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A Study on Durability Aspects of Self Compacting Concrete Subjected to Acid Attack

Rashmi R. Ghali[1], V. Sanjana[2], P. M. Nithin[3], R. Yogesh[4]
[1]*Assistant Professor, Department of Civil Engineering, JSS Academy of Technical Education, Bangalore, India*
[2,3,4]*UG Student, Department of Civil Engineering, JSS Academy of Technical Education, Bangalore, India*

***Abstract*: The cement is the main ingredient used for concrete. The production of cement involves emission of large amount of carbon dioxide into the atmosphere. Therefore, any other material like fly ash and GGBS which can be used as an alternative to cement, should lead to lowest possible environmental impact. The present experimental investigation aims at studying the durability of SCC with partial replacement of cement by 40% Fly ash and 0% GGBS and vice versa separately and also replacing the cement by the combination of 20% Fly ash & 20% GGBS and also replacing cement by combination of 30% Fly ash & 10% GGBS and 10% Fly ash & 30% GGBS which amounts to 40% replacement of cement and comparing the compressive strength and difference in weight gain or loss for 7, 28 &56 days with respect to control SCC before and after immersing the specimen into acid media. Conclusions are drawn based on the experimental results.**

***Keywords*: fly ash, GGBS, Partial replacement, workability, compressive strength.**

1. Introduction

Development of self-compacting concrete (SCC) is a desirable achievement in the construction industry in order to overcome problems associated with cast-in-place concrete. Self-compacting concrete is not affected by the skills of workers, the shape and amount of reinforcing bars or the arrangement of a structure and, due to its high-fluidity and resistance to segregation it can be pumped longer distances. The concept of self-compacting concrete was proposed in 1986 by Professor Hajime Okamura (1997), but the prototype was first developed in 1988 in Japan, by Professor Ozawa (1989) at the University of Tokyo. Self-compacting concrete was developed at that time to improve the durability of concrete structures. Since then, various investigations have been carried out and SCC has been used in practical structures in Japan, mainly by large construction companies.

In the past industrial by-products like GGBS and fly ash are dumped in open places. But due to rapid development in technology and increase in demand, these industrial wastes are produced in considerably huge quantity which makes its disposal difficult. The disposal of industrial wastes such as fly ash, GGBS, etc. is a serious issue as it is very hazardous to the environment. The usage of these wastes in concrete reduces the burden on the environment making this type of concrete an eco friendly concrete.

SCC is becoming commonly used type of concrete in today's modern world since it's workability is more compared to normal concrete and is having a very good passing as well as filling ability comparatively, which reduces the time of construction and effort of manpower. It is most widely used in construction industries since latest trend like MI-VAN formwork requires SCC for ensuring better compaction in RCC structures.

2. Material used

The physical properties of cement, fine aggregates, coarse aggregates, fly ash, GGBS, super plasticizer and water used for mix design of M30 grade of concrete were tested in laboratory and are mentioned below.

A. Cement

The cement used was OPC 53 grade. The physical properties of the cement used are listed in the table below.

Table 1
Physical Properties of Ordinary Portland Cement

Properties	Test Values
Specific Gravity	3.15
Consistency (%)	30%
Initial Setting Time	48 min.
Final Setting Time	456min.

B. Fine aggregates

The manufactured-sand which was locally available and passing through 4.75mm IS sieve size was used as fine aggregate confirming to IS 383-1970. The physical properties of the fine aggregates are listed in the table below:

Table 2
Physical Properties of Fine Aggregates

Properties	Test Values
Specific Gravity	2.66
Water Absorption	1%
Fineness Modulus	2.85

C. Coarse aggregates

The coarse aggregates with nominal maximum size of aggregates as 16mm as per Indian standards were used. The physical properties of the coarse aggregates are as listed in table below.

Table 3
Physical Properties of Coarse Aggregates

Properties	Test values
Type	Crushed
Specific Gravity	2.87
Water Absorption	0.50%
Fineness Modulus	6.3

D. Fly ash

The fly ash used was of class F with specific gravity of 2.54.

E. GGBS

The specific gravity of GGBS used in the experiments is 2.9.

F. Super plasticizer

The super plasticizer used in experiment is Master Glanium Sky 8630 with Specific Gravity of 1.08.

G. Water

The water used for experiments was potable water.

