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Study on Behaviour of Steel Fibre Reinforced Concrete with Addition of Mineral Admixtures

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ABSTRACT- *It is now well established that one of the important properties of steel fibre reinforced concrete (SFRC) is its superior resistance to cracking and crack propagation. Fibre Reinforced Concrete (FRC) is very useful in extreme climate where shrinkage of concrete causes cracks. The Fibre Reinforced Fly ash concrete (FRFAC) has been successfully used to minimize cavitations / damages in hydraulics structures. This experimental investigation is to study the effects of replacement of cement (by weight) with three percentage of fly ash and the effects of addition of steel fiber composite. A control mixture of proportions was designed. Cement was replaced with three percentages (10%, 20% & 30%) of Class C fly ash. Three percentages of steel fibers (0.30%, 0.45% & 0.60%) having 20 mm length were used. This study reports the feasibility of use of steel fibres and their effect due to variation in fibre length, fibre content on structural properties such as cube compressive strength, cylinder compressive strength, split tensile strength, modulus of rupture and modulus of elasticity of this composite. Tests will be conduct on beams with optimum fibre parameters, and the results compared with those of identical Reinforced Concrete beam.*

KEYWORDS: Concrete, Fibre, mineral admixtures, Composite Concrete.

I. INTRODUCTION

The Concrete is very strong in compression but weak in tension. As a Concrete is a relatively brittle material, when subjected to normal stresses and impact loads. The tensile strength of concrete is less due to widening of micro-cracks existing in concrete subjected to tensile stress. Due to presence of fiber, the micro-cracks are arrested. The introduction of fibers is generally taken as a solution to develop concrete in view of enhancing its flexural and tensile strength.

Fly ash is the fine powder major waste material produced from many thermal power plants. The disposal of fly ash is the one of the major issue for environmentalists as dumping of fly ash as a waste material may cause severe environmental problem. Therefore, the utilization of fly ash as an low cost mineral admixture in concrete instead of dumping it as a waste material can have great beneficial effects.

The introduction of the paper should explain the nature of the problem, previous work, purpose, and the contribution of the paper. The contents of each section may be provided to understand easily about the paper.

The extensive investigation has been carried out on mixing of different types of fibers to the conventional concrete. The addition of steel fibers of suitable size, shape and aspect ratio to a properly designed concrete mix improves its resistance to tensile stress and modifies the brittle behaviour considerably and reduces shrinkage and temperature cracks.

The fibers and fly ash are added for improving its performance against creep, wear, fracture and decrease in the permeability. The Fiber Reinforced Fly Ash Concrete (FRFAC) has been successfully used to minimize cavitations / erosion damages in hydraulic structures such as sluiceways; navigation docks and bridge piers where high velocity flows are encountered.

1.1 USE OF STEEL FIBRE

The use of steel fibre in concrete can improve its many properties. The benefits of using steel fibres in concrete are as follows:

1. Steel Fibres are generally distributed throughout a given cross section whereas reinforcing bars or wires are placed only where required
2. Steel fibres are relatively short and closely spaced as compared with countinuous reinforcing bars of wires.
3. It is generally not possible to achieve the same area of reinforcement to area of concrete using steel fibres as compared to using a network of reinforcing bars of wires.
4. Steel Fibers are typically added to concrete in low volume dosages (often less than 1%), and have been

shown to be effective in reducing plastic shrinkage cracking.
5. Steel Fibers typically do not significantly alter free shrinkage of concrete, however at high enough dosages they can increase the resistance to cracking and decrease crack width (Shah, Weiss, and Yang 1998).

1.2 BENIFITS OF STEEL FIBER REINFORCED CONCRETE

- SFRC distributes localized stresses.
- Reduction in maintenance and repair cost.
- Provides tough and durable surfaces.
- Reduces surface permeability, dusting and wear.
- Cost saving.
- They act as crack arrestor.
- Increases tensile strength and toughness.
- Resistance to impact.
- Resistance to freezing and thawing

II. MATERIALS USED

II.1 WATER

In this experiment portable water with pH values of 7 is used. It is used for the purpose of hydration of cement and to provide workability during mixing and placing of concrete.

II.2 CEMENT

In this experimental work 53 grade ordinary Portland cement is used. The properties of cement are given in table 2.1

Table2.1 Properties of Cement

S. No	Description	Values
1	Specific gravity	3.15
2	Standard consistency	29 %
3	Fineness (by sieve analysis)	4.60 %
4	Initial setting time	30 minutes

2.3 FINE AGGREGATE

Natural river sand is used as a fine aggregate in this experimental work. The sand confirmed to grading zone II of IS 383-1970. The properties of fine aggregate are represented in table 3.2.

