Original Research Article

THERMOPHYSICAL CHARACTERIZATION OF GRANITE, BASALT AND MARBLE ORNAMENTAL STONES IN BENIN ~~ORNAMENTAL STONES THERMOPHYSICS: CASE OF GRANITE, BASALT AND MARBLE~~

ABSTRACT

~~**Aim:**~~ This work aims to evaluate the thermophysical~~s~~ characteristics of ~~the~~ local ornamental stones in order to facilitate their choice as efficient flooring materials ~~more efficient~~.

~~**Location and duration of the study:** the study was conducted at the LEMA from May to December 2015.~~

~~**Place and Duration of Study:** the study was conducted at the LEMA from May to December 2015.~~

Methodology: Three varieties of the most known and requested ornamental stones on the market~~, have been selected for this work. This is~~ which include granite, marble and basalt extracted from the Beninese ground and subjected to~~. This study allowed us to use the~~ asymmetric hot plane method to determine their thermal effusivity, thermal conductivity, thermal diffusivity and volumetric heat capacity ~~of these materials~~. The parallelepiped-shaped samples of 10 cm × 10 cm × 3 cm ~~have been~~were performed for measurements.

~~**Results:**~~ ~~Investigations have~~ The results show~~shown~~ that granite has the lowest thermal conductivity value (3.22 $W.m^{-1}.K^{-1}$); effusivity (2470.51 $J.m^{-1}.K^{-1}.s^{-1/2}$) and diffusivity (1.70. 10^{-6} $m^2.s^{-1}$) and the highest value of the volumetric heat capacity (2362.73 $KJ.K^{-1}.m^{-3}$) is obtained with marble.

~~**Conclusion:**~~ Therefore granite is~~seems to have a character~~ more insulating and ~~the~~ marble has better~~a strong~~ ability to store heat~~, than the other two materials~~.

Comment [GT1]: Give values for all the rock types

Keywords: ornamental stones, Thermophycial~~s~~ properties, less energy-intensive, ~~and~~ energy storage material.

BOM

λ : Thermal conductivity ($W.m^{-1}.K^{-1}$)

λ_L : Value of the thermal conductivity derived from the literature ($W.m^{-1}.K^{-1}$).

a : Thermal diffusivity ($m^2.s^{-1}$)

a_L : Value of the thermal diffusivity derived from the literature ($m^2.s^{-1}$).

E: Thermal effusivity ($J.m^{-1}.K^{-1}.s^{-1/2}$)

ρC: Volumetric heat capacity ($KJ.K^{-1}.m^{-3}$)

T_{mod}: Temperature given by the model

T_{exp}: Temperature given by experience

u_x: Standard uncertainty of x

u_c(y): Composite standard uncertainty of y
OBRGM: Office search Benin geological and mining.

1. INTRODUCTION

~~The~~ Benin has huge deposits of ornamental stones with a wide variety of products ~~to consider an expansion of domestic production~~. These stones, after having been worked, ensure the aesthetic ~~aspect of~~ finishing ~~and can in this case~~ to be used for ~~covering~~ tiling floors and walls. ~~But it is clear that this wealth is unfortunately very little exploited particularly in the area of the building to residential tenancies. This~~The low level of exploitation is indicative of ~~a multitude~~ many~~of~~ problems ~~that prevents the ornamental stone sectorto take off. We can mention among other things~~. The following were identified as some of the challenges :~~:~~

~~•~~ The Thermophycial~~s~~ performance of these ornamental stones are not ~~yet~~ known to ~~, which does not~~ encourage investors ~~to engage in buildings for which there do not have a technical guarantee of energy saving.~~

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~~•~~ ~~A lack of alliance~~ The relationship between 'aesthetic aspect of these stones and their ~~abilities~~ potential for~~as a~~ use as materials for insulation in the modern architecture.

- Artisanal mining methods do not have much care for ~~with irregular shapes and a bad provision of~~ these stones ~~in~~ to preserve their~~the~~ coatings hence it~~. So the appearance of finishing that present these stones shapes no national built heritage, which~~ limits their fields of application (Figure 1).

