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# Nonlinear thermal behaviour of compressed earth blocks (CEB) in the state of humidity

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***Abstract*— Since ancient times the earthen material was considered one of the most important building materials used by human for construction. This material that provide the thermal comfort of the building and are environmentally friendly, affordable and sustainable, and the earth compressed block is an example. It is important to measure the local thermal conductivity within these local materials when exposed to temperature and humidity. This work is an experimental study to the analysis of the hygrothermal properties of compressed earth block with various ratios water content, that lead to high density of the sample, and then a change in its thermal behavior. The experimental results measurements were performed by hot ring method, the measurement performed via thermocouple existing in the center of ring of the method.**

***Keywords*— compressed earth block, hot ring method, temperature, thermal conductivity, water content.**

## I. Introduction

Construction materials have a significant impact on indoor climate, thus on thermal comfort of the building, especially on temperature and humidity, depending on the thermal capacity of building materials and their ability to transmit energy. Thermal capacity is the amount of energy needed to raise the body temperature by one degree Celsius, which is evidence of the ability of materials to store energy, earth building were prevalent in the some countries of the world compared to modern stone and cement.This creates the need to develop an alternative earth building material with minimal environmental impact and excellent thermal performance. Earth blocs is a construction material which has been used to build thermally-comfortable structures. And the Compressed Earth Block is model for that and for eco-minded green building and sustainable.In this study, we are interested in measuring the thermal behavior of compressed earth block with various ratios water content as in [1], [2].

The results of temperature and thermal conductivity measurements were performed by hot ring method, the measurement performed via thermocouple existing in the center of ring of the method. The principle of measurement is by a ring at the center of which the temperature rise is measured, the measurement of the temperature rise at the center of the ring allows to determine the heat conductivity of the porous medium.

## II. Materials and Methods

The materials used in this work for making compressed earth block are the soil and water. The soil must satisfy the criteria of suitability specific to the soil intended for the production of compressed earth block. The soil used from Fez in Morocco, after determining its granulometry and other specific characteristics.

The process making the compressed earth block: we have put the mixture of soil with water in the molds cylindrical form by compacting (2MPa) it to make it more compact by machine and we got the samples of compressed earth blocks, we have left the compressed earth block for drying 28 days away from the direct sunlight. The compressed earth block takes cylindrical form, the dimensions of the samples are 12 cm high and 8 cm diameter as in [3].

The measurement of thermal conductivity used of hot ring method to estimate the thermal conductivity of a compressed earth block from the evolution of the temperature measured by a thermocouple placed middle a ring. The probe consisting of the ring and the thermocouple in an insulating support in slab kapton, is positioned between two parts of the same sample of the compressed earth block, where the sample of compressed earth block is divided into two parts (Figure1) as in [4], [5]–[7].

Fig. 1 Hot ring method

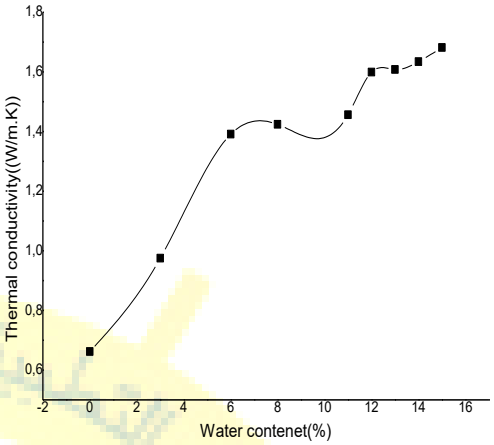


Fig. 2 The results in figure showed strong dependence of thermal conductivity with water content.

## III. Results

The study of the effect of humidity on the physical thermal properties of materials building is necessary, because as water is the main factor in the deterioration of earth structures. The study to investigate the thermal behavior of the compressed earth block containing the humidity. The humidity cause damage into the measure of the thermal properties of the compressed earth block, because that moisture change the temperature behavior into the sample. The results indicate the thermal conductivity change with adding water to the sample of compressed earth block.

The results in the figure2 indicate that for the dry state of compressed earth block 0% water content, where thermal conductivity is low, and when adding gradually the ratios water content % into the sample by spraying with water compressed earth block, we also observed from the curve that thermal conductivity is increasing gradually, and continues to increase to become unable to increase more, that mean the sample of compressed earth block reaches the saturation state, it mean that the sample of compressed earth block becoming unable to absorb more water.

The compressed earth block specimen was tested. The curve in figure 2 shows a slightly rise in conductivity for the specimen. The humidity dependence of the thermal conductivity is shown in the measurements.

## IV. Conclusions

The following conclusions for thermal behavior of compressed earth block with different ratios water content:

The measurements of the thermal behavior with the hot ring method have been performed on compressed earth block. The measurements were performed at same parameters of temperatures and with different water content on the CEB.

The results showed that the addition of water to the sample of CEB has a effect on the strength of thermal insulation of the sample CEB.

The results showed experimental research that water content is a basic parameter for evaluating thermal parameters. Thermal conductivity depends strongly on water content in the sample and the water content in the samples of CEB significantly affects the thermal comfort.

## REFERENCES

[1] N. Zakham, K. Gueraoui, H. Bouabid and M. Cherraj, "Effect of Variation in temperature on thermal conductivity of earth compressed block (CEBs) in dry state and ambient", International Review of Civil Engineering (I.RE.C.E.), Vol. 7, N. 4, ISSN 2036- 9913, July. 2016.

[2] S. Azakine Sindanne, GE. Ntamack, RP. Lemanle Sanga, CA. Moubeke , ES. Kelmamo Sallaboui, H. Bouabid, K. Mansouri and SC. D'Ouazzane, "Thermophysical characterization of earth blocks stabilized by cement, sawdust and lime", J. Build. Mater. Struct. (2014) 1: 58-64.

[3] P. Meukam, Y, A. Jannot. Noumowe and T.C. Kofane, "Thermo physical characteristics of economical building materials", Construction and Building Materials, 18 (2004) 4.7–443.

[4] R. Coquard, D. Baillis and D. Quenard, "Experimental and theoretical study of the hot-ring method applied to low-density thermal insulators", International Journal of Thermal Sciences, 47 (2008) 324–338.

[5] S. Guettala, M. Bachar and L. Azzouz, "Properties of the Compressed-Stabilized Earth Brick Containing Cork Granules", Journal of Earth Science and Climatic Change, Guettala, et al, J Earth Sci Clim Change (2016).

[6] Younoussa Millogo, Jean-Claude Morel, "Microstructural characterization and mechanical properties of cement stabilised adobes", Materials and Structures (2012) 45:1311–1318.

[7] B.V. Venkatarama Reddy, M.S. Latha. Retrieving clay minerals from stabilised soil compacts, Applied Clay Science 101 (2014) 362–368.