STRENGTH AND DURABILITY PROPERTIES OF HIGH PERFORMANCE CONCRETE INCORPORATING SILICA FUME AND FLY ASH

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ABSTRACT

This paper deals with an experimental work on the effect of fly ash, silica fume and their combinations of strength and durability characteristics of high performance concrete. The normal concrete is failing its usage in modern days and it does not serve the present needs. Hence to improve strength, workability and durability of the concrete, high performance concrete with mineral admixtures, lower water cement ratio and super plasticizers are used. Fly ash (FA) is replaced with cement by various percentages i.e., 5%, 10%, 15%, 20%, 25% and silica fume (SF) as addition of 10% by weight of cement. It has been observed that the workability and required strengths are achieved at optimum percentage i.e. 10% silica fume is addition and 15% fly ash is replacement by weight of cement. Water cement ratio is 0.32. Water cement ratio is kept constant for all trail mixtures. This paper deals with the study of properties like compressive strength, workability, durability, flexural strength and split tensile strength for M80 grade concrete. Admixtures use will lead to a reduction in cement content therefore reduce the emission of co2 and reduce the environmental pollution.

KEYWORDS—*high performance concrete, fly ash, Silica fume, Compressive Strength ,Split tensile strength, Flexural strength, workability, durability.*

I. INTRODUCTION

Concrete is one of the most widely used construction material in the world. Now a day's concrete is being used for many purposes to make it suitable in different conditions. In these conditions normal concrete may fail to exhibit the require strength and durability. In such cases, admixtures are used to modify the properties of normal concrete so as to make it more suitable for any situation.

High performance concrete: In recent years, the term "High Performance Concrete" has been introduced into construction industry. High performance concrete is used for concrete mixture which has high strength, high workability, high durability, high density, and high modulus of elasticity, low permeability and resistance to chemical attack as compared to normal strength concrete. To produce such a high performance concrete mineral admixtures like silica fume, fly ash metakaolin, GGBS on the one hand and super plasticizer on the other hand used along with normal ingredients. High performance concrete is not a special concrete. It is same as conventional concrete but because of lower water cement ratio, the use of some admixtures and super plasticizer etc…

American Concrete Institute (ACI) defines high performance concrete as "a concrete meeting special combination of performance and uniformity requirements that cannot always be achieved routinely using normal materials and normal mixing, normal placing and normal curing.

High performance concrete having several advantages (or) properties like high strength, high durability, low permeability, compaction without segregation, long term mechanical properties, easy of placing, toughness and impact resistance and much lesser micro cracking than conventional concrete.

II. EXPERIMENTAL STUDY

2.1 Materials

The materials 53 grade ordinary Portland cement confirming to IS: 12269. Sand was conforming zone II according to IS: 383. Coarse aggregates size 12.5mm and 20mm are used. Sand is locally available river sand is used. The bulk density of coarse aggregate is 1710kg/m^2. Silica fume is a byproduct of producing silicon metal or ferrosilicon allows. Silica fume play an important role in improving the strength of concrete particularly at early ages. Fly ash is principle byproduct of coal fired power plants. Mineral admixtures like Silica fume and fly ash are industrial waste byproducts. In the present study water reducing admixture Glenium B233 obtained from BFSA chemicals was used. The chemicals used for durability tests are Hydrochric acid (HCL) and Sulphuric acid (H2SO4).

Table 1: Values for the mix design

Material	Specific gravity	Fineness modulus
Cement	3.14	283(m2/kg)
Fine aggregate	2.62	2.8
Coarse aggregate	2.86	7.11
Silica fume	2.2	-
Fly ash	2.05	-

III. EXPERIMENTAL PROGRAM

The mix design guidelines are taken from ACI 211.1-91 Reapproved 2009. The mix ratio that are fixed are shown in fig

Table 2: Mix proportion of M80 grade concrete

Grade	Mix ratio	Water cement ratio
M80	1:0.8:1.7	0.32

Silica fume (SF) as addition of 10% by weight cement is constant for all trail mixes. Fly ash is replacement by weight cement varying up to 30%. Mix proportion of concrete is given below table 3.

