Performance of Ultra-High Performance Concrete Containing Mineral Admixtures

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ABSTRACT

This paper presents the development of Ultra-Performance Concrete (UHPC)using High economical materials. UHPC mixture proportions were developed using local materials such as silica fumeso that UHPC may be made more affordable to a wider variety of applications. The Ultra-High Performance Concrete (UHPC) tested in this research is steel fiber reinforced concrete consisting of an optimized gradation of fine powders and a very low water/cement ratio. Experimental investigation was carried out for two different UHPC mixes(Mix1 and Mix2) with different water cement ratio of 0.26 and 0.3 respectively. Both the UHPCmix had different values of steel fibre in terms of volume fraction (1%, 1.5% and 2%). At the end of 28 days it was found that the UHPC Mix1 with water cement ratio of 0.26 showed 31.5% increase in compressive strength for 2% of steel fibre content. Also the UHPC Mix1 showed a higher split tensile strength of about 6.36Mpa.

Keywords: Ultra-High Performance Concrete, silica fume, steel fibers, compressive strength, split tensile strength.

I. INTRODUCTION

The term Ultra High Performance Concrete (UHPC) has been used to describe a fiberreinforced, super plasticized, silica fume cement mixture with very low water-cement ratio (w/c) characterized by the presence of very fine quartz sand (0.15-0.40 mm) instead of ordinary coarse aggregate [2]. The absence of coarse aggregate was considered by the inventors to be a key-aspect for the microstructure and the performance of the UHPC in order to reduce heterogeneity between the cement matrix and the aggregate. However, due to the use of very fine sand instead of ordinary aggregate, the cement density of UHPC is as high as 900-1000 kg/m³[5]. One of the primary benefits of this class of concrete is that it can exhibit significant tensile strength and toughness. Much of such properties enhancement is imparted to the concrete by the addition of short, discontinuous fibers during the mixing procedure [3]. In fact there are limited studies on Ultra High Performance or Reactive Powder Concrete. UHPC's tend to exhibit enhanced strength, ductility, and durability

properties when compared to high-performance concrete [4].UHPC could have a compressive strength 2 to 3 times greater than High Performance Concrete and a flexural strength 2 to 6 times greater, and such mechanical properties of UHPC make it ideal for prestressing applications. It was also stated that before UHPC could be used in a prestressing application, bond performance between the UHPC and the prestressing strands had to be seriously investigated [1] [6].Compressive strength that is greater than 150Mpa internal fiber reinforcement to ensure non brittle behavior and a high binder content with special aggregates. The constituents are cement, fine sand, silica fume, quartz powder, super plasticizer, a low watercement ratio, and inclusion of either high-strength steel fibers or nonmetallic fibers [8] [7].

II. MATERIALS

A. Cement

The Ordinary Portland cement of 53-grade was used in this study conforming to IS: 12269-1987 [9]. The specific gravity of cement is 3.15. The initial and final setting times were found as 35 minutes and 178 minutes respectively. Standard consistency of cement was 31%.

B. Fine aggregates

The river sand is used as fine aggregate conforming to the requirements of IS: 383-1970 [10], having specific gravity of 2.62 and fineness modulus of 2.86 has been used as fine aggregate for this study.

C. Silica Fume

A white undensified Silica Fume (SF) with Blaine fineness about $200(m^2/g)$ is a pozzolanic material which has a high content of amorphous silicon dioxide and consists of very fine spherical particles. It reacts with calcium hydroxide Ca(OH)₂, producing calcium silicate hydrate (secondary gel). It is added as partial replacement by weight of cement.The specific gravity of silica fume is 2.2.

D. Water

Water used for experiments was potable water conforming as per IS: 456-2000 [11]

E. Steel fibers

The Fibers are used to increase tensile capacity and improve ductility. Straight brass coated steel fibers 13 mm long with a diameter of 0.2 mm and an aspect ratio of 65 were used throughout the experimental program.

F. Chemical admixture

A high performance concrete superplasticize rpolycarboxylic Ether Pc 8860 was used to ensure a good consistency and stability in concrete.

III. EXPERIMENTAL PROCEDURE

Admixtures for ultra high performance concrete namely silica fume was used in both mixes, Mix1 and Mix2 with three different steel fibers of volume fraction 1.0 %, 1.5% and 2.0%. A total of 18 cubes and 18 cylinders were casted and tested in this study. Each specific UHPC mix was tested uniaxial compression to assess under the compressive strength of UHPC at 3,7, and 28 days.Mix1 has w/c ratio of 0.26 and Mix2 has w/c ratio of 0.30. Similarly the Mix1 and Mix2 were tested for its split tensile strength at 3, 7 and 28 days. Table 1 and Table 2 shows the compressive strength and split tensile strength of UHPC Mix1 and Mix2.

Table 1. Mix Proportion and Strength of concrete UHPC in Mpa

UPHC Mix	Mixture details				Compressive Strength, (MPa)		Split Tensile Strength, (MPa)	
	Cement (Kg/m ³)	Silica Fume (%)	Steel Fiber (%)	w/c ratio	7 days	28 days	7 days	28 days
Mix 1	709	10	1	0.26	56	108	1.9	3.8
	709	10	1.5	0.26	61	126	2.7	5.4
	709	10	2	0.26	71	152	3.18	6.36

Table 2. Mix Pro	portion and Strength o	of concrete UHPC in Mpa
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UPHC Mix	Mixture details				Compressive Strength, (MPa)		Split Tensile Strength, (MPa)	
	Cement (Kg/m ³)	Silica Fume (%)	Steel Fiber (%)	w/c ratio	7 days	28 days	7 days	28 days
Mix 2	710	10	1.0	0.30	38	90	1.25	2.19
	710	10	1.5	0.30	40	95	1.73	3.79
	710	10	2.0	0.30	44	104	2.08	4.64

IV. RESULTS AND DISCUSSION

- 1. An increase in volume fraction of fibers from 1.0% to 2.0% in mix1 showed an increase of compressive strength from 108Mpa to 152Mpa at 28 days as shown in fig 1.
- 2. An increase in volume fraction of fibers from 1.0% to 2.0% in mix2 should an increase of compressive strength from 90Mpa to 104Mpa at 28 days as shown in fig 2.
- 3. Hence compressive strength of mix1 with steel fibre of volume fraction 2% found to have an increase of 31.57% [4] when compared to mix2 at the end of 28 days.

- 4. The split tensile strength for mix1 was found to increase from 3.80Mpa to 6Mpaas shown in fig.3 and the split tensile strength for mix2 was found to increase from 2.19Mpa to 4.64Mpa[4] at 28 days as shown in fig.4.
- 5. Hence split tensile strength of mix1 with steel fibre of volume fraction 2% found to have an increase of 24.07% when compared to mix2 at the end of 28 days.







Figure 2. Compressive Strength of UHPC Mix2 for w/c 0.30



Figure 3. Split Tensile Strength of UHPC Mix1 for w/c 0.26



Figure 4. Split Tensile Strength of UHPC Mix2 for w/c 0.30

V. CONCLUSION

- 1. It is concluded from the above discussion that the mix1 with w/c 0.26 and silica fume 10% and steel fibre of 2% result in increase of compressive strength as well as split tensile strength.
- 2. The addition of steel fibres content improves the compressive strength and split tensile strength at the age of 28 days. It is recommended to use of steel fibres as an enhancing material to UHPC.
- 3. Hence UHPC using locally available materials can be used in order to manufacture precast

ultra performance concrete in an economic manner.

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