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Thermo-mechanical properties of fired clay brick incorporating industrial by-product materials cork waste

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***Abstract*— The quantity of solid wastes (domestic, agricultural or industrial) throughout the world is increasing and their elimination becomes more complex. However, recycling industrial by-product materials waste has become an attractive topic of materials research in civil engineering. These industrial by-product materials waste must be managed responsibly to insure a clean environment. The use of waste in fired clay brick production may also save clay from avoidable depletion and reduce the environmental contamination by waste, contributing to sustainability. The aim of this research is to study the influence of Ground Cork Waste (GCW) on the thermo-mechanical properties of fired clay brick. For this purpose, increasing amounts of Cork Waste (0, 5, 10 and 15% of weight) with a grain size under 1.00 mm were mixed with a clay to produce clay bricks by pressing, drying and then firing at 900°C. The results obtained demonstrate that an increase in the content of CW leads to a significant increase in apparent porosity of fired clay brick. The compressive strength and thermal conductivity of the samples decreased with the increase in content of (GCW).**

***Keywords*— Brick; Ground Cork Waste; Temperature; Compressive strength; Thermal Analysis.**

I. INTRODUCTION

In the context of sustainable development, new regulations on thermal insulation in the building sector are calling on scientists to discover new materials capable of meeting the dual objectives of home comfort and energy savings [1]. An example of a solution to both these problems is the importance of recycling agricultural waste in the manufacture of porous bricks. These materials refer to bricks that are lighter than traditional bricks, and are primarily aimed at improving thermal insulation. In this line of research, a number of residues have already been tested, including sawdust, charcoal, paper sludge and straw [2], crushed date stone [3], olive pomace [4], rice husk ash [5], tea waste [6], cherry seeds [7], cigarette butts [8], and peanut hulls used as a partial replacement for sand in cement blocks [9]. Lamrani et al [10] have used peanut shells as an additive in plaster to improve insulation and reduce density.

The use of plant waste in the manufacture of clay bricks has a promising future. We propose to explain why it would be useful to incorporate crushed cork waste in the manufacture of clay bricks: In order to limit the quantities sent to landfill and preserve natural raw material resources, regulations require waste to be recycled and the search for new ways to reduce the thermal losses of buildings. The use of heavy walls requires excessive consumption of materials not available in abundance. What's more, this solution doesn't provide a satisfactory level of comfort.

The present work focuses on the manufacture of clay brick, with the incorporation of ground cork waste (GCW), with the aim of increasing its porosity and reducing its thermal conductivity, while preserving its mechanical properties. To this end, the influence of (GCW) content on the thermo-physical and mechanical properties of the mixes was studied.

II. MATERIALS AND METHODS

The clay used in this study comes from a local Remila (Bejaia) quarry in Algeria; it is used in the manufacture of bricks. The clay was first sun-dried for 72 hours, then oven-dried at 105°C for 48 hours and finally sieved through 2 mm sieves. Cork is an agricultural product that grows around the trunk of the cork oak tree. Average cork production in Algeria is around 60,000 Qx per year. Cork is a cellular material, almost 90% of whose volume is air, giving it low density and excellent thermal and acoustic insulation qualities as shown in Fig. 1. It is ground and sieved to obtain particle sizes of less than 1mm as shown in Fig. 2. Different percentages of crushed cork waste

(0%, 5%, 10% and 15% by weight) were incorporated into the clay brick. After homogenization of the fresh material, a uniaxial hydraulic press was used to press the mixture into a mold of dimensions (40x40x160) mm^3 for measurement of physico-mechanical properties, and (20 x 60 x 80) mm^3 for measurement of thermal properties (7 samples in each series). The samples were kept in a storage chamber at a controlled temperature of 20°C for 72 hours. Before firing, the samples were oven-dried at 105°C until a constant mass was obtained. Finally, the green samples were burnt in a kiln with an initial slow heating rate of 2ºC/min (to ensure incineration of organic substances without igniting them) up to 600°C, then 4°C/min up to 900°C. The clay bricks manufactured have been subjected to a series of tests in accordance with the relevant standards.

Fig. 2 cork raw materials

Fig. 2 crushed cork

III. Results and Discussion

The physical (apparent porosity), mechanical (compressive strength) and thermal (thermal conductivity) properties of fired bricks have been characterized.

Porosity is one of the main parameters affecting the compressive strength of clay bricks. The addition of ground cork waste has a significant effect on the microstructure of clay brick. Crushed cork is easily consumed during firing, resulting in a multitude of pores. Fig. 3 shows the variation in compressive strength and apparent porosity of GCB added to clay bricks.

The results show that the compressive strength depends on the apparent porosity of the additives. Increasing GCB content caused a proportional increase in porosity and a decrease in compressive strength of the clay brick. Typically, in clay-based ceramic systems, high porosity values result in lower compressive strength.

The values found are even higher than those required by Algerian standards, which require a compressive strength for clay bricks between 10 and 40 MPa (NA 5023) [11]. On the other hand, according to the British standard, the compressive strength of clay bricks should be higher than 5 MPa [12]. Compressive strength generally decreases with increasing porosity in clay-based ceramic systems.

