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Experimental Study on Behaviour of Hybrid Fibre Reinforced Concrete

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ABSTRACT: Performance of conventional concrete is enhanced by addition of fibres in concrete. The brittleness in concrete is reduced and the adequate ductility of concrete is ensured by the addition of fibres in concrete. In this paper the behaviour of concrete is strengthened by using hybrid fibre reinforced concrete is analysed. The concrete mould is casted for grade of M20 as per IS10262-2009. The fibre used are steel (crimped end) and polypropylene fibres in various volume functions. The main reasons for adding steel fibres to concrete matrix is to improve 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 fibres of steel (crimped end) and polypropylene are taken in following ratios and concrete are cast. 0% of steel fibre and 0% of polypropylene fibre, 0.25% of steel fibre and 0.75% of polypropylene fibre, 0.5% of steel fibre and 0.5% of polypropylene fibre, 0.75% of steel fibre and 0.25% of polypropylene fibre. Concrete are cast and test under flexure.

KEYWORDS: Steel fibre, Polypropylene fibre, Compressive strength, Split tensile strength & Flexural strength.

I. INTRODUCTION

Fibers are usually used in concrete to control cracking due to plastic shrinkage 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. Generally fibers do not increase the flexural strength of concrete, and so cannot replace moment-resisting or structural steel reinforcement.

Concrete is a composite material containing hydraulic cement, water, coarse aggregate and fine aggregate. The resulting material is a stone like structure which is formed by the chemical reaction of the cement and water. This stone like material is a brittle material which is strong in compression but very weak in tension. This weakness in the concrete makes it to crack under small loads, at the tensile end. These cracks gradually propagate to the compression end of the member and finally, the member breaks. The formation of cracks in the concrete may also occur due to the drying shrinkage. These cracks are basically micro cracks. These cracks increase in size and magnitude as the time elapses and the finally makes the concrete to fail.

The main reasons for adding fibres 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. Also, it helps to maintain structural integrity and cohesiveness in the material. The initial researches combined with the large

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volume of follow up research have led to the development of a wide variety of material formulations that fit the definition of Fibre Reinforced Concrete.

II. RELATED WORK

K.Ramadevi, et.al. -2012. ‘‘Experimental investigation on flexural Behaviour of hybrid (steel-polypropylene) fibre reinforced concrete beams’’.This study is an experimental research on the flexural behaviour of hybrid fibre added concretes which are obtained using steel fibres and polypropylene fibres in proportions. The percentage of fibres used was 0.5%,1%,1.5%,2% and the result were compared with control beam specimen. The ultimate deflection for the HFRC beams was found to be increasing when compared to the control specimen. Which is due to the increase in ductility of the beams by the introduction of fibres, the deflection of the mid span was 20.18mm for control beam and gradually decreased upto 2%. HFRC beams which indicate the decrease in mid span deflection with an increase hybrid fibre proportion.

III.HYBRID FIBER REINFORCED CONCRETE

Addition of two types of fibers of different properties can be used in concrete. 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.

A) POLYPROPYLENE FIBER

Polypropylene is one of the cheapest & abundantly available polymers polypropylene fibers are resistant to most chemical & it would be cementations matrix which would deteriorate first under aggressive chemical attack. Its melting point is high (about 165 degrees centigrade). So that a working temp. As (100 degree centigrade) may be sustained for short periods without detriment to fiber properties. Polypropylene fibers being hydrophobic can be easily mixed as they do not need lengthy contact during mixing and only need to be evenly distressed in the mix. Polypropylene short fibers in small volume fractions between 0.5 to 1% commercially used in concrete.

Table I Properties of Polypropylene Fibre

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

B) STEEL FIBER

A number of steel fiber types are available as reinforcement. Round steel fiber the commonly used type are produced by cutting round wire in to short length. The typical diameter lies in the range of 0.25 to 0.75mm. Steel fibers having a rectangular c/s are produced by silting the sheets about 0.25mm thick. Fiber made from mild steel drawn wire.

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Conforming to IS: 280-1976 with the diameter of wire varying from 0.3 to 0.5mm have been practically used in India. Round steel fibers are produced by cutting or chopping the wire, flat sheet fibers having a typical c/s ranging from 0.15 to 0.41mm in thickness and 0.25 to 0.90mm in width are produced by silting flat sheets. Deformed fiber, which are loosely bounded with water soluble glue in the form of a bundle are also available. Since individual fibers tend to cluster together, their uniform distribution in the matrix is often difficult. This may be avoided by adding fibers bundles, which separate during the mixing process.

IV. EXPERIMENTAL INVESTIGATION AND RESULTS

Concrete Mix Design

Mix design of M₂₀ grade was done as per IS 10262.

Table II Mix Design

MIX RATIO	CEMENT	FINE AGGREGATE (SAND)	COARSE AGGREGATE	WATER
MIX(KG)	425.73	680.03	1067.69	191.58
RATIO	1	1.58	2.50	0.45

Tests were conducted to determine the hardened properties of both conventional concrete and hybrid fibre reinforced concrete. Concrete test specimen consists of 150x150x150mm cubes, Cylinders of 150mm diameter and 300mm height and 100x100x500 beams. Concrete cube specimen were tested at 7 and 28 days to obtain the compressive strength of concrete. Cylindrical specimen were tested at 7 and 28 days to obtain the split tensile strength of concrete.

