EXPERIMENTAL STUDY ON EFFECT OF SILICA FUME AS PARTIAL REPLACEMENT OF CEMENT IN CONCRETE WITH USING THE ADDITION OF HYBRID FIBER

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Abstract : Concrete is most extensively used in construction industry due to structural stability and strength. In this paper shows the investigation on M 35 grade of concrete with water cement ratio 0.42 due to the inclusion of silica fume and hybrid fiber. Consider various percentage of silica fume as 6%, 8%, 10%, 12%, & 14%, to obtained optimum percentage of silica fume is 10% which used as partial replacement with cement. Addition 0.2% of polypropylene fiber diameter 0.034mm, length 12mm with an aspect ratio 352 and various percentage as 0%, 0.5%, 1.0%, 1.5% & 2.0% of hook end steel fiber diameter 0.6mm, length 30mm with an aspect ratio 50 by weight of cement. Various test conducted for finding out the mechanical properties of concrete like compressive strength at 7, 28 & 56 days. The mechanical properties of hybrid fiber concrete is reasonably good as compared to the conventional concrete.

Keywords **— Cement, Silica fume, Polypropylene fiber, Steel fiber, Compressive strength**

I. INTRODUCTION

Concrete is commonly used as construction material in India with annual consumption exceeding 100 million cubic meter. Concrete traditionally consist of cement, fine aggregate, coarse aggregate and water. Concrete containing mineral admixture such as metakaolin, silica fume, alccofine, GGBS, fly ash, copper slag etc. All of the above mineral admixture, silica fume given the best performance in mechanical properties of concrete.

Silica fume react as highly pozzolanic material in concrete and create additional binder material called calcium silicate hydrated which is improved the both fresh and hardened properties. When silica fume used as a partial cement replacement, it enhanced the effectiveness of addition of fiber on the properties of concrete.

Internal micro cracks are inherently present in the concrete and its poor tensile strength due to the micro cracks, eventually leading to brittle fracture of the concrete. It has been recognized that addition of small, uniformly dispersed and closely spaced fiber in the concrete act as crack arresters and substantially improve the mechanical strength.

Fibers produced as a by-product from industrial processes acts as "secondary reinforcement" in concrete. Number of research done on using single type of fiber as reinforcement in a concrete. However, single type of fiber improves the properties of concrete in a limited range on the contrary hybrid fiber reinforced concrete consist of two or more different types of fibers are mixed in a common matrix.

Many fiber have used in concrete and widely available for commercial application in which steel fiber have an excellent ductility, toughness and improved durability as compared to other fibers. Polypropylene fibers are also compatible with all concrete and possesses the low modulus of elasticity, lower fire resistance, resistance against acids. Polypropylene fiber used as lower volume fraction in fiber reinforced concrete which is decrease the unit weight of concrete and improve the crack prevention.

II. MATERIALS USED

2.1 Cement

Ordinary Portland cement of Ultra tech 53 grade confirming to IS: 12269-1987 was used in this research work. Specific gravity of cement =3.15, Fineness (m^2/kg) = 330, Consistency (%) = 29.8, Initial setting time (min) = 130, Final setting time (min) = 170.

2.2 Fine aggregate

Locally available river sand passing through 4.75 mm IS sieve used as fine aggregate. Conforming to grading zone-II of IS: 383-1970 was used. Specific gravity, Fineness modulus and Water absorption were 2.44, 2.67, 2.02%.

2.3 Coarse aggregate

Crushed aggregate conforming to IS: 383-1987 was used. Specific gravity of 10mm & 20mm aggregate were 2.86 & 2.65. Water absorption of 10mm & 20mm aggregate were 1.21% & 1.61%.

2.4 Water

Water conforming to as per IS: 456-200 was used for mixing as well as curing of concrete specimens.

2.5 Silica fume

Silica fume conforming to IS: 15388-2003 was used. Silica fume is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150 nm. Specific gravity = 2.22.

