

Experimental Investigation of SCC Using Silica Fume

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ABSTRACT: Self compacting concrete (SCC) is a special type of concrete that can flow through intricate geometrical configurations under its own mass without external or internal vibration or segregation. Construction of durable concrete structures requires skilled labour for placing and compacting concrete. Therefore, there is a need to render the durability of the concrete structures to be independent of the quality of the construction worker. For the above, Self Compacting Concrete is an obvious answer. The proposed experimental program is aimed to evaluate performance of SCC by varying the percentage of Silica fumes as replacement of cement. An attempt has been made to study fresh and harden properties of Self Compacting Concrete with Silica fume as a mineral admixture. The trial mix which satisfies the fresh concrete properties as per EFNARC guidelines. In this project the strength characteristics of M₂₅ grade of Self Compacting Concrete and Conventional concrete were tested by casting concrete specimens using 43 grade of OPC. Various workability tests and strength tests were conducted.

Cement replaced with various percentage of Silica fume (0,2.5% and 5%) compared with conventional Concrete. Based on the test results, Self Compacting Concrete with (0,2.5% and 5%) showed better results when compared to conventional concrete.

KEYWORDS: Self Compacting Concrete, Silica Fume, Fly Ash, Fresh Concrete test etc

I. INTRODUCTION

Self – consolidating concrete has recently been used in the pre – cast industry and in some commercial applications, however the relatively high material cost still hinders the wide spread use of such specialty concrete in various segments of the construction industry, including commercial and residential construction. Self – compacting concrete (SCC) is a fluid mixture, which is suitable for placing difficult conditions and also in congested reinforcement, without vibration. In principle, a self – compacting or self – consolidating concrete must: Have a fluidity that allows self – compaction without external energy. Remain homogeneous in a form during and after the placing process. Flow easily through reinforcement.

The SCC essentially eliminates the need for vibration to consolidate the concrete. This results in an increase in productivity, a reduction in noise exposure and a finished product with few if any external blemishes such as “bug holes”. However, after completion of proper proportioning,

This project presents the feasibility of the usage of Fly ash and silica fume partially substitutes for cement in self compacting concrete. Tests were conducted on cubes, beams and cylinder to study the compressive, tensile and flexural strengths of concrete for SCC with Fly ash and silica fume partially as cement.

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Fly ash is like a slag an industrial waste that is widely used as mineral admixture in the cement and concrete industry the chemical composition of fly ash depends on the composition of the original coal ash. Fly ash improves concrete's workability, pump ability cohesiveness, finish, ultimate strength and durability as well as solves many problems experienced with concrete today and all for less cost.

Silica fume As per ACI 116R, silica fume is defined as a by-product from electric arc furnaces used in the manufacture of silicon metal or silicon alloys. It exhibits excellent pozzolanic characteristics. The use of Fly ash as a partially in cement in self compacting concrete is expected to affect some properties, such as the compressive strength, durability, strength development, and economy. However the reduction in compressive strength of Fly ash in self compacting concrete was overcome when mineral admixtures such as silica fume are used. Silica fume is a highly reactive pozzolana and the micro filling abilities of its ultrafine particles results in concrete with a much denser matrix. Silica fume is 100 times finer than fly ash and has over 90% of silicon hydroxide. This will mean an increase rate of gain of strength and improved impermeability at a much earlier age than a fly ash mix. Silica fume was more effective than fly ash to overcome the loss of strength and produced the highest level of compressive strength at any age.

II. MATERIAL USED AND THEIR PROPERTIES

A. General

Locally available Fly ash was the primary material used in this project work. Besides that, for concrete mixing purposes, Ordinary Portland Cement, crushed stone coarse aggregate, river sand, silica fume were used. Normal tap water was used for both concrete mixing and curing purposes. The tests conducted to find the physical and chemical composition of the fly ash. These properties are the particle size distribution based on IS 383: 1970, the specific gravity (IS 2386(part III) 1963) for assessing batch quantities; bulk density (IS: 2386 (Part III) 1963) which enables quantities of materials for concrete to be converted from quantities by weight to volume. In order to produce a workable mix, batching by volume is adopted. The required quantity of cement was measured and mixed with the fly ash. After even consistency, the required quantity of the coarse aggregate as well as water was added. The constituents were thoroughly mixed until a good consistency mix was obtained. The top surfaces of the specimens were troweled in the laboratory for 24 hours, demoulded and cured in water and tested at the specified periods of 7, 14 and 28.

