Study on the strength characteristics of High strength concrete with Micro steel fibers

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Abstract. The study of High Strength Concrete (HSC) has become interesting as concrete structures grow taller and larger. The usage of HSC in structures has been increased worldwide and has begun to make an impact in India. Ordinary cementitious materials are weak under tensile loads and fiber reinforced cementitious composites (FRCCs) have been developed to improve this weak point. High Strength concrete containing Alccofine as mineral admixture and reinforced with micro steel fibers were cast and tested to study the mechanical properties. The concrete were designed to have compressive strength of 60 MPa. Mixtures containing 0% and 10% replacement of cement by Alccofine and with 1%, 2% and 3% of micro steel fibers by weight of concrete were prepared. Mixtures incorporating Alccofine with fibers developed marginal increase in strength properties at all curing days when compared to control concrete.
Key words: HSC, Alccofine, Micro steel fibers, Fiber content, Compressive strength, split tensile strength.

1. Introduction

The study of high strength concrete has become interesting as concrete structures grow taller and larger. The usage of high strength concrete in structures has been increasing worldwide and has begun to make an impact in India. A few years ago, a characteristics compressive strength 40 MPa would have been considered high in India but now it has become normal phenomena. Presently, concrete with a 28 days curing and characteristics cube strength of 60 MPa and above will be considered as HSC. The achievement of such HSC has been made possible primarily through the introduction of supplementary materials viz. silica fume, slag, Alccofine, fly ash etc. The addition of micro steel fibers to concrete is expected to arrest cracks, improved ductility and post cracking performance of concrete and improve bond and corrosion resistance due to superior performance.Today Engineers have shown keen interest to introduce ingredients in concrete containing mineral and chemical admixtures. The purpose of adding Alccofine and steel fibers to concrete is to improve the strength, crack resistance, strain capacity and toughness parameter of concrete. Shahid Iqbal et.al [1] found out that by varying in the addition of micro steel fibers form 0 to 1.25% the concrete increases its compressive strength in the beginning and then reduces but the split tensile strength is gradually increased till final. Saurav and Ashok Kumar Gupta [2] found that by addition of a supplementary cementatious material alccofine the compressive strength can be increased by varying the percentages from 0 to 18% the optimum was found to be 13% for M50 grade. Jianming Gao et.al [3] found that addition of steel fibre to light weight improved its strength characteristics improving the compressive strength to some extent and by increasing the split tensile and flexural strength largely. Thus they came to a conclusion that by

varying the fiber content in light weight concrete by 1-1.5% is extremely effective in improving the strength and toughness of concrete. Song et. al [4] found that for a high strength concrete by addition of 1.5% fibre showed maximum strength and above that percentage showed to decrease in strength but the split tensile strength showed increasing in strength by increasing in fibre volume fractions. Fouzia and Yatin et. al [5&6] found that by varying the percentages in the replacement of cement by metakaolin showed improved strength but the maximum strength was achieved when the cement was replaced by 10% of alccofine. Zoubir et.al [7] found that by addition of sulfuric acid the changes in weight and compressive strength was checked for 30, 60, 90,120 and 180 days

2. Experimental Programme

Experimental work was carried out to study the basic strength properties of the alccofine blended high strength concrete of M60 grade prepared with micro steel fibers at the percentages of 1,2 and 3 percent by weight of cement. A design mix was done as per ACI method [8] 1:0.56:1.89 with water- binder ratio of 0.33, and aggregate binder ratio of 2.0 was adopted in this investigation. In the case of super-plasticizer, the water-binder ratio was reduced from 0.33 to 0.3 and then super-plasticizer was added between 0.8 to 1.2 per cent depending upon the quantity of cement used.

Table 1.Materials and its properties

Property of Cement	Value	Grade/Type/ Source
Specific Gravity	3.12	OPC-53
Initial and Final setting time	60 and 450 minutes	
Property of Fine aggregate		
Specific Gravity	2.65	Locally available river sand passing through 4.75 mm and retained on 2.36 mm sieve was used .
Fineness Modulus	3	
Coarse aggregate		
Specific Gravity	2.7	Locally available 20 mm size was used
Fineness modulus	6.5	
Water Absorption (%)	3	
Water	Ordinary portable water was used	-
Alccofine		As per Manufacturer's
Specific Gravity	2.9	Manual
Bulk density	600-700 kg/m^3	
CaO	31-33%	
SiO_2	33-35%	
Al_2O_3	23-25%	
Micro steel fiber		Go Green Technologies, Chennai
Aspect ratio (l/d)	33-35	
Yield strength	2100 MPa	As per Manufacturer's
Elastic Modulus	2.1 x 10^5 MPa	Manual
Super plasticizer(HRWRA)	Specific gravity- 1.220-1.225	Master Glenium Sky 8233,
	pH $\geq$6	BASF Chemical Company
	Aspect Light Brown Liquid	Limited, Mumbai.
	Relative Density 1.08 $\pm$ 0.01 at 25°c	As per Manufacturer's Manual

