

Analysing the Performance of Silica Fume in Addition of Superplasticizer on Cement Concrete Mixes

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ABSTRACT:Portland cement is the most important component of concrete and comparatively a high price construction material. Due to its huge production in industries, environmental issues are generated which causes depletion of natural resources. Due to this warning to ecosystem, researchers directed the use industrial by-products as supplementary cementitious material. Silica fume is a type of industrial by-product which is non-metallic and non-hazardous by-product of silicon metal and Ferro-silicon alloys which is obtained from electric arc furnaces. It is suitable for concrete mixes when treated thoroughly which improves the properties of concrete such as strength and durability. In this experimentation, the silica fume is used as partial replacement in normal concrete thereby increasing the mix design variables. This study is directed to investigate the influence of silica fume on strength and physical parameter such as compressive strength, flexural strength and workability of concrete when cement is partially replaced (by volume) with silica fume and the comparison when silica fume concrete mix is further treated with chemical admixture i.e. superplasticizer (water reducing agents).

KEYWORDS:Silica fume, Superplasticizer, Concrete, Workability, Compressive Strength, Flexural Strength

I. INTRODUCTION

The search for any such material, which can be used as a whole or as a replacement for cement should lead to sustainable development in civil construction and lowest possible environmental impact. Sustainable development and cost savings can be achieved when industrial by-products are used as a partial replacement of cement. Some of the materials are fly ash; ground granulated blast furnace slag and condensed silica fume which can be used in concrete as partial replacement of cement. Various research work have been done in India as well as other countries to study the performance of the above industrial by-products as cement replacement and the results are found very satisfactory.

In order to analyse the performance of silica fume in concrete mix, there are the few objectives that need to be accomplished.

The objectives are as follows:

- 1) To evaluate the performance of fresh silica fume concrete with varying percentages in concrete mix while maintaining constant water cement ratio.
- 2) To determine the effects of silica fume addition on the water-cement ratio while maintaining its workability.
- 3) To determine the effects on addition of superplasticizer (water reducing agents) with silica fume mixes.
- 4) To obtain and compare the workability and strength of mixes with the addition of plasticizer with silica fume and normal mix with silica fume.

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- 5) To obtain and compare the compressive and Flexural strength of ordinary concrete and modified concrete at different age.

II. METHODOLOGY & EXPERIMENTAL PROGRAM

A. Test Material

1. Silica fume

Silica fume is very fine non-crystalline silica produced in electric arc furnaces as a by-product of the production of essential silicon or alloys containing silicon. It is produced as a grey colour powder, slightly similar to Portland cement or some fly ashes. Silica fume collected directly from the collection filter or bag house located in an electric arc furnace. The bulk density of silica fume ranges between 150-350 kg/m³. Silica fume is further treated to increase the bulk density by particle agglomeration. The bulk density typically increased above 500 kg/m³. Silica fume is treated as add-on to the cementitious material. This term refers to materials that are used in concrete mixes in addition to partially replace Portland cement. Silica fume is obtained for Topken silica fume co. ltd, (Mumbai)

2. Cement

The cement used for experimental purpose is Ordinary Portland Cement (OPC) of 43 Grade (UltraTech OPC) conforming to IS: 8112-1989 is used.

Sr. no	Physical properties of cement	Result	Requirement as per I.S Code (IS:4031-1988)
1	Specific Gravity	3.15	
2	Standard Consistency (%)	29.50%	
3	Initial Setting Time (Min)	110 Min	30 min Minimum
4	Final Setting Time (Min)	205 Min	600 min Maximum
5	Compressive Strength-7Day	29.28 N/mm ²	33 N/mm ²
6	Compressive Strength-28Day	56.18 N/mm ²	43N/mm ²

Table 1 – Physical characteristics of Ultratech OPC 43 cement

3. Fine aggregate

In this study used sand of Zone-II, known from the sieve analysis using different sieve sizes (10mm,4.75mm,2.36mm,1.18mm,600μ,300μ,150μ) adopting IS 383:1963. Whose Specific Gravity is 2.60, Water absorption 1.5% and Fineness Modulus 2.44 was used.

