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EXPERIMENTAL INVESTIGATION ON HYBRID FIBRE REINFORCED CONCRETE

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ABSTRACT

The addition of fibres into the brittle concrete shall imparts tensile nature. The addition of two or more fibres in the concrete named as Hybrid Fibre Reinforced Concrete(HFRC) which derives more benefits from each of the individual fibres than the Single Fibre Reinforced Concrete (SFRC). The present experimental investigation focus on the properties of HFRC using various percentages of Polypropylene and steel fibres for M20 grade of concrete. To control the propagation of micro crack to macro crack, polypropylene fibres of Recron 3s (PPF - 0.1%, 0.2%, 0.3%, 0.4%) have used, while the double hooked end steel fibres (SF- 0.5%, 1.0%, 1.5% and 2%) are used to impart the tensile nature in the concrete. The objective of the study is to observe the transformation of concrete from brittle to ductile and to find the optimum performance of fibres in HFRC. The stress strain behavior of Hybrid Fibre Reinforced Concrete is studied by comparing with individual fibre incorporation.The study conclude that the hybridization of metallic and non- metallic fibres has the ability to arrest the propagation of micro and macro cracks in the cement matrix of the concrete with increased extensibility and tensile nature.

Keywords-Hybrid fibres, Microcracks, Macrocracks, Polypropylene fibre, Steel fibre, Stress strain curves

I. INTRODUCTION

Concrete is a composite material, mainly consist of coarse aggregate and fine aggregate bonded together with cement. Concrete is strong in compression and weak in tension. Now-a-days due to recent developments, concrete has become more and more compressive than the rise in the tensile nature and ductility. The addition of various classes of fibres will impart the ductile nature reducing the brittleness on the whole. The transformation of concrete from brittleness to ductileness can be obtained by incorporating fibres. This makes the concrete more homogenous and isotropic [4].short discrete fibres, which are randomly oriented, shall improve various aspects of overall structural integrity. The major disadvantage of conventional concrete is, it develops small cracks and propagates and deteriorates. Similarly, when that concrete member subjected to loading there is a rapid propagation of these cracks which leads to ultimate failure of the material. In this modern age, every structure has its durability requirements and hence to meet this purpose, modification in traditional cement concrete has become mandatory. To overcome these types of disadvantages, fibre materials are incorporated in the concrete such that the mechanical properties durability and survivability of the structure are improved. Fibres has a great role to control the cracking due to plastic shrinkage and drying shrinkage [5]. Since, 1960's fibres such as steel fibres, glass fibres and synthetic fibres such as polypropylene fibre and polyolefin fibres has have great importance. Basically, fibres are divided in to two categories: 1) High elastic modulus like: nylon, cellulose and polypropylene fibres. 2) low elastic modulus like: steel, glass, fiber, etc. According to Anand (2016), with the incorporation of glass and polypropylene fibres the compressive strength and split tensile increased with increase in addition of fibres and decreased with further increase, but the study did not conclude about the stress strain behavior of the HFRC. Similarly, Kumaravel et al., (2015) investigated the behavior of steel and polypropylene based HFRC at low volume fraction of below 0.5%and concludes that flexural strength can improved with fibre incorporation. Okan et al (2007), investigated on different proportions of fly ash such as 0, 15 & 30% and volume fraction of fiber steel (0, 0.25, 0.5, 1, 1.5%) in volume basis and aspect ratio varying from 50 to 70 were used and found that addition of steel fiber of 1% with 0 to 15% of fly ash gave an increase of 30% tensile strength and usage of 1.5% fiber gave an 66% increase in tensile strength. Fibres having low elastic modulus are added to concrete to improve strain performance of the concrete, whereas fibre having high modulus enhances strength performance of concrete. In the present study Hybrid Fibre Reinforced

Concrete (HFRC) containing both high elastic modulus and low elastic modulus is consideredand the performance of HFRC is observed. The objective of the study is to observe the transformation of concrete from brittle to ductile and to find the optimum performance of fibres in HFRC. The stress strain behavior of HFRC is studied by comparing with individual fibre incorporation. The study conclude that the hybridization of metallic and non-metallic fibres has the ability to arrest the propagation of micro and macro cracks in the cement matrix of the concrete with increased extensibility and tensile.

