

Experimental Investigation on Hybrid Fibre Reinforced Concrete

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ABSTRACT: Concrete is a tension weak building material, which is often crack ridden connected to plastic and hardened states, drying shrinkage. Plain cement concrete is good at providing reasonable compressive strength but it tends to be brittle in nature and is weak in tensile strength, and minimum resistance to cracking, poor toughness. The addition of small closely spaced and uniformly dispersed fibers to concretes would act as a crack resistor. This type of concrete is called Fibre reinforced concrete. The addition of more than one type of fiber in concrete is called Hybrid fiber reinforced concrete. To overcome the deficiencies of concrete, fibres are added to enhance the performance of concrete. In the present study hybrid fibres consists of two different types of fiber combinations i.e glass and polypropylene fibers are used with conventional concrete. The fiber proportion of 0%, 0.5%,1% and 1.5% is used. Strength parameters are compressive strength, split tensile strength and flexural strength will be tested and result were analysed.

KEYWORDS: Hybrid fiber, glass and polypropylene fibers, Compressive Strength, Tensile strength, Flexural strength

I. INTRODUCTION

Concrete is a mixture of cement, fine aggregate, coarse aggregate and water. Concrete plays a vital role in the development of infrastructure such as buildings, industrial structures, bridges and highway etc. concrete is most widely used as a building material because of its versatility and desirable engineering properties. Concrete can be made on site easily using available materials. It can be moulded into any shape and the texture and coloured for aesthetic purposes. Most importantly it is produced with cost effective material. The quality of concrete is determined by its mechanical properties as well as its ability to resist deterioration. The strength of the concrete is most important characteristics, as it has strong relationship with quality. Also the stress-strain behaviour of concrete depends upon the properties of the material with which the concrete is made and the loading parameters.

II. LITERATURE REVIEW

Suresh Babu.R (2013). Studied chloride, porosity, permeability, voids, glass fiber reinforced concrete. the behavior of fiber reinforced concrete with two different concrete strength (M25 & M50) and different percentages of fiber additions (0.5, 1, 1.5%) are studied. Permeability test is carried out. the permeability index value get reduced due to addition of glass fiber, it is about 6.4% by the addition of 0.5%, 12.6% by the addition of 1% and 26.3% by the addition of 1.5% of glass fiber in M25 concrete when compared to control concrete. Similarly for M50 concrete, the permeability value is about 8.7% by addition of 0.5% of glass fiber, 15% by addition of 1% of glass fiber and 30.1% by addition of 1.5% glass fiber. The compressive strength increased by about 16.4% by the addition of 0.5%, 24.7% by the addition of 1% and 47.3% by the addition of 1.5% of glass fiber in M25 concrete when compared to 0% of glass fiber in concrete. Similarly for M50 concrete, the compressive strength is about 14.3% by addition of 0.5% of glass fiber, 22.3% by addition of 1% of glass fiber and 43.5% by addition of glass fiber to that of 0% glass fiber in concrete.

Yogesh Iyer Murthy et al, (2012). Carried out study on the compressive strength, flexural strength and workability of concrete containing varying proportions of glass fiber as replacement of fine aggregate. 25 micrometer in diameter and 5cm long are used for the preparation of standard M30 grade concrete by replacing fine aggregate by fiber up to 1.5%.

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The increase in compressive strength is nominal while the flexural strength increased significantly as expected with the increase in percentage of glass fiber. The reduction in slump with the increase in glass fiber content. The flexural strength of beam with 1.5% glass fiber shows almost 30% increase in the strength compared to the beam with 0% glass fiber.

P.R. Srinivasa et al, (2010). Carried out study on strength properties of glass fiber concrete. In this paper experimental investigation the alkali resistance glass fibers has been used to study the effect on compressive, split tensile and flexural strength on M20, M30, M40 and M50 grades of concrete. The addition of about 1.5% chopped glass fibers (by weight) to the material increases the modulus of rupture by about 20% and the fracture toughness by about 55%. Glass fibers improve the strength of the material by increasing the force required for deformation and improve the toughness by increasing the energy required for crack propagation.

