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Contribution to the valorization of clay composite materials in Algeria: Application building materials

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Abstract— **This work is part of the development of local products such as clays in the Maghnia region, using them in the manufacture of cementitious building materials, such as mortars, to improve their performance. The results of tests on the cementitious products (mortar) after firing show that the compressive and flexural strength (at 7 days) by substituting the sand by the bentonite clay are important compared to the reference material. Adding refractory clay to building materials causes an increase in the mechanical and thermal resistance of the product after sintering. This highlights the diversity of application of this material (boiler coatings, chimneys, flue gas systems, steel plant floors, parts of ovens, .etc up to 1400°C) without forgetting the economic and environmental interest.**

Keywords— **valorisation des argiles; argiles réfractaire; mortiers; thermomécanique; composite materials.**

I. Introduction

The steel industry requires specific materials capable of meeting a number of requirements including a good ability to withstand repeated mechanical and thermal stress. Indeed, the materials thus solicited are likely to deteriorate prematurely and thus, lead to the ruin of structures in service entailing significant risks for operators and significant production losses. To improve the performance of these materials, it is imperative to have a good vision of the evolution of their thermomechanical properties [1], [2]. This evolution can result from their microstructural state, which is necessarily evolutionary in the conditions of service.The design of the refractory structures must seek the adequacy between the types of stresses undergone in a specific place and the nature of the material to be used [3], [4]. In this context, the research laboratories on materials are working on the development of new cementitious composites, for the economic purpose (reduce the cost of production), ecological (giving importance to local raw materials) and technical (improving the mechanical and thermal properties of mortars or concretes) [5]. The study described in this article aims to take stock of the valorization of refractory clays which are in abundance in cement and brick factories Algerian, and this, for the manufacture of mortars in order to study and improve certain thermomechanical properties.

II. EXPERIMENTATION

A. Materials and experimental process

The resistance to compression and flexion (three-point bending) of a parallelepiped (4 × 4 × 16cm) was achieved using a branded equipment (Zwick / Roell) (reference Z2.5KN), 0.5mm / min of displacement. These tests or experiments consist in placing a test piece between the jaws of a compression or bending machine, the applied force is recorded, which is then converted into deformation and stress. The materials used in this study are: Ain El kbira - Sétif cement, Tébessa standardized sand and Maghnia bentonite. The formulation of the reference mortar is shown in the table below:

TABLE I
CONSTITUENTS OF MORTARS

Formulation	Cement (g)	Sand (g)	Water (g)
Reference	450	1350	225

For mortar mixing, add 225g (+/- 1) of water and 450g (+/- 2) of cement to the mixer and start immediately at low speed. After 30 sec of mixing, add 1350 g (+/- 5) of sand regularly for the next 30 sec. Divide the mortar into pieces and fill the molds in two layers. Put a first coat and start the appliance: 60 shocks will be made to spread the first layer of mortar. Turn off the device and then put the second layer of mortar. Restart the device: 60 shocks will be carried out again, as soon as the operation is carried out and that the mortar is well spread on the mold, equalized with a spatula. When the mortar is solidified, the test piece is removed. Here, the manufactured test pieces were demolded at 2_{days} and 7_{days}.

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Fig. 1 Manufacture of mortar specimens

The figure and table below show the composition of the mortars when substituting normalized sand with bentonite.

TABLE II
DIFFERENT FORMULATIONS SUBSTITUTING NORMALIZED SAND WITH BENTONITE.

Formulation	Cement (g)	Sand (g)	Water (g)	Clay (g)
V1	450	1350	225	0
V2	450	1080	225	270
V3	450	945	225	405

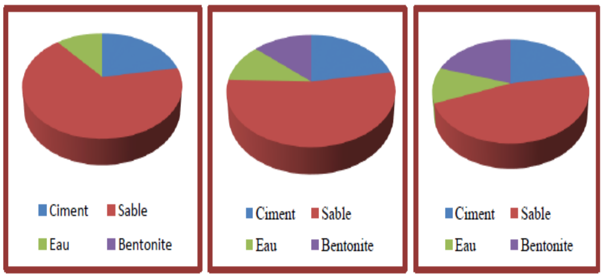

Fig. 2 Different formulations substituting normalized sand with bentonite.

The effect of the temperature will cause a modification of the components (cement paste, sand, and bentonite) as well as the structure of our mortar. Remove the test pieces of the basin after storage under water for 2 days (temperature: 20°C). Leave to air dry, then steam at a temperature of 100 to 105°C. Subject the test pieces to a high temperature (1400 ° C) in an oven, maintain a constant heating rate (V) up to 1400°C and allow this step for 30 minutes so that the test tubes heat homogeneously. Cooling the oven in the opposite direction at a speed (-V) and remove the test pieces. Follow the same steps for 7 day mortars.

