# Experimental Study on Properties of Concrete By Using Glass And Steel Fibers

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**Abstract:** In the world concrete is used most commonly as well as durable material for building of various civil engineering structures. It has been found that different type of fibers added in specific percentage to concrete improves the durability, mechanical properties, and serviceability of the structure. . In this paper effect of fibers on the different mechanical properties of M 30 grade concrete mix proportion 1:2.11:2.80 with water cement ratio 0.35 have been studied. Mixing combination of two different types of fibers knows as hybridization. The experimental work has been carried out for M30 mix proportion fibers are hybridized and added in the percentages of 1%, 2% and 3% and the results are compared with conventional concrete. Crimped steel fibres having aspect ratio 50 and glass fibers having 14 micron diameter and 12mm length are added by weight of cement equally.

**Keywords:** Steel fiber, concrete, properties, crack, ductility, technology. Compressive strength, ductility, flexural strength, Fiber Reinforced Concrete, Steel fiber, Split tensile strength, toughness, workability

## I. INTRODUCTION

Concrete is a rigid material with high compressive strength and weak in tensile strength. Reinforcing bars are used to improve the tensile strength.In addition to that fibres can make the concrete more homogenous and can improve the tensile response, particularly the ductility. The various types of fibres added to concrete are steel, glass, carbon, hemp fibre.[1]The process of selecting suitable ingredients of concrete and determining their relative amounts with an objective of producing a concrete of required strength, durability, and workability as economically as possible is termed as concrete mix design. Here we are doing concrete mix design of M30 grade by adding various types of fibers and get more strength as well as it's become economical mix design as far as cost is concern.[2]

The principle reason for incorporating fibres into a cement matrix is to increase the toughness and tensile strength and improve the cracking deformation characteristics of the resultant composite. For FRC to be a viable construction material, it must be able to compete economically with existing reinforcing system. FRC composite properties, such as crack resistance, reinforcement and increase in toughness are dependent on the mechanical properties of the fibre, bonding properties of the fibre and matrix, as well as the quantity and distribution within the matrix of the fibres.[3]

In this report Steel Fibers and Glass Fibers are used as Fiber reinforcement to concrete and compare with conventional concrete. Objective of this study is to add the Steel fibers (crimped) and Glass fiber in to the concrete and to study the strength properties of concrete with the variation in fiber content. i.e. to study the strength properties of concrete ( M30 Grade) for fiber content of 1%, 2% and 3% at 28 days.

### 1.1 Effect of fibres in concrete

Fibres are usually used in concrete to control cracking due to both plastic shrinkage and drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibres produce greater impact, abrasion and shatter resistance in concrete.

Fibres with a non-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.

**1.2Objectives of the study**

The objectives of the current research work to study the durability properties of:

- M30 grade of concrete with varying percentages of addition of glass and steel fibres 0, 1,2 and 3 % at 28 days
- Comparing properties of concrete with their percentage of addition of glass and steel fibres.

## II. LITERATURE REVIEW

A research work has been done and is going on the use of steel and glass fibres. Research work done by different research is discussed here in brief.'

**Praveen Kumar Goud , Praveen K.S**This paper focuses onOptimization Of Percentages Of Steel And Glass Fiber Reinforced Concrete. Cementitious matrices are the fragile materials that possess a low tensile strength. The addition of fibers randomly distributed in these matrices improves their resistance to cracking, substantially. However, the incorporation of fibers into a plain concrete disrupts the granular skeleton and quickly causes problems of mixing as a result of the loss of mixture workability that will be translated into a difficult concrete casting in site. This study was concerned on the one hand with optimizing the fibers reinforced concrete mixes in the fresh state, and on the other hand with assessing the mechanical behaviour of this mixture in the hardened state, in order to establish a compromise between the two states . In this paper optimization of fibers by using different percentages in steel and glass fiber reinforced concrete of grade M 70 have been studied. It optimizes 1.5% for steel Fiber content and 1% for glass fiber content by the volume of cement is used in concrete.

**A.M. Shende, A.M. Pande, M. GulfamPathan**: This paper focuses on the Critical investigation for M-40 grade of concrete having mix proportion 1:1.43:3.04 with water cement ratio 0.35 to study the compressive strength, flexural strength, Split tensile strength of steel fibre reinforced concrete (SFRC) containing fibers of 0%, 1%, 2% and 3% volume fraction of hook tain. Steel fibers of 50, 60 and 67 aspect ratio were used. A result data obtained has been analyzed and compared with a control specimen (0% fiber). A relationship between aspect ratio vs. Compressive strength, aspect ratio vs. flexural strength, aspect ratio vs. Split tensile strength represented graphically. Result data clearly shows percentage increase in 28 days Compressive strength, Flexural strength and Split Tensile strength for M-40 Grade of Concrete.

