Experimental Investigation on Strength Characteristics of Fly Ash Added Steel Fiber Reinforced Concrete

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***Abstract*: Steel fiber improves the tensile properties of concrete whereas fly ash acts as partial substitute for cement in concrete. This paper incorporates both the properties of steel fiber and fly ash. The study is carried out in M25 mix. Steel fibers varied from 0%.0.5%,1%,1.5% of different aspect ratios 20, 30 and 40 and replacement of fly ash varies from 10%,20% and 30%. The specimens are generally tested for7 and 28 days and the behaviour of fly ash based steel fiber reinforced concrete were studied. The specimens are generally tested for compressive strength, tensile strength and flexural strength.**

***Keywords*: fly ash, steel fiber reinforced concrete**

1. Introduction

Concrete is strong in compression but weak in tension. To overcome this weakness in concrete, steel reinforcement is utilized to carry the tensile forces and prevent any cracking or by pre-stressing the concrete so that it remains largely in compression under load. The introduction of steel fibers was brought in as an alternative to developing concrete in view of enhancing its flexural and tensile strengths. Although the basic governing principles between conventional reinforcement and fiber systems are identical, there are several characteristic variations; such as - fibers are generally short, closely spaced and dispersed throughout a given cross section. Steel fibers helps to reduce the problems associated with congestion of shear reinforcement such as interference with concrete compaction. These may have attributed to the honeycombing and poor quality of concrete, particularly at critical sections such as beam-column junctions.

The rate of production of carbon dioxide released to the atmosphere is increasing due to the increased use of Portland cement in the construction. On the other side, fly ash is the waste material of coal based thermal power plant available abundantly but this poses disposal problem. Several hectares of valuable land are acquired by thermal power plants for the disposal of fly ash. The present investigation deals with the investigation of fiber reinforced concrete added with fly ash.

2. Aim

1. To study the effect of flyash and steel fibers on the strength properties of concrete.
2. To study the strength properties of flyash added SFRC and compared with normal concrete.
3. To determine the maximum volume fraction of flyash and steel fibers.
4. To study the effect of aspect ratio on flyash added steel fiber reinforced concrete

3. Fibre Reinforced Concrete

In Fiber reinforced concrete (FRC), thousands of small fibres are dispersed and distributed randomly in the concrete during mixing, and thus improve concrete properties in all directions. Fiber is a small piece of reinforcing material possessing certain characteristics properties. They can be circular, triangular or flat in cross-section. These fibers are produced from different materials like steel, plastic, glass, carbon and other natural materials. The fiber is often described by a convenient parameter called aspect ratio. The aspect ratio of the fiber is the ratio of its length to its diameter. The principle reason for incorporating fibers into a cement matrix is to increase the toughness and tensile strength and improve the cracking deformation characteristics of the resultant composite.

4. Methodology

Based on the objectives, a methodology for present thesis work has been adopted

1) The experiment is conducted in M25 grade concrete.
2) Determination of material properties.
3) Mix design is done as per IS 10262:2009.
4) Casting of specimens with partial replacement of cement (0%, 10%, 20% and 30% flyash) with addition of steel fibers (0.5%, 1.0% and 1.5%).
5) The mechanical properties of flyash based steel fiber reinforced concrete.

5. Experimental Tests

A. *Compression test*

Compression test on cubes and cylinders were performed on flyash based SFRC specimens to determine the compressive strength. At first the mix were prepared according to the mix design values. After that cubes and cylinder specimens were casted with replacement of cement with flyash in 10, 20 and 30% with an addition of 0.5,1 and 1.5% steel fibers of 20 and 30 aspect ratios. After curing of 7 and 28 days specimens are tested for compressive strength under compression testing machine.

Fig. 1. Compression test on SFRC specimen

B. Split tensile strength test

Steel fibers are generally used to increase the tensile strength of concrete. Steel fibers also helps to reduce the cracks developed in concrete due to plastic shrinkage and drying shrinkage. Concrete is not usually expected to resist direct tension because of its less tensile strength and brittle nature. Split tensile test is used to access the tensile strength of concrete with the addition of steel fibers. Mix were prepared according to the adopted mix design values. Specimens for split test were casted with replacement of cement by 10, 20 and 30% of flyash with an addition of 0.5, 1and 1.5% steel fibers of 20 and 30 aspect ratios. After curing of 7 days and 28 days specimens were tested for split tensile test under compression testing machine. Cylinder specimens are placed horizontally between the loading surface of compression testing machine and the load were applied until the failure of specimens.