B. Materials used

Cement Ordinary Portland cement (43-grade)

Fine aggregate River sand

Coarse aggregate 12.5mm (angular)

Mineral admixtures Fly ash and Silica fume

Super plasticizer Conplast SP430

C. Cement

Cement is the important binding material for the production of concrete. For using cement in important and major works it is incumbent on the part of the user to test the cement to confirm the requirements of the Indian Standard specifications with respect to its physical and chemical properties. In our project we had used Ordinary Portland cement 43 grade conforming to IS 8112:1989. The specific gravity and the fineness modulus of cement are 3.15 and 1.1 respectively.

D. Testing of cement

1. Fineness test
2. Consistency test

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- 3. Setting time cement
- 4. Specific gravity

E. Physical Properties of Cement

S.No	Property	Value
1	Normal Consistency	29%
2	Initial Setting Time (min)	65%
3	Final Setting Time (min)	240
4	Specific gravity	3.15
5	Fineness of cement	1.2

F. Fly ash (class –F type)

The flow ability of self compacting concrete depends on the powder and paste content. Hence, in order to increase the flow ability, mineral admixtures such as fly ash has been used. A class ‘f’ flyash obtained from thermal power plant. Salem was used.

G. Physical Properties of fly ash

S.No	Property	Test results
1	Colour	Grey (Blackish)
2	Specific gravity	2.12

H. Silica fume

Silica fume is a waste by-product of the production of silicon and silicon alloys. Silicafume is available in different forms, of which the most commonly used in a densified form. In developed countries it is already available readily blended with cement. The details of silica fume used in this experiment.

I. Physical properties of the silica fume

S.No	Property	Test results
1	Colour	Grey
2	Specific gravity	2.3
3	Fineness modulus	520 kg/m ²
4	Specific surface area	520m ² /kg

J. Fine aggregate

Fine aggregate shall consist of natural sand. Fine aggregates should be selected so as to reduce the water demand hence rounded particles are thus preferred to crush rock fines where possible. The finest fractions of fine aggregate are helpful to prevent segregation. For the fine aggregate river sand conforming to IS 383-1987 was used.

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K. Test for aggregates

1. Sieve analysis

The aggregates used for making concrete are normally of the maximum size 80mm, 40mm, 20mm, 10mm, 4.75mm, 2.36mm, 600micron, 300micron, 150micron are termed as fine aggregate. The aggregate fraction from 80mm to 4.75mm is termed as coarse aggregate and those fractions from 4.75mm to 150micron are termed as fine aggregate. Grading pattern of a sample of coarse aggregate or fine aggregate is assessed by sieving a sample successively through all the sieves mounted one over the other in the order of size, with large sieve on the top. The material retained on each sieve after shaking, represents the fraction of aggregate coarser than the sieve in question and finer than the sieve above. Sieving can be done either manually or mechanically.

S.No	Sieve size	Weight retained in gms	Cumulative weight retained gms	% of Cumulative weight retained	% of finer
1	4.75 Mm	0	0	0	100
2	2.36 Mm	10	10	2	98
3	1.18 Mm	50	60	12	88
4	600 micron	50	110	22	78
5	300 micron	95	205	41	59
6	150 micron	175	380	76	24
7	75 micron	85	465	93	7
8	Pan	35	500	100	0
Fineness modulus of sand					2.46

2. Grading curve

Grading curve indicates the particle size distribution of fine aggregate. The grading of aggregate is the major factor that influences properties of concrete. The particles size grading curve, which depicts the 'cumulative percentage passing' against standard IS sieves size.

