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# A Study on Flexural Behavior of Steel Fiber Reinforced Concrete with Addition of Mineral Admixture

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***ABSTRACT***
*When subjected to normal stresses and impact loads, concrete is a relatively brittle material. The widening of the microcracks that are already present in concrete when it is subjected to tensile stress reduces the material's tensile strength. The primary waste material produced by numerous thermal power plants is fly ash, a fine powder. The impact of fly-ash-based FRC on concrete's strength properties is the subject of this investigation. With regard to various fly-ash and steel fiber replacements, various strength characteristics like compressive strength, tensile strength, and flexural strength are investigated. It is now possible to determine enhancements in strengths for various fly ash contents and fiber percentages by weight on the basis of these test results. An ideal combination of 20% fly ash and 0.30% fiber results in an increase in cube strength of 5% to 20% after seven days and 25% to 40% after 28 days. Comparable upgrades in elasticity and modulus of burst are noticed making these composites an effective material over concrete with the utilization of neighborhood materials and innovation. Steel fiber composites generally perform better when they contain up to 20% fly ash and 0.3 percent fiber. The ideal level could be 0.15 percent fiber in 10 or 15 percent fly ash, which would result in an increase of 12 to 42.2%.*

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## I. INTRODUCTION

The broad examination has been done on blending of various kinds of filaments to the customary cement. In extreme climates where shrinking concrete causes cracks, Fiber Reinforced Concrete (FRC) is very useful. It is increasingly being used to line tunnels, precast elements, and airport runways. While fly ash increases the compressive strength and decreases permeability of FRC while maintaining its workability, The fibers and fly ash are added to boost the material's resistance to creep, wear, fracture, and loss of permeability. In hydraulic structures like sluice ways, the Fiber Reinforced Fly Ash Concrete (FRFAC) has been used successfully to reduce erosion and cavitation damages; bridge piers and navigation docks where high-velocity flows are encountered. Additionally, it is rapidly gaining acceptance as a suitable material for concrete structure repair, rehabilitation, and renovation. Through experiments, Topçu and Canbaz [1] demonstrated that the addition of fibers improves concrete performance, while the inclusion of fly ash in the mixture may adjust the workability and strength gains caused by fibers. For the purpose of investigating the compressive and flexural strengths of steel fiber reinforced concrete (SFRC), the M-25 grade of concrete with a mix ratio of 1:1.50:3.17 and a water-to-cement ratio of 0.465 was utilized. The SFRC contained fibers with a volume fraction of hook end steel fibers with an aspect ratio of 71 and an interval of 0.5% from 0% to 1.5%. a relationship between flexural strength and compressive strength over time For prepared concrete, the mechanical properties, compressive strength, and splitting tensile strength were investigated. The findings demonstrated that the strength properties of PPC concrete are diminished when steel fiber- reinforced fly ash is added. The fraction of steel fiber in concrete that varied from 0.0 to 1.0% was used to test the FRC with and without fly ash. The improved characteristics of FRFAC are due to the addition of fly ash, which results in the formation of additional calcium silicate hydrates in the hydrated cement matrix. It has been discovered that the number of Fibers has no effect on the initial tangent modulus of FRC and FRFAC. The expansion in the Fiber content expands the compressive strength, smashing strain and Poisson"s Proportion of FRC and FRFAC.

Concrete's permeability decreased as its fiber content increased. Finally, contrast fiber- reinforced concrete's fresh and hardened properties with those of conventional concrete.

## II. MATERIALS AND ITS PROPERTIES

Materials used for the experiment includes Portland cement, fine aggregate of size less than 4.75 mm, coarse aggregate and Steel fiber.

I. Cement

The cement used in this experimental work Portland Cement. The specific gravity of the cement is 3.15. The initial and final setting times were found as 90 minutes and 180 minutes respectively. Standard consistency of cement was 31.25%. Physical and chemical characteristics of cement play a vital role in developing strength and controlling rheology of fresh concrete as per IS 8112. The results obtained are reported in table 1.1.

