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Experimental Investigation On Hybrid Steel and Polypropylene Fibre Reinforced Concrete

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Abstract:

Concrete is the most widely used construction material across the world. Mainly fibres are provide in concrete means of arresting crack growth. Short discontinuous fibres have the advantage of being uniformly mixed and dispersed throughout the concrete. Two fibres namely steel fibre and polypropylene fibre are used in this investigation. Polypropylene fibre having low modulus, light density and not susceptible to corrosion and steel fibre increases ductility, toughness and impact resistance. Polypropylene fibre is good in preventing micro cracks while steel fibre is reliable in preventing macro cracks in the concrete. In this paper an investigation is made to find the effect of polypropylene fibre by varying the proportions as 0.3%,0.4%along with0.75% steel fibres. Compressive strength, split tensile strength, flexural strength are the various parameters were investigated.

***Keywords*—Steel fibre, Polypropylene fibre, Compressive strength, Split tensile strength, Flexural strength.**

I. INTRODUCTION

Conventional concrete designed on the basis of strength parameters. Hence problems like shrinkage, creep, thermal expansion etc., are faced. To meet the functional and durability requirements such as impermeability, thermal cracking adequately it is required to go for hybrid fibre concrete. Fibre reinforced concrete are designed to provide several benefits in the construction of concrete structures that cannot always be achieved routinely using conventional ingredients, normal mixing and curing process.Hybrid fibre reinforced concrete is a composite material consisting of hydraulic cement, Fine aggregate, Coarse aggregate, Water and more than one type of fibres. Fibres helps to improve post peak ductility performance, pre-crack tensile strength, fatigue strength and eliminate temperature cracks. The low tensile strength of concrete is improved by providing steel reinforcement. Further to improve the tensile strength to the concrete, different fibres like steel fibres, polypropylene fibres, glass fibres and many other natural fibres are added to it. The fibre in the concrete matrix acts as crack arrestors which resists the growth of flaws in the matrix preventing from enlarging under load, into cracks which eventually cause failure.

II. LITERATURE SURVEY

Several works has been carried out in the past to study the behaviour of concrete with addition of fibres.Rashid Hameed et al [1] investigated This contribution investigates the flexural properties of metallic-hybrid-fibre-reinforced concrete. Two types of fibres were used: amorphous metallic straight fibre characterized as non slipping fibre due to its rough surface and large specific surface area, and carbon steel hook-ended fibre characterized as slipping fibre. The fibre was incorporated at 20 and 40 kg/m3 for single-fibre reinforced concrete, and at 20, 40 and 80 kg/m3 for hybrid-fibre-reinforced concrete.

Narasimha raj [2] Conductedexperimentalstudyonconcretemix design by packing density method Results obtained by packingdensitymethodarecomparedwithIScodemeth od. The optimum bulk density was obtained at proportion of 42% coarse aggregates (20mm

downsize), 18% coarse aggregates (12.5mm downsize) and 40% fineaggregates.

Patil swetha [3] studied the properties of steelfiberreinforcedconcretelikeflexureandcompressive strength. They conducted tests to study the flexural and compressivestrengthofsteelfibrereinforcedconcretewith varying percentage of fibre. In the experiments conducted four aspect ratio were selected i.e. 40,50,60,andpercentageofsteelineachcasevariedfrom 0.5% to 2.5% at interval of0.5%.

Roohollah Bagerhzadeh [4] Studiedtheinfluenceofpolypropylenefibersin different proportioning and fiber length to improve the performance characteristics of the cement composites.Fiberswereusedintwodifferentlengths(6mm and 12mm) and fibre proportions (0.15% and 0.35%) by cement weight in the mixture design.Compressive strength, splitting tensile strength,water absorption were evaluated.

Vikrant S. Vairagade et al [5] investigated The use of two or more types of fibres in a suitable combination may potentially improve the overall properties of concrete and also result in performance concrete. The combining of fibres, often called hybridization, is investigated in this paper for a M25 grade concrete. Based on experimental studies, the paper identifies fibre combinations that demonstrate maximum compressive and split tensile strength of concrete. Mortar reinforced with higher percentage of steel fiber would reduce the shrinkage significantly. Flexural toughness was enhanced by the hybridization process as a result of the bridging effect from the flexible fibers in the post crack zone.

