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Performance of Self Compacting Concrete Incorporating Fly Ash

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ABSTRACT: *Self compacting concrete (SCC) is defined as the highly workably concrete that can flow through dense reinforced or geometrically complex structural elements under its own weight to adequately fill the voids without segregation or excessive bleeding and without vibration. It was developed by Prof.Okarmura and his team in Japan in early nineties, and its guiding principle is based on the fact that sedimentation velocity of a\particle exists. The use of self compacting concrete in construction can lead to the elimination of equipment and labour involved in the compaction, reduction of noise and harmful vibration at the work site and better quality assurance. In this paper an attempt has been made to study the effect of fly ash replacement on self compacting concrete. The flow characteristics of the self compacting concrete such as flowability, passing ability and segregation resistance has been tested using slump cone, L-box, V-funnel, U-box and J-ring. It has been observed that the optimum percentage of fly ash replacement was 30%, for this replacement the SCC yielded better compressive strength.*
Keywords : *Self compacting concrete, fly ash, viscosity modifying agent, compressive strength, split tensile strength*

I. INTRODUCTION

The conventional concrete needs external vibration for its full compaction. The failure to achieve full compaction of conventional concrete in congested reinforcements and deep structural elements has often been a drawback. In such situations, self compactiong concrete has been found extremely useful. This trend setting construction material was first proposed by Prof. Okurama and et al. at the University of Tokyo.

It is a concrete that flows within the formwork and fills it without any external vibration, passing through the reinforcement without any segregation. Such a concrete is obtained by limiting the water/cement ratio incorporating an effective superplasticizer, a high quality of fines (cement, mineral admixtures and mineral dust) increasing the sand/ aggregate ratio and if needed a visocity modifying agents. The result is a material that has good flowability, passing ability (for passing through gap without blocking) and resistance against segregation [1,2].

II. LITERATURE REVIEW

Self compacting concrete is considered as a concrete which can be placed 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 [1]. The working environment is significantly enhanced through avoidance of vibration induced damages, reduced noise and improved safety [2]. The technology is improving its performance in terms of hardened material properties like surface quality, strength and durability. It is used to facilitate and ensure proper filling and good structural performance of restricted areas and heavily reinforced structural members [3]. SCC is such a concrete which utilizes more fines than coarser material which indirectly results in a high performance concrete [4,5].

III. EXPERIMENTAL INVESTIGATIONS

3.1 Materials

The following materials have been used in the experimental study [15]

a) Ordinary Portland cement (43 grade) confirming to IS:8112-1989 [13]having specific gravity 3.15.
b) Fly Ash (Class F) collected form Raichur Thermal power plant having specific gravity 2.00.
c) Fine aggregate: Sand confirming to Zone –II of IS:383-1970 [8] having specific gravity 2.63 and fineness modulus of 2.72.
d) Coarse aggregate: Crushed granite metal confirming to IS:383-1970 [8] having specific gravity 2.86 and fineness modulus of 6.15.
e) Water : Clean Potable water for mixing
f) Superplasticizer (SP) : GLENIUM B233 having specific gravity 1.08 [11]
g) Viscosity modifying agent (VMA) : GLENIUM STREAM 2 having specific gravity 1.19.

3.2 Test details

Normally the tests to evaluate the fresh characteristics of SCC were conducted as per EFNARC standards and the limits are presented in Table 1. The tests to access the strength parameters of SCC were conducted on specimen of standard size as per IS:516-1959 and IS:5816-1999 [9,10]. Details of tests conducted and specimens used are given in Table 2. All results of various tests conducted on concrete specimen are given in Table 4 and 5.

Table 1. Acceptance criteria for self compacting concrete

Method	Unit	Typical range of values	
		Minimum	Maximum
Slump flow by Abrams cone	mm	650	800
T 50 cm slump flow	sec	2	5
J-ring	mm	0	10
V-funnel	sec	6	12
Time increase, V-funnel at T5 minutes	sec	0	3
L-box	(h2/h1)	0.80	1
U-box	mm	0	30
Fill box	%	90	100
GTM screen stability test	%	0	15
Ormiet	sec	0	5

Table 2: Details of specimen used and tests conducted

Type of tests conducted	Size of specimen	No. of specimen (for each mix)
Compressive strength	150x150x150mm, cube	3
Split tensile strength	100x200mm, cylinder	3

3.3 Mix design procedure

In self compacting concrete, the coarse and fine aggregate contents are fixed so that self compact ability can be achieved by adjusting the water powder ratio, superplasticizer dosage and viscosity modifying agent dosage. The paste requires high viscosity as well as high deformability. This can be achieved by using superplasticizer, which results in a low water powder ratio and high deformability. Adding viscosity modifying agent ensures high viscosity. Therefore once the mix proportion is decided, self compactability is tested by slump flow, L box, U box and V funnel tests. For the present study M30 grade concrete is designed as per IS:10262-2009 [14] and then the proportions are converted as per EFNARC standards [16]. The mix proportions of self compacting concrete thus obtained are presented in Table 3.

