International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN: 0974-4290
Vol.8, No.1, pp 01-05, 2015

Effect of Silica Fume in Flow Properties and Compressive Strength of Self Compacting Concrete

S.S.Vivek* and G.Dhinakaran

School of Civil Engineering, SASTRA University, Thanjavur, India

Abstract: In the present paper to evaluate performance of Self Compacting Concrete (SCC) by replacing cement with varying the silica fume (SF) percentages. An attempt was made to study the performance of fresh concrete by slump flow test, T_{500} test and the hardened properties of concrete by compression test. There were four mixes of SCC were made by replacement of cement with various percentages of silica fume from 5 to 20% with an increment of 5%. Tests were carried out to assess the compressive strength of concrete at different ages namely 7, 14 and 28 days. For SCC, super-plasticizer (Conplast SP430) was added in optimized dosage. It was found that replacement of cement by 10% of silica fume with a water to powder (w/p) ratio of 0.8 gave better results on fresh properties and compressive strength of admixed concrete.
Keywords: SCC, slump flow, w/p ratio, compressive strength, silica fume.

Introduction

Self compacting concrete is one of the modern types of concrete widely employed in the construction industry. It has vital properties like flow ability, passing ability, etc. To develop SCC, one should play a key role in handling chemical and mineral admixtures. In present study, SCC was developed by replacing cement by Silica fume (varying from 5% to 20% with an increment of 5%). Silica fume also referred to as micro silica or condensed silica fume, is another material that is used as an artificial pozzolonic admixture. It is a product resulting from reduction of high purity quartz with coal in an electric and furnace in the manufacture of silicon or ferrosilicon alloy. Silica fume rises as oxidized vapors. It cools, condenses and is collected in cloth bags. It is further processed to remove impurities and to control particle size. Condensed silica fume is essentially silicon dioxide (more than 90%) in non-crystalline form. It is extremely fine with particle size less than 1 micron and with an average diameter of about 0.1 micron, about 100 times smaller than average cement particles.

Usage of high reactive Metakaolin and Flyash, as an admixture and mix design was prepared with 29% of coarse aggregate, replacement of cement with Metakaolin and class F flyash, combinations of both and controlled SCC mix with 0.36 water/cementitious ratio(by weight) and 388 litre/m^3 of cement paste volume. Crushed granite stones of size 16 mm and 12.5 mm used with a blending 60:40 by percentage weight of total coarse aggregate[1]. Self compacting concrete a highly flow able, yet stable concrete that can spread readily into place and fill the formwork without any consolidation. The characteristics of materials and the mix proportion influences self-compactability to a great extent[2]. An experimental study on self-compacting concrete (SCC) was made with three types of mixes, the first consist of different percentages of fly ash (FA), the second uses different percentages of silica fume (SF), and the third uses a mixture of FA and SF in cement replacement. The slump and V-funnel test was carried out on the fresh state and SCC with 15% of SF gives higher values of compressive strength than those with 30% of FA[3]. Silica fume was a viable secondary mineral material, leads to higher than usual modulus value and from the mixes was studied. It was suggested that no more than 6% silica be replaced by mass[4]. A research study was made on SCC consists of lime stone and silica fume[5]. A new mix

design method for self-compacting concrete (SCC) was developed, comparison made with Japanese Ready-Mixed Concrete Association (JRMCA), proved simpler, easier for implementation and less time-consuming, requires a smaller amount of binders and saves cost[6]. As per EFNARC guidelines, fresh state behavior on SCC were studied [7, 8].

Material Properties

Sieve analysis was carried out for fine aggregate and coarse aggregate and the results were obtained. Proportioning of aggregate was done to find the proportion of coarse to fine aggregate in SCC to obtain maximum density. Preliminary tests such as consistency test and setting time tests were carried out on the Ordinary Portland Cement (OPC). The specific gravity of silica fume material and cement were determined using density bottle method.

