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Compressive Strength Development of Dune Sand Reactive Powder Concrete (RPC) Under Different Curing Conditions

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Abstract. Reactive powder concrete (RPC) is a special type of concrete with remarkable properties, particularly compressive strength. Some of its main disadvantages include its high cement and SF content, fine quartz with a preferred size of 150 µm - 600 µm, and low water-to-binder ratio. These characteristics increase the cost of RPC production and affect sustainable development. Because of this, researchers have resorted to exploring substitutes to cement and quartz to produce an eco-friendlier type of RPC. Accordingly, this research aims to study the compressive strength development of RPC prepared with dune sand and supplementary cementitious materials (SCM). Three main factors were investigated including 1) replacing cement with 30% ground granulated blast furnace slag (GGBS), 2) using ternary blends of GGBS and fly ash (FA) in RPC, and 3) applying 100^{o}C hot air curing (HAC) to RPC. Overall, the results showed that the compressive strength of HAC and water cured specimens exceeded 120 MPa after 12 hours and 28 days, respectively. Moreover, the compressive strength development of the mixes incorporating SCM was slower than that of the control mix incorporating cement only under HAC conditions.

1. Introduction

Reactive powder concrete (RPC) is considered an innovative type of ultra-high-performance concrete (UHPC) that was developed in the ’90s [1]. RPC exhibits superior properties and microstructural properties as compared to ordinary concrete. Some of its properties as reported in the literature include compressive strength, modulus of rupture, and fracture energy which are typically in the ranges of 200-800 MPa, 25-150 MPa, and 12-40 kJ/m^2, respectively [2], [3]. Such properties make the use of RPC desirable in slender elements, tall buildings, large-span structures [2]. The properties of RPC are usually attained through microstructural engineering approaches which include 1) the replacement of coarse aggregates with fine aggregates (typically quartz) with sizes of 150 µm and 600 µm, 2) the use of high cement and silica-rich components with typical amounts of 800–1100 kg/m^3 and 150–300 kg/m^{3}of cement and silica fume (SF), respectively, 3) reduction of the water-to-binder (w/b) ratio and 4) the incorporation of steel fibers [4].

Although such approaches produce RPC with remarkable properties, there are several disadvantages linked to RPC and its production. For example, the use of quartz which is preferable in RPC is limited due to the quartz scarcity in some countries. Also, the population growth has resulted in a boost in the construction industry worldwide. This has increased the production and use of cement which contributes to around 8 to 10% of the total anthropogenic greenhouse gas (GHG) emissions [5]. The global production of cement in 2019 was estimated to be around 4.1 billion tons and is expected to increase by 216% by 2030 [6]. Therefore, since RPC comprises high cement content as compared to