ON THE THERMO-MECHANICAL CHARACTERIZATION OF CEMENTITIOUS MORTARS EXPOSED TO HIGH TEMPERATURE

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ABSTRACT

Compartmentation is one of the key aspects in Fire Engineering, as it prevents – or limits - fire spreading to adjacent rooms. A proper fire compartmentation guarantees that the consequences of a fire are not disproportionate with respect to the fire itself; from this point of view, compartmentation is a sort of extension of the concept of *robustness*, that is a key concept in modern Structural Engineering.

A typical barrier to fire spreading is represented by fire-resistant walls, consisting of hollow clay bricks or concrete blocks and mortar joints. The typical fire performance that a load-bearing or non load-bearing wall should guarantee is a combination of integrity (E Criterion about the ability to prevent the passage of flames, hot gases and smoke from the *hot* side to the *cold* side of the wall), and insulation (I Criterion about the ability to keep the temperature rise at the *cold* side below specified levels) [1]. Clearly, the overall fire performance of a wall is controlled by the properties of the two component materials, i.e. clay bricks or concrete blocks, and mortar (in the joints).

Some recent technical documents on fire-resistant load-bearing and non load-bearing walls are bringing to the stage the thermo-mechanical behavior of the mortars, whose thin layers should not be the weakest link in a wall system, in terms of heat transfer, integrity and mechanical resistance. Information on mortars decay at high temperature, however, can hardly be found in the technical-scientific literature.

Within this context, the thermo-mechanical characterization of three mortars in *residual* conditions (i.e. past a cycle at high temperature) is presented in this paper. The first mortar (M5) is an ordinary mortar (*reference* mortar, $f_c \geq 5$ MPa), while the second and third mortars (M10 and M15) are high-performance/high-strength mortars ($f_c \geq 10$ MPa and $f_c \geq 15$ MPa, respectively). All mortars are tested in compression and in tension by bending in virgin conditions and past a single high-temperature cycle at 200, 400 and 600°C.

Since the focus of this research project is on the fire performance of the walls

made of hollow concrete blocks, the behavior of the mortars is systematically compared with that of concrete, represented by the provisions of Eurocode 2 [2].

In terms of thermal properties (Figure 1a), the three mortars exhibit a thermal diffusivity significantly lower than that of ordinary concrete (from -25 to -40%). This is a plus, since in a wall the mortar joints unavoidably act as a thermal bridge (because of their continuity from the *hot* side to the *cold* side).

As for the mechanical properties, the two higher-grade mortars (M10 and M15) exhibit better strength properties than the lower-grade mortar M5, at all temperatures; the curves of the normalized strength, however, are not only very close among themselves, but also very close to those of ordinary concrete, up to 600°C (Figure 1b). The same applies to the elastic modulus, and to the tensile strength in bending. The similar loss of mechanical performance in the mortars and in ordinary concrete is something welcome, as the loss of integrity in a fire-exposed wall depends mainly on the differences exhibited by the mechanical properties and thermal dilation, between the concrete of the blocks and the mortar of the joints [3,4].

Summing up, the good performance of the mortars in question, in terms of insulation ability and integrity leads to the conclusion that in a wall, the mortar joints do not represent the *weakest link*; moreover, the good insulating properties (= low thermal diffusivity) indicate that mortars may be efficiently used in the fire protection of FRP plates, jackets and ribbons.
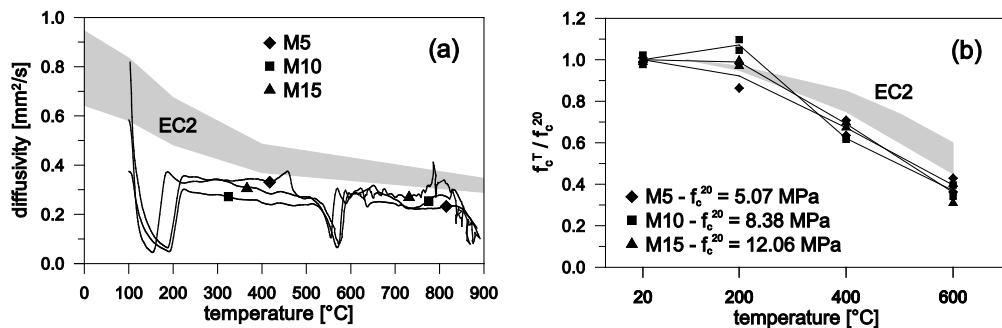

Figure 1. (a) Thermal diffusivity; and (b) residual normalized compressive strength.

MAIN REFERENCES

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A further example:

Regan P.R. and Kennedy Reid I.L. (2009). "Assessment of Concrete Structures Affected by Cover Delamination – Part 1: Effect of Bond Loss". *Studies and Researches – Annual Review of Structural Concrete,* Ed. by Politecnico di Milano and Italcementi, Vol. 29, pub. by Starrylink (Brescia, Italy), 245-275.

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