Table 2.2 Properties of Aggregate

S. No	**Description**	**Fine Aggregate**
1	Specific gravity	2.64
2	Fineness modulus	2.76
3	Water absorption	1%
4	Bulk Density	1668.0 kg/m³

2.4. Coarse Aggregate

The coarse aggregate is the strongest and least porous component of concrete. Coarse aggregate in cement concrete contributes to the heterogeneity of the cement concrete and there is weak interface between cement matrix and aggregate surface in cement concrete.

Table 2.3 properties of coarse aggregate

S.NO	TESTS	VALUES
1	Specific gravity	2.60
2	Bulk density	1652.89 kg/m^3
3	Impact value	11.48%
4	Fineness modulus	7.6

2.5. FLYASH

Fly ash, also known as "pulverized fuel ash", is one of the coal combustion products from thermal power plants, composed of the fine particles that are driven out of the boiler with the flue gases. The properties of fly ash are listed in Table 3.3.

Table 2.4 Properties of Flyash

S. No	Description	Values
1	Specific gravity	2.6
2	Surface area (m^2/kg)	500-5000
3	Bulk Density(kg/m^3)	900-1300

2.6. Fibers

The steel fiber is procured from precision Drawell Pvt. Ltd., Nagpur. The steel fiber used in the study is the hook ended type HK0750 having aspect ratios 71. The constant dosages of 0.5 % fibers up to 1.5% are used by total volume of concrete. The length of dividing fiber is 50mm and the diameter of fiber is 0.7.

Table 2.5 Properties of steel fibre

Property	Value
Density of steel fibre (kg/m3)	7850
Length (mm)	25
Diameter (mm)	0.6
Aspect ratio (L/D)	41.7
Grade of steel fibre	I

III. METHODOLOGY

In this experimental programme firstly the properties of the materials used were studied. As per IS 10262- 2009 mix was designed for Light Transmitting concrete of M20 grade. The mix design is detailed in Table 4.1 . The fresh and hardened properties of light transmitting concrete such as slump flow test, Compressive Strength Test, Water Absorption , Split tensile strength Flexure Strength accelerated corrosion test was carried out. The specimen details are given in table 4.2.

Table 3.1- Mix Design

Cemen t	Fly ash	FA	Fibre	C.A	Wate r
Mix proportion					
341 kg	42	546	4.48	999.1 3	191.6

Mix ratio					
0.89	0.11	1.42	0.4	2.93	0.50

Table 3.2- Specimen Details

Specimen	No of Specimen	Test Detail	
Cube	78	Compressive Strength Test	Conventional 39+ composite 39
Cylinder	78	Split tensile strength	Conventional 39+ composite 39
Prism	78	Flexure Strength	Conventional 39+ composite 39

IV. EXPERIMENTAL INVESTIGATION

IV.1 WORKABILITY

Workability is that property of plastic concrete mixture which determines the ease with which it can be placed and the degree to which it resists the segregation to produce full compaction. Workability was measured by the slump cone test.

Figure 4.1 Slump test

IV.2 COMPRESSIVE STRENGTH TEST

Compression test is the most common test on hardened concrete, because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength.

Figure 4.2 compressive strength test

IV.3 SPLIT TENSILE STRENGTH TEST

Splitting tensile strength is used in the design of structural light weight concrete members to evaluate the shear resistance provided by concrete and this test method covers the determination of splitting tensile strength of cylindrical concrete specimens.

$f_t = 2P/\Pi ld$

Figure 4.3 Split tensile strength test

4.4 FLEXURAL STRENGTH TEST

Flexural testing is used to determine the flex or bending properties of the material. The specimens are tested as per IS: 516-2004.

Flexural strength (f_b) = P x L / b x d^2

Figure 4.4 Flexural strength test

V. RESULT AND DISSCUSSIONS

5.1 Compression Test

The aim of this experimental test is to determine the maximum load carrying capacity of test specimens. The compression test specimens were tested on a compression testing machine (CTM) of capacity 1000 KN. The specimen was placed on machine in such a way that its position is at right angles to its own position which it had at the time of casting.