II. EXPERIMENTAL PROGRAM

To study the mechanical properties of hybrid fibre reinforced concrete by varying polypropylene and steel fibre percentage incorporation in conventionalconcrete. The objectives of the study is:

1)To find the suitability of PPF and SF addition in conventional concrete.
2)To enhance the tensile properties of conventional concrete by addition of metallic and non-metallic fibres.
3)To find the optimum percentage incorporation of metallic and non-metallic fibres for better performance of HFRC.
4)To understand the performance of polypropylene fibres instead of steel fibre to minimizethe corrosion effect in the concrete

Table 1 Properties of fibres

Description	Polypropylene fibres Recron 3s	Double hooked Steel fibres
Length	12mm	30mm
ameter	18 micron	0.6mm
Specific Gravity	0.91 g/cc	7.9 g/cc
Aspect Ratio	600	50

Table 2 Properties hardened conventional concrete

Description	Result	
	7days(N/mm^2)	28 days(N/mm^2)
Compressive strength	15.61	22.3
Split tensile strength	1.22	

Table 3 Results on Cement

Description	Result
Fineness	5%
Specific gravity	2.72
Initial setting time	65minutes
Standard consistency	34%

Table 4 Results of Fine Aggregate

Description	Result
Fineness modulus	2.8
Bulk density	1.57 g/cc
Voids ratio	0.52
Bulking	21.6cm at 3%
Porosity	34.2%
specific gravity	2.4

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Table 5 Results on coarse aggregate

Description	Results
Fineness modulus	7.5
Bulk density	1.5 g/cc
Voids ratio	0.88
Porosity	50.5%
Specific gravity	3.03

Table 6 Properties fresh conventional concrete

Description	**Result**
Slump	70mm
Compaction factor	0.79

Table 7 Workability of various mixes

Steel fibre %	**Polypropylene fibre%**	**Slump (mm)**	**Compaction factor**
0.5	0.1	120	0.87
1.0	0.2	100	0.78
1.5	0.3	90	0.75
2.0	0.4	60	0.65

Figure 1 Stress strain test for (0.2%PPF+1.0%) HFRC

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Figure 2 Compressive strength test of (0.5%PPF+0.1%) HFRC

III. RESULTS AND DISCUSSION

Based on the experimental results the following observations were found from figures 1-6.

