PERFORMANCE OF ULTRA HIGH-PERFORMANCE CONCRETE USING STEEL FIBRE

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Abstract

Ultra High-Performance Concrete (UHPC) is another brand of new generation constructing materials with exceptional feature and incredible mechanical characteristics. The aim of this investigation to evaluate the compressive/crushing strength and split/direct tensile strength for several ages of UHPC. Cement, silica fume (SF), marble waste as binder, fine aggregate, W/B as 0.18 and 0.20, SP as 2.6% and Steel fibres of 0 to 2% were the material used for making concrete. Totally 8 mixes were used for investigation, two without fibre and 6 mixes with Steel Fibre. Crushing strength and Direct tensile strength enhances with the escalate in Steel Fibre addition for two water binder ratios. Maximum crushing strength of 142MPa was attained for UHPC7 blend containing 1.5 percentages of steel fibres and water binder ratio as 0.18. Utilization of marble waste powder as a replace in cement will enhance economy and ecology of the environment.

Keywords — Ultra High-Performance Concrete; Marble Powder; Steel Fibre; Compressive Strength; Split Tensile Strength.

INTRODUCTION

Ultra High-Performance Concrete (UHPC) is another brand of new generation constructing materials with exceptional characteristics and incredible mechanical properties. It is material that is utilized worldwide because of its potential over typical concrete being progressed, quickened, and improved. UHPC has superior strengths which might be about ten times the energy of traditional concrete. The blends of UHPC require increasingly binder materials because of the exclusion of mix inside the concrete when contrasted with traditional concrete [1-3]. With the world watching out for a progressively green sort development, the amount of cement can be supplemented by other siliceous additives, for example, fly debris. The excessive power of concretes along with UHPC is characterised by using lesser water binder ratio. Besides, to enhance the quality, it has a lesser porosity and expands the material protection from disintegration and corrosion that regularly happen in the structures. Because of enhanced behaviour, utilizing UHPC can have a more drawn out assistance life and making it a progressively handy material for practically all auxiliary applications [4, 5].

Materials such as silica fume, cement, quartz powder and sand were utilized for granular packing to upgrade the mechanical and durability performance. Results are compared with hypothetical packing model [6]. In UHPC choice of element and methods of curing take part in crucial attainment function in strength behaviour due to its pozzolanic activity [7]. Binder material used for making UHPC were OPC, FA, SF and GGBFS, silica sand and steel fibres. The impact on the hydration conduct, microstructure, mechanical and volume properties is examined close by the assessment on the environmental exhibition of UHPC blends containing steel slag. With the replacement of steel slag affect the initial hydration is slower, which in turn affect the compressive strength in initial ages but, in term of long-term strength its affects marginally with upgraded eco-amicability of UHPC blends containing steel slag [8]. Sleepers were created utilizing the enhanced UHPC blend with coarse aggregates and GGBFS. It exhibits that the bendable trait of UHPC strengthened with steel strands brought about stable basic conduct and remarkable break obstruction abilities considerably after the underlying splits created. [9]. Attempts have been made on the implementation of steel fibres and SF on the hardened strength and fracture behaviours of UHP geopolymer concrete [10]. The ecological

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effect of ordinary Portland Cement (OPC) is huge; its manufacturing emits enormous amounts of CO_2. Replacement of cement with industrial by-products or waste materials with binding characteristics benefits to reduce the emission of carbon dioxide [11].The utilization of these materials, as partial or complete substitution will rise in cost-effective and ecological benefits. It has been predicted that numerous million lots of marble dirt are generated all through quarrying around the world. Consequently, usage of marble dust has embellished a significant effective material in the productive use in mixes for superior characteristics of concrete. Based on the above perspective marble waste materials and silica fume were utilized for the replacement of cement for making ultra-high-performance concrete as investigated in the current work.

MATERIALS AND MIX

A. Materials Used

1. Cement

The OPC-53 grade was utilized in the experimental investigation as per IS 12269-2013. The Specific gravity of OPC-53 grade is 3.14. The consistency of OPC-53 is 33%.

2. Fine Aggregates

The fine aggregate used in the experimental work is the conventional river sand available at the local site and it is conforming to the IS 383-2016. The fine aggregate having specific gravity of 2.61 and the bulk modulus of 1586 kg/m^3.

3. Silica Fume (SF)

SF is having a siliceous property, so it is used as a partial substitution for cement its specific gravity as 2.2.

4. Marble Dust

Marble dust powder is metamorphic rock composed of carbonate material. The Marble dust has the specific gravity of 3.1.

5. Steel Fibres

A steel fibre of 0.2 mm as dia was used in the investigation and the aspect ratio depends on the cube casting.

6. Water Reducing Admixture

In the present investigation a high-performance super plasticizer for concrete based on a Poly Carboxyl ate Ether polymer is used. The percentage of super plasticizer used in the investigations is 2.6 % of binder content.

7. Water

The water used for blending and curing process should be portable, without salts and other impurities and pH value as per Indian Standard.

