"EXPERIMENTAL INVESTIGATION ON STRENGTH AND DURABILITY PROPERTIES OF HYBRID FIBER REINFORCED CONCRETE"

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Abstract:

When two different fibres are added to concrete to make the composite structure and it gives maximum strength to concrete that type of concrete is hybrid fibre reinforced concrete (HFRC). In this experimental work using of two different fibres they are crimped steel fibre and polypropylene fibre with different mix proportion of hybrid fibres to form the hybrid fibre reinforced concrete. Steel and polypropylene fibres have different properties and these properties will increases the tensile, flexural, impact strength of concrete. Initial cracks, shrinkage can be resist by using of polypropylene fiber and steel fiber is to increases the strength parameters. In present experimental work for M25 grade of concrete can be designed according to IS 10262:2009 with three different proportions of hybrid fibres are added with concrete ingredients. The proportion of steel and polypropylene fibres are added by 50% each with different hybridization ration i.e. 0%,0.5%, 1.0 %, 1.5% .For strength parameters compressive, tensile, flexural, impact strength specimens are casted and cured for 28 days and tested for hardened concrete. For durability study Sorptivity test is carried out to know the absorption of water by capillary. To evaluate the strength parameters different tests are conducted and results are tabulated. From the present work results showed that as the percentage of fibres increases the strength of concrete increases. Hybrid ratio 1.5 % gives maximum results in all the strength parameters compare to other different hybrid ratios.

Key words: crimped steel fibre, polypropylene fiber, Compressive strength, Tensile strength, Flexural strength, impact resistant strength, Sorptivity of HFRC.

1. INTRODUCTION:

Concrete is made up of cement, aggregates, water and with or without admixture and mixing of all these materials gives a composite material is concrete or conventional concrete. Concrete made with this material its quite brittle due to less strength of materials. Conventional concrete have good compressive strength and it is very less or poor strength in tension as well as in flexural strength. So for increasing concrete tension as well as flexural strength it's required to add any innovative materials like fibres, admixture, and waste material having good pozzolanas properties, construction chemical.

Fiber reinforced concrete (FRC) is concrete were the addition of fibers to concrete contains short discrete fibers that are uniformly distributed in concrete. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers. The weakness in tension can be overcome by the use of sufficient volume fraction of certain fibers. In order to improve the mechanical properties of concrete it is good to mix cement with fiber which have good tensile strength. Adding fibers to concrete greatly increases the toughness of the material. The use of fibers also alters the behavior of the fiber matrix composite after it has cracked, thereby improving its toughness. When two different fibers added to concrete to make the composite structure gives maximum strength to concrete that type of concrete is hybrid fiber reinforced concrete (HFRC).

Priyanka dilip (March 2014) [1], studied with crimped steel fiber And polyolefin fiber content at 0%, 0.5%, 1%, 1.5%, 2%. For the above given ratio they added steel fiber 80% and polyolefin 20% for each hybrid fiber content for M25 grade concrete and conclude that compressive, Flexural, tensile strength increases for hybrid ratio 1% and beyond 1% of hybrid ratio all the parameters strength may decreases. Selina ruby g (January 2014) [2] studied with crimped steel and polypropylene fiber with the ratio S0.25+P0.75, S0.5+P0.5,S0.75+P0.25,(p-polypropylene, S-steel) for M40 concrete, conclude that S0.75+P0.25 gives maximum compressive, Flexural, tensile strength. S.c. Patodi (October 2012) [3] studied with crimped steel and polyester fibre with ratios P0+S0, P1+S0, P0+S1, P0.5+S0.5, P0.3+S0.7, P0.7+S0.3 for M20 concrete,