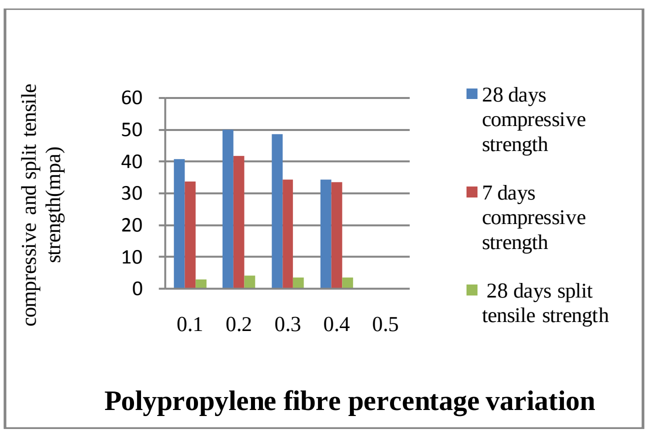

Figure 1 Compressive Strength of PFRC at various percentages of polypropylene

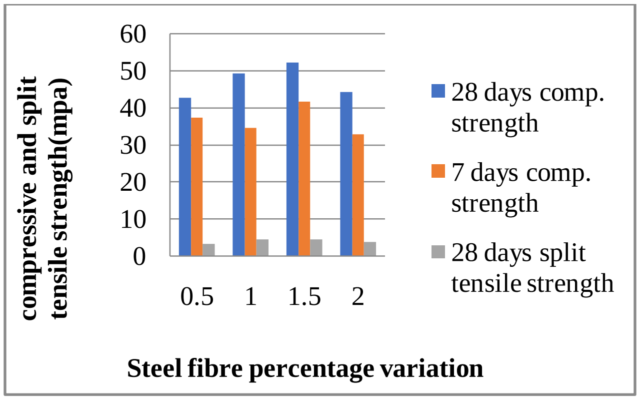

Figure 2 Compressive Strength of SFRC for varying percentages of steel fibres

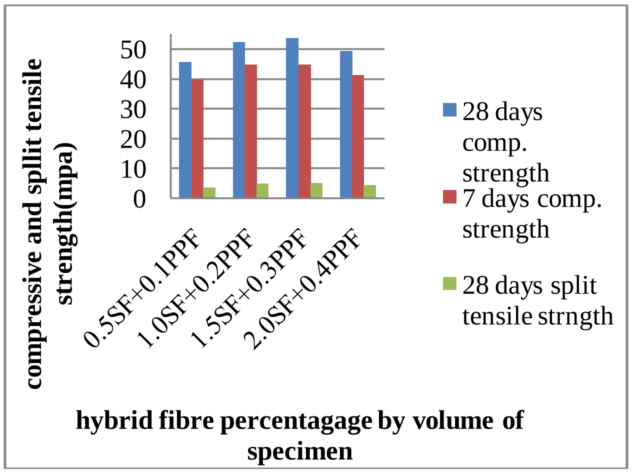

Figure 3 Compressive Strength of varying fibre percentage of steel and polypropylene

