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Experimental Study of Self Compacting Concrete for Partial Replacement of Cement by Fly Ash and Silica Fumes

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ABSTRACT

The Self-Compacting Concrete (SCC) is that which gets compacted due to its self-weight and is deaerated (no entrapped air) almost completely while flowing in the form work. In recent times self-compacting concrete has been accepted as a quality product and are widely used. The addition of fly ash and silica fumes to concrete imparts superior mechanical properties to Self Compacting Concrete. The aim of this project work is to study the strength behavior of SCC partial replacement of cement with fly ash and silica fumes. Fly ash silica fume Self Compacting Concrete (FASFSCC) has been cast with volume fractions of 00%, 05%, 10% and 15% of silica fumes based on "Nan Su et.al" method and tested after 28 days of normal curing. This work also comprises the study of the effect of steel fibres on workability in fresh state and the compressive strength of cubes (150mmx150mmx150mm), split tensile strength of cylinders (diameter 150 mm and height 300mm), modulus of rupture of beams (100mmx100mmx500mm) in hardened state after 7,14, and 28 days of normal water curing. The results showed that the ultimate strength has increased marginally. The optimum volume fraction of silica fumes for better performance in terms of strength and ductility has been found to be 10%. Based on the results obtained from the investigations and after rational discussion, the conclusions have been developed on the fresh state properties of FASFSCC, hardened properties of FASFSCC, and the optimum dosage of silica fume.

Keywords: Fly Ash and silica fume self-compacting concrete, Mix design, and construction material.

INTRODUCTION

Self-compacting concrete (SCC) is broadly used for construction of civil engineering structures, like as in precast industries, high rise buildings and structures that need congested reinforcement. The main important characteristic of SCC in construction industry with the three main advantages which are workability, flowability and passing ability.

These properties of self-compacting concrete, concrete can be placed to complex shape moulds under its own weight without segregation and bleeding. During casting, energy consumption, labour works and construction time are reduced since external vibration is not required.

Basically Plain concrete is a brittle material that is strong in compression and weak in tension and flexure. From the light of the structural steel reinforcement contribution to the tensile strength of concrete, fly ash and silica fume usage in concrete industry has also been developed recently.

Silica fume is a by-product of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolan. Concrete containing silica fume can have very high strength and can be very durable.

Silica fume is available from suppliers of concrete admixtures and, when specified, is simply added during concrete production. Placing, finishing, and curing silica-fume concrete require special attention on the part of the concrete contractor.

The present work deals with a mix of silica fumes in different proportions like 05%,10%,15%. The main objective of this study is to determine the effect of fly ash and silica fumes on SCC in terms of the workability of FASFSCC and Compressive strength.

From literature the author Nan Su et al (2001) proposed new Mix design method based on experimental investigation carried out in Taiwan & finding in his research Packing Factor is used to determine the aggregate contents and the volume of fine aggregate is more than coarse Aggregate. Humbler, informal for implementation and less-time consuming, requires lesser amount of binders and saves cost as paralleled to the method developed by JRMCA (Japanese Ready-Mixed Concrete Association).

MATERIALS

The following materials are used in the concrete to achieve fresh and hardened properties.

Cementitious Material – Cement & Fly ash and silica fumes.

Cement – Binding material and Strength of concrete. OPC cement of grade 53 grade have been used having specific gravity as 3.04.

Fly ash – Class F Fly ash of specific gravity 2.44 and conforming to IS 3812-2003 procured from “Adhunik Power Plant, Gamharia Jamshedpur” has been used as a Mineral Admixture for partial replacement for cement.

Silica Fumes: Silica fume, also known as micro silica, is a by-product of the production of silicon and ferrosilicon alloys in electric arc furnaces. Silica fume is produced as a by-product during the production of silicon metal and ferrosilicon alloys. These alloys are commonly used in the steel and aluminium industries. The process involves the reduction of high-purity quartz or silicon dioxide (SiO_2) with carbon in an electric arc furnace

Fine aggregate – Locally available sand with 4.75 mm maximum size was used as fine aggregate. The specific gravity of fine aggregate used were 2.55 confirming to IS 383–1970. The fineness modulus of fine aggregate was found to be 2.65 of zone II.

Coarse aggregate- Locally available crushed stone with maximum size 20mm was used as coarse aggregate. The specific gravity of coarse aggregate used was 2.78.confirming to IS 383–1970. The fineness modulus of coarse aggregate was found to be 6.78.

Water dropping Admixture – Super plastizer reduce water cement ratio.

Viscosity Modifying Agent– To increase the flowable property of concrete.

