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Experimental study on "behaviour of HPC using steel fibers, polypropylene fibers & polymers"

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ABSTRACT

There are many ways to minimize the failure of the structures made up of reinforced concrete. The custom approach is to adhesively bond fiber polymer Composite on to the structure. This also helps to increase the toughness and tensile strength & to improve the cracking & deformation characteristic of the resultant composite. But this method adds another layer, which is prone to degradation, when exposed to marine environment due to surface blistering. As a result adhesive bond strength is reduced, which results in the de-lamination of composite. So, the approach is to use fibers in concrete known as FRC. This method of reinforcing the concrete substantially alters the properties of non-reinforced cement based matrix which is brittle in nature, possesses little tensile strength compared to the inherent. Compressive strength.

Introduction

The principle reason for incorporating fibers into a cement matrix is to increase the toughness & tensile strength & to improve the cracking deformation characteristics of the resultant composite. In order for fiber reinforced concrete to be a viable construction material, it must be able to compete economically with existing reinforcing system. Only a few type of fibers have been found suitable for commercial applications. This experimental study deals with concrete reinforced with the polypropylene fibers, steel fibers & polymer S.B.R. latex. For which M 35 Grade of concrete is tested for compressive, flexural, split tensile, pull out test & Rebound Hammer test. Results of polypropylene fiber, steel fiber reinforced concrete with polymer & without polymer are compared with test results of P.C.C.

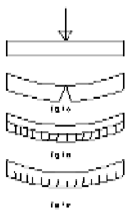

Fig. (1) Flexture failure of Beams with

a) No Reinforcement.

b) Continuous bars Or Prestressing wires.

c) Short Discrete Fibres

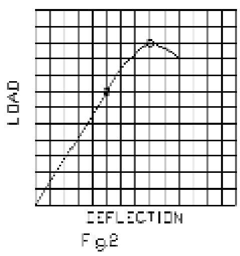

Fig.2 Load Deflection curve

Mechanism of Polymerized Fiber reinforcement:

The idea behind the FRC as shown in Fig. (1). Without the fibres the crack runs through the material very easily. It does not matter whether the crack is present initially or not. Brittle materials including concrete possess minimum resistance to any charge row flow. When concrete is reinforced with small discrete fibres, the fibres effectively help in delaying the occurrence of the first crack. However if cracks are present & cracking strain of PFRC is much greater say 10 times greater than the cracking strain of concrete, then the fibres remains in place, bridging the cracks. Of course the fibres besides having a larger failure strain than the matrix must be able to withstand the load placed upon them when the matrix breaks. This means that they must also be sufficiently strong. If both conditions are fulfilled then even if the crack in the concrete runs across the piece, the piece will remain unbroken because the fibre hold it together. If at this stage straining is continued the weak concrete will break again at another place & will again be hold together by the fibres bridging the cracks. If FRC material is loaded in flexture, two distinct stages are generally observed in load deflection curve as shown in Fig.(2). The curve can be considered almost linear up to point X& beyond point X, the curve is significantly non-linear and attains a maximum at point Y. The load of stress corresponding to point X has been called "First crack strength" as " Elastic Limit" or "Proportionality Limit" while the stress corresponding to Y has been called as "Ultimate Strength".

Components of Polymerized fibre Reinforced Concrete:

Polymerised FRC is a composite material consisting of Cement, Aggregate, Water, discrete discontinuous fibres and cement composites. As the ingradients are responsible for producing good as well as bad concrete, their contributions should be clearly understood. The fibre is often described by convenient numerical parameters called "Aspect ratio". It is the ratio of length of the fiber to the least lateral dimension of the same. It is normally ranges from 30 to 150 for fiber length of

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6mm to 75mm. The further development of Reinforced concrete entirely depends upon the utility of appropriate type of fiber.

Technical specifications for fibers and Polymers used:

Polypropelment fibers:

Absorption - Nil.
Fibre length - 6.35 mm to 50.8 mm.
Melt Point – 324^0F.
Thermal conductivity – 10w
Acid & Salt resistance – High
Sp. Gravity – 0.91
Young's modulus – 0.5 to 3.5 Kn/mm^2
Alkali resistance – Alkali Proof
Ignition Point - 1-100^0 F.
Electrical Conductivity - 10w.

