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Modeling of the Variation of Physical and Mechanical Properties of Compressed Earth Blocks Stabilized With Treated Bamboo Fibers

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---***ABSTRACT***---
The main objective of this research is to model the variation of the physical and mechanical properties of Compressed Earth Blocks (CEB), stabilized with bamboo fibers treated with sodium hydroxyde (NaOH) according to the cure time. To do this, two types of samples were produced: earth-fibers (A) and earth-cement-fibers (B). The cement and fiber contents in the mixes are respectively 8% and 0.75%, for a compaction stress of 15 MPa. The cure times were 21, 42, 63, and 84 days. The tests focused on the density, porosity, resistance to compression and its Young modulus, resistance to bending and its Young modulus. The results lead to the obtaining, for each property studied, of an equation of the type $y = ax^2 + bx + c$, where each property (y) varies as a function of the cure time (x); which makes it possible to obtain for a cure period (x), the trend (improvement or not) that the property studied takes; we can thus observe the following with regard to this study:

- The densities of CEB of earth-fiber formulation (A) increase, while those of earth-cement-fiber formulation (B) decrease.
- The porosities of the two groups decrease with increasing cure time.
- The compressive strengths of the two groups increase with the cure time.
- The flexural strengths increase with the curing time.
- The elasticity modules, both in compression and in flexion, increase with the cure time.

These results could make it possible to predict the general behavior of CEB, and even to choose the cure time corresponding to the desired resistance in relation to future use.

KEY WORDS: *modeling, compressed earth block, bamboo fibers, chemical treatment, physical and mechanical properties.*

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I. INTRODUCTION

Earthen construction is gaining renewed interest around the world, although neglected for a time in favor of steel and concrete (Rigassi, 1995; Namango, 2006).

The difficult economic situation as well as the environmental contingencies, have brought up to date the valorization of local materials, which justifies the multiplication of research on this material.

Indeed, several studies have shown that the performances of Compressed Earth Blocks (CEB) can be improved by stabilizers of plant origin (Abdulrahman, 2009; Taallah, Guettala, & Kriker, n.d; Sihem Chaibeddra, 2012; taallah, 2014; jehanne paulus, 2015; yaser khaled abdulrahman al-sakkaf , 2009; fabien betene ebanda, 2012; Drissa Boro, 2017) and would help reduce cracking due to shrinkage and improve the compressive strength and bending ofCEB when dried (Houben, 2006 ; mariette moevus et al, 2014; Namango, 2006).

But their hygrophilia exacerbates the problem of water absorption (taallah, 2014), thus their preconised treatment for example with sodium hydroxyde (NaOH)(Randriamalala & Zolimboahangy, n.d.; Nambinina et al, 2015).

Two types of samples were used: earth-fibers (A) and earth-cement-fibers (B). The cement and fiber contents in the mixes are 8% and 0.75% respectively. The cure times were 21, 42, 63, and 84 days.

In case the water absorption problem is solved by this chemical treatment, and because of the probable chemical interactions between NaOH and the other components of CEB,are the characteristics of the other properties preserved? (in this case, the physical and mechanical) and why not improved? how do these properties vary according to the duration of the cure time?

The present study would help predict the variation the physical and mechanical properties of Compressed Earth Blocks,with consideration of their cure time after chemical treatment, all that would allow the CEB cure time to be calibrated according to the type of future use and could even help to save time.

II. MATERIALS AND METHODS

2.1 The materials

2.1.1 The soil

The soil used comes from the Yaoundé-Nsimalen region, and its granular composition is determined by granulometric and sedimentometric analyzes, according to standards NE P 18-560 and NE P 94-057. The results of the tests are presented in the table below.

Table 1: The granularity of the soil

Sample	Type of particle			
	% of gravel Φ>2 mm	% of sand 2> Φ >0.02 mm	% of silts 0.02> Φ >0.002 mm	% of clay Φ <0.002 mm
Soil studied	1,5	57,2	20,8	20,5
Accepted values	0-40	25-80	10-25	8-30

According to the classification of the "texture triangle" of lNRA, it can be said that it is a sandy-clay-loam soil

2.1.2 Cement

Compressed Earth Blocks will be stabilized at 8% with ordinary Portland CEM II cement.

2.1.3 Water

The water used is running water from the Cameroon water authority, it complies with the requirements of the Cameroonian standard on CEB, NC 114, 2002-2006

2.1.4 Bamboo fibers (bambusa vulgaris)

a- skins removed **b- bamboo strips** **c- bamboo fibers**

Figure 1: Bamboo defibration steps

The bamboos were collected in the city of Edéa on the coast of Cameroon. Fiber extraction is carried out in the laboratory at the ENSET in Douala.