During the preparation of concrete mix, the water quantity was divided approximately into three parts and the admixture was added with the third part so that the interaction of admixture with

the water would be more effective than adding it at the beginning itself. Subsequently, after this 10% of alccofine were added as cement replacement. Afterwards, micro steel fiber was added to this by 1, 2 and 3% by weight of concrete. Cubes of size 100 mm × 100 mm × 100 mm, cylinders of 100 mm diameter and 200mm long, 100mm diameter and 50mm long were cast. All the specimens were removed from the mould after giving a minimum period of 24 hours as setting time and curing was done using the curing tank. After 28 days the specimen was then taken from the tank for testing and allowed for surface drying for a minimum period of 5-6 hours. It was placed in ASTM Compressive Testing Machine and allowed to transfer the load at the rate of 2.9 kN/sec. The tests were conducted on concrete specimens for 7 and 28 days of curing. Cubes were tested to evaluate compressive strength of concrete as per IS516 [9], cylinders were tested as per ASTMC496 [10] to determine split tensile strength.

3. Results and Discussion

3.1 Effect of Accofine and Micro steel fiber on Compressive strength

The compressive strength of concrete cubes made with various weight fraction of steel fiber was plotted against different days of curing are shown in figure 1. Three specimens were tested to assess the compressive strength for control and 10% alccofine with steel fiber content (0%, 1%, 2% and 3%) in weight fractions. From results it is clear that the maximum compressive strength is attained for mixes containing 10% alccofine along with 2% fibers at 7 and 28 days of curing and the strength has enhanced for all fiber specimens compared to control concrete. From figure 2, the percentage improvements in compressive strength compared to control concrete are 7.35%, 23.93%, 32.51%, 25.13% and 7.62%, 24.48%, 33.56%, 28.29% at 7 and 28 days respectively.

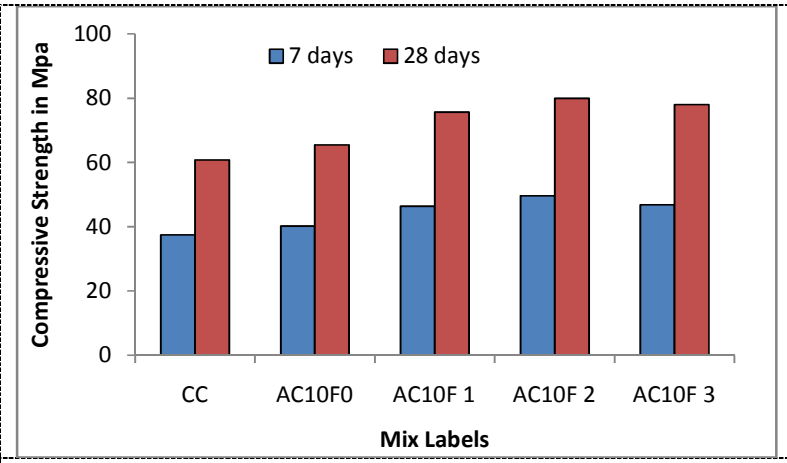

Figure 1. Compressive strength for 10% Alccofine and Micro steel fiber (%)