Parveen and Ankit Sharma [6] investigated The aim of the present study is to investigate the effect of variation of polypropylene fibres ranging from along with steel fibres on the behaviour of fibrous concrete. The investigation suggested that hybrid fiber substantially reduce the damaged area and arrested the crack development. The result shows that addition of polypropylene fibre has a little effect on the compressive strength, but there was significant increase in the tensile strength with increase in fibre volume fraction. The present investigation shows an increase of 47% of split tensile strength and 50% of flexural strength. The result shows that ultimate load mainly depended on percentage volume fraction of fibre.

III.MATERIAL PROPERTIES

Cement:

In this investigation Ramco Cement which is of the OPC (Ordinary Portland Cement)of 43 grade was used for this entire works.

Table – 1: Properties of cement

S. N	Test Conducted	Result Obtained	Requirement- As per Is 8112
1.	Normal Consistency	34%	Not specified
2.	Initial setting time	45min	Shall not be less than 30 min
3.	Final setting time	300 min	Shall not be more than 600 min.
4.	Compressive Strength	56.4 MPa	Shall not be less than 43Mpa
5.	Specific gravity	2.6	3.16
6.	Soundness	5.1mm	Shall not be more than 100mm

Fine Aggregate:

The fine aggregate used in this investigation was coming under ZONE-II as per IS code, whose max size is 4.75mm the sand was first air-dried in order to reduce considerably its moisture content. The specific gravity of fine aggregate is 2.67.

Coarse Aggregate:

Locally available crushed blue granite metal aggregate was used as coarse aggregate of size 20mmasper IS:383-1970 guidelines. Specific gravity of coarse aggregate is 2.65.

Water:

Potable water available in laboratory with pH value of not less than 6 and conforming to the requirement of IS 456-2000 was used for mixing concrete and curing the specimen as well. Since it helps to form strength, the quantity and quality of water is to be looked very carefully.

Fibre: Two types of fibres were used in this investigation. They are (i) steel fibre (ii) polypropylene fibre.

Steel fibre:

The hooked end steel fibre was used through this programme. The steel fibre developed are used in this investigation was DURAFLEX fibre supplied by kasturi metal composites.

Table-2: Properties of Steel Fibre

Material	Low carbon drawn wire
Type	Hooked end steel fibre
Length(mm)	35mm
Diameter(mm)	0.6mm
End anchorage	Hooked ends
Tensile strength	> 1100 Mpa
Density	7850Kg/m³
Appearance	Clear, Bright with hook end anchorage

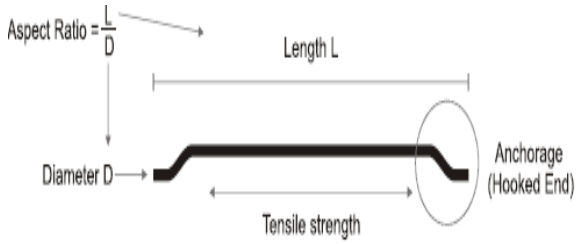

Fig 1: Hooked End Steel fibre

Polypropylene Fibre:

The polypropylene fibre developed are used in this investigation was BOASEE FIBRE supplied by MJ supplier.

Table-3: Properties of polypropylene fibre

Appearance	**Monofilament**
Length	20mm
Thickness	0.12
Tensile strength	400Mpa
Density	869.14Kg/m³

Fig 2: Polypropylene fibre

Super Plasticizer:

To improve the workability of fibre reinforced concrete. 0.5% of super plasticizer by weight of cement is added to the mix concrete. The name of plasticizer used Conplast sp-430.

Table-4: Properties of Super Plasticizer

Appearance	Brown liquid
Specific gravity	1.18
Alkali content	Typically<55g

IV. EXPERIMENTAL METHODOLOGY

Experimental programme were conducted on concrete specimen prepared withaddition of different percentage of fibres (steel and polypropylene). Hybrid fibres are adding for concrete by varying the proportions as 0.3%, 0.4% of polypropylene fibre along with 0.75% of steel fibres. These results are compared with nominal concrete (Without adding fibres).

