# EXPERIMENTAL STUDIES ON STEEL FIBRE REINFORCED CONCRETE

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**Abstract -** *The project aimed at determining the properties of steel fibre reinforced concrete. The main aim of this project is to make a comparative study on different ratios of steel fibre and determine which ratio provides best results of properties of concrete. Fibre ratios of 0.5%, 1%, 1.5% and 2% by volume of concrete were used in the experimental study. Concrete beams of size 500mm X150mmX 150mm and concrete cylinders of 150mm diameter and 300mm length were used for strength test and concrete cubes of size 150mm X150mmX 150mm were used for durability tests. Addition of small amount of fibre to concrete will reduce binder drainage, increase in addition will affect in-service properties such as cohesiveness, stiffness and resistance to deformation. Another property of Steel fibre reinforced concrete is it will reduce losses during fibre breakouts.*

**Key Words*:* steel fibre reinforced concrete, strength, stiffness, cohesiveness, deformation.**

## 1. INTRODUCTION

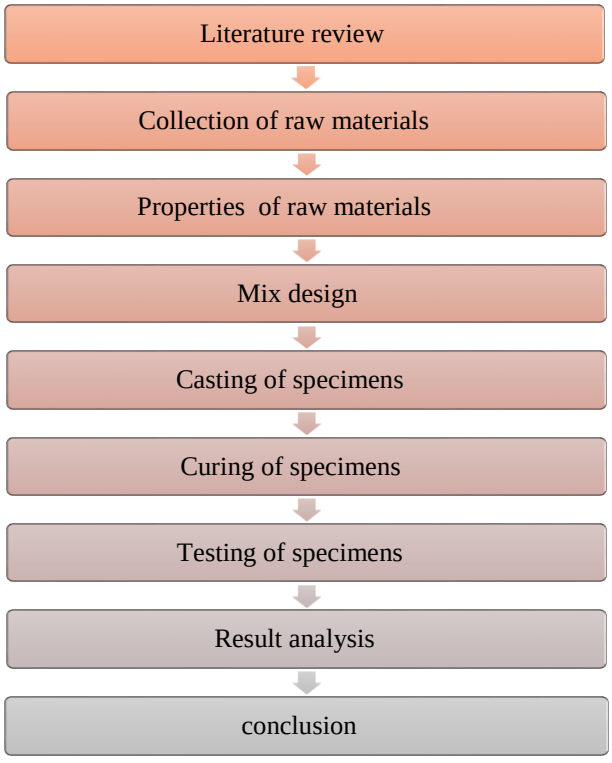
Fibres are provided to the concrete since they contain certain characteristic properties and provide reinforcement to the concrete. They may be flat or circular in shape. Aspect ratio is the term that is always used to describe the type of fibre being used. Aspect ratio is defined as ratio of length of fibre to its diameter. Typically aspect ratio varies from 30-150.fibre reinforced concrete is defined as composite material consisting of mixture of cement ,concrete or mortar and uniformly dispersed fibres in it.. fibre reinforced concrete are of different types and has various properties depending upon type of fibre used in the mixture. The important property of fibre reinforced concrete is increasing the structural integrity.It contains fibres which are short discrete materials and are randomly uniformly distributed in the mixture. Fibre also includes steel fibre, glass fibre, synthetic fibres, jute fibres and many other artificial and natural fibres. Of these fibres, the geometry, orientation, properties, changes based on type of fibre used in the mixture and aspect ratio of fibre been used in the mixture of fibre reinforced concrete.

## 2. EXPERIMENTAL STUDY

This experimental studies mainly focus on steel fibre ratios such as 0.5%, 1%, 1.5% and 2% resistance to its strength and durability properties. Mix proportions were designed using IS 456-2000 and IS 10262-2009. Ordinary Portland cement of 53grade was used for this experiment. River sand was used as a fine aggregate with finess ratio of 2.742, specific gravity of 2.5 grading to zone-II were used in this experiment. Coarse aggregate 20mm size of specific gravity of 2.7, specific gravity of 2.7, and fineness modulus of 7.164 was used in the experiment. Hooked end steel fibres of aspect ratio of 60 and specific gravity of 7.8 were used in the experiment. SP430 was used as super plasticizer to improve the workability of the mixture. Portable water were used for mixing.Cubes of size

