

# Experimental Investigation on Durability Properties of Silica Fume blended High Strength Concrete

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## Abstract:

The most adaptable building material is concrete, which is created by combining cement, sand, and aggregate with water. After water, concrete is the material that is utilised the most globally. Concrete has a high fire resistance and durability. Yet, the design of the mix, the curing procedure, and the calibre of the materials employed all affect the quality and strength of the concrete. There are now many different kinds of high-strength materials available, including high-strength concrete, thanks to the development of new technologies and materials. The compressive strength of high-strength concrete is claimed to be much higher than that of regular concrete.

This study is mainly focused on the strength properties as well as the durability properties of silica fume based High strength concrete. In this study, SF is kept at a replacement level of 15% in the manufacture of HSC for three different mixes i.e. M60, M70 and M80. In this study, the strength properties viz., compressive strength of HSC was determined at an age of 7, 14 and 28 days of curing and the durability properties viz., Sorpitivity test were studied at 7, 14 and 28 days of curing.

**Keywords:** High Strength Concrete, Silica fume, Durability properties, Sorpitivity test.

## 1) Introduction:

### 1.1 General

In place of normal concrete, high-strength concrete (HSC) is increasingly being employed in a number of building applications [1]. This is because to the unique characteristics of HSC, such as its high compressive strength, improved durability, and reduced permeability. HSC was created by the use of cutting-edge ingredients and procedures such as silica fume, fly ash, and superplasticizers, which increase the mechanical properties and durability of the concrete [2]. One benefit of employing HSC instead of ordinary concrete is the use of smaller cross-sections, which results in less material being utilised and cheaper prices. Moreover, the use of HSC may result in structural components that are lighter and thinner, thereby increasing architectural expression and design flexibility [3].

In this instance, HSC has been used in place of regular concrete to replace the pozzolanic components. Silica fume, a by-product of the manufacture of silicon or ferro silicon, is the primary pozzolanic material used in this experiment [4]. Replacement of silica fume is kept at 15 For the successful and economical use of pozzolanic materials, the relationship between pozzolanic material and cement must be studied [5]. A construction made of concrete should be capable of housing humans for an extended period of time without sacrificing the

material's intrinsic properties [6]. Durability is the long-term need that tenants place on the structure [7]. The strength and durability traits, specifically, Sorpitivity, are the subject of the current investigation.

### 1.2 Objective of the study:

This investigation relates mainly to the production of high strength concrete (HSC) using SF (Silica Fume). In this study, the replacement level of SF kept at 15%. Based on the context of this project, the research comprised the following stages:

- To develop a mixture proportioning process to manufacture High strength concrete replacing Portland cement with Silica fume (Micro silica).
- To study compressive strength of SF based HSC after 7, 14 and 28 days of curing.
- To study the absorption rate of water (Sorpitivity test) by HSC after 7,14 and 28 days of curing.

## 2) Materials used

### 2.1 Cement:

ULTRATECH-53 grade ordinary Portland cement conforming to IS: 12269 -2015 was used in this study for

the manufacture of concrete. The physical and chemical properties of OPC 53 grade are shown in table 1 and its specific gravity is noted to be 3.15.

| Characteristics      | Test Results |
|----------------------|--------------|
| Grade                | 53           |
| Fineness modulus     | 6.5%         |
| Specific gravity     | 3.12         |
| Standard consistency | 32%          |
| Initial setting time | 50 min       |
| Final setting time   | 450 min      |
| Soundness            | 1.2 mm       |

Table 1: Properties of cement

### 2.2 Fine Aggregate:

In this study, natural river sand was used as fine aggregate. The bulk specific gravity in oven-dry condition and water absorption of the sand is observed as 2.6 and 1% respectively. The Fineness modulus of sand is observed as 2.69

### 2.3 Course Aggregate:

In this study, we used natural aggregates of crushed stone of size 10mm as coarse aggregates. The bulk specific gravity in over dry conditions and water absorption of the coarse aggregates of 10mm size are observed as 2.6 and 0.3% respectively.

### 2.4 Silica fume:

The pozzolanic material used in this study is silica fume. Silica fume known as micro silica is one of the by-products of the manufacture of silicon or ferrosilicon metal. It is an amorphous silicon dioxide. In this, the cement is replaced by silica fume at 15%.

