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Behavior of composite cement pastes containing silica nano-particles at elevated temperature

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HIGHLIGHTS

- The compressive strength of OPC–GBFS–NS pastes increase with NS up to 4%.
- Gel/space ratio of composite pastes increase with GBFS content up to 40 mass%.
- Free lime content of composite cement pastes increases up to 7 days then decreases.
- The compressive strength of mix IV.2 shows higher values up to 1000 °C.
- Total porosity of composite pastes with 40% GBFS have lower values up to 1000 °C.

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ABSTRACT

The work aims to study the effect of substitution of nano-silica (NS) on the behavior of composite cement pastes containing ordinary Portland cement (OPC) and blast-furnace slag (GBFS) exposed to elevated temperature up to 1000 °C. The composite cements are composed of different amount of NS up to 6 mass% as well as 30–60 mass% GBFS. The behavior of hydration kinetics were studied for 1, 3, 7, 28 and 90 days. The fire resistance of composite cement pastes was evaluated for specimens cured for 28 days after firing at 250, 450, 600, 800 and 1000 °C with rate of heating 3 °C/min for 3 h soaking time, then cooled to room temperature in the furnace switched off. The compressive strength of OPC–NS and/or GBFS cement pastes increase with NS content up to 4%. Increases of the contents of NS up to 6% the values of compressive strength of OPC–NS cement pastes decreases. Gel/space ratio of OPC–GBFS–NS containing 4 mass% NS shows an increase with the increase of GBFS up to 40 mass% (mix IV.2). The compressive strength of III.2 and IV.2 show higher values at all thermally treatment temperature up to 1000 °C. The compressive strength of the superplasticized OPC–NS–GBFS composite shows a higher values up to 1000 °C in comparison with those pastes. It can be included that 30–60% GBFS in the presence of 4 mass% NS has a higher resistance to fire than all composite cement pastes.

1. Introduction

The applications of nano-technology have been gaining popularity in different fields of science and technology, especially in concrete industries. The developments of new materials within new functions or improvements in the properties of existing materials using nano-technology are new areas of interest in civil engineering [1,2]. These concrete products can already be seen today through many current applications such as surface coatings, self-cleaning capacity, and fire resistance [3]. The physical and chemical reactions, microstructure of concrete, improvement of these concretes and implementing novel methods employing materials with nano-scale are those within the dimension less than 100 nm. These nano-materials can efficiently fill nano-pores in open pores system of hydrated cement mortars and increase strength of mortar-aggregates, mortar-fibers interfaces resulting in an improved the structural properties of contact area and durability of concrete [4–9].

Nano-silica particles possessing high efficiency in concrete technology can improve structural properties of cement-based materials [10]. The behavior of these materials is mainly influenced by chemical reactions at the interface. Therefore, the use of nano-particles in concretes modify their behavior in the fresh and hardened conditions [11]. Nano-SiO_2 behaves not only as a filler to improve the microstructure of cement, but also as a promoter of pozzolanic

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