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A study on high volume fly-ash concrete made with steel fiber

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ABSTRACT

The use of concrete containing high volume fly-ash (HVFC) has recently gained popularity as a resource efficient, durable, and sustainable option for a variety of concrete applications. If containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. In this research two categories, HVFC with fiber mixture is prepared one containing 40% fly-ash and other 50% fly-ash. For each mixture prepare M20, M25 and M30 grade concrete with fiber. The HVFC with fiber mixture reached similar to the ordinary concrete mix, due to the pozzolanic properties of the fly-ash and the lower water-cement ratio. The setting time for the HVFC with fiber mixtures was approximately six to seven hours longer than those of ordinary concrete mix. The drying shrinkage of concrete is directly influenced by the amount and the quality of the cement paste present. It increases with an increase in the cement paste-to-aggregate ratio in the concrete mixture, and also increases with the water content of the paste. Clearly, the water-reducing property of fly ash can be advantageously used for achieving a considerable reduction in the drying shrinkage of concrete mixtures. In HVFC with fiber mixture the heat of hydration is slower that raise the temperature difference between the interior and exterior concrete should not be more that is good for avoiding thermal cracking and presence of fiber the bonding of concrete is good, so in this concrete, the cracks are not easily developed. Use of steel fiber in concrete its increase the tensile strength of concrete. Due to the high volume of fines and low water content, fresh concrete mixtures of the HVFC with fiber system are generally very cohesive and show a little or no bleeding and segregation They show excellent pump-ability and workability at slumps as low as 125 mm, however, more-then 125 mm slump values may be specified with heavily reinforced structures. Consequently, the surface finish is usually smooth pleasing and without honeycombs and bug-holes. For countries like China and India, this technology can play an important role in meeting the huge demand for infrastructure in a sustainable manner

***Keywords**: Fly ash, Steel fiber, Admixture, Consistency, Workability, Compressive strength*

1. INTRODUCTION

The use of high-volume fly ash concrete (HVFC) with steel fiber has recently gained popularity as a resource-efficient, durable, cost-efficient, sustainable option for many types of Portland cement concrete (PCC) applications. Any concrete containing a fly ash content that is grater then 35 percent by mass of the total cementitious materials is considered HVFC. If containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. IS: 456-2000, code of Practice for Plain and Reinforcement Concrete allows replacements of OPC by Fly-ash up to 35 percent as a binding material, If Fly-ash is used in excess of 35 percent as replacement of OPC as binding material then it's known as High Volume Fly-ash Concrete (HVFC). The production of Portland cement is not only costly and energy-intensive, but it also produces large amounts of carbon dioxide. With large quantities of fly ash available around the world at low costs, the use of HVFC seems to offer best short term solution to rising cement demands. Fly ash is commonly used in concrete in replacements ranging from 0 to 30 percent by mass of the total cementitious material. However, research has shown that using 50% replacement of fly ash can have a wide range of benefits. Fly-ash is a by-product and therefore less expensive then Portland cement, it is also known to improve workability and reduce internal temperatures. The improved workability is a result of the "ball bearing" action of the spherical fly ash particles, fly ash improve the grading in the mixture by smoothing out of the fine particle size distribution While HVFC has a wide range of benefits, possibly the most attractive property of all is durability. The improvements in durability are a result of the reduction in calcium hydroxide, which is the most soluble of the hydration products and from a change in the pore structure.

2. MATERIALS USED

2.1 Cement

Ordinary Portland Cement (OPC) 53 grade was used. The various test of cement was conducted in the laboratory

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2.2 Fine Aggregate

Locally available aggregate and natural sand from Narmada River were used in the experimentation. The maximum size of aggregate used in the mix was 4.75mm. The preliminary tests on fine aggregate and coarse aggregate were conducted as per IS: 2386-1975 and IS 383. The fine aggregate was confirming to zone II. Specific gravity was fined 2.56.

2.3 Coarse Aggregate

Crushed stones of 20mm down and 10mm down will use as coarse aggregate. Specific gravity was fined 2.63.

