# "EXPERIMENTAL STUDY ON THE BEHAVIOUR OF STEEL FIBRE REINFORCED CONCRETE"

**Satyashiva prasad nannuta[1], Rashmi B R[2], Usha K[3] , E Balakrishna[4]**

[1,2,3,4] *Asst. Professor, Dept. Of Civil Engineering Bits Warangal.*

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**Abstract -** In recent years the applications of high strength concrete have increased many part of the world. This growth has been possible as a result of recent developments in technology and demand for high strength concrete there are many advantages in using high strength concrete in building construction. Such as, reduction in member size, reduction in self-weight and early stripping of formwork. Reduced member sizes increase amount of rental area and this is beneficial, when there are architectural restrictions on column size or when land prices are very high

The addition of steel fibre to high strength concrete in various volumes fractions, can be lengthen concrete in various volume fraction, can lengthen the time elapsed before cracking and can provide a confinement.

The experimental progamme was designed to the of effect of steel fibers on compressive strength, split tensile strength of high strength concrete and testing of cubes of size (150mm x 150mm x 150mm), cylinders of 150mm diameter, height 300mm.the mix proportion for M30 grade of concrete 1:0.91: 2.41 with w/c ratio 0.37 was obtained. Then the steel fibres were added in the volume fraction of 0%, 0.25%, 0.5%, 0.75%, 1.0%, and 1.25%.

The experiential results shown that the addition of steel fibre improves the crack arresting capacity of concrete .the addition of steel fibre prove that there is significantly enhancing the energy absorbing capacity of specimens.

***Key Words***: **Steel fibre Reinforced Concrete**, **high compressive strength**, **Flat steel fibres, Shear Resistance**, **Dynamic Resistance etc**

## 1. INTRODUCTION

Fibre reinforced concrete is a concrete mix that contains short discrete fibres that are uniformly distributed and randomly oriented. As a result of these different formulations, four categories of fibre reinforcing have been created. These include steel fibres, glass fibres, synthetic fibres and natural fibres. Within these different fibres that character of Fibre Reinforced Concrete changes with varying concrete's, fibre materials, geometries, distribution, orientation and densities. The amount of fibres added to a concrete mix is measured as a percentage of the total volume of the composite (concrete and fibres) termed Volume Fraction. Typically ranges from 0.1 to 3%. Aspect ratio (l/d) is calculated by dividing fibre length (l) by its diameter (d). Fibres with anon-circular cross section use an equivalent diameter for the calculation of aspect ratio. If the modulus of elasticity of the fibre is higher than the matrix (concrete or mortar binder), they help to carry the load by increasing the tensile strength of the material. Increase in the aspect ratio of the fibre usually segments the flexural strength and toughness of the matrix. However, fibres which are too long tend to "ball" in the mix and create workability problems. Unlike resin and metal the fibre composites in which the fibres are aligned and amount to 60 - 80 % of the composite volume, fibre reinforced Cement or Concrete composites contain a less percentage of fibres which are generally arranged in planar or random orientations. Unidirectional fibres uniformly distributed throughout the volume are the most efficient in uniaxial tension. While flexural strength may depend on the unidirectional alignment of the fibres dispersed for away from the neutral plane, flexural shear strength may call for a random orientation. A proper shape and higher aspect ratio are also needed to develop an adequate bond between the concrete and the fibre so that the fracture of the fibres may be fully utilized.

### 1.1 FEATURES AND BENEFITS OF SFRC

- Elimination of manufacturing, handling, storage and positioning of reinforcement cages.
- Reduction in the production cycle time resulting in increased productivity.
- Improved impact resistance during handling, erection.
- Increased load bearing capacity and less spalling damage.
- Enhanced durability.
- Important time savings due to the elimination of the manufacturing, transport, handling and positioning of the conventional reinforcement.
- No damage to sealing due to reinforcement.
- Excellent corrosion resistance, spalling is totally excluded.
- Excellent crack control, the fibres control and distribute the cracks.
- The fibres give resistance to tensile stresses at any point in the shot Crete layer.
- Reinforces against the effect of shattering forces.
- Reinforces against material loss from abrading forces.
- Reinforces against water migration.

