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Int. J. Cur. Tr. Res (2015)4 (1):109-114

ISSN:**2278-8042**
www.injctr.com

Mechanical characterization of an eco-material: Case of compress earth bloc (CEB) with addition of cotton waste

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Received: 25 November, 2015/ Accepted: 15December 2015/ Published online 26 December 2015.

Abstract

This work studies the prospect of incorporation of cotton waste in the CEB. This study, prompted by the desire to reduce the cost of construction as well as reducing the weight of CEB incorporating their low density materials such as cotton waste, fits well with the policy of promotion and development of local building materials Benin. This work is focused on the determination of mechanical properties of composite: soil–cement-waste cotton material. First, we characterized the land of study. Characterization tests in the laboratory were used to classify the material according to the classification of the standard NF P 11 300 and the GTR. These tests, our study are a land of clay - sand mixture, which contains a high proportion of fines. Its plasticity index is adequate for achieving the CEB. Then, with the addition of CEB cotton waste percentages 10%, 20 %, 30 %, 40% and 50% were tested for simple compression, 3-point bending, abrasion and water absorption capillarity. The incorporation rate which provide the best mechanical resistance levels are 10 % and 20 %. For these rates, unconfined compressive strength at 21 days of age blocks are respectively 3.30 MPa and 3.01 MPa, their flexural strength three points are respectively 0.76 MPa and 0.70 MPa. Moreover, the comparative study between the test results for the CEB with the addition of cotton waste and those without adding simply stabilized cement revealed that CEB with the addition of cotton waste to 21 days of age are slightly less durable and less porous than simply stabilized. The resistance values obtained allows us to affirm that the use of CEB with the addition of cotton waste is possible in light constructions.

Keywords: CEB, mechanical properties, cotton waste, simple compression, three-point bending.

Introduction

For thousands of years that men build cities, the mud was and is, through historical and popular traditions, one of the main construction materials used on our planet. Thus more than a third of the world's population now lives in earthen habitats at lower cost with good thermal comfort (Ottou, 1987). From tradition to build on land, there are very many construction methods with infinite variations that reflect the identity of places and cultures. Mainly we know twelve modes of use of the land under construction. Of these, seven (adobe, adobe, clay-straw, mud, shaping, cob, compressed earth blocks) (Quenum, 1976) are very commonly used and are the major technical genres; but only the technology of compressed earth blocks will be amply investigated in this study. The bricks in general, exhibit certain properties which justify their use for the thermal insulation of buildings. And improve these properties, the land was sometimes supplemented with mineral or

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vegetable or even animal materials (Romaric, 2012; Largum, 2012). In addition, the use of these bricks with additions (mineral, vegetable or animal) would solve environmental problems, since the waste will not be burnt but associated with the construction.

Materials and Methods

Materials

The sample material which served as basic element for our study is a bar Earth composite cement + + + cotton waste water in well studied proportions (Rigassi, 1994). Land The bar land used is from the Bakhita career in the town of Abomey Calavi (region located in southern Benin in the Littoral department). The Portland cement CPJ 35 cement was used for this study because of its relatively rapid curing (Ghomari, 2006). The cotton waste Cotton waste from ginneries and cotton fields pendant periods of crops were used. Sensitive to water but good insulator, it keeps its properties of thermal insulation, acoustic and mechanical in time. The betonniere and balances a mini-mixer motorized wheelbarrow which tank has a volume of 130 L and kneading capacity 105 L electric motor was used for the mixtures of the composite materials. Two type scales SARTORIUS (0.01g precision) and ROBERVAL, with an extension of the respective weighing 5000 g and 20000 g, and are used for weighing the various inputs forming the mixture.
A capacity 500mL beaker was used to determine the volume of water entering the composition of mixtures for manufacture of blocks, Tap water supplied by the National Society of Benin's waters was used. HYDRAULIC PRESS This is a mechanical press-type SATEC MKIII 60TVI, equipped with a digital display control console. It was used for resistance testing in three-point bending and compression.

Methods

Physical characterization of the bar of earth

In this part of the study, we characterized the bar earth quarries Bakhita. Thus, we determined its physical properties such as moisture content, particle size, bulk density, Atterberg limits, the equivalent of sand, Proctor optimum (ORAF, 1998).

Cement

The Portland cement used was kept in the best conditions of temperature and humidity.

