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# Incorporation of Silica fume in concrete

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***Abstract:*** *The use of silica fume as a mineral admixture to produce high strength high performance concretes is gaining importance in recent years. This paper presents better understanding of the efficiency of silica fume in concrete and experimental work on the properties of fresh and harden concrete containing different levels of silica fume. The aim of the study was to investigate the effects of binder systems containing different levels of silica fume on fresh and harden properties of concrete. The work was focused on concrete mixes having a fixed water cement ratio of 0.35 with the addition of super plasticizer at a constant total binder cement content of 412 kg/m$^3$. The percentage of silica fume replaced with cement in this research was: 5%, 10%, 15% and 20%. At 10% replacement of cement with silica fume, it gave the highest compressive strength. But higher replacement of cement by silica fume gave lower strength.*

***Keywords:*** *Compressive strength, spit tensile strength, flexural strength, Silica fume, Slump test, w/c ratio*

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## I. Introduction

Silica fume is an industrial byproduct mainly produced from ferrosilicon and silicon metal. It reacts readily with the calcium hydroxide, which is produced during Portland cement hydration. Addition of silica fume refines pore structure and produces concrete of improved mechanical strength. Silica fume has a very high specific surface and acts as a reactive pozzolan. Normally, silica fume is used in small amounts compared to other pozzolanic materials. Its homogeneous dispersion in concrete is problematic. From perspectives silica fume is a very promising mineral admixture particularly for producing high strength to ultra high strength concrete, but care must be taken during mixing.

In this research the advantages of using silica fume in concrete in partial replacement of cement are found. The present experimentation has been carried out to determine the mechanical properties of conventional concrete and concrete using silica fume. Suitable percentage of silica fume was found by replacing cement with silica fume at varying percentage and the strength parameters was compared with conventional concrete.

## II. Materials And Research Methodology

### 2.1 Mix Design Proportions

The percentage of silica fume used was 5%, 10%, 15%, 20%. Water binder ratio was kept constant at 0.35 and the amount of super plasticizer used was kept constant at 2% to attain the requirement of the mix to develop better rheological properties of Concrete. The ratio of mix proportion for M50 grade concrete after designing was **1:1.05: 3.54.**

### 2.2 Materials

The materials Used for this Study are as follows:

**Cement:** Ordinary Portland cement of grade 53 was used for experimental work. The OPC used was grey in colour and was free of hard lumps.

**Fine aggregates:** stone Crushed Sand was used as fine aggregate.

**Course aggregates:** Locally available coarse aggregates having the maximum size of 20 mm was used. The aggregates were washed to remove dust and dirt and were dried to surface dry condition. The aggregates were tested as per IS: 2386 (1963) (Part 3).

**Water** tap water is used for this work.

**Silica fume:** Silica fume used was white in colours and was very finely divided residue resulting from the manufacture of silicon or ferro-silicon alloys that is passed from the furnace by the exhaust gases. It normally comes in three forms of powder, condensed and in slurry form. Silica fume is often used in the creation of high-strength concrete with or without the addition of fly ash or slag. Silica fume generally has a high surface area and a low density and consist of very finely divided particles that are approximately 100 times smaller than the

normal cement particle. It offers reactive pozzolanic activity and is very effective due to its high fineness and silica content. Typical physical prosperities of silica fume used for the experimental works is given below in *Table.*

| Property | Value |
|---|---|
| Particle size | <1 um |
| Bulk density As produced | 130 – 430 kg/m3 |
| Slurry | 1,320 – 1,440 kg/m3 |
| Densified | 480 – 720 kg/m3 |
| Specific gravity | 2.22 |
| Surface area | 13,000 – 30,000 kg/m3 |

## 2.4 Casting and Curing

For casting, the entire test specimen was cleaned and oiled properly. These were securely tightened to correct dimensions before casting. Care was taken that there were no gaps left from where there would be any possibility of leakage of slurry. Careful procedure was adopted in the batching, mixing and casting operations. The coarse aggregates and fine aggregates were weighed first with an accuracy of 0.5g. The concrete mixture was prepared by mixing it manually by hand mixing. On the non-absorbing platform, the coarse and fine aggregates were mixed thoroughly. Then water was added carefully so that no water was lost during mixing. To this mixture, the cement was added. These were mixed to uniform colour. Then water was added carefully so that no water was lost during mixing. For each mix 21 samples were prepared, which consists of 9 cubes (150 x 150 x 150 mm) for 3, 7 and 28 days compressive strength and 9 cylinders (150 x 300 mm) for split tensile strength at 3, 7 and 28 days and 3 beams (750 x 150 x 150 mm) for flexural strength at28 days.