2.2 Chemical treatment of bamboo fibers

2.2.1 Preparation of solutions

In this treatment, the mass ratio S / L (solid to liquid) used is 1/5, ie 100g of fibers per 500g of solution. A solution of 4% by mass of NaOH was prepared, ie 4g ofsodium hydroxide for 85ml of water. So the concentration is: $c = n / v$ or $n = m / M$, then

$c = m / (m \times v)$

The fibers were treated with sodium hydroxide (NaOH) at 4%, the traces of which are neutralized with a solution of distilled water at 2%, then they were dried in open air for 6 h, then in an oven at 105 ° C vacuum for 24 hours and finally cut into 3cm lengths.

Figure 2: Soaking the fibers in NaOH, drying in the free area for 6 hours and then drying in an oven at 105 ° C for 24 hours.

2.3 The making of blocks

2.3.1 Preparations of the material

The blocks were manufactured at the Laboratory for the Mission for the Promotion of Local Materials (MIPROMLO) in Yaoundé, according to the Cameroonian standard NC 103, the compacting force was 15 MPa. For physical tests; density and porosity, the blocks are of dimensions 16 × 4 × 4 cm^3 for a mass of 400 g. For the mechanical tests, the blocks of format 4 × 4 × 4 cm^3 were used for the compression tests according to the standard XP 13-901 for a mass of 150g, and for the bending tests, the mold used was 16 × 4 × 4 cm^3 for 400g of material. Each test being carried out on 5 test pieces from the same sample.

Figure 3: Production of different formats of CEBat MIPROMALO - Yaoundé

III. RESULTS AND DISCUSSIONS

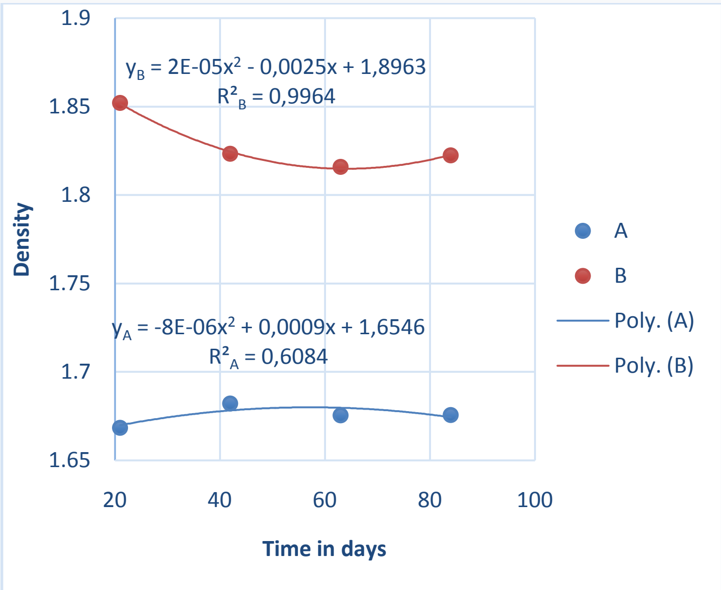

Figure 4: modeling of the variation of the density in function of the cure time

It is observed that the densities of the formulations of group (A), without cement, evolve in an increasing manner. They are (1.66g / Cm3, 1.67g / Cm3 and 1.68g / Cm3) while that of the formulations of group (B) are decreasing and are (1.85g / Cm3, 1.82g / Cm3, and 1.81 g / Cm^3); which could be due to the easier recovery of moisture from the less dense blocks of the cementless group; these results agree with those of Néhemson (Néhemson, 2015).