2.6 Steel fiber

Steel fiber conforming to ISO: 13270-2013 was used. Hook end steel fiber diameter 0.6mm, length 30mm with an aspect ratio 50.

2.7 Polypropylene fiber

Polypropylene fiber diameter 0.034mm, length 12mm with an aspect ratio 352 used in research work. Specific gravity = 0.91.

III. LITERATURE REVIEW

Afroughsabet Vahid, Ozbakkaloglu Togay, 2015 investigated **"Mechanical and durability properties of high-strength concrete containing steel and polypropylene fibers."** A parametric study was conducted to investigate when 10% silica fume was used as a cement replacement improves both mechanical and durability properties of concrete. It was observed that the effectiveness of fibers are incorporated into cementitious concretes to overcome this weakness, producing materials with increased tensile strength, ductility, toughness and improved durability properties. It was concluded that of replacement of silica fume into the matrix improves the bond between the cement paste and the aggregate particles as well as increasing the density of the cement paste, which in turn improves the compressive strength of the concrete. It was further found that an increase in the fiber content of both Polypropylene and steel fiber reinforced concretes results in enhancements in mechanical properties of the concrete.

Taner Yildirim, Cevdet Ekinci, Fehim Findik, 2010 investigated **"Properties of hybrid fiber reinforced concrete under repeated impact loads."** It was found that steel fiber content and length/diameter increases, impact strength of concrete increases and an excellent performance under impact loads. It was further found that polypropylene fiber was the more effective than glass fiber in the hybrid fiber reinforced concrete including 1% volume percent steel fiber. It was founded that the hybrid fibers were quite effective in decreasing each type of cracks in concrete.

Mahmoud Nili, Vahid Afroughsabet, 2011 investigated **"Property assessment of steel fiber reinforced concrete made with silica fume."** It was concluded that the inclusion of steel fiber in silica fume specimens led to the highest long-term

compressive strength and the lowest resistivity. It was found that rate of strength development in the high water–cement ratio specimens was higher than those for low water–cement ratio samples.

Mahmoud Nili, V. Afroughsabet, 2009 investigated **"The effects of silica fume and polypropylene fibers on the impact resistance and mechanical properties of concrete."** It was shows that adding fiber to concrete increases the energy absorption capacity of concrete and provides a more ductile structure. It was concluded that increase of polypropylene fiber in the mixtures from 0.2% to 0.5%, generally increased the compressive strength. They was also investigated that an increased in compressive strength up to 30% at the age of 91 days.

Somasekharaiah, Adanagouda, Basavaraj, 2015 investigated **"Experimental investigation on strength characteristics of silica fume based high performance concrete with steel fiber and polypropylene fiber."** It was shown that addition of polypropylene fiber decrease the unit weight of concrete and increases its strength. It was observed that the composite fibers increase the compressive strength of concrete and also resist the sudden collapse of the hardened concrete. Based on experiments it has been observed that using 1.25% composite steel and polypropylene fiber volume with 10% silica fume concrete increase in compressive strength is 28.61%.It was further found that using 1.25% composite steel and polypropylene fiber volume with 20% silica fume concrete decrease in compressive strength is 4.13%, split tensile strength is 3.21% and flexural strength is 0.91% over plane concrete without fiber.

IV. EXPERIMENTAL METHODOLOGY

Experimental investigation is carried out for M 35 grade of concrete with water cement ratio 0.42. Silica fume used as partial replacement by cement with optimum dosage 10% with containing hybrid fiber. Here used fixed amount of polypropylene fiber 0.2% and hook end steel used various percentage as 0%, 0.5%, 1.0%, 1.5% & 2.0% by weight of cement. The tests are conducted to find out the mechanical properties like compressive strength by using cubes (150mm×150mm×150mm) different concrete specimens cast and tests.