Cotton waste

Cotton waste from ginneries and cotton fields used pendants were obtained after cutting into thin fibers from 10 to 20mm. The bulk density of this cotton waste is about 79 kg / m3 which is relatively smaller than the densities of the clay and the earth bar.

Packaging of samples with CEB of incorporation of cotton waste

Production cycle of compressed earth blocks Bakhita extracted from the bar earth career, the land intended for the manufacture of CEB is spread in thin layers the air for seven days. Is freed plant debris and clumps with a sieve whose mesh width is 10 mm. Then determines the average water content of the bar of land in order to calculate the volume of water necessary to the composite mixture. Then, based on the mass composition, it is the mixture which is introduced into a press for making the CEB (Rigassi, 1994).

Volume of produced water

It gradually brings the mixing water to bring the mortar to the optimum moisture content (Xop) of the earth determine from Proctor. Thus, the volume of water in liters to be added is given by the following formula::

$$Veau = \frac{(\mathrm{TEO}-\mathrm{wth}).\mathrm{Mth}}{100+\mathrm{wth}} \quad \text{(Zéphérin,2012)}$$

The production of CEB specimens was made according to the following major steps: extraction, preparation, mixing, pressing, curing and storage. Mass Composition specimens CEB with polystyrene added

Table 1Composition mass mixtures

	LATERITE	CEMENT	COTTON WASTE
CEB10 10%	80%	10%	10%
CEB10 20%	70%	10%	20%
CEB10 30%	60%	10%	30%
CEB10 40%	50%	10%	40%
CEB10 50%	40%	10%	50%

This table provides information on the mass composition of different mixtures (Earth + cotton waste Cement + Water) made for sampling .

Cure and conservation block

The room in which the blocks are made is well insulated from sunlight and moist cure specimens after preparation was made in a transparent polyester cover for 7 days. This done, we go to the dry cure (short) in the room without any damage on the blocks.

Characterization mechanics CEB with addition of cotton waste

As part of this work, the mechanical characteristics are studied. The three point bending strength, compression, abrasion resistance, and resistance to water uptake by capillarity. For the three points bending strength test, the block of the support face is placed on two spaced tubes of 20 cm and perpendicular to the block length. In the middle of the upper face, a third parallel to the first tube is installed. We submit the sample of CEB to a constant load and note the load at break. The flexural strength of the blocks is given by the formula.

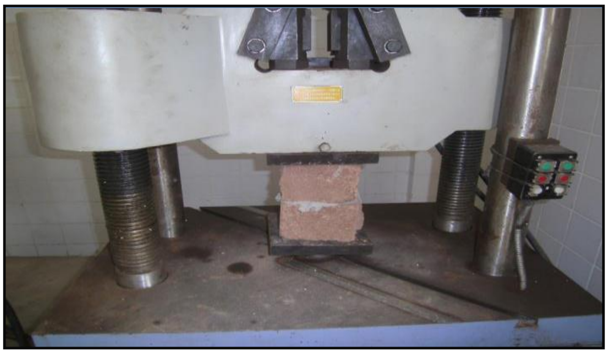
$$\square = \frac{(1.5\times E\times P)}{(l\times h^2)} \qquad (2)$$

Figure A flexural strength test three points on BT

For compressive strength test, the procedure adopted is the compression of two half-blocks of CEB from the 3 point bending test (Clément, 2012). These two half-blocks after the 3-point flexural break are not always regular. Thus, the retainer section for the calculation is the average of the lower and upper surfaces of the two half-blocks. The compressive strength is found by the formula.

$$\mathbf{fb\,sec} = \mathbf{10} \times \frac{F}{S} \qquad (3)$$

Figure B compressive strength test on CEB



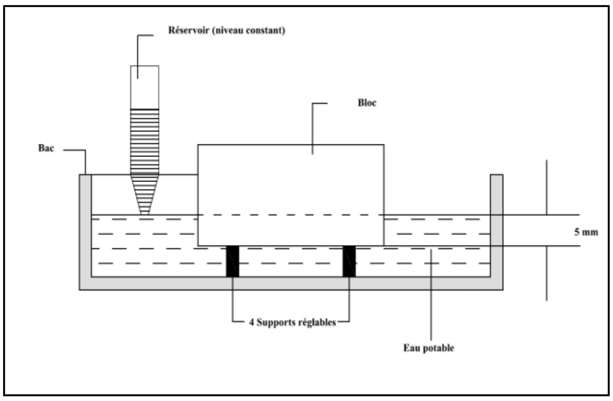
To achieve the abrasion resistance test, the facing side of the CEB is brushed with a wire brush on which has been properly secured in its center a mass of 3kg. Brushing is done because of a round trip per second for 1 minute (Clément, 2012). At the end of brushing elements during brushing posted are cleaned and weighed. The abrasion coefficient (Ca) expresses the ratio of the brushed surface S (in cm²) by the mass of loose material during brushing.