From fig. 4, it can be seen that thermal conductivity decreases considerably with increasing GCB percentage. The additive leaves voids in the structure during combustion during firing.

As a result, the higher proportion of air inside the brick, the better thermal insulation properties of the material, since air is a good insulator compared to solids.

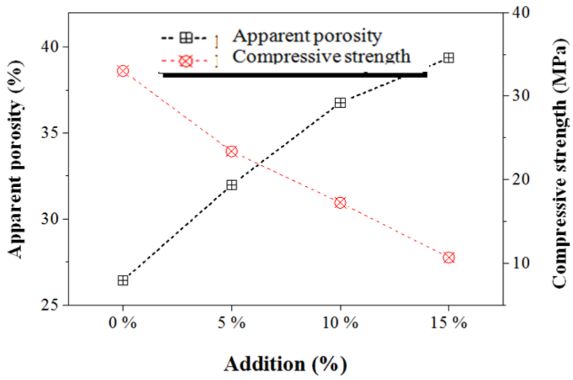

Fig. 3 Compressive strength (MPa) and apparent porosity (%) of fired samples as a function of GCW content.

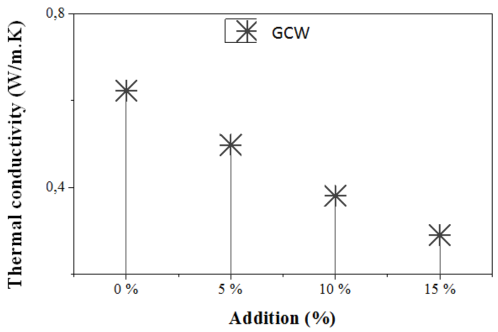

Fig. 4 Thermal conductivity (W/m.K) of fired samples as a function of GCW content.

IV. Conclusions

Experimental tests revealed the effect of the content of ground cork waste on the technological properties of clay bricks, and enabled us to draw the following conclusions: The addition of organic residues to clay has increased open porosity. This effect can reduce the thermal conductivity of the clay brick after firing. The compressive strength of fired samples is reduced by the addition of ground cork waste. Nevertheless, the values are still higher than those required by Algerian standards. This experimental study could therefore be a small step towards safeguarding the environment and the economy in the future.

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References

[1] N. Benmansour, B. Agoudjil, A. Gherabli, A. Karechea, A. Boudenne., *Thermal and mechanical performance of natural mortar reinforced with date palm fibers for use as insulating materials in building*. Energy and Buildings, vol. 81, pp. 98-104, 2014.

[2] I. Demir, M.S. Baspinar, M. Orhan., *Utilization of kraft pulp production residues in clay brick production*. Building and Environment, vol. 40 (11), pp.1533-1537, 2005.

[3] G. Djafri, N. Chelouah., *Influence of the diameter of ground date pits on the technological properties of clay bricks.* Cerâmica, Vol. 64, pp. 589-597, 2018.

[4] S. Arezki, N. Chelouah, A. Tahakourt., *The effect of the addition of ground olive stones on the physical and mechanical properties of clay bricks.* Materiales de Construcción, Vol. 66(322), pp. 1-10 ,2016.

[5] P. Milak, M.T. Souza, C.P. Bom, P. Mantas, F. Raupp - Pereira, A.P. Novaes de Oliveira., *Valorization of rice husk ash in ceramic bricks*. Cerâmica, Vol. 63, pp. 368-368, 2017.

[6] I. Demir., *An Investigation on the production of construction brick with processed waste tea*. Building and Environment, Vol. 41, pp. 1274–1278, 2006.

[7] L. Barbieri, F. Andreola, I. Lancelot, R. Taurino., *Preliminary study on characterization and valorisation in clay matrix bricks.* Waste Management, Vol. 33 (11), pp. 2307-2315, 2013.

[8] N.A. Sarani, A. Abdul Kadir., *Thermal Conductivity Of Fired Clay Bricks Incorporated With Cigarette Butts.* Advanced Materials Research, Vol. 690-693, pp. 919-924, 2013.

[9] N. Sathiparan, H.T.S.M.De Zoysa., *The effects of using agricultural waste as partial substitute for sand in cement blocks*, Journal of Building Engineering, vol.19, pp.216-227, 2018.

[10] M. Lamrani, N. Laaroussi, A. Khabbazi, M. Khalfaoui, M. Garoum, A. Feiz., *Experimental study of thermal properties of a new ecological building material based on peanut shells and plaster*. Case Stud. Construction Materials, vol.7, pp.294-304, 2017.

[11] Algerian Norms, NA 5023, "*Firing clay bricksdetermination of compressive strength of bricks*" (1995).

[12] British Standard, BS 3921, "*Specification for clay bricks*" (1985).

[13] S. Ahmada, Y. Iqbal, R. Muhammad., *Effects of coal and wheat husk additives on the physical, thermal and mechanical properties of clay bricks.* Boletín de la Sociedad Española de Cerámica y Vidrio, vol. 56(3), pp.131-138, 2017.