4. Coarse Aggregate

The coarse aggregate used here with having maximum size is 12.5mm. We used the IS 383:1970 to find out the proportion mix of coarse aggregate. Whose Specific Gravity is 2.74, Water absorption 0.5% and Fineness Modulus 4.01 was used.

5. Water

Portable water free from any harmful amounts of oils, alkalis, sugars, salts and organic materials was used for proportioning and curing of concrete.

6. Superplasticizer

In the present experimental investigations Superplasticizer Conplast SP430 (G) was used for enhancing workability and supplied as a brown liquid instantly dispersible in water. Conplast SP430 (G) has been specially formulated to give high water reductions up to 25% without loss of workability or to reduce high quality concrete of reduced permeability. The properties were Specific gravity 1.20 to 1.22 at 300C.

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B. Mix Design:

The desired characteristic strength of 40 N/mm² at 28 days was attained in this study. IS 456-2000, IS 10262 2009 method was applied in designing the mix. A total of 60 cubes were prepared for this study in 12 sets and 48 Beam were prepared in 12 sets. All set were prepared in control mix in w/c = 0.42. 1,1,3 samples from each set of the mix were tested at the age of 7, 14, and 28 days respectively for compressive strength and 1,3 samples from each set of the mix were tested at the age of 7 and 28 days respectively for flexural strength.

1. Silica fume - cement mix proportion:

Design mix proportion for Silica Fume with cement for 1 m³ of concrete

Water	Cement	Fine Aggregate	Coarse Aggregate
168 Litre	400 kg	804 kg	1078 kg
0.42	1	2.01	2.69

2. Silica fume – Cement with Superplasticizer mix proportion:

Design mix proportion for Silica Fume with cement and addition of superplasticizer for 1 m³ of concrete.

Water : Cement : FA : CA : SP				
Water	Cement	Fine Aggregate	Coarse Aggregate	Super plasticizer
168 Litre	400 kg	804 kg	1078 kg	4 litre
0.42	1	2.01	2.69	0.01

III. TESTING OF SAMPLES

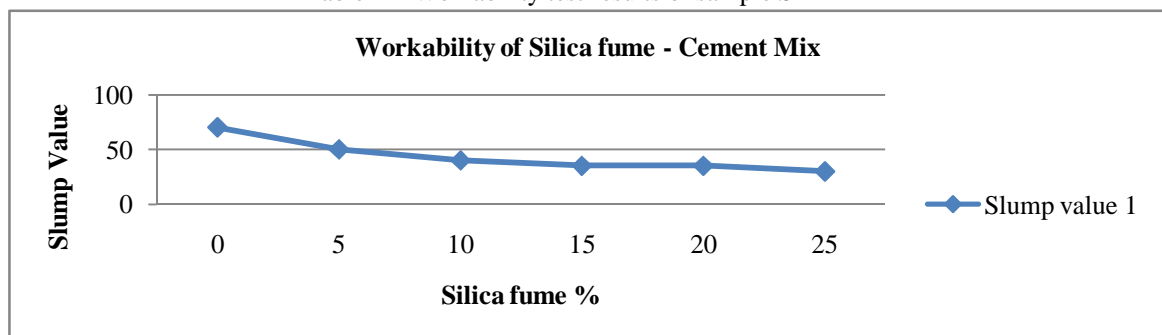
A. Workability Test of Concrete Mixtures:

1. Workability Of Silica Fume – Cement mix:

Slump cone test for workability was performed on concrete mix. All materials used were consistent in terms of the moisture content. Graph shows the decrease in slump value in increase in silica fume content.

