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FLEXURAL BEHAVIOUR OF HYBRID FIBER REINFORCED CONCRETE BEAM

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ABSTRACT:
Performance of conventional concrete is enhanced by addition of fibers in concrete. The brittleness in concrete is reduced and the adequate ductility of concrete is ensured by the addition of fibers in concrete. In this paper the behaviour of RC beam structures strengthened by using hybrid fiber reinforced concrete is analyzed. The concrete beams are casted for a grade of M25 as per IS: 10262-2009. The fibers used are steel (hooked end) and polypropylene fibers in various volume fractions. The main reasons for adding steel fibers to concrete matrix is to improve the post-cracking response of the concrete i.e., to improve its energy absorption capacity and apparent ductility and to provide crack resistance and crack control. The polypropylene fibers of various ratios [0.5 to 1.25%] steel and (0.05 to 0.125)polypropylenefibers to the volume of concrete were used in the concrete

INTRODUCTION

1.1General

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

1.2 CONCRETE

Concrete is a construction material that consists of cement, (commonly Portland cement as well as other cementations materials such as fly ash and slag cement) coarse aggregate such as gravel limestone or granite, fine aggregate such as sand or manufactured sand and water and chemical admixtures. Often, additives and reinforcements are included in the mixture to achieve the desired physical properties of the finished material. When these ingredients are mixed together, they form a fluid mass that is easily molded into shape. Over time, the cement forms a hard matrix which binds the rest of the ingredients together into a durable stone-like material with many uses.

1.3 Fiber Reinforced Concrete (FRC)

Concrete containing hydraulic cement, water, fine or fine and coarse aggregate and discontinuous discrete fibers are called fiber-reinforced concrete (FRC). FRC is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. In addition, the character of fiber-reinforced concrete changes with varying concretes fiber materials, geometrics, distribution, orientation and densities. Concrete is relatively brittle, and its tensile strength is typically only about one tenths of its compressive strength. indeed, reinforcing brittle materials through the embedment is quite an ancient discovery , for adding natural fibers , such as horse hair, jute, straw, to fresh clay or mud in order to builthuts, houses walls is a practice whose origin tracks back to the early stage of mankind, Regular concrete is therefore normally reinforced with steel reinforcing bars. For many applications, it is becoming increasingly popular to reinforce the concrete with small, randomly distributed fibers. Their main purpose is to increase the energy absorption capacity and toughness of the material, but also increase tensile and flexural strength of concrete..

Aspect Ratio: The important factor which influences the properties and behavior of composite is the aspect ratio of fiber. It has been reported that up to aspect ratio of 75, increase on the aspect ratio increase the ultimate concrete linearly. Beyond 75, relative strength and toughness is reduced. One of the differences between conventional reinforcement and the fiber reinforcement is that in conventional reinforcement, bars are oriented in the direction desired while fibers are randomly oriented. To see the effect of randomness, mortar specimens reinforced with 0.5% volume of fibers were tested

Strength of FRC: The most important contribution of fiber reinforced in concrete is not to strength but to the flexural toughness of the material. When flexural strength is the main consideration, fiber reinforcement of concrete is not a substitute for conventional reinforcement. The greatest advantage of fiber reinforcement of concrete is the improvement in flexural toughness (total energy absorbed in breaking a specimen in flexure).

Durability: Fiber reinforced concrete is generally made with a high cement content and low water/cement ratio. When well compacted and cured, concretes containing steel fibers seem to possess excellent durability as long as fibers remain protected by cement paste. Ordinary glass fiber cannot be used in Portland cement mortars and concretes because of chemical attack by the alkaline cement paste.

Toughness: Toughness is defined as the area under a load-deflection (or stress-strain) curve. As can be seen from figure, adding fibers to concrete greatly increase the toughness of the material. That is, fiber-reinforced concrete is able to sustain load at deflections or strains much greater than those at which cracking first appears in the matrix.

Properties of Fibers: Type of fibers used, Volume percent of fiber (volume fraction=0.5 to 1%), Aspect ratio (the length of a fiber divided by its diameter), Orientation and distribution of the fibers in the matrix, It prevents spalling of concrete shape, dimension and length of fiber is important, strength of the fiber.

