Research Journal of Engineering Sciences ISSN 2278 – 9472
Vol. **9(1),** 1-6, January **(2020)** *Res. J. Engineering Sci.*

Study of rice husk ashes influence on djagble clay soil characteristics in Togo

AYITE Yawovi Mawuénya Xolali Dany*, P'KLA Abalo, PACHOUKOVA Irina and BEDJA Koffi-Sa
High National School of Engineers, University of Lome, 01 BP 1515, Lome 01, TOGO
danyayite@gmail.com

Available online at: www.isca.in, www.isca.me
Received 17th November 2019, revised 7th December 2019, accepted 15th January 2020

Abstract

Rice husks and their ashes are agricultural by-products coming from rice decortication and containing a significant rate of silica causing its application in the field of the construction. In this paper the effect of adding rice husk ash on the characteristics (CBR, Proctor density and water content, Atterberg limits) of a plastic clay soil is studied. For this, rice husk ash is added to the soil in various proportions. The results obtained from the tests carried out make it possible to say that rice husk ash addition to clay soil reduces clay soil plasticity, swelling and density but increases its consistency and its CBR index.

Keywords: Rice husk ash, clay, CBR index, consistency, swelling, plasticity.

Introduction

The construction on clay is often responsible for losses due to the movements of the grounds. The withdrawal-swelling is indeed one of the primary causes of disorder with consequences that can go as far as the reconstruction of the property in extreme cases. If the shrinkage-swelling phenomenon cannot be avoided, however, it is sufficient to adapt the construction system to the clay to ensure stability and thus durability or sometimes to increase the overall mechanical characteristics of the soil in place or reported.

Techniques for increasing soils mechanical properties can be classified into two categories[1-3]: i. soil improvement techniques where the soil structure is improved, especially at the level of the contacts between the grains, by an additive, a binder, a grout, or modified by reducing the voids between the grains, to reach a denser state; ii. soil strengthening techniques in which structural elements are placed in the soil in order to increase mainly the mechanical strength.

Rice husk are products of agricultural origin derived from the decortication of rice, having a chemical composition giving rise to its application in many fields, especially the field of construction. Studies have shown the possibility of using rice husk and rice husk ashes as a building material. The rice husk ash contains around 90% of silica[4] and has been used to improve properties of soil[4-21]. Generally, rice husk ash use is benefit to the plasticity, unconfined compression strength and California Bearing Ratio (CBR) of a soil.

In Togo, in rice production areas, rice husk management is often difficult. Farmers are often forced to burn these rice husk. Even in this case, they have to manage the ash produced, which is another puzzle. In this article, it is envisaged to improve the mechanical characteristics of a plastic soil, Djagble soil in Lome, Togo, by adding rice husk ash.

Materials and methods

Rice husk ash are collected in Kovie, a village located about 27 km north of Lomé, the capital of Togo. These rice husk ashes are light (Table-1), granular class 0/3.15 (Figure-1) and absorb a lot of water during the first hour (Figure-2). The soil material was collected in the canton of Djagble located about fifteen kilometers north-east of Lomé. The characteristics of this soil are presented in Table-1. It is a fine soil (Figure-1) and plastic (Table-1).

Table-1: Materials used characteristics.

Characteristics		Clay soil	Rice husk ash
Apparent density(g/cm^3)		1,05	0,20
Atterberg limits	Liquidity limit (%)	65	-
	Plasticity limit (%)	28	-
	Plasticity index(IP)	37	-
Consistency index		1	-

To determine the effect of rice husk ash addition on Djagble clay soil characteristics, we varied the mass of ash with respect to the clay soil in a range from 0 to 16% in steps of 4%. Table-2 gives the quantities of materials used for each dosage.

The tests carried out on each mixture are: Atterberg limits according to standard NF P94-051[22], Proctor tests Modified according to standard NF P94-093[23] and CBR immersion test with swelling measurement according to standard NF P94-078[24].

