

STUDY ON CHEMICAL RESISTANCE PROPERTY OF CONCRETE WITH SILICA FUME

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ABSTRACT: Concrete is the most widely used construction material in India with annual consumption exceeding 100 million cubic metres. It is well known that conventional concrete designed on the basis of compressive strength does not meet many functional requirements such as impermeability, resistance to environment exposure, resistance to frost, thermal cracking adequately. As a result, innovations of supplementary materials and composites have been developed. Therefore, it is felt necessary to improve the strength and performance of concrete with suitable admixtures to cater present need. Due to enhanced mechanical and durability properties, high performance concrete (HPC) has gained wider acceptance in the construction of tall buildings, bridges and marine structures. In the present experimental investigation, the mechanical properties of high-strength concrete of grades M60 at various ages of curing period with different replacement levels of cement with silica fume (SF) are considered. The mechanical and durability properties of M60 grade of high performance concrete with a constant replacement of polypropylene fiber 1.5% and 5%, 7.5% and 10% of the mass of cement by silica fume at a constant water-binder ratio of 0.32 has been considered. The study revealed that the use of waste material like silica fume improved the mechanical and durability properties of high strength concrete, which is otherwise hazardous to the environment and thus may be used as a partial replacement of cement.

KEYWORDS: high performance concrete (HPC), polypropylene fiber, silica fume, mechanical properties, durability properties.

1. INTRODUCTION

High strength silica fume concrete is a concrete that meets special combinations of performance and uniformity requirements which cannot always be achieved routinely using conventional constituents and normal mixing and placing and curing practices. To produce high performance concrete it is generally essential to use chemical and mineral admixtures in addition to the same ingredients, which are generally used for normal concrete. Silica fume is a mineral admixture that can yield concrete of high compressive strength, which obtain 100-150 MPa in the laboratory. In addition, potential advantages of silica fume concrete appear in a better thermal resistance, minimized alkali-silica reactions as well as the enhanced resistance to freezing and thawing. Combining both silica fume and polypropylene fibres to form high strength concrete, the new composite is expected to possess superior properties in terms of strength, cohesion, low permeability and enhanced chemical resistance. At the same time, reduced shrinkage, reduced cracking, high abrasion resistance, high flexural and splitting tensile strengths.

2. MATERIALS AND ITS PROPERTIES

2.1 Cement

The cement used in this study was Ordinary Portland cement of 53 grade conforming to IS 8112-1989 is used. The physical properties of cement was determined by testing the cement as per IS 12269:1987 (reaffirmed 2004) using pycnometer and vicat's apparatus and the test results are shown in Table 2.1.

Table 2.1 Physical properties of OPC 53 grade

Sl.No	Test particulars	Results Obtained
1.	Specific Gravity	3.15
2.	Standard consistency	32%
3.	Setting time	
	(i) Initial setting time	125 mins
	(ii) Final setting time	281 mins

2.2 Fine aggregate

Natural river sand is used as fine aggregate. For sands used in concrete, the fineness modulus generally ranges from 2.3 to 3.1. Aggregates for concrete shall be procured from approved sources conforming to the specifications of IS:383 - 1970 and shall be chemically inert, clean, strong, durable, with limited porosity and free from deleterious materials which cause corrosion of reinforcement or may impair the strength and durability of concrete. The fine aggregate was tested as per the limits specified IS:2386 (Part-3):1963. The properties are shown in Table 2.2. In this study, fine aggregate having a fineness modulus of 2.7 and it confirming to zone II.

Table 2.2 Properties of Fine Aggregate

Sl.No	Test particulars	Results Obtained
1	Specific gravity	2.66
2	Fineness modulus	2.7
3	Bulk density	1.65 kg/m ³
4	Type of sand	Medium sand (zone II)

2.3 Coarse aggregate

In this study, crushed aggregate of size 12.5 mm in angular shape is used its properties are shown in Table 2.3.