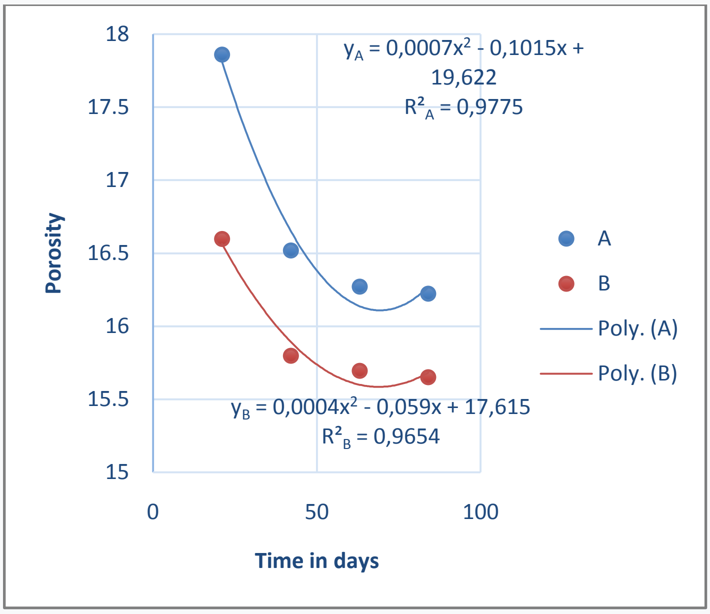

Figure 5: modeling of the variation of porosity in function of the cure time

This figure shows that the porosity curves evolve in a decreasing fashion, although the CEB stabilized in laterite - cement - fibers of group (B) are slightly less porous than those in laterite - fibers of group (A). This could be due to the fact that cement tends to reduce the amount of voids in the soil (Rigassi, 1995), but also that the adhesion between the fibers and the matrix improves with the curing time.

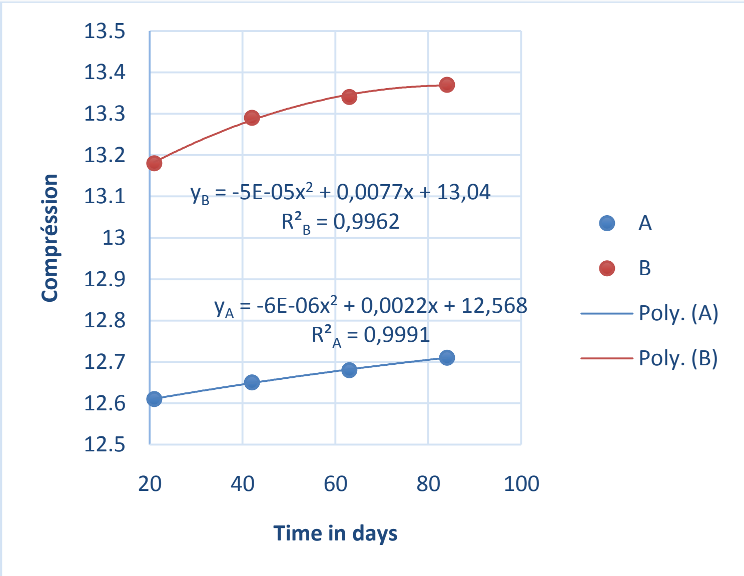

Figure 6: modeling of the variation of compressive strength in function of cure time

The figure above shows that there is an increase in compressive strengths for the two groups of BTC, which is proportional to the duration of the cure time; these results are in agreement with those of Malanda (Malanda et al, 2017) who stabilized the BTC with sugar cane molasses and bagasse fibers according to the durations of 14 days 21 days and 28 days, and those of Ouedrago (Ouedraogo et al, 2015) on cement + paper stabilized BTCs with durations of 1 month, 2 months and 3 months.

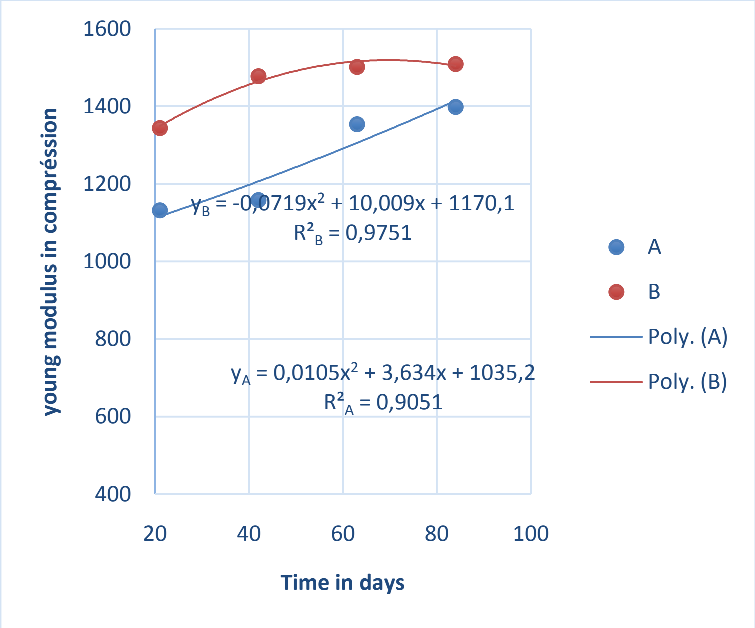

Figure 7: modeling of the variation of young modulus in compression in function of cure time

This figure indicates that the value of the longitudinal elastic modulus in compression increases with increasing cure time.