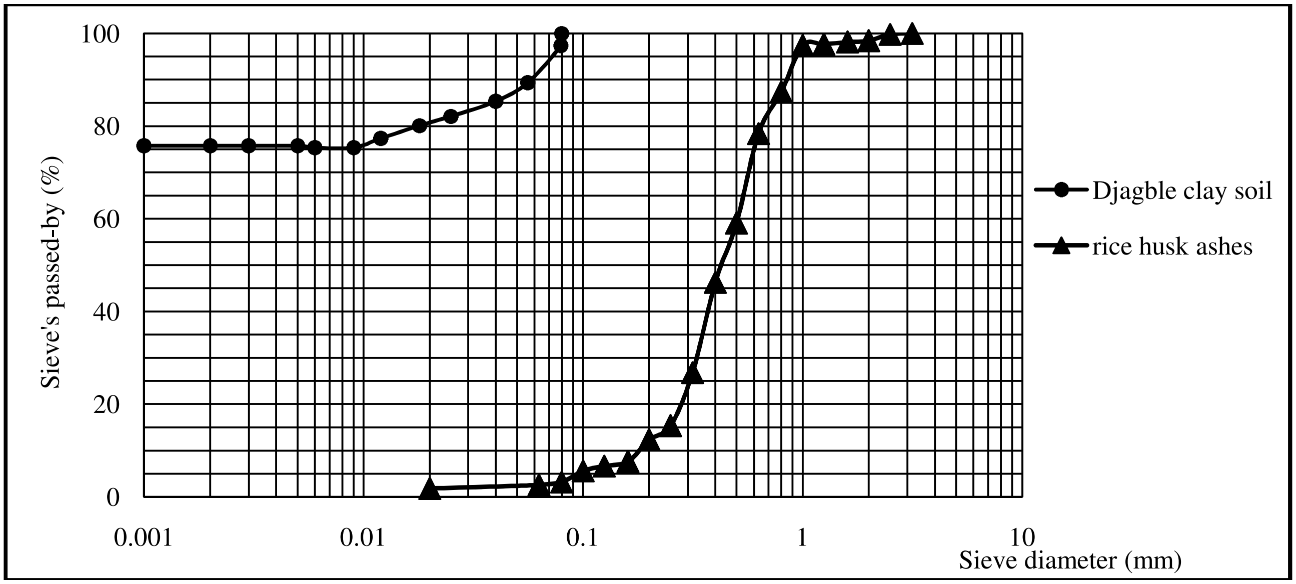

Figure-1: Materials used grading curve.

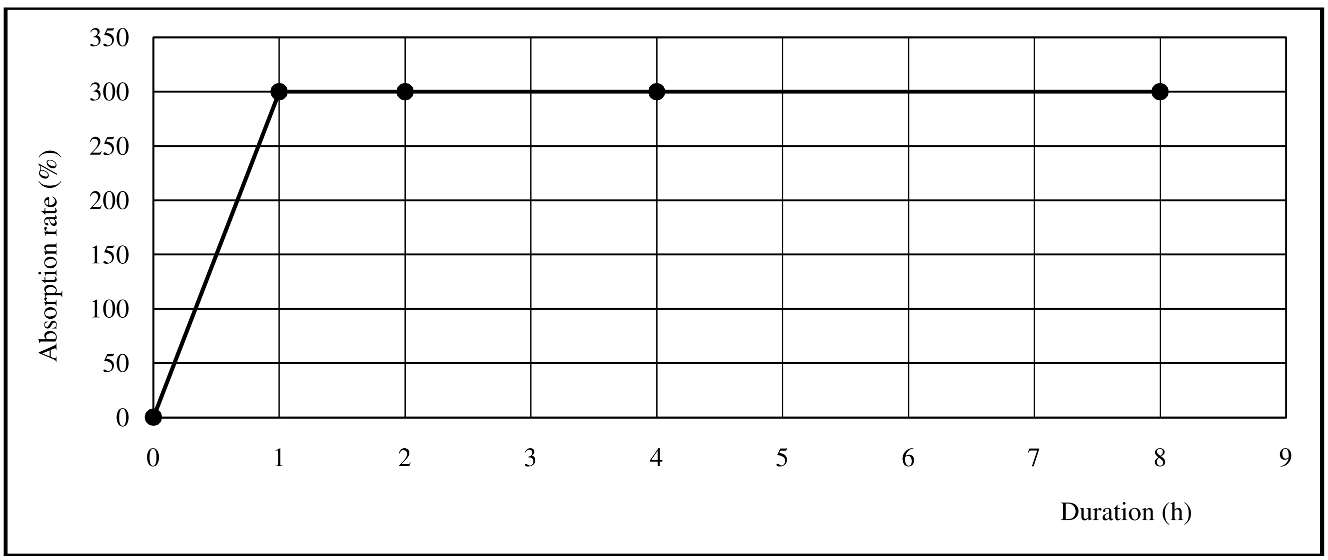

Figure-2: Rice husks ash water absorption Kinetic curve.

