Journal of Building Engineering 44 (2021) 103238

Contents lists available at ScienceDirect

Journal of Building Engineering

journal homepage: www.elsevier.com/locate/jobe

Impact of using different materials, curing regimes, and mixing procedures on compressive strength of reactive powder concrete - A review

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ARTICLE INFO

Keywords:
RPC
UHPC
Compressive strength
Mineral admixtures
Supplementary cementitious materials
Fibers
Curing regimes
Mixing procedures

ABSTRACT

Reactive powder concrete (RPC) is an ultra-high performance concrete (UHPC) with an enhanced microstructure. Over the past few years, the demand for RPC has increased due to its superior properties. However, RPC is characterized by its low water-to-binder ratio, high cement and silica fume (SF) content, and absence of coarse aggregates which not only harm sustainable development, but also increase the production costs of RPC and generate shrinkage problems. Within this framework, many studies attempted to use different materials to address these problems and produce eco-friendly RPC with similar performance to that of the traditional RPC. The primary objective of this paper is to present an updated review of the literature on the list of materials used for RPC production and assess their viability as partial and full replacement of cement, SF, and quartz sand/powder to produce ultra-high strength RPC. The effects of employing different curing regimes and mixing procedures on the compressive strength of RPC will also be reviewed. The results highlight that 1) the use of alternative mineral admixtures (glass powder, limestone & phosphorous slag) can successfully replace cement by up to 50%; 2) replacing SF with mineral admixtures such as slag and fly ash is possible and can yield comparable results by monitoring the molar Ca/Si ratio of the mixes; 3) Quartz sand/powder can successfully be replaced with other types of aggregates/fillers (titanium slag, glass sand, glass powder, rice husk ash, etc); 4) Waste steel fibers can yield comparable strength results to that of steel fibers and the hybridization of glass-steel and polypropylene-steel improves the strength compared to steel or other types alone; and 5) Four-stage mixing yields better strength properties (up to 22% enhancement) compared to three-stage mixing, but further research is required to confirm this finding and establish standard guidelines for the mixing of RPC.

1. Introduction

Recent advances in concrete technology have led to the development of a new revolutionary material known as reactive powder concrete (RPC). RPC is an ultra-high performance concrete (UHPC) that provides both ultra-high strength and remarkable ductility through microstructural enhancement techniques. In fact, RPC is the most commonly utilized type of UHPC. UHPC is defined with a minimum specified strength of 120 MPa [1]. However, according to ACI Committee 239, the minimum specified strength is even higher at 150 MPa [2]. The term 'reactive powder' in general refers to the idea that all powder components in the concrete react chemically [3]. RPC can be classified into two grades depending on their strengths: RPC200 and RPC800. The compressive and tensile strengths of the former are in the ranges of 150–230 MPa and 20–50 MPa, respectively, and those of the latter are in the ranges of 500–800 MPa and 45–140 MPa, respectively [4,5]. The other mechanical properties, as reported in the literature, include Young's modulus in the range of 50–70 GPa, modulus of rupture in the range of 25–150 MPa, ultimate tensile strain at the order of 1%, and fracture energy in the range of 12–40 kJ/m^2 [5–9]. These superior

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https://doi.org/10.1016/j.jobe.2021.103238
Received 1 June 2021; Received in revised form 1 September 2021; Accepted 1 September 2021
Available online 3 September 2021