5.2 Split Tensile Test

The cracking is a form a tensile failure. The main of this experimental test is to determine the maximum load carrying capacity of test specimens. Cylinders of size 150 mm in diameter and 300 mm height were cast for split tensile test. Two numbers of specimens were tested 28days. The splitting tests are well known as indirect tests used for determining the tensile strength of concrete.

5.3. Flexure Test

The specimen is subjected to two points loading and the load at the failure of the specimen is noted down.Prisms of size 100 x 100 x 500 mm were cast. Two numbers of specimens for each set were tested for 28days. These specimens were tested in universal Testing Machine (UTM) of capacity 400 kN.

Table 5.1 Compressive strength

Compressive strength in N/mm^2			
Replacement in Concrete	**7 Days Test**	**14 Days Test**	**28days Test**
Conventional concrete	19.78	22.67	26.00
10 % Flyash (0.3% fibre)	20.22	23.33	26.00
10 % (0.45% fibre)	20.71	23.56	26.67
10 % (0.6% fibre)	21.11	24.67	27.33
20 % (0.3% fibre)	21.33	25.78	27.78
20 % (0.45% fibre)	22.67	27.33	29.11
20 % (0.6% fibre)	21.56	25.56	27.78
30 % (0.3% fibre)	21.33	25.56	27.11
30 % (0.45% fibre)	21.56	25.56	27.33
30 % (0.6% fibre)	20.89	24.89	26.67

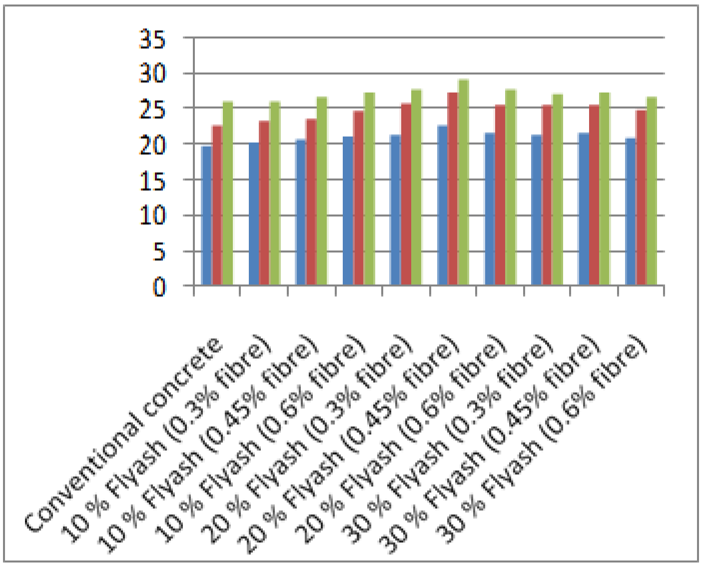


Chart 5.1Compressive strength

Table 5.2 Split Tensile strength

Split Tensile strength in N/mm^2			
Replacement in Concrete	**7 Days Test**	**14 Days Test**	**28days Test**
Conventional concrete	2.48	2.76	3.61
10 % Flyash (0.3% fibre)	2.62	2.97	3.75
10 % Flyash (0.45% fibre)	2.55	2.97	3.68
10 % Flyash (0.6% fibre)	2.76	3.11	3.75
20 % Flyash (0.3% fibre)	3.18	3.40	3.96
20 % Flyash (0.45% fibre)	3.61	4.03	4.25
20 % Flyash (0.6% fibre)	3.61	3.75	4.03
30 % Flyash (0.3% fibre)	3.54	3.68	3.96
30 % Flyash (0.45% fibre)	3.54	3.68	3.96
30 % Flyash (0.6% fibre)	3.47	3.54	3.61

Table 5.3 Flexural strength

Replacement in Concrete	**7 Days Test**	**14 Days Test**	**28days Test**
Conventional concrete	4	5.05	7.4
10 % Flyash (0.3% fibre)	4.6	5.6	7.6
10 % Flyash (0.45% fibre)	4.9	6.25	8.1
10 % Flyash (0.6% fibre)	5.05	6.4	8.15
20 % Flyash (0.3% fibre)	6	7.1	9.05
20 % Flyash (0.45% fibre)	7.25	7.9	9.55
20 % Flyash (0.6% fibre)	6.6	7.6	9.4

30 % Flyash (0.3% fibre)	6.6	7.65	9.4
30 % Flyash (0.45% fibre)	6.5	7.6	9.2
30 % Flyash (0.6% fibre)	6.55	7.05	8.6