II. Coarse aggregate

The strength of Fibre Reinforced Fly ash Concrete maybe controlled by the strength of the coarse aggregate, which is not normally the case with the conventional cement concrete 20MSA:-Crushed aggregate available from local sources has been used. The coarse aggregates with a maximum size of 20 mm having the specific gravity value of 2.958 and fineness modulus of 7.136 are used as coarse aggregate. The loose and compacted bulk density values of coarse aggregates are 1531 and 1726 kg/m3 respectively, the water absorption of 1.835%. The properties of coarse aggregate are presented in Table 1.2

III. Fine aggregate

Locally available sand passed through 4.75mm IS sieve is used. The specific gravity of 2.84 and fineness modulus of 3.895 are used as fine aggregate. The loose and compacted bulk density values of sand are 1094 and 1162 $kg/m^3$ respectively, the water absorption of 1.491%. Both river sand and crushed stones may be used. Coarser sand may be preferred as finer sand increases the water demand of concrete and very fine sand may not be essential in Fibre Reinforced Fly ash Concrete as it usually has larger content off in particles in the form of cement and mineral admixtures such as fly ash, etc. The sand particles should also pack to give minimum void ratio as the test results show that higher void content leads to requirement of more mixing water. The properties of fine aggregate as observed from the laboratory tests are presented in Table 1.3

IV. Steel fiber

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

**Table1.1:** Properties of cement.

| Sl. No | Physical properties | Values |
|---|---|---|
| 1. | Specific gravity | 2.92 |
| 2. | Fineness | 3.52% |
| 3. | Initial setting time | 250 minutes |
| 4. | Final setting time | 315 minutes |
| 5. | Consistency | 31.5% |
| 6. | Soundness | 0.13 |

**Table 1.2:** Properties of Coarse Aggregate.

| Sl.no | Physical properties | Values |
|---|---|---|
| 1. | Specific gravity | 2.60 |
| 2. | Fineness modulus | 6.4 |
| 3. | Impact value in % | 11.48% |
| 4. | Crushing value in % | 9.26 |
| 5. | Bulk density | 1652.8 |

**Table 1.3:** Properties of Fine Aggregate.

| Sl.no | Physical Properties | Values |
|---|---|---|
| 1. | Specific gravity | 2.60 |
| 2. | Fineness modulus | 2.53 |
| 3. | Bulk density | 1580 |

**Table 1.4:** Properties of steel slag

| Sl. No | Physical properties | Values |
|---|---|---|
| 1. | Density | 7850 |
| 2. | Length | 25 |
| 3. | Diameter | 0.6 |
| 4. | Aspect ratio (L/D) | 41.7 |
| 5. | Grade of fibre | I |

## MIXTURE PROPORTION AND TEST PREPARATION

a. Mix design proportion

The mix design involves the calculation of the amount of cement, fine aggregate and coarse aggregate in addition to other related parameters dependent on the properties of constituent material. The modifications are made and quantities of constituent materials used to cast Fly Ash Fiber Reinforced concrete. The proportions for normal mix of M30 Normal Mix are as follows.

b. Cube compressive strength

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. The 7 days and 28 days cube compressive strength of plain concrete and fiber reinforced concrete specimens obtained from tests tabulated and bar charts for comparative interpretation are drawn. The results of 7 and 28 days cube compressive strength for concrete specimens containing various plastic content. The cube compressive strength for concrete specimens containing various plastic fiber was obtained and tabulated under table 6.1. The comparison of compressive strength of different types of concrete after 7 days and 28 days curing is shown in figure 6.1.It can be seen that the average compressive strength increased with an increase in fiber content. On addition on plastic fibers of 2% the strength is found to increase 3.78% then the conventional concrete specimen.

c. Split tensile tensile strength

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.

d. Flexural strength 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. The flexural strength of plain concrete and fiber reinforced concrete specimens obtained from 7 days and 28 days tests are tabulated below. The testing apparatus set-up and the load various displacement graph of flexural test is shown below. The table gives the results of 7 and 28 days prism flexural strength for concrete specimens containing various plastic content. The bar chart gives the results of 7 days and 28 days prism flexural strength for concrete specimens. The prism flexural strength test of concrete specimens containing different volume of fiber was done at the end of 7 days and 28 days curing and the results are tabulated under table 6.3. The comparison of flexural strength of different concrete specimens is shown in fig 6,4.It can be seen that the average flexural strength increased with an increase in fiber content, showing a maximum increase in strength by 1.22% for 2% addition of fiber.