**Eng. Pshtiwan N. Shakor, Prof. S. S. Pimplikar :**In this paper study on Glass-fibre reinforced concrete (GRC). Glass reinforced concrete is a material made of a cementatious matrix composed of cement, sand, water and admixtures, in which short length glass fibres are dispersed. It has been widely used in the construction industry for non-structural elements, like façade panels, piping and channels. GRC offers many advantages, such as being lightweight, fire resistance, good appearance and strength. In this study trial tests for concrete with glass fibre and without glass fibre are conducted to indicate the differences in compressive strength and flexural strength by using cubes of varying sizes. Various applications of GFRC shown in the study, the experimental test results, techno-economic comparison with other types, as well as the financial calculations presented, indicate the tremendous potential of GFRC as an alternative construction material.

## III. MATERIALS USED & IT'S PROPERTIES

1. **Cement :**Portlandpozzolona cement with ISI mark was used for test on fresh and hardened concrete. Specific gravity of cement is 3.15 and Standard consistency of cement is 29%.
2. **Sand:** Local river sand with fineness modulus 3.17 and specific gravity 2.63 was used.
3. **Coarse aggregate:** Locally available crushed stone aggregates with size 5mm to 12.5 mm and of maximum size 12.5 mm having specific gravity of 2.74, fineness modulus of 7.4.
4. **Water:** Potable water was used for the experimentation with pH of 7.1, was used.
5. **Steel Fibers:** - In this experimentation Crimped type Steel fibers were used. The aspect ratios adopted were 50 having length 30 mm with diameter 0.6 mm resp

Photo No. 1: Separation of Steel Fibers.

6. **Glass Fibers :** The glass fibers used are of Cem-FIL Anti-Crack HD with modulus of elasticity 72 GPA, Filament diameter 14 microns, specific gravity 2.68, length 12 mm.

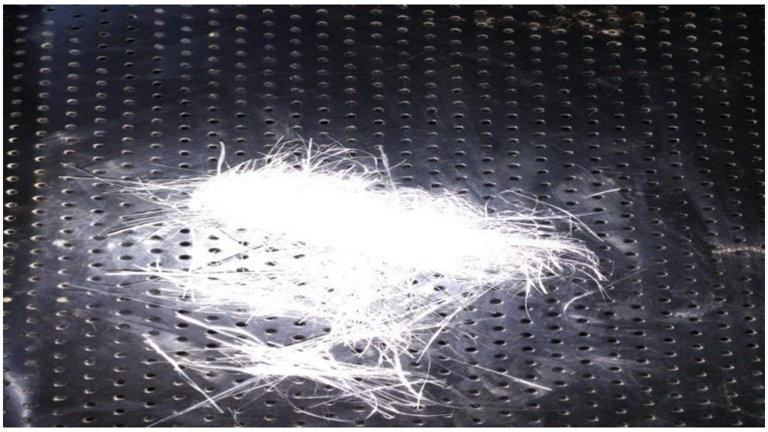


Photo No. 2: Separation of Glass Fibers.

7. The design mixed M30with proportion 1:2.11:2.80 (Cement: Fine aggregate: Coarse Aggregate) for concrete on weight basis. The mix design was done as per IS 10262:2009. Water cement ratio of 0.35kept constant for concrete.

**Table 1: Quantity of material per cubic meter of concrete (M30)**

| Material | Proportion by weight | Weight in $kg/m^3$ |
|---|---|---|
| Cement | 1 | 400 |
| F.A | 2.11 | 844 |
| C.A | 2.80 | 1119 |
| W/C | 0.35 | 140 lit |

**Table 2: Quantity of material per 50 kg of cement(M30)**

| Material | Proportion by weight | Weight in kg/m$^3$ |
|---|---|---|
| Cement | 1 | 50 |
| F.A | 2.11 | 106 |
| C.A | 2.80 | 140 |
| W/C | 0.35 | 18 lit |

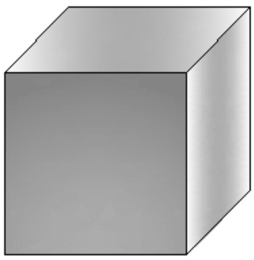
**Table 3 - Details of Specimens to be cast**

| Grade of Concrete | % of Steel fiber | % of glass fiber | Number of Specimen | | |
|---|---|---|---|---|---|
| | | | Cube | Cylinder | Beam |
| M30 | 0 | 0 | 9 | 3 | 3 |
| M30 | 1 | 1 | 9 | 3 | 3 |
| M30 | 2 | 2 | 9 | 3 | 3 |
| M30 | 3 | 3 | 9 | 3 | 3 |

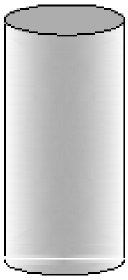
**3.2 Specimen details:**

1. Cube moulds of 150 x 150 x 150 mm are used for casting the specimens for compressive strength.
2. Cylindrical moulds of 150 mm diameter and 300 mm long are used for casting the specimens for split tensile strength test.
3. Rectangular moulds of 100 x 200 x 1800 mm are used for casting the specimens for flexure test.

