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Microstructure and Mechanical Property Evaluation of Dune Sand Reactive Powder Concrete Subjected to Hot Air Curing

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Abstract: The use of different sustainable materials in the manufacture of ultra-high-performance concrete (UHPC) is becoming increasingly common due to the unabating concerns over climate change and sustainability in the construction sector. Reactive powder concrete (RPC) is an UHPC in which traditional coarse aggregates are replaced by fine aggregates. The main purpose of this research is to produce RPC using dune sand and to study its microstructure and mechanical properties under different curing conditions of water curing and hot air curing. The effects of these factors are studied over a long-term period of 90 days. Quartz sand is completely replaced by a blend of crushed and dune sand, and cement is partially replaced by using binary blends of ground granulated blast furnace slag (GGBS) and fly ash (FA), which are used alongside silica fume (SF) to make a ternary supplementary binder system. Microstructural analysis is conducted using scanning electron microscopy (SEM), and engineering properties like compressive strength and flexural strength are studied to evaluate the performance of dune sand RPC. Overall, the results affirm that the production of UHPC is possible with the use of dune sand. The compressive strength of all mixes exceeded 120 MPa after 12 h only of hot air curing (HAC). The SEM results revealed the dense microstructure of RPC. However, goethite-like structures (corrosion products) were spotted at 90 days for all HAC specimens. Additionally, the use of FA accelerated the formation of such products as compared to GGBS. The effect of these products was insignificant from a mechanical point of view. However, additional research is required to determine their effect on the durability of RPC.

Keywords: RPC; UHPC; curing regimes; GGBS; hot air curing; SEM

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1. Introduction

Reactive powder concrete (RPC) is an innovative cement-based material with exceptional mechanical and durability properties. Richard and Cheyrezy explained the key principles for developing RPC, including the elimination of coarse aggregates, the reduction in water-binder ratio by using superplasticizers, and the incorporation of small-sized steel fibers [1]. In order to prepare RPC, very fine powders such as Portland cement, silica fume, and quartz powder are utilized. Granular packing of these powders is optimized to achieve maximum density. Thus, RPC can attain compressive strengths greater than 150 MPa, while still maintaining good ductility due to the inclusion of steel fibers.

However, several problems hinder the production of RPC on a large scale. It is well known that the manufacturing of RPC requires high dosages of cement and silica fume. These high amounts not only increase the production cost, but also have adverse effects on the environment, as the cement industry has a very high carbon footprint. Thus, replacing cement and silica fume with mineral admixtures like fly ash (FA) or ground granulated blast furnace slag can resolve this issue [2]. Other types of sustainable cementitious