Experimental Investigation on Self-Compacting Concrete using Fly Ash

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Abstract- Self-compacting concrete (SCC) is an innovative concrete that is able to flow under its own weight, completely filling formwork and achieving full compaction without vibration. It had three key properties to evaluating the SCC they are fluidity, filling ability and segregation risk of the fresh concrete. This paper investigated to comparison of control plain self- compacting concrete (SCC) of M40 grade mixture and with fly ash plain self-compacting concrete. The various fractions of fly ash are10%, 20% and 30%. Workability was determined through slump flow diameter, L-box, U-box, J-ring and V-funnel flow time tests. Mechanical characteristics were obtained through compressive strength and splitting tensile strength tests with standard cube 150*150*150mm and cylindrical specimens of 150*300 mm, and flexural strength test with standard prism 700*100*100mm.

Keywords – SCC, Fly Ash, Compressive Strength, Splitting tensile test, Flexural strength test.

I. INTRODUCTION

Self-compacting concrete (SCC) is considered as a concrete which can beplaced and compacted under its self-weight with little or no vibration effort, and which is at the same time, cohesive enough to be handled without segregation or bleeding. It is used to facilitate and ensure proper filling and good structural performance of restricted areas and heavily reinforced structural members. SCC was developed in Japan in the late 1980‘s to be mainly used for highly congested reinforced structures in seismic regions. Recently, this concrete has gained wide use in many countries for different applications and structural configurations. SCC can also provide a better working environment by eliminating the vibration noise. There are many advantages of using SCC, especially when the material cost is minimized. These include: · Reducing the construction time and labour cost; · Eliminating the need for vibration; · Reducing the noise pollution; · Improving the filling capacity of highly congested structural member. Such concrete requires a high slump that can easily be achieved bySuperplasticizer addition to a concrete mixture. However, for such concrete to remain cohesive during handling operations, special attention has to be paid to mix proportioning. To avoid segregation on super plasticizer addition, a simple approach consists of increasing the sand content at the cost of the coarse aggregate content by 4 to 5 %. But the reduction in aggregate content results in using a high volume of cement which, in turn, leads to a higher temperature rise and an increased cost. An alternative approach consists of incorporating a viscosity-modifying admixture to enhance stability. Chemical admixtures are, however, expensive, and their use may increase the materials cost. Saving in labour cost might offset the increased cost, but the use of mineral admixtures such as fly ash, blast furnace slag, or limestone filler could increase the slump of the concrete mixture without increasing its cost. The investigations show that the use of fly ash improves rheological properties and reduces cracking of concrete due to the heat of hydration of the cement (6). Kim et al. (7) studied the properties of super flowing concrete containing fly ash and reported that the replacement of cement by 10%, 20% and 30%fly ash resulted in excellent workability and flowability. The objective of this study is to assess the effects of high volume fly ash replacement on the fresh and hardened properties of SCCs. Even though, the suitability of using such a fly ash needs muchdetailed investigations, this study covers some fresh and hardened properties of mixtures In addition to the fly ash; were used at different volume fraction in making the concrete. For comparison, a control plain self-compacting concrete (SCC) of M40 grade without fly ash and with fly ash are used. In this study included a polycarboxylic based superplasticizer (SP).

II. MATERIALS

A. Cement-

The cement used in all mixtures was commercially available Ordinary Portland cement (OPC) of 43 grade manufactured by Chettinad company confirming to IS: 12269 was used in this study. The specific gravity of the cement was 3.13. The initial and final setting times were found as 36.2minutes and 313 minutes respectively.

B. Fine aggregate

Locally available river sand passed through 4.75mm IS sieve was used. The specific gravity 2.66 and fineness modulus of 2.72 were used as fine aggregate. The loose and compacted bulk density values of sand are 1600 and 1688 kg/m3 respectively.

C. Coarse aggregate

Crushed granite aggregate available from local sources has been used. The coarse aggregates with a maximum size of 12mm having the specific gravity value of 2.78 and fineness modulus of 7.36 were used as coarse aggregate. The loose and compacted bulk density values of coarse aggregates are 1437 and 1526 kg/m3 respectively.

D. Fly ash

Fly ash gotfrom near hollow block manufacturing plant, kundampatti,sivakasi, India was used in this study. The fly ash had a relatively low specific gravity and fineness modulus of 1.975 and 1.195 respectively.

E. Super plasticizer

MasterGlenium SKY 8233 is an admixture of a new generation based on modified polycarboxylic ether. The product has been primarily developed for applications in high performance concrete where the highest durability and performance is required. The product shall have specific gravity of 1.08 & solid contents not less than 30% by weight.

F. Water

Portable water are used to concrete mix.

Mixing and Testing Procedure

In this paper, various volume fractions of fly ash 10%, 20%, and 30%were used. In partial replacement of fly ash by cementstrength classes of SCC (40 Mpa) were investigated. The concrete mix designs are given in Table 1. Overall, mix designs were made, two of which were plain and with fly ash.

