Influence of Silicafume on Self Cured Self-Compacting Concrete - An Experimental Investigation

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Abstract **- In the recent years, one of the most outstanding advances in the concrete technology is "Self-Compacting Concrete". Self-compacting concrete (SCC) has gained wide use in congested reinforced concrete structures. In the construction industry, various curing methods are adopted especially for vertical structures, inaccessible areas, high rise buildings, water scarcity areas. In such cases, it is not so possible to use conventional curing. So there is need for efficient curing which enhances the strength and durability of concrete.**

The mix design which was carried out in the study is Nan-su method. Investigations were made to study the fresh concrete tests on self-compacting concrete and compressive strengthat 28 days of curing and optimum result is obtained for different percentages of Silica Fume 2%, 4% and 6%. The investigation carried out in this work shows that the introduction of 4% of silica fume (SF) in concrete yield better strength compared to other percentages of silica fume added. In this experimental study, compressive strength of SCC at 28 days using different percentages of Silica fume was determined.

This study proposes whether the use of self-curing compound is economical without compromising the compressive strength.

Keywords - Self Compacting Concrete , Self Curing, Silica fume, Compressive strength.

I. INTRODUCTION

Self-compacting concrete is a concrete mixture that can be able to compact under its own weight. The fluidity nature of SCC makes it appropriate for placing in the sections with congested reinforcement. The main advantage of SCC is that the time required to place large sections is considerably reduced. The problems of defective workmanship could overcome by scc concrete. This led to the development of scc, primarily through the work by Okamura.

SCC plays a major role if there is need to improve the structures quality when it's difficult to compact the concrete. Besides fluidity, SCC has to be tested for properties such as resistance to segregation and the blockage at narrow spaces.

The process of controlling the rate and extent of moisture loss from concrete during hydration of cement is called curing. Since cement hydration takes days and weeks instead of hours curing must be undertaken for a reasonable period.

A. Mechanism of Self Curing

Continuous evaporation of moisture takes place from an exposed surface due to the difference in chemical potentials between the vapour and liquid phases. When curing compound is applied externally to a fresh cementitious surface theemulsion breaks to form a continuous, non-penetratingwhite coating. This dries to form a continuous clear filmwhich provides a barrier to moisture loss, ensuring moreefficient cement hydration, improved durability andreduced shrinkage.

B. Objectives of the Study

The main objectives of this investigation is to find suitable percentage replacement of silica fume and its influence in scc. And to find the compressive strength of scc using water curing and self-curing.

II. MATERIALS AND PROPERTIES

A. Cement

In this experimental study, Ordinary Portland Cement of 53 grade (Chettinad Cement) conforming to IS : 12269 – 1987 was used. The physical properties of the cement used are shown in Table 1.

TABLE 1 : PROPERTIES OF CEMENT

Physical properties	Results
Fineness	7
Specific gravity	3.15
Consistency	30.5 %
Initial Setting Time	40 minutes
Final Setting Time	120 minutes
Compressive Strength at 28 days	53.14 N/mm2

B. Aggregates

Coarse aggregate used was natural crushed aggregate. To suit the needs of scale of the test specimen, coarse aggregates used was passed through IS 20 mm sieve and retained on IS
12.5 mm sieve. Locally available natural sand of maximum size 4.75mm was used as fine aggregate. The physical properties of coarse and fine aggregate are shown in Table 2. and not as an independent document. Please do not revise any of the current designations.

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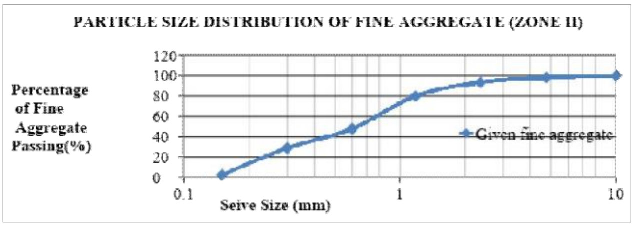
TABLE 2 : PROPERTIES OF AGGREGATES

Properties	Fine Aggregate	Coarse Aggregate
Specific gravity	2.5	2.63
Fineness modulus	2.47	7.27
Bulk density	1550.43 kg/m3	1778.63 kg/m3

Fig. 1. Particle Size Distribution of Fine Aggregate



C. Silica Fume

Silica fume (SF) is a byproduct of producing silicon metal or ferrosilicon alloys. The most beneficial use of this material is as a mineral admixture in concrete. Because of its chemical and physical properties, it is a very reactive pozzolana. Concrete containing silica fume can have very high strength and can be very durable. The microstructure of silica fume improves the durability of the concrete and hence bleeding and segregation is reduced.

Silica fume used for this study is of Grade 920 D of ELKEM was procured from CIDO Agencies, Coimbatore. The image of silicafume is shown in the figure 2. The specific gravity of silica fume is 2.4. The chemical composition of Silica fume is given in Table 3.

