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The Influence of the Nature of Plant and Mineral Wastes on Clay Slabs Resistance to Flexion-Traction

Ferland Ngoro-Elenga[1,2,3*], Hilaire Elenga[1,4], Timothée Nsongo[1,2,4] and Gilbert Ganga[1]
[1]Faculté des Sciences et Techniques, Université Marien Ngouabi, BP 69, Brazzaville – Congo
[2]Groupe de Recherches sur les Propriétés Physico-chimiques et Mécaniques des Matériaux et Biomatériaux, Université Marien Ngouabi, BP 69, Brazzaville – Congo
[3]Laboratoire de chimie minérale appliquée, Université Marien Ngouabi, BP 69, Brazzaville – Congo
[4]Centre de Recherches Géologiques et Minières, Congo
fngoroelenga@yahoo.fr

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Abstract

The influence of the nature of the sand (crushed and white) and of the types of wood (limba and kambala) sawdust on the resistance of baked clay slabs to flexion was analyzed in the Present study. The chemical composition of the various samples was determined by Inductively Coupled Plasma- Optic Emission Spectrometry (ICP-OES). The best resistance to flexion - traction was achieved in the sample « clay stabilized at 4% of cement blended with 4% of kambala sawdust and 10% of white sand ». The minimal resistance to flexion - traction enabled us to list these brick slabs in the T_2 category. The results achieved showed a predominance of SiO_2 in all the samples we analyzed, a predominance of Al_2O_3 in the raw clay and an important amount of K_2O in the crushed sand.

Keywords: Clay, Sawdust, Limba, Kambala, Sand, Resistance to flexion-traction, Pavers, ICP-OES.

Introduction

The present study is a contribution to the valorization of local materials and aims at using wood wastes as an alternative in the protection of the environment. The recycling of wood wastes mixed with clay can be a solution for the improvement of brick slabs physico-chemical characteristics. Many researches[1-5] have shown that the incorporation of wood wastes reduces mechanical resistance. The present study focusing on the mixing of plant wastes (Limba or kambala sawdust) and mineral (clay, white or crushed sand) aims at making resistant slabs and at establishing between the waste amount and the resistance to flexion - traction.

Materials and Methods

Materials: For the production of the brick slabs the materials used were found locally.

Here they are: i. Clay, the base material from Makoua located 570 km from Brazzaville. Geographical coordinates: N 00°00.453; E 015°35.364 at an altitude of 333m. ii. Limba and Kambala sawdust from carpentry workshops, iii. White and crushed sand respectively from Bilolo and Kombé quarries located 25 km North and 15 km South of Brazzaville. iv. Three-point flexion device to study the resistance to flexion - traction, v. ICP-OES spectrometer Icap 6500 with Thermo radial torchlight for the chemical analysis.

Methods: Chemical analysis: The chemical composition of the raw material has a significant influence on the thermal performance and the mechanical properties of the finished products. The clayey raw material AMK1 and the samples FNE1, FNE2, FNE3, FNE4, FNE5 and FNE6 were submitted to spectrometric analyses of major and minor elements by ICP-OES. i. AMK1: clayey sample, ii. FNE1:White sand sample, iii. FNE2: Crushed sand sample, iv. FNE3: AMK1 +4% kambala sawdust+4% cement+5% FNE2, v. FNE4: AMK1+4% kambala sawdust+4% cement+10% FNE2, vi. FNE5: AMK1+4% kambala sawdust + 4% cement + 15% FNE2, vii. FNE6: AMK1+4% kambala sawdust+4 % cement+10% FNE1.

Themaking of the brick slabs: The clayey material of a less than 2 mm diameter and the sand (crushed and white) of a less than 1 mm diameter were used. The brick slabs were produced in a mould of 160 mm x 40mmx40mm dimensions. The casting was made in two layers. After having compacted and scarified the first layer, the second one was cast and compacted again. The casting method used was the ASTM D 698 method described by Bel Hadj Ali I.[6].

As regard our study several types of formulations were made: i. Clay+ cement+limba sawdust, ii. Clay+crushed sand + cement+ limba sawdust, iii. Clay+ crushed sand + cement +kambala sawdust, iv. Clay+white sand+cement+limba sawdust, v. Clay+white sand + cement+kambala sawdust, vi. The baking temperatures were 950;1000;1050 and 1100 °C.

