COMPARISON OF PERFORMANCE OF NON METALLIC FIBRE REINFORCED CONCRETE AND PLAIN CEMENT CONCRETE

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Abstract: *If properly designed, constructed and maintained, reinforced or pre-stressed concrete structures are generally very durable. However, for structures in aggressive environment , corrosion of steel can be significant problem. Examples of structures that may be particularly at risk include marine structures, bridges subjected to de-icing salts and industrial buildings. In the last decade, there has been a considerable increase in interest in the use of non-metallic reinforcement to cope with this corrosion problem at many institution, advanced composite reinforcing materials have been developed, typically consisting of align continuous fibers embedded in resin and shaped to form beams and slabs, grid shape structures.*

Synthetic fibers used in our study are Polypropylene and Polyester. Recron Fibers are engineered micro fibers with a unique "Triangular" Cross-section, used as secondary reinforcement of Concrete. It complements Structural Steel in enhancing Concrete's resistance to shrinkage cracking and improves mechanical properties such as Flexural / Split Tensile and transverse Strengths of Concrete along with the desired improvement in Abrasion and Impact Strengths.

Compressive strength test and flexural strength tests was conducted on the cubical and beam specimens respectively for all the mixes at different curing periods as per IS 516 (1991). Three cubes of size 150 mm x 150 x 150 mm were cast and tested for compressive strength.

Key Words: Fibre Reinforced Concrete, Polypropylene Fibre, Polyster Fibre, Flexural strength and Sorptivity test.

1.INTRODUCTION

Transportation contributes to the economic, industrial, social and cultural development of a country. Even though there are four modes of transportation, namely, roadways, railways, waterways and airways the transportation by road is the only mode which can give maximum service to one and all. This mode has maximum flexibility for travel with reference to route, direction, time and speed of travel etc. Therefore the construction of roads and its maintenance has got much importance than other modes of transportation.

2.FIBER REINFORCED CONCRETE

Plain concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Internal micro cracks are inherently present in the concrete and its poor strength is due to the propagation of such micro cracks, eventually leading to brittle fracture of the concrete.

In plain concrete and similar brittle materials, structural cracks (micro-cracks) develop even before loading, particularly due to drying shrinkage or other causes of volume change. The width of these initial cracks seldom exceeds a few microns, but their other two dimensions may be of higher magnitude.

When loaded, the micro cracks propagate and open up, and owing to the effect of stress concentration, additional cracks form in places of minor defects. The structural cracks proceed slowly or by tiny jumps because they are retarded by various obstacles, change of direction in bypassing the more resistant grains in matrix. The development of such micro cracks is the main cause of inelastic deformations in concrete.

It has been recognized that the addition of small, closely spaced and uniformly dispersed fibers to concrete would act as crack arrester and would substantially improve its static and dynamic properties. This type of concrete is known as Fiber Reinforced Concrete.

Fiber reinforced concrete can be defined as a "composite material consisting of mixtures of cement mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibers".

The concept of using fibers as reinforcement is not new. Fibers have been used as reinforcement since ancient times. Historically, horsehair was used the concept of composite materials came into being and fiber-reinforced concrete was one of the topics of interest. Once the health risks associated with asbestos were discovered, there was a need to find a replacement for the substance in concrete and other building materials. By the

1960s, steel, glass (GFRC), and synthetic fibers such as polypropylene fibers were used in concrete. Research into new fiber-reinforced concretes continues today.

3.MATERIALS USED

The materials used for the preparation of concrete samples were cement, water, aggregates, water reducing agent admixture and the fibers.

3.1 Cement

Penna cement 53 grade as per specified IS-269:1989

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Table -1: Properties of Cement

Specific gravity	3.15
Fineness of cement	225 m2/kg
Initial setting time	30 min
Final setting time	600 min

3.2 Coarse Aggregates

Aggregates which retain on 4.75 mm sieve
Grading of CA is supplied in nominal sizes.
Granite, angular crushed of maximum size 20 mm confirming to is-383:1970 is used.
Proportions of other sizes are determined as per is-2386:1986.

3.3 Fine Aggregates

Aggregates passing 4.75 mm sieve.
Fines are graded into zones based on their fineness.
Based on percentage passing through 600 micron sieve gives the zone of the aggregate.
River sand is used.