Fig. 2. Silica Fume

TABLE 3 : PROPERTIES OF AGGREGATES

Constituents	Quantity (%)
Silicon (% as SiO2)	>85
Aluminium (% as Al2O3)	<2
Iron (% as Fe2O3)	<1
Calcium (% as CaO)	<1
Magnesium (% as MgO)	<1
Sodium (% as Na2O)	<1
Titanium (% as TiO2)	<2

D. Chemical Admixture

MasterGlenium SKY 8233 is an admixture based on modified polycarboxylic ether. This chemical admixture has been used for applications in high performance concrete where the highest durability and performance is required. MasterGlenium SKY 8233 is free of chloride and low alkali. By using this superplasticizer, flowable concrete with greatly reduced water content is obtained. MasterGlenium SKY 8233 was procured from BASF India limited, Chennai.

E. Curing Compound

Concure WB is a water based concrete curing compound based on a low viscosity wax emulsion. It is supplied as a white emulsion which forms a clear film on drying. The recommended coverage rate is between 3.5 and 5.0 m²/litre (0.200 to 0.285 litres/m²). Concure WB has to be applied to the surface of newly hardened concrete immediately after demoulding. This curing compound compiles with ASTM C309-90 standard. The details of the concure WB were given in table 4.

TABLE 4 : PROPERTIES OF CURING COMPOUND

Description	Values
Colour	Bulk liquid - white
Minimum Shelf Life	12 months
Specific Gravity	1 to 1.01

F. Water

For this experimental work, potable water complying the requirements of IS 456 was used for the concrete and curing of concrete specimens.

III. EXPERIMENTAL PROGRAM

A. Mix Design

The mix design was done based on Nan –Su method proposed by Nan- Su. The mix proportion was carried out for concrete of grade 50 MPa. The details of mix proportion were given in the table 5.

TABLE 5 : PROPORTION FOR M50 GRADE CONCRETE BY NAN-SU METHOD

Cement	Fine Aggregate	Coarse Aggregate	Silica Fume	Super Plasticizer	Water
1	2.37	2.32	0.019	0.010	0.40

The estimated quantities of material per cubic meter of concrete are shown in table 6. Mixing of concrete was done in respective ratios of cement, silica fume, river sand and coarse aggregate, water. After uniform mixing of above materials, Master Glenium sky 8233 super plasticizer was added and mixed.

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TABLE 6 : ESTIMATED QUANTITIES OF MATERIAL PER CUBIC METER OF CONCRETE

Materials	Quantity
Cement	416.07 kg/m3
Fine Aggregate	987.93 kg/m3
Coarse Aggregate	965.43 kg/m3
Silica Fume	8.321 kg/m3
Super Plasticizer	4.243 kg/m3
Water	163.07 kg/m3

B. *Tests conducted on SCC*

Tests on fresh concrete were carried out to study the workability of SCC with silica fume such as Slump flow test, L-box test, U-box test and V-funnel which characterizes filling ability, resistance to segregation, passing ability respectively. These test were conducted and the results are reported. Typical acceptance criteria for SCC with a maximum aggregate size of up to 20 mm are listed in table7.

TABLE 7 : ACCEPTANCE CRITERIA FOR SCC AS PER EFNARC GUIDELINES

Test Methods	Properties	Acceptance Range	Units
Slump flow	Filling ability	650 - 800	mm
V- Funnel	Segregation resistance	6 - 12	sec
L- Box	Passing ability	0.8 - 1	H2/H1
U- Box	Passing ability	0 - 30	H2- H1 mm

VI. RESULTS AND DISCUSSION

A. *Workability of SCC*

After mixing of concrete, various workability tests such as Slump flow, V-Funnel, L-Box were conducted on the fresh SCC mix prepared based on Nan-Su method. The test results on the fresh concrete were shown in table 8 and graphs showing variation in workability were shown in the figure 3,4,5,6. It is observed that the workability tests on fresh concrete are found to be better for scc mix which have been prepared by incorporating silica fume mineral admixture upto 4 % replacement. Also, all the test results are within the limits provided in EFNARC specifications.

TABLE 8 : TEST RESULTS ON FRESH CONCRETE

Percentage Replacement of Silica Fume	Slump Flow (mm)	V-Funnel (Seconds)	L – Box H2/H1	U –Box (H1 – H2) mm
SF -0%	660	11	0.82	19
SF -2%	670	10	0.87	24
SF -4%	678	8	0.93	26
SF -6%	675	9	0.931	27

Figure 3: Variation In Workability (slump) for Different Percentage of Silica Fume