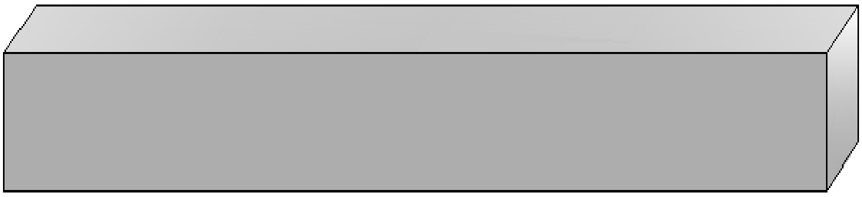
**3.3Preparation of Specimens**



Cube (150 x 150x 150 mm)



Cylinder (150φ x 300 mm)



Beam (100x200x1800mm)

Figure No.1: Specimen Dimensions

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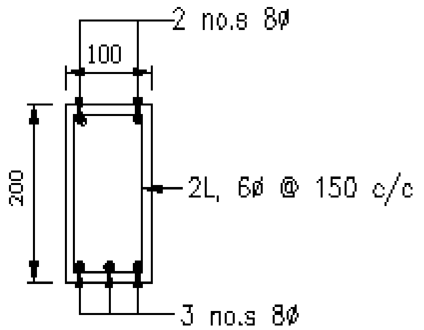
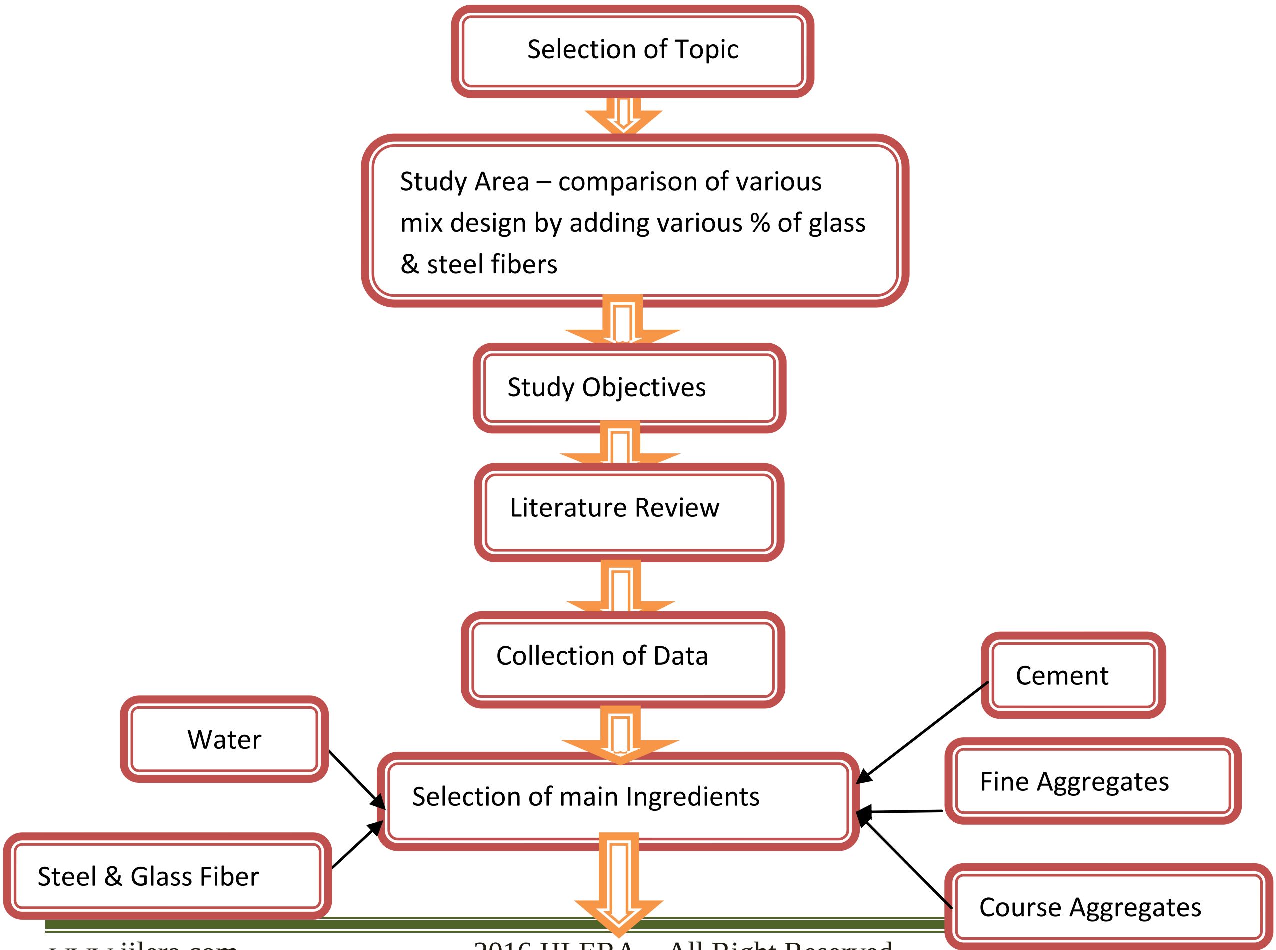