Physical properties of sand

S.No	Property	Sand
1	Specific gravity	2.52
2	Fineness modulus	2.4
3	Uniformity coefficient	3.33
4	Curvature coefficient	0.948

3. Course aggregate

Crushed stone coarse aggregate conforming to IS 383 – 1987 was used. The values of loose and compacted bulk density values of coarse aggregates were 1600 and 1781 Kg/m³, respectively & physical properties

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S.No	Sieve size (mm)	Weight retained in gms	Cumulative weight retained gms	% of Cumulative weight retained	% of finer
1	40	-	-	-	-
2	20	-	-	-	-
3	10	350	350	5.83	94.2
4	4.875	5214	5564	92.73	7.27
8	Pan	436	6000	100	0
Fineness modulus of course aggregate					5.91

Physical properties of course aggregate

S.No	Property	Sand
1	Specific gravity	2.72
2	Fineness modulus	5.91
3	Uniformity coefficient	1.5
4	Curvature coefficient	1.1

4. Super plasticizer

The Sulphonated Naphthalene Formaldehyde based super plasticizer (Conplast Super Plasticizer – SP 430) was used.

Physical properties of super plasticizer

S.No	Property	Result
1	Solid content	42%
2	Specific gravity	1.22%

III. EXPERIMENTAL PROGRAMME

A. Mix design general

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required strength, durability, and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredient of concrete is governed by the required performance of concrete in two states, namely the plastic and the hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability therefore becomes of vital importance.

1. Conventional concrete
2. Self Compacting Concrete

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1. Conventional Concrete

Water	Cement	Fine aggregate	Coarse aggregate
247 Kg/m ³	550 Kg/m ³	679.22 Kg/m ³	877.36 Kg/m ³
0.45	1	1.23	1.60
Mix Design for M25 = 1 : 1.23 : 1.60			

2. Self Compacting concrete

Water	Cement	Fine aggregate	Coarse aggregate
220 Kg/m ³	550 Kg/m ³	907 Kg/m ³	713 Kg/m ³
0.4	1	1.65	1.29
Mix Design for M25 = 1 : 1.65 : 1.29			

IV. RESULTS AND DISCUSSIONS

A. General

To study and compare the behavior of self compacting concrete using fly ash and silica fume as partially with cement content experimental investigations as mentioned were carried out on concrete samples for their strength and properties. To compare the test results, conventional concrete with self compacting concrete with replacement of fly ash and silica fume in cement content. The tests were carried out after 7, 14, 28 days of the casting of concrete specimen. Summary of the test result for self compacting concrete mixes with fully partially replacement of cement by fly ash and silica fume as recorded in tables. The percentage variation in properties of self compacting concrete using silica fume is 2.5, 5% replacement for fly ash content.

B. Workability tests

The concrete mix used for the test are of low workability hence Slump flow, U box, V funnel and J ring tests are carried out since it is relevant for the study. The workability was improved by adding Super plasticizer to the concrete.

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Fig.5.1 Workability Test (Slump Flow)



Fig.5.2 Workability Test (V-Funnel)

C.Result of Workability Test on SCC (2.5% OF SILICA FUME)

S.No	Super plasticizer	Slump flow (650-800 mm)	V-Funnel (6-12 sec)	L-Box (h2/h1 = 0.8-1)
1	0.1	200	No flow	No flow
2	0.2	220	No flow	No flow
3	0.3	310	No flow	No flow
4	0.4	440	No flow	No flow
5	0.5	560	4	0.82
6	0.6	610	5	0.8
7	0.7	650	6	0.75
8	0.8	710	6	0.83

D.Result of Workability Test on SCC (5% OF SILICA FUME)

S.No	Super plasticizer	Slump flow (650-800 mm)	V-Funnel (6-12 sec)	L-Box (h2/h1 = 0.8-1)
1	0.1	200	No flow	No flow
2	0.2	235	No flow	No flow
3	0.3	265	No flow	No flow
4	0.4	320	No flow	No flow
5	0.5	355	No flow	No flow
6	0.6	375	4	0.75
7	0.7	405	5	0.72
8	0.8	650	6	0.82
9	0.9	720	6	0.83

E. Compressive strength of concrete

The compressive strength of hardened concrete is considered one of the most important properties and is often used as an index of the overall quality of concrete. The 2.5% and 5% replacement of cement with Silica fume

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increases the compressive strength of concrete. This is due to the excessive fineness content and in appropriate content of 12.5 mm coarse aggregate and fineness of Silica fume.