Cube Specimen				Beam Specimen				Slump Value (mm)
Sr.no	Cube Sample name	SF %	Weight of SF (gm.)	Sr. no	Beam Sample name	SF %	Weight of SF in mix (gm.)	
1	SF 0	0	0	1	SFB 0	0	0	70
2	SF 5	5	78	2	SFB 5	5	78	50
3	SF 10	10	156	3	SFB 10	10	156	40
4	SF 15	15	234	4	SFB 15	15	234	35
5	SF 20	20	312	5	SFB 20	20	312	35
6	SF 25	25	390	6	SFB 25	25	390	30

Table 2 – Workability test results of sample SF



Graph 1–Workability of Silica Fume- Cement mix

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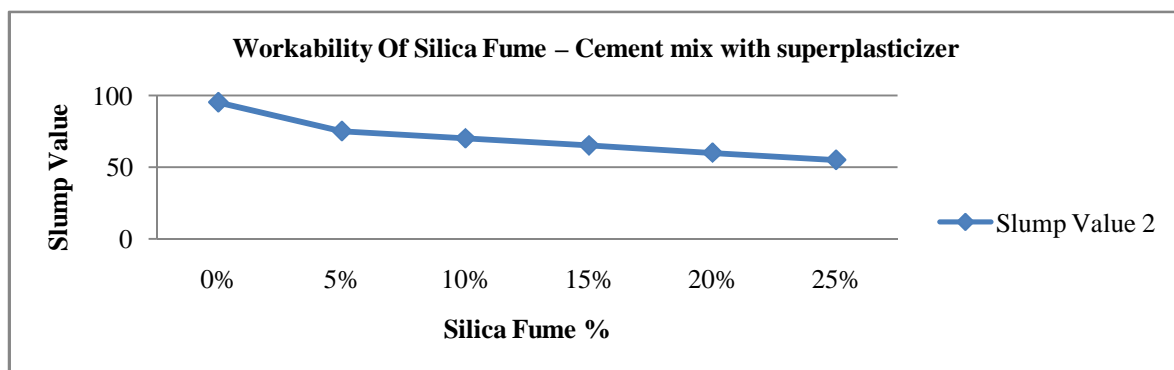
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2. Workability Of Silica Fume – Cement mix with superplasticizer:

Slump cone test for workability was performed on concrete mix. All materials used were consistent in terms of the moisture content. Graph shows decrease in slump value in increase in silica fume content but however it is comparatively low than previous mix.

Sr. no	Superplasticizer %	Cube specimen			Beam sample			Slump Value (mm)
		Cube sample name	Silica fume%	Wt. of SF (gm.)	Beam sample name	Silica fume %	Wt. of SF (gm.)	
1	0.01	SFS 0	0	0	SFSB 0	0	0	95
2	0.01	SFS 5	5	78	SFSB 5	5	78	75
3	0.01	SFS 10	10	156	SFSB 10	10	156	70
4	0.01	SFS 15	15	234	SFSB 15	15	234	65
5	0.01	SFS 20	20	312	SFSB 20	20	312	60
6	0.01	SFS 25	25	390	SFSB 25	25	390	55

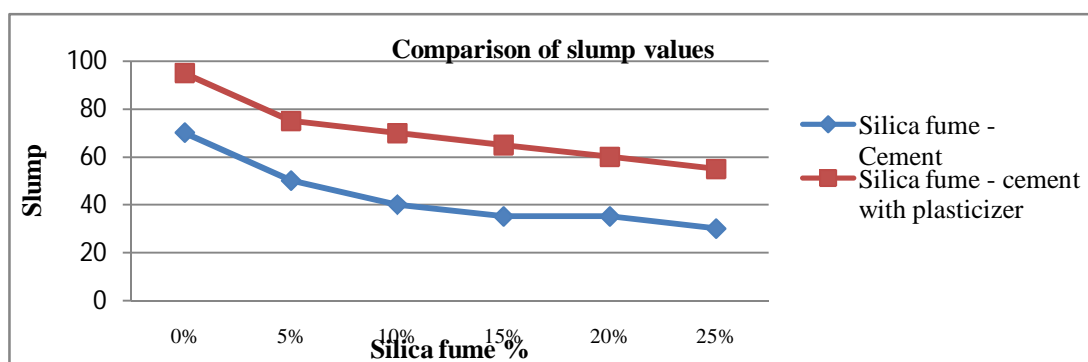
Table 3 – Workability test results of sample SFS



Graph 2 – Workability of Silica Fume- Cement mix with superplasticizer.