# III. Results And Discussion

## 3.1 Fresh concrete properties

The fresh concrete properties for different mixes of were studied for slump cone test. And the result obtained was true slump.

## 3.2 Hardened concrete properties

A hardened property was studied for test such as compressive strength, split tensile strength and flexural strength for 3, 7 and 28 days.

### 3.2.1 Compressive Strength

In order to study the effect on compressive strength when silica fume is added to the concrete, as cement replacement, the cube containing different proportions was prepared and cured for 3, 7 days and 28 days. From the results as mentioned in *Table 1*, it is concluded that 28 days strength is higher than 3 & 7 days strength. This is basically due to continuous hydration of cement. It was also observed that specimen containing 10% silica fume gave the highest compressive strength at 3, 7 and 28 days. Addition of 15% and 20% silica fume further decreased the compressive strength of the specimen as compared to the concrete specimen without silica fume.

**Table 1: Compressive Strength**

| % of Silica Fume | 3 Days strength (MPa) | 7 Days strength (MPa) | 28 Days strength (MPa) |
|---|---|---|---|
| 0 | 27.833 | 28.766 | 50.033 |
| 5 | 28.3 | 30.4 | 52.13 |
| 10 | 30.266 | 31.866 | 54.86 |
| 15 | 26.933 | 28.66 | 49.63 |
| 20 | 24.466 | 25.66 | 47.66 |

In ***Figure 1*** addition of silica fume considerably increased the compressive strength of high strength concrete cube at older age. As compared the control specimen, replacement by silica fume at 10% increased the compressive strength.

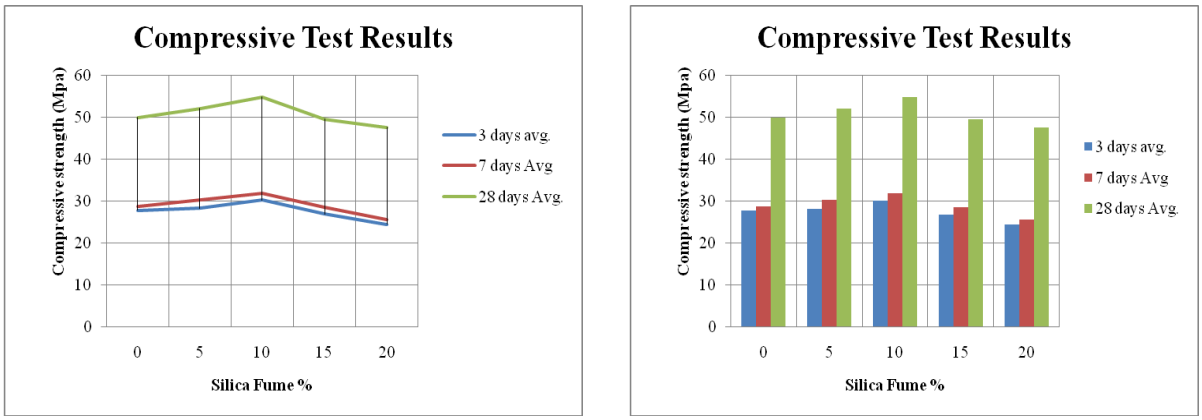


**Figure 1: Compressive Strength**

### 3.2.2 Split Tensile Strength Test

Split tensile strength studies were carried out at the age of 3, 7 & 28 days. Cement has replaced by silica fume at percent 5%, 10%, 15%, 20%

**Table 2: Split Tensile Strength Test**

| % of Silica Fume | 3 Days strength (MPa) | 7 Days strength (MPa) | 28 Days strength (MPa) |
|---|---|---|---|
| 0 | 1.6466 | 1.85 | 2.16 |
| 5 | 1.96 | 1.966 | 2.33 |
| 10 | 2.473 | 2.563 | 2.67 |
| 15 | 1.9066 | 1.9 | 2.15 |
| 20 | 1.703 | 1.773 | 1.94 |

It was observed that by adding silica fume considerable increase the split tensile strength of the standard concrete at 3 ,7, 28 days as compared to the control specimen of standard concrete. The increased was observed to be liner from 0% to 20% addition of silica fume. The highest value for split tensile strength test was observed for 10% & lowest value was observed for 20%. It clearly shows that the split tensile strength increased with the addition of silica fume as compared to specimen without silica fume. It was also observed that at later age the split tensile strength increased considerably as compared to 3, 7 days strength.