2.4 Fly Ash: Fly ash is a by-product of burning pulverized coal in electric power generating plants. During combustion, mineral impurities in the coal (clay, feldspar, quartz, and shale) fuse in suspension and float out of the combustion chamber with the exhaust gases. As the fused material rises, it cools and solidifies into spherical glassy particles called fly ash. Fly ash is collected from the exhaust gases by electrostatic precipitators or bag filters. The fine powder does resemble Portland cement but it is chemically different. Fly ash chemically reacts with the by-product calcium hydroxide released by the chemical reaction between cement and water to form additional cementitious products that improve many desirable properties of concrete

Table 1: Physical & Chemical Properties of Fly Ash.

Chemical characteristics	Singrauli Fly-ash	IS 3812-Part 1 specifications
Sio_2	66%	35 (min)
Al_2O_3	22%	Not Specified
Fe_2O_3	6%	Not Specified
$Sio_2 + Al_2O_3 + Fe_2O_3$	94%	70 (min)
Cao	1%	Not Specified
Mgo	0.6%	5 (max)
Na_2O	1.3%	1.5 (max)
So_3	0.2%	3 (max)
Reactive silica %	30	20

Physical properties	Singrauli Fly-ash	IS 3812-Part 1 specifications
Specific Gravity g/cc	2.0	Not Specified
Specific surface area (cm^2/g)	3334	3200
Lime reactivity (Mpa)	7.2	4.5 (min)
Soundness	3	Not specified

2.5 Steel Fiber: The amount of fibers added to a concrete mix is expressed as a percentage of the total volume of the composite (concrete and fibers), termed "volume fraction" (V_f). V_f typically ranges from 0.1 to 3%. The aspect ratio (l/d) is calculated by dividing fiber length (l) by its diameter (d). Fibers with a non-circular cross section use an equivalent diameter for the calculation of aspect ratio. If the fibre's modulus of elasticity is higher than the matrix (concrete or mortar binder), they help to carry the load by increasing the tensile strength of the material. Increasing the aspect ratio of the fiber usually segments the flexural strength and toughness of the matrix. However, fibers that are too long tend to "ball" in the mix and create workability problems.

3. RESULT AND DISCUSSION ON EXPERIMENTAL TEST

3.1 Slump test

Slump test is used to determine the workability of fresh concrete. Slump test as per IS: 1199 – 1959 is followed. The apparatus used for doing slump test is Slump cone and tamping rod. The slump measured should be recorded in mm of subsidence of the specimen during the test. Any slump specimen, whom collapses or shears off laterally gives incorrect result and if this occurs, the test should be repeated with another sample. If in the repeat test also, the specimen shears, the slump should be measured and the fact that the specimen sheared, should be recorded the slump of HVFC mixture is 120mm when the percentage of Fly-ash is 50% and the slump is 108mm when the percentage of Fly-ash is 60%.