Table-2: Different dosages summary.

Mixtures	Different dosages			
	Clay soil		Rice husk ash	
	(%)	(g)	(%)	(g)
Clay soil	100	6000	0	0
Clay soil + Rice husk ash	96	5760	4	140
Clay soil + Rice husk ash	92	5520	8	480
Clay soil + Rice husk ash	88	5280	12	720
Clay soil + Rice husk ash	84	5040	16	960

Results and discussion

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

The plasticity index decreases as the rice husk ash content increases: the material becomes less and less plastic. This trend is confirmed by the increase in the consistency index. Indeed, the increase of the ash content in the clay soil increases its consistency which makes it more solid and therefore decreases its plasticity.

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

From the results of Table-4, we plot Figures-3 to 6 curves showing the evolution of the dry density and the water content at the Proctor optimum, the swelling and the CBR index as a function of rice husk ash rate.

Table-3: Atterberg limits Results.

Ash rate	Liquidity limit (WL)	Plasticity limit (WP)	Plasticity index (IP)	Soil condition according to IP	Consistency index (IC)	Soil condition according to IC
0%	64,60	27,29	37	Plastic	1	Plastic
4%	64,40	31,5	33	Plastic	2	Solid
8%	64,00	33,22	31	Plastic	3	Solid
12%	61,80	34,18	28	Plastic	4	Solid
16%	61,00	36,18	25	Little plastic	4	Solid

Table-4: Proctor optimum densities and water contents, swellings and CBR index results.

Ash rate	Proctor optimum density (g/cm^3)	Proctor optimum water content (%)	Swellings (mm)	CBR index
0%	1,638	18,00	3,06	0,44
4%	1,580	18,50	2,78	0,88
8%	1,560	21,00	2,38	1,24
12%	1,470	21,50	2,06	1,85
16%	1,420	23,00	1,5	2,23

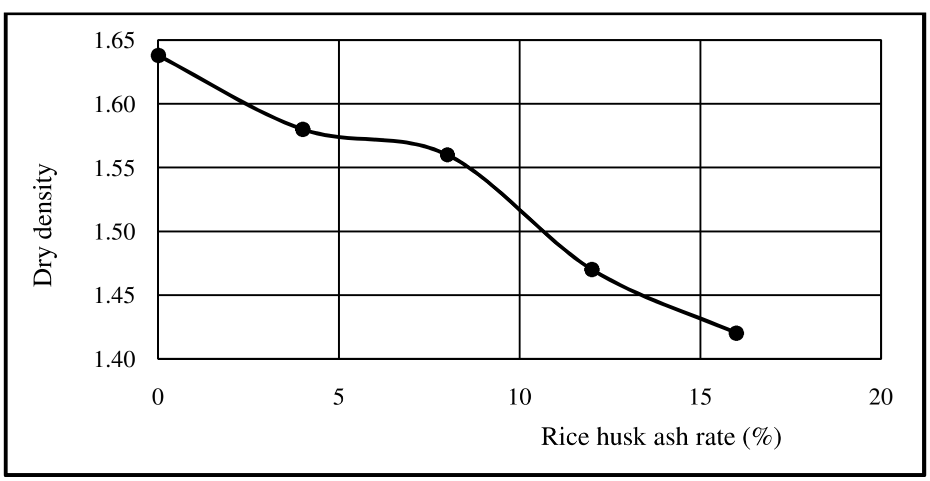

Figure-3: Proctor optimum density evolution according to rice husk ash rate.