Cement: Ordinary Portland cement, 53 grade was used. The typical content of cement is 350 – 450 kg/m^3. The maximum size of coarse aggregate was generally limited to 12.5 mm. River sand was used as fine aggregates. Super plasticizers are an essential component of SCC to provide necessary workability. Super plasticizer: Conplast SP 430 with a dosage 1% weight of cement was employed.

Experimental Programme

The experimental programme was carried out by the selection of material and its properties, mix proportioning of SCC in a laboratory was developed by varying w/p ratio under slump flow and T_{500} tests. With that final mix proportion was arrived. With w/p ratio of 0.8, tests for self-compacting concrete in fresh and hardened state were studied with replacement of cement by 5 to 20% of silica fume.

Mix Design For Self-Compacting Concrete

The SCC mix design was developed by preparing trial mix in the laboratory by conducting slump flow test and measuring the spreaded diameter of the flow in the tray of 900 mm square. In total mix proportions,1 part of cement, 50% of fine aggregate (1.5) and 50% of coarse aggregate(1.5) was kept equal initially, later the fine aggregate was increased more than coarse aggregate content, to develop the flow characteristic of SCC. The final arrived mix for satisfying flow was determined as 1: 2: 1.64. i.e. powder content viz. silica fume and fine aggregate has been raised in the mix. Powder type SCC was prepared by chemical admixture namely super plasticizer (Conplast SP430) and mineral admixture namely silica fume with w/p ratio of 0.8.

Tests on Fresh Concrete

Slump flow test and T_{500} test

It is the most popular method for testing the flow ability of concrete. It is done to assess the horizontal free flow of concrete in the absence of obstruction. T_{500} represents time taken in seconds for the slump flow to reach horizontal diameter of 500 mm.

Figure 1 &2 - Slump flow and T_{500} test

Casting and curing of test specimen

Moulds of size 100 mm x 100 mm x 100 mm were used for casting concrete specimens meant for testing compressive strength of self compacting concrete at the ages of 7, 14 and 28 days respectively.

Compressive strength test was carried out on the specimens using automatic compression testing machine.

Table 1: Materials required per m^3 of SCC

Components	SF 5	SF 10	SF 15	SF 20
CEMENT (kg)	4.75	4.50	4.25	4.0
SF (kg)	0.25	0.50	0.75	1.0
FA(kg)	10	10	10	10
CA(kg)	8.2	8.2	8.2	8.2
SP(%)	1.0	1.0	1.0	1.0
W/p Ratio	0.8	0.8	0.8	0.8
WATER (litres)	4.0	4.0	4.0	4.0

Results and Discussion

The experimental work was carried out to study the material properties involved in SCC mix, slump flow and hardened properties of self-compacting concrete with w/p ratio of 0.8 and Super plasticizer (Conplast SP430) were discussed as follows:

Table 2 -Properties of Materials

Fine aggregate	**Fineness modulus:2.7**
Coarse aggregate	Bulk density:1388.09 kg/m^3
Cement(OPC)	Initial setting time:31 min
	Std. consistency:31%
	Specific gravity:3.01
Silica fume	Specific gravity:2.08

Table 3 -Properties of SCC in fresh state

Test methods	SF 5	SF 10	SF 15	SF 20	Permissible values as per EFNARC
Slump Flow Test T-500 (s) Spread diameter (mm)	 4.8 520	 5.4 540	 4 550	 4 480	 2-7 550-800

Table 4 -Hardened properties of SCC

Sl.No.	Mix	Compressive Strength (MPa)		
		Age at 7days	Age at 14days	Age at 28days
1	SF5	10.11	15.9	17.03
2	SF10	8.41	9.70	22.62
3	SF15	5.92	12.96	17.16
4	SF20	6.22	8.20	14.13