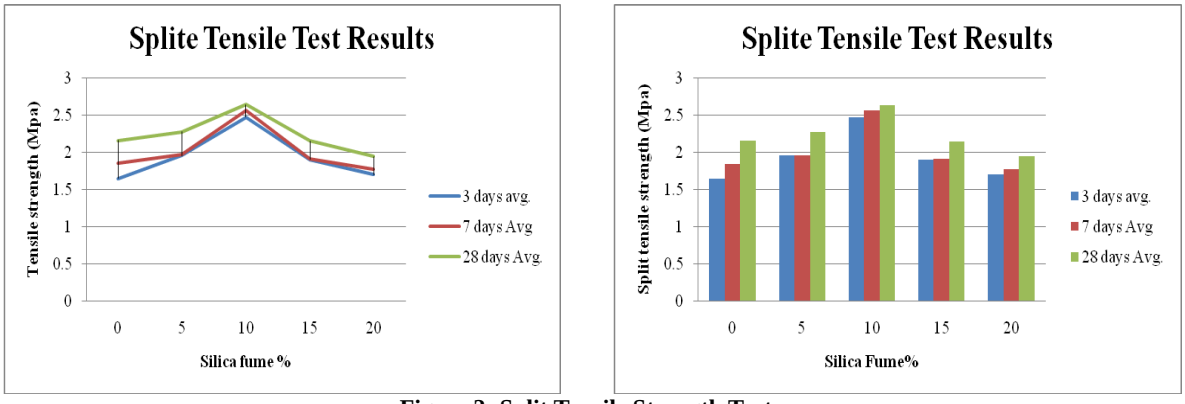


**Figure 2: Split Tensile Strength Test**

### 3.2.3 Flexural strength test

Flexural strength for all specimens was tested for 28 days. It was observed that with replacement of cement with silica fume increased flexural strength considerably as compared to control specimen.

**Table 3: Flexural strength test**

| % of Silica Fume | 28 Days strength (MPa) |
|---|---|
| 0 | 2.62 |
| 5 | 2.69 |
| 10 | 2.77 |
| 15 | 2.60 |
| 20 | 2.52 |

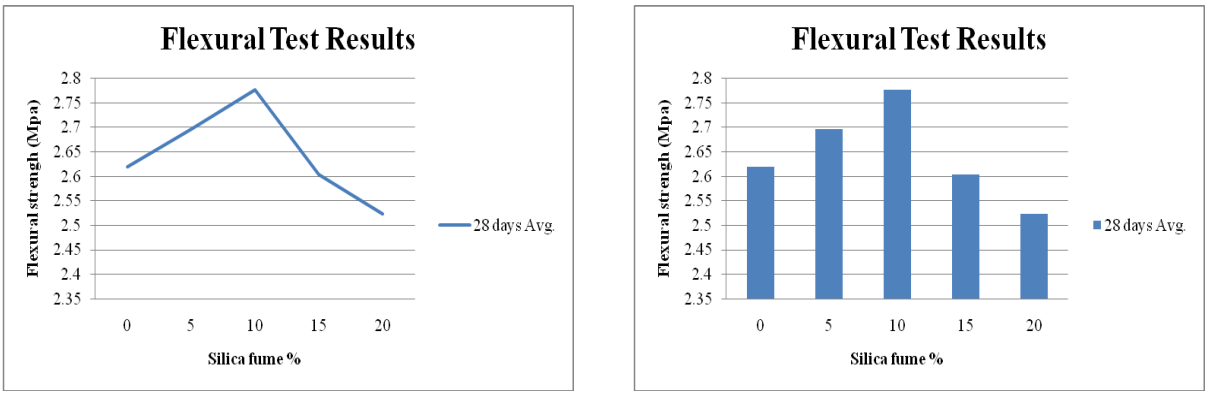


**Figure 3: Flexural strength test**

***Figure 3*** clearly shows that with addition of silica fume in the mixture, the flexural strength for 3,7,28 days increased considerably as compared to specimen without silica fume. The highest value for flexural strength was observed for specimen containing silica fume at 10%.

## IV. Conclusion

1] The present results show that it is possible to design a standard concrete mix incorporating silica fume. The standard concrete mixes have a true slump. With incorporation of silica fume, the workability of standard concrete was reduced.

2] The compressive strength increased of specimen with silica fume increased as compared to the specimen without silica fume. It was observed that with the addition of silica fume, the compressive strength of concrete was increased greatly at early ages after which not much increase was observed.

3] The result for splitting tensile strength was similar to that of the compressive strength. With incorporation of silica fume in standard concrete as replacement of cement, the split tensile strength of the entire standard concrete specimen was increased and greater increase was observed at later ages.

4] The strength increase for flexural test was observed to be greater at later ages. And it was observed that the strength increase was more for standard concrete specimen containing silica fume.

5] The consistency of the standard concrete was improved with incorporation of silica fume and the probability of bleeding and segregation was reduced.

6] Compressive, split tensile and flexural strength of the standard concrete specimen was increased significantly for specimen containing silica fume.

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