concluded that compressive, tensile, Flexure, impact, Shear strength is increases for mix proportion of S0.7+P0.3. Prof. Pravin b (February 2015) [4] studied on Flat crimped steel and polypropylene fibre hybridization Ratio such as S0+P0%, S0+P100%,S25+P75%,S50+P50%,S75+P25%,S100+P0 % for M30 concrete conclude that compressive strength of HFRC is gives maximum for the Ratio 75-25% Split tensile strength concrete increases the strength with 100% steel fiber i. e. Ratio 100-0%. Flexural strength of HFRC of 50-50% & SFRC 100-0% both ratio results is same. M. Tamil selvi, (July 2013) [5] studied on crimped steel and polypropylene fibre with proportion such as 4% steel and polypropylene and 4% of hybridization Ratio such steel and polypropylene 2% each by volume of cement for M30 concrete conclude that increase in compressive strength when using SFRC at 4% but concrete mix with 4% steel fiber shows very stiff and difficult to compact and workability is decreases and when they using 4% Macro Synthetics polypropylene fiber concrete become more slippery and difficult compact. Split tensile strength may increase for SFRC with addition of 4% steel fiber and decrease for Hybrid fiber with addition of 2% each i.e. steel and polypropylene.

The main objective of this project is to study the different strength parameters like compressive, tensile, flexural, impact strength of hybrid fibre reinforced concrete with different mix proportion of fibres for M25 grade concrete and comparing with the conventional concrete and to know the optimum percentage of addition of fibres to concrete and finding maximum hybrid ratio and to determine workability of HFRC and to study the durability properties.

2. MATERIALS AND METHODS:

Cement: Ordinary Portland cement confirming to IS 10262-2009 was used. Ultratech cement 53 grade procured from single source, properties of which are tested in the laboratory are given in Table 1.

Properties	Results
Specific gravity	3.10
Soundness of cement	5mm
Normal consistency	33 %
Initial setting time	45 minutes
Final setting time	300 minutes

Table 1 Physical properties of cement.

Fine aggregate: locally available sand used as fine aggregate for experimental work and passing through 4.75mm as per **IS 383-1978.** Sand is brought from bhima river bed near shahapur. The preliminary tests like specific gravity, water absorption, fineness modules are tested and results are tabulated below.

Specific gravity	2.40
Water absorption	2 %
Fineness modules	2.0
Type of sand	River sand
Zone	II

Table 2. Physical properties of Fine aggregate.

Coarse Aggregates: In the present investigation locally available aggregates are brought from lahoti crusher, shahbad road, Kalaburagi, Karnataka. Size fractions i.e., 20mm down size coarse aggregates were used. Different test such as specific gravity, water absorption and etc were carried out in laboratory for coarse aggregates. The results are presented in Table 2.

Properties	Results
specific gravity	2.73
water absorption	16 %
shape of aggregate	angular
fineness modules	4.0

Table 3: Physical properties of coarse aggregates

Water: Potable water which is available in laboratory is used for casting of specimen and as well as curing of specimen as per IS 456-2000.

Steel Fibres: In the present work crimped steel fiber with flat end used. These steel fibres are brought from Kasturi Metal Composites Pvt. Ltd Amravati, Nagpur, Maharashtra. The properties off steel fibres with their specifications are mentioned in the table 3 below.

Polypropylene Fibres: in the present investigation the polypropylene fibres with 12mm cut length,with fibrillated having tensile strength 500-750 mpa is used. These polypropylene fibres are brought from Kasturi metal Composites Pvt. Ltd Amravati, Nagpur, Maharashtra.

Properties	Specification
Type of steel fiber	Crimped
Material	Low carbon drawn flat wire
Length of fiber	25mm
Diameter of fiber	0.5 mm
Aspect ratio	50
Tensile strength	500-750mpa
Appearance	Clear, bright, flat end crimped steel fiber
Applications	Tunnel shot create, industrial flooring, road and Pavement

Table 4: Properties of steel fibres.

Percentage variation of fibres in mix:

The proportions of fibres used in concrete mix are at percentage of 0.5%, 1%, 1.5% and for each proportion equal quantity (50% of each) of fibers are added in the mix.