Konapure and Kalyankar (2015). This paper highlights the investigate the HFRC such as basalt fiber reinforced concrete (BFRC) & polypropylene fiber (PP) on the normal mix. Addition of 0.5% Fibers results is marginal increase in Compressive & Flexural Strength of Concrete. The flexural strength is improved for 0.5% fiber & decreased for 1% fiber this may be because of fibrillated nature of basalt & polypropylene fiber which affect the homogeneity of concrete.

Leshma (2015). In this paper highlights the HFRC in exterior beam with the use of steel and polypropylene fibres. The M40 grade concrete used. The compressive strength of the HFRC reached a maximum at 0.38%ST & 0.12% PP volume fraction, being a 7.5% improvement over the SFRC.

Mahendra Prasad et al [2013] conducted investigations on Polypropylene fiber reinforced silica fume concrete of M30 grade. The cement replacement by silica fume was 0%, 5%, 10%,15% and fibers were added in the 0%, 0.2%, 0.4%, 0.6% by volume fraction of concrete. It is reported that the increase in flexural strength was around 40% with use of Polypropylene fibers and silica fume in concrete.

Peng Zhang and Li [2013] used 0.04%, 0.06%, 0.08%, 0.1% and 0.12% of polypropylene fibers in concrete containing 15% fly ash and 6% silica fume. They reported by testing beam specimens under three point loading, that addition of fibers greatly improved the fracture parameters of concrete composite such as fracture toughness, fracture energy, effective crack length, maximum mid-span deflection, critical crack opening displacement etc. With increase in fiber volume fraction from 0 to 0.12%, there is increase in fracture parameters.

Preeti A Patel et al [2012] reported that the workability of concrete reduced with higher polypropylene fiber content. Vee Bee time indicated that at 0.5% of fiber content workability is high while at 1% it is medium.

Rama Devi and Venkatesh Babu [2012], studied the Flexural behaviour of Hybrid Steel - Polypropylene Fiber Reinforced Concrete Beams and observed that use of steel polypropylene Hybrid fiber reinforced concrete improves flexural performance of the beams during loading.

Gencel et al [2011] conducted the split tensile strength using fibers upto 9 kg/m³. It is found that the split tensile strength increased with increasing fiber content Fibers tend to bridge the micro cracks and hamper the propagation of cracks. When tensile stress is transferred to fibers, the micro cracks are arrested and thus improve the split tensile strength of concrete.

III. MATERIAL USED

Cement: Ordinary Portland cement (OPC 53) grade conforming to IS 12263-1987 was used.

Table 3.1 Physical Properties of Cement

Property	Value
Standard Consistency test	33%
Initial setting time	45 min
Final setting time	285 min
Fineness test	6%
Specific Gravity	3.15

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Fine aggregate: A locally available fine aggregate used for the experimental program and passing through 4.75mm IS sieve as per IS 383 provision recommended. The specific gravity is found to be 2.7. The water absorption is found to be 1.28%. Fineness modulus is 2.7

Coarse aggregate: Locally available coarse aggregate having 20 mm down size and conforming to IS 383 are used in the present investigation work. The specific gravity is found to be 2.74. The water absorption is found to be 0.33 and crushing test values 25.82% are found.

Chemical admixture: Master Glenium SKY 8233 is an admixture of a new generation based on modified polycarboxylic ether. The product has been primarily developed for applications in high performance concrete where the highest durability and performance is required. It is free of chloride & low alkali. It is compatible with all types of cements.

Glass Fibre : Glass fibre is a material consisting of numerous extremely fine fibres of glass. Glass fibre is commonly used as an reinforcing agent for many polymer products to form a very strong and light popularly known as “Glass Fibre”.

Table 3.1 Physical Properties of Glass Fibre

Property	Value
Diameter in mm	12
Tenacity	6.3 – 6.9 gm/den
Density	2.5 gm/c.c
Specific gravity	2.60
Failure strain	3.0%
Elasticity GPa	72.4
Tensile strength MPa	2400



Fig 3.1 Glass Fiber

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Polypropylene Fibre: In this study fibrillated 12mm cut length fibres were used.



Fig 3.2 Polypropylene Fiber

IV. DESIGN MIX FOR M30 GRADE CONCRETE

Mix design can done as per IS 10262-2009.

