STUDIES ON STRENGTH CHARACTERISTICS OF FLY ASH ADMIXED STEEL FIBRE REINFORCED CONCRETE

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ABSTRACT: Concrete has unlimited opportunities for innovative applications, design and construction techniques. Its great versatility and relative economy in filling wide range of needs has made it very competitive building material. The ever rising functional requirements of the structures and the capacity to resist aggressive elements has necessitated developing new cementations materials and concrete composites to meet the higher performance and durability criteria. The environmental factors and pressure of utilizing waste materials from industry have also been the major contributory factors in new developments in the field of concrete technology. In this direction, an attempt has been made in the present investigation to evaluate the workability, compressive strength, split tensile strength and flexure strength on addition of Fly Ash (0 – 30%) along with crimped steel fibers (0-1%) in concrete. Standard cubes of 150 X 150 X 150 mm have been cast and tested for obtaining 28 days and 60 days compressive strength. Standard cylinders of 150mm diameter and 300 mm height were cast and tested for Split tensile strength. Standard Beams of 500mmx100mmx100mm were cast and tested for Flexural strength. Results were analyzed to derive useful conclusions regarding the strength characteristics of Fly Ash fiber reinforced concrete.
Key Words: Fibre Reinforced Concrete, Fly Ash, Admixture, Concrete, Strength, Durability

I. INTRODUCTION

With the advancement of technology and increased field of applications of concrete and mortars, the strength workability, durability and other characters of the ordinary concrete need modifications to make it more suitable by situations. Added to this is the necessity to combat the increasing cost and scarcity of cement. Under these circumstances the use of admixtures is found to be an important alternative solution. The production of superior quality of Ordinary Portland Cement (OPC) in the country was primarily responsible for introducing the grading system in OPC by Bureau of Indian Standard (BIS) during 1986-87. The other varieties of structural cements, such as sulphate resisting Portland cement, Pozzolana cement and blast furnace slag cement found their way in the improvement of quality of prompted the structural engineers and major consumers to adopt higher grades of concretes in the construction work. This has been marked difference in the quality of concrete during this period primarily due to the availability of superior quality of cements in the market. The trend is continuing more and more varieties of cements are coming to the markets which help to the consumers to make appropriated grade quality of concrete to meet the specific construction requirement. In the past continuous efforts were made to produce different kinds of cement, suitable for different situations by changing oxide composition and fineness of grinding. With the extensive use of cement, for widely varying conditions, the types of cement that could be made only by varying the relative proportions of the oxide compositions were not found to be sufficient. Recourses have been taken to add one or two more new materials, known as additives, to the clinker at the time of grinding, or to the use of entirely different basic raw materials in the manufacture of cement. The use of additives, changing chemical composition, and use of different raw materials have resulted in the availability of many types of cements to cater to the need of the construction industries for specific purposes. The most important Pozzolana materials are fly ash, silica fume and Metakaolin whose use in cement and concrete is thus likely to be a significant achievement in the development of concrete technology in the coming few decades. The high Performance fiber reinforced, polymer concrete composites and ready mixed concrete have been progressively introduced for specific applications.

NEED FOR PRESENT INVESTIGATION

Though a lot of research is focused in the last decade on use of various admixtures in producing concrete, very little information is available on Fly Ash fiber reinforced concrete. As already mentioned, Fly ash is an admixture: a pozzolana as it is generated as a by-product of combustion in coal power plants. Thus this waste material has lot of potential for use in concrete. Hence, there is need to study the strength and workability characteristics of FLY ASH-FRC(Fly Ash based fiber reinforced concrete).

OBJECTIVE IF THE PRESENT WORK

In this work experiments were planned to estimate the workability characteristics and various strength characteristics like compressive strength, Split tensile strength, and flexural strength.