TABLE - 1 MIX PROPORTION OF SCC

Grade of concrete	W/C ratio	Specimen	Cement	Fly ash	Fine aggregate	Coarse aggregate	Super Plasticizer % by wt
M40	0.45	TRIAL – 1	600	0	673.3	708.16	0.6
		TRIAL – 2	540	60	673.3	708.16	0.6
		TRIAL – 3	480	120	673.3	708.16	0.6
		TRIAL - 4	420	180	673.3	708.16	0.6

The process of making SCC is done with fly ash being added during the mixing process. The SCC mixture was made in 3 steps. First, the powder materials and aggregates were mixed in dry form for 1 min. Then the water containing the whole super plasticizer was poured and mixed for 3 min. After the materials were mixed, fresh concrete tests were performed to determine the workability of the SCC. The flow rate of SCC depends on the viscosity of the concrete. SCC must have four main characteristics. First, it should be able to fill out the form with

its weight. Besides, it should be of an acceptable level of resistance against segregation. Yet another important characteristic of SCC is its ability to pass through spaces between rebars, and finally, it needs to have a smooth surface after demoulding. In order to achieve these characteristics, there are some tests in EFNARC[8] and ACI 237R such as slump flow diameter, V-funnel flow, U-box, J-ring, and L-box.
Immediately after the completion of fresh concrete tests, the fresh concrete was poured into the oiled molds to form 150 *150*150 mm cubes for compressive and 150*300 cylinders splitting tensile strengths testing at 7 and 28days and into 700*100*100 mm prisms for flexural strength. The samples were de-molded after 24 h and then cured in a water tank (at 20 ± 2C) for 7 and 28 days. The compressive and splitting tensile strengths were determined according to ASTM C 39 [12] and ASTM C 496 [13], respectively, at 7 and 28 days.

III. TEST RESULT

Test on Fresh Concrete

Many different test methods have been developed in attempts to characterize the properties of SCC. So far no single method or combination of methods has received universal approval and most of them have their own adherents. For the present study the Slump flow, V-Funnel, J-Ring, L- Box and U- Box tests have been performed for evaluating properties of fresh SCC as given table1 in EFNARC guidelines.

TABLE - 2 TEST RESULT ON FRESHCONCRETE

TRIAL	UNITS	1	2	3	4
SLUMP FLOW	mm	755	750	750	740
V- FUNNEL	Sec	11	10	9	9
J - RING	Mm	4	4	3	3
L - BOX	H_2/h_1	0.8	0.85	0.8	0.8
U - BOX	H_2-h_1	10	12	15	14

Test on Hardened concrete:

The following tests were carried out on the hardened concrete specimens. The testing procedure conformed to the relevant Indian Standard Codes.

Compressive Strength Test

Uniaxial compressive strength testing was carried out on 150 x 150 x 150 mm concrete cubespecimens.

TABLE – 3 COMPRESSIVE STRENGTH WITH FLY ASH

Fly ash dosage (% by wt)	7 days	28 days
0	34.2	44.43
10	34.5	44.8
20	36	45.7

Split Tension Strength

The split tension test was carried out on concrete cylinders of 150mm diameter and 300 mm length.

TABLE – 4 SPLIT TENSILE STREGTH WITH FLY ASH

Fly ash dosage (% by wt)	7 days	28 days
0	3.97	4.49
10	4.09	4.41
20	4.2	4.57
30	4.02	4.44

Flexural Test on Concrete

Flexural test was carried out on concrete beams of size 700 x 100 x 100mm.

TABLE – 5 FLEXRUALSTREGTH WITH FLY ASH

Fly ash dosage (% by wt)	7 days	28 days
0	6.9	8.02
10	7.2	8.3
20	7.42	8.29

IV.CONCLUSION

The even dispersion of fly ash content has proven that it is possible to develop self- compacting concrete without any significant detrimental effects to its workability. The SCC mix developed has satisfied all the requirements of self compact ability and has exhibited a maximum compressive strength of 45.7 MPa at 28 days, with a fly ash content of 20%. SCC is likely to experience some resistance to passing ability when used in structures having congested reinforcement. In general, significant improvements in various strengths are observed with the inclusion of fly ash in the mix. However it appears that maximum gain in strength of SCC is found to depend on the optimum dosage of fly ash content.

REFERENCES

[1] IS: 3812-2003, "Specifications for Pulverized fuel ash", *Bureau of Indian Standards*, New Delhi, India.

[2] IS: 8112-1989, "Specifications for 43 grade Portland cement", *Bureau of Indian Standards*, New Delhi, India.

[3] IS: 383-1970, "Specifications for Coarse and Fine aggregates from Natural sources for Concrete", *Bureau of Indian Standards*, New Delhi, India.

[4] *American Concrete Institute*. —"Self-Consolidating Concrete", ACI 237R-07.

[5] *American Society for Testing and Materials*. —"Standard specification for coal fly ash and raw or calcined natural pozzolan for use in Concrete", ASTM C 618 (2003).

[6] *Bureau of Indian Standards*. —"Plain and reinforced concrete code for practice‖", IS-456 (2000), New Delhi.

[7] *EFNARC (European Federation of national trade associations representing producers and applicators of specialist building products),* "Specification and Guidelines for self- compacting concrete", February 2002, Hampshire, U.K.

[8] *EFNARC*. —"Specification and guidelines for self-compacting concrete". European Federation of Producers and Applicators of Specialist Products for Structures‖, 2002.

[9] Goodier, —"Development of self-compacting concrete", *Proceedings of the Institution of Civil Engineers*, Nov 2003, Issue SB4, PP 405-414.

[10] MuctebaUysal et-al, —"Effect Of Mineral Admixtures On Properties Of Scc",*Cement&Concrete Composites* 33 ,12 April 2011, PP 771-776