

Mechanical and Durability Properties of HSC Containing Silica Fume And 100% M-Sand

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ABSTRACT

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This project is related on the use of Silica fume as a substitution of cement and 100% m- sand as fine aggregate. Concrete is the most widely utilized material in the construction industry and will hold good for years. The credit is attributed to the properties of concrete like excellent strength, durability and less maintenance costs. But in the recent years, the concrete industry is facing a big challenge mainly due to the cement which is a vital component.

In order to improve the durability properties many types of special concretes such as High Strength Concrete, High Performance Concrete, Fibre Reinforced Concrete, Self-Compacting Concrete, etc. have been developed. High performance concrete has become an attractive option to Civil Engineers due to the special characteristics like early strength, ease of placement, permeability, mechanical and durability properties. The performance of High strength Concrete (HSC) is enhanced by the addition of admixtures which act as pozzolans as well as fillers, thereby improving the microstructure of the interfacial transition zone making it denser and impermeable. Silica Fume (SF) is a commonly used pozzolanic material owing to its high silicon dioxide content and fineness. This ultra fine property of SF used in concrete to improve its strength and durability.

Keywords : High strength Concrete, HSC Containing Silica M-Sand

I. INTRODUCTION

Concrete is an important structural material in human history. Concrete holds the credit of being the most widely utilized man-made material in the

construction industry and will hold good for many years. The credit goes to the properties of concrete like excellent strength, durability, less maintenance costs and use in many structural applications. But in the recent years the concrete industry is facing a big

challenge mainly due to the cement which is a vital component. International Energy Agency state that the cement production accounts for 7% of total global carbon dioxide (CO₂) emissions. Worldwide cement production is increasing day by days and it is expected to rise about 5 billion tons by 2020. Thus, CO₂ emission from cement production industries increases 100% by 2020.

1.1 Environmental issues on river sand

The most important sources of sand and gravel are the river banks and flood plains. The fine and coarse aggregates were obtained from river sand, gravel and pebbles from river channels. Sand is a loose, non-cohesive granular material whose size varies between 75µm to 4.75 mm. River sand takes millions of years to be formed and it is a non-renewable resource and very essential part of human life. The process of extraction of river sand is very simple as there is no need of processing other than gradation. But as of now, continuous and indiscriminate sand mining causes serious environmental issues like lowering of river beds, erosion and failure of river banks, damage to the bridge foundations and other structures situated closer to the rivers, coastal erosion and saline water intrusion into the land. Also the transportation of river sand to the construction sites increases its cost significantly.

1.5 Scope of the present study

The present study highlights the strength and durability of HSC involving partial replacements of cement by silica fume and full replacement of natural sand with manufactured sand. Furthermore, the information obtained from the study will be helpful to understand the significance of M-Sand and Silica fume in HPC. To obtain objective of research following methodology is followed:

- To develop a mix for high performance concrete with various combinations of silica fume and 100% replacement of manufactured sand.

- To evaluate the mechanical properties such as
 - (i) compressive strength
 - (ii) split tensile strength
 - (iii) flexural strength and
 - (iv) Modulus of elasticity for various percentage replacement of M-Sand and silica fume.
- To conduct durability experiments on typical HPC mixes to ascertain the suitability of HPC under various environmental conditions

The methodology of the research is presented in **Figure 1.1 and 1.2**

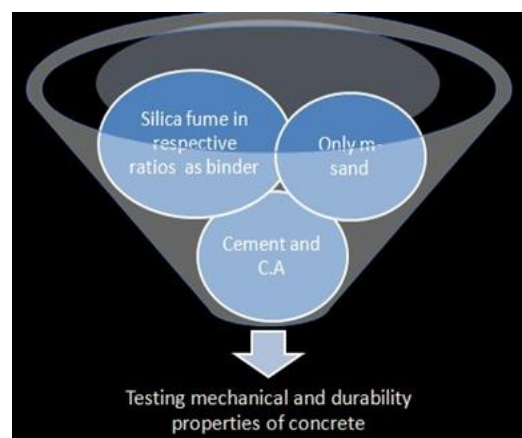


Figure 1.1: Research methodology

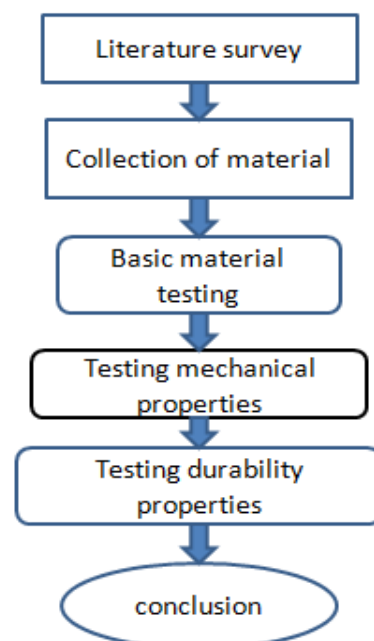


Figure 1.2 : Research methodology

2. Strength and durability properties of silica fume

Kadri & Duval (2009) and Cong et al (1992) conducted the studies on the influence of silica fume on the hydration heat of concrete. Portland cement was replaced by silica fume in 1030% by mass with water - cementitious materials (w/cm) ratios varying between 0.25 and 0.45. They concluded that 10% silica fume in concrete, gives greater cumulative hydration heat and greater compressive strength than reference concrete. At 30% silica fume content, total heat of hydration decreased, since at a later stage the hydration rate of cement slows down and forms less Ca(OH)_2 . The pozzolanic reaction is controlled by the Ca(OH)_2 formation and depends on the available amount of Ca(OH)_2 .