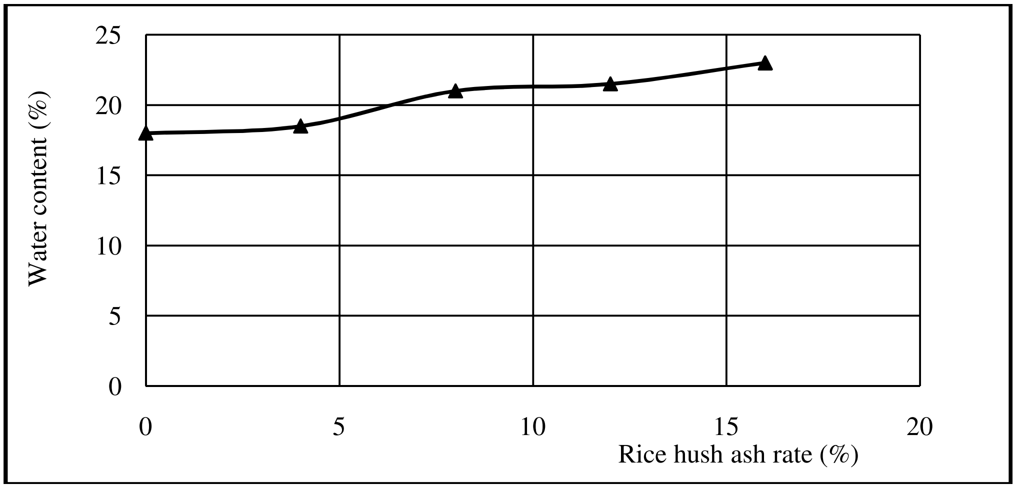

Figure-4: Proctor optimum water content evolution according to rice husk ash rate.

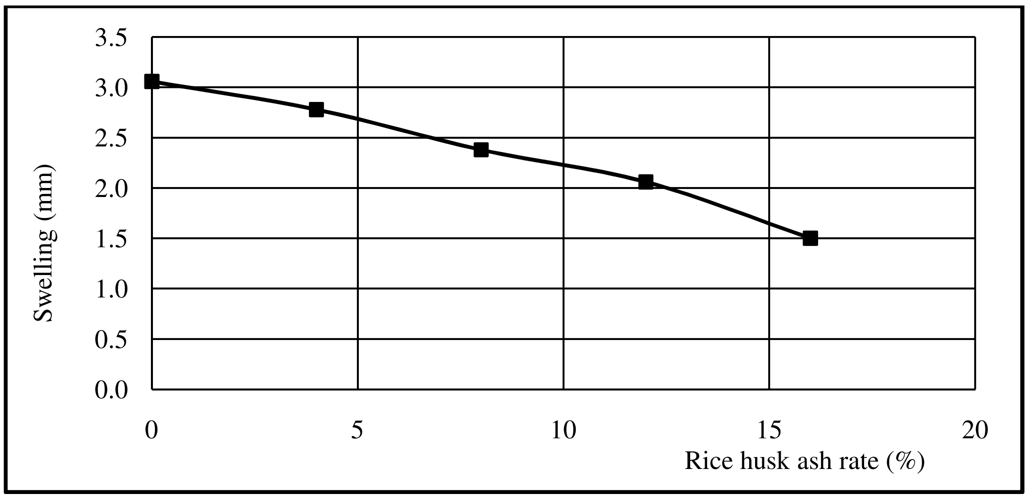

Figure-5: Swelling evolution according to rice husk ash rate.