Figure No. 2:Reinforcement detailing of beam

Photo No.3: Reinforcement for Beam Design

## IV. EXPERIMENTAL METHODOLOGY

### 4.1 Study Flow Chart



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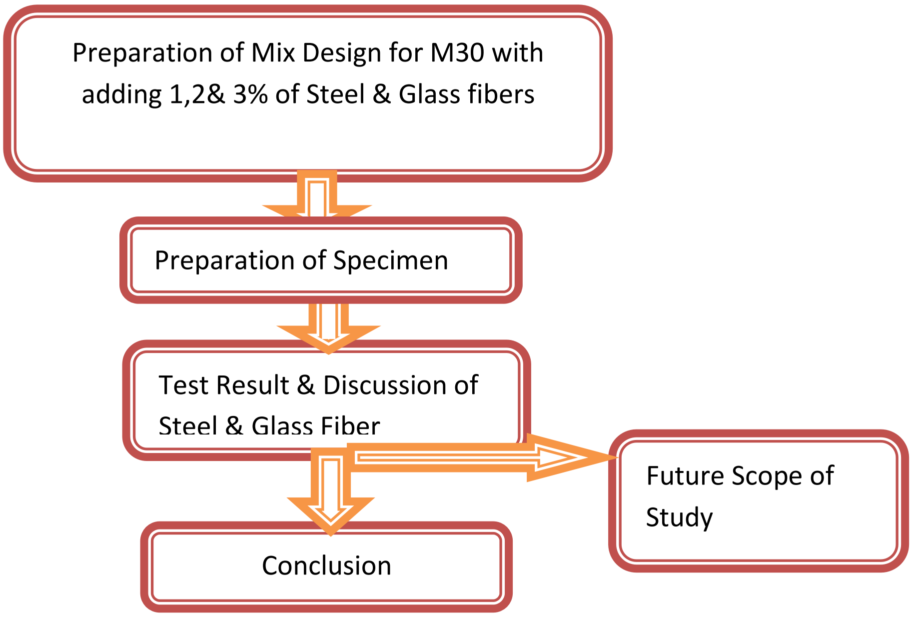


**Figure No.3: Study Flow Analysis**

**4.2 Test setup:**

**4.2.2 Testing of Cube Specimens for Compressive Strength:**

For the compression test, the cubes are placed in machine in such a manner that the load is applied on the Faces perpendicular to the direction of cast. In Compression testing machine, the top surface of machine is fixed and load is applied on the bottom surface of specimen. The rate of loading is gradual and failure (crushing) load is noted. Also the failure pattern is observed precisely.

The compressive strength was calculated as follows.

Compressive strength (MPa) = Failure load / cross sectional area.


Photo No 4: Testing of cube on CTM

**4.2.2 Testing of Cylinder Specimens for Split Tensile Strength:**

For determining split tensile strength, cylinder specimens are placed between the two plates of Compression Testing Machine. Plywood strips of 3 mm thick, 25 mm wide and 300 mm long, are placed between the plates and surface of the concrete specimens. The load is applied at a uniform rate till the specimen failed by a fracture along vertical diameter.The split tensile strength is calculated from the formula,

  

$t = 2P/\pi DL$

Where, P is the load at failure and D and L are the diameter and length of specimen, respectively.

Photo No. 5:Split Tensile Strength Test

**4.2.3 Testing of Beam Specimens for Flexure:**

In flexure test, the beam specimen is placed in the machine in such a manner that the load is applied to the upper most surface as cast in the mould. All beams are tested under two-point loading in Universal Testing Machine of 100-tonne capacity. The load is increased until the specimen failed and the failure load is recorded

The flexural strength is calculated from the formula

$$f_b = PL / bd^2$$

Where, P = the applied load at failure and,
d = depth of specimen,
b = breadth of specimen and
L = Length of specimen respectively.


PhotoNo.6: Digital Universal Testing Machine of 100 tones capacity

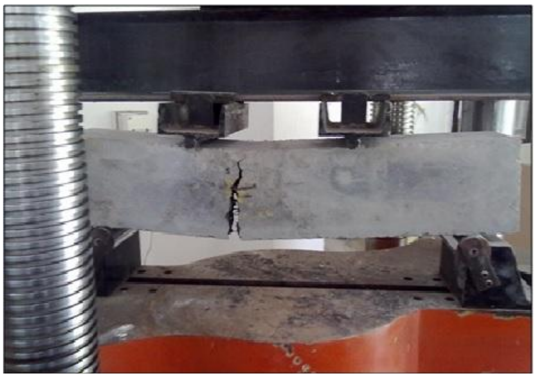
Photo No.7: Failure Pattern of Beam with Steel And Glass Fiber.