$$Ca = \frac{S}{m1 - m2} \quad \text{(standards ARS 674, 675, 676, 677)} \quad (4)$$

Figure C Abrasion resistance test

To test water absorption by capillary action, determining the dry weights of the CEB is then introduced into a water tank so as to be immersed 5 mm block height (Clément, 2012).

Figure 1 Apparatus for water absorption test by capillarity of CEB



After 10 minutes, the blocks are removed from the water and wiped with a damp cloth. And weighed wet mass block during the test. The water absorption coefficient Cb of each block is expressed by the formula: (CDI et al., 1996).

$$C_b = \frac{100\times(mh - md)}{S\sqrt{t}} \quad \text{(Standards ARS 674,675, 676, 677)} \quad (5)$$

Results and Discussion

Characterization of the bar earth Bakhita

The water content

The water content of the bar land of our study is about 8.37%. Particle size analysis by sieving. The percentage of fine earth in the bar of our study is 44.88%. As the maximum grain diameter is 2mm. Referring to the NF P 11-300 classification standard and GTR 92 (Earthworks Road Guide), the bar land of our study is class A; so it's a fine soil. Indeed, this classification brings together in class A, soils having a percentage of fines and a maximum diameter >35mm < 50mm.

Atterberg Limits

The liquid limit our bar earth is 65.028% and plasticity limit is 34.98%. The value of the consistency index is Ic=1,88.
- The plasticity index of our land is 30,098 (25<Ip=30,098<40); this land is plastic after the NF P 11-300 classification standard and GTR 92 (Earthworks Road Guide) .It is precisely under class A3: clay and marl clay, highly plastic silt).
- modified Proctor test. The optimum water content obtained from the modified Proctor test is Wopt=12,64% while the natural water content Wn of our bar earth is equal to 8.37%. It is found that,0,7 Wopt = 8,848 > Wn. Ic = > 1.88 1.3. So according to standard NFP 11-300 and GTR, the material is very dry. This information complements the conclusion in paragraph 5.1.1, and we can say that the earth is of type "clay and marl clays, silts very dry." ¬ The sand equivalent The bar has an equivalent land of sand equal to 15% which is <50% we can conclude that the land of our study is to sandy - clay type. ¬ The bulk density. The bulk density of our earth bar is 1.11 Mg / m3. This value meets the test standard as it is between 1.05 Mg / m3 and 3.00Mg / m3. *Mechanical Characterization of CEB with added, cotton waste. Evolution of mechanical strength depending on the age.*

Figure 2 Evolution of compressive strengths of CEB with additions cotton waste

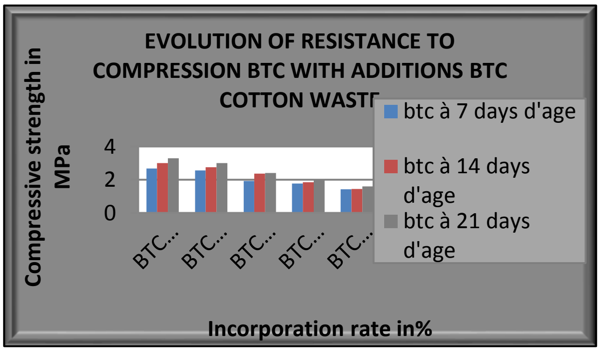


Figure 3 Evolution of the flexural strength of three points with additions CEB cotton waste

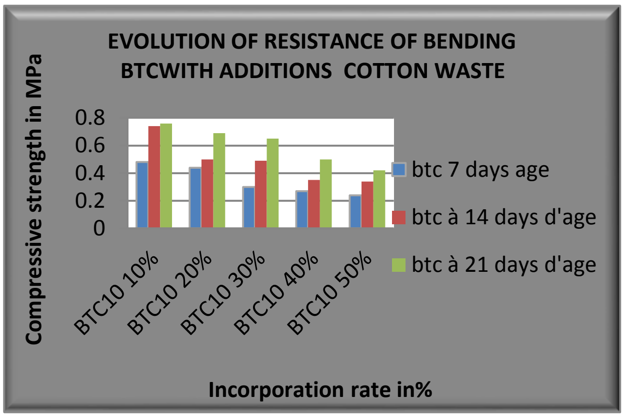


Figure No. 4 Evolution of the absorption coefficients of CEB with additions cotton waste