II. MATERIALS AND METHODS

The scope of present investigation is to study and evaluate the effect of addition of Fly Ash (0, 10, 20 & 30%) and Crimped Steel Fibers (0, 0.5, 0.75 & 1%) in concrete. Cubes of standard size 150mmx150mmx150mm were cast and tested for 28 and 60 days compressive strength. Standard cylinders of size 150mm x 300mm were cast and tested for 28days and 60days split tensile strength. Also standard beams of size 500mm x100mm x 100mm were cast and were tested for 28 days and 60 days flexural strength

Materials Used
Cement: - OPC Cement of 53-grade was used.
Coarse Aggregate: - Crushed granite metal with 50% passing 20mm and retained on 12.5mm sieve and 50% passing 12.5mm and retained on 10mm sieve was used. Specific gravity of coarse aggregate was 2.75.
Fine aggregate: - River sand from local sources was used as fine aggregate. The specific gravity of sand is 2.68.
Water: - Potable fresh water, which is free from concentration of acid and organic substances was used for mixing the concrete.
Fiber: Steel Fibers is supplied by "STEWOLS INDIA (P) LTD, An ISO 9001: 2008 Company" at Nagpur. The most important parameter describing a fiber is its Aspect ratio. "Aspect ratio" is the length of fiber divided by an equivalent diameter of the fiber, where equivalent diameter is the diameter of the circle with an area equal to the cross sectional area of fiber. The properties of fiber reinforced concrete are very much affected by the type of fiber. Different types of fibers which have been tried to reinforce concrete are steel, carbon, asbestos, vegetable matter, polypropylene and glass. In the present investigation crimped round fibers used, Aspect ratio of 50.
Fly Ash: - Fly Ash is generated as a by-product of combustion in coal-fired power plants. It is obtained from the near -by thermal power plant.

Figure 2.1 Crimped Steel Fibre


Figure 2.2 Fly Ash

TEST PROGRAMME
To evaluate the strength characteristics in terms of compressive, split tensile and flexural strengths, a total of 16 mixes were tried with different percentages of Fly Ash (0,10,20 & 30%) and different percentages of crimped steel fibers (0,0.5,0.75 & 1%). In all mixes the same type of aggregate i.e. crushed granite aggregate; river sand and the same proportion of fine aggregate to total aggregate are used. The relative proportions of cement, coarse aggregate, sand and water are obtained by IS - Code method. M30 is considered as the reference mix.
CASTING OF CUBES:
For each trail mix 3 cube specimens were cast for calculating 28 days strengths. The dimensions of specimen for cube are of 150mm x 150mm x 150mm.
CASTING OF CYLINDERS:
For each trail mix 3 cylinder specimens were cast for calculating 28 days strengths. The dimensions of the cylindrical specimen are of
Height = 300mm
Diameter = 150mm
CASTING OF BEAMS:
For each trail mix 3 beam specimens were cast for calculating 28 days strengths. The dimensions of the beam specimen are of 500mm x 100mm x 100mm.

III. RESULTS AND DISCUSSION
The results obtained from the experimental procedures were tabulated and presented below. The variations of parameters with respect to the percentage of admixtures are also shown in graphs below.
Effect of addition of Fly Ash on workability
Table 3.1: Workability in terms of Compaction Factor

S.No	% of fiber	Compaction Factor			
		0% FLY ASH	10% FLY ASH	20% FLY ASH	30% FLY ASH
1	0.00% CSF	0.931	0.864	0.822	0.782
2	0.50% CSF	0.863	0.842	0.821	0.786
3	0.75% CSF	0.861	0.844	0.804	0.752
4	1.00% CSF	0.834	0.787	0.761	0.731

The workability of FLY ASH-FRC (Fly Ash fibre reinforced concrete) mixes has been measured by conducting Compaction factor test. From workability tests, it can be observed that the compaction factor of FLY ASH-FRC mixes decrease with the increase with the addition of Fly Ash content indicating a decrease in the workability. This is due to the absorption of water from the mix by the Fly Ash. The Variation of compaction factor with percent fly ash and percent crimped steel fibre is shown in the fllowing Figure 3.1(A).