Joshi (2001) studied method adopted for designing and optimizing the M60 grade HPC in the construction of a long bridge connecting Bandra Worli sea link at Mumbai. He concluded that target strength of 74 Mpa could be achieved at 28 days with a minimum cement content of 330 kg/m³, 10% silica fume by weight of cement and 3% of superplasticizer dosage.

3. Properties of material

The constituent materials used in this investigation were procured from the local sources and their characteristics are explained in the following paragraphs.

3.1 Cement

Ordinary Portland cement of C53 grade (Conforming to the requirements of IS: 12269) was used in all these investigations. This cement, in general, also confirms to the provisions of Type I cement as per ASTM. The characteristics of the cement used in the present investigation were presented in the Table 3.1



Figure 3.1: image of cement

Table 3.1: Characteristics of the cement

Sl.	Characteristics	C53 grade
PHYSICAL CHARACTERISTICS		
1	Fineness % (90 passing)	7%
2	Standard consistency	33
3	Specific Gravity	3.15
4	Setting Time	-
	initial (min.)	160
	Final (min.)	247
5	Compressive Strength	
	1 day	24
	3 day	37.5
	7 day	49.5
	28 day	65
CHEMICAL CHARACTERISTICS (%)		
7	SiO ₂	21
8	CaO	64

3.2 River sand

River Sand that is available in nearby locality has been used as fine aggregate. Other foreign matter present in the sand has been separated before use. The specific gravity of sand used in this investigation is 2.60. Properties of river sand are shown in table 3.3



Figure 3.2: image of sand

Table 3.2 : Properties of River sand

Material	Specific gravity	Fineness modulus
River Sand	2.6	2.9

3.3 Water

Water is an important ingredient of concrete as it chemically participates in the reactions with cement to form the hydration product, CSH gel. Potable tap water confirming to the requirements of IS: 456-2000 was used for making concrete and curing.

4. Fresh state Characteristics

4.1 Workability

Workability is defined as the ability or ease with which the concrete is handled, transported and placed in the forms with minimum loss of homogeneity. In the present study, workability was determined using slump cone test for the concretes with different proportions of fine and coarse manufactured sand mixes. The slump test was performed as per IS: 1199 -1959, the slump test is the most well-known and widely used test to characterize the workability of fresh concrete. It is an inexpensive test, which measures

consistency, and is used on job sites to rapidly determine whether a concrete batch should be accepted or rejected. The slump value obtained for 100% M-Sand mixes are presented in Table 4.1 which shows the variation of slump value in concrete mixes with 100% M-Sand and silica fume.

Table 4.1 : Slump values of concrete.

Sl. No.	Name	Slump (mm)
1	C-1	200
2	SF0M	190
3	SF5M	200
4	SF10M	210
5	SF15M	200

4.2 Tensile strength Characteristics

Cylinders of 100mm diameter and 200mm height were used for split tensile strength and this test was carried out in the same compressive strength testing machine at the age of 28 days. The sample was placed horizontally between two platens with two pieces of plywood strips of 220 x 25 x 4mm size on top and bottom of the specimen and the load was applied. Split tensile test of concrete is shown in Fig 4.2

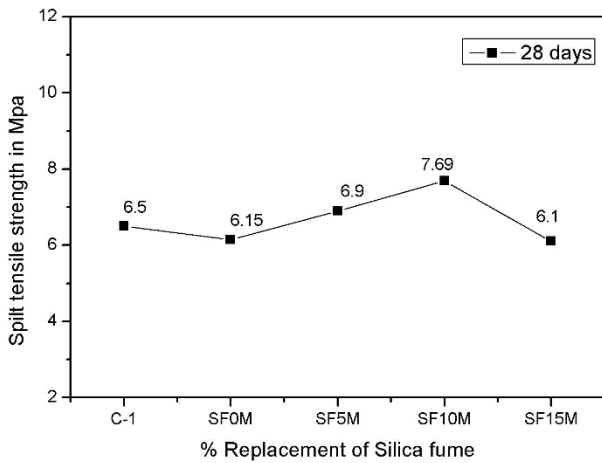
Results are presented in Table 4.3



Figure 4.2 : Split tensile test of concrete

Table 4.2 : 28 days Split tensile Strength of concrete

Sl. No.	Name	Split tensile Strength (Mpa)
		28Days
1	C-1	6.50
2	SF0M	6.15
3	SF5M	6.90
4	SF10M	7.69
5	SF15M	6.10



The split tensile strength results were obtained at the age of 28 days for normal

5. DURABILITY CHARACTERISTICS

5.1 Water absorption

This study was done to know the relative porosity or permeability characteristics of the concretes and was carried out according to ASTM C 642-82 at 28 days.