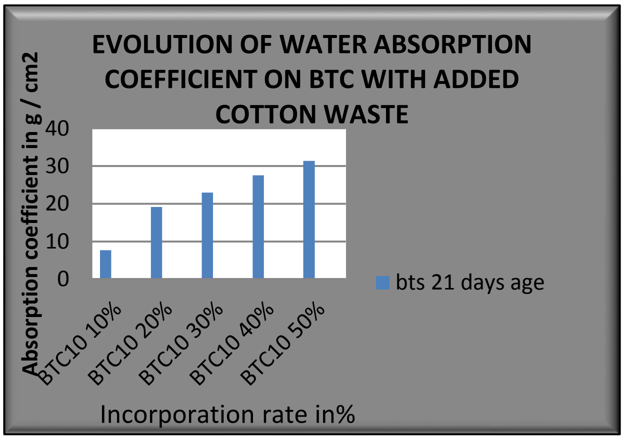
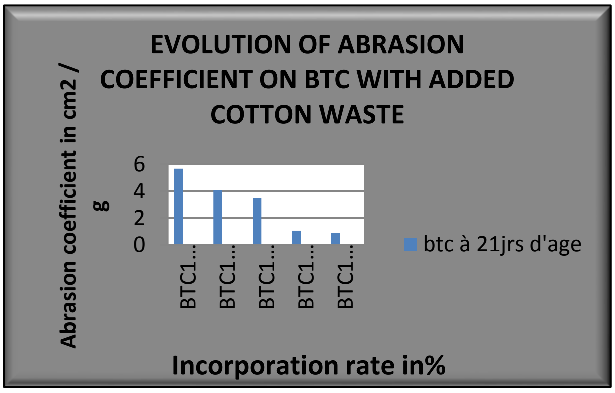


Figure 5 Evolution of the abrasion resistance of the CEB with additions cotton waste



These evolution curves provide information about the fact that the flexural strength and compressive strength of the CEB with additions cotton waste is related to the rate of incorporation and age of the blocks. The higher cotton waste is increasing the resistance decreases (Largum, 2012). Also, over the age of blocks increases, the resistances of the blocks with added augmente.les CEB cotton waste have adequate strength in bending and compression from 14 days of age and offer better compression strength to 21 days of age. Furthermore, the coefficient of water absorption of the CEB with additions cotton waste is related to the waste incorporation rate. The higher cotton waste is increasing the absorption rate increases. Finally, the abrasion resistance of the CEB with additions cotton waste is related to the waste incorporation rate. More rate increases cotton waste more the abrasion coefficient decreases (Clement, 2012). Thus, we will use the CEB with cotton waste addition to 21 days of age to highlight the influence of the incorporation rate of cotton waste on mechanical strengths of CEB. Influence of the incorporation rate of the mechanical strength of the CEB with additions cotton waste.

Figure 6 Influence of cotton waste rate on the compressive strength of CEB

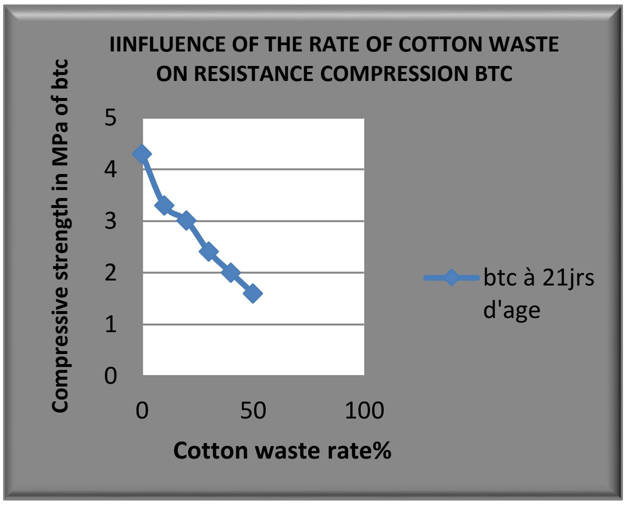
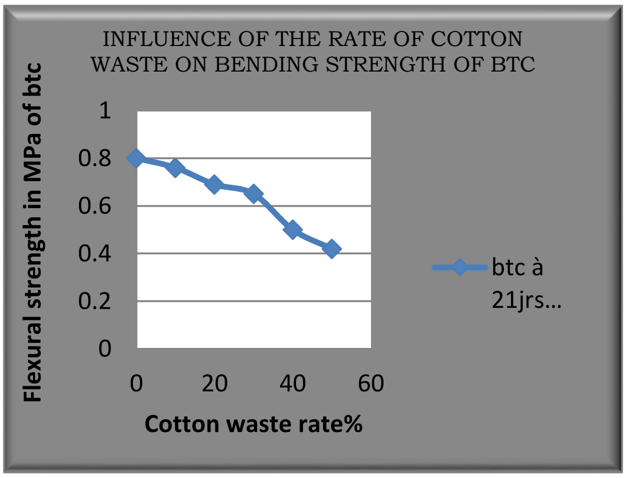


