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RESEARCH ARTICLE

COMPARATIVE STUDY OF THE MECHANICAL CHARACTERISTICS OF STABILIZED COMPRESSED EARTH BLOCKS: CASE OF STABILIZATION WITH LIME AND CEMENT

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Abstract

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This article presents the preliminary results of the comparative study of mechanical characteristics of compressed earth blocks stabilized with cement and lime. This study is relevant to the study of the possibility of replacing cement with lime in the techniques for stabilizing compressed earth blocks. This study, prompted by the concern to reduce the cost of construction, fits well with the policy of promotion and valorization of local construction materials in Benin. This work focuses on the comparative study of the mechanical characteristics of compressed earth blocks stabilized with cement and lime. In this study, we were interested in ferralitic soils called "terre de barre" wich we will name "bar soil" stabilized with cement and lime. Identification tests in the laboratory made it possible to classify the material according to the classification of the NF P 11 300 standard and the GTR. Calavi bar soil contains a high proportion of fine particles. It is a sand-clay mixture. Its plasticity index shows that it is a material that can be used in the making of stabilized earth blocks. The Compressed Earth Block (CEB) stabilized with cement and lime at the same percentage, namely 6-8 and 10%, underwent simple compression tests, three-point bending, abrasion and water absorption by capillary action. The comparative study of the results revealed that CEB stabilized with cement are more resistant and less porous than those stabilized with lime.

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Introduction:-

Nomenclature

Symbols:

CEB: Compressed Earth Block
SCB : Société des Ciments du Bénin
OBRGM : Office Béninois de Recherches Géologiques et Minières
GTR : Guide desTerrassement Routier
Volume of water in liters
Optimum water content obtained in the Proctor test
Water content of wet sample
Mass of wet soil

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E: spacing between two tubes in cm
P: the breaking load in KN
l: width of the blocks in cm
h: height of the blocks in cm

Compressive strength of blocks in MPa or in MN/m² or in N/mm²
F: Maximum load supported by the two half-blocks in kilo Newtons ;
S: Average surface area of the test faces in cm² ;
(: Mass of water, in grams, absorbed by the block during the test;
t: block immersion time, in minutes.

1- Material-Materials:

The sample material which served as the basic element for our study is a composite of bar earth + cement + water and bar earth + lime + water, in well-studied proportions.

1.1- Soil

The bar earth used comes from the Bakhita quarries in the commune of Calavi (region located in southern BENIN in the Littorale Department).

Pre-sieving was necessary given the presence of clods of earth in the sample.

1.2-Cement

We keep the study cement in better conditions so that it retains these characteristics. We also chose CPJ 35 cement produced by the Benin cement company (SCB) because it is well suited for masonry work.

1.3-Lime

The lime used for the stabilization of the CEB is Golden Horse quicklime produced by Spain given the unavailability of lime produced in Benin by OBRGM. It has a mass of 25kg and has a particle size ≥ 10mm. Before its use we passed the lime through the Los Angeles machine to bring out the powdered lime after sieving

1.4-Mechanical Press

It is a TERSTARAM APPRO-TECHNO type mechanical press with mono compaction with the movable lower piston. The test tubes made are parallelepiped with dimensions of 29 cm x 14 cm x 10 cm.

2-Methods:-

2.1. Physical Characterization of Bar Soil

In this part of the study, we were interested in characterizing the bar soil of the Bakita quarries. This characterization consists of determining physical properties such as; water content, particle size, Atterberg limits, bulk density, sand equivalent, actual density of the pre-dried product (specific weight) and particle size by sedimentation.

2.2. Confection of Specimens (CEB)

2.2.1. Compressed earth production cycle

Pretreatment by sieving, using a 10 mm mesh sieve, of the bar soil intended for making the CEBs was necessary because of the presence of clods of earth in the soil samples, which are spread in thin layers on the outdoors for seven (7) days, to ensure natural drying. We then determine the average water content of the earth in order to deduce the volume of water necessary for the composite mixture. Likewise, the masses of the different components used in the preparation of the dry mixture were obtained. An adequate mixture of bar soil + Cement + Water and bar soil + lime + Water was made, and introduced into a press to make the CEB. The CEB produced are stabilized at 6%, 8%, 10% binder [1].

2.2.2. Production water volume

The mixing water is gradually added until the mortar is brought to the optimum water content (X op) of the earth determined by the Proctor test. Thus the volume of water in liters to add is given by the following formula:
(1)

The production of the CEB test pieces was carried out following the following main stages: extraction, preparation, mixing, pressing, curing and storage [2].

2.2.3. Cure and conservation of blocks

The room in which the blocks are manufactured is well isolated from solar radiation and the cure was carried out under a tarpaulin. This precaution allowed after the 7th day of conservation to extend the cure uncovered in the room without there being any damage to the blocks [2].

2.3. Mechanical Characterization of CEB

As part of this study we were interested in the classic characteristics which are: resistance in three-points bending, in compression, abrasion and water absorption by capillarity [3].