3.4 Synthetic Fibers

Synthetic fibers used in our study are Poly propylene and Polyester. Recron Fibers are engineered micro fibers with reinforcement of Concrete. It complements Structural Steel in enhancing Concrete's resistance to shrinkage cracking and improves mechanical properties such as Flexural / Split Tensile and transverse Strengths of Concrete along a unique "Triangular" Cross-section, used as secondary with the desired improvement in Abrasion and Impact Strengths. Recron' 3s Fibers are manufactured in an ISO 9001:2000 facility for use in Concrete as a "Secondary Reinforcement" at a rate of dosage varying from 0.1% to 0.4% by volume (0.9kgscu.M — 3.60K'Cu.M)

Fig-1: Polypropylene fibers

Fig-2: Polyester fibers

4.EXPERIMENTAL PROCEDURE

M45 grade was chosen according to the mix design three different concrete samples are prepared with two different fibers namely polypropylene, polyester.

Control concrete was used as the reference for comparing the performance of the fiber. The cement content, water cement ratio and admixture dosage adopted were 420 Kg/cu.m, 0.4 and 0.5%. According to the manufacture the dosage of fibers was adopted for the concrete mixes. Hand mixing is done to mix the ingredients of concrete.

In mixing procedure, aggregates are added and allowed to mix uniformly.Next cement is added and waited for uniform mix .Then little water is added before the addition of water reducing admixture Akarsh SP 123 which will react with the cement paste,then remaining water is added and is well mixed. Slump test is conducted and slump value is recorded before casting in the moulds.

Extreme care was taken to simulate similar conditions for all concrete mixes cast in a day including the materials used.Concrete specimens are casted in steel moulds. Sizes of Cube moulds: 0.15 X 0.15 X 0.15 Cu m. The above procedure must be used for the preparation of Beams. Concrete specimens are casted in steel moulds. Sizes of Beam. 0.50 X 0.10 X 0.10 Cu m. The specimens are cured in water at temperature of 27oc after de-molding after 1 day.

Comparison is done between fiber concrete and control concrete with compressive strengths of corresponding cubes and flexural strengths of beams.

Table – 2: Mix Proportion For 1 m3 Concrete

CEMENT Kg	FINE AGGREGATE Kg	COARSE AGGREGATE Kg	WATER Kg	ADMIXTURE
410	725	1170	160	0.5 – 0.8 % of weight of cement

5.RESULTS AND DISCUSSIONS

The various cubes are casted and tests were conducted on the cubes after standard curing and results are as follows:

5.1 Compressive Strength

Table -3: Compressive Strength of Control Sample

Cubes	Slump	Day	Wieght	Strength	Average compressive strength
1	50	7 days	8.605	44.75	44.93
2	50	7 days	8.57	45.06	
3	50	7 days	8.55	44.93	
4	50	14 days	8.15	58.75	56.77
5	50	14 days	8.14	55.68	
6	50	14 days	8.17	55.86	
7	50	28 days	8.46	67.51	69.26
8	50	28 days	8.49	69.73	
9	50	28 days	8.45	70.53	

Table -4: Compressive Strength of poly propylene Sample

Cubes	Slump	Days	Wieght	Strength	Average compressive Strength (N/mm2)
1	50	7 days	8.395	46.22	48.03
2	50	7 days	8.415	48.8	
3	50	7 days	8.44	49.06	
4	50	14 days	8.42	57.55	56.78
5	50	14 days	8.445	56.8	
6	50	14 days	8.53	56	
7	50	28 days	8.47	70.97	70.47
8	50	28 days	8.47	70.48	
9	50	28 days	8.438	69.95	

Table -5: Compressive Strength of Polyester Concrete Sample

Cubes	Slump	Days	Wiegh t	Strength	Average compressive strength (N/mm^2)
1	50	7 days	8.62	49.15	49.03
2	50	7 days	8.49	46.8	
3	50	7 days	8.59	51.15	
4	50	14days	8.19	54.844	54.61
5	50	14days	8.38	55.77	
6	50	14days	8.37	53.24	
7	50	28days	8.44	64.13	72.47
8	50	28days	8.40	76.35	
9	50	28days	8.42	76.93	

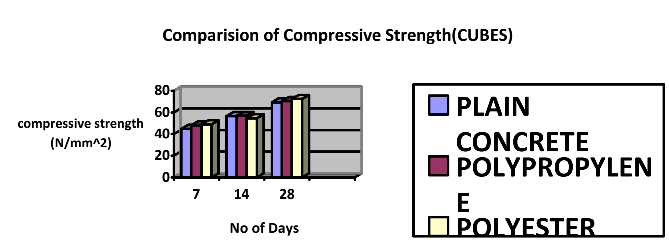

Fig-3: Comparision of compressive strength

The Compressive strengths of all the samples are tabulated below.