## V. EXPERIMENTAL RESULTS

The results obtained by carrying out the tests on the cubes, cylinders and beams made with mix proportions decided earlier are as stated below.

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**Table 4 : Comparative Statement of Compressive Strength:**

| Sr. No. | Grade Sample | Water Cement Ratio | % of Steel Fiber | % of Glass Fiber | Compressive Strength, Mpa | |
|---|---|---|---|---|---|---|
| | | | | | 7days | 28 days |
| 9 | M30 | 0.35 | 0 | 0 | 24.76 | 37.52 |
| 10 | M30 | 0.35 | 1 | 1 | 25.23 | 38.05 |
| 11 | M30 | 0.35 | 2 | 2 | 27.90 | 42.28 |
| 12 | M30 | 0.35 | 3 | 3 | 26.49 | 40.14 |

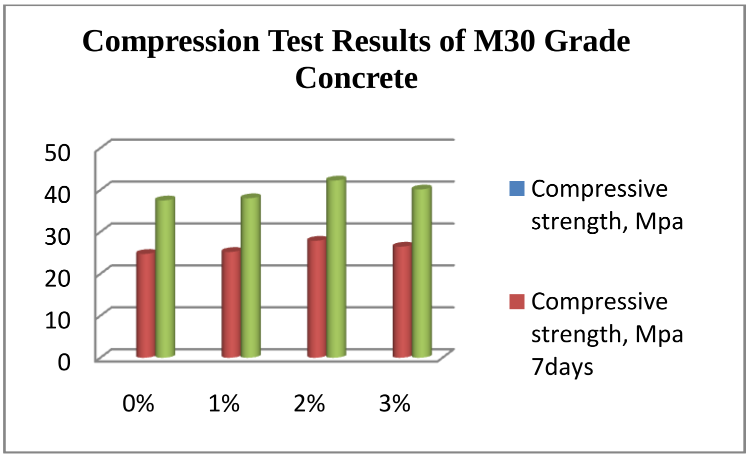



Chart-1Comparison chart of compressive strength

**Table No. 5:Comparative Statement Split Tensile Test Results of M30 Grade of Concrete**

| Grade | w/c | % of Glass Fiber | % of Steel Fiber | Load at Failure in KN | Split tensile Strength In $N/mm^2$ | Average Split tensile Strength In $N/mm^2$ |
|---|---|---|---|---|---|---|
| M30 | 0.35 | 0 | 0 | 338 | 4.78 | 4.80 |
| | | | | 362 | 5.12 | |
| | | | | 319 | 4.52 | |
| M30 | 0.35 | 1 | 1 | 401 | 5.68 | 5.27 |
| | | | | 351 | 4.97 | |
| | | | | 366 | 5.18 | |
| M30 | 0.35 | 2 | 2 | 440 | 6.23 | 6.05 |
| | | | | 415 | 5.87 | |
| | | | | 422 | 5.98 | |
| M30 | 0.35 | 3 | 3 | 369 | 5.23 | 5.66 |
| | | | | 422 | 5.98 | |
| | | | | 405 | 5.73 | |