Fig. 1: Compressive strength results

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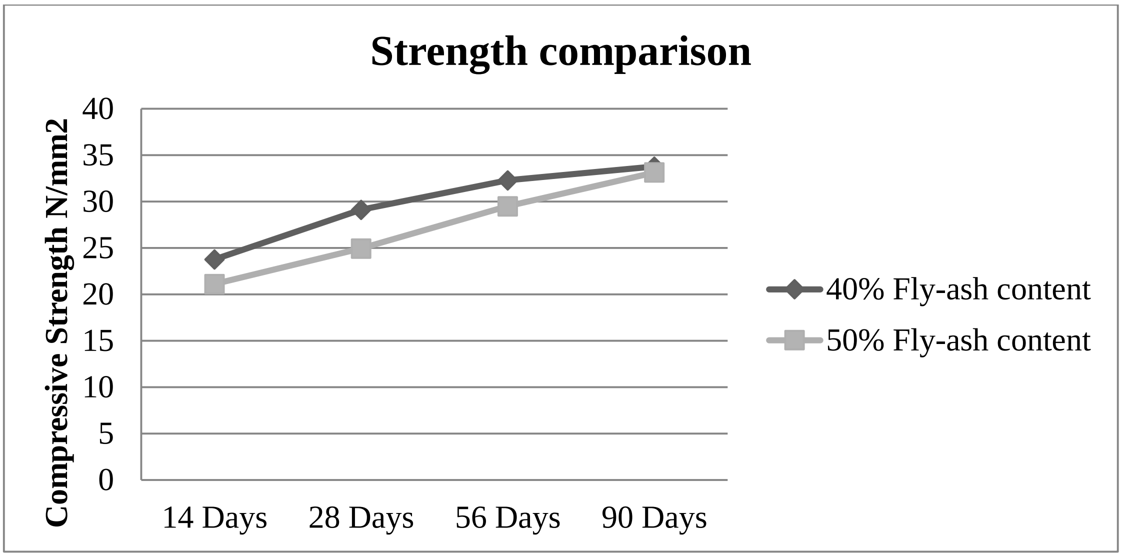
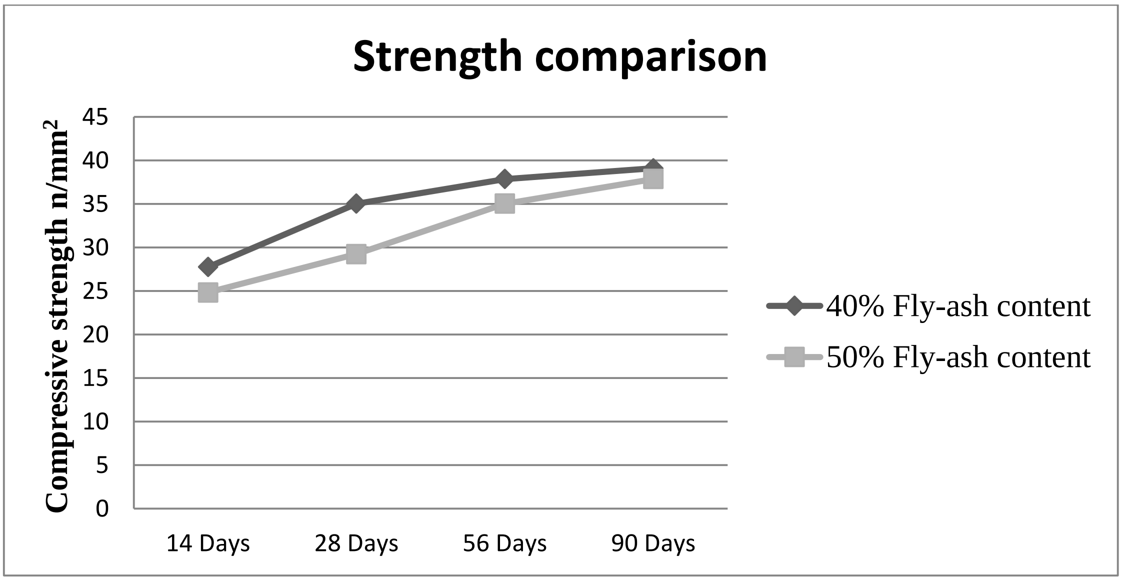
For 40% Fly-ash content

Average compressive strength of M20 concrete cube = 23.78 N/ mm^2 (at 14 days)
Average compressive strength of M25 concrete cube = 27.76 N/ mm^2 (at 14 days)
Average compressive strength of M30 concrete cube = 30.04 N/ mm^2 (at 14 days)
Average compressive strength of M20 concrete cube = 29.12 N/mm^2 (at 28 days)
Average compressive strength of M25 concrete cube = 35.05 N/mm^2 (at 28 days)
Average compressive strength of M30 concrete cube = 36.69 N/mm^2 (at 28 days)
Average compressive strength of M20 concrete cube = 32.30 N/mm^2 (at 56 days)
Average compressive strength of M25 concrete cube = 37.88 N/mm^2 (at 56 days)
Average compressive strength of M30 concrete cube = 39.86 N/mm^2 (at 56 days)
Average compressive strength of M20 concrete cube = 33.78 N/mm^2 (at 90 days)
Average compressive strength of M25 concrete cube = 39.10 N/mm^2 (at 90 days)
Average compressive strength of M30 concrete cube = 40.88 N/mm^2 (at 90 days)