Flexion-traction test: The produced brick slabs sized 160 mm x 40 mm x40 mm were submitted to flexion-traction test. The ruptureoccured under the concentrated load by means of a machine equipped with a three-roller device. The flexion-traction device had two roller supports of 10mm diameter, 106,7mm apart, on which the brick slabs stood following a lateral casting side and a third roller of the same diameter, equidistant from the first two ones, conveying the breaking load F. The rupture by high bending load R is determined by the relation:

$$R = \frac{3FL}{2lb^2}$$

F: The bending load (N), L: The distance between the supports (mm), l = 40 mm: The width, b = 40 mm: The test tube square section edge (mm), $\frac{F}{b}$: The linear load (N/mm)

Results and Discussion

Spectrometric analysis of major and minor elements: The results of the analyses by ICP-OES presented in Table-1 show out a predominance of SiO_2 in all the analyzed samples, of Al_2O_3in the raw clay and an important amount of K_2O in the crushed sand.

The silica (SiO_2) and alumina (Al_2O_3) contents in the raw clay AMK1 and in the formulations of « stabilized clay at 4% of cement and mixed up with plant and mineral wastes » vary respectively from 52, 57 to 55,22% and from 21,38 to 25,91%. The alumina percentage in these samples being lower than 45%, these materials are not therefore refractory[7] and can be used in the making of terracotta products[8,9].

We made slabs in accordance with the formulation: clay+ limba sawdust+ 4% cement and limba sawdust contents vary from 4; 6 and 8% for different temperatures.

Figure-1 shows the variations of the resistance to flexion-traction according to the temperature.

Table-1
Chemical composition of the samples AMK1, FNE1, FNE2, FNE3, FNE4, FNE5, and FNE6 (in percentage)

	SiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	LF	Total
AMK1	55,22	25,91	2,90	<DL	0,20	0,09	<DL	0,31	1,27	<DL	13,90	99,80
FNE1	99,71	0,10	0,03	<DL	<DL	<DL	<DL	<DL	0,07	<DL	0,12	100,02
FNE2	84,05	7,14	1,60	0,02	0,39	0,34	1,21	3,26	0,34	<DL	1,38	99,73
FNE3	52,57	22,52	2,51	<DL	0,31	2,29	0,10	0,47	1,08	<DL	17,90	99,74
FNE4	54,54	21,95	2,50	<DL	0,31	2,16	0,15	0,60	1,05	<DL	17,29	100,55
FNE5	55,40	21,38	2,47	<DL	0,32	2,16	0,20	0,72	1,02	<DL	16,45	100,11
FNE6	55,04	21,57	2,36	<DL	0,28	2,18	0,04	0,30	1,04	<DL	17,12	99,94

LF: loss on fire at 1000 °C, DL: detection limit

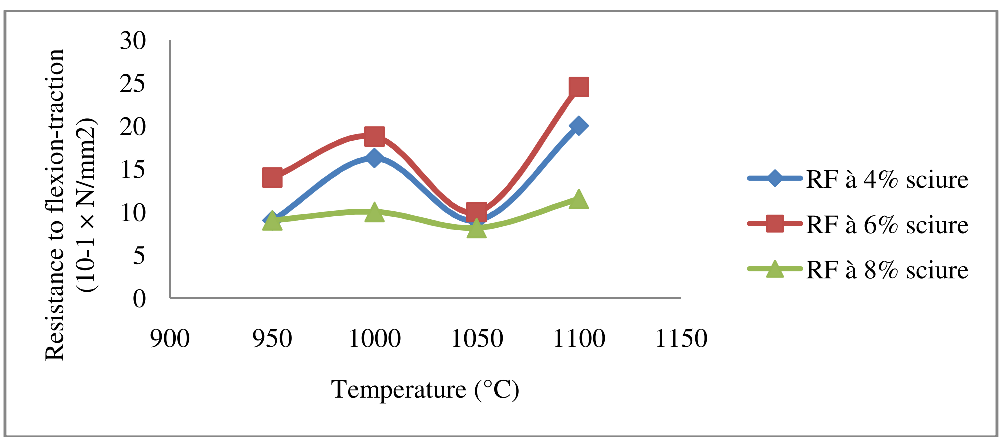

Figure-1
Variation of the resistance to flexion-traction according to the blend clay+ limba sawdust stabilized at 4% of cement

Whatever the baking temperature, the performance of the resistance to flexion is the same. It reaches a maximum and a minimum and stabilizes at 1050°C.

The influence of the nature of the sands and the wood species sawdust will be studied in the following part for the formulations « clay+4% wood sawdust+ % sand + 4% cement ».

The influence of the white and crushed sands: On the resistance to flexion-traction of the brick slabs based on 4% limba sawdust: The figure below shows out the variation of the resistance to flexion-traction according to the percentage of the nature of sand.

Whatever the nature of the sand (white or crushed), the addition of limba has no significant effect on the resistance to flexion – traction.

On the resistance to flexion - traction of the brick slabs based on 4% kambala sawdust: The results achieved are presented in Figure-3.