3. Comparison between the slump value 1 and slump value 2:

Slump test results of both mix proportions is compared in the chart below which suggests that addition of superplasticizer with silica fume mixture helps in achieving the desired workability.



Graph 3 – Comparison of workability of both mix designs

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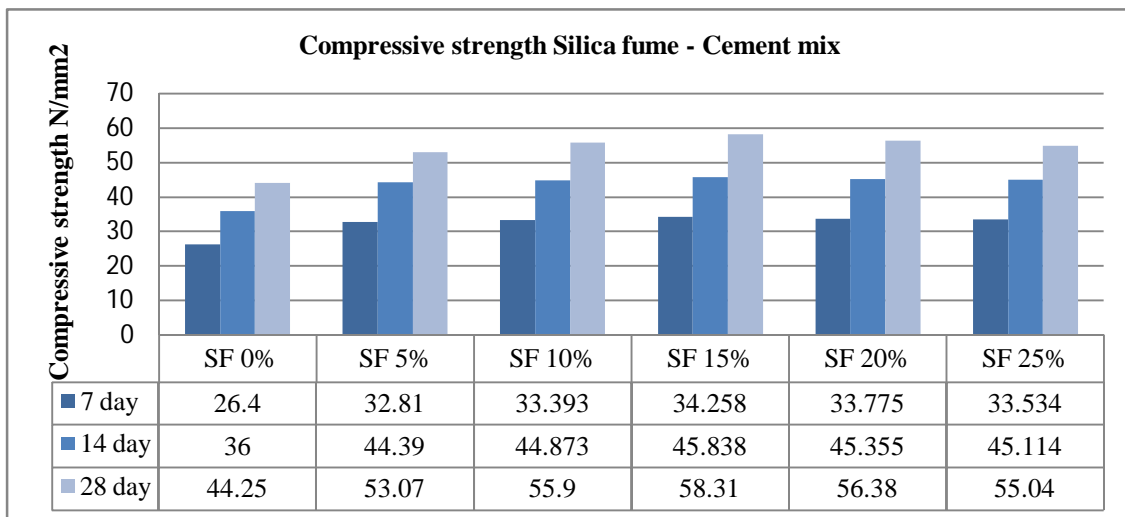
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4. Compressive strength:

The compressive strength and flexural strength of all concrete specimens was determined following Indian standard testing procedure [IS 516:1959]. The specimens were removed from the mould after 24 hours and subsequently immersed in water for different age of testing. For each test three specimens were tested for the determination of average compressive and flexural strength. Test was performed on compression testing machine having capacity of 200 MT. The compressive strength test was conducted on a Compression testing machine and flexural strength was carried on third point loading machine. Average value of samples has been reported below.