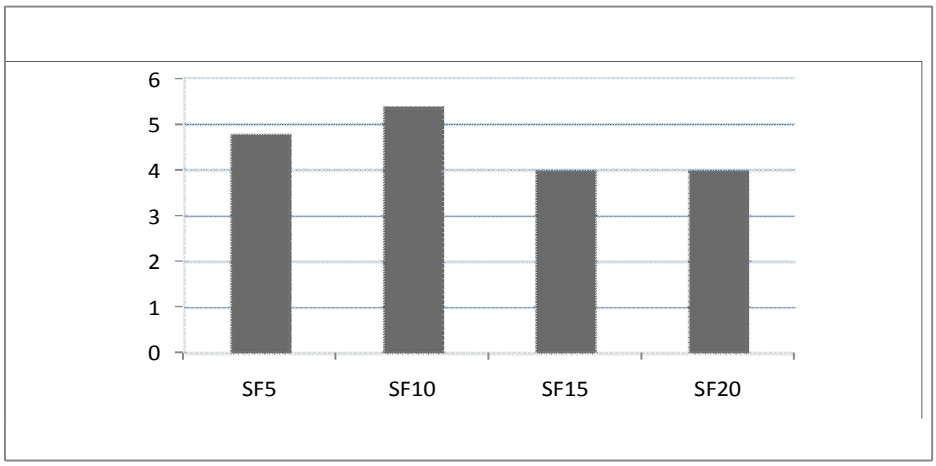

Figure 3 T_{500} (Slump Flow) – Time (s) Vs SF mixes

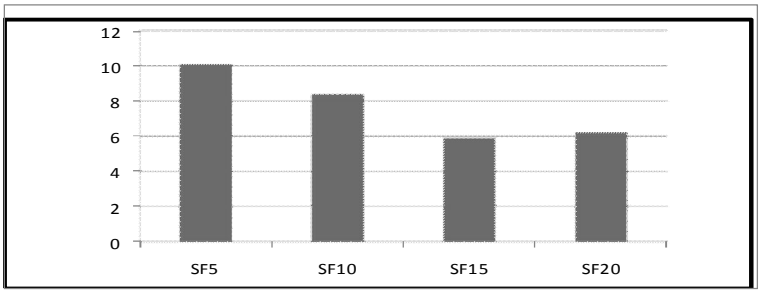

Figure 4. Compressive Strength in MPa Vs SF at the age of 7 days

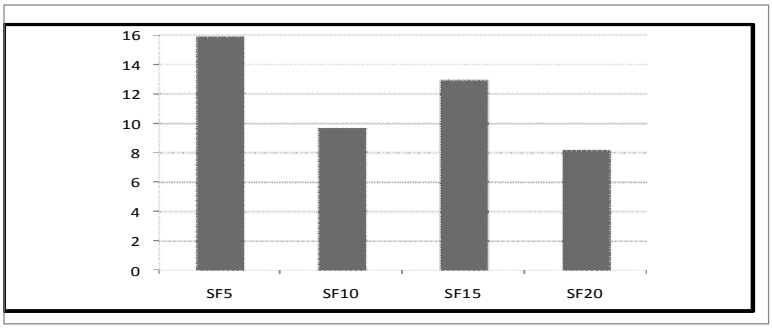

Figure 5. Compressive Strength in MPa Vs SF mix at the age of 14 days

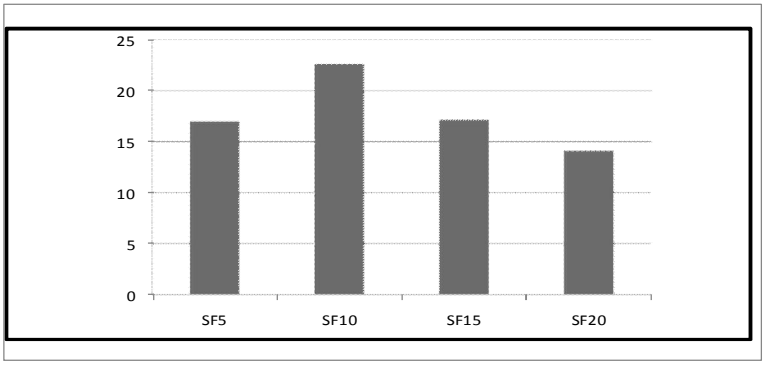

Figure 6. Compressive Strength in MPa Vs SF mix at the age of 28 DAYS

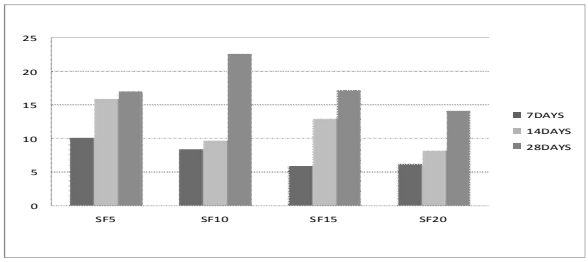

Figure 7 Comparison of compressive strength in MPa Vs SF mix at different ages

Comparison of T_{500} values:

On comparing T_{500} values of all mixes SF15 and SF20 have the least value of 4 seconds i.e, they have high flow ability.SF5 has the moderate value of 4.8 seconds and has less flow ability compared to SF15 and SF20. SF10 has the high value of 5.4 seconds and has the very low flow ability compared to all the other mixes.

Comparison of compressive strength values:

The compressive strength for 7 days and 14 days obtained was 10.11 N/mm^2 and 15.9 N/mm^2 for SF5, which is higher compared to other SF mixes namely SF 10, 15 and 20 respectively. The compressive strength for SF10 at the age of 28 days is 22.62 N/mm^2, has higher value compared to other SF mixes respectively.

Conclusion

Effect of silica fume content in the self compacting concrete was investigated and concluded as follows:

- Cement was replaced by silica fume in percentages of 5%, 10%, 15% and 20% respectively.
- The super plasticizer Conplast SP430 was added in optimum dosage (1%) by keeping w/p ratio of 0.8 in order to gain more strength.
- Replacement of cement by 15% of silica fume with a w/p ratio of 0.8 gave better results in Slump flow and T_{500} test.