Table -6: Comparison of Compressive Strengths of concrete cubes

Sl. no	Sample	Grade of concrete	Compressive strength (N/mm²)		
			7 DAYS	14 DAYS	28 DAYS
1	Control sample	M-45	44.93	56.77	69.26
2	Concrete with polypropylene fiber	M-45	48.03	56.78	70.47
3	Concrete with polyester fiber	M-45	49.03	54.61	72.47

5.2 Flexural strength

Table -7: Flexural strength of Plain Concrete Sample

Beams	Slump	Days	Weight	Strength	Average Flexural strength (N/mm²)
1	50	7 days	11.50	3.06	3.07
2	50	7 days	11.49	3.10	
3	50	7 days	11.50	3.05	
4	50	14days	11.50	3.42	3.73
5	50	14days	11.51	3.92	
6	50	14days	11.50	3.86	
7	50	28days	11.49	5.23	5.59
8	50	28days	11.50	5.86	
9	50	28days	11.50	5.68	

Table -8: Flexural strength of Poly proylene Concrete Sample

Beams	Slump	Days	Weight	Strength	Average flexural strength
1	50	7 days	11.49	4.27	4.26
2	50	7 days	11.49	4.52	
3	50	7 days	11.50	4.00	
4	50	14days	11.50	5.03	5.20
5	50	14days	11.51	5.28	
6	50	14days	11.51	5.30	
7	50	28days	11.50	6.07	6.18
8	50	28days	11.49	6.29	
9	50	28days	11.49	6.20	

Table -9: Flexural strengths of Poly Ester Concrete Sample

Beams	Slump	Days	Weight	Strength	Average flexural strengths (N/mm²)
1	50	7 days	11.51	5.39	5.16
2	50	7 days	11.49	5.00	
3	50	7 days	11.49	5.10	
4	50	14days	11.51	6.09	6.16
5	50	14days	11.50	6.22	
6	50	14days	11.51	6.18	
7	50	28days	11.50	6.57	6.63
8	50	28days	11.49	6.50	
9	50	28days	11.51	6.82	

The flexural strengths of all the samples are tabulated below:

Table -10: Comparison of Flexural Strengths of concrete beams

Sl.no	Sample	Grade of concrete	Flexural strength (N/mm²)		
			7 days	14 days	28 days
1	Control sample	M-45	3.07	3.73	5.59
2	Concrete with polypropylene fiber	M-45	4.26	5.20	6.18
3	Concrete with polyester fiber	M-45	5.16	6.16	6.63

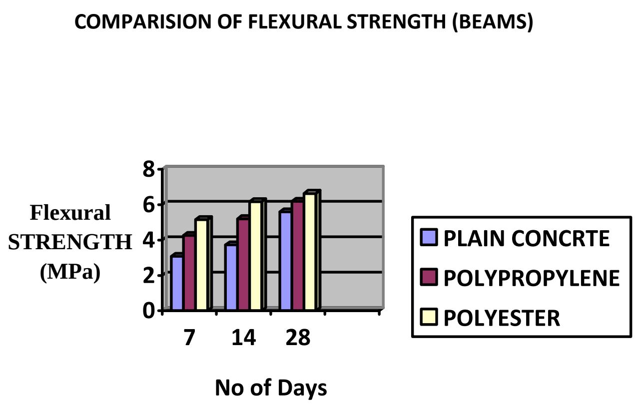

Fig-4: Comparision of flexural strength

The compressive strength and flexural strength of polyester has higher values when compared to other samples and control sample has least value. The compressive strength of the polyester reinforced concrete is 72.47N/mm2 which is far better than required i.e. 45N/mm2 and the flexural strength is 6.63 N/mm2 which is greater than control samples flexural strength. So inclusion of polyester fibers in concrete increases not only strength but also resists cracking which is far better than required

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5.3 Split tensile strength

Table -11: Split tensile strength of FRC

% of Fibers	Age (days)	Split tensile strength (MPa)	% Variation of split tensile strength of HFRC over controlled concrete
0	7	2.59	0
0.5		2.74	5.79
1		2.88	11.20
1.5		2.95	13.90
2		2.62	1.16
0	28	3.09	0
0.5		3.25	5.18
1		3.34	8.09
1.5		3.41	10.36
2		3.21	3.88