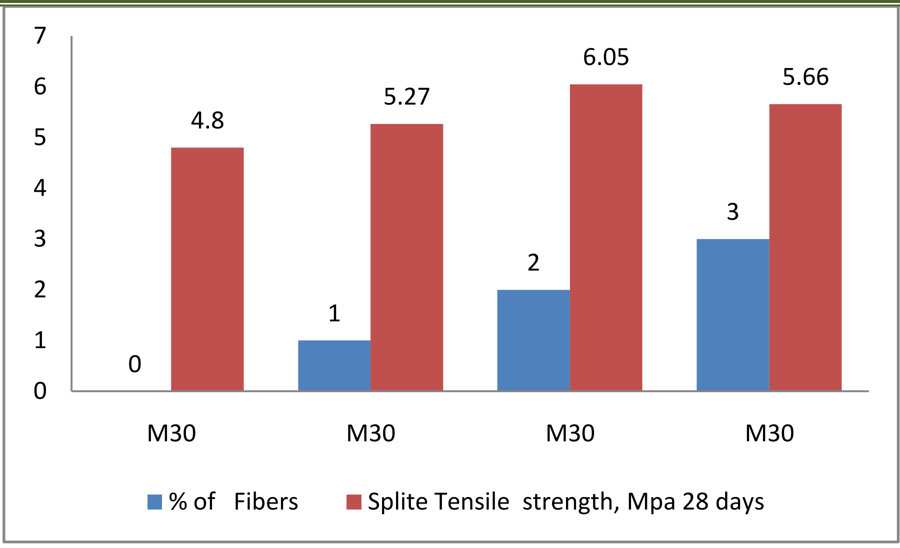



Chart 2:Comparison chart of Split Tensile Strength

**Table 6:Comparative Statement Flexural Test Results of M30 Grade of Concrete**

| Grade | w/c | % Glass Fiber | % Steel Fiber | Load At Failure in KN | Flexural Strength In $N/mm^2$ | Average Flexural Strength In $N/mm^2$ |
|---|---|---|---|---|---|---|
| M30 | 0.35 | 0 | 0 | 29.18 | 7.78 | 7.51 |
| | | | | 27.34 | 7.29 | |
| | | | | 27.90 | 7.44 | |
| M30 | 0.35 | 1 | 1 | 31.46 | 8.39 | 8.71 |
| | | | | 33.64 | 8.97 | |
| | | | | 32.89 | 8.77 | |
| M30 | 0.35 | 2 | 2 | 37.43 | 9.98 | 9.93 |
| | | | | 36.94 | 9.85 | |
| | | | | 37.16 | 9.91 | |
| M30 | 0.35 | 3 | 3 | 37.28 | 9.94 | 9.72 |
| | | | | 36.53 | 9.74 | |
| | | | | 35.55 | 9.48 | |

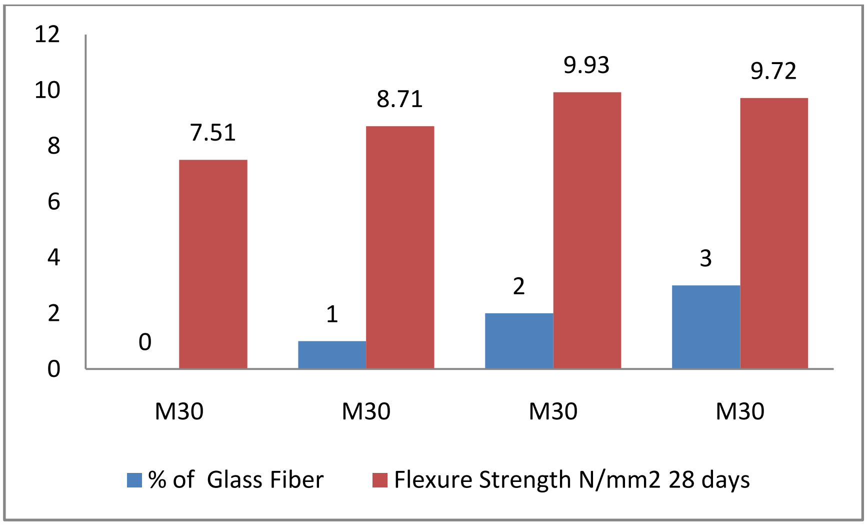



Chart 3: Comparison chart of Flexural strength

**Table 7:Reading of tested beam of M30 Grade concrete without Glass & Steel Fiber**

| **Load $X10^3$(N)** | **Deflection (mm)** | **Area ($mm^2$)** | **Length (mm)** | **Stress $N/mm^2$** | **Strain** | **Remark** |
|---|---|---|---|---|---|---|
| 0 | 0 | 20000 | 1600 | 0 | 0 | |
| 6.1 | 0.3 | 20000 | 1600 | 0.305 | 0.000187 | |
| 10.7 | 0.7 | 20000 | 1600 | 0.535 | 0.000487 | |
| 11.8 | 0.9 | 20000 | 1600 | 0.59 | 0.000568 | |
| 13.9 | 1.0 | 20000 | 1600 | 0.695 | 0.000656 | |
| 17.54 | 1.4 | 20000 | 1600 | 0.877 | 0.000906 | |
| 21.34 | 1.8 | 20000 | 1600 | 1.067 | 0.001125 | |
| 24.4 | 2.2 | 20000 | 1600 | 1.22 | 0.0014 | $1^{st}$ Crack |
| 28.94 | 2.7 | 20000 | 1600 | 1.447 | 0.00171 | |
| 30.94 | 3.0 | 20000 | 1600 | 1.547 | 0.00193 | |
| 32.04 | 3.3 | 20000 | 1600 | 1.602 | 0.00212 | Failure |

**Table 8: Reading of tested beam of M30 Grade concrete with 1% of Glass & Steel Fiber**

| **Load $X10^3$(N)** | **Deflection (mm)** | **Area ($mm^2$)** | **Length (mm)** | **Stress $N/mm^2$** | **Strain** | **Remark** |
|---|---|---|---|---|---|---|
| 0 | 0 | 20000 | 1600 | 0 | 0 | |
| 7.14 | 0.6 | 20000 | 1600 | 0.357 | 0.0004 | |
| 9.25 | 0.9 | 20000 | 1600 | 0.4625 | 0.000612 | |
| 11.86 | 1.3 | 20000 | 1600 | 0.593 | 0.00084 | |
| 14.13 | 1.8 | 20000 | 1600 | 0.7065 | 0.00113 | |
| 16.17 | 2.0 | 20000 | 1600 | 0.8085 | 0.00128 | |
| 18.98 | 2.3 | 20000 | 1600 | 0.949 | 0.00146 | |
| 21.17 | 2.7 | 20000 | 1600 | 1.0585 | 0.00173 | $1^{st}$ Crack |
| 24.98 | 3.1 | 20000 | 1600 | 1.249 | 0.00196 | |
| 26.56 | 3.6 | 20000 | 1600 | 1.328 | 0.00225 | |
| 29.04 | 3.8 | 20000 | 1600 | 1.452 | 0.002375 | Failure |