The specimens used for this test were 100mm cube cured in water for 28 days. The concrete cubes were cleaned by light scrubbing to remove any loose material and the initial weights were taken (w1). The cubes

were dried in a hot air oven at 105⁰c and changes in the weights were measured at regular intervals. This drying was continued till the differences between any two successive weights were less than 0.2% of the lowest weight obtained. Then the specimens were removed from the oven and were allowed to cool to room temperature naturally without absorbing any moisture.

After this, specimens were totally immersed in water (with a minimum of 25mm water on top) and weights were taken at regular intervals (w2, w3.). This was continued till the difference between successive weights (between the final 12 hour intervals) was less than 0.2% of the highest weight (72 hours). The testing of Water absorption is shown in fig 5.1



Figure 5.1: Testing of Water absorption

The results of this study for all the concretes were presented in Table 5.1 and Fig. 5.2 presents a typical variation of absorption with time for the high strength concretes. The initial absorption values (at 30 min.) for all concretes were presented in Table 5.1 which were compared with recommendations given by Concrete Society (CEB, 1989) for 30 minutes (Table.5.2). From these results, it can be seen that, absorption values of the normal as well as the silica fume concrete with 100% m-sand at all strength levels were slightly lower than the limit of 3 % specified for good concretes.

Table 5.1: Absorption characteristics of Silica fume concrete

Sl. No	Name	Initial (g)	Water absorption (%) /Time(hrs)				Final Weig (gms)
			0.6	2.4	4.8	7.2	
1	C-1	243	1.1	2.2	2.3	2512	
2	SF0M	244	0.1	1.1	2.2	2513	
3	SF5M	250	0.1	1.1	2.2	2569	
4	SF10M	253	0.0	1.1	2.2	2594	
5	SF15M	254	0.1	2.2	2.3	2624	

Table 5.2: Assessment criteria for absorption (CEB, 1989)

Absorption (% @ 30)	Absorption Rating	Concrete Quality
< 3.0	Low	Good
3.0 to 5.0	Average	Average
> 5.0	High	Poor

The final absorption results of these (Fig. 5.3 and Table 5.1) shows that conventional concrete has more water absorption than silica fume concrete with m-sand and with increase in strength concrete water absorption has been reduced.

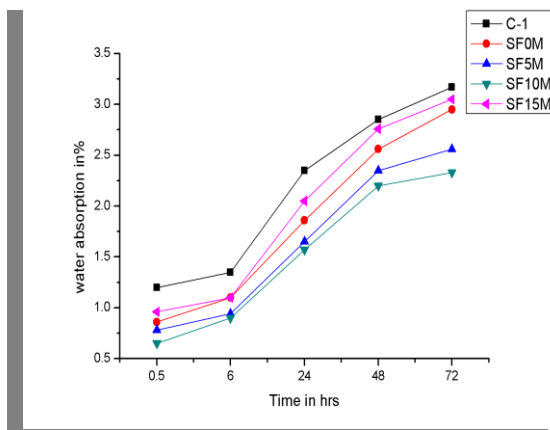


Figure 5.2: Variation of absorption with time of concrete investigated

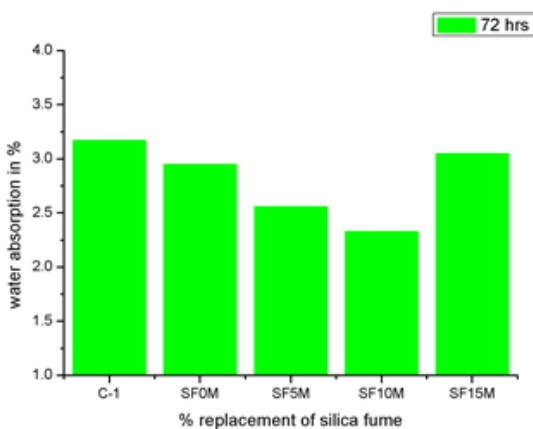


Figure 5.3 : Total absorption values (@ 72 hrs) of concrete investigated

II. CONCLUSIONS

1. The slump value of HSC mixes decreased with addition of 100% m-sand and by using admixture with varying proportion from 0.5 to 1% slump value has been maintained in between 180-200 for all mixes.
2. The mechanical properties like compressive strength, split tensile strength, and flexural strength increased with increase in silica fume in the concrete mix upto 10% replacement. After this percentage of replacement the mechanical properties decreased. Therefore, an optimum replacement of 10% silica fume can be considered.
3. The HPC mixes containing M-Sand were found to be highly resistant to chloride ion penetration when tested by RCPT method. On incorporation of 10% silica fume with 100% m-sand the chloride ion penetration was reduced when compared to control mixes.

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