Grade designation : M40 Type of Cement : OPC

Cement content : 423.80 kg/m³ Water/Cement ratio : 0.42 River sand content : 624 kg/m³ Coarse aggregate : 972 kg/m³

Chemical admixture : Master Glenium SKY 8233

Table 4.1 Mix Proportion

Cement (Kg/m ³)	Fine Aggregate (Kg/m ³)	Coarse Aggregate (Kg/m ³)	Water (lit)
423.80	6.24	972	178
1	1.47	2.29	0.42

V. TESTS CONDUCTED ON SPECIMENS.

For finding compressive strength of concrete, cube of size 150mm x 150mm x 150mm were used. For finding split tensile strength of concrete, cylinders of size 100mm x 200mm were used and for finding flexural strength 500mm x 100mm x100mm prism cast

Table 3.2 Properties of Polypropylene Fibre

Property	Value
Length of Fibre	12mm cut
Specific Gravity	0.91
Elongation	25-40%
Young's modulus	5500-7000 MPa

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VI. RESULTS AND DISCUSSIONS

Table 6.1 : Test results for compressive strength for 28 days

% of fibre added	Split tensile strength N/mm ²		
	Glass fibre	Polypropylene fibre	GF+PPF
0%	5.13	5.13	5.13
0.5%	5.47	3.88	4.58
1%	4.98	4.50	4.08
1.5%	4.29	4.61	3.78

Table 6.2 Test results for Split tensile strength for 28 days

% of fibre added	Split tensile strength N/mm ²		
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0%	5.13	5.13	5.13
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1.5%	4.29	4.61	3.78

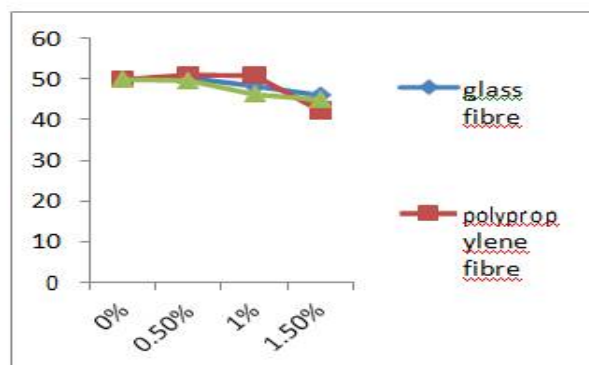


Fig 6.1 Test results for compressive strength for 28 days

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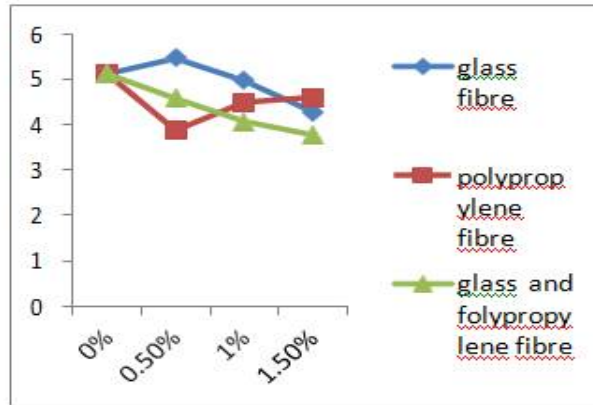


Fig 6.2 Test results for Split tensile strength for 28 days

- a) In addition of 0.5% glass fibre in the concrete, percentage increase at the strength at 0.84% respectively compared to the plain cement concrete of strength 49.87N/mm²
- b) In polypropylene fibre percentage increase at the strength at 0.5% and 1%, were 2.14% and 1.96% respectively compared to the plain cement concrete of strength 49.87N/mm²
- c) In hybrid fibre reinforced concrete the strength was gradually decreased in 0.5%, 1% and 1.5% addition of (glass fibre + polypropylene fibre) hybrid fibre when compared to the plain cement concrete of strength 49.87N/mm²

Fig 6.2 Test results for Split tensile strength for 28 days

- a) In addition of 0.5% glass fibre in the concrete, percentage increase at the strength at 6.62% respectively compared to the plain cement concrete of strength 49.87N/mm²
- b) In the polypropylene fibre reinforced concrete and Hybrid fibre reinforced concrete the strength of the concrete were decreased when compared to the conventional concrete strength.