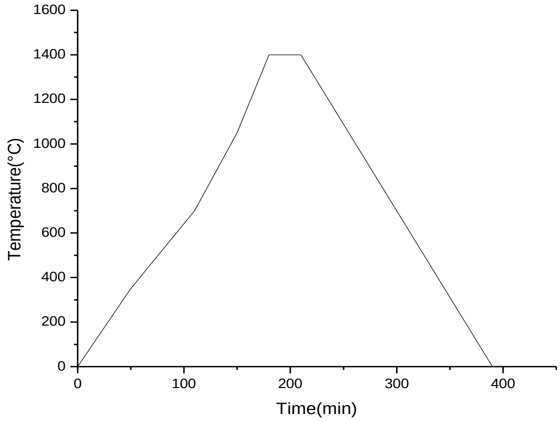

Fig. 3 Thermal cycle of mortar specimens

Fig. 4 Test specimens before heat treatment

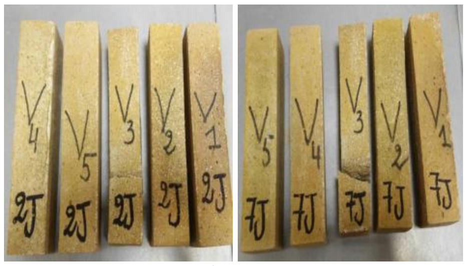

Fig. 5 Test specimens after heat treatment at 1400°C.

The tables and figures below show the evolution of the mechanical resistance to compression and bending of the various mortars after firing.

TABLE III

RESULTS OF MECHANICAL TESTS ON MORTARS BY SUBSTITUTING NORMALIZED SAND WITH BENTONITE.

Formulations	2 days		7 days	
	Flexion (MPa)	Compression (MPa)	Flexion (MPa)	Compression (MPa)
V_1	3.0	20.1	3.8	24.7
V_2	2.2	20.6	4.4	21.3
V_3	1.9	14.15	3.6	14.35

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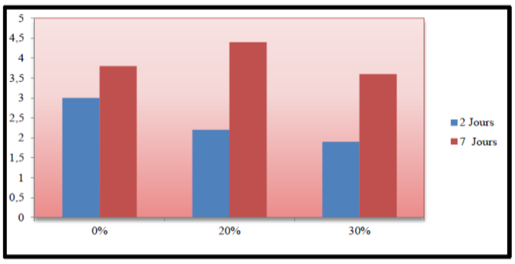

Fig. 6 Results of flexural tests by substituting normalized sand with bentonite

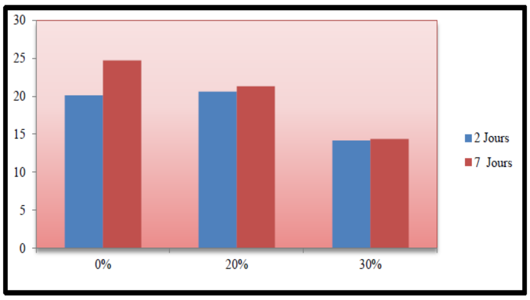

Fig. 7 Compression test results by substituting normalized sand with bentonite

III. RESULTS AND DISCUSSION

The main rule of mechanical strength of mortars is directly related to the ratio (E / C) [6], [7]. Figures 6 and 7 show the evolution of the mechanical resistance to compression and bending of the various mortars formulated. From these histograms, we find that the reference mortar has a higher mechanical strength than those of other mortars containing bentonite, before the heat treatment. In ordinary concrete, during the increase of the temperature, there is a modification of the physicochemical properties of this one [8], [9], it is almost the same case for the mortar; it results from the rise of the temperature a modification of the thermal properties which also influences on a macroscopic point of view. From these histograms, we notice that after cooking, there is a decrease in the resistance of the reference mortars. On the other hand we observe an increase of the resistances of the substituted mortars. From the results obtained, we can deduce that the addition of bentonite positively influences the mechanical behavior of the substituted mortars, so they can be valorised mechanically. Nevertheless, the ordinary mortar remains here, more resistant than the latter.

III. CONCLUSIONS

In conclusion, we can say that clay-substituted mortars can be used in moderately stressed structures, even if this does not bring significant improvements. Nevertheless, these results highlight the influence of clays on the properties of cementitious materials, highlighting the economic and environmental interest of cement substitution by calcined clays. In general, it is possible to exploit refractory clay mortars up to 1400°C.

of this template was provided by courtesy of Causal Productions (www.causalproductions.com)".

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In my present work I made a substitution of refractory clay Maghnia in the building materials on one side to value the clays of our country and another to lower the cost of return of the raw materials. In a future study we would like to analyze our materials by physical and mechanical analysis.

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