Table-5: Mix Design Of M_{35} Grade Concrete

Materials	**Mix proportion**	**Mix Weighs(Kg/m^3)**
Cement	1	425.7
Fine Aggregate	1.64	700.83
Coarse Aggregate	3.08	1311.5
Water	0.45	174
Super Plasticizer	5.20*	-

In this investigation performed various tests in hardened concrete like compressive strength test, tensile strength and flexural strength test.The observation is tabulated and the results are calculated. Graphs are plotted if it necessary by using suitable readings.

V. RESULTS AND DISCUSSION

COMPRESSIVE STRENGTH TEST:

The concrete cube specimens are made by adding both steel and polypropylene fibres in a hybrid manner and by adding single type of fibres in eachspecimen. Specimens of dimensions 150x150x150mm were prepared. They are tested on

compression testing machine as per Is:516-1959 guidelines.

Fig 3: Compressive strength test

The compressive strength is calculated by using the equation,

$$F = P/A$$

F= Compressive strength of the specimen (in MPa).
P= Maximum load applied to the specimen (in N).
A= Cross sectional area of the specimen (in mm²).

Table-5: Compressive Strength Test Results

S.NO	Volume Of Fibres Adding (%)	Curing age	Compressive Strength(N/mm²)
1	0	7 Days	31.14
		24 Days	36.64
2	0.3% PF+ 0%SF	7 Days	32.3
		24 Days	36.96
3	0.4% PF+0% SF	7 Days	31.5
		24 Days	36.87
4	0%PF 0.75% SF	7 Days	33.07
		24 Days	37.45
5	0.3%PF+0.75% SF	7 Days	35.42
		24 Days	40.7
6	0.4% PF+0.75%SF	7 Days	30.91
		24 Days	38.83

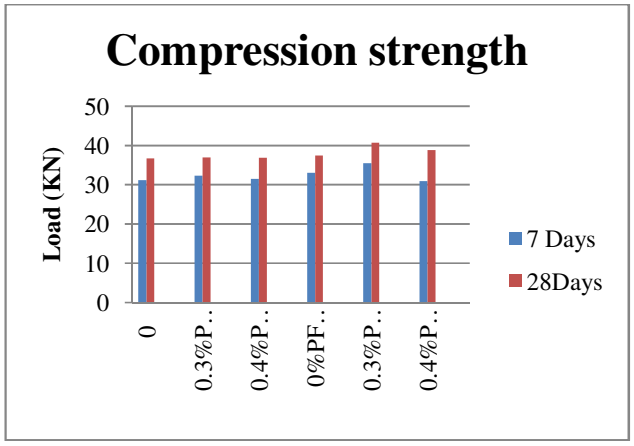

Chart -1: Compressive strength of concrete

SPLIT TENSILE STRENGTH TEST:

Cylindrical shape specimens of diameter 150mm and length 300mm were prepared and tested under a compression testing machine. The tension develops in a direction at right angles to the line of action of the applied load on the specimen.

Fig 4: Tensile strength test

The tensile strength is calculated using the equation,

$$F = 2P/(\pi D L)$$

Where,
F = Tensile strength of concrete (in MPa).
P = Load at failure (in N).
L = Length of the cylindrical specimen (in mm).
D = Diameter of the cylindrical specimen (in mm).

Table – 5: Split Tensile Strength Test Results

S.NO	Volume Of Fibres Adding (%)	Curing Age	Split Tensile Strength(N/mm²)
1	0	7 Days	2.67
		28 Days	3.73
2	0.3%PF+0%SF	7 Days	3.52
		28 Days	4.28
3	0.4%PF+0%SF	7 Days	3.27
		28 Days	4.01
4	0%PF+0.75%SF	7 Days	4.19
		28 Days	4.73
5	0.3%PF+0.75%SF	7 Days	4.29
		28 Days	4.98
6	0.4%PF+0.75%SF	7 Days	4.22
		28 Days	4.88