## 1.2 APPLICATIONS OF SFRC

Steel fibre reinforced concrete has gained widespread use in applications such as the following:

- Rock slope stabilization and support of excavated foundations, often in conjunction with rock and soil anchor systems.
- Industrial floorings, road pavements, warehouses, Foundations labs.
- Channel linings, protect bridge abutments.
- Rehabilitation of deteriorated marine structures such as light stations, bulkheads, piers, sea walls and dry docks.
- Rehabilitation of reinforced concrete in structures such as bridges, chemical processing and handling plants.
- Support of underground openings in tunnels and mines.

## 2. EXPERIMENTALINVESTIGATION

In order to study the interaction of steel fibres with concrete under compression, split tension. The experimental investigation was taken up on M30 grade of concrete. The investigation was aimed at studying the effect of steel fibres on compressive strength, split tensile strength of M30 grade of concrete to reach the purpose this research, experimental laboratory study was developing on using the materials-53 grade Portland cement, graded coarse aggregate and sand.

The casting work was done in batches for preparing 3 numbers of cubes size 150mm x150mm x150mm.
3 numbers of cylinder of 150mm diameter & 300mm height.

The coarse aggregate used in the casting graded coarse aggregate of this size 20-12.5mm; 12.5-10mm; in the ratio of 60%: 40%: respectively.

The steel fibres were added in the volume fractions of 0%, 0.25%, 0.50%, 0.75%, 1.0% and 1.25%.

The details of steel fibres percentage, No. of cubes and cylinders are shown in the following Table No 1

**Table 1: Details of experimental programme**

| S.no | Specimen | Steel fibers | No. Of cubes | No. Of cylinders |
|---|---|---|---|---|
| **1** | A | 0.00% | 6 | 6 |
| **2** | B | 0.25% | 6 | 6 |
| **3** | C | 0.50% | 6 | 6 |
| **4** | D | 0.75% | 6 | 6 |
| **5** | E | 1.00% | 6 | 6 |
| **6** | F | 1.25% | 6 | 6 |

**Steel fibres:** Fibre is a small piece of reinforcing material possessing certain characteristics properties. The fibres are added small amount of tensile strength. Fibres are different types they are plastic, glass and steel fiber etc. Steel fibres are used in the present investigation. The steel fibres have same expansion and contraction as that of concrete.

**Fig -1 Steel fibres**

### Design of M30 grade concrete by ACI method:

Fineness of coarse aggregate =2.40%
Bulk density of coarse aggregate = 1700 kg\m3
Slump required =85 mm
Grade of concrete = M30
Size of aggregate = 20 mm

**Step-1:-** Target mean strength
Fmin = fmin +ts
=30+1.65*4
=36.6 N/mm2

**Step-2:-** water cement ratio
Water cement ratio for 36.6 Mpa is 0.37

**Step-3:-** cement content required:
Slump required =85mm
Aggregate size =20 mm
From table 11.8 water content =200 kg/m3
Water/cement =0.37
Cement = 200/0.37
Weight of cement =540.54 kg/m3

**Step-4**:- requirement of coarse aggregate
Density = 1710 kg/m3
Size of aggregate = 20 mm, fineness modulus =2.40
From table 11.4, volume =0.66
Weight/volume =density
Weight of coarse aggregate =density *volume = 1710*.66 = 1128.6 kg/m3

**Step-5:-** requirement of fine aggregate:-
F.A:- density of concrete- weights of (cement+C.A+water)
Size of aggregate= 20mm
Density of concrete =2355 kg/m3 from table 11.9
F.A = 2355-(540.54+1128.6+200)
= 491.86kg/m3
Step-6:- mix proportions:

Cement : F.A : C.A : water
540.54 : 491.86 : 1128.6 : 200
1 : 0.91 : 2.41 : 0.37

**M30 Grade:**
Mix proportions
C: F.A: C.A: W/C
1: 0.91: 2.41: 0.37

**CUBE CALCULATION:**

Cube Sizes: 150mm x 150mm x 150mm
Weight of cube = volume x density
=0.15x0.15x0.15x2400
=8.1 kg or 9 kg
Cement= 1x9/1+0.91+2.41+037
= 1.91 or 2.2 kg
F.A = 0.91 X 2.2 =2.002 kg
C.A = 2.41 X 2.2 =5.30 kg
W/C = 0.37 X 2.2 =0.814 kg
0.5 % of steel fibre volume of concrete
Volume of concrete $=0.15^3$
Volume of steel fibre $=0.5x0.15^3 /100 =1.68 x10^{-5}$
Weight of steel fibre = $(0.5 x0.15^3 /100) x 7850$ = 0.132 kg or 132 gm.

