11272 [21];
- Atterberg limits according to standard NF P94-051 [22];
- Proctor tests Modified according to standard NF P94-093 [23];
- and CBR at 4 days of imbibition test with swelling measurement according to standard NF P94-078 [24].

A GTR classification of the different mixtures is also carried out (standard NFP 11-300) [19].

3. Results and Discussion

Figure 1 shows the granulometric curve of the different mixtures

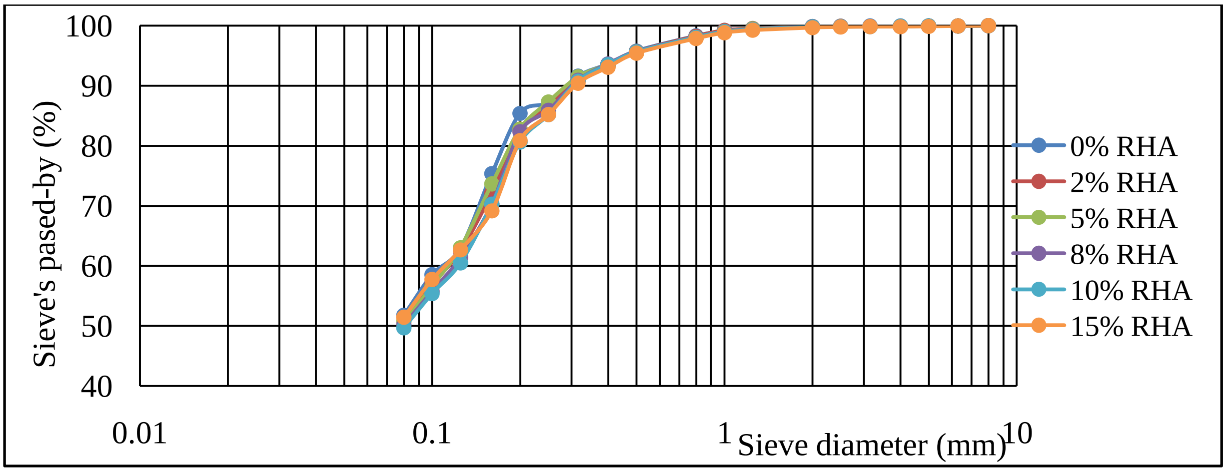

Figure 1: Granulometric curve of the different soil-RHA mixtures

The addition of RHA has little changed the grain size of the soil: in fact, the two materials being of a fine nature, their mixture has preserved this nature (passing through the sieve 80 microns almost always greater than 50%).

Table 3 gives the results of Atterberg limits (limit of liquidity and plasticity, plasticity and consistency index) and the nature of the soil.

Table 3: Atterberg limits results

RHA rate	Liquidity limit (WL)	Plasticity limit (WP)	Plasticity Index (PI)	Soil nature according to PI	Consistency Index (CI)	Soil nature according to CI	GTR Classification
0%	32.11	19.44	12.67	Little plastic	1.57	Solide	A2
2%	35.17	27.21	7.96	Little plastic	2.88	Solide	A1
5%	35.63	27.78	7.85	Little plastic	2.98	Solide	A1
8%	38.83	32.05	6.78	Little plastic	3.92	Solide	A1
10%	41.26	35.07	6.2	Little plastic	4.68	Solide	A1
15%	42.99	38.75	4.24	Non plastic	7.25	Solide	A1

The plasticity index (PI) decreases as RHA rate increases: the material becomes less and less plastic. The PI rate of decrease varies from 37% to 67%. This tendency is confirmed by the consistency index increase with rate increase ranging from 83% to 362%. At 15% of RHA, the material loses its plasticity and becomes non-plastic and very consistent. Soil-RHA mixtures are class A1 (fine sand with low pollution), whereas Zogbedji soil is class A2 (fine clay sands). The RHA addition canceled out the effect of the clay from the rate of 2%, which results in a class change according to the GTR classification. This tendency is confirmed by the PI decrease.

The results of Proctor optimum densities and water contents, swellings measured after four days of immersion and CBR index are presented in Table 4.

Table 4: Apparent density, Proctor and CBR test results

RHA rate	Apparent density (g/cm^3)	Proctor optimum density (g/cm^3)	Proctor optimum water content (%)	Swelling (mm)	CBR index
0%	1.36	2.065	11.4	6.91	0.8
2%	1.33	2.06	12.4	4.78	1.9
5%	1.27	2.05	12.8	4.68	2.7
8%	1.22	2.02	13.22	4.34	2.7
10%	1.19	1.97	14.4	4.95	4.2
15%	1.14	1.95	16.24	3.82	5.5

From the results of Table 4, we draw the curves of Figures 4 to 8 showing the evolution of the apparent density, the dry density and the water content at the Proctor optimum, the swelling and the CBR index depending on RHA rate