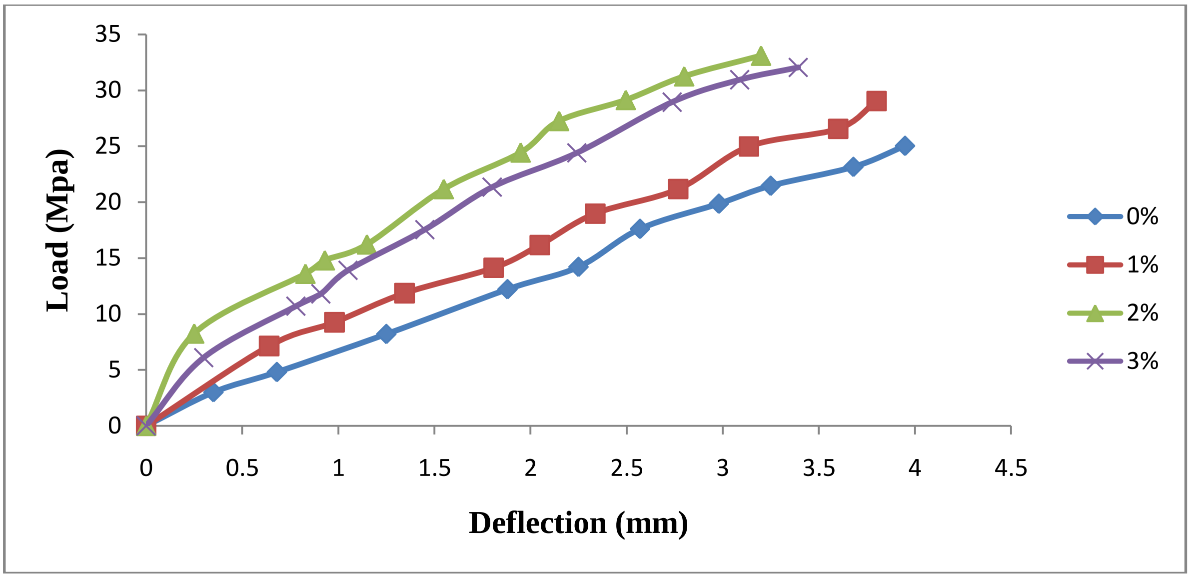
**Table 9:Reading of tested beam of M30 Grade concrete with 2% of Glass & Steel Fiber**

| **Load $X10^3$(N)** | **Deflection (mm)** | **Area ($mm^2$)** | **Length (mm)** | **Stress $N/mm^2$** | **Strain** | **Remark** |
|---|---|---|---|---|---|---|
| 0 | 0 | 20000 | 1600 | 0 | 0 | |
| 8.25 | 0.25 | 20000 | 1600 | 0.4125 | 0.0001562 | |
| 13.6 | 0.8 | 20000 | 1600 | 0.68 | 0.000518 | |
| 14.8 | 0.9 | 20000 | 1600 | 0.74 | 0.000581 | |
| 16.22 | 1.1 | 20000 | 1600 | 0.811 | 0.000718 | |
| 21.17 | 1.5 | 20000 | 1600 | 1.0585 | 0.000968 | |
| 24.44 | 1.9 | 20000 | 1600 | 1.222 | 0.001218 | |
| 27.26 | 2.1 | 20000 | 1600 | 1.363 | 0.001343 | $1^{st}$ Crack |
| 29.14 | 2.4 | 20000 | 1600 | 1.457 | 0.00156 | |
| 31.25 | 2.8 | 20000 | 1600 | 1.5625 | 0.00175 | |
| 33.1 | 3.2 | 20000 | 1600 | 1.655 | 0.002 | Failure |