Fig. 2. Split tensile strength test on SFRC specimen

C. Flexural strength test

Steel fibers also help to increase the flexural strength of concrete. Mix were prepared according to the adopted mix design values. Specimens for flexural test were casted with replacement of cement by 10, 20 and 30% of flyash with an addition of 0.5, 1and 1.5% steel fibers of 20mm and 30mm aspect ratios. After curing of 7 days and 28 days specimens were tested for flexural test under UTM. . The load is applied on the specimens at a rate of loading of 400kg/min. The load is applied on the specimen till the failure of specimen.

Fig. 3. Flexural strength test on SFRC specimen

6. Experimental Results

The experimental results of flyash based SFRC specimens of 28 days curing were shown in tables given below.

Table 1
Test results of 20 aspect ratio

Specimen	Cube strength (N/mm^2)	Cylinder strength (N/mm^2)	Tensile strength (N/mm^2)	Flexural strength (N/mm^2)
Control	18.35	14.71	2.027	2.03
FA10SF0.5	20.29	16.69	2.56	2.76
FA20SF0.5	18.8	14.89	2.44	2.41
FA30SF0.5	9.18	7.54	2.14	2.09
FA10SF1	20.66	16.69	4.62	3.70
FA20SF1	18.94	14.77	3.59	3.18
FA30SF1	10.88	8.39	2.78	2.53
FA10SF1.5	19.63	15.36	2.46	2.58
FA20SF1.5	18.42	14.55	2.39	2.33
FA30SF1.5	7.84	6.69	2.11	2.09

Table 2
Test results of 30 aspect ratio

Specimen	Cube strength (N/mm^2)	Cylinder strength (N/mm^2)	Tensile strength (N/mm^2)	Flexural strength (N/mm^2)
Control	31.4	22.24	3.81	5.06
FA10SF0.5	33.92	25.46	4.61	5.76
FA20SF0.5	31.89	24.89	4.54	5.51
FA30SF0.5	17.25	13.2	4.38	5.27
FA10SF1	34.36	26.21	5.66	5.89
FA20SF1	31.96	25.56	5.32	5.62
FA30SF1	17.77	14.23	4.54	5.33
FA10SF1.5	33.03	25.84	4.34	5.58
FA20SF1.5	31.29	25.03	4.22	5.39
FA30SF1.5	14.96	11.03	3.99	5.14

Table 3
Test results of 40mm aspect ratio

Specimen	Cube strength (N/mm^2)	Tensile strength (N/mm^2)	Flexural strength (N/mm^2)
Control	31.4	3.81	5.06
FA10SF0.5	35.32	5.29	6.22
FA20SF0.5	32.98	5.02	5.91
FA30SF0.5	22.41	4.81	5.67
FA10SF1	35.88	5.94	6.35
FA20SF1	33.26	5.65	6.03
FA30SF1	22.82	5.22	5.79
FA10SF1.5	34.32	4.86	5.98
FA20SF1.5	31.96	4.59	5.52
FA30SF1.5	20.34	4.44	5.43