150mmX150mmX150mm, beams of same size of 500mmX150mmX150mm and cylinders of300mm diameter and 150mm length were casted to conduct the experiment

## 3. METHODOLOGY




## 4. MIX DESIGN

In this experimental studies, water cement ratio of 0.45 was adopted for M40 grade of concrete. Steel fibres of different ratios of 0.5%, 1%, 1.5% and 2% was used for casting the specimens

## 5. TESTING OF SPECIMENS:

**5.1 Strength tests:** In concrete designing and testing, strength is mainly used to describe the quality of concrete. Strength is considered important because carrying out strength test for the specimens is relatively easy. Concrete has high compressive strength but low tensile strength because concrete is good in compression and weak in tension. The compressive strength of concrete is mainly based on water cement ratio used for forming the mixture and the tensile strength mainly depends upon additives added to the concrete.

**5.2 Durability tests:** durability test is mainly carried out to find the behaviour of concrete when exposed to aggressive environment. Many environmental problems such as acid rain, sulphate attack, polluted water etc mainly influences the durability of concrete. When concrete is exposed to such a environment concrete gets detoriated like sulphate attack, acid attack, chloride attack, corrosion and fail. So durability also is essential along with strength to determine the quality of concrete mixtures.

## 6 RESULTS AND DISCUSSIONS

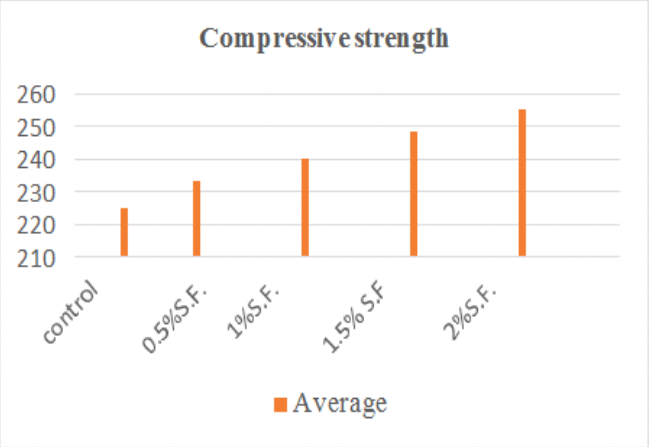
### 6.1.1 COMPRESSIVE STRENGTH

The main aim of this experimental studies is to determine the load carrying capacity of steel fibre reinforced concrete as per IS 516-1959. Sizes of cubes 500x100x100mm were cast. Three specimens were at 28th day. Compression testing machine of 2000KN was used for the testing of the specimens. The mean value of the three specimens of each was taken as final compressive strength.

**Table 6.1 Compressive Strength for M40 Design**

| Cube type | Specimen | Strength | Average |
|---|---|---|---|
| control | Beam 1 | 223 | 225 |
| | Beam 2 | 225 | |
| | Beam 3 | 227 | |
| 0.5%S.F | Beam 1 | 230 | 233 |
| | Beam 2 | 240 | |
| | Beam 3 | 234 | |
| 1%S.F. | Beam 1 | 247 | 240 |
| | Beam 2 | 234 | |
| | Beam 3 | 239 | |
| 1.5% S.F | Beam 1 | 243 | 248 |
| | Beam 2 | 255 | |
| | Beam 3 | 246 | |
| 2%S.F. | Beam 1 | 254 | 255 |
| | Beam 2 | 250 | |
| | Beam 3 | 261 | |

**GRAPH 6.1 Comparison of Weight**




## RESULTS

Steel fibre with 2%fibres showed higher strength compared to plain cement concrete

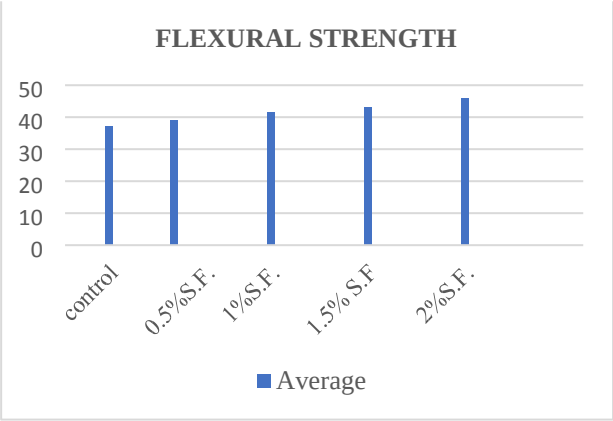
### 6.1.2. FLEXURAL STRENGTH

The main aim of this experimental studies is to determine the flexural strength as per IS 516-1959. Sizes of beams 500x100x100mm were cast. The mean value of the three specimens of each was taken as final compressive strength.

