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Short communication

Experimental study of thermal properties of a new ecological building material based on peanut shells and plaster

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A B S T R A C T

The aim of the present work was to investigate the thermal properties of a new building material consisting of a mixture of plaster and peanut shells for use as insulating materials in building. The properties are commonly measured by using the steady state asymmetric hot plate method, the asymmetrical transient hot plate method and the flash method. The experimental study that we have conducted, enabled us to determine the conductivity, the effusivity and the thermal diffusivity of our material. The influence of the size and the mass fraction of the peanut shell shards on thermophysical properties of tested material, was investigated. Our experimental data show a good efficiency and a significant decrease in the thermal conductivity of material with peanut shell shards compared to simple plaster material. The purpose is to obtain ecological composite materials with better thermal performance, which can contribute to improve the thermal comfort in constructions in Morocco. The results show that the density of the new material was not substantially influenced by the size of the peanut shell shards. However, the thermal conductivity and diffusivity decrease from 0.3 $Wm^{-1} K^{-1}$ and $3.75 \times 10^{-7} m^2 s^{-1}$ to 0.14 $Wm^{-1} K^{-1}$ and $2.11 \times 10^{-7} m^2 s^{-1}$, respectively, according to the variation of the mass fraction of peanut from 0 to20%.

1. Introduction

Estimating thermophysical as well as mechanical parameters of building materials is critical in the building sector, in which the excessive consumption of energy weighs heavily on the energy bill of the developing countries. Several attempts have been made to improve energy efficiency in the building sector in order to decrease energy consumption.

Studies have been carried out focusing on local materials such as cement or lime stabilized clay, concrete and plaster lightened with cork. However, several works have reported on composite materials containing cement, clay or gypsum plaster. Ezbakhe et al. [1] conducted a thermal study of the cement stabilized earth for construction in the north of Morocco. El Bakkouri et al. [2] presented a thermo-mechanical study of cork or olive-residue lightened concrete. The thermal and mechanical characteristics of an insulating material based on cork and cement mortar were performed by Khabbazi et al. [3] using the boxes method. The study managed by Kellati et al. [4] allow concluding that the cork is an example of a natural material suitable as a wall insulation product. The thermal properties characterization of materials based on granular cork bound with two different binders: cement mortar and plaster were investigated by khabbazi et al. [5]. Later, Cherki et al. [6] studied the thermal properties of this insulating material based on cork and cement mortar using the asymmetrical transient hot plate method.

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The improvements of the thermal properties of cork-clay composite using the hot plate and the flash methods were conducted by Mounir et al. [7]. These authors used the same methods to measure the thermal properties of clay-wool composite [8].

An experimental study of the thermal properties of a gypsum containing micro encapsulated phase change material was realized by Toppi and Mozzarella [9]. The thermal characteristics of incorporating PCMs (Phase Change Materials) into gypsum boards were evaluated by Oliver [10] to increase building heat storage capacity and to reduce energy consumption.

The mechanical properties of date palm fibers and concrete reinforced with date palm fibers in hot-dry climate were handled by Kriker et al. [11]. The periodic method was used to determine the thermal conductivity and diffusivity of date palm wood at room temperature by Tlijani et al. [12]. Agoudjil et al. [13] investigated on the thermophysical, chemical and dielectric properties of three varieties of date palm wood. They showed that the date palm wood is a good material for the development of efficient insulating green materials.

The hot-disk, the hot-wire and the hot-ring methods are also applied to characterize the thermal insulators by Coquard et al. [14–16]. Jannot et al. [17] presented the symmetrical device of hot plate method dedicated to thermal conductivity measurement of thin insulating materials. The thermal properties of clay bricks used in construction are measured using transient and steady state hot-plate and flash methods [18,19]. Ball et al. [20] characterized the thermal conductivity of the Laterite based bricks with millet waste additive as a function of their water and millet contents. Dadi et al. [21] interested in studying the effect of cow's dung on the thermo-physical characteristics of materials based on clay. Recently, the works dealt with composite materials which are based on date palm fibers were studied in an [22,23] for use as an ecological insulating materials in building.

In this study, we are interested in exploring the effect of peanut shell shards (PS) on the thermophysical characteristics of materials based on plaster coming from the Moroccan Lafarge's factory [24]. The thermal performances of a mixture of plaster and crunched peanut shells according to studied proportions are performed. All the brick samples are having the same size and taking from the new material based on (PS) with different percent peanut content. Knowing that the plaster is used for construction in walls or ceilings section and by mixing it with a natural and renewable product such as (PS) to develop an efficient insulating materials. The effect of the various diameters of (PS) addition in the ratio of 0%, 2.5%, 5.5%, 10%, 15% and 20% by weight on the thermal conductivity "λ", diffusivity "a", effusivity "E" and capacity "C_p" are experimentally obtained and their values are reported for design purposes. At the end, a comparative study based on different experimental methods is performed and the measurements are compared.

2. Protocol and experiences

As the objective is to improve thermal properties of plaster which may be used in walls and false ceilings with maximum thickness of 20 mm, all the samples were manufactured with 20 mm of thickness. After having crushed (PS) and split into classes of different sizes by a standardized screening process, we proceed to the preparation of the samples according to the variation of the size and the (PS) mass fraction.

– The first category of composite samples is prepared with the same mass fraction of (PS), (ϕ_m = 20%) and by varying the size of (PS) in order to reveal the effect of this variation on the thermal properties of the composite (Fig. 1).

Four classes of different size categories were prepared, using a normalized sieving process with a various diameters (d_1–D_1 = 2.5–5 mm, d_2–D_2 = 5–6.3 mm,d_3–D_3 = 6.3–8 mm, d_4–D_4 = 8–10 mm) and keeping three composite samples per category that seemed best for each type of test.

– The second category of the samples is prepared with different mass fraction ϕ_m of (PS) in the mixture with a mean diameters of (d_3–D_3 = 6.3–8 mm).

The composite samples were obtained by mixing plaster and water with different mass fraction ϕ_m of (PS) with (0%, 2.5%, 5.5%, 10%, 15% and 20%). Furthermore, a sample of plaster (ϕ_m = 0) without (PS) was prepared in order to compare the variation of thermal properties of peanut shells–plaster material with those of clean plaster.

The (PS) and plaster were mixed with water at a water-plaster ratio by mass of (w/g = 0.7). The cubic molds

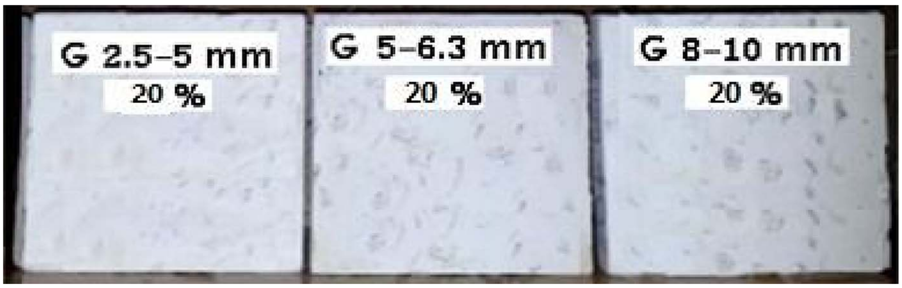

Fig. 1. View of plaster-peanut shells composite material(ϕ_m = *20%*)for different sizes of (PS).