### 2.5 Super plasticizer:

In this study, superplasticizer we used Poly- carboxylate ether which is used to reduce the water content in the manufacture of high-strength concrete. This is one of the essentially utilized superplasticizers in concrete cement.

### 2.6 Water:

One of the main components while manufacturing high-strength concrete. In this research, we used potable and drinking water for casting and curing purposes as per the IS 456-2000 coal provisions.

### 3) Mixing, Casting, and Curing:

- **Mixing:** Mixing as per mix design, the silica fume is added at a percentage of 15% by replacing cement with silica fume for three different grades of concrete viz., M60, M70, and M80 grades of concrete.
- **Casting:** For this research work, we proceeded with the casting of 36 cubes of size 100mm \* 100mm \* 100mm and 36 cylinders of size 50mm \* 100mm. These specimens are undergone various tests such as compressive strength and durability tests namely the Sorpitivity test.
- **Curing:** After completion of the casting, the specimens are left for curing. The curing duration may be varied for different tests of specimens. For the compressive strength test and Sorpitivity test, the curing duration is for 7 days, 14 days, and 28 days.

### Mix proportions:

The main objective of this research work is to enhance the compressive strength and durability properties by adding blended materials such as silica fume. As per IS: 10262-2019 guidelines, the mix design is prepared. Here we used M60, M70, and M80 grade concrete shown in table 3, which shows the percentages of cement, fine aggregate, and coarse aggregate by 1:1.97:3.24, 1:1.53:2.48 and 1:1.685:2.75 with water/cement ratio of 0.398, 0.348 and 0.251 each respectively.

| Materials / Grades                        | M60   | M70   | M80   |
|---|-------|-------|-------|
| Cementitious ratio (Kg / m <sup>3</sup> ) | 402.5 | 460   | 517.5 |
| Cement (Kg / m <sup>3</sup> )             | 350   | 400   | 450   |
| Silica fume (Kg / m <sup>3</sup> )        | 52.5  | 60    | 67.5  |
| Water (lt / m <sup>3</sup> )              | 160   | 160   | 130   |
| W/ C ratio                                | 0.398 | 0.348 | 0.251 |
| Coarse Aggregates (Kg / m <sup>3</sup> )  | 1133  | 1101  | 1118  |
| Fine Aggregates (Kg / m <sup>3</sup> )    | 692   | 674   | 692   |
| Super plasticizer (lt / m <sup>3</sup> )  | 3.22  | 3.68  | 4.144 |

Table 2: Mix proportions of concrete.

### 4) Experimental setup:

The cubes and cylindrical specimens were cured as designated above-mentioned conditions and tests were carried out as per IS: 516-1959 for the testing of strength, and IS 1124 (1974) for the Sorpitivity test.

### 4.1 Compressive strength test:

The cubes of size 100mm\* 100mm\* 100mm are tested under the compression testing machine as per IS: 516-1959 under saturated conditions by completely wrapping out the moisture content on the surface period of 7 days, 14 days, and 28 days. The relation between cement and silica fume was done with a silica fume percentage of 15%.



Fig 1(a): Compressive strength test setup



Fig 1(b): Compressive strength reading

### 4.2 Sorpitivity test:

The cylinders of size 100mm\*50mm of grades M60, M70 and M80 are firstly oven dried after curing at a surface period of 7 days, 14 days, and 28 days. Later these specimens are tested by applying epoxy resin to them as per the code IS 1124 (1974). Then these specimens' weights are noted and then placed in the water for about thirty minutes after thirty minutes the specimens are removed from the water and then dried for 30 seconds and then weighed and the test is repeated for about 6 to 8 trials where any two consecutive weights of specimens are equal. After obtaining the weights of the specimens,

the rate of penetration of water into the concrete is calculated.