Table 2.3 Properties of the Coarse Aggregate

Sl.No	Test particulars	Results Obtained
1	Specific gravity	2.935
2	Density	1567 kg/m ³
3	Impact value	22.12% < 45%
4	Crushing value	24.44% < 45%

2.4 Water

Water is a crucial and important ingredient of concrete, it actively participate in the chemical reaction with the cement in concrete and results in hardening of concrete. The water used was confirming to the requirements of IS 456-2000.

2.5 Super Plasticizer

In this investigation, Super plasticizer Conplast S337, based on Sulphonated naphthalene polymers, complies with IS 9103-1999 and ASTM C-494 was used. Its specific gravity varies from 1.22 to 1.225

2.6 Polypropylene fibers

In this study, polypropylene fibers are used an average diameter of 10 µm, a length of 18mm. Polypropylene fibers with an aspect ratio of 857:1 are used.

3. MIX PROPORTIONS

Water	:	(Cement + SF)	:	F.A	:	C.A
0.32	:	1	:	1.29	:	2.3

4. RESULT AND DISCUSSION

The results of the tests that were carried out on the trial mixes of M60 grade of high performance concrete to determine their strength and durability related properties are presented. The effects of partial replacement of Silica fume and admixtures on the properties of the concrete mixes are also discussed.

The strength related tests such as cube compressive strength, splitting tensile strength, flexural strength and modulus of elasticity tests on hardened concrete were carried out as per the BIS specifications and the test results are shown in Table 4.1 and 4.2.

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization

Volume 3, Special Issue 2, April 2014

Second National Conference on Trends in Automotive Parts Systems and Applications (TAPSA-2014)

On 21st& 22nd March, Organized by

Sri Krishna College of Engineering & Technology, Kuniamuthur, Coimbatore-641008, Tamilnadu, India

The durability related tests such as rapid chloride permeability test, acid and sea water resistance tests, saturated water absorption test, sorptivity and porosity tests on hardened concrete were carried out on as per specifications and tests results are shown in Table 4.3 to 4.5.

Table 4.1 Cube Compressive Strength Results At Various Ages

Mix designation	SF (%)	Average cube compressive strength at various ages (N/mm ²)					
		1 st day	3 rd day	7 th day	28 th day	56 th day	90 th day
CC	0	12.6	37.1	38.8	62.4	64.9	67.4
SF 5	5	13.3	40.1	44	63.9	74.7	77.1
SF 7.5	7.5	13.7	42.6	46.2	69	76.7	78.3
SF 10	10	16.1	38.7	45.7	64.6	75.2	77.9