B. Mix proportion

UHPC mixes were arrived from the trials as there is no specific code available for mix design, based on the workability behaviours satisfaction condition. Mix have arrived with the materials of cement, SF, marble dust as binder contents and fine aggregate, SP as 2% is arrived with W/B ratio of 0.2. The principal parameter of the UHPC is very denser. The final mix in the ratio of 1:1.3 (Cement: Fine Aggregate). The various mixes are listed in Table 1. Two mixes without fibres and six mixes with steel fibres with two independent W/B ratios are used as 0.18 and 0.2.

TABLE 1MIXES/BLENDS OF UHPC

S.NO	***MIXES***	***CEMENT (Kg/m^3)***	***SF (Kg/m^3)***	***MARBLE DUST (Kg/m^3)***	***FA (Kg/m^3)***	***Steel Fibre (%)***	***W/B***
1	*UHPC1*	*655.4*	*151*	*201.6*	*1310*	*0*	*0.2*
2	*UHPC2*	*655.4*	*151*	*201.6*	*1310*	*1*	*0.2*
3	*UHPC3*	*655.4*	*151*	*201.6*	*1310*	*1.5*	*0.2*

4	*UHPC4*	*655.4*	*151*	*201.6*	*1310*	*2*	*0.2*
5	*UHPC5*	*655.4*	*151*	*201.6*	*1310*	*0*	*0.18*
6	*UHPC6*	*655.4*	*151*	*201.6*	*1310*	*1*	*0.18*
7	*UHPC7*	*655.4*	*151*	*201.6*	*1310*	*1.5*	*0.18*
8	*UHPC8*	*655.4*	*151*	*201.6*	*1310*	*2*	*0.18*

RESULTS AND DISCUSSION

Compressive strength of UHPC without fibres for two independent water binder ratios for 7 and 28 days are shown in Figure 1. With the increase in W/B from 0.18 to 0.2 its crushing strength decreases for about 12%. Crushing strength at 28 days varies between 102 to 116 MPa.

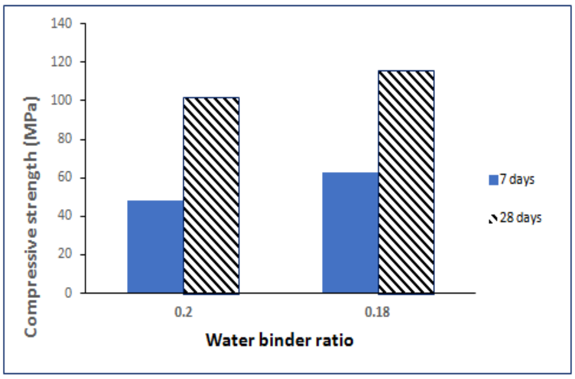

Fig. 1 Compressive Strength without Fibre Vs W/B ratio

From the Figure 2 it shows that attainment of strength at initial stage of development that is seven days is less when compared to attainment of crushing strength at 28 days. Addition of steel fibre escalates the crushing strength gradually for 1 and 1.5% of steel fibre in UHPC. With further increment in fibre content decreases the crushing strength marginally. The crushing strength with water binder ratio 0.2 varies

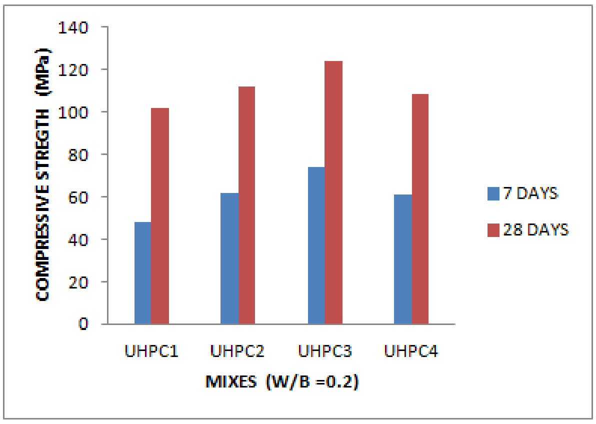

Fig. 2 Compressive Strength with various percentage of Steel Fibre (W/B = 0.2)

between 112 to 108 MPa. The maximum attainment of compressive strength is 124 MPa for 1.5% fibre in UPHC3. Same pattern of strength attainment is observed in 7 days also. Average increase in compressive strength from 7 to 28 is about 54% which is extremely more when compared to normal concrete.