Table3: Mix proportions of concrete

Mix name	Mix description	Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	FA (kg)	SF (kg)
CM	Control mix	600	502	1060	0	0
HPC1	SF 10%+FA 5%	570	502	1060	30	60
HPC2	SF10%+FA 10%	540	502	1060	60	60
HPC3	SF10%+FA 15%	510	502	1060	90	60
HPC4	SF10%+FA 20%	480	502	1060	120	60
HPC5	SF10%+FA 25%	450	502	1060	150	60
HPC6	SF10%+FA 30%	420	502	1060	180	60

EXPERIMENTAL PROCEDURE

The cubes of size 150mm x150mm x 150 were casted to find the compressive strength for 7 days and 28 days. The beams of size 500mm x 100mm x 100mm were casted to find the flexural strength for 7 days and 28 days. The cylinders of size 300mm x150mm were casted to find the split tensile strength for 7 days and 28 days. For each trail, specimens are casted and removed the moulds after 1 day. The removed specimens are placed in water curing in order to test for 7 days and 28 days strength. After water cured specimens were taken out and allowed to dry under shade and then concrete specimens were tested for compressive strength, flexural strength and split tensile strength.

The cubes of size 100mm x100mm x 100mm were casted to find the concrete durability. For durability test the cubes are kept for water curing in 28 days were taken out and allowed to dry and same specimens were kept immersed in 5% concentrated HCL and 5% H2SO4 for 60 days for durability observations. The weight loss due to acid immersion was noted. Weight loss due to compressive strength was noted.

IV. Results and Discussion

4.1 Compressive strength

In this test is silica fume as addition by weight of cement is 10% and fly ash is replacement by weight of cement is 15% gives required strengths.

Table 4

Mix Name	Compressive strength (N/mm^2)		Slump(mm)
	M 80 grade		
	7 days	28days	28 days
CM	54.5	80	72
HPC 1	56.4	82.1	70
HPC 2	60.3	85	68
HPC 3	62.5	91	68
HPC 4	57.6	87	65
HPC 5	52.5	83	61
HPC 6	52	79	55

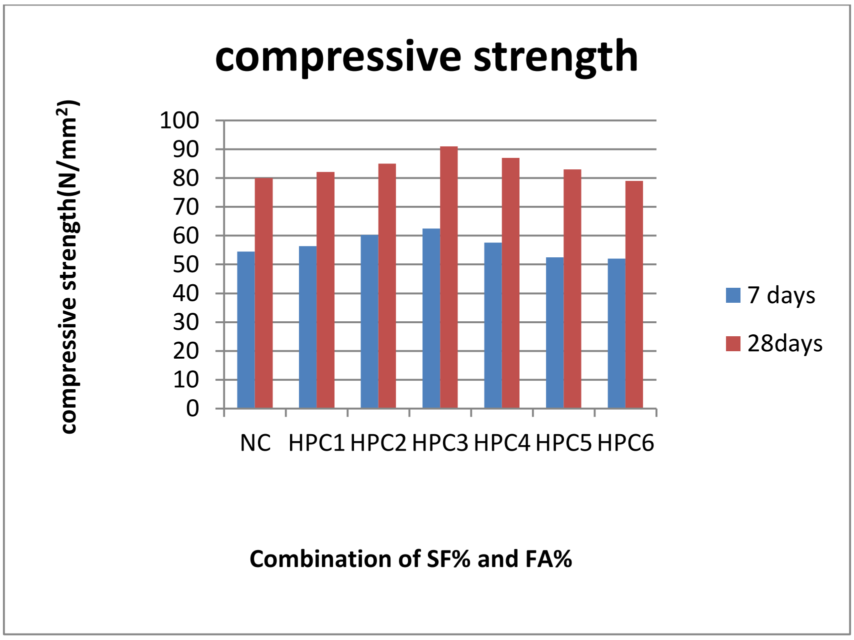

Fig. 1: Compressive strength of SF & FA

4.2 split tensile strength

Table 5

Mix Name	Split tensile strength (N/mm^2)	
	M 80 grade	
	7 days	28days
CM	2.5	3
HPC1	2.8	3.6
HPC2	2.9	3.9