In Figure-3 results show that the nature of the sand has a big influence on the resistance to flexion-traction when it is mixed up with the kambala. That resistance to flexion-traction is stable at 10% of the crushed sand and has a great value in the case of the white sand.

Influence of the nature of the wood species on the resistance to flexion– traction: The Figures-4 and 5 show the influence of the nature of the wood species (limba and kambala) on the resistance to flexion - traction of the brick slabs produced.

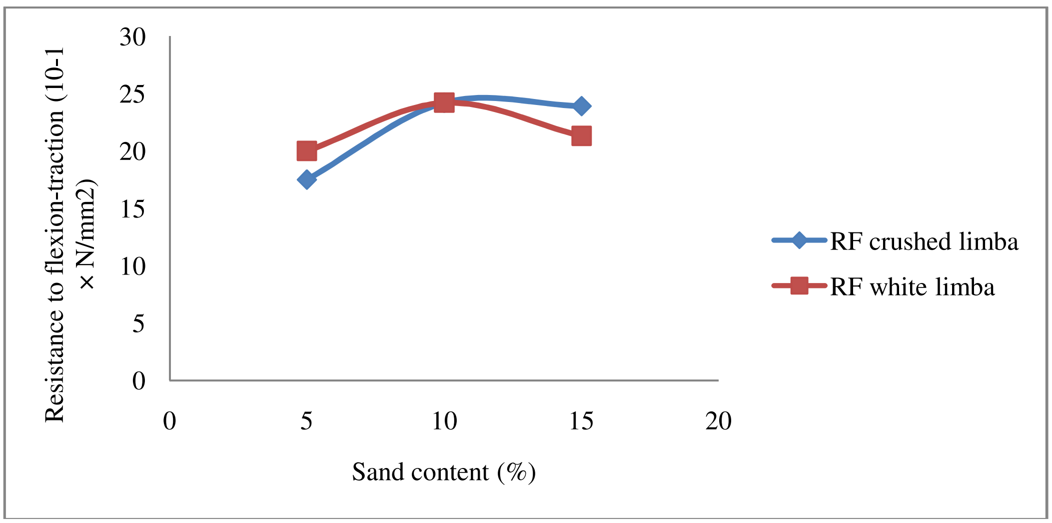

Figure-2
Variation of the resistance to flexion - traction according to the sand content

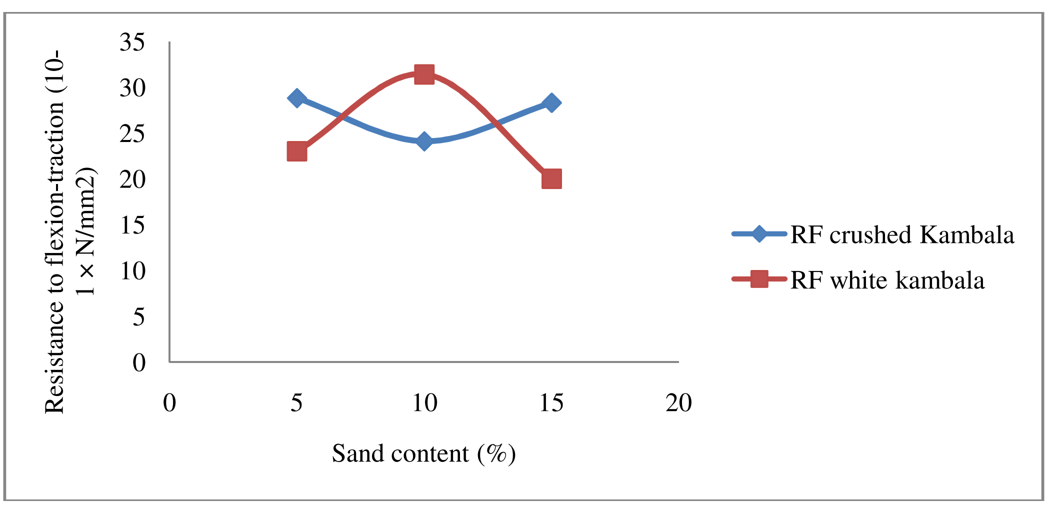

Figure-3
Variations of the resistance to flexion-traction according to the sand content