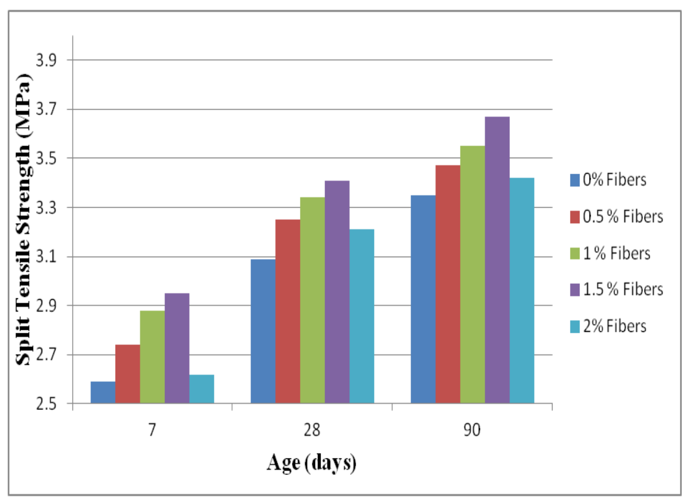

Fig-5: Split tensile strength versus Age

Split tensile strength was also tested for the same mixes with the addition of various percentage of fibers i.e., of 0%, 0.5%, 1%, 1.5% and 2% by volume and weight of cement in concrete. The samples were tested after curing periods of 7, 28 and 90 days. It was observed that there was a significant increase in tensile strength with the increase in percentage of fibers from 0% to 1.5% in all curing periods.

After 7 days of curing, 1.5% fibers sample exhibited a tensile strength of 2.95 MPa, whereas after 28 days of curing it was 3.41 MPa .

5.4 Sorptivity test

Table -12: Sorptivity test results of HFRC

% Fibers	Dry weight (gm)	Wet weight (gm)	Sorptivity (10^{-5} mm/min$^{0.5}$)
0	8108	8112	3.24
0.5	9036	9044	6.49
1.0	8624	8636	9.73
1.5	8642	8655	10.54
2	8672	8687	12.17

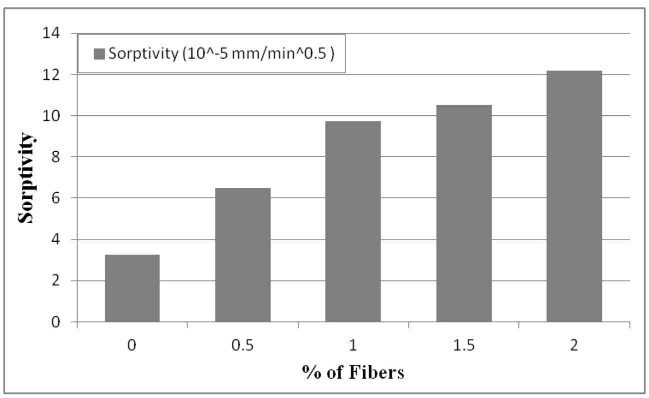

Fig-6: Comparision of sorptivity test on FRC

From the Table 8.0 and it is clear that the sorptivity values have been increasing from 0% to 2%. At 0.5% fiber percentage the sorptivity value is 3.24. As the fiber percentage is increased from 0.5%, 1%, 1.5% and 2% the values of sorptivity are 6.49, 9.73, 10.54 and 12.17 respectively. Finally I concluded that the percentage of fibers influence the sorptivity of HFRC directly. Here, the sorptivity values are in 10^{-5} mm/ min$^{0.5}$

6.CONCLUSION

From the discussions it has been proved that the fiber-reinforced concrete not only has capability to reduce the cracks but also has capability of inducing additional compressive strength to the concrete. Fiber reinforced concrete utilization in pavements reduces the maintenance cost by reducing the overall lifecycle cost though it has high initial cost. The inclusion of fibers is more advantage in case of pavements by reducing the crack formation and also giving additional early compressive strength to the concrete.

The concrete with Polyester fiber is most efficient in inducing the additional strength to the concrete when compared to other fibers.The concrete with Polyester fiber is most economical when compared to other fibers.
So we conclude that the concrete with Polyester fiber is the best fiber for Pavement Quality Concrete when compared to Control plain sample and Polypropylene fiber.

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