1.4 Hybrid fiber reinforced concrete

A Hybrid Fiber Reinforced Concrete is formed from a combination of different types of fibers, Addition of two types of fibers of different properties can be used in concrete. which differ in material properties, remain bonded together when added in concrete and retain their identities and properties. The hybridization of fibers provides improved specific or synergistic characteristics not obtainable by any of the original fiber acting alone this type of concrete is known as Hybrid concrete. The fibers in hybrid concrete increase the flexural strength, Impact strength & toughness properties of concrete. The effectiveness of the combined performance of fibers depends on the volume of the combined fibers & on the uniformity of dispersion of fibers in concrete.

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REVIEW

In this study is an experimental research on the mechanical features of hybrid fibers added to the concretes which are obtained using steel fibres and polypropylene fibers in different volumetric proportions. Their impact on strength and toughness studied. When the fibers were used in a hybrid form, the increase in above study parameters was about 82.1 % and 30.2% respectively, when compared to the plain concrete.

Surinderpalsingh, et al.,(2011) Fatigue strength of hybrid steel-Polypropylene fibres fibrous concrete beams in flexure. Experimental programme was conducted to obtain fatigue lives of hybrid fiber reinforced concrete specimen at different stress levels flexural fatigue tests were conducted. The specimen incorporated different proportions of steel and polypropylene fibers of 25-75%, 50-50%, and 75-25% by volume at total fiber content of 0.5%. Average compressive strength of 6.40MPa, 44.20 MPa and 46.10 MPa was obtained for hybrid fiber reinforced concrete beams or respective above mentioned fiber volumes respectively. The test data has been used to develop S-N-Pf curves for hybrid fiber reinforced concretes and a relationship between stress level, fatigue life and survival probability has been determined.**Chunxiangqian,et al., (2000), Fracture properties of concrete reinforced with steel – polypropylene hybrid fibers**. Discusses polypropylene fibers and three sizes of steel fiber reinforced concrete. The fiber content ranges from 0% to 0.95% by volume of concrete. The research results show that there is a positive energy effect between large steel fibers and polypropylene fibers on the load bearing capacity and fracture toughness in the small displacement range. the results obtained the large steel fibres and polypropylene fiber significantly influence the load bearing capacity of hybrid fibers concrete in the small displacement range.**Tonoli, et al.,(2011)Hybrid reinforcement of sisal and polypropylene fibers in cement-based composites,** The objective of evaluate composites produced by the slurry dewatering technique followed by pressing and air curing, reinforced with combinations of polypropylene fibres and sisal Kraft pulp at different pulp freeness. The results showed the great contribution of pulp reinforcement on the improvement of the mechanical strength in the composites. Higher intensities of refinement resulted in higher modulus of rupture for the composites with hybrid reinforcement after accelerated and natural ageing.**Manavmittal,et al., (2013) Effect of polypropylene fiber, steel fiber & glass fiber on properties of concrete,** In this study fiber reinforced concrete is most widely used solution for improving the tensile and flexural strength of concrete. Various types of fibers such as steel, polypropylene, glass and polyester are generally used for improving the properties of concrete. Polypropylene, steel and glass fiber with different level of reinforcement index were investigated with pre-designed concrete mixtures consisting of various polypropylene dosages (0% to 0.45%), steel fiber (0% to 2 %) and glass fiber (0% to 0.04%).Characteristics of polypropylene-steel fibers were dependent on optimum fiber dosage upto 0.45% and 2% while for polypropylene-glass it was 0.3% and 0.04%.Any further addition of fiber resulted in loss in workability in both cases.

PRELIMINARY INVESTIGATIONS

4.1 General

In this chapter various physical properties of cement, fine aggregate and coarse aggregate .To discussed on, steel and polypropylene fibers. The test program is consisting of casting and testing of concrete specimens of cubes (150mm x 150mm x 150mm), cylinders (Diameter 150mm, height 300 mm), and prisms(100mmx100mm x 500mm) to determine the compressive strength, tensile strength, and flexural strength respectively.

4.6 Properties of fibers

Steel Fibers

NOVOCON 1050 hooked end steel fibers are used in the study. It is designed specifically for the reinforcement of concrete, mortars and other cementations mixes. It is a cold drawn wire fiber, deformed with hooked ends or flat ends to provide optimum anchorage within the concrete mix. These are ASTM complaint and specifically designed to meet or exceed the defined performance requirements.

Fig4.3 Hooked end steel fiber

Chemical and physical properties of hooked end steel fiber

Fiber Length	30mm
Equivalent Diameter	0.039 in (1.0)
Aspect Ratio	50
Tensile Strength	152,000 psi (1050 MPa)
Deformation	Hooked end (HE)
Appearance	Bright and clean wire

Polypropylene Fiber

It conforms to ASTM C-1116- Standard specification for fiber reinforced concrete. The properties of PP are given in table.