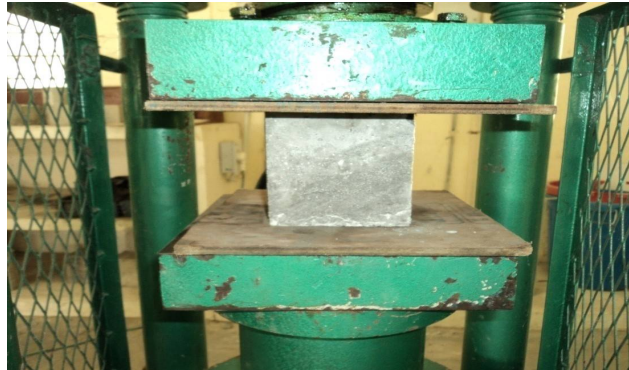


Fig.5.3 Specimens for Compressive Strength of Cubes

S.No	Curing days	Average compressive strength in N/mm ²		
		Conventional concrete (cement only)	SCC (2.5%) of silica fume	SCC (5%) of silica fume
1	7	11.5	12	14
2	14	21	24.5	28
3	28	29.5	32	36.5

Table 1. Test Result of Cube for Compression

S.No	Curing days	Average compressive strength in N/mm ²		
		Conventional concrete (cement only)	SCC (2.5%) of silica fume	SCC (5%) of silica fume
1	7	9.2	9.5	11.2
2	14	16.7	19.6	22.4
3	28	23.5	25.8	29.4

Table 2. Test Result of Cylinder for Compression

F. Split tensile strength of concrete

The test was carried out according to IS 5816-1999 to obtain the splitting tensile strength of M25 grade of SCC concrete. The test results of different types of concrete are presented. Tensile strength of silica fume in SCC is slightly decrease, when compared to convention concrete. As replacement level of silica fume increases there is an decrease in splitting tensile strength.



Fig 5.4 Specimen for Split Tensile Strength of Cylinders



Fig 5.5 Failure of Split Tensile Strength of Cylinders

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S.No	Curing days	Average compressive strength in N/mm ²		
		Conventional concrete (cement only)	SCC (2.5%) of silica fume	SCC (5%) of silica fume
1	7	0.36	0.32	0.35
2	14	1.9	1.78	1.82
2	28	3.6	3.4	3.45

Table 3. Test Result of Cylinder for split tensile

G. Flexural strength of concrete

Flexural strength test was carried out according to IS 516-1959. Flexural strength of silica fume in SCC is slightly decreases when compared to conventional concrete.



Fig 5.6 Specimen for Flexural Strength of Beam

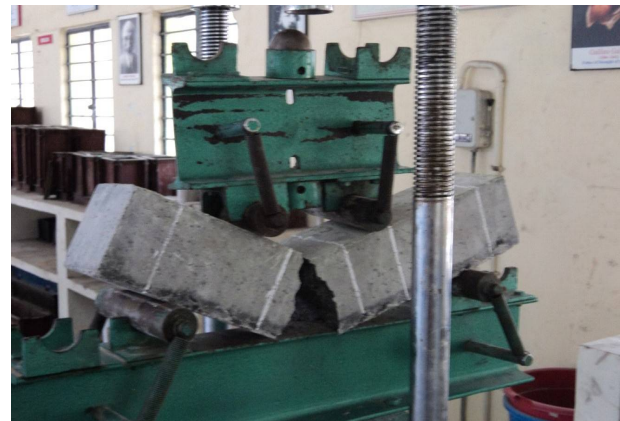


Fig 5.6 Failure of Flexural Strength of Beam

S.No	Curing days	Average compressive strength in N/mm ²		
		Conventional concrete (cement only)	SCC (2.5%) of silica fume	SCC (5%) of silica fume
1	7	0.92	0.91	0.89
2	14	4.72	4.6	4.5
2	28	10.1	9.9	9.8