Chart 5.3 Flexural strength

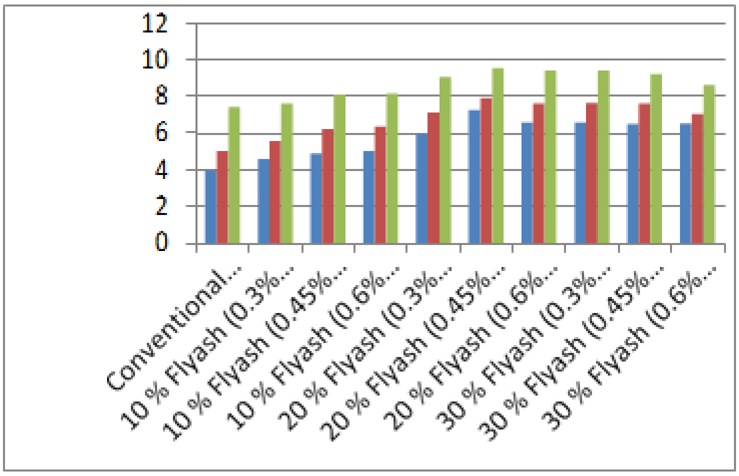
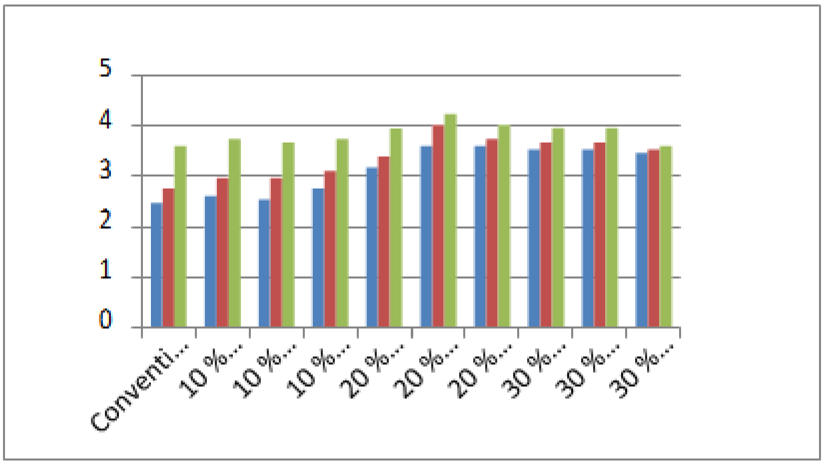
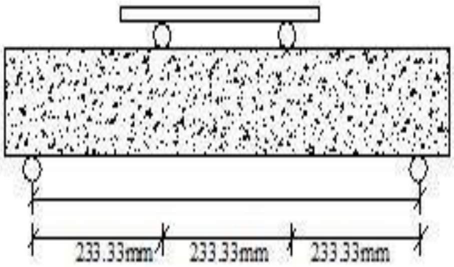


Chart 5.2Split-Tensile strength



5.4 BEAM ELEMENT TEST



Modulus of Rupture

The determination of flexural tensile strength is essential to estimate the load at which the concrete members may crack. As it is difficult to determine the tensile strength of concrete by conducting a direct tension test, it is computed by flexure testing. The flexural tensile strength at failure is called **modulus of rupture**.

Designation	Load @ First Crack kN	Load @ Failure kN	Deflection @ First Crack	Max. Deflection
Conventional	29	59	2.1 mm	4.5mm
20 % Flyash (0.3% fibre)	40	75	3.0 mm	5.1mm
20 % Flyash (0.45% fibre)	45	88	2.2 mm	4.4mm
20 % Flyash (0.6% fibre)	45	79	2.8 mm	4.5mm

VI. CONCLUSION

Based on experimental test, the fly ash can serve as a good substitute for cement in reasonable proportions by volume and whatever deficiencies that may result can be easily overcome by use of steel fibres. Properties of the resulting composites show better performance than plain concrete both in terms of mechanical and structural strengths.

Based on these test results it is now possible to find out enhancements in strengths for different fly ash contents and fibre percentages by weight. An ideal choice would be 20% fly ash with 0.45% of fibre gives an increase of 5% to 20 % increase in cube strength at the end of seven days and 25% to 40% at the end of 28 days. Similar enhancements in tensile strength and modulus of rupture are observed making these composites an efficient material over concrete with the use of local materials and technology.

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