~~On the bibliography on the topic, it is important to note that few~~ Not many studies ~~devoted to the~~ are on characterization of ornamental stones ~~in the literature~~. ~~Thus, 11~~ Moroccan ~~varieties of~~ building stones ~~have been~~ were subjected to~~of a~~ Petrographic studies~~y~~ [1]. ~~The study of t~~The influence of the petro-structural feature on the mechanical properties of the quartzites of atacora in Benin revealed that the Micro-Deval coefficients ~~obtained at the level of~~ the sites of Berecingou ~~and~~ are ~~respectively~~ 6.4% and 8.3% respectively [2]. Furthermore, the characterization of bi-layer mineral ~~material helped~~ showed that 20% ~~of rate~~ of coarse sand, ~~the Bilayers offer~~ is ~~good~~ resistant to~~ce in~~ bending three points at ~~(~~9.875MPa~~)~~, compression at ~~(~~22.083MPa ~~)~~ with a normal water absorption rate ~~normal~~ [3]. Other works ~~are~~ were devoted to the origin and evolution ~~of the term "small granite" [4]~~.~~However, n~~No ~~study is addressed~~ thermophysical characterization of local ornamental stones of~~such as~~ granite, marble, and basalt was undertaken~~. Which explains the interest on these stones which can be used in the coating of buildings when their thermophysical characteristics are known.~~ This study carefully~~is therefore part of a logic of~~ addressed~~valorization of~~ these stones with regards to their energy efficientcy, coating materials, for durability, aesthetic appearance and finishing for~~in the~~ building ~~as more energy efficient coating materials, offering both durability and aesthetic appearance of the finishes~~.

Fig. 1. ~~Picture~~ Photograph of ~~the~~ a building of ~~the~~ a prestigious ~~s~~School of the T~~t~~rades of the F~~f~~uture

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2. MATERIAL AND METHODS

~~2.1 Origin of raw materials~~

Rock samples~~The raw materials used in the present work are~~ were extracted from ~~the ground of~~ Benin in West Africa. ~~Selected g~~Granite and basaltic rocks ~~are~~ were from the Marian Grotto of Dassa-Zoumé and of the basin volcano ~~-~~ sedimentary rocks of Idaho-mahou in Savalou, respectively. ~~As for m~~Marble~~, it was extracted~~ were taken from a pile~~reserve of marble~~at Bagbononhoue in Abomey (~~see location in~~ Figure 2).

Fig. 2. Geographical location map of Benin showing of rock sampling sites

2.2. Method of eDetermination ofstimating thermophysicals properties

In this work, we used aAn asymmetric hot plane device [5] was used for sample characterization. In the process, a section probe (10 cm ×10 cm) is placed below the sample As shown in (Figure 3), a section probe (10 cm ×10 cm) is placed below the sample. The device has a A type K thermocouple consisting of wires of 5.10^{-3}mm in diameter, is placed below the probe. This The set is placed between two blocks of extruded polystyrene foam of 5 cm and on the other hand two aluminum blocks of thickness 4 cm to impose the generate temperature on at the contact surfaces. A flow step is sent into the heating element and the temperature is recorded in at the center.

Theeis system is modeled with a unidirectional heat transfer hypothesis (1D) at the center of the sample during measurement.

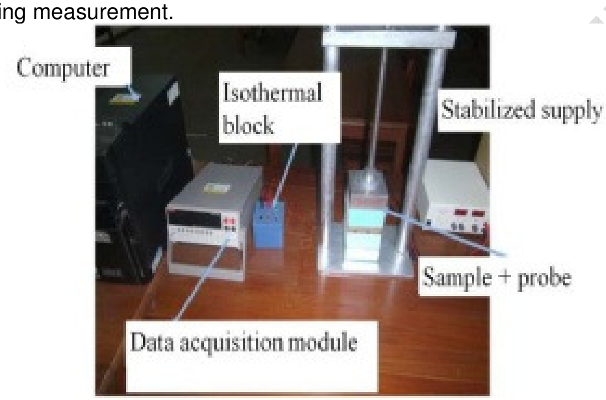

Fig. 3. Experimental mechanism of thermical characterization of experience test

2.3 Measurement procedure

To begin the measurement, there are two parameters:

- The data acquisition time
- The intensity of the heating current.

At a given Thus, we choose the values of time and intensity sensitivity allowing for pc, there is and a rise in temperature of about 10 °C required for a model of one-way transfer (1 d) with the, assumption that thewill be checked afterwards by an analysis of residue: difference between the temperatures given by the Tmod model and the one given by the Texp experience.

The operation is made for each sample. As illustration, we present fFigure 4 shows temperatures of the front and back curves and of residues obtained for granite.

Where there is We are seeing a rise in temperature of the front, 10 °C 180 nearby for an intensity of

0.625A. By referring to the model and experimental curves, we see that the two curves overlap perfectly. The residues are also flat.

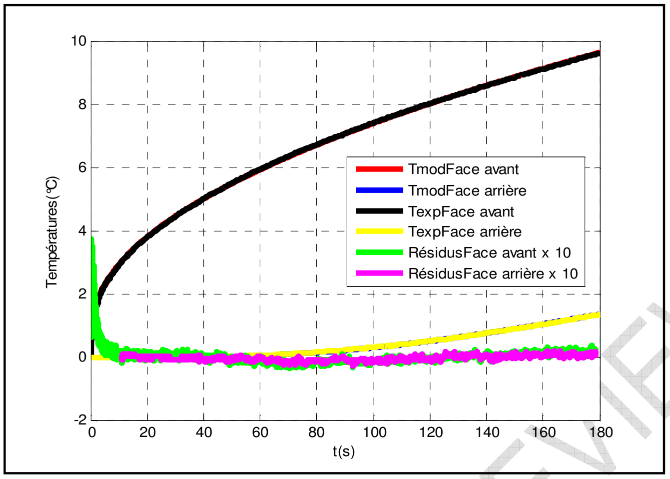

Fig. 4. Curve Mmodel curvesand for experimental and test on the granite waste

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2.4- Assessment of uncertainties