HPC3	3.1	4.2
HPC4	2.8	4.02
HPC5	2.7	3.68

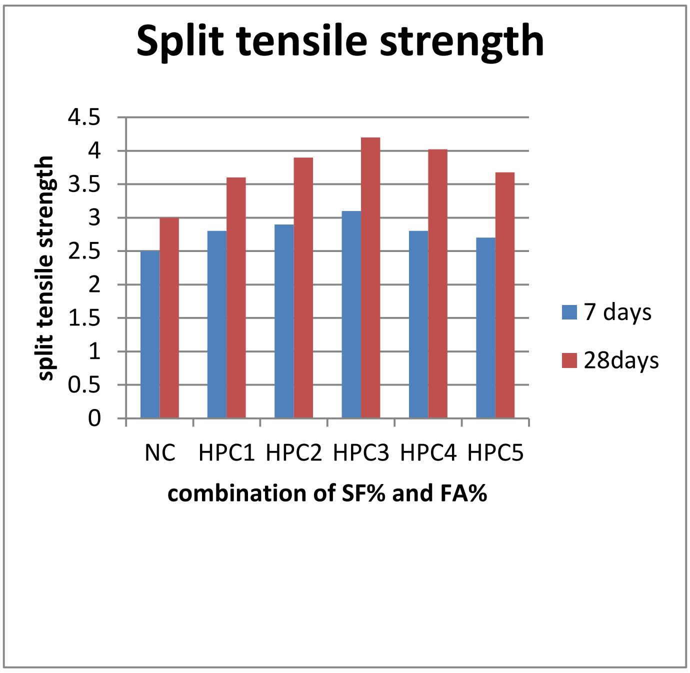

Fig. 2: Split tensile strength

4.3 Flexural strength

Table 6

Mix Name	Flexural strength (N/mm²)	
	M 80 grade	
	7 days	28days
CM	4.7	6
HPC1	5.4	6.8
HPC2	6.1	7.9
HPC3	6.64	8.5
HPC4	6.08	7.6
HPC5	5.21	6.4

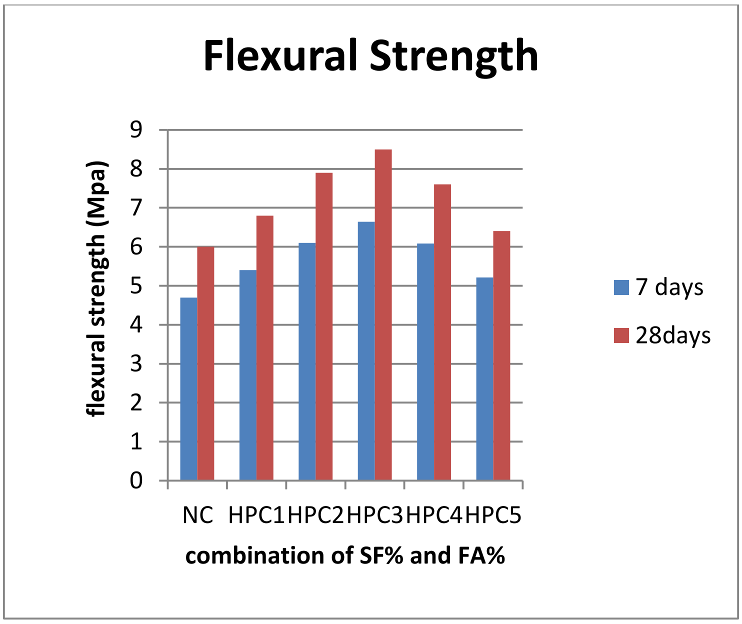

Fig. 3: Flexural Strength

4.4 Durability test

Durability Test Immersed In Hcl

Mix name	Specimen Weight (kg)		Compressive strength (N/mm²)	
	Before immersing	After 60 days	Before immersing	After 60 days
HPC1	2.6	2.48	79	73
HPC2	2.75	2.54	83	77
HPC3	2.73	2.5	86	81
HPC4	2.68	2.43	85	78
HPC5	2.73	2.52	82	75
HPC6	2.72	2.49	80	74