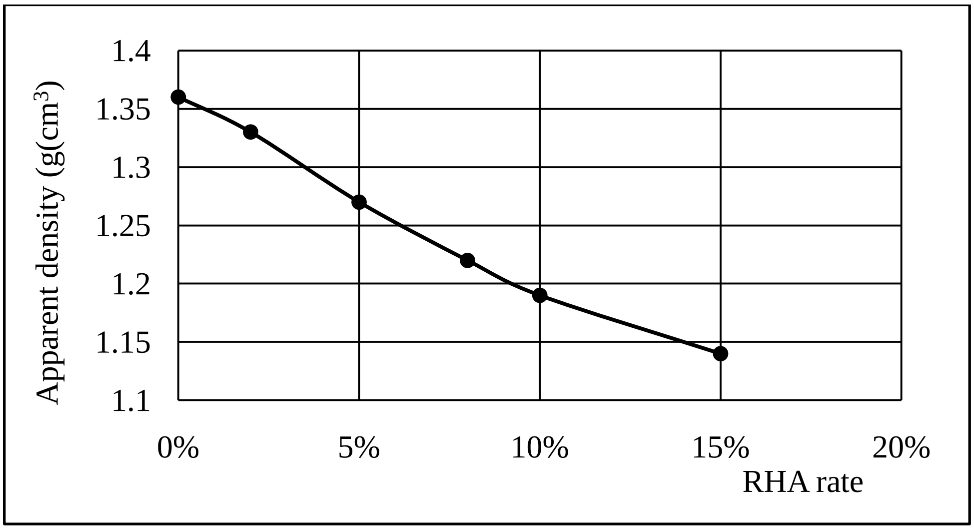

Figure 2: Evolution of the apparent density according to RHA rate

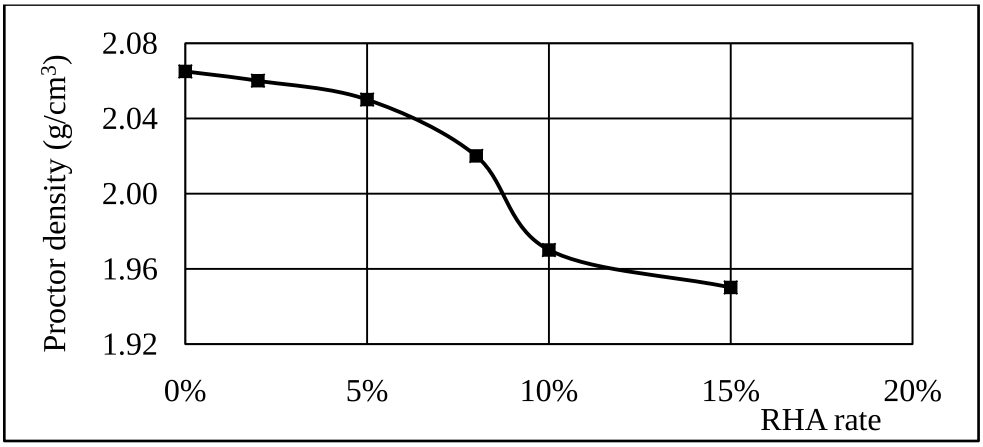

Figure 3: Evolution of the Proctor dry density according to RHA rate

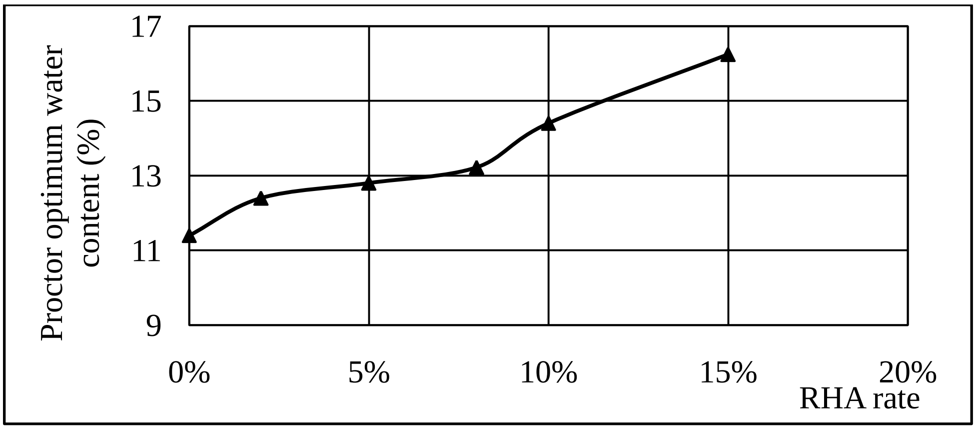

Figure 4: Evolution of Proctor water content according to RHA rate

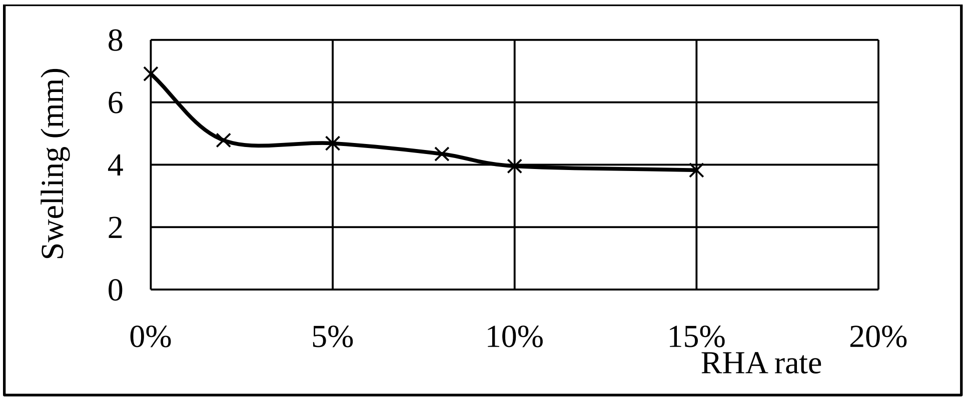

Figure 5: Evolution of the swelling according to RHA rate

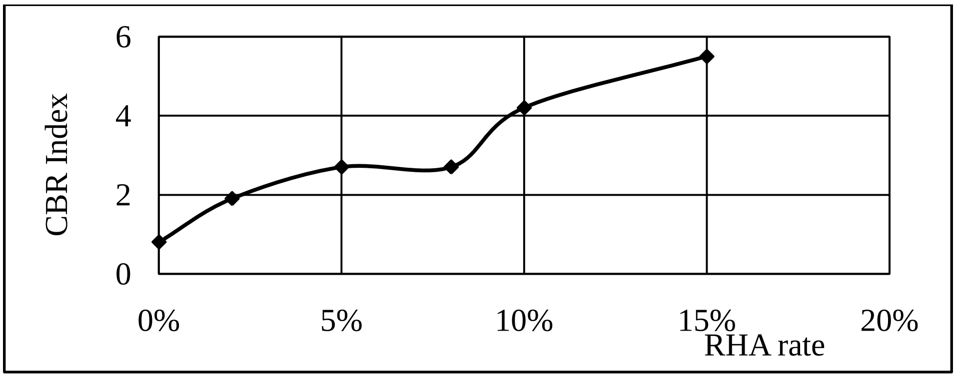

Figure 6: Evolution of the CBR index according to RHA rate

From Figure 2, it will be noted that the mixtures apparent density decreases from 2% to 16% with the RHA rate, which is due to the RHA lightness relative to the ground. The Proctor optimum dry density of Zogbedji clay soil is 1.64g/cm^3 for a water content of 18.00%. By varying the amount of RHA in the sample up to 15% the dry density (Figure 3) decreases to 1.42 g/cm^3, a decrease of 3.5% to 13.3%. The water content at the Proctor optimum (Figure 4) increases to 23.00%, an increase of 2.8% to 27.8% according to RHA rate. The increase in water content is due to the RHA water absorption, RHA being very hygroscopic. The decrease in the dry density is due to the lightness of the RHA compared to the soil: indeed, the increase of the RHA in the mixture corresponds to a decrease of the density because the quantity of the heavy material that is the soil decreases.

The results also show that the swelling (Figure 5) decreases with RHA rate increasing, as the soil plasticity decreases as RHA rate increases. This decrease varies between 9% and 51%. This tendency confirms the RHA influence on the plasticity index and consistency index. Indeed, the decrease of the clay content in the soil and therefore of the plasticity corresponds to a decrease of the swelling, since it is the clay which is the source of the swelling.