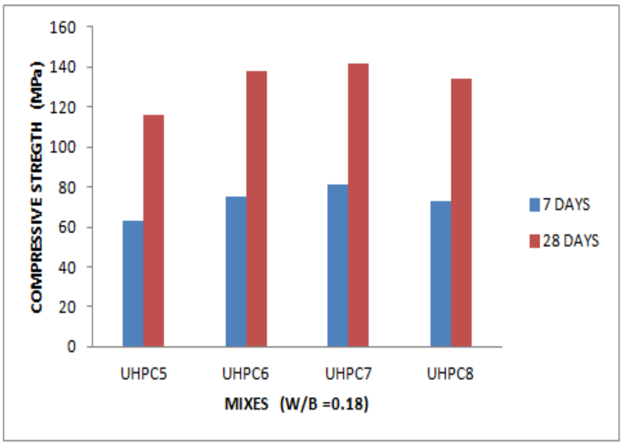

Fig. 3 Compressive Strength with various percentage of Steel Fibre (W/B =0.18)

Development of compressive strength for different steel fibre content used in UHPC blends are illustrated in Figure 3. The crushing strength varies between 63 to 81 MPa for 7 days and 116 to 142 MPa for 28 days. Percentage attainment of crushing strength from 7 to 28 days has almost similar to water binder as 0.2. The crushing strength of UHPC blends raises with the increment of steel fibre, same pattern has been seen in water binder ratio of 0.18 also as 0.20. Maximum compressive strength is 142 MPa for 1.5% of steel fibre in the UHPC7 blend. Variation of direct tensile strength with and without steel fibre utilization with the increment of 0.5% steel fibre for W/B as 0.2 & 0.18 are shown in Figure 4 and 5

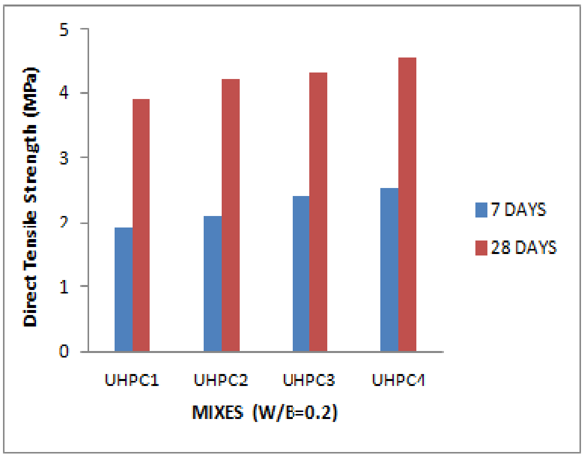

Fig. 4 Direct Tensile Strength Vs Percentage of Steel Fibre (W/B = 0.2)

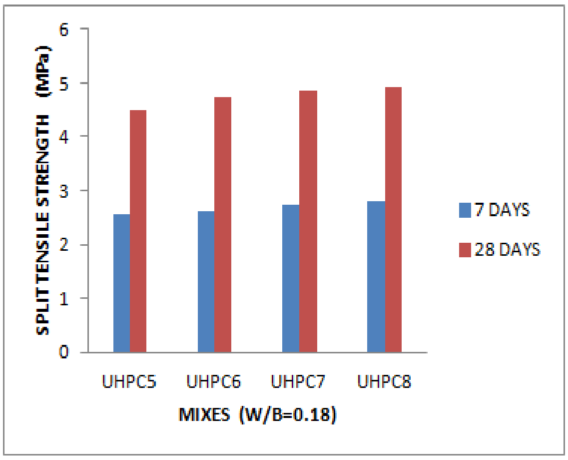

Fig. 5 Direct Tensile Strength Vs Percentage of Steel Fibre (W/B = 0.18)

It has been noticed that direct tensile strength follows the same patterns as replicated in crushing strength of the blends. Utilization of steel fibres enhanced the split tensile strength gradually for both W/B ratios. The direct tensile strength varies between 1.92 to 2.54 MPa for 7 days and 3.91 to 4.56 MPa for 28 days with the water binder ratio of 0.2. Similarly, for water binder ratio of 0.18 its 28 days strength varies between 4.48 to 4.92. Maximum split tensile strength the observed at 2% of steel fibres for both water binder ratio. By comparing the incremental raise in the direct tensile strength of 1.5% steel fibres attained highest split tensile strength for both case (UHPC3 and UHPC7). Highest Direct tensile strength was noticed as 4.92 MPa by considering both fibres and also water binder ratio.

By considering the Crushing strength and direct tensile strength into consideration the suitable percentage of steel fibre is 1.5%. In general, the strength attainment is more in case of reduced W/B; same pattern is noticed in this study also. For further progress of W/B ratio of 0.18 is considered for preparation of ultra high-performance concrete. Utilization of marble waste powder as a replace in cement will enhance environmental and ecological benefit. Further, reduction in CO_2 was assessed while producing the cement. It also reduces the disposal problem of waste marble powder, which in term better sustainability to the environment.

Conclusions

The following observations were identified in this investigation

a. Utilization of steel fibre addition up to 1.5% in the mixes indicates raises in Compressive strength for both water binder ratios.

b. Same trend is followed in split tensile strength of UHPC.

c. Maximum Crushing strength of 142MPa was observed for the mix as UHPC7 with 1.5% steel fibres and water binder as 0.18.

d. Maximum split tensile strength observed as 4.92 MPa.

e. Sustainable environmental were developed by replacement of cement by Marble powder.

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