Table 4.1: Mix name with percentage specification of silica fume concrete and hybrid fiber content details

Sr. No.	Mix No.	Silica fume (%)	Steel fiber (%)	Polypropylene fiber (%)
1	Mix – 1 (CC)	0	0	0
2	Mix – 2	10	0	0.2
3	Mix – 3	10	0.5	0.2
4	Mix – 4	10	1.0	0.2
5	Mix – 5	10	1.5	0.2
6	Mix – 6	10	2.0	0.2

V. MIX PROPORTIONS

The concrete used in this study is M 35 grade of concrete designed as per IS: 10262-2009 code specification.

Table 5.1: Mix proportion

Material	Conventional concrete Weight of material (kg/m^3)	Silica fume, Steel fiber and Polypropylene fiber Weight of material (kg/m^3)
Cement	**470**	**423**
Water	**197.4**	**197.4**
Fine aggregate	**640.92**	**640.92**
Coarse aggregate	**1072.82**	**1072.82**
Silica fume	**0**	**47**
W/C ratio	**0.42**	**0.42**

VI. TEST RESULTS

6.1 Compressive strength test:

Compressive strength examine using the cube size 150mm×150mm×150mm conforming to IS: 516-1964. Cubes are cast after 24 hours moulds were demoulded and placed for water curing. Before testing, the cubes were air dried, after crushing load applied noted the average compressive strength of 3 specimens at 28 days. Conventional concrete and silica fume concrete with hybrid fiber compressive strength shown in Table 6.1 and their graphical trends are shown in figure 6.1, 6.2, 6.3 & 6.4.

Table 6.1: Compressive strength results for different mix at 7, 28 & 56 days.

Mix Name	Compressive strength (N/mm^2)		
	7 days	28 days	56 days
Mix - 1 (CC)	24.45	38.93	41.17
Mix - 2	25.68	41.23	44.61
Mix - 3	29.05	44.57	48.15
Mix - 4	31.92	48.10	51.02
Mix – 5	34.83	51.53	53.98
Mix – 6	34.29	51.03	54.71

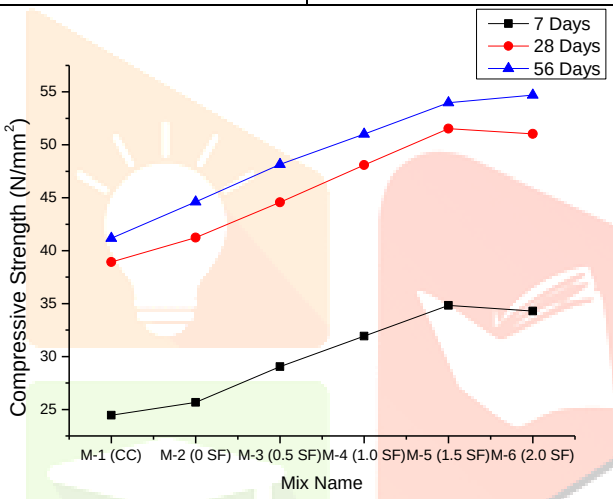

Fig. 6.1 Compressive strength versus different mix containing silica fume with different percentage of hybrid fiber at 7, 28 & 56 days.

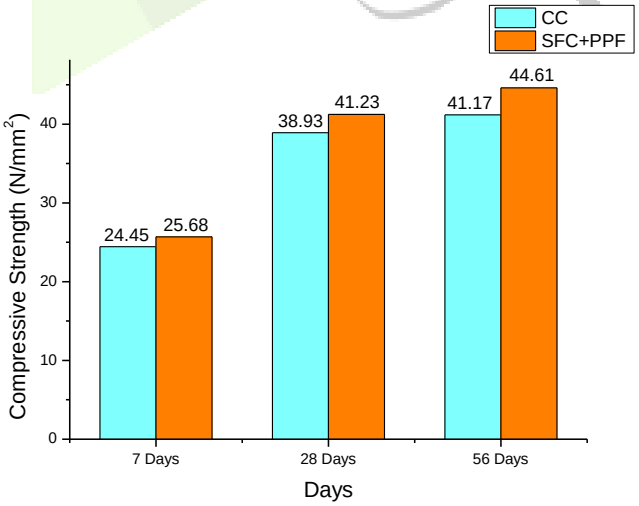

Fig. 6.2 Comparison of compressive strength for conventional concrete specimens & polypropylene fiber specimens containing 0.2% at 7, 28 & 56 days.