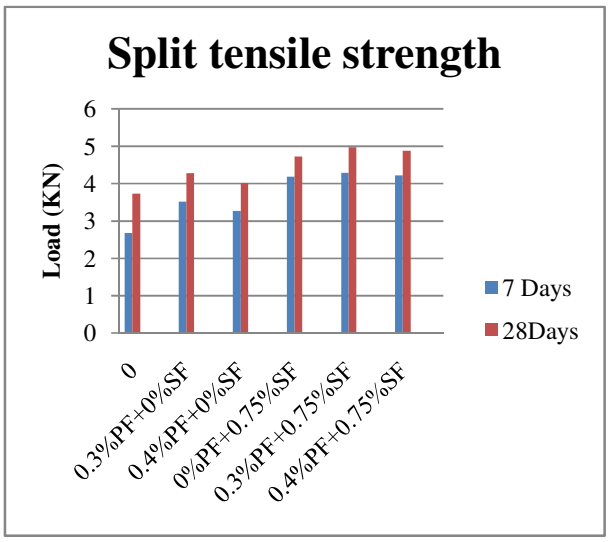

Chart -2: Split tensile strength of concrete

FLEXURAL STRENGTH TEST:

For flexural strength test, the concrete specimen of dimensions of 150mm x 150mm x 700mm were prepared and testing under central point loading was adopted on an effective span of 600mm as per IS:516-1959 guidelines.

Fig 5: Flexural strength test

Flexural strength is calculated using the equation:

$$F = PL/(bd^2)$$

Where,
F= Flexural strength of concrete (in MPa). P= Failure load (in **N).**
L= Effective span of the beam (mm).
b= Breadth of the beam(mm).

Table-6 Flexural Strength Test Results

S.NO	Volume Of Fibres Adding (%)	Curing Age	Flexural Strength(N/mm²)
1	0	7 Days	5.75
		28 Days	8.5
2	0.3%PF+0%SF	7 Days	6.7
		28 Days	9.9
3	0.4%PF+0%SF	7 Days	5.61
		28 Days	8.75
4	0%PF+0.75%SF	7 Days	7.66
		28 Days	10.25
5	0.3%PF+0.75%SF	7 Days	7.95
		28 Days	11
6	0.4%PF+0.75%SF	7 Days	7.72
		28 Days	10.75

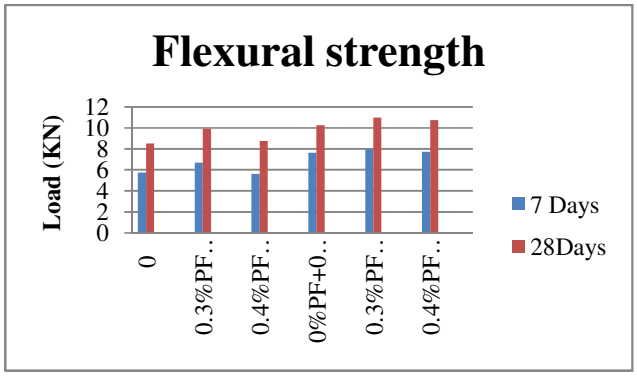

Chart -3: Flexural Strength Results

VI. CONCLUSIONS

The study on the hybrid fibre reinforced concrete members gives better understanding for the behaviour of fibres which incorporating in concrete. From this investigation the following conclusions were made,

1) The maximum gain in split tensile strength was achieved for 0.3% polypropylene fibre. Thereafter increase in fibre content has marginally reduced the split tensile strength.

2) Steel-polypropylene fibre reinforced concrete showed increase in flexural strength when compared with steel fibre reinforcedconcrete. The maximum gain in flexural strength was achieved for 0.3% polypropylene fibre. Thereafter increase in fibre content has marginally reduced the flexuralstrength.

3) When compared to nominal concrete gives better strength ability factors for fibre reinforced concrete specimen. Because of increasing steel fibre content it also increasing the tensile strength of the concrete.

4) The toughness of the Fibre reinforced concrete specimen was increased since fibre acts as crack resistors.

5) This investigation indicated the concrete with 0.3% of polypropylene fibre along with 0.75% of steel fibre by volume of concrete promote convincing behaviour under various test conducted hence can be concluded as optimum dosage of fibres.

6) By addition of fibres in concrete specimens did not yield to sudden breakage as observed in this investigation.

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