Table 3: Materials per cum of self compacting concrete

Sl. No	Grade of concrete	% of Fly Ash	Cement (kg/m^3)	Fly Ash (kg/m^3)	C.A (kg/m^3)	F.A (kg/m^3)	Water (in lit/m^3)	SP (in lit/m^3)	VMA (in lit/m$^{3)}$
1	M30	Control	438.13	-	1127.76	640.26	197.16	6.57	1.53
2		10%	394.32	43.81	1127.76	640.26	197.16	6.57	1.53
3		20%	350.50	87.63	1127.76	640.26	197.16	6.57	1.53
4		30%	306.69	131.44	1127.76	640.26	197.16	6.57	1.53
5		40%	262.88	175.25	1127.76	640.26	197.16	6.57	1.53

3.4 Procedure

The dry mix of cement, fly ash, sand, aggregate (in the desired proportion) was mixed dry and to this water was added and thoroughly mixed. The superplasticizer and viscosity modifying agent were added subsequently and mixed intimately till a flowable mix is obtained. At this stage the flow characteristics experimentation for SCC were conducted. After conducting the flow characteristics experiments, the concrete mix was poured in the moulds required for strength assessment. It should be remembered that compaction was not given by any means and the concrete was allowed to set by its own weight. Even no finishing operation was done to the concrete. After 24 hours of casting, the specimens were demoulded and allowed to cure for 28 days before testing.

IV. RESULTS AND DISCUSSIONS

Flow characteristics of fresh concrete

The effect of replacement of cement with percentage variation of fly ash on properties of fresh concrete was studied by conducting slump cone, L-box, V-funnel and U-box. The obtained values are presented in Table 4 and 5. The variations of test results are presented in Fig. 1 to 7.

The observations drawn are as below:

i. As the percentage of fly ash increases, the horizontal slump cone value increases. The variation is following a linear increasing trend.
ii. As the percentage of fly ash increases, the distance of flow at 50 cm diameter slump value also decreases. The variation is following a linear decreasing trend.
iii. The time observed with V-funnel set up decreases as there is increases in the quantity of fly ash in the mix.
iv. The same kind of observation was true with U-box set up also.

V. CONCLUSION

Based on the results of present investigation, the following conclusions were drawn:

i. To achieve the self compacting concrete properties, the mix should contain lower volume of coarse aggregate.
ii. The self compacting concrete can be achieved using the sequential procedure with superplasticizer for the given mix proportion with minor adjustment of coarse aggregate fly ash contents.
iii. The flow characteristic increases with increase in fly ash content.
iv. The mechanical properties like compressive, split tensile and flexural strength of SCC increases with increase in fly ash content up to 30%, hence the optimum replacement of fly ash content in SCC can be suggested as 30%.

Table 4: Test results on fresh concrete

Sl. No.	% of fly ash	Slump flow (mm)	T50 Slump flow (sec)	V-funnel (Sec)	L-Box (h2/h1)	U-Box (h2-h1) (mm)
1	Control	660	8	10	2	20
2	10%	680	7	12	2	22
3	20%	712	5	10	1.4	15
4	30%	730	3	9	0.9	12
5	40%	764	2	7	0.85	16

Table 5: Test results on hardened concrete

Sl. No.	% of Fly ash replaced	Compressive strength (N/mm^2)		Split strength (N/mm^2)	
		7 days	28 days	7 days	28 days
1	Control	24.86	38.24	2.87	5.60
2	10	21.09	31.20	2.01	4.22
3	20	22.10	32.65	2.03	4.35
4	30	22.93	33.12	2.56	5.26
5	40	20.46	30.42	2.50	4.28