The Sorpitivity rate is calculated by using the formula:

$$\text{Sorpitivity rate, } S = \Delta W \div (A * \rho * \sqrt{t})$$

Where, S = Sorpitivity rate

$\Delta W$  = Change in weights

A = Area of the specimen

$\rho$  = Density of water

t = time taken for the last testing



Fig 2(a): Weighing of specimen



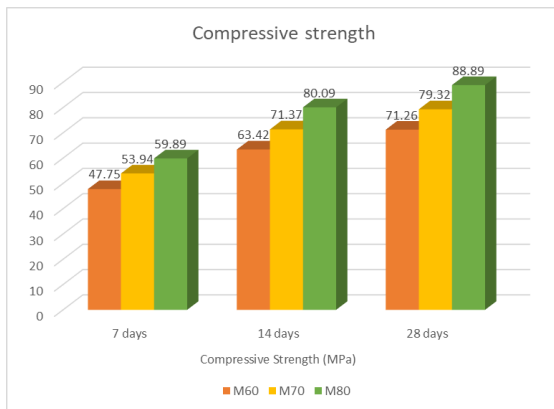
Fig 2(b): Setup for Sorpitivity testing.

## 5) Results:

### 5.1 Compressive Strength:

The compressive strength test results are shown in chart 1. It is seen that concrete of grade M60 attained the minimum compressive strength values when compared to the other two mixes after 7 days, 14 days and 28 days of curing. The mixes of M70 and M80 have attained the maximum compressive strength values of

53.94 MPa and 59.89 MPa when compared to mixes of M60 (47.75 MPa) after 7 days of curing. The mixes of M70 and M80 have attained the maximum compressive strength values of 71.37 MPa and 80.09 MPa when compared to mixes of M60 (63.42 MPa) after 14 days of curing. Likewise, for the age of 28 days, the concrete mix of grade M60 has attained the maximum Sorpitivity value of 1.64. The mixes M70 and M80 attained the Sorpitivity values 1.35 and 1.21 respectively which are less when compared to the mix M60 after 28 days of curing.

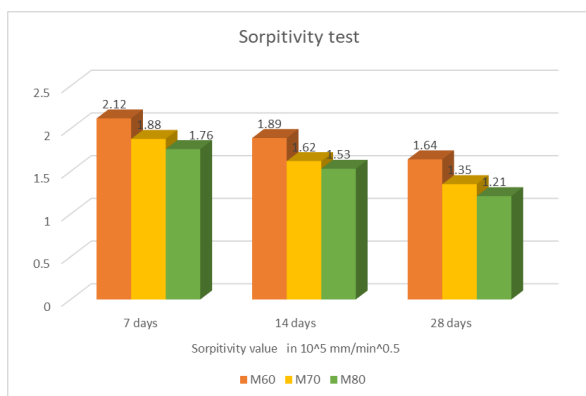


**Chart 1:** The comparisons of compressive strength values for different grades of concrete at different ages.

compared to mixes of M60 (63.42 MPa) after 14 days of curing. The mixes of M70 and M80 have attained the maximum compressive strength values of 79.32 MPa and 88.89 MPa when compared to mixes of M60 (71.26 MPa) after 28 days of curing.

### 5.2 Sorpitivity test:

The Sorpitivity test results are shown in the chart 2. It is clearly observed that concrete mix of grade M80 attained the less Sorpitivity values when compared to those of the other two mixes after 7, 14 and 28 days of curing.



**Chart 2:** The comparisons of Sorpitivity test values for different grades of concrete at different ages.

The concrete mix of grade M60 has attained the maximum Sorpitivity value of 2.12 after 7 days of curing. The mixes M70 and M80 attained the Sorpitivity values 1.88 and 1.76 respectively which are less when compared to the mix M60 after 7 days of curing. Likewise, for the age of 14 days, the concrete mix of

grade M60 has attained the maximum Sorpitivity value of 1.89. The mixes M70 and M80 attained the Sorpitivity values 1.62 and 1.53 respectively which are less when compared to the mix M60 after 14 days of curing. Likewise, for the age of 28 days, the concrete mix of grade M60 has attained the maximum Sorpitivity value of 1.64. The mixes M70 and M80 attained the Sorpitivity values 1.35 and 1.21 respectively which are less when compared to the mix M60 after 28 days of curing.

### 6) Conclusions:

Based on the test results, the following conclusions are drawn:

1. The increase in compressive strength has been observed in the mixes M60, M70 and M80 grades of concrete. It is clearly observed that as the grade of concrete is high then, the higher is the compressive strength.
2. As the age of curing increases, the compressive strength also increases gradually.
3. As the grade of concrete increases, the Sorpitivity value decreases and it is seen that as the curing period of concrete is increasing, the Sorpitivity values are decreasing.

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