For the three-points bending resistance test, the support face of the block is placed on two tubes spaced 20 cm apart and perpendicular to the length of the block, in the middle of the upper face, a third tube parallel to the first is installed. We subject the CEB specimen to a constant load and record the load at break. The bending strength of the blocks was determined by the formula:

(2)

Photo 1:- Bending strength test (three points) on CEB.

The procedure adopted for the compression test is compression on two half CEBs resulting from the three-point bending test. The two halves are not always regular in shape; the two halves of the block are joined with mortar, left to harden for 72 hours before passing the sample through the press for testing. The section used for the calculations is the average of the lower and upper surface. The compressive strength is obtained by the formula [5]:

(3)

The compressed earth blocks also offer a resistance to simple compression which increases according to the duration of cure, regardless of the stabilization rate and varies little from the 21st day

The abrasion resistance test consists of brushing the facing surface of the CEB with a metal brush overloaded at its center with a mass of 3 kg. Brushing was done at a rate of one round trip per second for a minute. At the end of brushing, the CEBs were cleaned of the elements that had detached from them and then weighed. By definition, the abrasion coefficient (Ca) expresses the ratio of the brushed surface S (in cm²) to the mass of material detached by brushing [4].

(Norms ARS 674, 675, 676, 677) (4)

Water absorption test by capillary action of CEB: After determining their mass dry, the blocks were introduced into a water tank to have 5mm of submerged block height

After 10 minutes, the blocks were removed from the water and wiped with a damp cloth and weighed.
The water absorption coefficient Cb of each block is conventionally expressed by the formula [4]:
(Norms ARS 674,675, 676, 677) (5)

The nature of the material used also determines the magnitude of the resistance of the stabilized earth blocks. Indeed, stabilization is more effective with sandy materials. The plasticity index of the earth to be stabilized is very important in the resistance presented by the stabilized earth blocks to simple compression. The experience of our predecessors has shown that the lower the plasticity index of the material, the greater the resistance of the stabilized earth blocks coming from it.

3- Results and Discussions:-

3.1. Physical characteristics of the study bar earth

The water content of the bar soil taken from Bakhita is estimated at 3.09%. The percentage of fines is 40.91%. The maximum grain diameter is 2 mm. By referring to the classification standard NF P 11-300 and GTR 92, we can deduce that the bar earth used for our study is class **A** (it is therefore taken from fine soil; Indeed, this classification groups soils in class A with a percentage of fines > **35** and a maximum diameter < **50** mm), this assertion is reinforced by the theory on Atterberg limits where the plasticity index found is 27.24 ($25 < Ip = 27.24 < 40$); which allows us to conclude precisely that the sample bar soil is subclass **A3** (clays and marly clays, very plastic silts). In conclusion, the results mentioned above reveal that our soil has good characteristics for the manufacture of CEB with acceptable mechanical performance.

The Proctor tests make it possible to retain the following characteristics for the soil studied: An optimal water content (Xop) of 5.82% and a maximum dry density of 2.27 T/m3. Beyond these characteristics, we can note that the consistency index Thus, according to the NFP 11-300 standard and the GTR road earthworks guide, the earth used is in a very dry state; its sand equivalent is 15%, which gives this material perfect stability and a sandy-clayey texture. Its use in CEB is therefore possible and can give good results.

For the comparative study of the mechanical characteristics of the blocks we decided to take the blocks stabilized with 10% binder and 21 days of age.

Graph 1.1: Comparison of three-point bending strengths of CEB stabilized with cement and lime.

The flexural strength of cement-stabilized CEB is higher than that of lime-stabilized CEB; a difference of **0.051 MPa** is observed.

3.2. Compressive strength

The compressive strength of CEB stabilized with cement is a little higher than that of CEB stabilized with lime with a difference of **0.451 MPa.**

Graph 1.2: Comparison of the compressive strengths of CEB stabilized with cement and lime

3.3 Resistance to abrasion

Graph 1.3: **Comparison of abrasion resistance of CEB stabilized with cement and lime**

The abrasion resistance value of cement-stabilized CEB is higher than that of lime-stabilized CEB. We can therefore say that blocks stabilized with cement are more resistant to abrasion than those stabilized with lime.

3.4. Water absorption by capillary action

Graph 1.4: Comparison of the results of the water absorption test of CEB stabilized with cement and lime

In contact with water, CEB stabilized with lime absorb more water, the difference is 7.66% compared to CEB stabilized with cement.

Conclusion:-

The studies carried out as part of this work, the objective of which is the valorization of local construction materials in Benin, focused on the comparative study of the mechanical characteristics of CEB stabilized with cement and lime.
After evaluating the optimal rate of water, cement, lime and the comparative study of mechanical resistance, we can conclude that:
-CEBs stabilized with lime absorb more water than those stabilized with cement
- The compressive and flexural strengths of lime-stabilized CEBs are acceptable compared to cement-stabilized blocks; their strengths are approximately similar.

At the end of our work and in view of the results obtained and the behavior of the lime, the blocks stabilized with lime offer good resistance which favors their use in construction.

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