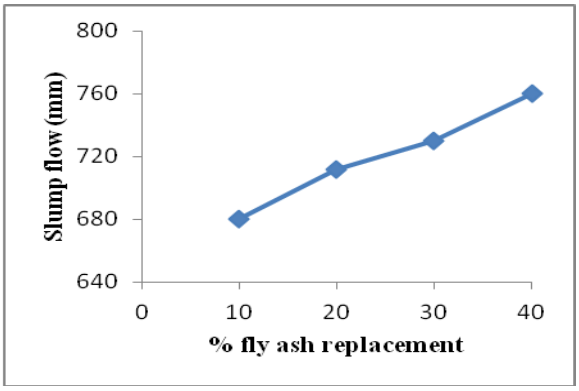

Fig. 1 Percentage fly ash Vs Slump flow

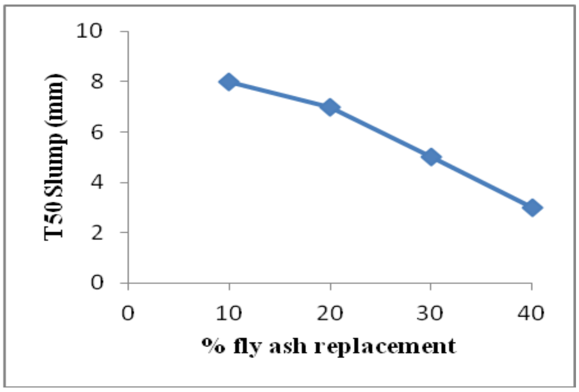

Fig. 2 Percentage fly ash T50 Slump

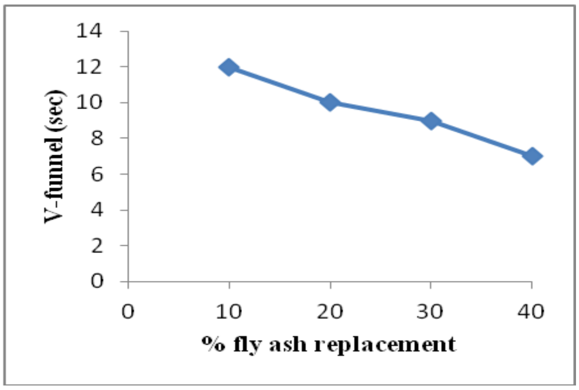

Fig. 3 Percentage fly ash Vs V-funnel

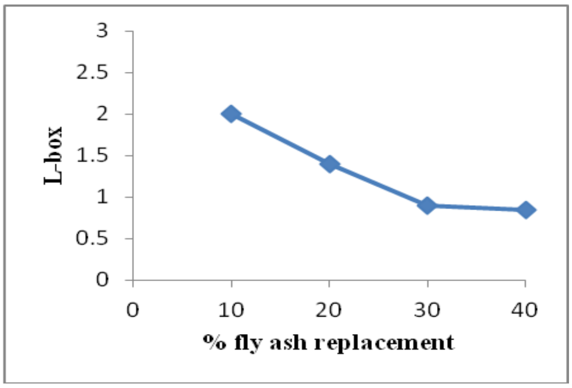

Fig. 4 Percentage fly ash Vs L-box

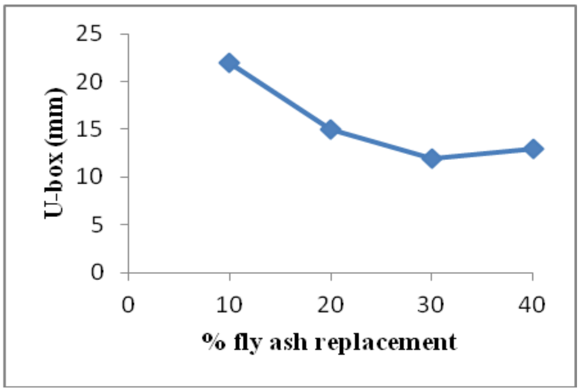

Fig. 5 Percentage fly ash Vs U-box

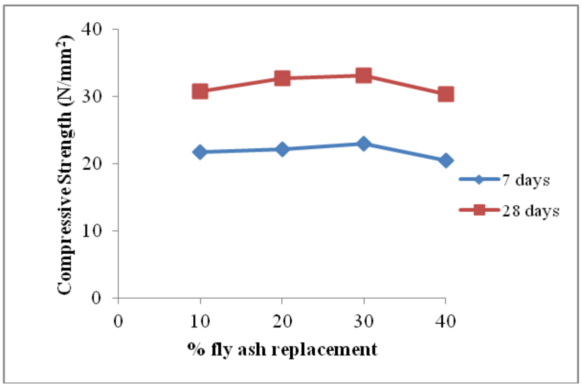

Fig. 6 Percentage fly ash Vs Compressive strength

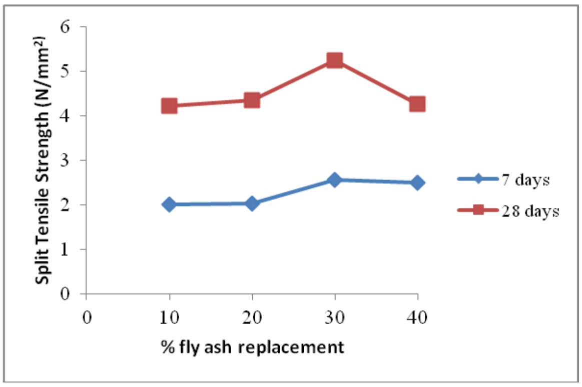

Fig. 7 Percentage fly ash Vs Split tensile strength

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