7. Graphical representation

A. Comparison of 20 aspect ratio

1) Relation between cube strength and flyash content

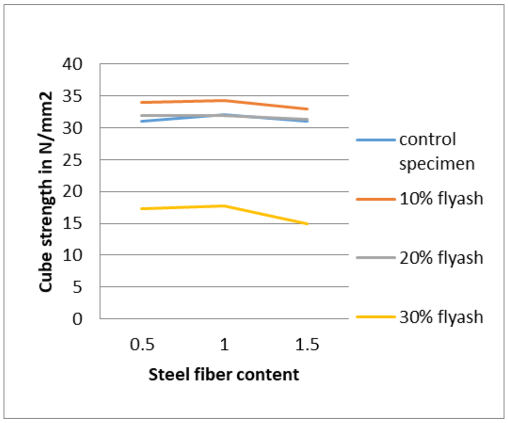

Fig. 4. Variation of cube strength in 20 aspect ratio

2) Relation between tensile strength and flyash content

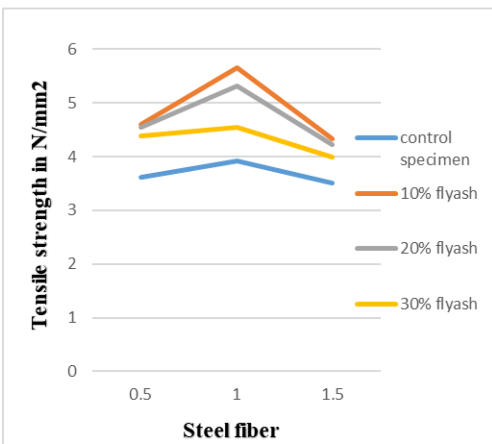

Fig. 5. Variation of tensile strength in 20 aspect ratio

3) Relation between flexural strength and flyash content

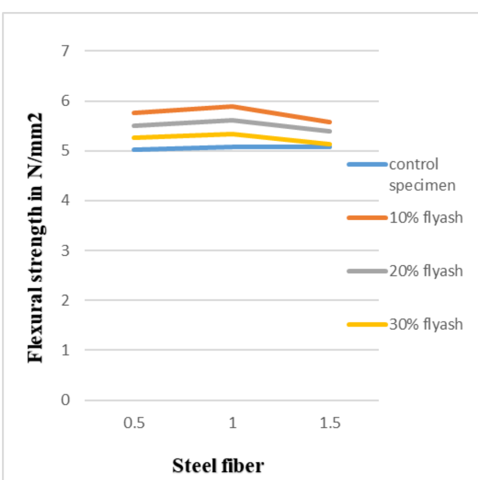

Fig. 6. Variation of flexural strength in 20 aspect ratio

B. Comparison of 30 aspect ratio

1) Relation between cube strength and flyash content

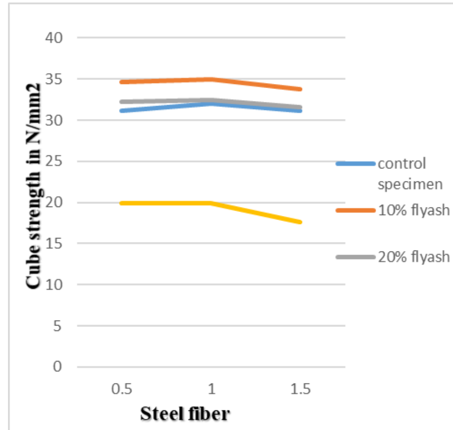

Fig. 7. Variation of cube strength in 30 aspect ratio

2) Relation between tensile strength and flyash content

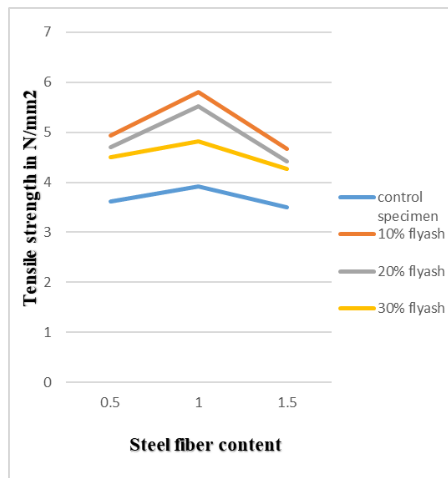

Fig. 8. Variation of tensile strength in 30 aspect ratio

3) Relation between flexural strength and flyash content

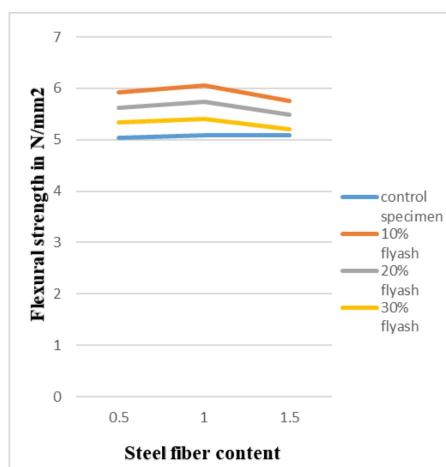

Fig. 9. Variation of flexural strength in 30 aspect ratio

C. Comparison of 40mm aspect ratio

1) Relation between cube strength and flyash content

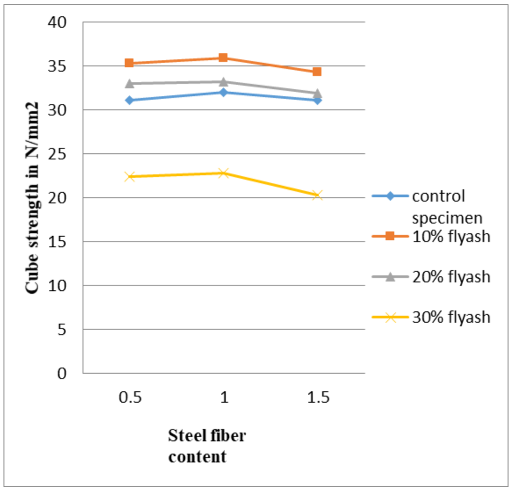

Fig. 10. Variation of cube strength in 40mm aspect ratio

2) Relation between tensile strength and flyash content

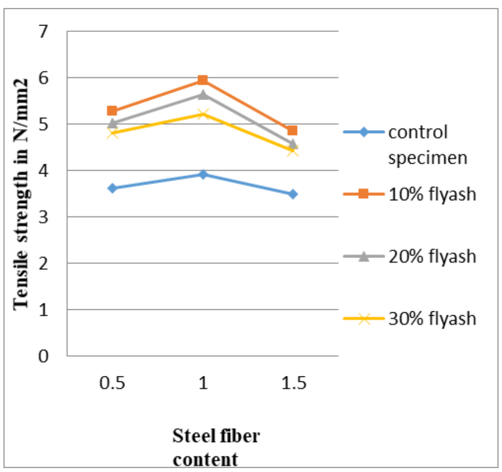

Fig. 11. Variation of tensile strength in 40mm aspect ratio