V. EXPERIMENTAL RESULTS

COMPRESSIVE STRENGTH OF CONCRETE

This test was conducted as per IS 516-1959. The cubes of standard size 150x150x150mm were used to find the compressive strength of concrete. Specimens were placed on the bearing surface of UTM, of capacity 100tones without eccentricity and a uniform rate of loading of 550 Kg/cm² per minute was applied till the failure of the cube. The maximum load was noted and the compressive strength was calculated

Cube compressive strength (f_{ck}) in MPa = P/A

Table III Compressive Strength Of Concrete

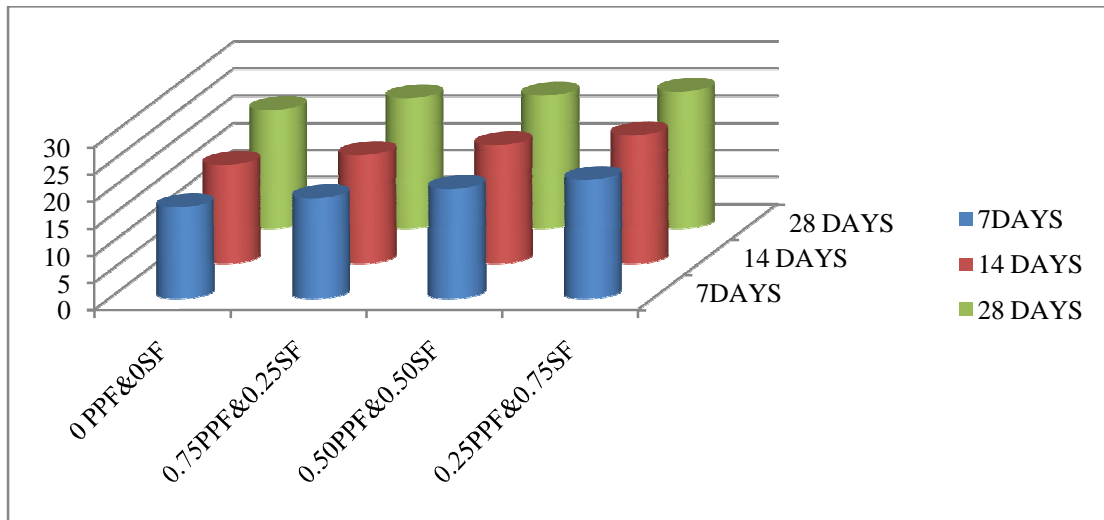
SI.NO	CUBE			7 DAYS COMPRESSIVE STRENGTH (Mpa)	14 DAYS COMPRESSIVE STRENGTH (Mpa)	28 DAYS COMPRESSIVE STRENGTH (Mpa)
	% OF FIBRE	% OF POLY PROPYLENE FIBRE	% OF STEE FIBRE			
1	0	0	0	16.88	18.22	21.84
2	1.0	0.75	0.25	18.568	20.04	24.02
3	1.0	0.50	0.50	20.27	21.86	24.5
4	1.0	0.25	0.75	21.94	23.68	25.23

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SPLIT TENSILE STRENGTH ON CONCRETE

Cylinders of size 15cm (dia) x 30cm (height) are casted. The test is carried out by placing a cylindrical specimen horizontally between the loading surface of a compression testing machine and the load is applied until the failure of the cylinder, along the vertical diameter. When the load is applied along the generatrix, an element on the vertical diameter of the cylinder is subjected to a horizontal stress of $2P/\pi ld$.

Where,

P is the compressive load on the cylinder

l is the length of the cylinder

d is diameter of the cylinder.

Table IV Split Tensile Strength Of Concrete

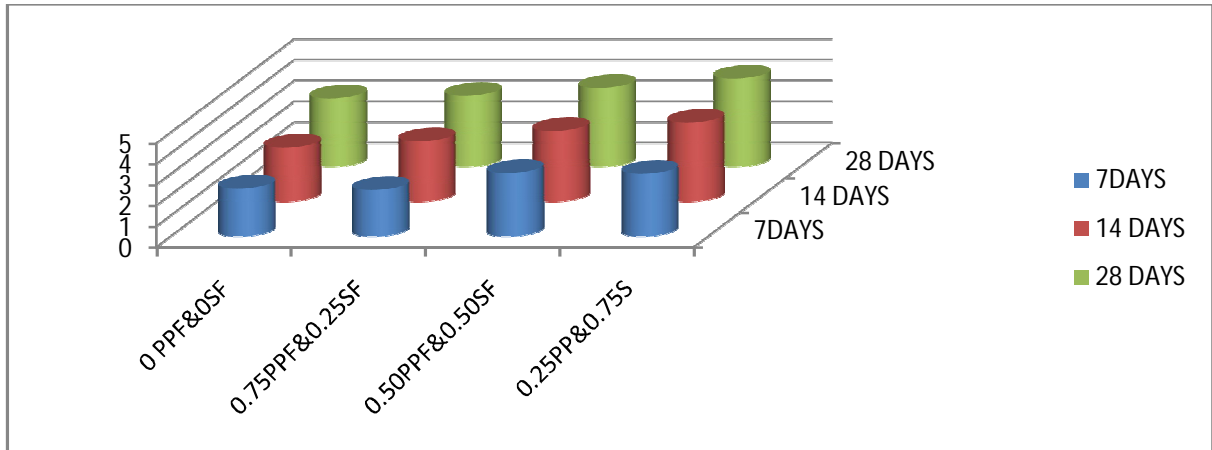
SI.NO	CYLINDER			7 DAYS COMPRESSIVE STRENGTH (Mpa)	14 DAYS COMPRESSIVE STRENGTH (Mpa)	28 DAYS COMPRESSIVE STRENGTH (Mpa)
	% OF FIBRE	% OF POLY PROPYLENE FIBRE	% OF STEE FIBRE			
1	0	0	0	2.3	2.6	3.3
2	1.0	0.75	0.25	2.23	2.9	3.42
3	1.0	0.50	0.50	3.04	3.4	3.8
4	1.0	0.25	0.75	3.006	3.8	4.25