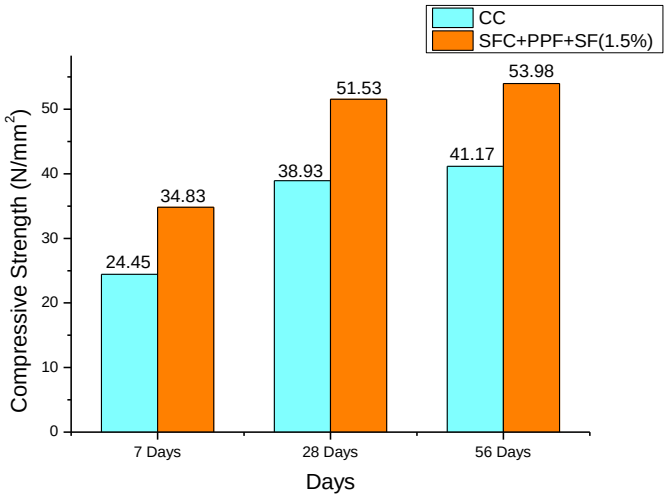

Fig. 6.3 Comparison of compressive strength for conventional concrete specimens & Hybrid fiber specimens containing steel fiber 1.5% at 7, 28 & 56 days.

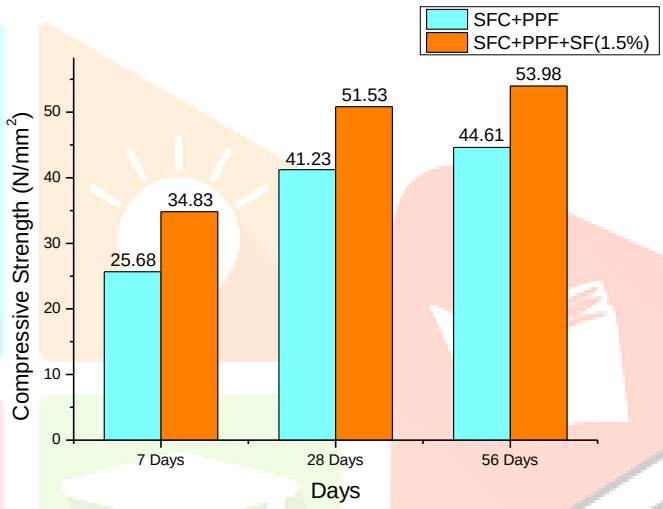

Fig. 6.4 Comparison of compressive strength for polypropylene fiber specimens & hybrid fiber specimens containing steel fiber 1.5% at 7, 28 & 56 days.

VII. CONCLUSION

1. Silica fume optimum dosage taken as 10% which used as partial replacement to cement for giving maximum possible compressive strength at any age for hybrid polypropylene and steel fiber to the concrete.
2. It has found that the effectiveness of polypropylene fiber reduced the bleeding property.
3. The compressive strength of silica fume concrete with using 0.2 % polypropylene fiber & 1.5 % steel fiber of composite mix given strength is 34.83 MPa, 51.53 MPa and 53.98 MPa at 7, 28 &56 days respectively.
4. From experimental results observed that 10 % replacement of silica fume with 0.2 % polypropylene fiber & 1.5 % steel fiber increase compressive strength by 42.45%, 32.36% and 31.11% at 7, 28 & 56 days compared to conventional concrete.
5. From experiments observed that using 10% silica fume with composite fiber optimum percentage recommended as 1.7% in compressive strength for achieving maximum benefits in strength.
6. Polypropylene fiber achieving maximum benefits in strength with very lower volume fraction content. Polypropylene fiber reduce the settlement, water absorption and shrinkage.
7. Compressive strength increase with percentage of steel fiber content increase upto 1.5% after addition of fiber there is no significant increment in strength.

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