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Behavior of composite cement pastes containing microsilica and fly ash at elevated temperature

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HIGHLIGHTS

- Five mass% SF showed the higher values of bulk density than the other pastes.
- Cement pastes containing 10, 15, and 20 mass% SF is thermally stable up to 600 °C.
- SF10 and SF15 have higher resistance to fire than all SF-pozzolanic cement pastes.
- Strength of cement pastes with 5–10 mass% FA increases by 39.3% and 35.7% at 450 °C.
- Composite cements with 10% SF and FA% have good fire resistance up to 450 °C.

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ABSTRACT

The work aims to study the effect of substitution of micro-silica (SF) and fly ash (FA) on the behavior of composite cement pastes exposed to elevated temperature. The composite cements are composed of 80 mass% OPC with variable amounts of SF and/or FA. The fire resistance of composite cement pastes was evaluated after firing at 250, 450, 600, and 800 °C with rate of heating 3 °C/min for 3 h soaking time. The physico-mechanical characteristics such as total porosity, bulk density and compressive strength of cement pastes were determined at each firing temperature. Moreover, the phase composition, free lime and microstructure for some selected samples were investigated. Cement pastes containing 10 and 15 mass% have higher firing resistance than all SF-pozzolanic cement pastes at 600 °C. It can be also, concluded that the composite cement pastes made from 10% of SF and 10% FA have good fire resistance in comparison with cement pastes made from only SF-pozzolanic cement pastes up to 450 °C.

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1. Introduction

Pozzolanas are natural or artificial and can define as siliceous and aluminous materials, which possess little or no cementitious properties. But, in a finally divided form and in the presence of moisture, they react with lime to form calcium silicate and calcium aluminate silicate hydrates. The most important are fly ash (FA), silica fume or micro-silica (SF), blast-furnace slag (Ggbfs), and natural pozzolanas such as volcanic ash. FA is a finely divided waste by-product that precipitated electrostatically from the combustion of pulverized coal at the thermal power plants. It is the most common artificial pozzolana. FA particles are spherical and have the same fineness as cement so that the silica is readily available for reaction. SF is a by-product from the manufacture of ferrosilicon alloys. It consists of very fine amorphous SiO_2 with 1–2 μm diameter.

Calcium hydroxide (CH) is one of the major phases formed in set Portland cements. The formation of CH in hydrating Portland cement not only determines the percentage of reaction of hydration, but may also influence its mechanical properties, especially in the presence of reactive pozzolanic materials such as SF. When SF is added to cement, pastes, mortars and concrete, it acts both as a chemical inert filler, improving the physical structure and as a pozzolanic materials, reacting chemically with CH formed during hydration of cement. The starting time of the pozzolanic reaction varied with the properties of pozzolana from 1 day to 28 days [1–3]. Previous studies [4–6] have shown that the addition of SF accelerates the early stage of hydration of Portland cement and its individual compounds. The authors propose that the increased of the rate of hydration may be due to enhanced precipitation of hydration products on the surface of pozzolana, which possibly

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