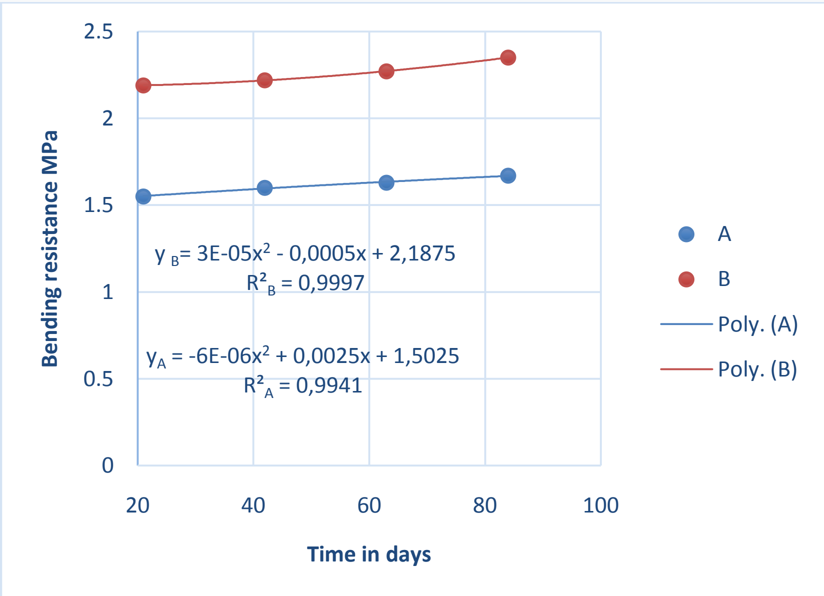

Figure 8: modeling of the variation of the bending resistancein function of the curing time

It is observed that the flexural strengths increase with the curing time. The cementless specimens are 1.55MPa to 1.67MPa and 2.19MPa to 2.35MPa for the CEB of group B with cement, results which are in agreement with those of Nambinina (Nambinina et al, 2015) who have worked with BTC stabilized with bambusa vulgaris fibers treated with NaOH at 2% concentration for a fiber content of 5%, and carried out bending tests on test tubes of 28 and 60 days of cure.

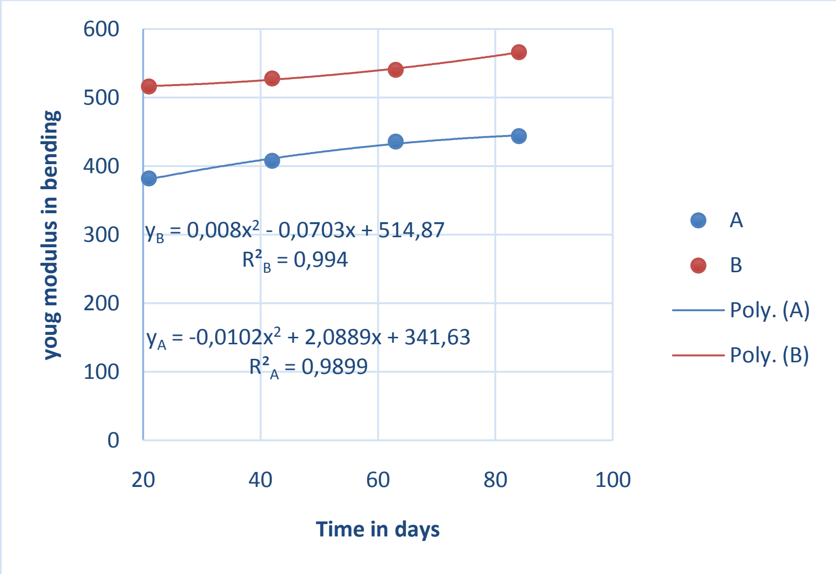

Figure 9: modeling of the variation of young's modulus in bending in function of the cure time

The figure above indicates that the Young's modulus of the samples of the two groups (A) and (B) in flexion are increasing with respect to the number of cure days, and that the earth-cement-fiber specimens are more resistant than those in earth-fibers.

IV. CONCLUSION

The objective of this study was to model the variation in the physical and mechanical properties of compressed earth blocks stabilized with bamboo fibers treated with sodium hydroxyde, compared to the curing time.

According to the results,conclusion can be made that the equation obtained,$y = ax^2 + bx + c$, were each property (y) varies as a function of the cure time (x), makes it possible to predict the value, the evolution that the property studied will take, according to a given cure time, and thus, makes it possible to choose a given cure time according to the use and the resistance needed specifically.

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