- Replacement of cement by 5% of silica fume with a w/p ratio of 0.8 gave better compressive strength at the age of 7 and 14 days but it fails in flow properties.
- Replacement of cement by 10% of silica fume with a w/p ratio of 0.8 gave better fresh concrete performance and compressive strength at the age of 28 days.
- Further, the flow ability of concrete in SCC by silica fume can be developed using Combination type consisting Viscosity Modifying Agent and chemical admixtures namely, poly carboxylated ethers and sulphonates.

References

1. Krishnamurthy N, Narasimharao AV, Ramanareddy IV, Vijayasekhar reddy M. Mix Design Procedure for Self Compacting Concrete. IOSR J Eng., 2012, 2(9); 33-41.
2. Hardik Upadhyay, Pankaj Shah, Elizabeth George. Testing and Mix Design Method of Self-Compacting Concrete. Nat. Conf. Rec. Trends in Eng. & Tech., 2011.
3. Heba AM. Effect of Flyash and Silica fume on compressive strength of SCC under different curing conditions. Ain Shams Eng. Journal, 2011, 2; 79-86.
4. Salem AS. Influence of silica fume on the properties of self compacting concrete. World Academy of Sci. Eng. and Tech., 2013, 77; 459-462.
5. Salem AS, Hakeem E, Waneisa AG. Influence of Silica Fume on the Properties of Self-Compacting Concretes. EngOpt 2012 – 3rd Int. Conf. Eng. Optn. Rio Janeiro, Brazil, 2012.
6. Nan Su, Kung-Chung Hsu, His-Wen Chai. A simple mix design method for self-compacting concrete. Cem & Conc Res, 2001, 31; 1799–1807.
7. EFNARC. Specification and Guidelines for Self-Compacting Concrete, 2002, 1-32.
8. The European Guidelines for Self-Compacting Concrete Specification, Production and Use, 2005, 1-63.

*****