**Table 6.2 Flexural Strength for M40 Design**

| Cube type | Specimen | Strength | Average |
|---|---|---|---|
| control | Beam 1 | 35 | 37 |
| | Beam 2 | 36 | |
| | Beam 3 | 40 | |
| 0.5%S.F. | Beam 1 | 37 | 39 |
| | Beam 2 | 44 | |
| | Beam 3 | 36 | |
| 1%S.F. | Beam 1 | 40.05 | 41.35 |
| | Beam 2 | 43 | |
| | Beam 3 | 41 | |
| 1.5% S.F | Beam 1 | 45 | 43.15 |
| | Beam 2 | 41.35 | |
| | Beam 3 | 43.15 | |
| 2%S.F. | Beam 1 | 48 | 46 |
| | Beam 2 | 47 | |
| | Beam 3 | 43 | |

**GRAPH 6.2 Comparison of Weight**




**RESULTS**

It is concluded from the test that 2% of steel fibres shows higher strength compared to ordinary concrete and concrete with 0.5%, 1%, 1.5% steel fibres.

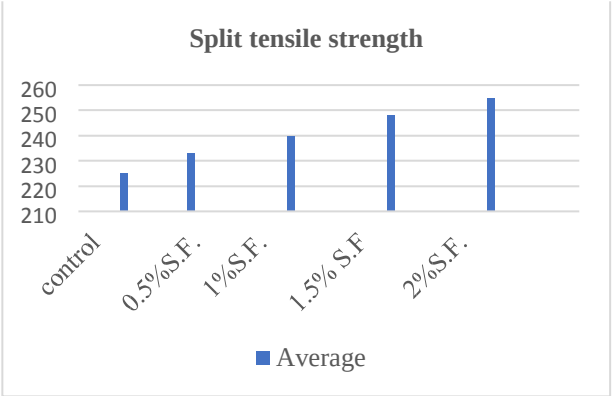
### 6.1.3 SPLIT TENSILE STRENGTH

The main aim of this experimental studies is to determine the split tensile strength as per IS 516-1959. Sizes of cubes 500x100x100mm were cast. Three specimens were at 28th day. The mean value of the three specimens of each was taken as final compressive strength.

**Table 6.3 Split Tensile Strength for M40 Design**

| Cube type | Specimen | Strength | Average |
|---|---|---|---|
| control | Cylinder 1 | 3.2 | 3 |
| | Cylinder 2 | 3 | |
| | Cylinder 3 | 2.9 | |
| 0.5%S.F. | Cylinder 1 | 3.13 | 3.15 |
| | Cylinder 2 | 3.20 | |
| | Cylinder 3 | 3.12 | |
| 1%S.F. | Cylinder 1 | 3.41 | 3.29 |
| | Cylinder 2 | 3.24 | |
| | Cylinder 3 | 3.22 | |
| 1.5% S.F | Cylinder 1 | 3.60 | 3.53 |
| | Cylinder 2 | 3.48 | |
| | Cylinder 3 | 3.51 | |
| 2%S.F. | Cylinder 1 | 3.82 | 3.74 |
| | Cylinder 2 | 3.69 | |
| | Cylinder 3 | 3.71 | |

**GRAPH 6.3 Comparison of Weight**




**RESULTS**

It is concluded from the test that 2% of steel fibres shows higher strength compared to ordinary concrete and concrete with 0.5%, 1%, 1.5% steel fibres.