Product	Fibrillated (mesh)
Polymer	100% Virgin Polypropylene Homo- polymer
Tensile strength	0.67 kN/mm^2
Modulus (young's)	4.0 kN/mm^2
Specific gravity	0.91
Melting Range of PP	165 degree Celsius
Absorption	Nil
Diamond Length	10-12mm
Density bulk	910 kg/m^3
Colour	Natural
Dispersion	Excellent
Thickness	35-40 µ
Thermal & Electrical Conductivity	Low

Fig.4.4

Polypropylene fiber

4.8 Preparation of Hybrid Fiber Reinforced Concrete

First of all dry mortar is prepared, specified proportion of polypropylene fiber is added to the dry mortar and it is mixed properly. After that, coarse aggregate is added and suitable percentage of water is added, Then steel fiber is added to the concrete mix, concrete is prepared for suitable slump for good workability. The below figures shows the preparation of fiber reinforced concrete. Then the concrete is casted in specimen and well compacted, the specimens are placed to vibrator, to control the air voids.

Table 4.7: Mix of Hybrid fiber reinforced concrete

Sl. No :	Mix Ratio	Hooked End Steel Fiber (%)	Polypropylene Fiber (%)
1	1:1.78:3.03	0	0
2	1:1.78:3.03	0.5	0.05
3	1:1.78:3.03	0.75	0.075
4	1:1.78:3.03	1	0.1
5	1:1.78:3.03	1.25	0.125

Fig. Mixing of polypropylene in dry mortar

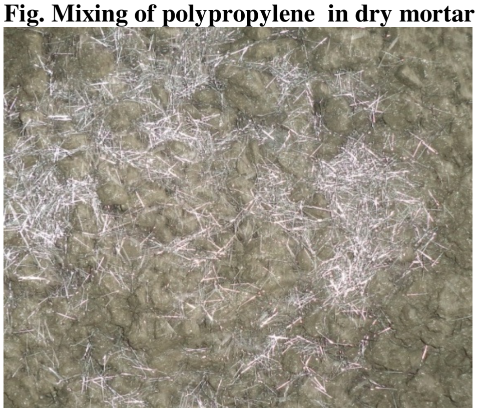


Fig.4.6 Mixing of steel fiber

4.9 Test Of Specimens

Table 4.8 Compressive strength of Control Concrete cubes (150mm)28 days

Sl no :	Area (mm2)	Ultimate load (KN)	Compressive strength (N/mm^2)	Average compressive strength test (N/mm^2)
	22500	730	32.44	32.08
	22500	715	31.77	
	22500	721	32.04	

Table 4.9 Compressive strength of HYFRC (vol-1) cubes (150mm) 28 days

Si no:	Area (mm2)	Ultimate load (kN)	Compressive strength (N/mm^2)	Average Compressive strength (N/mm^2)
1	22500	775	34.44	34.14
2	22500	784	34.84	
3	22500	746	33.15	

RESULT AND DISCUSSION

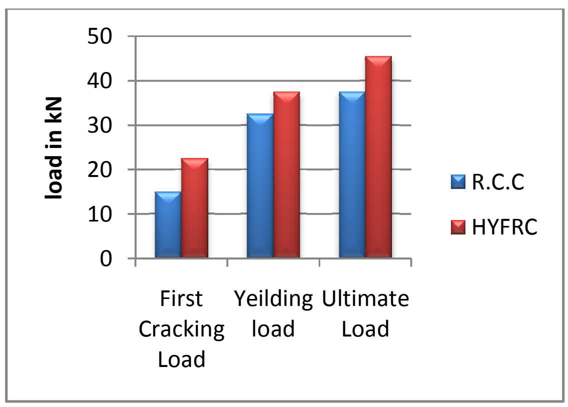
6.1 General

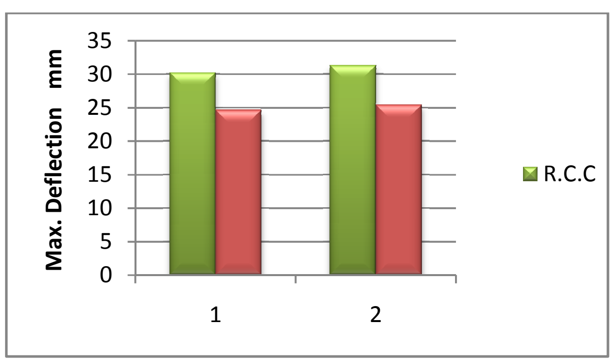
Tests were conducted on cement concrete and Hybrid Fiber Reinforced concrete (HYFRC) beams and observations were made. The moment curvature, load Vs deflection, behaviors were plotted.

