

# Design of High Strength Concrete using Silica Fume

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**Abstract**— Generally, for making the civil structures Ordinary Portland cement is used worldwide. Silica Fume can be used as partial replacement for cement to attain high strength. Silica fume is a nonmetallic byproduct waste of industries. It improves properties of concrete i.e. compressive strength and much suitable for concrete mixes. The main parameter investigated in this study is M40 grade concrete with partial replacement of cement by silica fume by 0%, 3.5% and 5%. This paper presents a detailed experimental study on Compressive strength at age of 7, 21 and 28 day. The effect of Silica fume on various Concrete properties are also been tested. This paper provides an objective to understand the effect of Silica Fume on Concrete for mix design of high strength.

**Key words:** Compressive strength, Silica fume (SF), Slump test, w/cm ratio, high strength concrete

## I. INTRODUCTION

Mineral additives are used in concrete widely, especially for reduction of cement required for making concrete which can reduce cost of construction. Mostly, the materials used are byproduct materials and use of these materials shows waste reduction, save in energy consumption to prepare concrete and makes the process ecofriendly to the environment. Silica Fume is one of pozzolona non cementious replacement of cement. It contain 85 to 98% silica. Silica fume, without having any cementious properties, reacts with Ca(OH)<sub>2</sub> on hydration of cement produces the gel i.e. calcium-silicate-hydrate (C-S-H) which has good cementious properties. The American concrete institute (ACI) defines silica fume as a “very fine noncrystalline silica produced in electric arc furnaces as a byproduct of production of elemental silicon or alloys containing silicon”. It is grey colored powder, somewhat similar to Portland cement. Addition of silica fume to concrete improves the durability of concrete, increase the compressive strength and also protect the embedded steel from corrosion, due to the reaction between the Silica Fume and the calcium hydroxide produced by the cement hydration reactions. The advantages of using silica fume in concrete in partial replacement of cement is that in quantity replacement high compressive strength can be achieved. The present experimentation in this paper determine the compressive strength of conventional concrete and concrete using silica fume as replacement.

## II. EXPERIMENTAL INVESTIGATION

### A. Materials

#### 1) Cement

Ordinary Portland Cement of Ultratech brand of 43 grade confirming to IS: 12269-1987(9) was used.

#### 2) Coarse Aggregate

Crushed aggregate confirming to IS: 383-1987 was used.

#### 3) Fine Aggregate

The Bhandara river sand was used as fine aggregate.

#### 4) Water

Water conforming to as per IS: 456- 2000 was used for mixing as well as curing of concrete specimens.

#### 5) Silica Fume

- Silica fume was procured from Steel Wire Industries, Nagpur.
- The chemical composition of silica fume are: Contains more than 90 percent silicon dioxide.
- The physical composition of silica fume are:
- Diameter is about 0.1 micron to 0.2 micron Surface area about 30,000 m<sup>2</sup>/kg. Density varies from 150 to 700 kg/m<sup>3</sup>.

### B. Mix Proportioning

For this study, M 40 grade of concrete and 0.48 as W/C ratio, after calculating the quantities three types of concrete mix are prepared. Type I was conventional concrete (0% SF), type II as concrete with replacement (3.5% SF), type III as concrete mix with (5%SF). Workability is defined as the properties of freshly mixed concrete or mortar which determines the homogeneity with which it can be mixed, placed, consolidated and finished. As per considerations workability slump cone test conducted to represent the work that do be done for compacting the concrete in mould. The following table 1 represents the slump cone test valves.

Types of concrete mix	% replacement of cement by SF	Slump for W/C ratio (0.48)
Type I	0	68 mm
Type II	3.5	59 mm
Type III	5	48 mm

Table 1:

The mix proportion quantities of materials for volume of 9 cubes for each type of mix are discussed in the table 2 as per W/C ratio 0.48.

Mix No.	Cement (kg)	SF (kg)	Fine Agg. (kg)	Medium Agg. (kg)	Course Agg. (kg)	Water (kg)
I	10.8	0	18.52	12.015	18.06	5.184
II	10.422	0.378	18.52	12.015	18.06	5.0
III	10.26	0.54	18.52	12.015	18.06	4.925

Table 1:

### C. Experimental Procedure

Standard cube of size (150 mm x 150 mm x 150 mm) was used as specimens for determination of compressive strength of concrete. Three specimens were tested for 7, 14 & 21 days with each proportion replacement of silica fume. Total

27 cubes were casted for compressive strength test. An electric mixer was used for mixing purpose. Weight batching was used for proportioning the quantity of materials. The W/C ratio adopted was 0.48. The concrete was filled in different layers and each layer was compacted using tamping rod. After 24 hours, the specimens were removed from the mould and cured in clean water for 7, 14 & 28 days and then tested for compressive strength as per Indian Standard Guidelines. The materials for each batch of concrete mix were mixed separately using the quantities of dry materials, conforming to the proportions and the quantity of water was determined. The temperature of the water used for mixing and curing was  $27 \pm 2^\circ \text{C}$ .

### III. CONCLUSION

On the basis of experimental investigation about the replacement of cement using silica fume, the following conclusions are concluded.

- 1) Basic strength test, i.e. 7 days for various percentage replacements of cement by silica fume as been used to increase the target strength of the design mix proportionally and complete the mix design with modifications suitable to it.
- 2) The procedure of mix design followed in the investigation is similar and flexible and hence can be recommended for practical use.
- 3) Considerable saving in cement content is recorded from the present design mix. With increase in replacement of silica fume increase the saving percentage of cement content.
- 4) The savings in the overall cost of concrete mix is about 15% for a silica fume percentage in between 30 to 40 of total cement plus silica fume in the concrete mix.
- 5) On the basis of present investigation carried out, it may be finally recommended for mass concreting as well as for normal structural concrete, as per prefring silica fume mixes.
- 6) It is observed that the strength gain between 7 and 21 days of concrete containing silica fume is higher than concrete with respect to that without silica fume.

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