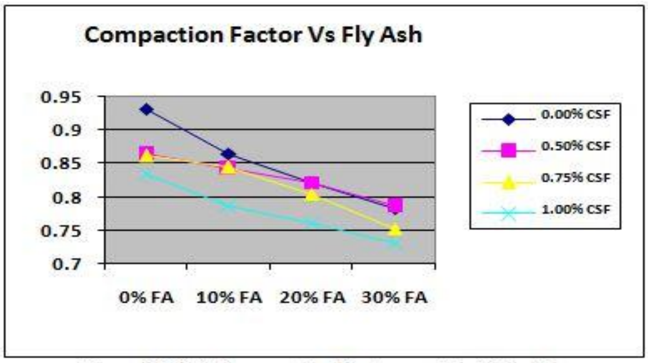

Figure 3.1 (A): Compaction Factor vs. % of Fly Ash

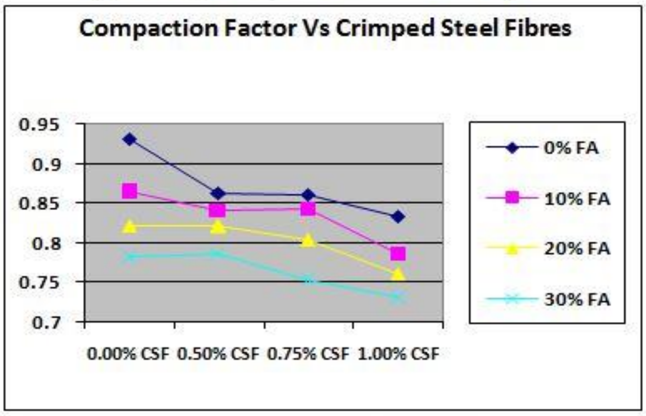

Figure 3.1(B): Compaction Factor Vs % of Crimped Steel Fiber

Effect of percentage of steel fibres on workability:
It can be observed from the Figure 3.1(B), that the compaction factor decreases with the increase in the percentage of crimped steel fibre. Thus indicating decrease in the workability with the increase in the crimped steel fibre content.
Effect of addition of Fly Ash on Compressive Strength: From Figure 3.2(A) it can be observed that the 28 days compressive strength increases with the increase in the percentage of Fly Ash up to 20% addition level. On 20% addition of Fly Ash there is increase of cube compressive strength by 11.3% over plain concrete. At 10% level, the compressive strength has increased by 8.18%. But at 30% level, the compressive strength has decreased by 16.1%.
Effect of percentage of steel fibres on Compressive Strength: From Figure 3.2(B), it can be observed that with the increase in the percentage of fiber up to 0.75%, the compressive strength has increased by 10.2% over plain concrete. At 0.5% fiber volume the compressive strength has increased by 5.4% and at 1.00% fiber volume the compressive strength has increased by 9.7% respectively. Hence 0.75% of fiber volume can be taken as optimum content. Similar trends were observed even case of Fly ash mixes on addition of fibers.
Effect of addition of Fly Ash on Split Tensile Strength: From Figure 3.3(A) it can be observed that the 28 days split tensile strength increases with the increase in the percentage of Fly Ash up to 20% addition level. On 20% addition of Fly Ash there is increase in split tensile strength by 8.92% over plain concrete. At 10% level, the split tensile strength has increased by 3.20%. But at 30% level, the split tensile strength has decreased by 15.8%.
Effect of percentage of steel fibres on Split Tensile Strength: From Figure 3.3(B), it can be observed that with the increase in the percentage of fiber up to 0.75%, the split tensile strength has increased by 29.75% over plain concrete. At 0.5% fiber volume the split tensile strength has increased by 21.51% and at 1.00% fiber volume the split tensile strength has increased by 24.94% respectively. Hence 0.75% of fiber volume can be taken as optimum content. Similar trends were observed even case of fly ash mixes on addition of fibers
Effect of addition of Fly Ash on Flexural Strength: From Figure 3.4(A) it can be observed that the 28 days flexural strength increases with the increase in the percentage of Fly Ash up to 20% addition level. On 20% addition of Fly Ash there is increase of flexural strength by 8.93% over plain concrete. At 10% level, the flexural strength has increased by 5.83%. But at 30% level, the split tensile strength has decreased by 16.11%. Similar trends were observed even in case of FRC (Fiber reinforced concrete) mixes on addition of Fly Ash.
Effect of percentage of steel fibres on Flexural Strength: From Figure 3.4(B), it can be observed that with the increase in the percentage of fiber up to 0.75%, the flexural strength has increased by 30.48% over plain concrete. At 0.5% fiber volume the flexural strength has increased by 21% and at 1.00% fiber volume the flexural strength has 25.82% respectively.Hence 0.75% of fiber volume can be taken as optimum content.