Figure 7 Influence of cotton waste rate on the flexural strength of CEB



To hight the influence of cotton waste, on the mechanical properties of our CEB, we consider only. Those properties obtained after 2 1 days of age. And with reference to the above curves, we see that most cotton waste increases, the compressive strengths, to the three-point bending and abrasion (Largum, 2012) resistance decrease. As regards the coefficient of water absorption, it increases with the cotton waste rate. Resulting in that, the cotton with excellent absorbency.

Figure 8 Influence of cotton waste rate on the absorption coefficient of CEB

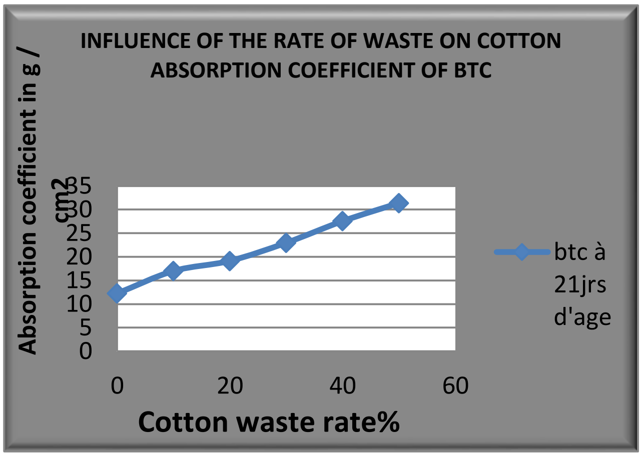
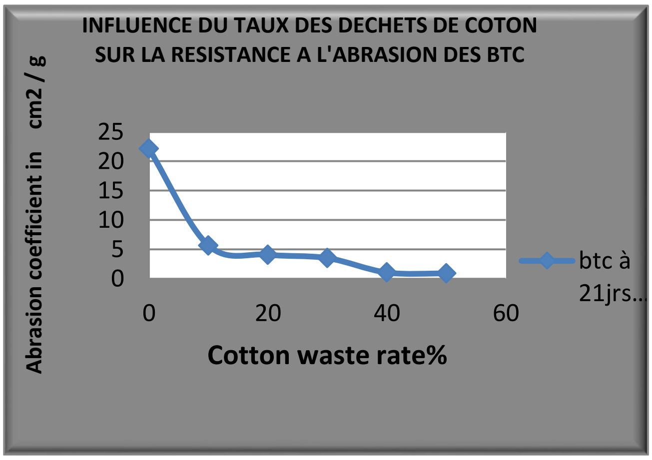


Figure 9 Influence of cotton waste rates on the abrasion coefficient of CEB



Conclusion

The results of this study, it appears that the addition of cotton waste CEB is favorable for the mechanical properties. The use of polystyrene with CEB addition is possible in lightweight constructions. cotton waste increases the flexural strength of compressed earth blocks (CEB) as herbs traditionally used in the molding of adobe block is the case of rice balls in some parts of Africa the West.

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Nomenclature

symbols:

Latin letters:

E : Distance between tubes, cm U Maximum load supported by both dismissed blocks kN

F ': compressive strength test pieces, MN / m²

H : Height of the specimens, cm

L :The width of CEB specimens cm

M :Ground matter, kg

P : breaking load, kN three-point bending.

S : Average area of test faces cm²

V : Volume, m3

X: Moisture,

Greek letters:

φ : Density, kg m -3

Clue : has apparent

b test