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Study of the Influence of Corn Stalks Fibers on the Characteristics of Compressed Earth Bricks

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ABSTRACT

The objective of the present study is to determine the optimal dosage of corn stalks fibers to obtain good resistance of compressed earth bricks. After determining the properties of the fibers and the clay soil, a volume variation of the fibers is carried out in relation to the mass of the mixture for making bricks of dimensions 10.5x22x6.5 cm^3 which are stored in a sheltered place. On these bricks, the densities and compressive strength are determined at 28 days of age. Both poorly graded and well graded fibers are used in this study.
From this study it appears that the fibers are light and that the earth is not very plastic, containing no humus. The density of the bricks decreases and the resistance increases with the increase in the fiber content. Resistance is better with well graded fibers.

Keywords: corn stalks, compressive strength, clay soil, fibers.

INTRODUCTION

The valorization of local achievements remains, in the subconscious of man, one of the major forces in his quest to tame the universe. It will then be easier and easier to appropriate and use locally available resources if a specific need requires it.

Also, one of the essential challenges of human beings being the establishment of a decent habitat, this quest for well-being has shaped human life throughout the centuries. Thus, composite materials have been used since the dawn of time, especially in the field of construction, resulting from mixtures of locally available materials (earth for example) with other materials of mineral origin (limestone and other) or vegetable (straw, wood in various shapes, palm nut shavings, etc.) [3-4]. As the materials thus obtained are used, the constant search for efficiency pushes the development of new forms and formulas of use [5-11].

Earth concrete (a mixture of earth and water in suitable proportions) is one of the oldest and most used materials in construction, and especially today, in rural areas. Used in a sustainable manner, earth concrete remains an abundant and local resource that is easily recyclable. Raw earth materials provide inertia and exceptional humidity regulation. However, it offers limits because of its great shrinkage (appearance of cracks limiting its tensile strength) and its aptitude for excessive creep. This material therefore has limits in its use. And to compensate for these inadequacies, the recent development of composite products, reinforced with

fibers of natural (plant), artificial and synthetic origin in the construction sectors, has offered the possibility of correcting these shortcomings [6- 9].

In the south of Togo, corn cultivation takes place in two seasons: the long season (April to June) and the short season (September to November). However, it is clear that after the harvest, no other use is made of plant debris, represented mainly by corn stalks. These stalks are either burned (generally between the high season and the short season where the stalks do not have enough time to rot naturally in the fields), or left in the fields (between the short season and the long season where there is a possibility that the stalks will rot in the fields). In the case of burning, it appears obvious that this process increases greenhouse gases. In all cases, it is necessary to find an alternative to the use of corn stalks after harvest.

In this article, it is envisaged to cut the corn stalks into fibers and incorporate them into the soil-water mixture. The objective of this work is therefore to study the effect of corn stalks fibers on the mechanical characteristics of compressed earth bricks.

MATERIALS & METHODS

The materials that will be used as part of the experiments are clay soil extracted on a construction site in Avédji, a district of the capital Lomé, corn stalks recovered in an experimental field in Badja, a village located 44 km north of Lomé. The clayey soil is taken from a stratigraphic depth of 70cm to 100cm after stripping the plant layer to a thickness of 30cm. It is a low plastic silt containing no humus whose characteristics are presented in Table 1. The grain size curve of the clay soil is presented in Figure 1.

Table 1: Characteristics of the materials used

Characteristics		Clay soil	Corn stalks fibers
Apparent density		1.24	0.087
Clay content (%)		31%	-
Sand content (%)		69%	-
Atterberg limits	Liquidity limit	25	-
	Plasticity limit	12.53	-
	Plasticity index	12.47	-
Absorption rate (%)		-	193,60% in one minute