METHODOLOGY

Mix Design for SCC

The method of mix design used in this experimental study is Nan-Su method. Nan-Su method is the only method that specifies the grade of concrete in SCC. The main limitation of this method is it gives required mix proportions for the grades which are more than M50. Hence certain modifications were made by Vilas V. Karjinni and Shrishail. B. Anadinni and this method were used for mix design of SCC for grades less than M50 by taking a correction factor.

Workability test on fresh properties of SFRSCC

The various tests done to check the workability are Slump test, V-Funnel test, L-Box test and J-Ring test. According to the experimental investigations to keep self-compacting effect of mixtures modified with steel fibres. The results have been presented in Table 1. According to the EFNARC specification the workability test gives the better result when we add 10% of silica fumes in the concrete mix.

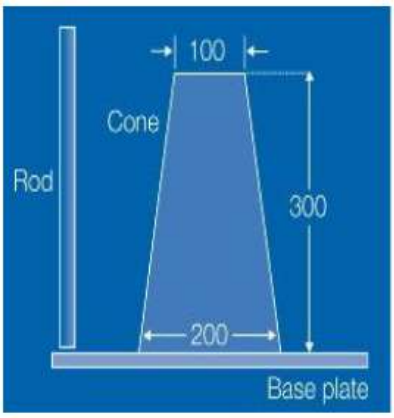

Fig.1: Slump Flow test apparatus

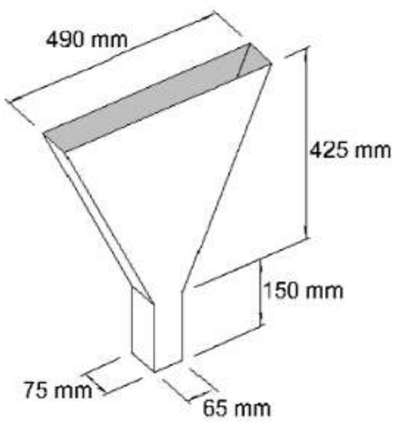

Fig. 2: V- Funnel test apparatus

Fig. 3: J- Ring test apparatus

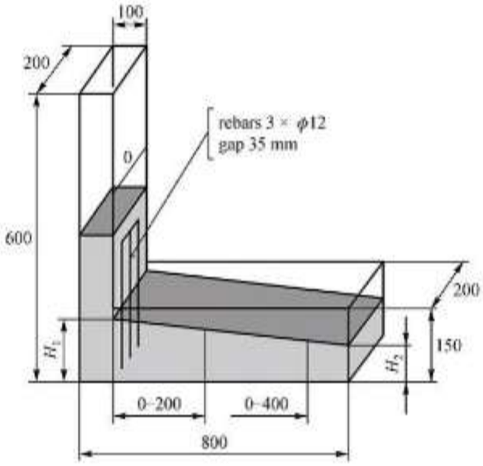

Fig. 4: L- Box Test apparatus

Table 1: Experimental result for workability test

S. No.	Silica fumes (%)	Slump Flow (mm)	T50 Slump Flow (sec)	V-Funnel (sec)	J-Ring (mm)	L-Box (H2/H1)
1	00	680	3.0	8.0	15	0.86
2	05	675	3.0	9.0	17	0.83
3	10	650	4.0	9.0	19	0.82
4	15	630	5.0	10.0	21	0.80

Table 2: Minimum acceptance criteria for SCC Recommended by EFNARC (2002)

s. no	Method	Unit	Minimum	Maximum
1.	Slump flow test	mm	650	800
2.	T50cm slump flow	Sec	2	5
3.	V-funnel test	Sec	6	12
4.	J-ring Height reduction	mm	0	20
5.	J- Ring Flow reduction	mm	0	100
6.	L-Box test	h_2/h_1	0.8	1.0

EXPERIMENTAL SETUP AND RESULT

The main objective of this research was to determine the properties of self compacting concrete using different percentage of fly ash and silica fumes in concrete mix.

Here compressive strength test was performed using concrete cube of size 150mm x150mm x150mm.for split tensile strength test cylindrical mould of diameter 150mm and of length 300mm. for flexural strength is performed on beam of size 100mm x 100mm x 500mm.

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Compressive Strength

The test of compressive strength of cubes (150mmx150mmx150mm) in hardened state after 7, 14 and 28 days of normal water curing. The testing of the specimens will be carried out on a hydraulic compression testing machine of capacity 200T. After cleaning off the bearing surface of the testing machine the specimens will be placed in the machine in such a manner that the loads could be applied to opposite sides of cubes as cast. The axis of the specimen will be kept carefully aligned with the centre of thrust of the spherically seated platen.