**Mix proportion:**

The investigation was carried on M30 grade of concrete. The mix proportion adapted was 1:0.91:2.41 with w/c ratio 0.37

## DISCUSSIONS OF TEST RESULTS

### Experimental results on m30 grade of concrete

**AFTER 28 DAYS**

| S.NO | Specimen | Steel fibres | Compressive strength (N/mm²) | Split tensile strength (N/mm²) |
|---|---|---|---|---|
| 1 | A | 0.% | 31.15 | 2.64 |
| 2 | B | 0.25% | 33.24 | 2.92 |
| 3 | C | 0.50% | 36.17 | 3.30 |
| 4 | D | 0.75% | 38.92 | 3.62 |
| 5 | E | 1.0% | 42.06 | 3.86 |
| 6 | F | 1.25% | 49.74 | 4.10 |

**COMPRESSIVE STRENGTH RESULTS FOR 0.75% STEEL FIBRES:**

| DAYS | COMPRESSIVE STRENGTH N/mm² | | AVG COMP STRENGTH N/mm² |
|---|---|---|---|
| 7 | 24.15 | 26.28 | 25.21 |
| 14 | 31.25 | 33.75 | 32.50 |
| 28 | 37.85 | 39.99 | 38.92 |

**COMPRESSIVE STRENGTH RESULTS FOR 1.0% STEEL FIBRES:**

| DAYS | COMPRESSIVE STRENGTH N/mm² | | AVG COMP STRENGTH N/mm² |
|---|---|---|---|
| 7 | 27.12 | 29.85 | 28.48 |
| 14 | 33.85 | 34.95 | 34.40 |
| 28 | 41.12 | 42.96 | 42.06 |

**COMPRESSIVE STRENGTH RESULTS FOR 1.25% STEEL FIBRES:**

| DAYS | COMPRESSIVE STRENGTH N/mm² | | AVG COMP STRENGTH N/mm² |
|---|---|---|---|
| 7 | 31.85 | 32.96 | 32.40 |
| 14 | 36.15 | 38.78 | 37.46 |
| 28 | 48.25 | 51.25 | 49.74 |

**SPILT TENSILE STRENGTH RESULTS FOR 0.75% STEEL FIBRES:**

| DAYS | SPLIT STRENGTH N/mm² | | AVG SPLIT TENSILE STRENGTH N/mm² |
|---|---|---|---|
| 7 | 2.12 | 2.45 | 2.28 |
| 14 | 2.31 | 2.56 | 2.43 |
| 28 | 3.45 | 3.79 | 3.62 |

**SPILT TENSILE STRENGTH RESULTS FOR 1.0% STEEL FIBRES:**

| DAYS | SPLIT STRENGTH N/mm² | | AVG SPLIT TENSILE STRENGTH N/mm² |
|---|---|---|---|
| 7 | 2.45 | 2.95 | 2.70 |
| 14 | 2.95 | 3.5 | 3.05 |
| 28 | 3.78 | 3.95 | 3.86 |

**SPILT TENSILE STRENGTH RESULTS FOR 1.25% STEEL FIBRES:**

| DAYS | SPLIT STRENGTH N/mm² | | AVG SPLIT TENSILE STRENGTH N/mm² |
|---|---|---|---|
| 7 | 2.95 | 3.15 | 3.05 |
| 14 | 3.45 | 3.95 | 3.70 |
| 28 | 3.95 | 4.25 | 4.10 |

## 3. CONCLUSIONS

The following results are inferred based on the experimental results discussed on the previous chapters.

1. Addition of steel fibres to concrete increases the compressive strength of concrete marginally.
2. The addition of steel fibres increases the tensile strength. The tensile strength was found to be maximum with volume fraction of 1%.
3. By the addition of steel fibres the flexure strength was found to decrease marginally.
4. The addition of fibres to concrete significantly increases its toughness and makes the concrete more ductile as observed by the modes of failure of specimens.

5. The stiffness of beams was studied and was found to be maximum for hooked end fibre with 1% volume fraction.
6. The empirical equations developed in this experiment can be used for calculating the toughness indices or percentage of fibre whichever is required.
7. The ductility of steel fibre reinforced concrete was found to increase with increase in volume fraction of fibres and the maximum increase was observed for hooked fibres with 1%volume fraction.
8. The improvement in the energy absorption capacity of steel fibre reinforced concrete panels with increasing percentage of steel fibres. The following results are inferred based on the experimental results discussed on the previous chapters.

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