International Journal of Advanced Information Science and Technology (IJAIST) ISSN: 2319:268
Vol.3, No.1, January 2014 DOI:10.15693/ijaist/2014.v3i1.57-61

An Experimental Study on the Properties of Self Compacting Concrete (SCC) Containing Silica Fume and Fly Ash

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***Abstract* - Self compacting concrete is a high performance concrete which has high deformability and resistance to segregation. It gets compacted under its own weight. In this study self compacting concrete containing 40% cement replacement with combination of silica fume and fly ash is used. Fly ash is varied from 25% to 35% and silica fume is varied from 5% to 15%. Experiments were conducted to study the effect of silica fume and fly ash on the properties of fresh and hardened concrete. Compressive, split tensile and flexural strength tests were carried out to study the properties of hardened concrete. Results showed that increase in silica fume content increases all the properties. Similarly slump flow, T-50, J-Ring, U Box, L Box and V funnel tests were conducted to study the properties of fresh concrete and found that the increase in silica fume content has a positive effect.**

Key words- Silica fume; fly ash; fresh properties; hardened properties

I. INTRODUCTION

Concrete is a man-made material which has the vastest utilization worldwide and this leads to important problems regarding its design and preparation to finally obtain an economic product which is friendly with the environment during its fabrication process and also its aesthetical appearance when it is used in the structures. Society continuously demands improvements in the performance of concrete in order to satisfy the above mentioned facts.. Many studies have been made concerning the use of additives and super–plasticizers in the concrete for passing the frontier of minimum water content for a good workability of a concrete. As a result of this, high performance concretes were developed having a superior durability. Self-compacting concrete (SCC) is an innovative concrete.

Self compacting concrete is a highly workable concrete that can move under the force of gravity without vibration, during mixing, transportation, handling and placement.SCC can flow through densely reinforced and complex structural elements under its own weight and adequately fill all voids without segregation, without the need for vibration or mechanical consolidation. The properties of SCC differ considerably from conventional slump concrete.

II. RELATED WORK

K.Turk and Mehmet Karatas[3] studied the effect of Silica fume and Fly ash when added separately as partial replacement of cement from 5% to 20% and 25% to 40% at 5% intervals respectively and found that SCC with SF/FA had in general higher compressive and tensile strength than NC specimens for all curing ages. SCC with SF15 had the highest compressive and tensile strength

A.Navaneethakrishnanand V.M.Shanthi [7] conducted experiments in self compacting concrete and reported that SCC with 15 percentage replacement of cement with silica fume showed good results both in compression and Tension.

MuctebaUysalet.al [5] investigated on the properties of self-compacting concrete (SCC) in which Portland cement (PC) was replaced with fly ash (FA), granulated blast furnace slag (GBFS), limestone powder(LP), basalt powder (BP) and marble powder (MP) in various proportioning rates and the influence of mineral admixtures on the workability, compressive strength, ultrasonic pulse velocity, density and sulphate resistance of SCC was investigated. The test results showed that among the mineral admixtures used, FA and GBFS significantly increased the workability and compressive strength of SCC mixtures.

HebaA.Mohamed[6] experimental investigations on self compacting concrete with fly ash and silica fume under curing conditions showed that SCC with 15% of SF gives higher value of compressive strength than those with 30% of Fly ash and specimens at the age of 28 days give the highest value of compressive strength.

R.Ramanathan et al. [4]investigatedon strength aspects and workability of SCC with silica fume and concluded that the use of admixtures improved the performance of self compacting concrete in fresh state and its strength and also avoided the use of viscosity modifying admixtures

The objective of the study is to find an appropriate combination of silica fume and fly ash in SCC and to compare its properties with SCC containing only fly ash.

III. EXPERIMENTAL INVESTIGATION

A. Materials Used

Cement:Ordinary Portland cement of grade 53 conforming to IS 12269-1987 is used.

Coarse aggregate:In this study aggregate with nominal size 12.5 mm is used. Specific gravity of coarse aggregate used is 2.76 and bulk density is 1540kg/m3.

Fine aggregate:River sand of specific gravity 2.73 and bulk density 1670kg/m3 conforming to zone II of Is 363 was used in this study

Silica fume: it is amorphous and, Silicon dioxide content is more than 85%.Trace elements depending upon type of fume.Bulk density of silica fume (as-produced) is 130 to 430 kg/m3 and (densified) is 480 to 720 kg/m3 ,Specific gravity is 2.2 and Specific surface 15,000 to 30,000m2/kg

***Fly ash*:**Fly ash is a fine residue resulting from the burning of powdered coal at high temperatures. The most common sources of fly ash are electric power-generating stations. Fly ash confirming to IS: 3812 was used.