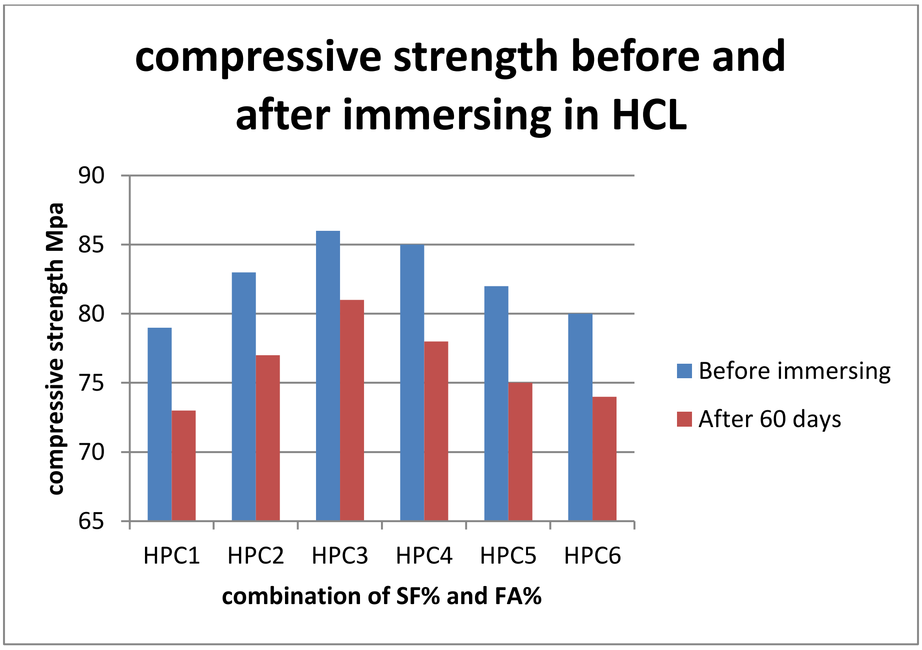

Fig. 4: Compressive strength before and after immersing in HCL

durability test immersing in H2SO4

Mix name	Specimen Weight (kg)		Compressive strength (N/mm2)	
	Before immersing	After 60 days	Before immersing	After 60 days
HPC1	2.68	2.51	81	76
HPC2	2.69	2.54	83	78
HPC3	2.71	2.61	86	82
HPC4	2.73	2.63	80	76
HPC5	2.67	2.50	77	72
HPC6	2.72	2.63	72	67

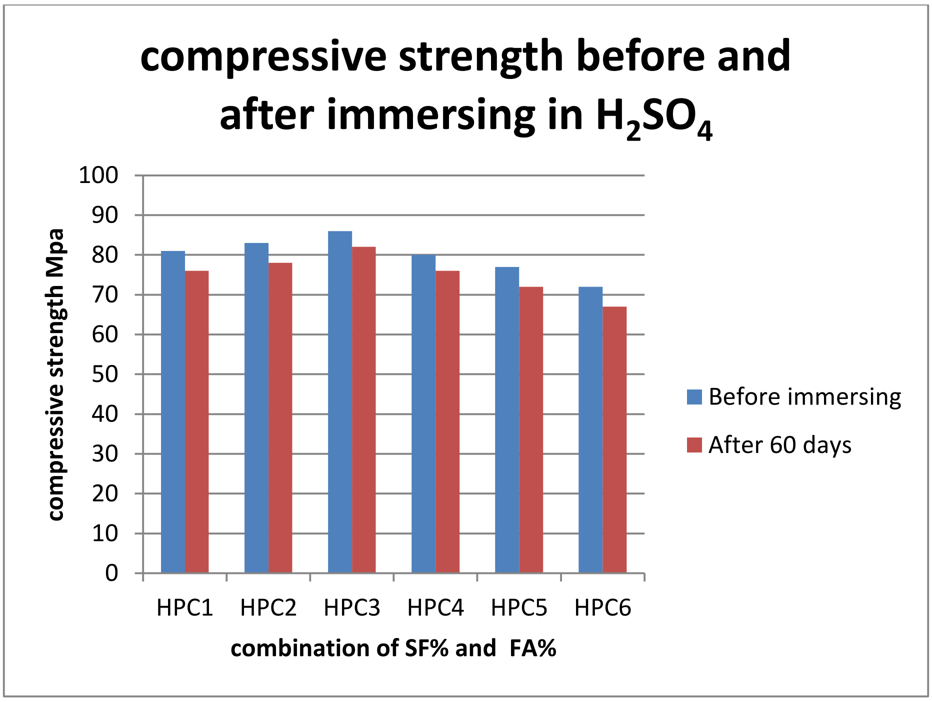

Fig. 5: Compressive strength before and after immersing in H2SO4

V. Conclusions

1. The compressive strength is increased by 11% for replacement of cement by 15% fly ash and silica fume 10% was addition of cement.

2. The flexural strength test value for 28 days was found to be 8.5 N/mm^2. The split tensile strength test value for 28 days was fund to be 4.2N/mm^2.

3. It can be concluded that the percentage weight loss due to HCL and H_2SO_4 solutions for combination of SF %10 as addition of cement and 15% FA replacement of cement is minimum compare to all trails.

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