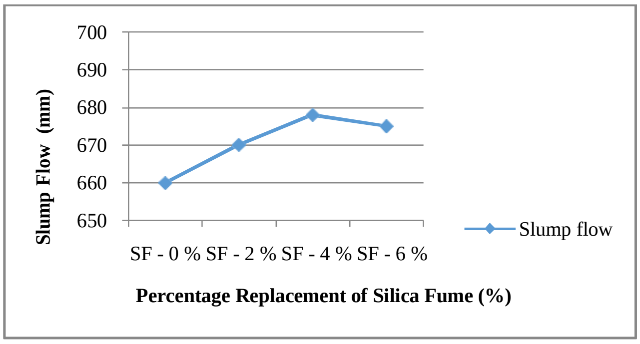


Figure 4: Variation In Time (V-funnel) For Different Percentage of Silica Fume

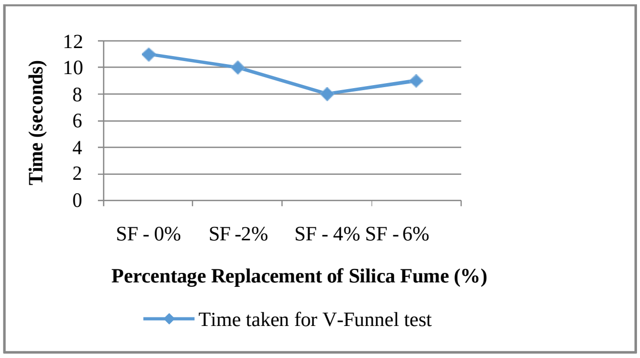


Figure 5 : Variation In H2/H1 (L-Box) For Different Percentage of Silica Fume

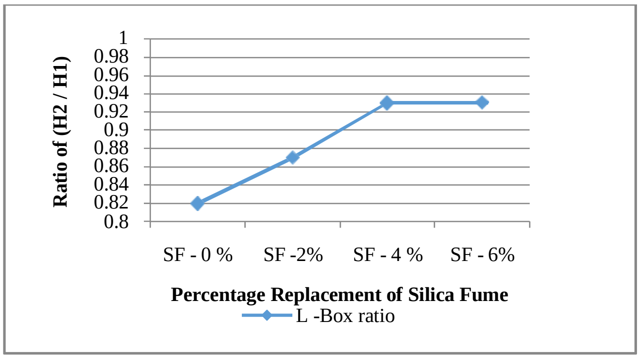
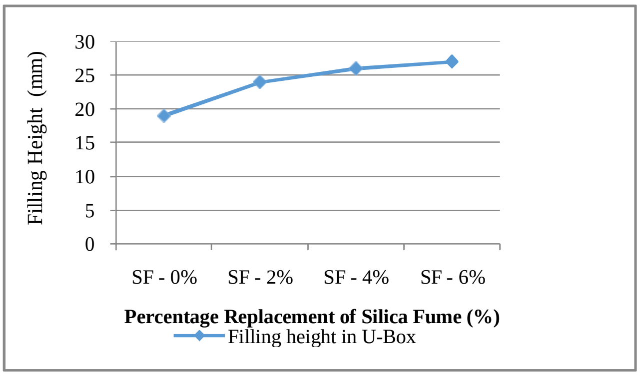


Figure 6 : Variation In Filling Height (U-box) for Different Percentage of Silica Fume



B. *Test on hardened concrete of SCC*

The concrete cube specimens of size 150x150x150 mm were cast for the SCC mix and tested at 28 days for compressive strength. The water curing and self-curing specimens were shown in the figure 7, 8. Table 9 gives the compressive strength of normally cured and self-cured concrete. The graph showing variation in compressive strength for normally cured SCC and self-cured SCC were shown in the figure 9.

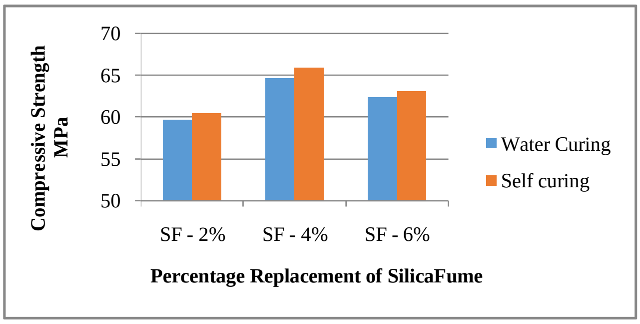
Figure 7 : Water curing concrete specimens

Figure 8: Externally Self cured concrete specimens

TABLE 9 : TEST RESULTS ON HARDENED CONCRETE

Percentage Replacement of Silica fume	Average Compressive Strength MPa	
	Water Curing	*Self-Curing*
SF – 2%	59.65	60.38
SF – 4%	64.68	65.90
SF – 6%	62.376	63.14

Figure 9: Variation in Compressive Strength for Water Cured and Self-Cured Concrete



CONCLUSIONS

From the experimental investigation on the effect of replacement of cement with Silica Fume in concrete, the following conclusions are drawn

1. Development of M50 grade SCC satisfies the workability properties determined by the tests namely slump flow, V - Funnel, L-Box, U- Box for the mix prepared by varying percentage replacement of Silica Fume have been found to be within the specified range of EFNARC guidelines.
2. The Nan-Su mix design method can be used for designing M50 grade SCC.
3. The compressive strength increases with increase in Silica Fume content up to 4% replacement with cement for normal curing as well as self-curing.
4. The results encourages the use of Silica Fume as pozzolanic material for replacement of cement in producing high strength concrete.
5. Compared to normal curing, curing by Concure WB has improved the compressive strength of SCC having Silica Fume at 28 days.

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