Lastly, the RHA enormously improve the bearing (figure 6) of the Zogbedji soil: the increase of the RHA content in the mixture results in an increase of the CBR index from 100% to 407%. Indeed, the consolidation of the clay soil by RHA reduces the swelling and makes the material more solid therefore more resistant or bearing.

At the end of this work we can conclude that the increase of the RHA in the Zogbedji clay soil:

- decreases the plasticity of the material;
- increases the consistency of the clay soil;
- increases the CBR index;
- decreases the swelling.

4. Conclusion

The study of the influence of rice husks ash (RHA) coming from Kovié on the mechanical properties of the Zogbedji clay soil is the main objective of this work. For this, the RHA are mixed with the clay soil with a mass ratio ranging from 2% to 15%. The soil-RHA mixtures obtained are subjected to density, Proctor and CBR tests. The results of the materials tests indicate that the Zogbedji clay soil is plastic and has a low CBR (0.8). The RHA is light with a high hygroscopic power and is comparable to a fine sand. The characterization of the various mixtures makes it possible to conclude that the RHA improve the mechanical characteristics of the soil. In fact, the increase of the RHA content in the soil causes a decrease in its plasticity, its dry density and its swelling but on the other hand it increases its consistency, its water content and its CBR index. At 15% of RHA, the improved soil can serve as a sub-base course (CBR> 5) in road construction. It would be necessary to continue studies on different types of clay soils and see if the RHA effect is the same and from there, generalize the results obtained.

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