Table 3: Average compressive strength of M30 grade FASFSCC

Sl No.	% silica fume	Average Compressive strength at 7 days (in MPa)	Average Compressive strength at 14 days (in MPa)	Average Compressive strength at 28 days (in MPa)
1	00	26.4	34.6	36.0
2	05	27.1	35.6	36.9
3	10	27.8	36.4	38.13
4	15	27.36	36.0	37.4

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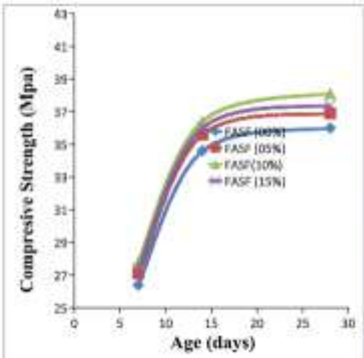

Figure 5: Variation of compressive strength of FASFSCC with age of specimen

Split-Tensile Strength

Split-tensile strength test was performed on the cylinder having a diameter of 150mm and 300mm height. The test was done after 7, 14, and 28 days of curing.

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Table 4: Average split tensile strength of M30 grade FASFSCC

Sl No.	% silica fume	Average split tensile strength at 7 days (in mpa)	Average split tensile strength at 14 days (in mpa)	Average split tensile strength at 28 days (in mpa)
1	00	2.52	3.37	3.65
2	05	2.65	3.51	3.86
3	10	2.73	3.65	4.17
4	15	2.66	3.55	3.93

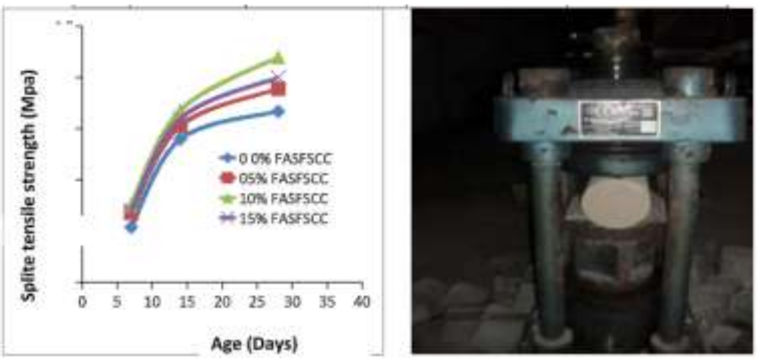

Figure 6: split-tensile strength of FASFSCC with age of specimen cured in normal water

Flexural Strength

Flexural strength test was performed on the beam size of 100mm x 100mm x 500mm. The test specimens were tested after 7, 14 and 28 days of normal curing.

Table 5: Flexural Strength of M30 grade FASFSCC

Sl No.	% of silica fumes	Flexural strength at 7 days (in mpa)	Flexural strength at 14 days (in mpa)	Flexural strength at 28 days (in mpa)
1	00	1.84	2.58	3.53
2	05	1.99	2.79	3.65
3	10	2.30	3.03	3..95
4	15	2.17	2.90	2.80

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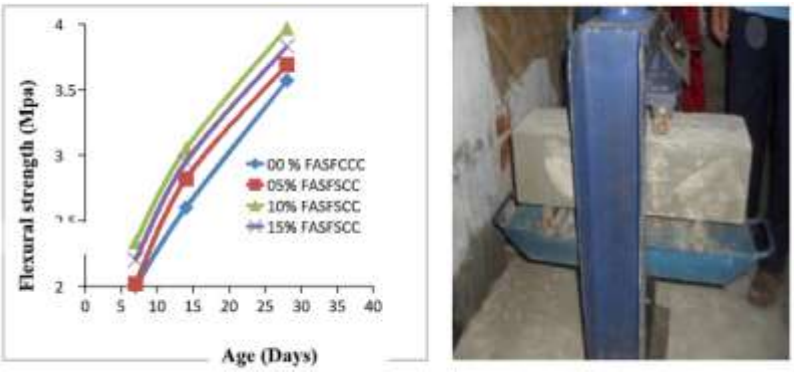

Figure 7: Variation of flexural strength of SFRSCC with different % of steel fibre

CONCLUSIONS

Based on the results obtained from the investigations and after rational discussion, the following conclusions have been drawn on the fresh state properties of FASFSCC, hardened properties of FASFSCC and the optimum dosage of fly ash and silica fume.

- The workability results were found to be satisfactorily acceptable according to EFNARC standards. FASFSCC with high workability and good slump retention can be obtained a silica fumes content up to 10%.
- The compressive strength increased a due to the addition of fly ash and silica fumes up to certain limit. After certain limit the strength decreases.

- Split-tensile strength of FASFSCC is higher than those of SCC for the same cube compressive strength. It has been observed that up to the addition of 10% of silica fume to the concrete, the split tensile strength of concrete increases constantly.
- From the graph it can be reported that as the flexural strength of concrete is increase up to certain limit. After certain limit the strength decreases.
- From all the experimental results obtained and rational discussion, it can be said that the optimum dosage of silica fumes was found to be 10%.

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