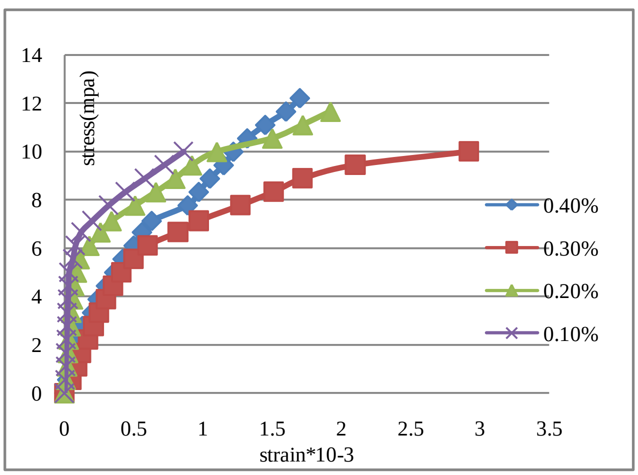

Figure 4 Behavior of PFRC for varying % of Polypropylene fibres

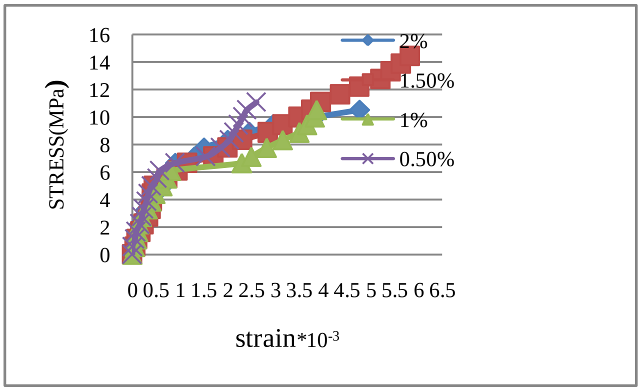

Figure 5 Behavior of SFRC for varying % of steel fibre

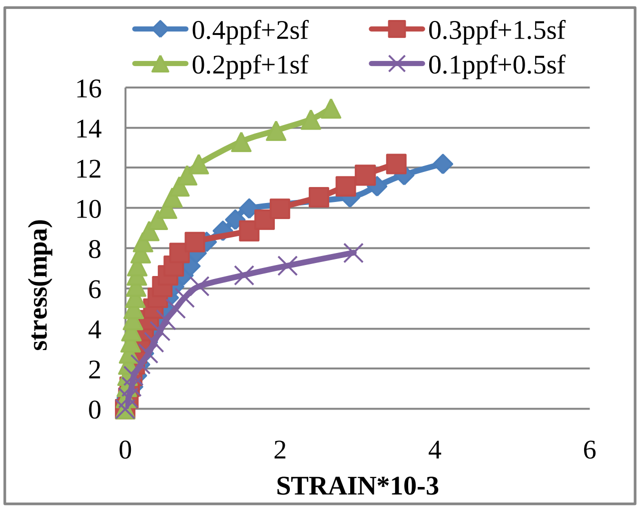

Figure 6 Behavior of HFRC for varying % of steel and polypropylene fibres.

- From figure 1,it was observed that at 0.2% PFRC the maximum increase in strength at 28 days and it was 55% more than the conventional concrete. Similarly, split tensile strength was 69% compared to conventional concrete. And with further addition decreased, this could be due to possibility of balling effect the matrix which causes voids and pores in concrete.
- From figure 2, it was observed that at 1.5% SFRC the strength is double the strength of conventional concrete and further decreased, however at any proportion of Steel fibre the strength is higher than the conventional concrete.
- From figure 3,.
- From Table 7, the workability of PFRC decreases with increase in the fibre content. This may be because of the addition of fibres causes entrapped air voids in the concrete and hence the increased air content reduces the workability.
- From figure 2, the maximum increase in 28 days compressive strength was observed to be 57% and split tensile strength was 73% and at 1.5%SF compared to convention concrete. The bonding of SF with the cement matrix increases, thereby causing ductile from brittle. With the increase of SF the concrete mix becomes non-homogeneity of mix and becomes difficulty during mixing and compaction
- From the figure 4 the stress strain behavior of PFRC is found to develop a maximum strain at 0.3% of PPF incorporation and corresponding stress is 9.99 and strain is 2.92.

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- From figure 5, the stress strain behavior of SFRC is found to develop maximum stress at 1.5% of SFRC incorporation and corresponding stress is 14.43 and strain is 8.82
- From figure 6, the stress strain behavior of HFRC is found to develop maximum stress at 0.4%PPF+2%SF of HFRC incorporation and corresponding stress is14.985 and strain is 2.66.

IV. CONCLUSIONS

In this investigation, we observed that the strength values of HFRC are increased by increasing the fibres addition up to a certain percentage and then on further addition of fibre the values decreased. And it is also observedthat the workability has decreased by increasing the fibre content in the mixes. The following are the specific conclusions derived from the results and discussions.

- It is observed that at 0.3%PPF+1.5%SF hybrid fibre has the maximum 28 days Compressive strength of 58.4% and split tensile strength of 75.4% when compared to the conventional concrete. Since with the addition of SF the propagation of macro-cracks has reduced, while PPF has reduced the propagation of micro-cracks to macro-cracks, thereby enhancing the bonding of fibrous materials with cement matrix.With the hybrid fibre incorporation in the concrete both the fibres properties have derived to the concrete.
- It was observed that, the optimum incorporation are 1.5% of SF and 0.3 PPF, the concrete has high strength compared to other mix proportions.
- At optimum number of fibres, bridging the cement matrix with metallic and non-metallic fibres will reduces the crack propagation in-terms of width and openings. However the bridging effect can be factored by orientation of fibres, aspect ratio, distribution of fibres in the concrete.
- The workability of HFRC decreased with the addition of fibres to the concrete. However, the ease of working with the HFRC can be enhanced by addition of admixture in prescribed dosage up to certain extent.