Table 3.2 : 28 days Compressive Strength values in N/mm^2

S.No	% of fibre	Compressive Strength (Mpa)			
		0% FLY ASH	10% FLY ASH	20% FLY ASH	30% FLY ASH
1	0.00% CSF	39.2	42.2	43.6	32.9
2	0.50% CSF	41.3	43.8	45.7	34.7
3	0.75% CSF	43.2	45.6	47.8	35.8
4	1.00% CSF	42.8	44.9	47.2	35.2

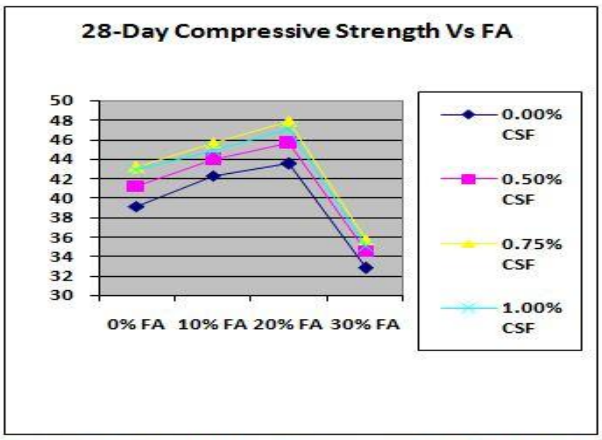

Figure 3.2(A): 28 Days Compressive Strength Vs % of FLY ASH

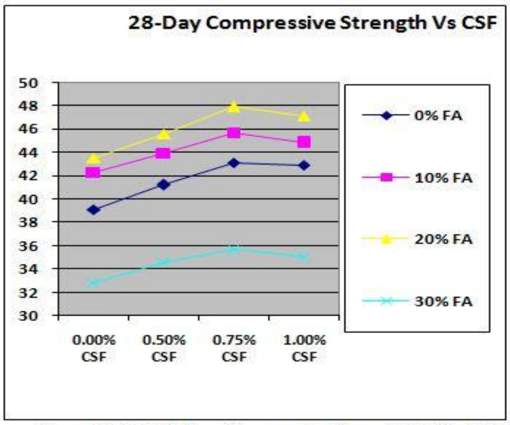

Figure 3.2(B): 28 Days Compressive Strength Vs% of CSF

Table 3.3 : 28 days Split Tensile Strength values in N/mm2

S.No	% of fibre	Split Tensile Strength (Mpa)			
		0% FLY ASH	10% FLY ASH	20% FLY ASH	30% FLY ASH
1	0.00% CSF	4.35	4.52	4.74	3.64
2	0.50% CSF	5.32	5.58	5.81	4.44
3	0.75% CSF	5.64	5.82	6.22	4.67
4	1.00% CSF	5.26	5.65	6.05	4.66

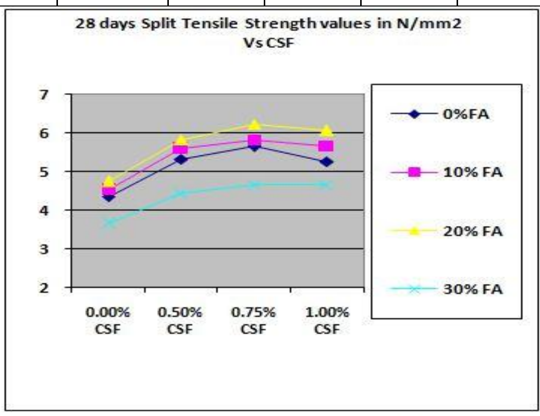

Figure 3.3(B): 28 Days Split Tensile Strength Vs % of CSF

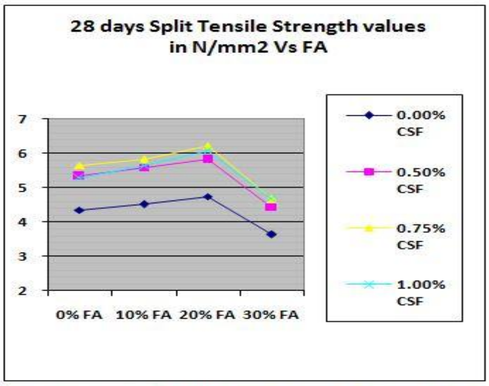

Figure 3.3(A): 28 Days Split Tensile Strength Vs % of FLY ASH

Table 3.4 : 28 days Flexural Strength values in N/mm^2

S.No	% of fibre	Flexural Strength (Mpa)			
		0% FLY ASH	10% FLY ASH	20% FLY ASH	30% FLY ASH
1	0.00% CSF	5.15	5.45	5.61	4.32
2	0.50% CSF	6.23	6.51	6.79	5.17
3	0.75% CSF	6.72	6.99	7.28	5.68
4	1.00% CSF	6.48	6.78	7.09	5.47