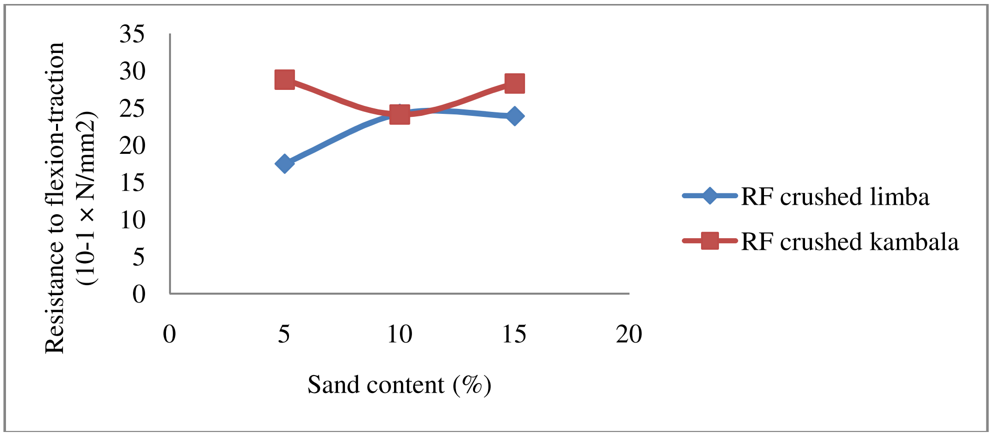

Figure-4
Influence of the wood species on the variation of the resistance to flexion - traction with crushed sand

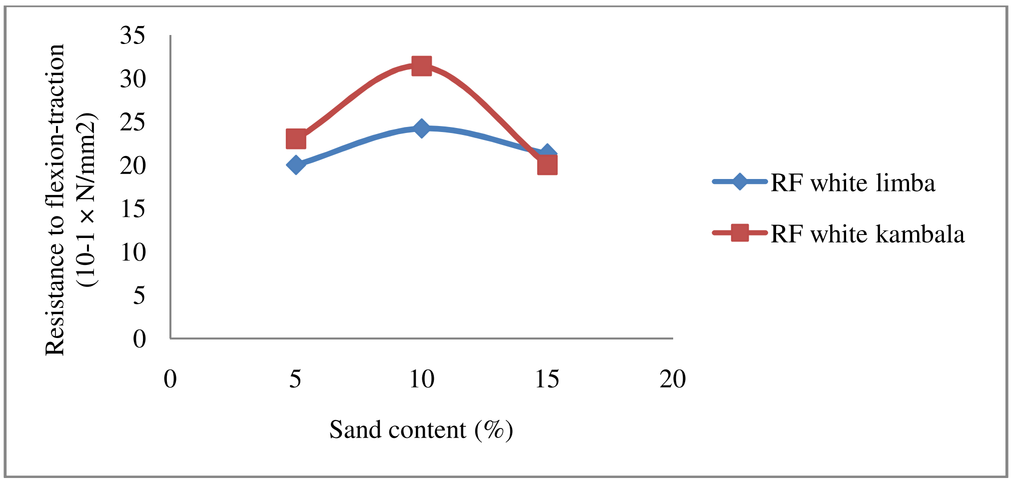

Figure-5
Influence of the wood species on the variation of the resistance to flexion - traction with white sand

These results show that the nature of the wood species has an influence on the resistance to flexion - traction in the case of the crusheds. We have also noticed that the resistance to flexion - traction reaches a maximum in the case of the white sand whatever the nature of the wood may be.

The resistance to flexion-traction in the case of the crushed sand shows a different performance according to the species of the timber. With the kambala, the resistance to flexion-traction (2,41 N/mm^2) is stable at 10% of the crushed sand whereas with the limba sawdust, the resistance to flexion - traction reaches its maximum at the same value at 10% of the same sand. That performance might be linked to the chemical reactions taking place between the different chemical elements present in the wood species and the major elements of the crushed sand notably the alkaline (Na_2O and K_2O)[10]. On the other hand, the performance of the resistance to flexion-traction is the same with the white sand whatever the wood species may be. The result is consistent with the one achieved by Chemani H. et.al[2]. That difference in the performance might be attributed to the near absence of the elements Na_2O, K_2O in the white sand. The maximum resistances to flexion-traction for the kambala (3,14 N/mm^2) and for the limba (2,42 N/mm^2) are achieved at 10% of the white sand. These values correspond respectively to the linear loads of 31, 39 N/mm and 24,19 N/mm and confirm the ones enforced by the NF EN 1344[11] and NBN EN 134[12] standards.

Conclusion

In our survey, we have studied the resistance to flexion - traction under different combinations of plant and mineral components. The results achieved show that the inclusion of plant wastes into the raw clay reduces the resistance to flexion - traction. It is possible to increase the resistance to flexion - traction by blending plant and mineral components. The best resistance to flexion has been achieved for the sample « clay stabilized at 4% of cement mixed with 4%of kambala sawdust and 10 % of white sand». Which enable us to make resistant brick slabs complying with the NF EN 1344 standard listed in Class T_2 (light traffic).

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