Mix designation of concrete	Percentage of fiber added in overall concrete mix (%)	Steel Fibers by Volume of Concrete (%)	Polypropylene Fibers by Weight of Cement (%)
S1	0	0	0
S2	0.5	0.25	0.25
S3	1	0.50	0.50
S4	1.5	0.75	0.75

Table 5 : Percentage variation of fibres in mix.

3. CONCRETE MIX DESIGN:

In this study, M25 grade of concrete was used. The Concrete mix design was done using IS 10262:2009.The water- cement ratio adopted is 0.50. cubes, beams, cylinders are casted with addition of different hybrid ratio and cured for 28 days. The Mix proportions are shown in table.

Materials	Quantity	Ratio
cement	383 Kg/M3	1
Fine Aggregate	625.63 Kg/M3	1.63
Coarse Aggregate	1161.12 Kg/M3	3.03
Water	191.5 Liters	0.50

Table 6: M25 Concrete Mix Proportion.

4. RESULTS AND DISCUSSION

Cubes and cylindrical specimens were tested for compressive strength in the Compression testing machine of capacity 2000KN.The cylindrical specimens also were tested to determine split tensile strength. The prism specimens were tested in Universal testing machine of capacity 2000KN.An average of three specimens was tested for each strength.

1. COMPRESSIVE STRENGTH TEST

Mix designation of concrete	% Hybrid fibers	Compressive strength at 28 days (N/mm^2)	Percentage increase in strength
S1	0	29.56	0 %
S2	0.5	32.74	10.75%
S3	1	37.62	27.26%
S4	1.5	39.55	33.79%

Table 7: Compressive strength test results.

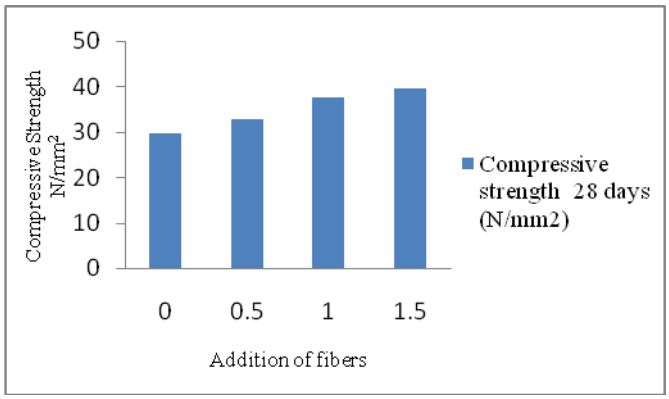

Figure 1. Compressive strength of HFRC.

From the above fig 1 we can know that as there is an increment in the fiber content there is also an increment in the compressive strength. Thus compressive strength increases with the increase of addition of fibers in the mix. When compared with controlled concrete the increase in the compressive strength with fiber addition in percentages of 0.5%, 1%, 1.5% is 10.75%, 27.26%, 33.79% respectively.

2. TENSILE STRENGTH TEST:

Mix designation of concrete	% Hybrid fibers	Tensile strength in (N/mm²)	Percentage increase in strength
S1	0	2.71	0
S2	0.5	2.46	9.22 %
S3	1	3.39	25.09 %
S4	1.5	3.96	46.12 %

Table 8 : Tensile strength test results.

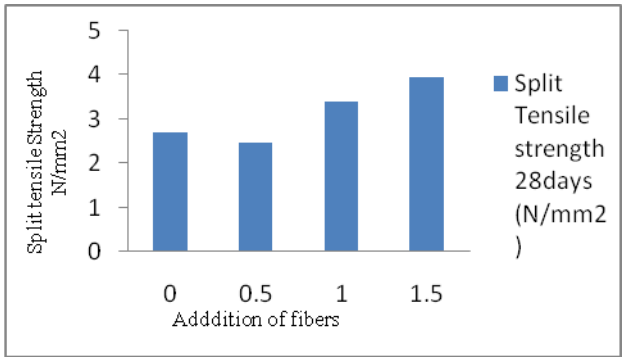

Figure 2. Tensile strength test results.