The results obtained for Hybrid Fiber Reinforced concrete (HYFRC) of M 25 grade show the encouraging results.

6.2 HYBRID FIBER REINFORCED CONCRETE

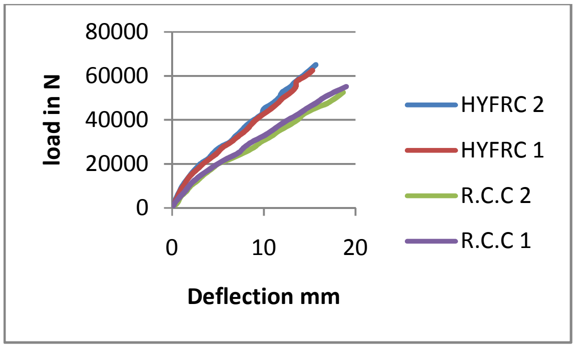
The concrete mix ratio was kept as 1: 1.78: 3. The Hybrid fiber reinforced concrete beam 1.0% of steel fibers and 0.10% of polypropylene fibers are obtained as a optimum dosage from different dosages of fibers by using flexural strength test from the prism specimens . The the water cement ratio was kept as 0.5. .HYFRC concrete cubes of average compressive strength of optimum dosage is 38.14 N/mm^2. Whereas 32.14 N/mm^2 obtained for RCC.



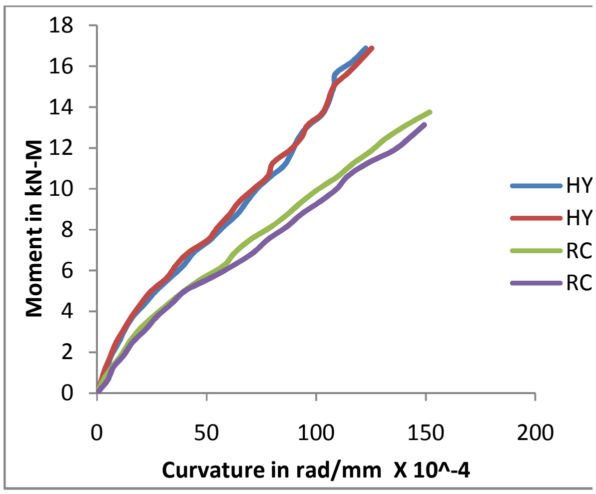


5.3 Load Vs Deflection Curves:

The load deflection curves for cement concrete control beams (CB1 and CB2) and HYFRC beams (HYFRC 1 and HYFRC 2) are shown in Figures 5.4 and 5.5.



Moment- curvature:



CONCLUTIONS

The following conclusions are made from this Thesis work.

1. M25 grade concrete mix is designed based on IS: 10262-2009 guide lines and the mix proportion obtained as 1: 1.78: 3.03 with w/c ratio 0f 0.5 to obtain 75 mm slump.
2. The compressive strength of M25 grade concrete for 28 days is 32.01 N/mm^2 and Compressive strength of optimum dosage of HYFRC is 38.16 N/mm^2
3. The modulus of elasticity of conventional concrete cylinder is 2.8212 x10^4 N/mm^2 and modulus of elasticity of optimum dosage of HYFRC is 3.0387 x10^4 N/mm^2
4. The flexural strength of conventional concrete prism is 5.2 N/mm^2 and flexural strength of optimum dosage of HYFRC is 7.46N/mm^2
5. Two identical beams are cast in control beam as well as HYFRC beams. The first crack load observed in control beams are 15 kN and 12.5 kN and the same observed in HYFRC beams are 22.5 kN and 25 kN. The HYFRC beam shows 9% increase in first crack load.
6. The yield load of control beams is 32 kN and 30 kN ,the beam in HYFRC beams is 35 kN and 37.5 kN the HYFRC beam shows 12% increase in yield load capacity.
7. The ultimate load carrying capacity of control beam is 35 kN and 37.5 kN and the same in HYFRC beam is 45 kN and 47.5 kN the HYFRC beam shows 23% increase in ultimate load carrying capacity when compared to control beams.
8. The deflection of HYFRC beam is reduced when compared to control beams. The maximum deflection observed in control beam is 45 mm and 50 mm and the same is reduced to 35 mm and 37mm in HYFRC beam.

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