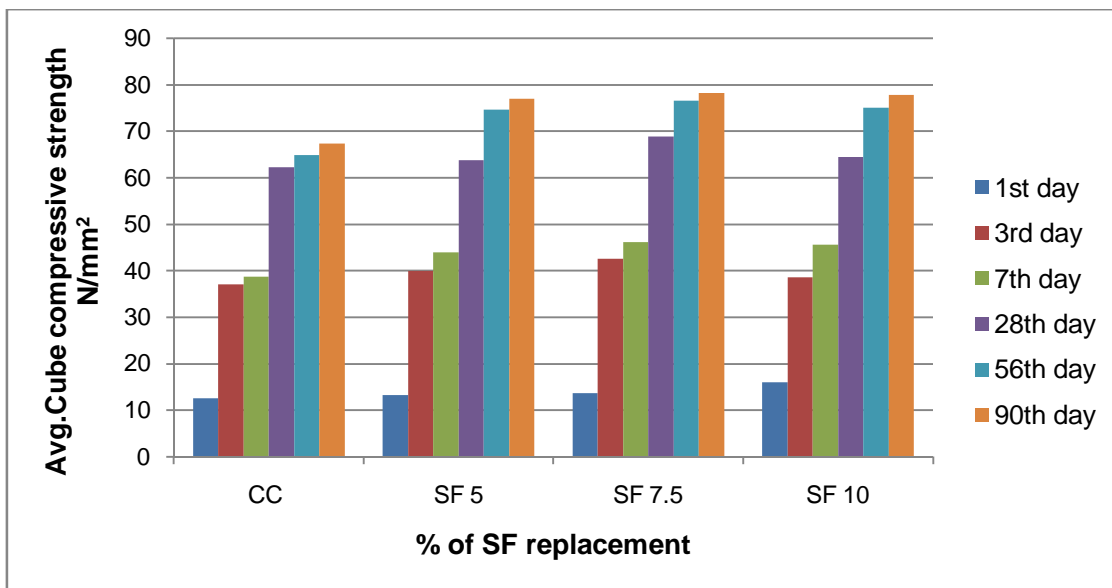


Chart 4.1 Variation of compressive strength for % of SF replacement

Table 4.2 Modulus of elasticity and Tensile strength of concrete at 28th day

Mix designation	SF (%)	Split tensile strength (N/mm ²)	Flexural strength (N/mm ²)	Modulus of elasticity (N/mm ²)
CC	0	5.78	7.5	45000
SF 5	5	6.30	8	50000
SF 7.5	7.5	7.25	9.5	68000
SF 10	10	6.89	9	60000

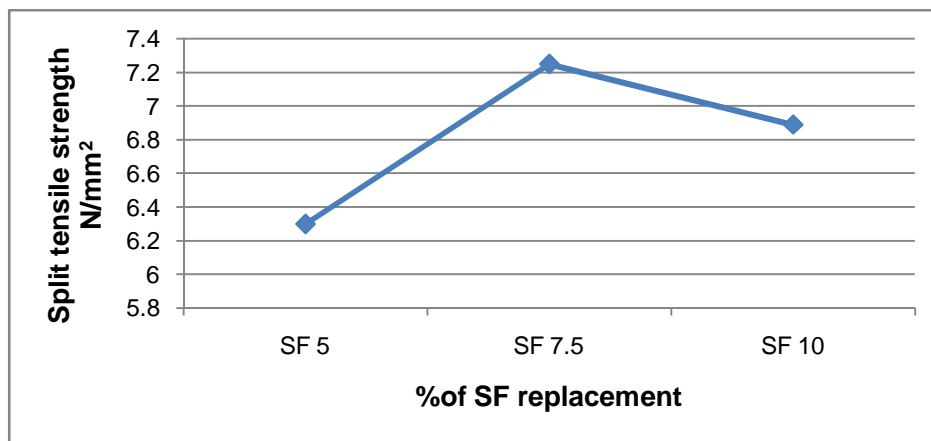


Chart 4.2 Variation of Split tensile strength at 28th day for % of SF replacement