5. Compressive strength result of Silica fume – Cement mix at 7, 14 and 28 day:

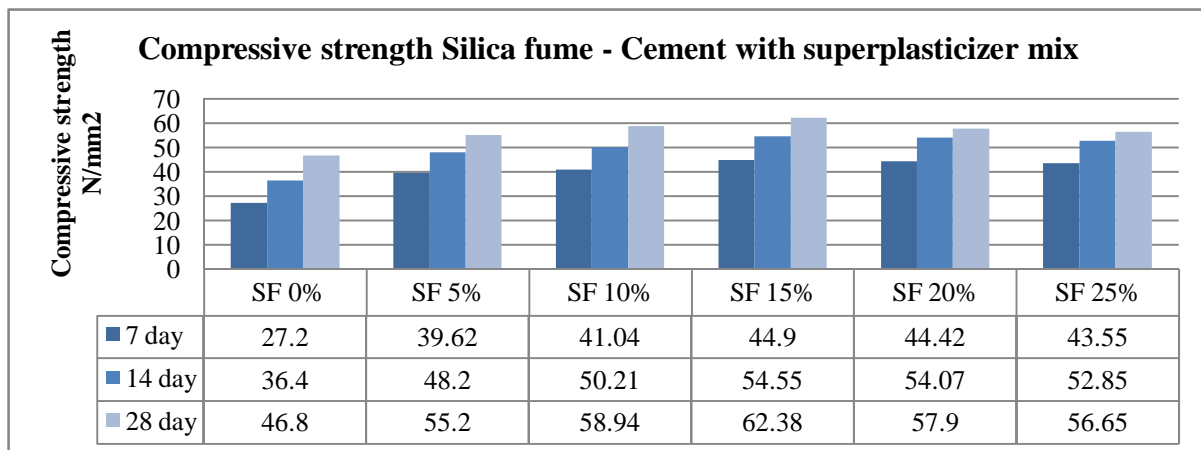
Compressive strength results of Silica Fume- Cement mixture shown in table and graph below. Increase in percentage of silica fume gives satisfactory results up to 15 % further increase in content shows decrease in strength.



Graph 4 - Compressive strength result of Silica fume – Cement mix

6. Compressive strength result of Silica fume - Cement mix with superplasticizer at 7, 14 and 28 day:

Compressive strength results of Silica Fume- Cement mixture with superplasticizer shown in graph below. Increase in percentage of silica fume gives satisfactory results up to 15 % further increase in content shows decrease in strength.



Graph 5 - Compressive strength result of Silica fume – Cement mix with superplasticizer

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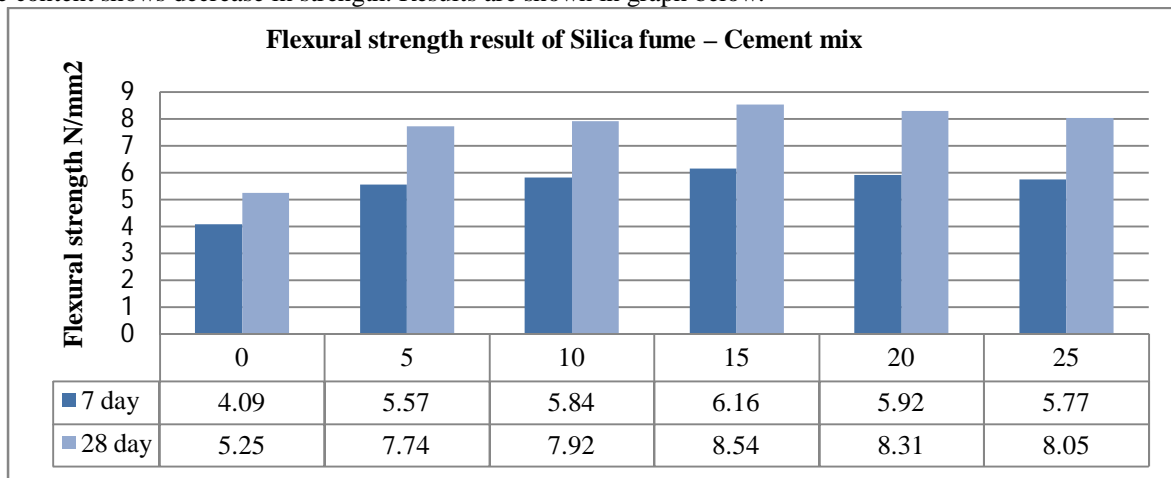
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7. Flexural Strength:

Flexural strength of concrete can be represented as the performance of concrete subjected to ultimate load under loading condition. The tests were performed on concrete specimens varying from the age of 7 days and 28 days and each point presented in the graphical plots were taken from the average of 3 readings.