For 50% Fly-ash content

Average compressive strength of M20 concrete cube = 21.12 N/ mm^2 (at 14 days)
Average compressive strength of M25 concrete cube = 24.84 N/mm^2 (at 14 days)
Average compressive strength of M30 concrete cube = 26.04 N/ mm^2 (at 14 days)
Average compressive strength of M20 concrete cube = 24.95 N/ mm^2 (at 28 days)
Average compressive strength of M25 concrete cube = 29.26 N/mm^2 (at 28 days)
Average compressive strength of M30 concrete cube = 30.56 N/mm^2 (at 28 days)
Average compressive strength of M20 concrete cube = 29.50 N/ mm^2 (at 56 days)
Average compressive strength of M25 concrete cube = 35.05 N/mm^2 (at 56 days)
Average compressive strength of M30 concrete cube = 35.99 N/mm^2 (at 56 days)
Average compressive strength of M20 concrete cube = 33.14 N/ mm^2 (at 90 days)
Average compressive strength of M25 concrete cube = 37.87 N/mm^2 (at 90 days)
Average compressive strength of M30 concrete cube = 38.69N/mm^2 (at 90 days





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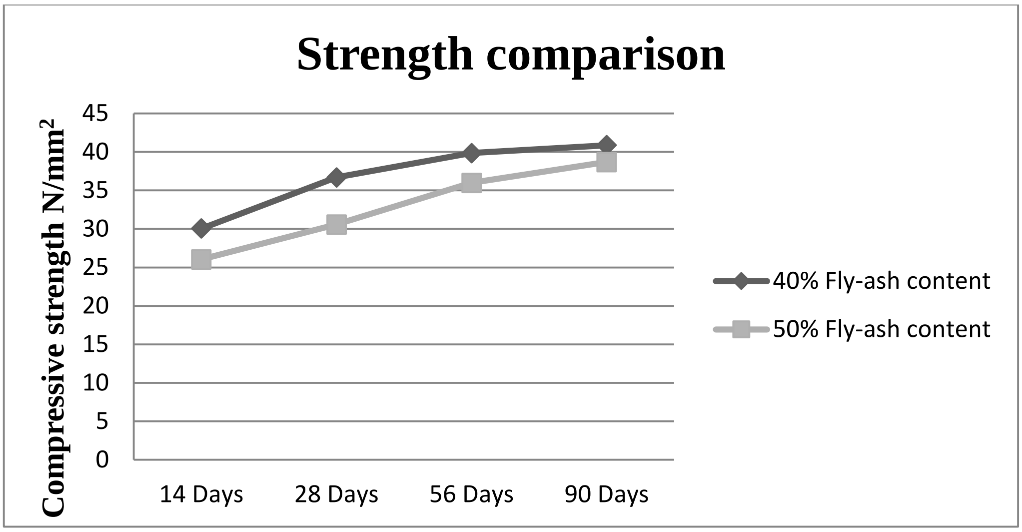

4. CONCLUSIONS

1. Use of HVFC is very suitable for tropical and hot climate countries like India
2. Abundant availability of Fly Ash makes HVFC more economical, environmental and ecologically friendly product.
3. It can be effectively used in structural and non-structural applications where normal concrete is used. HVFC wins over normal concrete in almost all Technical parameters.
4. Use of HVFC should be included in National Codes and in specifications of major construction departments / Companies.
5. Concerted efforts by Thermal Power Plants, Construction Organizations, Academic Institutions and National bodies are solicited for the promotion of HVFC in Coming years.
6. The Bulk dencity of HVFC block is low as compare to ordinery concrete

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