Table 6.3 Test results for flexural strength for 28 days

% of fibre added	Flexural strength N/mm ²		
	Glass fibre	Polypropylene fibre	GF+PPF
0%	4.89	4.89	4.89
0.5%	7.53	5.29	5.94
1%	6.31	6.61	4.91
1.5%	5.40	5.94	4.15

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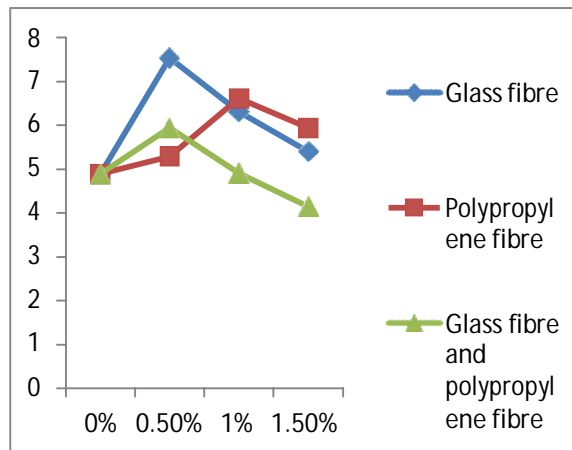


Fig 6.3 Test results for flexural strength for 28 days

was stripped off and specimens were cured for a period of 28 days.

- In addition of 0.5%, 1% and 1.5% glass fibre in the concrete, percentage increase at the strength at 53.98%, 29.03% and 10.42% respectively when compared to the plain cement concrete of strength 49.87N/mm².
- In polypropylene fibre percentage increase at the strength at 0.5% , 1% and 1.5% were 8.17%, 35.17% and 21.47% respectively compared to the plain cement concrete of strength 49.87N/mm².
- In hybrid fibre reinforced concrete the strength was gradually increased in 0.5% and 1% addition of (glass fibre + polypropylene fibre) hybrid fibre were 21.47% and 0.40% respectively when compared to the plain cement concrete of strength 49.87N/mm²

VII. STRUCTURAL BEHAVIOUR OF HYBRID FIBRE REINFORCED CONCRETE BEAM

Preparation of Beam Specimen

The specimen was designed as per IS 456- 2000 and the detailing of beam and column was done by IS 13920-1993. The beam was casted by our laboratory dimensions. The stirrups with 8mm diameter at a spacing of 50mm at left and right end over a length of 2d and at a spacing of 100mm at centre. The 2 nos of 16mm diameter are used in bottom reinforcement and 2 nos of 12mm are used in top reinforcement. Wooden moulds for casting beam were oiled and properly aligned to exact dimension on the concrete platform. Reinforcement cage was placed inside the mould maintaining proper cover. After filling the mould, the concrete surface was leveled and finishing using a trowel. After 24 hours, the formwork

Experimental set up for beam specimen

The beam was placed in such a manner that the load applied through the load cell, lever arm in to the roller support placed in the top of the specimen. The specimen was tested by using loading frame in Structural Engineering Laboratory. The load was gradually applied to the specimen by using hand operated hydraulic jack. The LVDT was used to measure the deflection at mid-span. At each increment of loads, deflections and crack pattern were recorded. The failure mode of specimen also observed.

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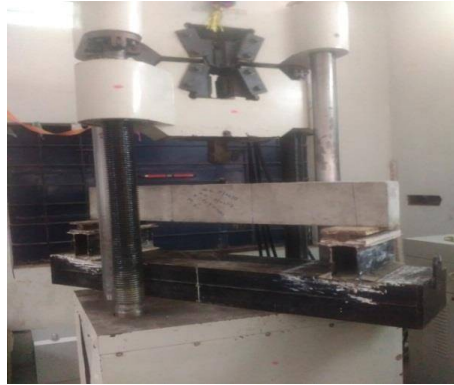


Fig 7.1 Testing of beam specimen



Fig 7.2 Crack pattern of 0.5% beam specimen

VIII. RESULT AND DISCUSSION FOR BEAM

The test results of beam specimen are discussed in the following.