***Super plasticizer*:** MasterGlenium SKY 8233(Formerly Glenium B233) is an admixture of new generation based on modified polycarboxylic ether. Master Glenium SKY 8233 is free of chloride & low alkali. It is compatible with all types of cements. It is a Light brown liquid with relative density: 1.08 + /- 0.01 at 25°C and pH is greater than 6. The Chloride ion content is less than 0.2%

Water:Potable water is used for mixing the materials and curing the specimen

B. Mix design and combinations

Experimental investigationswere done on four mix proportions including the control mix. In control mix, 40% of cement is replaced with fly ash alone. In all other mixes cement replacement of same percentage with a combination of silica fume and fly ash were done SF5, SF10, SF15 were themixes made with silica fume content varying from 5% to 25% and fly ash from 35% to 25% respectively. For control mix 2.2 percentage of super plasticizer was used and for all other mixer 2.5 percentage was used. Mix proportions for different combinations of silica fume and fly ash is shown in Table.1

Table 1.Mix Proportions

Mix ID	Cement kg/m^3	Fly Ash kg/m^3	Silica Fume kg/m^3	Fine Aggregate kg/m^3	Coarse Aggregate kg/m^3	Water l/m^3	Super plasticizer %
CM	312	208	-	1000	790	172	2.2
SF 5	312	182	26	1000	790	172	2.5
SF 10	312	156	52	1000	790	172	2.5
SF15	312	130	78	1000	790	172	2.5

IV. RESULTS AND DISCUSSIONS

Test results obtained for SCC with 40% replacement of cement with silica fume and fly ash in different proportions varying from 5% to 15% and 25% to 35% respectively are shown in the tables below.

A. Properties of Hardened Concrete:

Compressive Strength, Split tensile strength and Flexural strength tests were conducted to study the hardened properties of concrete. Compression test is conducted on cubes of size 150 x 150 x 150 mm. Tensile strength of concrete is obtained from the split tensile strength test conducted on the cylinder specimen of height 300mm and diameter 150mm. Compressive and split tensile strength tests were carried out on the specimens at the age of 7 days, 14 days and 28 days Flexural strength test is conducted on prism specimen of size 100 x 100 x 500 mm, at the age of 28 days only.

Compressive strength increased with age of curing and found to be the maximum for the mix with 15% silica fume and 25 % fly ash. As per IS 456 the split tensile strength value is $0.7(fck)^{½}$ and is satisfied by SF 15 at 28 days curing.Split tensile strength value also increased with age of curing.SF 15 attained maximum split tensile strength which indirectly indicated the compressive strength.Flexural strength is tested after 28 days curing and showed the same variation as that of split tensile and compressive strength. Mixes containing both silica fume and fly ash showed more strength compared to control mix which contained only fly ash (40%).

Table 2.Test results on hardened concrete

Mix ID	Weight kg	Density Kg/m^3	Compressive Strength N/mm^2			Split Tensile Strength N/mm^2			Flexural Strength N/mm^2
			7 Days	14 Days	28 Days	7 Days	14 Days	28 Days	28 Days
CM	8.533	2528.29	32.36	34.125	35.256	2.246	2.286	2.340	3.339
SF 5	8.556	2540.02	38.42	39.123	42.355	2.302	2.362	2.560	3.519
SF 10	8.042	2382.71	41.28	41.940	42.140	2.334	2.312	2.640	3.679
SF15	8.402	2491.25	41.60	42.040	43.173	2.290	3.052	3.080	3.819

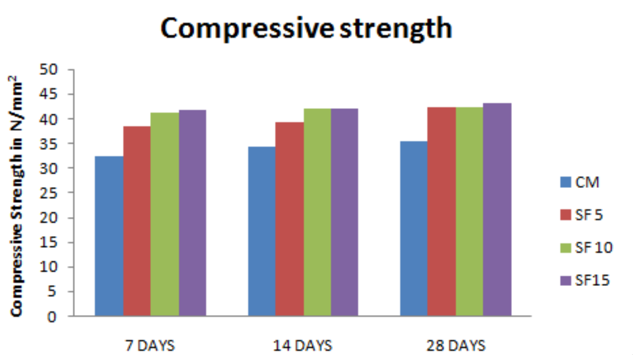

Fig.1 Compressive strength of all the mixes

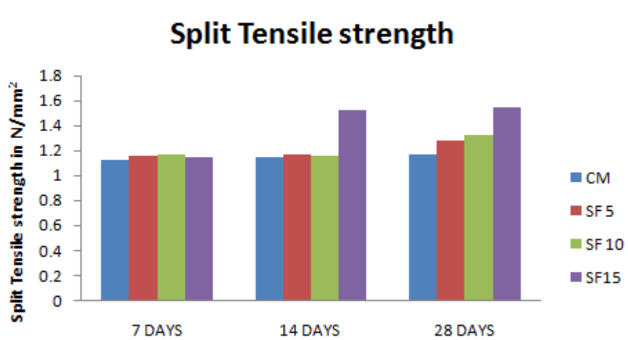

Fig.2 Split Tensile strength of all the mixes

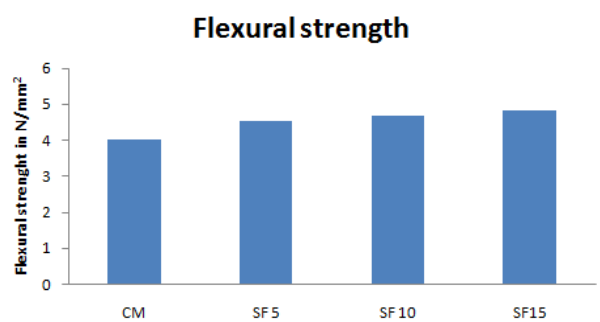

Fig.3 Flexural strength of all mixes

B.Properties of Fresh Concrete:

Fresh properties on Concrete were studied by conducting slump flow and T50 test., V-funnel test, J-ring test, L-Box test and U Box test and the result obtained is shown in table. All these tests were conducted to find the filling ability of concrete under its own weight and in reinforcement congested constructions. The slump flow diameter is found to lie between 600 and 800mm. The time taken by all the mixes to spread 50 cm diameter(T50) was also measured during slump flow test. Lower time shows higher fluidity. Fresh concrete test result for all the mixes satisfied the specifications but SF15 was found to have the optimum value. Flow ability is least for control mix containing fly ash alone. Silica fume content had a positive effect on the fresh properties of self compacting concrete.

Table 3.Tests results of fresh concrete

Mix ID	Slump Flow mm	T_{50} sec	V-Funnel Sec	L-Box (h2/h1) mm	U-Box (h2-h1) (mm)
CM	630	4.7	11.23	1	28
SF 5	640	4.5	10.83	0.97	26
SF 10	645	4.2	10.14	0.94	25
SF15	645	4.1	9.74	0.89	23

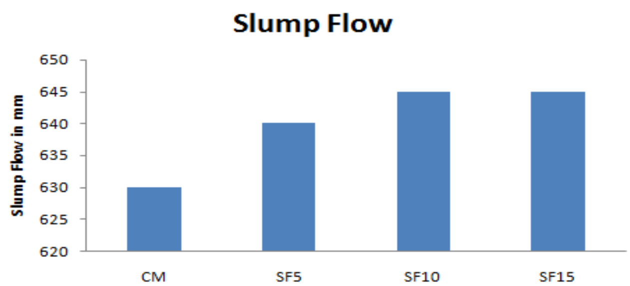

Fig.4 Slump flow diameter for all the mixes

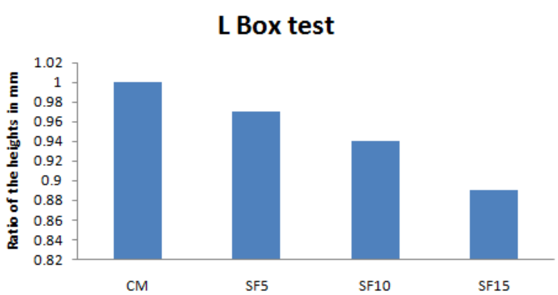

Fig.6 L Box test results of all the mixes

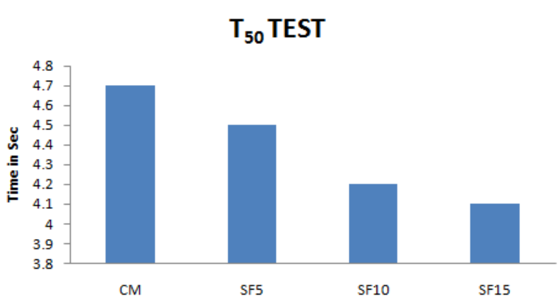

Fig.5 T50 Test results of all the mixes

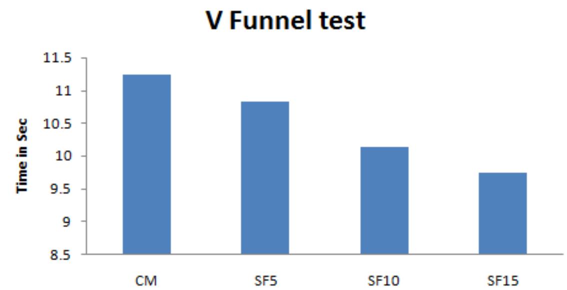

Fig.7 V funnel Test Results of all the mixes

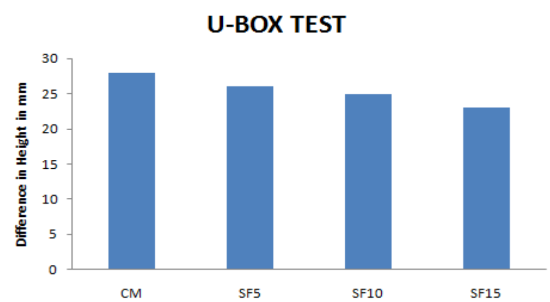

Fig.8 U Box test results of all the mixes

V. Conclusion

From the experimental investigations, it was seen that the increase in silica fume content had positive effect on theproperties of fresh and hardened concrete All the mixes developed satisfied the requirements of SCC specified by EFNARC. Increase in silica fume content improves the fresh and hardened properties of SCC. Cost of construction can be reduced by reducing cement. The compressive strength of the mix with silica fume 15% is improved by about 22.25% than the control mix. Tensile strength of the mix with silica fume 15% is enhanced by 22.25% comparing the control mix. The flexural strength obtained for SF15 is superior to thecontrol mix by 14.37%.

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