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An Experimental Investigation on Properties of Highstrength Fiber Reinforced Concrete by Partial Replacement of Cement Withsilica Fume and Fly Ash

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ABSTRACT

The cost of construction materials is currently so high that only governments, corporate organizations and wealthy individuals can afford to do meaningful constructions. Unfortunately, production of cement involves emission of large amount of carbon-dioxide gas into the atmosphere, a major contributor for greenhouse effect and global warming, hence it is inevitable either to search for another material or partly replace it by some other material. The search for any such material, which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact. The use of supplementary cementitious materials or mineral admixtures such as silica fume as fly ash in concrete fits very well with sustainable development. The volume of silica fume and fly ash in concrete mixtures contain lower quantities of cement. With the passage of time to meet the demand, there was a continual search in human being for the development of high strength and durable concrete. The history of high strength concrete (HSC) is about 35 years old, in late 1960s the invention of water reducing admixtures lead to the high strength precast products and structural elements in beam were cast in situ using high strength concrete (HSC). After the technology has come to age and concrete of the order of M60 to M120 are commonly used. Concrete of the order of M200 and above are a possibility in the laboratory conditions. In the 1950s 34 N/mm^2 was considered high strength concrete, and in the 1960s compressive strengths of up to 52 N/mm^2 were being used commercially. More recently, compressive strengths approaching 138N/mm^2 have been used in cast-in-place buildings. The dawn of pre-stressed concrete technology has given incentive for making concrete of high strength. In India high strength concrete is used in pre-stressed concrete bridges of strength from 35N/mm^2 to 45N/mm^2. Presently Concrete strength of 75 N/mm^2 is being used for the first time in one of the flyover at Mumbai. Also in construction of containment dome at Kaiga power project used High Strength Concrete (HSC) of 60MPa with silica fume as one of the constituent.

The utilization of fine Pozzolanic materials in high-strength concrete (HSC) like silica fume and fly ash leads to reduction in size of the crystalline compounds, particularly, calcium hydroxide. Consequently, there is a reduction of the thickness of the interfacial transition zone in high-strength concrete. Applications of mineral admixtures such as silica fume (SF), fly ash (FA) in concrete are effective and easy to future increase in the strength and make durable for high strength concrete. In the present study, the different admixtures were used to study their individual and combined effects on the resistance of concrete in addition to their effects on workability, durability and compressive strength by the replacement of admixtures by 10%, 15% of silica fume &10%, 20% and 30% of fly ash by the weight of cement with a constant amount of 0.5% steel hook fibers are added by volume of concrete, throughout the study.

Keywords: Global warming, Mineral admixtures, Silica fume, Fly ash, Compressive strengths , Pre-stressed concrete , Pozzolanic materials, Calcium hydroxide, Workability, Fibers.

I. INTRODUCTION

As our aim is to develop high strength concrete which does concern on the strength of concrete, it also having many other aspects to be fulfilled like less porosity, capillary absorption, durability. Also now a day's one of the great applications in various structural fields are high strength fiber reinforced concrete, which is getting popularity because of its positive effect on various properties of concrete.

High strength concrete (HSC) is used extensively throughout the world like in the gas, oil, nuclear and power industries are among the major uses. The application of such concrete is increasing day by day due to their greater structural performance, environmental friendliness and energy conserving implications. Apart from the usual risk of fire, these concretes are exposed to high temperatures and pressures for considerable period of time. Silica fume will protect concrete against deicing salts, seawater, road traffic and freeze/thaw cycles. Rebar corrosion activity and concrete deterioration are virtually eliminated, which minimizes maintenance expense. Fly ash is the most widely used supplementary cementations material in concrete.

II. METHODS AND MATERIAL

2. Experimental Procedure
2.1. Materials

The materials used are as follows

1. Cement-Ordinary Portland Cement (OPC)
2. Mineral Admixtures-
   a. Silica Fume and
   b. Fly-Ash
3. Fine aggregates
4. Coarse aggregates
5. Steel hook fibers and
6. Water

2.2 Materials Description And Their Properties

2.2.1 Cement

Ordinary Portland cement of 53 grades was selected for the experimental investigation. The compressive strength characteristics of cement were tested as per IS: 4031-1988 and IS: 12269-1987(9).The cement used in present study was Zuari cement.

Table 1. Physical Properties of OPC

S.No	Characteristic of cement	Value	Code specifications (IS 4031-1988)
1	Fineness of	**94.76**	**-**
2	Normal	**33%**	**Not**
3	Initial	**40**	>30
4	Final setting	**350**	<600
5	Specific	**3.14**	**-**

2.2.2 Mineral Admixtures

2.2.2 (A) Silica Fume

It is available in different forms, of which the most commonly used is in a dandified form. Silica fume used was conforming to IS: 1331(PART-1) 1992 and also ASTM C (1240-2000).