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3. Methodology

The aim of the present study was to study the effect of acid attack on compressive strength of concrete by partial replacement of cement with 0% 10%, 20%, 30% and 40% of fly ash and GGBS. The concrete mix of M30 grade was prepared as per IS10262:2009 with w/c ratio of 0.50. To carry out the experimental investigation a total of 63 cubes of size 100mm x 100mm x100mm were casted. 18 cubes were casted to determine the compressive strength of normal concrete without fly ash or GGBS. Similarly, a set of 9 cubes were casted to determine the compressive strength by varying the fly ash and GGBS with 10%, 20%, 30%, 40% replacement of cement respectively. In these 9 cubes, 3 cubes were utilized to determine the compressive strength of concrete after 7 days of curing, 3 cubes after 28 days of curing and remaining 3 cubes to determine the compressive strength of concrete at 56 days of curing. Compression Testing Machine of 2000kN capacity was used to determine the total compressive load taken by concrete at different ages. This ultimate load divided by the cross-sectional area of the cube (100mm x 100mm) gives the compressive strength of concrete.

Fig. 1. Cubes before immersion in acid media

Fig. 2. Cubes after immersion in acid media

Fig. 3. Specimen testing in Compression Testing Machine

Table 4
Composition of concrete mixes

Mixes	Cement (%)	Fly Ash (%)	Ggbs (%)	W/C Ratio	SP (Kg/m^3)
M0	100	0	0	.5	3.15
M1	100	0	0	.5	3.15
M2	60	30	10	.5	3.15
M3	60	10	30	.5	3.15
M4	60	20	20	.5	3.15
M5	60	40	0	.5	3.15
M6	60	0	40	.5	3.15

4. Results and discussions

Each set of 3 cubes of M30 grade concrete were tested in Compression Testing Machine with 0%, 10%, 20%, 30% and 40% replacement of cement with fly ash and GGBS to determine the compressive strength after 7,28 and 56 days of curing. The average compressive strength of cubes at the age of 7, 28 and 56 days were found as 27.77 N/mm² and 39.48 N/mm² and 40.11 N/mm² for normal concrete with no replacements and it is reduced to 17.07 N/mm² ,15.75N/mm² and 18.51 N/mm² when cement was replaced with fly ash and GGBS by 20% each. The compressive strength of M30 grade of concrete for different proportions of fly ash after 7, 28 and 56 days of curing are listed below in table 5.

Table 5
Compressive Strength of M30 grade of concrete for different proportions of Fly Ash and GGBS at the age of 7, 28 and 56 days of curing

Type of mix	Compressive Strength after subjected to HCl solution (N/mm^2)		
No. of days	7 days	28 days	56 days
M1 (100%cement)	14.2	29.8	22.11
M2 (60%cement 30%flyaash 10% GGBS)	14.39	16.82	21.21
M3 (60% cement 10% fly ash 30% GGBS)	16.44	28.35	23.71
M4 (60% cement 20% fly ash 20% GGBS)	17.07	15.75	18.51
M5 (60% cement 40% fly ash)	17.59	18.79	17.95
M6 (60% cement 40% GGBS)	19.74	26.01	31.64
M0 (ref. mix)	27.77	39.48	40.12

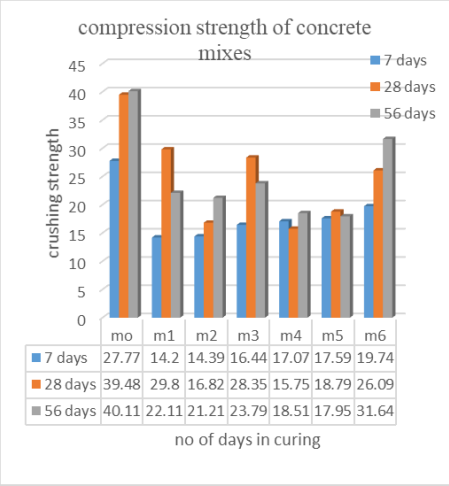

Fig. 4. Chart-1: Compressive Strength (N/mm^2) for different proportions of fly ash and GGBS after 7, 28 and 56 days of curing

5. Conclusion

From the experimental work carried out for M30 grade of concrete by partial replacement of cement with 10%, 20%,30% and 40% of fly ash and GGBS, the following conclusions were drawn.

1. All the SCC mix proportions developed, satisfied the requirement of Self-Compacting Concrete specified by EFNAARC.
2. Based on the results obtained, it is found that, when the SCC mixes are immersed 10% HCL solution for curing at different ages, the % gain in weight improved with age.
3. The workability of concrete improves with increase in fly ash content. This happens because fly ash molecules are finer than cement.
4. Based on the results obtained, we can conclude that when immersed in 10% HCL solution for 7, 28, 56 days of curing, the compressive strength of SCC cubes improved with age.
5. The strength of cubes are reduced with the increase in fly ash content.
6. The specimen subjected to 10% HCL solution when removed after 56 days of immersion shows change in colour from greyish green to brownish black
7. The experimental results conclude that the mix M6 (60% cement, 40 % GGBS) shows better percentage gain in weight and compressive strength compared to other mixes (except for reference mix).

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