3) Relation between flexural strength and flyash content

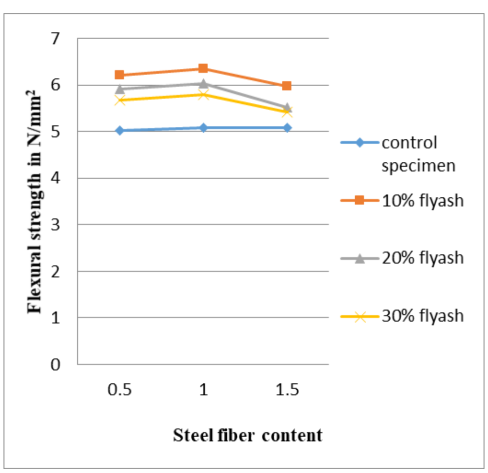

Fig. 12. Variation of flexural strength in 40mm aspect ratio

8. Summary and Conclusions

The present Experimental investigation is to study the Mechanical Properties of the Fly ash concrete reinforced with steel fibers. Steel fibers of different aspect ratios 20 and 30mm varies from 0%, 0.5%, 1% and 1.5% by weight of cement and replacement of fly ash varies from 0%, 10%, 20% and 30% and 40%. From the experimental tests it was found out that

1. The addition of steel fiber into the concrete significantly increases the strength properties of concrete.
2. From the experiments conducted it was found out that optimum content of flyash is about 10% but replacement can be possible up to a percentage of 20.
3. For 20 and 30 aspect ratio the optimum content of steel fiber is about 1%.
4. As the aspect ratio increases strength properties of concrete also increases.
5. Tensile strength and Flexural strength can be increased to 60% to 70% with the addition of steel fibers.
6. It is concluded that cement in concrete can be replaced up to 20% by flyash with incorporation of steel fibers up to 1.0% to improve its strength characteristics and the optimum aspect ratio is found as 30.

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