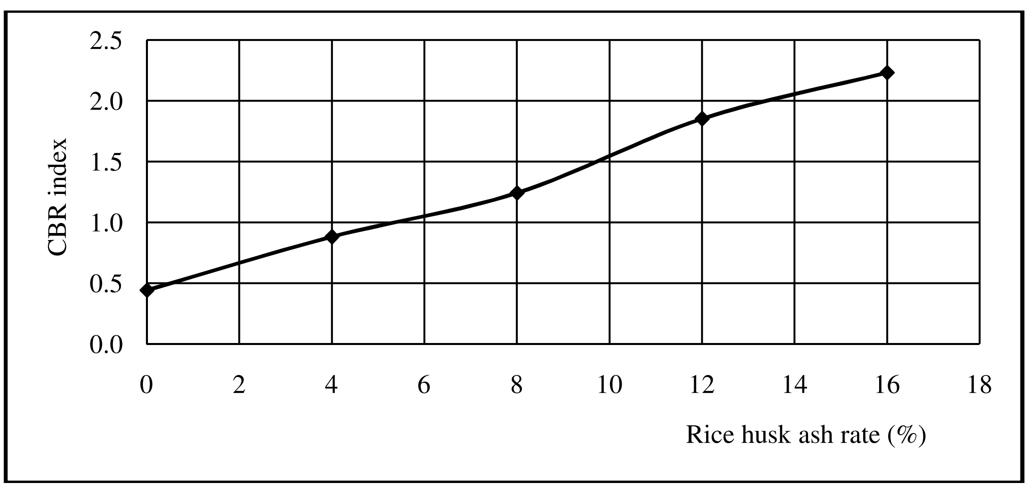

Figure-6: CBR index evolution according to rice husk ash rate.

Dry density at the Proctor optimum of Djagble clay soil is 1.64g/cm^3 for a water content of 18.00%. By varying the amount of ash in the sample up to 16% the dry density decreases to 1.42g/cm^3, a decrease from 3.5% to 13.3% and the water content increases to 23.00%, an increase of 2.8% to 27.8%. The water content increase is due to water absorption of rice husks ash, ashes being very hygroscopic. The dry density decrease is due to rice husk ash lightness: indeed, rice huskash increase in the mixture corresponds to density decrease because the heavy material quantity that is the soil decreases.

The results show that the swelling decreases with increasing ash, because the plasticity of the soil decreases as the ash rate increases. This decrease varies between 9% and 51%. This trend confirms the ashes influence on the plasticity and consistency indexes. Indeed, the ash rate increase reflects a clay content decrease in the mixture and therefore swelling, since it is the clay that is the swelling source.

Lastly, rice husk ashes increase enormously the lift (Figure-6) of Djagble soil: the ash rate increase in the mixture results in an increase of the CBR index from 100% to 407%. Indeed, clay soil consolidation by rice husk ashes reduces the swelling and makes the material more solid therefore more resistant or bearing.

At the end of this work we can conclude that rice husk ashes increase in the mixture ashes- Djagble clay soil: i. decreases material plasticity; ii. increases clay soil consistency; iii. increases CBR index; iv. decreases material swelling.

Conclusion

The aim of this paper is to study rice husk ash from Kovie influence on Djagble clay soil mechanical characteristics. To achieve this goal, we mixed the two materials by varying rice husk ash mass relative to clay soil mass at rates ranging from 4 to 16% and in steps of 4%. Finally, we did tests on the different mixtures. The results of the tests on the materials reveal that Djagble clay soil is of plastic nature and has a low CBR index (0,44). The rice husk ash 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 rice hush ashes improve soil mechanical characteristics. In fact, rice hush ash rate increase 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.

