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Novel fire-protecting mortars formulated with magnesium by-products

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ABSTRACT

Several kinds of sprayable mortars are commonly used as passive fire protection of building structures. Several authors have reported the effect of different kinds of aggregates (e.g. vermiculite, fly ashes) in the thermal behaviour of fire-protecting mortars. In this study, the use of magnesium by-products as aggregates in fire-protecting mortars has been evaluated. These by-products were obtained during the calcination process of natural magnesite. Endothermic decompositions of the different aggregates have been determined and analysed by means of thermal techniques. Mortars with different mixtures of these by-products have been prepared. Mechanical properties and temperature behaviour tests have been performed to evaluate the suitability of these substances as aggregates in fire-protecting mortars. During the endothermic decomposition of the studied aggregates the advance of temperature inside the mortar is delayed. Mortar with a mixture of 50% of both magnesium by-products shows a good agreement between mechanical properties and temperature behaviour.

1. Introduction

Fire protection is a topic of increasing interest due to the enforcement of the existing standards as well as to the society awareness of fire risks [1]. Different approaches can be taken in order to protect a building structure depending, among others, on the risk level, the required resistance time and material involved. Intumescent paints and fire-protecting mortars formulated with lightweight aggregates are a common solution to protect reinforced concrete, wood, or metal structures. Nevertheless, some differences should be made between these two products: i) intumescent paints provide a smooth finish, while mortars leave rough surfaces and ii) high resistance times cannot be reached with an intumescent paint.

Conventional fire-proof mortars formulated with vermiculite and/or perlite as lightweight aggregates take benefit of the low thermal conductivity and weight of these minerals as well as their capacity to retain water to obtain a porous insulating mortar easy to spray [2–5]. The initial critical temperature for steel structures is considered to be 400 °C [5–7]. In the case of concrete formulated with Portland cement, it undergoes important changes with temperature: release of free water (around 100 °C) and chemically bonded water (in a range of 100–300 °C), and portlandite decomposition (at approximately 450 °C). During the portlandite decomposition, volume changes can cause cracks in concrete which would contribute both to the decrease in mechanical properties as well as to the increase of thermal flow to the steel in the case of reinforced concrete [8]. Hence, developing new mortar formulations that increase the time needed to reach these temperatures keeping or improving the rest of the aspects would be a great challenge.

Another aspect of interest in the development of new mortars suitable as passive fire protection is the use of industrial wastes or by-products [9–11]. Fire resistance of mortars containing different kinds and contents of fly ashes has been tested successfully. The tests show that the addition of fly ashes increases the mortar insulating capacity and tendency to retain water [12]. This is due to the high porosity and specific surface of the added fly ashes.

This work has been focussed on the development of fire-protecting Portland mortars formulated with magnesium by-products obtained during the calcination of natural magnesite [13]. The possibility to develop new formulations to obtain mortars with enhanced thermal and fire behaviour from industrial by-products would lead to a combination of an economical and sustainable feasible solution for passive fire protection. Two magnesium by-products have been used: a low-grade magnesium hydroxide (LG-MH) and a low-grade magnesium carbonate (LG-MC). Both products undergo endothermic decompositions with the release of water and carbon dioxide in the range of 300–750 °C and 500–800 °C, respectively. The combined effect of heat absorption and water release from LG-MH has been used in the field of flame retardancy of polymers with promising results [14]. It is expected that the mortars formulated with these endothermic magnesium by-products will exhibit longer times to reach the external temperature. The aim of the present study is to evaluate the thermal and mechanical properties of the resulting

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