First crack load: The first crack load and load carrying of plain and hybrid fibre reinforced concrete specimen are the First crack was initiated in 38KN at the beam for CC specimen and in 41 KN for HFRC. As the load level was increased, cracks were noticed in the beam specimens. The crack development were very less compared to the conventional concrete beam.

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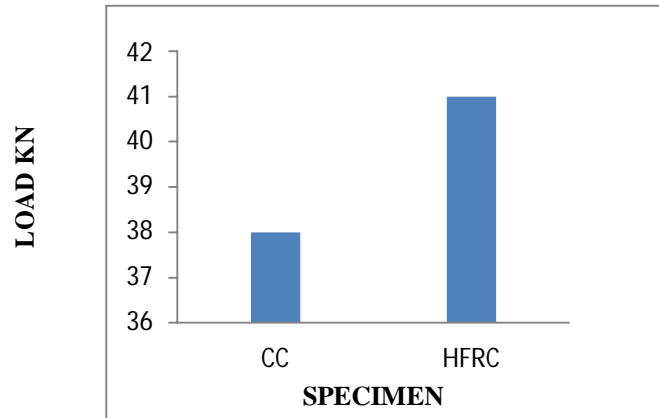


Fig 8.3 First crack load of RC beam

Ultimate load : The control specimen was loaded up to their load. It was noted that of all beam had the higher load carrying capacity compared to control specimen. The ultimate load for CC and HFRC are 115KN and 138KN respectively.

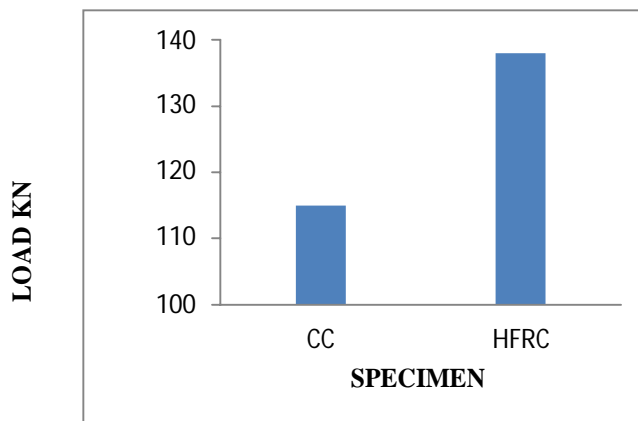


Fig 8.4 Ultimate crack load of RC beam

Ductility factor: Ductility is mechanical property which describes how much plastic deformation a material can sustain before fracture occurs. The ductility is defined as the ratio of maximum deflection of the specimen to the first deformation of specimen. The deflection was measured from the assumed bilinear load deflection diagram. The ductility factor for all the specimen are shown in Table

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Table 8.1 Ductility factor for beam specimen

Specimen	Ductility factor
CC	3.02
HFRC	3.36

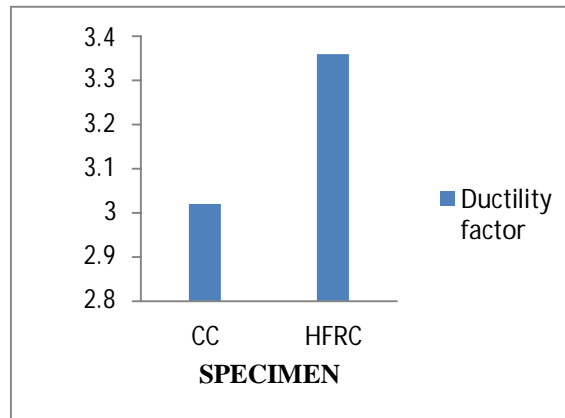


Fig 8.5 Ductility factor for beam specimen

Stiffness : Stiffness is defined as the force applied on the body for a unit displacement. A tangent was drawn from the origin to the load deflection curve and the slope of tangent gives the stiffness values. The stiffness of all the beams are listed in Table