### 6.2 DURABILITY TEST RESULTS

### 6.2.1 ACID RESISTANCE TEST

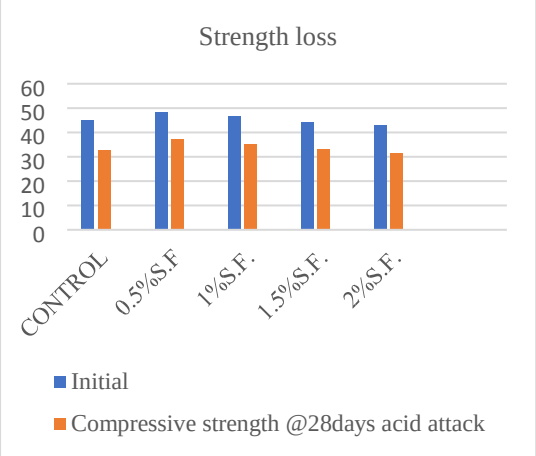
Fifteen concrete mixtures of 45 specimens were cast and tested for acid resistance. Each mixture consists of 3 cubes of various proportions of steel fibres in the concrete. Cubes are tested for acid resistance at 28th day. The results are shown in Table 4.5 &4.6 and plotted in Graph 4.1and 4.2.

**FIGURE 4.1 ACID ATTACK CUBES**

**Table 6.4 Results for Strength Loss Due To Acid Attack**

| Proportion | Initial Compressive strength ($N/mm^2$) | Compressive strength @28days acid attack ($N/mm^2$) | Loss in Compressive strength % |
|---|---|---|---|
| CONTROL | 45 | 32.7 | 27.3 |
| 0.5%S.F | 48.5 | 37 | 23.7 |
| 1%S.F. | 46.6 | 35.3 | 24.2 |
| 1.5%S.F. | 44.3 | 33.1 | 25.3 |
| 2%S.F. | 42.8 | 31.2 | 27.1 |

**GRAPH 6.4 Comparison of Strength Loss in Acid Attack**




**RESULTS**

The compressive strength of control specimens reduced from 27.3% and 23.7 for 0.5%S.F. and 24.2% for 1%S.F. and 25.3% for 1.5%S.F.. and 27.1 % for 2%S.F.. The Steel fibres specimens showed higher resistance to acid attack nearer to controlled specimens

**6.2.2 SULPHATE ATTACK TEST**

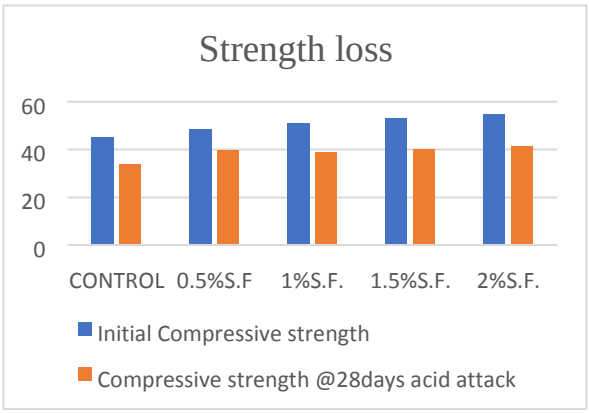
Fifteen concrete mixtures of 5 specimens were cast and tested for sulphate resistance. Each mixture consists of 3 cubes of various proportions of steel fibre in concrete.. Three cubes were tested for sulphate attack at 28 days.

**Figure 4.2 Sulphate Attack & Testing Of Specimens**

**Table 6.5 Results for Sulphate Attack**

| Proportion | Initial compressive strength | Compressive strength @28days acid attack | Loss in Compressive strength |
|---|---|---|---|
| | (N/mm²) | (N/mm²) | (%) |
| CONTROL | 45 | 33.7 | 25.1 |
| 0.5%S.F. | 48.3 | 39.6 | 18.01 |
| 1%S.F. | 50.6 | 39 | 22.9 |
| 1.5%S.F. | 53 | 40 | 24.5 |
| 2%S.F. | 54.6 | 41 | 24.9 |

**Graph 6.5 Comparison of Strength Loss Due To Sulphate Attack**




**RESULTS**

Steel fibre replaced specimens showed high resistance to sulphate attack. It is clear that the concrete prepared with steel fibre showed relatively lower strength change compared to controlled specimen. There will not be any considerable reduction in mass due to sulphate attack.

