Proceedings of the 7th World Congress on Civil, Structural, and Environmental Engineering (CSEE'22)
~~Lisbon, Portugal~~ Virtual Conference – April 10 – 12, 2022
Paper No. ICSECT 152
DOI: 10.11159/icsect22.152

Manufacturing Ultra-High Performance Concrete UHPC with Conventional Production Processes

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Extended Abstract

Ultra-high performance concrete (UHPC) is a composite material that offers interesting opportunities in civil engineering projects through the study of the critical properties of conventional concrete [2], [4]. The use of UHPC includes from the fabrication of precast/prestressed elements for infrastructure construction projects [1], [9], [10], to the manufacture of urban furniture and decorative products [5], [12]. Thanks to its low water content compared to conventional concrete, UHPC has higher mechanical strength, which stands on a low water to binder ratio and an optimized packing density of particles in the composite [6], [7], [13].

The production process is one of the most sensitive variables in the manufacturing of any concrete and becomes more demanding as the required mechanical properties increase considerably in magnitude, as in UHPC. Therefore, it is necessary to guarantee a correct manufacturing method that allows achieving the higher quality standards and that, at the same time, does not imply an overly complex make up methods, with specialized and costly materials and curing regimes [11]. It should be noted that several authors agree that little attention has been paid to the study of economic procedures of fabrication of UHPC [8], [11].For this reason, it is important to understand the production process of this type of concrete and this research analyzes the manufacture of UHPC through conventional economic methods.

In this study, 11 different UHPC mixtures designs were considered and about 30 cylinders (100 mm x 200 mm) were manufactured for each mixture to analyse the relationship between compressive strength, water/cement ratio, and packing density of the matrix.The material used were: general purpose portland cement Type I (ASTM C1157/C1157M-20), quartz sand with a diameter of 300 μm, and spherical steel particles with a diameter of 2.36 mm. A high-range water reducer was also added. Compression tests and splitting tensile tests were performed according to ASTM C39 and ASTM C496. Among the different UHPC mixtures proposed, a maximum compressive strength at 28 days of 120 MPa was found. By using undersized aggregates, the packing density of the matrix was optimized. Using a general purpose portland cement Type I significantly reduces UHPC production costs. The binders used in currently marketed UHPCs are more expensive [3]. The high-range water reducer improves the workability of the mixture.

The production methods and tools used in the fabrication of UHPC in this research are the same as those used in the manufacture of conventional concretes. It is possible to scale up the fabrication of the optimized UHPC mixture proposed in this study for use in-situ; it does not require special high-temperature curing regimes, high intensity mixers or temperature controlled environmental chambers, as is required for currently marketed UHPCs.

In this research, we studied the fabrication of UHPC with readily available materials, through simple manufacturing and curing processes, obtaining compressive and tensile strengths comparable to those of other UHPC currently used.

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