The asymmetric hot plan method to determine experimentally λ thermal conductivity and the thermal effusivity E with their respective uncertainties. Has the thermal diffusivity and volumetric heat capacity ρC are were determined from the following formulaes:

$$a = \frac{\lambda}{\rho C} = \frac{\lambda^2}{E^2} \quad (1)$$

$$\rho C = \frac{E^2}{\lambda} \quad (2)$$

The uncertainty in the calculation of ''a''and ''ρC'' are evaluated by the propagation method of uncertainties.

$$[u_C(a)]^2 = \left(\frac{\partial a}{\partial \lambda}\right)^2 (u_\lambda)^2 + \left(\frac{\partial a}{\partial E}\right)^2 (u_E)^2 \quad (3)$$

$$u_C(a) = \sqrt{\left(\frac{\partial a}{\partial \lambda}\right)^2 (u_\lambda)^2 + \left(\frac{\partial a}{\partial E}\right)^2 (u_E)^2} \quad (4)$$

By integrating the partial derivatives, we find:

$$u_C(a) = \sqrt{\left(\frac{2\lambda}{E^2}\right)^2 (u_\lambda)^2 + \left(-\frac{2\lambda^2}{E^3}\right)^2 (u_E)^2} \quad (5)$$

In addition:

$$[u_C(\rho C)]^2 = \left(\frac{\partial(\rho C)}{\partial \lambda}\right)^2 (u_\lambda)^2 + \left(\frac{\partial(\rho C)}{\partial E}\right)^2 (u_E)^2 \quad (6)$$

$$u_C(\rho C) = \sqrt{\left(\frac{\partial(\rho C)}{\partial \lambda}\right)^2 (u_\lambda)^2 + \left(\frac{\partial(\rho C)}{\partial E}\right)^2 (u_E)^2} \quad (7)$$

By integrating the partial derivatives, we find:

$$u_C(\rho C) = \sqrt{\left(-\frac{E^2}{\lambda^2}\right)^2 (u_\lambda)^2 + \left(\frac{2E}{\lambda}\right)^2 (u_E)^2} \quad (8)$$

3. RESULTS AND DISCUSSION

Table 1 shows the results of the thermal characteristics of the three samples. It can be seen that the values of volumetric heat capacity and thermal conductivity of three granite samples three are in agreement with those reported in the literature [6-7]. On the other hand, values of the thermal conductivity of the marble and basalt appear to contradict the values of literature workers [6]. There are two possible hypotheses and probable: the first is that the

tests are were not carried out at the same temperature and the second is that our the current samples used for this work and those used by previous workersfor the bibliography results have the same properties of chemical, and physical properties and as well as mineralogical composition. The second seems more likely.
Moreover, the thermal diffusivity and conductivity values obtained with granite seem to contradict other values of literature [8]. This observation seems to confirm the second hypothesis.

Table 1: Results of the Thermophycials measures.

	Average values		
Parameters	Marble	Basalt	Granite
E(J.m^{-1}.K^{-1}.s$^{-1/2}$)	3416.34±0.009	2744.22±0.004	2470.51±0.006
λ(W.m^{-1}.K^{-1})	4.94±0.02	3.85±0.008	3.22±0.01
λ_L (W.m^{-1}.K^{-1})	2.3-3.2[6]	1.2-2.3[6] and 1.7-2.5 [7]	2.6-3.1[6];2-4[7] and 2.8[8].
a (10^{-6} m².s^{-1})	2.09±0.01	1.967±0.008	1.70±0.01
a$_L$(10^{-6} m².s^{-1})			1.07[8].
ρC (KJ.K^{-1}.m^{-3})	2362.73±7.90	1956.49±4.07	1892.88±6.86

4. CONCLUSION

The thermophysical properties of granite, marble and basalt werehave been determined in the present work by the asymmetric hot plane method.

The results obtained showed that the granite has the lowest value of thermal conductivity, effusivity and diffusivity respectively equal to 3.22 W.m^{-1}.K^{-1}; 2470.51 J.m^{-1}.K^{-1}.s$^{-1/2}$ and 1.70.10^{-6} m².s-1 while the highest value of the thermal capacity is obtained with marble, 2362.73 KJ.K^{-1}.m^{-3}. It is tTherefore, deduced that granite is seems to have a more insulating whilecharacter and marble has a strong capacity to store heat than the other two materials.

Further research, based on a larger number of rock varieties, particularly of magmatic origin, is conceivable to support the results of this study.

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