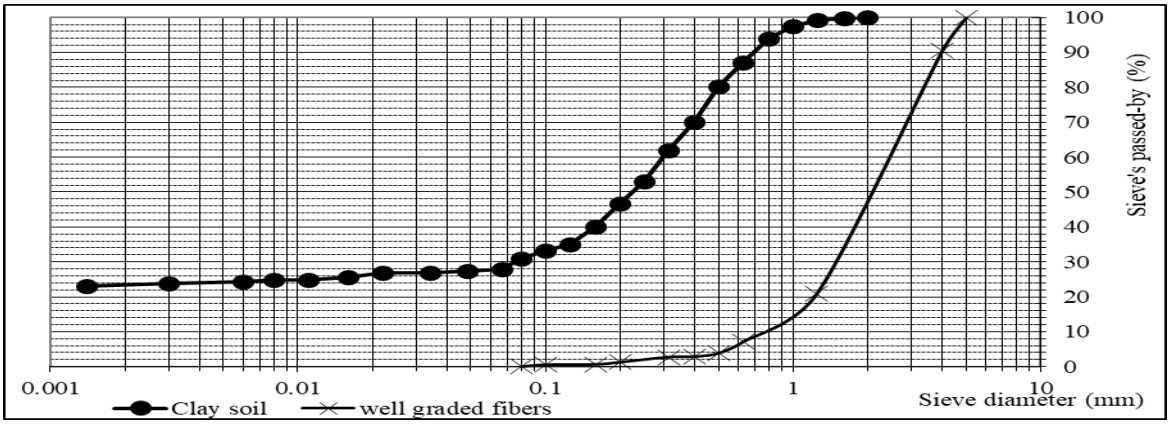

Figure 1: Particle size curve of the materials used

The corn stalks are manually stripped of leaves and roots. These stalks thus collected are crushed in a crusher (figure 2). Two types of fibers come from the crusher: poorly graded coarse fibers (figure 3) and well graded fibers with particle sizes ranging between 0.09 and 5mm (figure 4). These fibers are very hygroscopic in the first minute and light regardless of the type (Table 1). The particle size curve of the well graded fibers is shown in Figure 1.

Figure 2: Corn stalk crusher

Figure 3: Poorly graded fibers

Figure 4: Well graded fibers

The effect of the addition of corn stalks fibers on the characteristics of earth concrete is studied by varying the volume of corn stalks fibers relative to that of the mixture in a range from 12 to 28% to step of 4%. From these mixtures, bricks measuring 10.5cmX22cmX6.5cm are made. These bricks are obtained by compressing the earth-fiber mixture using a Testaram press. These bricks are unmolded the same day and kept in an enclosure at room temperature until the weight becomes constant (this constancy is established when the variation in mass of each sample is less than 0.1% between two weighings spaced by 24 hours). On these bricks the following tests are carried out:

- density;
- compressive strength according to standard EN 772.

The strength is measured by crushing on the large side with dimensions 22X10.5cm^2 and the medium side with dimensions 22X6.5cm^2.

RESULTS & DISCUSSION

Table 2 presents the results of measuring the density and compressive strength of the bricks measured at the 28th day of age, the age at which water loss stabilizes.

Table 2: Results of the different tests

Corn stalk fibers rate (%)	Bricks with well graded fibers			Bricks with poorly graded fibers		
	Density	Compressive strength on the medium side of the brick (MPa)	Compressive strength on the large side of the brick (MPa)	Density	Compressive strength on the medium face of the brick (MPa)	Compressive strength on the large face of the brick (MPa)
0	1.948	0.877	1.802	1.948	0.877	1.802
12	1.681	0.534	1.429	1.700	0.484	1.730
16	1.764	0.767	2.231	1.680	0.511	1.684
20	1.679	0.656	2.354	1.726	0.690	2.255
24	1.652	0.668	2.843	1.674	0.556	2.321
28	1.645	0.651	3.473	1.556	0.512	2.813

Figure 5 shows the evolution of the density of the bricks as a function of the fibers rate for well graded fibers and poorly graded fibers.