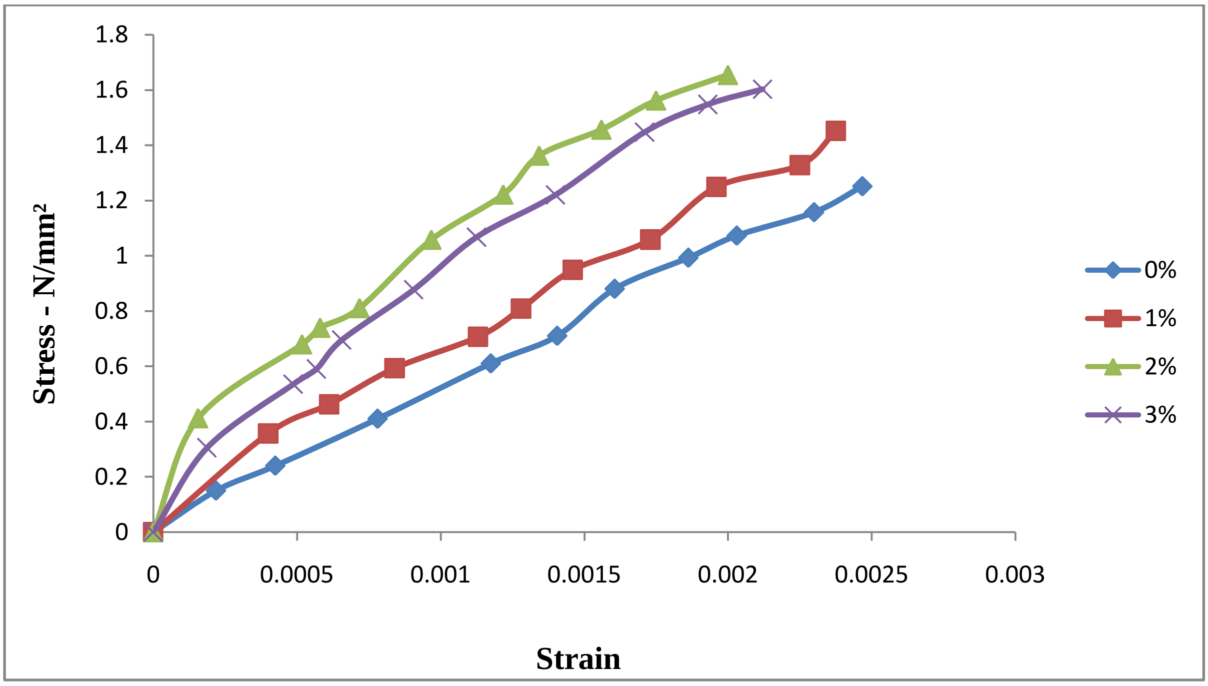
**Table 10: Reading of tested beam of M30 Grade concrete with 3% of Glass & Steel Fiber**

| **Load $X10^3$(N)** | **Deflection (mm)** | **Area ($mm^2$)** | **Length (mm)** | **Stress $N/mm^2$** | **Strain** | **Remark** |
|---|---|---|---|---|---|---|
| 0 | 0 | 20000 | 1600 | 0 | 0 | |
| 6.1 | 0.3 | 20000 | 1600 | 0.305 | 0.000187 | |
| 10.7 | 0.7 | 20000 | 1600 | 0.535 | 0.000487 | |
| 11.8 | 0.9 | 20000 | 1600 | 0.59 | 0.000568 | |
| 13.9 | 1.0 | 20000 | 1600 | 0.695 | 0.000656 | |
| 17.54 | 1.4496 | 20000 | 1600 | 0.877 | 0.000906 | |
| 21.34 | 1.8 | 20000 | 1600 | 1.067 | 0.001125 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 24.4 | 2.24 | 20000 | 1600 | 1.22 | 0.0014 | 1st Crack |
| 28.94 | 2.736 | 20000 | 1600 | 1.447 | 0.00171 | |
| 30.94 | 3.088 | 20000 | 1600 | 1.547 | 0.00193 | |
| 32.04 | 3.392 | 20000 | 1600 | 1.602 | 0.00212 | Failure |




**Graph 1: - Load Vs Defection Curve of M30 Grade of Concrete**




**Graph 2: - Stress- Strain Curve of M30 Grade of Concrete**

## CONCLUSIONS

- It is observed that compressive strength, split tensile strength and flexural strength are on higher side for 2% fibres as compared to that produced from 0%, 1% and 3% fibres.

- It is observed that compressive strength increases from 10 to 15% with addition of steel fibres.
- It is observed that flexural strength increases from 20 to 25% with addition of steel fibres.

- It is observed that split tensile strength increases from 15 to 20 % with addition of steel fibres.
- All mechanical properties are improved by addition of fibres irrespective of fibre type and w/c ratio.
- From above discussion it is conclude that, all mechanical properties viz. compressive strength, flexure strength, splitting strength, shear strength are improved by addition of fibers irrespective of fiber type andw/c ratio.
- The brittleness of concrete can also be improved by addition steel fibers and glass fibers. Since concrete is very weak in tension, the steel fibers are beneficial in axial-tension to increase tensile strength.
- From load deflection curve , it is observed that as the percentage of fibre increases with constant aspect ratio, the deflection of the beam is also increased before failure. The maximum deflection is observed with 2% fibrea and it was 3.2mm.
- A reduction in bleeding is observed by addition of glass and steel fibers in concrete mixes.

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The brittleness of concrete can also be improved by addition steel fibers and glass fibers. Since concrete is very weak in tension, the steel fibers are beneficial in axial-tension to increase tensile strength.

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