From the above fig 2 for 0.5 % addition of fibers there is decrees in strength compare to conventional concrete i.e 2.71N/mm². From this we can conclude that for 0.5% addition of fibers there is decrease in results thereafter addition of fibers i.e 1%,1.5% there may increase in strength When compared with controlled concrete the increase in the split tensile strength with fiber addition in percentages of 0.5%, 1%, 1.5% is 9.22%, 25.09%, 46.12% respectively.

3. FLEXURAL STRENGTH TEST

Mix designation of concrete	% Hybrid fibers	flexural strength at 28 days (N/mm²)	Percentage increase in strength
S1	0	3.90	0 %
S2	0.5	4.25	8.97 %
S3	1	4.68	20 %
S4	1.5	5.20	33.33%

Table 8 : flexural strength test results.

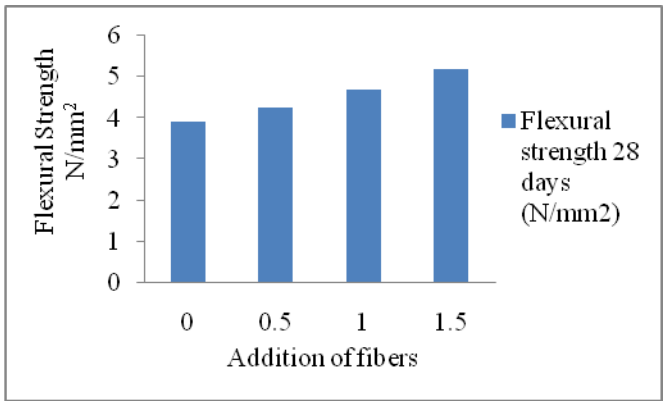

figure 3 : flexural strength test results.

From the above fig 3 if there is an increment in the fiber content there is also an increment in the flexural strength. Thus flexural strength increases with the increase of addition of fibers in the mix. When compared with controlled concrete the increase in the flexural strength with fiber addition in percentages of 0.5%, 1%, 1.5% is 8.97%, 20%, 33.33% respectively.

4. IMPACT STRENGTH TEST:

Mix designation of concrete	% Hybrid fibers	Impact strength no of blows(28 days)	
		Initial crack	Failure
S1	0	10	34
S2	0.5	13	51
S3	1	19	87
S4	1.5	24	125

Table 10 : Impact strength test results.

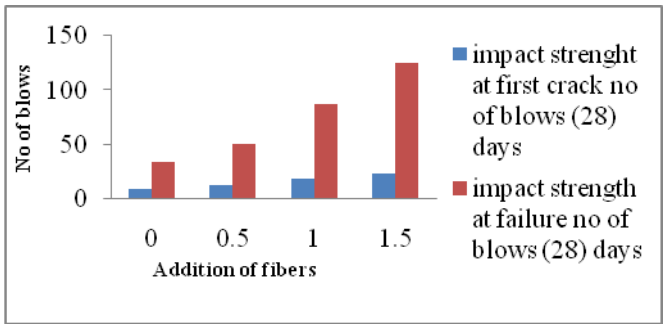

figure 4: Impact strength test results.

From the above fig 4 it is clear that at as the percentage of fibers increases the no of blows required to failure the specimen also increases. From this we can conclude that as there is an increment in the fiber content there is also an increment in the impact valve or strength.