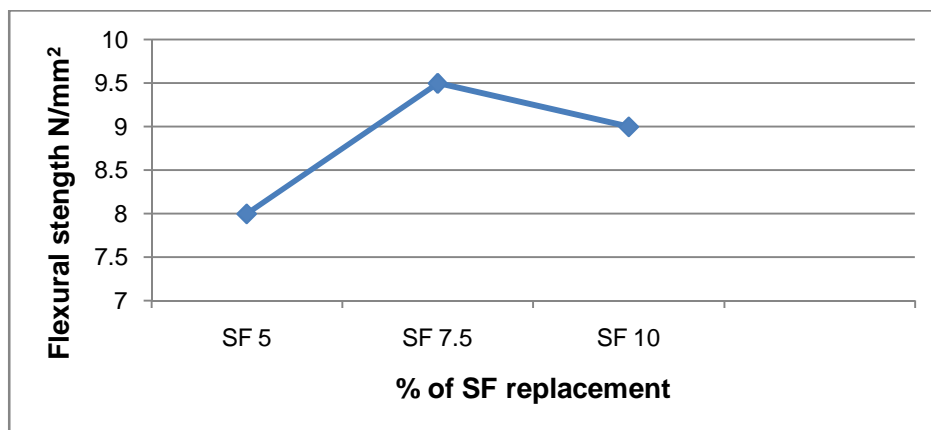


Chart 4.3 Variation of Flexural strength at 28th day for % of SF replacement

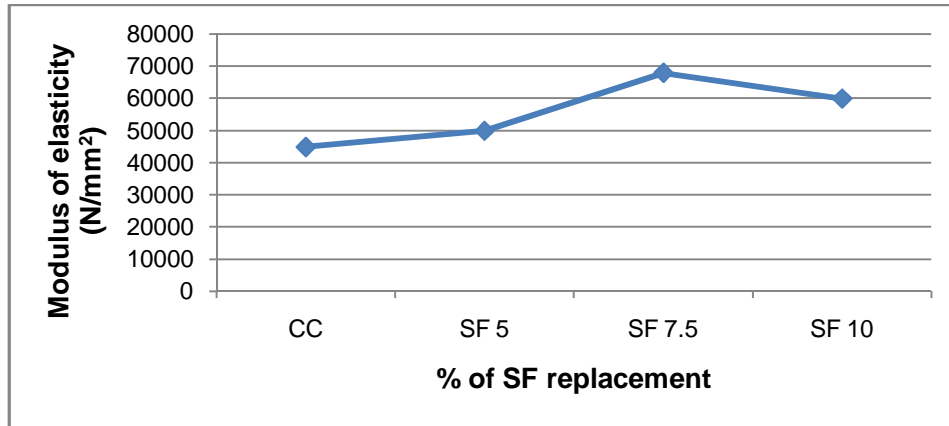


Chart 4.4 Variation of Modulus of elasticity for SF replacement

Table 4.3 Results of Saturated water absorption, Porosity and Sorptivity

Mix identification	Saturated water absorption (%)		Effective Porosity (%)		Sorptivity (mm/min) ^{0.5}
	28 th day	90 th day	28 th day	90 th day	28 th day
CC	1.656	1.652	2.534	2.529	0.085
SF 5	1.586	1.576	2.514	2.510	0.081
SF 7.5	1.553	1.591	2.418	2.412	0.064
SF 10	1.541	1.576	2.396	2.391	0.053

Table 4.4 Rapid chloride permeability results

Mix identification	% of SF replacement	Charge passed as per ASTM equivalent (coulombs)	Chloride Ion Penetrability
CC	0	1368	Low
SF 5	5	909	Very low
SF 7.5	7.5	881.1	Very low
SF 10	10	558.9	Very low

Table 4.5 Acid and Sea water resistance test results

Mix identification	SF(%)	Acid resistance	Sea water resistance
		Loss in weight (%)	Loss in weight (%)
CC	0	0.39	0.86
SF 5	5	0.56	0.7
SF 7.5	7.5	0.45	0.52
SF 10	10	0.43	0.4

5.CONCLUSION

- The average cube compressive strength at 28th day for the mix containing 5%, 7.5% and 10% of SF are increased by 1.2%, 1.5% and 0.8% respectively compared to that of Conventional concrete.
- The split tensile strength and flexural strength for the mix containing SF, the split tensile strength and flexural strength are increasing upto 7.5% SF only.
- The modulus of elasticity of concrete containing SF are higher compared to that of Conventional concrete. There is an linear increment in deformation of concrete.
- The trail mixes with the SF replacement shows less water absorption, porosity and sorptivity than the Conventional concrete. This indicates that the particle size of SF plays an vital role to make the concrete impermeable.
- The concrete mixes contain SF shows better resistance against chloride penetration, acid and sea water attack. This is due to the improvement in the microstructure due to filler effects of SF resulting in fine and discontinuous pore structure.
- The overall performance of SF in both mechanical and durability properties are better than the Conventional concrete. Therefore it can be concluded that NS replacement upto 10% having better mechanical and durability property. From the test results it shows that the optimum content of SF replacement are 7.5% only.
- The partial replacement of SF with cement leads to reduction in consumption of cement usage.

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