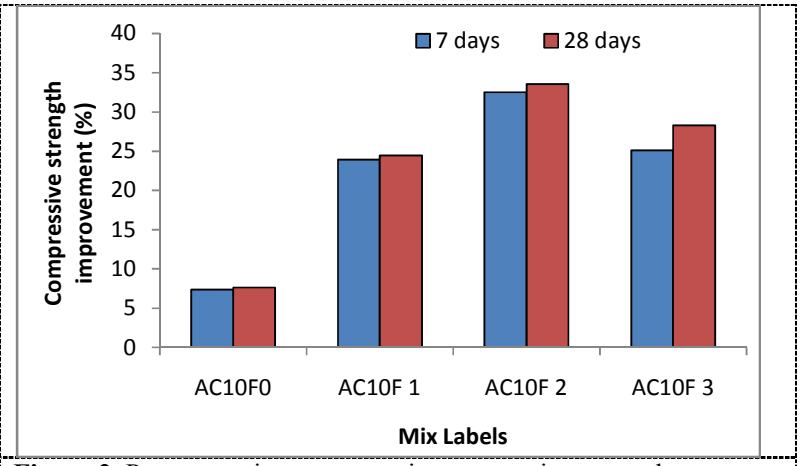

Figure 2. Percentage improvement in compressive strength

3.2 Effect of Alccofine and Micro steel fiber on Split tensile strength

Three specimens were tested to assess the split tensile strength with steel fiber content (0%, 1%, 2% and 3%) in weight fractions. From figure 3 there is an increase in split tensile strength of concrete with the increase in fiber content. The addition of steel fiber to HSC in weight fractions of 3% caused an maximum increase in strength compared to control concrete 7 and 28 days of curing. From figure 4, the percentage improvements in split tensile strength compared to control concrete are 12.12%, 27.88%, 46.46%, 60.8% and 34.29%, 41.76%, 65.57%, 73% at 7 and 28 days of curing respectively.

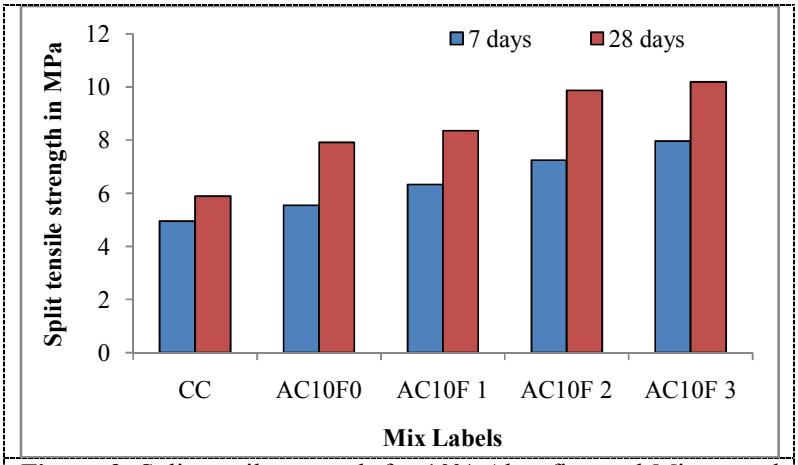

Figure 3. Split tensile strength for 10% Alccofine and Micro steel fiber(%)

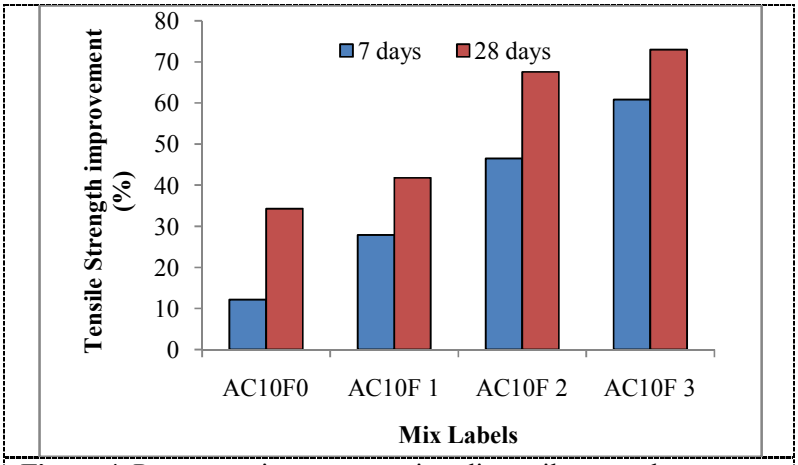

Figure 4. Percentage improvement in split tensile strength

4. Conclusions

From the result of this experimental investigation, the following conclusions were made on the addition of Alccofine and micro steel fibers.

1. The super-plasticizer for this high strength concrete was found to be 0.8 to 1.2 percent to maintain the adequate workability for Alccofine concrete and Alccofine with micro steel fiber concrete.
2. The compressive strength increases for 10% of Alccofine compared with concrete at 7 and 28 days of curing.
3. The compressive and split tensile strength of concrete increases with the addition of steel fiber in Alccofine concrete. The strength improvement was calculated for 7 and 28 days, at all fiber content exhibit superior strength improvement for split tensile than compressive strength.

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