8. Flexural strength result of Silica fume – Cement mix at 7 and 28 day:

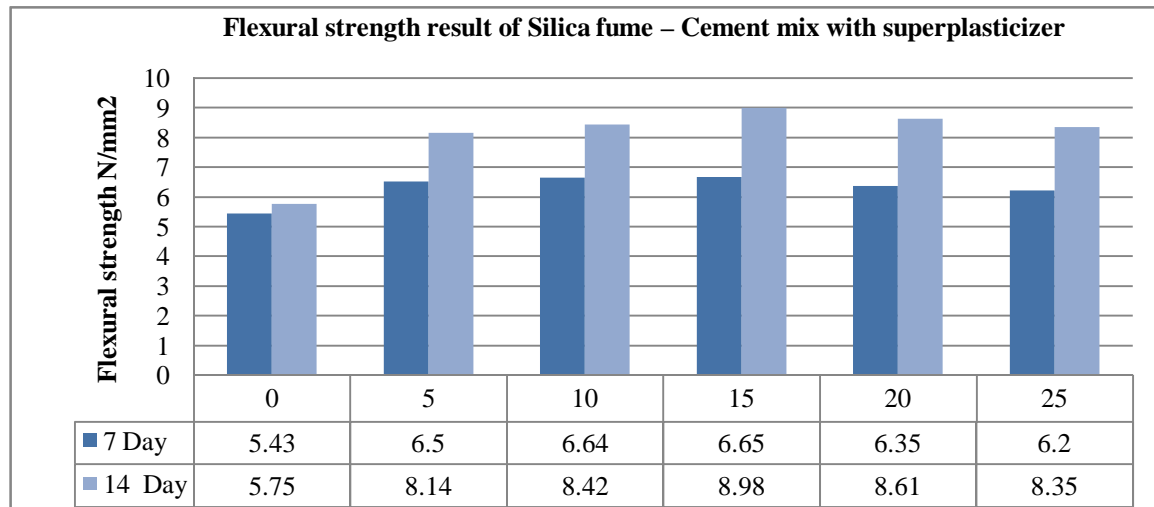
Flexural strength test on silica fume – cement mix shows satisfactory results at 15 % content further increase in silica fume content shows decrease in strength. Results are shown in graph below.



Graph 6 - flexural strength result of Silica fume – Cement mix

9. Flexural strength result of Silica fume – Cement mix with superplasticizer at 7 and 28 day:

Flexural strength test on silica fume – cement mix with superplasticizer shows satisfactory results at 15 % content further increase in silica fume content shows decrease in strength. It also suggests addition of superplasticizer gives comparatively better result. Results are shown in graph below.



Graph 7 - flexural strength result of Silica fume – Cement mix with superplasticizer.

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The compressive strength of the concrete cubes had been tested at the interval of 7, 14 and 28 days. It seems that the strength goes on increasing with the increase in silica fume but after replacement beyond 15% the strength of concrete specimen under compression gradually decreases.

The flexural strength of concrete is tested at the interval of 7 and 28 days and it is seemed that flexural strength goes on increase up to 15% replacement. The strength variation is more on compressive as compared to flexural strength.

IV. CONCLUSIONS

1. The workability of concrete decreases with the increase in silica fume content, the particles of silica fume are very fine which requires a high amount of water. This water demand can be stabilize by using water reducing agents in concrete mix which helps in producing a workable slump.
2. The compressive strength and flexural strength increases with the increase of Silica fume in concrete up to 15% replacement with cement in conventional mix further increase in content results decrease in strength , however the compressive strength increases more as compared to flexural strength, the values are acceptable as per IRC.
3. Mixing of Silica fume in concrete conventional mix has resulted in considerable variation in the properties of fresh concrete. Integration of Silica fume in concrete increased the cohesiveness of the mix, prohibited segregation and resulted in reduced bleeding. Higher percentages of Silica fume can cause a change in colour of the mix.
4. Addition of superplasticizer in silica fume provides suitable workability in comparison with normal concrete mix it also increases the strength within 10 % to 15% silica fume content range.
5. Incorporation of Silica fume in concrete can save the Silicon industry disposal costs and produce a greener concrete for construction.
6. The research can be conducted further on higher grades of concrete or integration of such waste material by which more impact can be created improvement of strength.

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