SORPTIVITY TEST: The following formula is used for the calculation of sorptivity

$I=S.t^{1/2}$

$S=I/t^{1/2}$

Where; S= measure of sorptivity in mm

t= the elapsed time in minutes

I=Δw/Ad

Δw= difference in weights = W2-W1

W1 = Oven dry weight of cube specimen in grams

W2 = Weight of cube specimen in grams after 30 minutes of capillary suction of water

. A= surface area of cube specimen were the penetration of water takes place.

d= water density

Sl. No	Percentage of fibers (%)	Dry weight in grams	Wet weight in grams	Sorptivity value in 10^-7mm/min^0.5
1	0	8018	8023	4.016
2	0.5	8757	8762	4.0.16
3	1.0	8784	8794	8.033
4	1.5	8846	8856	9.676

Table 10: Sorptivity test results.

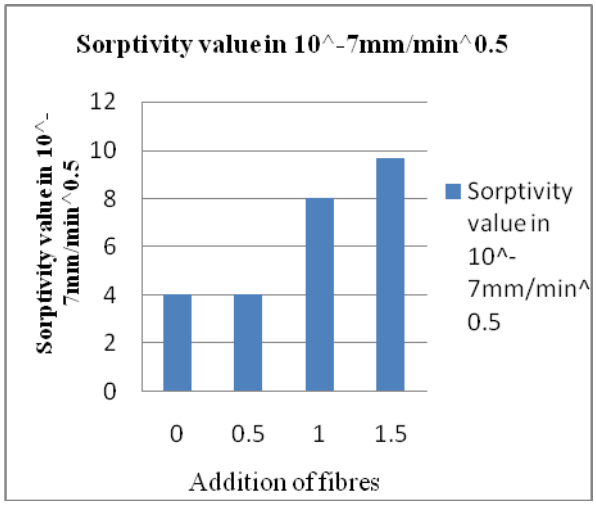

Figure 5 Sorptivity test results.

From the above fig 5 it is clear that conventional concrete and 0.5 % addition of fibers have same Sorptivity valves thereafter Sorptivity valves may increases for addition of fibers at 1% and 1.5%.so from this results we conclude that as the percentage of fibers is increases the Sorptivity will be increase.

5. CONCLUSIONS:

From my experimental investigation I concluded the following points.

- There is improvement in Compressive strength of HFRC compare to conventional concrete because of addition of fibers. The maximum increase in compressive strength observed at having hybrid ratio 1.5 % i.e. 0.75 % steel fiber and 0.75 % polypropylene fiber and When compared with controlled concrete the increase in the compressive strength with fiber addition in percentages of 0.5%, 1%, 1.5% is 10.75%, 27.26%, 33.79% respectively.
- Tensile strength may be decrease for the ratio 0.5 % of fibers compare to conventional concrete, thereafter it may increase in tensile strength and hybrid ratio having 1.5% gives maximum strength compare to other proportion. From this we can conclude that for 0.5% addition of fibers there is decrease in results thereafter addition of fibers i.e 1%,1.5% there may increase in strength When compared with controlled concrete the increase in the split tensile strength with fiber addition in percentages of 0.5%, 1%, 1.5% is 9.22%, 25.09%, 46.12% respectively.
- Flexural strength may be maximum for hybrid ratio 1.5% compares to conventional concrete. From this we can conclude that as there is an increment in the fiber content there is also an increment in the flexural strength. Thus flexural strength increases with the increase of addition of fibers in the mix. When compared with controlled concrete the increase in the flexural strength with fiber addition in percentages of 0.5%, 1%, 1.5% is 8.97%, 20%, 33.33% respectively.
- Impact strength of HFRC increases as the percentage of fibers increases the no of blows required to failure the specimen also increases. Thus impact strength increases with the increase of addition of fibers in the mix. When compared with controlled concrete the increase in the impact strength with fiber addition in percentages of 0.5%, 1%, 1.5% respectively.
- Sorptivity will be more as the percentage of fibers addition is increase. From results we can conclude that 0.5% addition of hybrid fibers gives same Sorptivity valve compare to conventional concrete.
- The optimum percentage of fibers addition is 1.5%. Addition of fibers up to 1.5% gives best results in all strength parameters compare to other mix proportion.

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