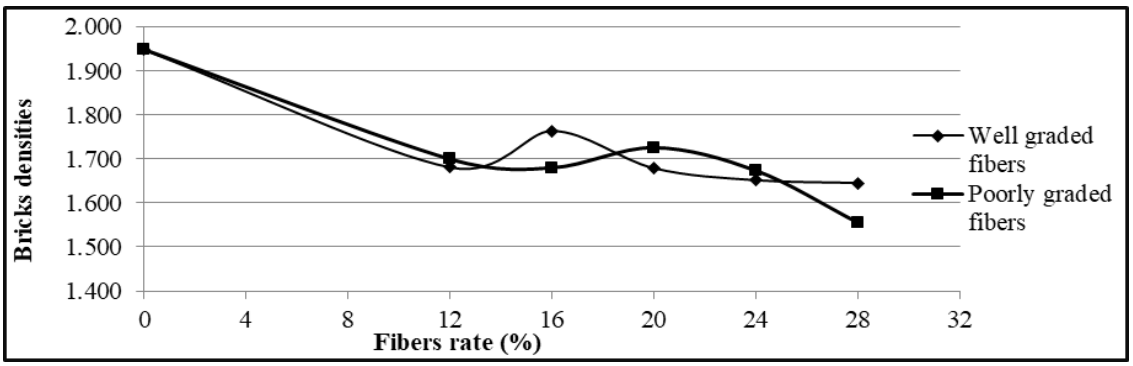

Figure 5: Bricks density evolution according to fibers rate

We notice that the density decreases with the increase in the fiber rate. This trend is observed for both well graded and poorly graded fibers. This is explained by the density of corn stalks fibers which are lighter than clay soil. An increase in the fiber rate corresponds to a reduction in the quantity of clay soil and therefore a reduction in the density of the bricks. This reduction is on average more significant at the level of bricks dosed with poorly graded fibers. This can be explained by the particle size of these fibers which also contain a little more void.

Figure 6, from Table 2, presents the variation in compressive strengths.

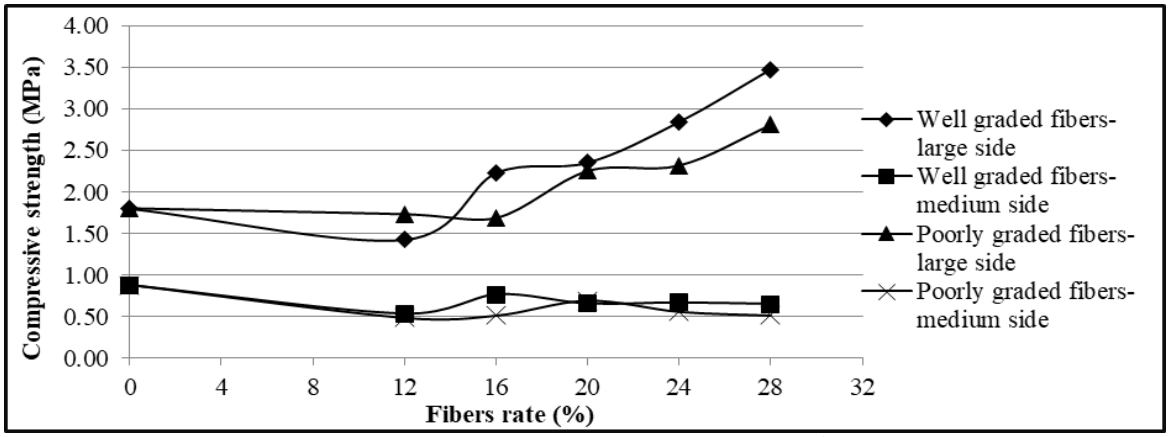

Figure 6: Bricks compressive strength evolution according to fibers rate

From Figure 6, we note an increase in strength as a function of the increase in the fibers rate in the concrete, ranging from a value of 1.429 MPa to 3.473 MPa for the large side with well graded fibers. The same observation, on the same side, is made for poorly graded fibers where the strength increases from 1.730 MPa to 2.813 MPa. Compared to the control bricks, which therefore do not contain fibers, the compressive strength on the same side gives a value of 1.802 MPa. We then note better strength with the well graded fibers with an increase of around 192.78% compared to the control brick and for a mixture composed of 72% clay soil and 28% corn stalks fibers. It should be noted that, beyond this 28% fiber mixture, it was difficult to effectively mold the specimens to be subjected to the various tests. We also note that the strengths obtained with well graded fibers are the best, reflecting the effect of the particle size of the fibers on the compressive strength. This trend would be due to the good distribution of these fibers, thus having few voids and giving denser and more compact bricks.

Conversely, the strengths are quite low on the medium sides, whatever the nature of the fiber used (well graded or poorly graded). This is due to the small contact surface offered in this direction. This fact then reinforces the observations of constructions made with the workers who lay the bricks oriented in this direction, often in double skins to increase the resistance of the walls.

CONCLUSION

The objective of this research is to study the influence of corn stalks fibers on the behavior of compressed earth bricks. The results obtained allow us to say that:

- corn stalks fibers can be incorporated into an earth concrete matrix;
- the grain size of the fibers influences the behavior of the mixtures;
- strength is better when the bricks are crushed along the large side and dosed with well graded fibers;
- the best mechanical compressive strength on 10.5*22*6.5 cm3 bricks is 3.473 MPa on the large side and for the well graded fibers with an incorporation rate of 28% compared to a strength of 1.802 MPa for fiber-free brick.

Declaration by Authors
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