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Tensile Strength of High Performance Concrete

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Extended Abstract

High performance concrete (HPC) and ultra high performance concrete (UHPC) are cement based composites with an optimized gradation of granular constituents and a high percentage of discontinuous internal fibre reinforcement [1]. HPC mix does not have coarse aggregate which is formulated using the particle packing design model to optimize the matrix density and minimize voids [2]. Thanks to its low water content compared to conventional concrete, HPC presents improved mechanical performance and durability [3], [4], [5].

Besides having a high compressive strength which exceeds 50 MPa, current research shows that HPC tensile strength may reach 15 MPa. A higher tensile strength in HPC would lead to higher ductility and to the elimination of reinforcement requirements (i.e., bars, wire, mesh). Therefore, there is more flexibility for using the HPC in a wider range of structural shapes and forms [6], [7]. Despite of high mechanical performance of this type of concrete, there are some barriers to manufacture HPC: high cost of materials, environmental impact, complex fabrication and curing processes [8], [9]. For this reason, it is important to understand the production process.

This research analyses the manufacture of HPC and its tensile strength through conventional economic methods. In this study, 5 different HPC mixture designs were considered and 20 cylinders (100 mm x 200 mm) were built for each one to examine the relationship between tensile strength, water to 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 and splitting tensile tests were performed according to ASTM C39 and ASTM C496. Among the different HPC mixtures proposed, a split tensile strength at 28 days of 5-15 MPa was measured: a value larger than that observed in Shotcrete type concretes, conventional concretes, and HPC found in the literature. By using undersized aggregates, the packing density of the matrix was optimized. Using a general purpose Portland cement Type I significantly reduces HPC production costs. Additionally, the high range water reducer improves the workability of the mixture.

In this research, HPC with high tensile strength was manufactured with common materials and using production methods and tools employed in the fabrication of conventional concretes. The HPC studied here does not require special high temperature curing regimes, high intensity mixers or temperature controlled environmental chambers, as required for currently marketed HPCs. It is possible to scale up the fabrication of the optimized HPC mixture proposed in this study for in-situ applications.

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