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Hydric and structural approaches for earth based materials characterization

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Abstract

The earth-based material considered in this work is called Stabilized Earth Bick (SEB). Two distinguish type of SEB were examined: SEB5-Tu and SEB5-Te; their difference refers to the freestone, or the red earth composition. Firstly, a morphological characterization has been done by comparing two different approaches: the water porosity test and the mercury porosimetry which provide access to the material porosity and the pore size distribution.
Then, the sorption-desorption isotherm were carefully evaluated for each SEB type. The dynamic gravimetric method was selected for such measurement. Further, theoretical modeling of the sorption desorption isotherm was investigated; here the model parameters allow more accurate interpretation of experimental results.
Most of these measurements provided the hygric and structural characteristics relating to the SEB materials and a comparison of their characteristics depending on the variation of their compositions.

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Keywords: *Porosity, experimental characterization, .sorption desorption isotherm, Stabilized Earth Brick, moisture storage capacity*

1. Introduction

The objectives set for builders are mainly related to minimize energy costs, improve the comfort inside the living space by using sustainable and inexpensive materials. So, materials based on earth respond to the problem of natural

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resources depletion and were, naturally, used for millennia. However, the major drawback of their use is their low resistance to erosion by rain and their tendency to swell or shrink after a number of humidification or drying cycles. The resulting dimensionless variations lead generally to dramatic modification of the thermophysical properties of these materials. To overcome these difficulties, a compaction of tempered based-earthed mixture is recommended to increase the material strength. Also, the addition of small stabilizers quantities such as cement, lime and bitumen is well adopted to reduce its water sensitivity. The resulting material is then called Stabilized Earth Bick (SEB). Two distinguish type of SEB were examined here (SEB5-Tu and SEB5-Te); their difference refers to the cement, freestone, and send percentages.

The thermophysical properties of these materials and their impact on the hygrothermal behavior and consequently the thermal building comfort have been little investigated by researchers. In other manner, characterizing correctly materials, involves precise answer one the essential properties and how accurate they must be defined to perform the heat and mass energy impact questions.

The studied materials are porous structure within which water, liquid or vapor may migrate, be stored or returned to the indoor environment. The non-regulation of the humidity rate inside the compartment is a major cause of damage to the walls of the building; in fact, besides the problems of durability that can be generated, the thermal performances are substantially modified. That's why, in this study we propose in a first step to characterize the SEB materials porosity and morphology, to better identify the microstructure of these material since the macroscopic behavior of materials is highly dependent on the mechanisms involved at the microscopic scale. Then, a hygrothermal characterization is performed through the measurement of the sorption desorption isotherm.

The determination of these characteristics allow, in a future step, to perform simulations based on the HAM models [1, 2, 3] to predict the behavior of the walls in SEB and improving building efficiency energy.

2. Experimental characterization

2.1. Studied materials

Two categories of Stabilized Earth Brick (SEB) materials were selected for the present study (see table 1). They were classified by the National Center for Studies and Research for integrated Building in Algiers (CNERIB) [4].

Despite their thermal insulation performance and low cost, these materials, different from conventional one, are little used. The improvement of earth materials becomes today possible due to two important actions that are chemical stabilization and compaction process. Stabilization step reduces the pore volume and thus increases the strength of the SEB. On the other side, compaction, using a manual or semi-industrial press, induces an increase in the density of the material and also contributes to the mechanical strength. The manufacturing process follows the classical screening stages, blending, compacting and molding. The detailed composition of the tested SEB materials is shown in Table 1. The detailed compositions are referenced to the CNERIB [5].

Table 1
Compositions of the studied materials

SEB 5 Tu	70% of sand (0.2-0.8mm)	25% of toffee (0.2mm)	5% of cement
SEB5 Te	70% of sand (0.2-0.8mm)	25% of red earth (0.2mm)	5% of cement

2.2. Microstructural characterization method

Mastering SEB's structural morphology is primordial; to better understand its response when subjected to hygrothermal solicitations. In fact, several studies have shown the close link between the topology of the environment and these hygrothermal transfers [6, 7]. Among the most influential parameters on these transfers, we find the porosity and the pore size distribution. Two main experimental protocols were used and compared to evaluate this parameter: water porosity and mercury intrusion porosimery.

Water porosity: The water porosity is measured according to the protocol defined by the AFPC-AFREM [8] and its expression is given by (1):