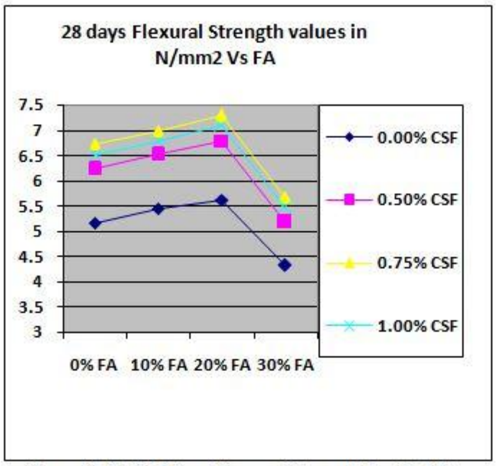

Figure 3.4(A): 28 Days Flexural Strength Vs % of FA

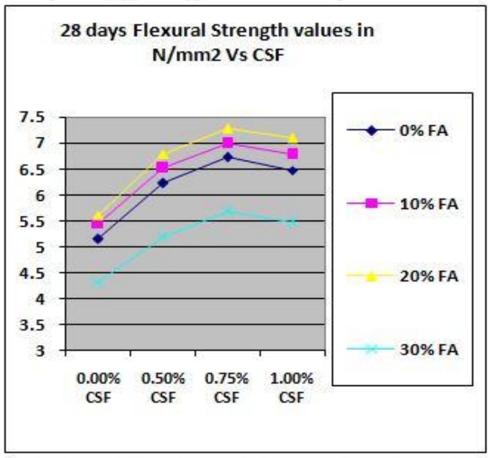

Figure 3.4(B): 28 Days Flexural Strength Vs % of CSF

IV. CONCLUSIONS

Results were analyzed to derive useful conclusions regarding the strength characteristics of Fly Ash fiber reinforced concrete (FLY ASH-FRC). M30 concrete has been used as reference mix. The following conclusions may be drawn from the study on strength characteristics of Fly Ash Fibre reinforced concrete properties.

The workability of concrete measured from compaction factor degree. As the percentage of Fly Ash and steel fibre increases the compaction factor decreases. Hence it can be concluded that with the increase in the Fly Ash content and fiber content workability decreases. From the experimental results, the optimum percentage recommended is 0.75% steel fiber volume with 20% addition of in Fly Ash achieving maximum benefits in compressive strengths, split tensile strengths and flexural strengths.

The compressive strength of FLY ASH FRC mixes at 28 days shows maximum values with the addition of Fly Ash up to 20% level and with the addition of steel fibres up to 0.75% level when compared to that of plain concrete.

The split tensile strength of FLY ASH-FRC mixes at 28 days shows maximum values with the addition of Fly Ash up to 20% level and with the addition of steel fibres up to 0.75% level when compared to that of plain concrete.

The flexural strength of FLY ASH-FRC mixes at 28 days shows maximum values with the addition of Fly Ash up to 20% level and with the addition of steel fibres up to 0.75% level when compared to that of plain concrete.
Beyond 20% Fly ash and 0.75% steel fibres the strengths were observed to decrease. Hence these percentages were considered as optimum.

RECOMMENDATIONS FOR FUTURE INVESTIGATIONS
Studies on different lengths, proportions and aspect ratios of steel fibers may be carried out. Studies on the different proportions of Fly Ash may be carried out. Mathematical / Empirical models can be developed for the Stress/Strain behavior of strength characteristics on Fly Ash fibre reinforced concrete. Durability studies such as resistance to Sulphate attack, Acid resistance etc., can be carried out on Fly Ash fibre reinforced concrete.

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