Table 4. Test Result of Cylinder for split tensile

V. CONCLUSION

In the present experimental study on Self Compacting concrete using Silica fume, specimens were tested and the following conclusions are formed from the experimental investigation.

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1. Increase the percentage of Silica fume (2.5% and 5%) reduce the flow of concrete.
2. SCC with 2.5% and 5% replacement of cement with Silica fume showed good results both in compression and tension.
3. Mix proportions, superplasticiser dosage and binder material type used is responsible for the variation in the concrete properties of flowing and self-compacting concretes. Therefore, proper mix design is essential to optimize the performance of both flowing and self compacting concrete.
4. Self compacting concrete with Silica fume give better properties due to the pozzolanic activity of the Silica fume with higher reactivity related with the higher fineness.
5. The increases of compressive strength of Self Compacting Concrete with 2.5 and 5% Silica fume by weight of cement were 8.5% and 23.72% respectively, when compared with conventional concrete without Silica fume.
6. However, on a more rational basis of total cost, including the labour charges, formwork and making good finished surfaces, SCC can be more advantageous.
7. Fly ash is very cheap, it can be used successfully in place of cement, it gives good results at very low content.

REFERENCES

- [1] Brain poulson, EFNARC, Secretary general, "Specifications and guidelines for self compacting concrete", Feb 2002.
- [2] Shetty. M.s.(2010) "concrete technology" S.Chand and company Ltd, Delhi
- [3] IS10262:2009 Concrete mix proportion guidelines
- [4] Gambhir.M.L,"concrete technology" Tata McGraw-Hill Publishing company Ltd, New Delhi,2004.
- [5] Santhakumar.A.K.S, "concrete technology" Oxford Publication, New Delhi,2006.
- [6] IS 456 : 2000 code of practice for plain and reinforced concrete(third revision)
- [7] IS 516: 1959 method of test for strength of concrete (Jan-99)
- [8] IS 2386 (PT3): 1963 method of test for aggregates for concrete part 3 specific gravity, density, voids, absorption and bulking (Feb-97)
- [9] IS 5816: 1999 methods of tests for splitting tensile strength of concrete (first revision)
- [10] IS:1199-1959. Indian Standard Methods of sampling and analysis of concrete. Bureau of Indian standards, New Delhi.
- [11] IS 3812-1981, Indian standard specification for fly ash for use as pozzolona and admixture,1st revision, bureau of Indian standard, New Delhi, June 1981.
- [12] IS: 8112-1989, *Specifications for 43 grade Portland cement*, Bureau of Indian Standards, New Delhi, India.
- [13] IS: 3812-2003, *Specifications for Pulverized fuel ash*, Bureau of Indian Standards, NewDelhi, India.
- [14] IS: 383-1970, *Specifications for Coarse and Fine aggregates from Natural sources for Concrete*, Bureau of Indian Standards, New Delhi, India.
- [15] De Schutter.G Guidelines for testing fresh self compacting concrete in 2005.
- [16]Nan Su., Kung-Chung Hsu., and His-Wen Chai., —A simple mix design method for self compacting concrete, Journal of Cement Concrete Research Vol. 31, No. 12, 1799-1807 pp., Dec. 2001.
- [16] Siddique, R., —Properties of self-compacting concrete containing class F fly ash, Journal of Materials and Design, Vol. 32, 1501-1507 pp., 2011
- [17] Japan Society of Civil Engineers, —Recommendation for Construction of Self Compacting Concrete,157- 164 pp., 1998