**TEST RESULTS**

a. Cube Compressive Strength of Concrete:

The test results are tabulated for concrete with 10 % fly ash and varying fiber content below:

| Fibre content % | 7th day strength | 14th day strength | 28th day strength |
|---|---|---|---|
| 0.3% | 19.00 | 22.20 | 24.60 |
| 0.45% | 18.64 | 21.20 | 24.00 |
| 0.6% | 18.20 | 21.00 | 23.40 |

The test results are tabulated for concrete with 20 % fly ash and varying fiber content below:

| Fibre content % | 7th day strength | 14th day strength | 28th day strength |
|---|---|---|---|
| 0.3% | 20.40 | 24.60 | 26.20 |
| 0.45% | 19.20 | 23.20 | 25.00 |
| 0.6% | 19.40 | 23.00 | 25.00 |

The test results are tabulated for concrete with 30 % fly ash and varying fiber content below:

| Fibre content % | 7th day strength | 14th day strength | 28th day strength |
|---|---|---|---|
| 0.3% | 19.20 | 23.00 | 24.40 |
| 0.45% | 19.40 | 22.10 | 22.80 |
| 0.6% | 18.80 | 22.40 | 23.10 |

b. Split tensile Strength of concrete:

The test results are tabulated for concrete with 10 % fly ash and varying fiber content below:

| Fibre content % | 7th day strength | 14th day strength | 28th day strength |
|---|---|---|---|
| 0.3% | 2.23 | 2.61 | 3.53 |
| 0.45% | 2.17 | 2.61 | 3.46 |
| 0.6% | 2.35 | 2.74 | 3.53 |

The test results are tabulated for concrete with 20 % fly ash and varying fiber content below:

| Fibre content % | 7th day strength | 14th day strength | 28th day strength |
|---|---|---|---|
| 0.3% | 2.70 | 2.99 | 3.72 |
| 0.45% | 3.07 | 3.55 | 4.00 |
| 0.6% | 3.07 | 3.30 | 3.79 |

The test results are tabulated for concrete with 30 % fly ash and varying fiber content below:

| Fibre content % | 7th day strength | 14th day strength | 28th day strength |
|---|---|---|---|
| 0.3% | 3.01 | 3.24 | 3.72 |
| 0.45% | 3.01 | 3.24 | 3.72 |
| 0.6% | 2.95 | 3.12 | 3.39 |

c. Flexural Strength of concrete:

The test results are tabulated for concrete with 10 % fly ash and varying fiber content below:

| Fibre content % | 7th day strength | 14th day strength | 28th day strength |
|---|---|---|---|
| 0.3% | 2.94 | 3.57 | 4.68 |
| 0.45% | 3.14 | 3.98 | 5.30 |
| 0.6% | 3.07 | 3.95 | 5.27 |

The test results are tabulated for concrete with 20 % fly ash and varying fiber content below:

| Fibre content % | 7th day strength | 14th day strength | 28th day strength |
|---|---|---|---|
| 0.3% | 4.16 | 4.78 | 5.88 |
| 0.45% | 4.03 | 4.53 | 5.57 |
| 0.6% | 3.97 | 4.72 | 5.67 |

The test results are tabulated for concrete with 30 % fly ash and varying fiber content below:

| Fibre content % | 7th day strength | 14th day strength | 28th day strength |
|---|---|---|---|
| 0.3% | 3.84 | 4.46 | 5.05 |
| 0.45% | 3.97 | 4.53 | 4.99 |
| 0.6% | 3.78 | 4.46 | 4.87 |

## III. DISCUSSION

To improve strength and durability of concrete, proper admixture is to be added. Therefore, the admixture chosen. The properties of different leaf to be studied and the leaves that give more strength and durability in concrete are chosen. For the admixtture is to be prepared. The test specimens to be cast are concrete cubes of size 150x150x150mm, cylinders of size 150x300mm and prism of size 100x100x500mm. Also a beam of 2m span with a cross section of 200mmx200 mm.

## IV. 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 0.30 % 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. In general steel fibre composites show better performance upto 20% fly ash and 0.3% fibre content. Optimum could be 0.15% fibre content at 10 or 15% fly ash giving a range of 12 to 42.2 % increase.

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