References

1. Little D.N. (1999). Evaluation of Structural Properties of Lime Stabilized Soils and Aggregates: Summary of Findings. National Lime Association, 1-89.
2. Thompson M.R. (1966). Lime reactivity of Illinois soils. *Journal of the Soil Mechanics and Foundations Division*, 92(5), 67-92.
3. Thompson M.R. (1970). Suggested Method of Mixture Design Procedures for Lime-Treated Soils. *ASTM Special Technical Publication*, 479, 430-440.
4. Ghassan Abood Habeeb and Hilmi Bin Mahmud (2010). Study on Properties of Rice Husk Ash and Its Use as Cement Replacement Material. *Materials Research.*, 13(2), 185-190.
5. Ayite Y.M.X.D., Pachoukova I., Agbo K.E. and Bedja K. (2017). Study of improvement of mud bricks stabilized with cement characteristics by addition of rice husks ashes. *Research Journal of Material Sciences*, 5(7), 1-4.
6. Alhassan M. and Mustapha A.M. (2011). Effect of Rice Husk Ash on Cement Stabilized Laterite. *Leonardo Electronic Journal of Practices and Technologies*, 11, 47-58.
7. Kumar A., Mohanta K., Kumar D. and Parkash O. (2012). Properties and industrial application of rice husk: A review. *International journal of emerging technology and engineering*, 2(10), 2-7.
8. Thiravetyan P. (2012). Application of Rice Husk and Bagasse Ash as Adsorbents in Water Treatment. *Application of Adsorbents for Water Pollution Control*, 23, 432-454.
9. Behak Leonardo (2017). Soil Stabilization with Rice Husk Ash. *Rice-Technology and Production*, Amanullah and Shah Fahad, Intech Open. ISBN: 978-953-51-3029-1, 978-953-51-3030-7, 1-238.
10. Korotkova T.G., Ksandopulo S.J., Donenko A.P., Bushumov S.A. and Danilchenko A.S. (2016). Physical properties and chemical composition of the rice husk and dust. *Orient. J. Chem*, 32(6), 3213-3219.
11. Sasui S., Jinwuth W. and Hengrasmee S. (2018). The Effects of Raw Rice Husk and Rice Husk Ash on the Strength and Durability of Adobe Bricks. *Civil Engineering Journal*, 4(4), 732-742. http://dx.doi.org/10.28991/cej-0309128
12. Isah H. (2015). The effect of rice husk on the chemical properties of clay soil. *Proceeding of 2nd International Conference on Chemical, Biological, and Environmental Sciences*, Dubai (UAE) 20th-21st May. 9-12. http://dx.doi.org/10.17758/IAAST.A0515036
13. Hossain S.S., Mathur L. and Roy P.K. (2018). Rice husk/rice husk ash as an alternative source of silica in ceramics: A review. *Journal of Asian Ceramic Societies*, 6(4), 299-313. https://doi.org/10.1080/21870764.2018.1539210
14. Portillo-Rodríguez A.M. (2013). Characterization of materials formed by rice husk for construction. 2nd International Meeting for Researchers in Materials and Plasma Technology. Journal of Physics: Conference Series, 466(1), 2038 doi:10.1088/1742-6596/466/1/012038
15. Mayooran S., Ragavan S. and Sathiparan N. (2017). Comparative study on open air burnt low- and high-carbon rice husk ash as partial cement replacement in cement block production. *Journal of Building*

Engineering, 13, 137-145. https://doi.org/10.1016/j.jobe.2017.07.011

16. Zareei S.A., Ameri F., Dorostkar F. and Ahmadi M. (2017). Rice husk ash as a partial replacement of cement in high strength concrete containing micro silica: Evaluating durability and mechanical properties. *Case studies in construction materials*, 7, 73-81.

17. Fapohunda C., Akinbile B. and Shittu A. (2017). Structure and properties of mortar and concrete with rice husk ash as partial replacement of ordinary Portland cement–A review. *International Journal of Sustainable Built Environment*, 6(2), 675-692.

18. Prasara-A.J. and Gheewala S.H. (2017). Sustainable utilization of rice husk ash from power plants: A review. *Journal of cleaner production*, 167, 1020-1028.

19. Park K.B., Kwon S.J. and Wang X.Y. (2016). Analysis of the effects of rice husk ash on the hydration of cementitious materials. *Construction and Building Materials*, 105, 196-205.

20. Sharma D.K. and Sharma R. (2018). Influence of rice husk ash and rice tiller ash along with chromate reducing agents on strength and hydration properties of Ordinary Portland Cement. *Construction and Building Materials*, 169, 843-850.

21. Eliche-Quesada D., Felipe-Sesé M.A., López-Pérez J.A. and Infantes-Molina A. (2017). Characterization and evaluation of rice husk ash and wood ash in sustainable clay matrix bricks. *Ceramics International*, 43(1), 463-475.

22. NF P94-051: Soil (1993). Investigation and testing - Determination of Atterberg's limits - Liquid limit test using Casagrande apparatus - Plastic limit test on rolled thread.

23. NF P94-093 (2014). Soils: Investigation and testing — Determination of the compaction reference values of a soil type — Standard Proctor Test — Modified Proctor Test.

24. NF P94-078 (October 2014). Soils: investigation and tests - CBR after immersion - Immediate CBR - Immediate bearing ratio - Measurement on sample compacted in CBR mould. May 1997

25. NF EN ISO 17892-4 (January 2016). Geotechnical investigation and testing - Laboratory testing of soil - Part 4: Determination of particle size distribution.

26. ISO H. (2017). Soil Quality—Determination of Dry Bulk Density. *Croatian Standards Institute: Zagreb*, Croatia.