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FLEXURAL STRENGTH OF CONCRETE

Beams of size 100x100x500mm are tested using a flexure testing machine. The specimen is simply supported on the two rollers of the machine which are 600mm apart, with a bearing of 50mm from each support. The load shall be applied on the beam from two rollers which are placed above the beam with a spacing of 200mm. The load is applied at a uniform rate such that the extreme fibres stress increases at 0.7N/mm²/min i.e., the rate of loading shall be 4 KN/min. The load is increased till the specimen fails. The maximum value of the load applied is noted down. The appearance of the fracture faces of concrete and any unique features are noted.

The modulus of rupture is calculated using the formula.

$$\sigma_s = Pl/bd^2$$

Where,

P = load in N applied to the specimen

l = length in mm of the span of specimen

b = measured width in mm of the specimen

d = measured depth in mm of the specimen at point of failure.

Table V Flexural Strength Of Concrete

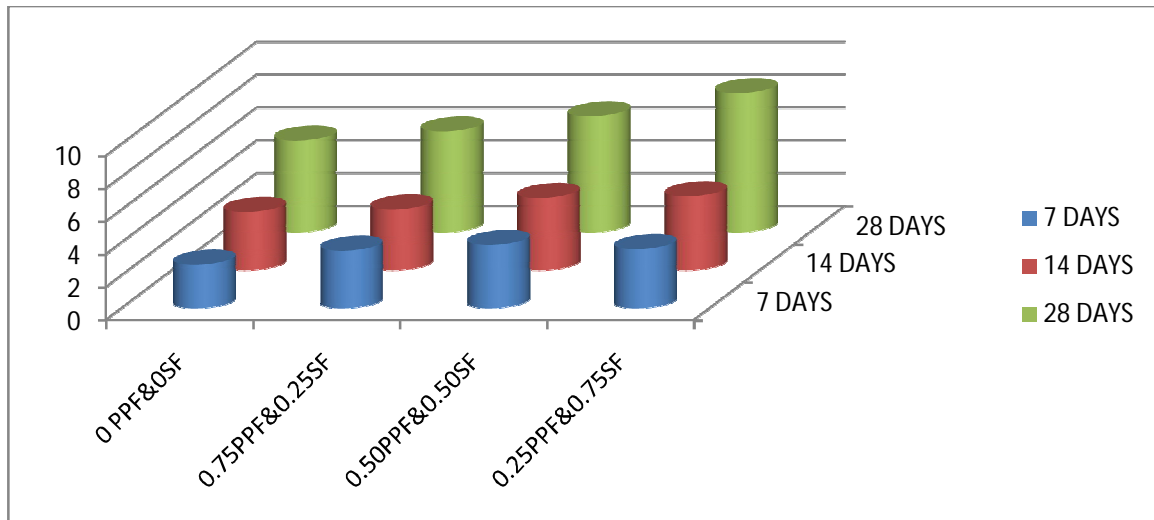
SI.NO	PRISM			7 DAYS COMPRESSIVE STRENGTH (Mpa)	14 DAYS COMPRESSIVE STRENGTH (Mpa)	28 DAYS COMPRESSIVE STRENGTH (Mpa)
	% OF FIBRE	% OF POLY PROPYLENE FIBRE	% OF STEE FIBRE			
1	0	0	0	2.65	3.55	5.58
2	1.0	0.75	0.25	3.5	3.7	6.14
3	1.0	0.50	0.50	3.85	4.4	7.06
4	1.0	0.25	0.75	3.6	4.5	8.47

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VI. CONCLUSION

The maximum compressive strength reaches in HFRCSF 0.75% PP 0.25% i.e. 75% steel fibres 25% of polypropylene fibres is high compared to other proportion and conventional concrete. The compressive strength increase by 30%. The split tensile strength increase by 28%. The flexural strength increase by 45%. Increasing the percentage of steel fibres in Hybrid combination reduces the slump value.

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