Table 8.2 Stiffness of beam specimen

Specimen	Stiffness
CC	41.2
HFRC	46.53

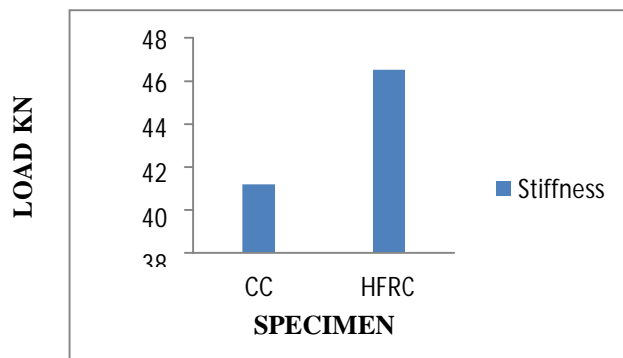


Fig 8.6 Stiffness of beam specimen

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Energy absorption capacity: Whenever a structure is subjected to loading some energy is absorbed by the specimen. In the investigation the area under the load deflection curve gives the amount of energy absorbed by the specimen during loading. The total energy absorption capacity of all beams is shown in Table

Table 8.3 Energy absorption capacity of beam specimen

Specimen	Energy Absorption Capacity (KN mm)
CC	210.1
HFRC	215.2

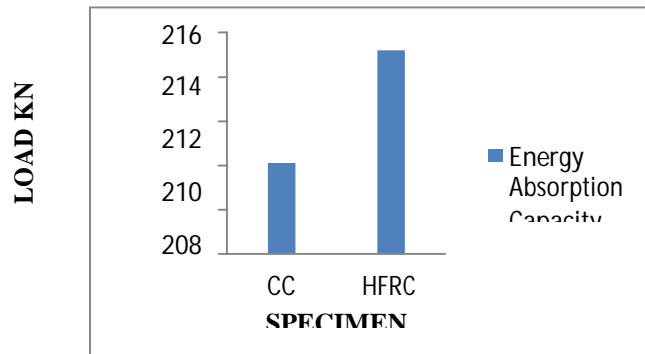


Fig 8.7 Energy absorption capacity of beam specimen

Energy index: Energy index calculated by the ratio of total energy absorbed by the specimen up to ultimate loading to that of the energy absorbed by the specimen during first crack.

Table 8.4 Energy Index of beam specimen

S.No	Specimen	Total Energy Absorbed in Specimen upto Ultimate loading	Total Energy Absorbed in Specimen during First crack	Energy Index (KN mm)
1	CC	210.1	19.70	10.66
2	HFRC	215.2	19.38	11.1

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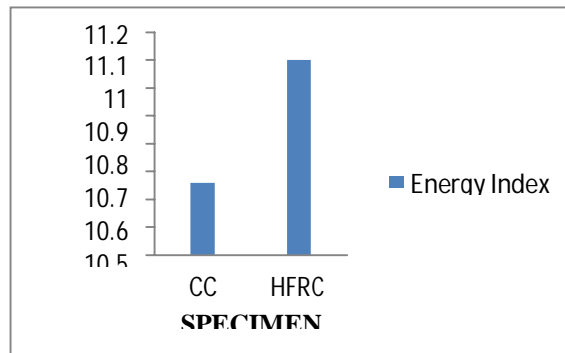


Fig 8.8 Energy Index of beam specimen

IX. CONCLUSION

Based on the study carried out to find the behaviour fibre fibre reinforced concrete, the following conclusions are arrived.

1. The optimum dosage level of addition of hybrid fibre (glass fibre + polypropylene fibre) is found as 0.5% by volume of concrete.
2. The flexural strength of HFRC is increased by 21.47% and 0.40% compared to conventional concrete
3. The ductility beam was increased by 11.25% than that of the control beam when compared to 0.5% of Hybrid Fibre in concrete.
4. The stiffness was increased by 12.93% than that of the control beam when compared to 0.5% of Hybrid Fibre in concrete
5. The Energy absorption capacity of beam was increased by 2.42% when compared to conventional concrete beam

There is a noticeable improvement in behaviour such as first crack load, ultimate crack load, ductility and energy absorption capacity. The fire resisting properties of glass fibre are used to build the innovative concrete structures.

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