**6.2.3 WATER ABSORPTION TEST**

This experiment was conducted as per ASTM C 642-06. The results were tabulated in Table 6.6 and plotted in graph Fig 6.6

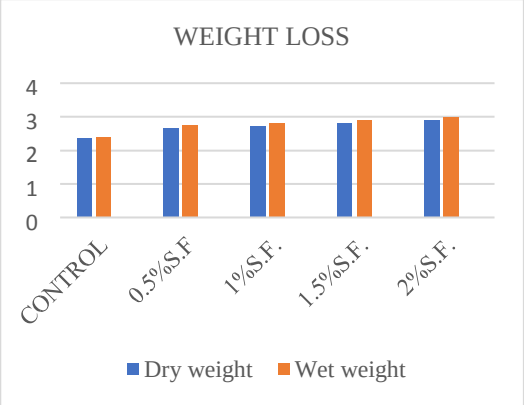
**Figure 6.3 Curing & Oven Drying Of Specimens**

**GRAPH 6.6 COMPARISON OF WATER ABSORPTION**

| Proportion | dry weight(kg) | Wet weight (kg) | Water absorption (%) |
|---|---|---|---|
| CONTROL | 2.35 | 2.41 | 2.55 |
| 0.5%S.F | 2.68 | 2.75 | 2.61 |
| 1%S.F. | 2.74 | 2.82 | 2.84 |

| | | | |
|---|---|---|---|
| 1.5%S.F. | 2.82 | 2.91 | 3.19 |
| 2%S.F. | 2.91 | 3.01 | 3.43 |

**Graph 6.6 Comparison Of water absorption Of Concrete**




**RESULTS**

Increase in water absorption will increase the segregation and bleeding effect in concrete. The maximum water absorption of 3.43 % attained at 2%S.F..

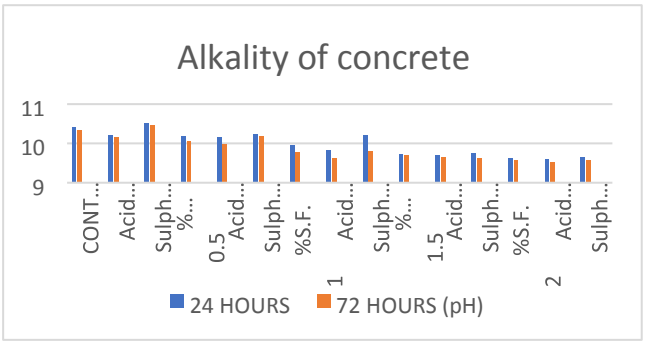
**6.2.4 ALKALINITY OF CONCRETE**

20grams of samples were taken from all ratios and mixed with 100ml of distilled water and kept undisturbed for 72 hrs. Alkalinity was measured using PH-METER.

**TABLE 6.7 RESULTS FOR ALKALINITY OF CONCRETE**

| Proportion | 24 HOURS | 72 HOURS (pH) |
|---|---|---|
| CONTROL | 10.41 | 10.35 |
| Acid attacked | 10.21 | 10.17 |
| Sulphate attacked | 10.53 | 10.48 |
| 0.5%S.F. | 10.18 | 10.07 |
| Acid attacked | 10.14 | 9.98 |
| Sulphate attacked | 10.25 | 10.18 |
| 1%S.F. | 9.96 | 9.77 |
| Acid attacked | 9.83 | 9.63 |
| Sulphate attacked | 10.2 | 9.81 |
| 1.5%S.F. | 9.73 | 9.69 |
| Acid attacked | 9.69 | 9.64 |
| Sulphate attacked | 9.76 | 9.63 |
| 2%S.F. | 9.62 | 9.57 |
| Acid attacked | 9.59 | 9.52 |
| Sulphate attacked | 9.65 | 9.58 |

**Graph 6.7 Comparison of Alkalinity of Concrete**




**RESULTS**

The pH value of controlled concrete is higher than the fibre mixed concrete specimens. The pH value of controlled specimen is 10.41 at 24 hours and 10.35 at 72 hours. The proportions of 0.5% S.F. show higher alkalinity value compared to 1%S.F., 1.5%S.F. &2%S.F.

**CONCLUSION:**

From the experiment we can conclude that steel fibre provides additional strength to the conventional concrete

Steel fibres of 2% ratio shows greater resistance to acid and sulphate attack while conventional mix has greater alkality compared to 0.5%,1%,1.5%and 2% ratio of steel fibres.

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