2.2.2 (B) Fly-Ash

For this project Fly ash is taken from Rayalaseema thermal power plant (RTPP), Kadapa. This fly ash conforms to the requirements of IS: 3812 part-I and also ASTMC-618 type-F.

2.2.3 Fine Aggregates

The sand used throughout the experimental work was obtained from the Muthireveluvanka near Chittoor, Chittoor district, Andhra Pradesh.

Table 3. Properties of Fine Aggregates

S.no	Properties	Results
1.	Specific gravity	2.583
2.	Bulking of sand	4
3.	particle size	0.15 to 4.75
4	Water absorption	1
5	Bulk Density of	1460
6	Fineness	2.8

2.2.4 Coarse Aggregates

The coarse aggregate used throughout the experimental work was obtained from the Muthireveluvanka near Chittoor, Chittoor district, Andhra Pradesh.

Table 4. Coarse Aggregate Properties

S.No	Properties	Unit	Results
1.	Specific	-	2.68
2.	Particle	mm	6.35 to
3	Fineness	-	6.26
4	Water	%	0.5
5	Bulk	kg/m^3	1469.8
6	Elongation	%	20.49
7	Flakiness	%	13.19

2.2.5 Steel Hook Fibers

Steel fibres make significant improvements in flexural, impact and fatigue strength of concrete. The additions of steel fibres shear strength increases significantly. Steel hook fibers compliance to the requirements of **ASTM A 820** (type-1 cold drawn wire)

TABLE 5. Properties Of Steel Hooke Fibres

1	Type	Hooked end
2	Diameter of fibers	0.60 mm
3	Length of fibers	30 mm
4	Aspect ratio (L/D)	50

III. RESULTS AND DISCUSSION

3.1. Compressive Strength Test Result

The compressive strength of concrete for different replacements of cement with 10% and 20% of silica fume and 10%,20% and 30% of fly-ash with 0.5% steel hook fibres by volume of concrete were tested for 3,7,28,56 and 90 days using compressive test machine. The water to cement ratio was taken as 0.35. Three cubes were casted for each proportion and the average of three test samples was taken for the accuracy for results. At the room temperature, the concrete cubes were cured.

Table 6. Compressive Strength Test Results

S. NO	SAMPLE	AVERAGE COMPRESSIVE STRENGTH				
		3 days	7 days	28 days	56 days	90 days
I	Controlled mix	27.62	44.23	68.07	75.18	78.74
2	10%SF+10%FA +0.5%SHF	36.96	49.40	75.33	79.77	81.11
3	10%SF+20%FA +0.5%SHF	40.18	50.07	81.92	82.67	83.40
4	10%SF+30%FA +0.5%SHF	39.33	49.63	76.60	81.06	82.00
5	15%SF+10%FA +0.5%SHF	39.18	49.48	74.88	80.51	81.55
6	15%SF+20%FA +0.5%SHF	36.96	48.67	74.67	79.11	80.66
7	15%SF+30%FA +0.5%SHF	36.41	47.33	71.55	73.55	78.00

3.2 Tensile Strength Test Results

From the below table it has been seen that, the comparison of split tensile strength results of concrete for various replacements of silica fume and fly ash with 0.5% steel hook fibers as admixture. At 10% silica fume and 20% fly ash gives maximum 28 days split strength as 5.2N/mm2.

Table 7. Tensile Strength Test Results

Days	Cases	Average split tensile strength (N/mm2)
	Controlled mix	3.27

28 days	10% SF+10% FA+ 0.5% steel fibers	4.5
	10% SF+20% FA+ 0.5% steel fibers	5.2
	10% SF+30% FA+ 0.5% steel fibers	4.8
	15% SF+10% FA+ 0.5% steel fibers	4.2
	15% SF+20% FA+ 0.5% steel fibers	4.4
	15% SF+30% FA+ 0.5% steel fibers	3.8

IV. CONCLUSION

Based on the results obtained from the present investigation the following conclusions were made;

1. By the addition of steel hook fibers in concrete leads to increase in compressive strength and makes concrete into ductile.
2. In split tensile and flexural tests, we notices that crack width reduced due to the presence of steel fibers when compared with conventional specimen.
3. When the cement is replaced with 10% silica fume and 20% fly ash gives the optimum compressive strength, split tensile strength and flexural strength.
4. At 10% silica fume and 20% fly ash replacement to cement, compressive strength were increased up to 20.34% when compared with conventional concrete for 28 days.
5. At 10% silica fume and 20% fly ash replacement to cement, split tensile strength were increased up to 60.85% when compared with conventional concrete for 28 days.

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