Steel Fibre :

Fiber – Xorex
Min. Tensile Strength - 828 Mpa.
Fiber length – 25.4, 38 and 50.8 mm
Avg. Equivalent dia – 1 mm.
Avg. Aspect Ratio – 25,38,50.
Deformation – Continuously deformed Circular Segments.
Appearance – Bright & clean wire.

S.B.R. Latex :

Brand Name - Perma Bond.
Base – Polymer latex.
Appearance – Milky white.
pH - > 8
Viscosity in Cps - 300-500.
Setting Characteristics – slow.
Sp. Gravity – 1.05 to 1.10

Properties & Applications & FRC:

Behaviour in Compression: The increase in comp. strength due to addition of fibres in variable ranging from 0 to 20 percent. A noticeable increase in strain at peak load and a significant increase in ductility resulting in substantially higher toughness generally characterize this charge. This increased toughness is useful in preventing sudden and explosive failure under static loading and in absorbing energy in dynamic loading.

Behaviour in flexure:

A significant difference in behaviour of plain and FRC is found in the flexture test. When the fiber concrete beams are loaded in flexture, two stages of behaviour are observed in load deflection curve as shown in fig. 2. Two factors that significantly influence the flexture test are fibre type and fibre volume. The effect of steel fibre on ultimate flextural strength is significant & with its better pullout performance, it is especially effective at large deformations and crack widths. Polymeric fibres, having relatively low modulus of elasticity, slightly reduce the initial stiffness & ultimate strength but their better extensibility results in a appreciable post-peak performance and toughness.

Direct tension: There is no standard test to determine the stress- strain curve of FRC in direct tension. Various parameters like size of specimen, method of testing, stiffness of the testing machine, gauge length, and unpredictable cracking pattern, will influence curves and tensile strength, the strength in direct tension is generally some as that of plain concrete. However, the toughness of FRC is one of the two orders of magnitude higher due to the large frictional Energy developed during fibre pullout.

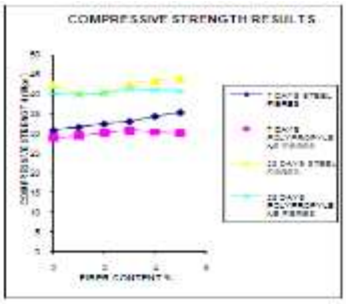
Application of FRC:

1) Hydraulic Structures.
2) Highways & Airfield Pavements.
3) Concrete pipes.
4) Shortcrete Applications.
5) Blast resistant structures.
6) Thin shells & walls

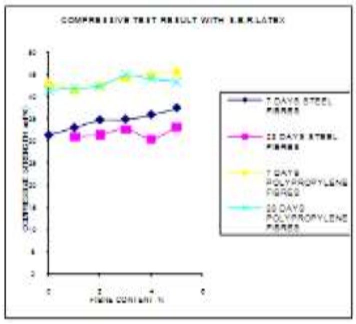
Properties of Material used:

- Grade of concrete M-35
- Cement used – 53 grade ppc.
- Sp.Gr.of Cement – 3.07
- Standard consistency of Cement – 33%
- Initial & find setting time of cement – 46 min. & 450 min.
- Sp.Gr.of 20mm Agg- 2.63
- Water absorption of 20mm Agg – 2.23%
- Surface moisture of 20mm Agg – 1.01%
- Sp.Gr. of 12-10 mm Agg. – 2.84
- Water Absorption of 12-10mm Agg- 1.87%
- Surface Moisture of 12-10 mm Agg. 0.8%
- Sp. Gr. Of Sand – 2.60
- Water Absorption of Sand – 2.31%
- Free surface moisture – 0.80
- W/c. Ratio - As per I.S. 10262-1994 W/c Ratio require for fek = 43.25N/mm^2 is 0.34.
- = Mix preparation
- Water : Cement : F.A : C.A.
- 0.37 : 1 : 1.02 : 2.67

Graphical Representation of Results



Graph:1



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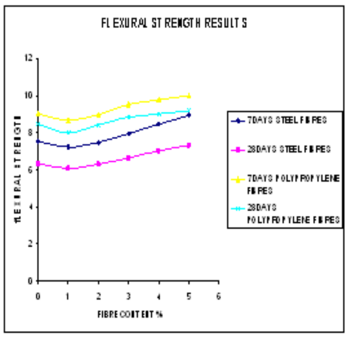

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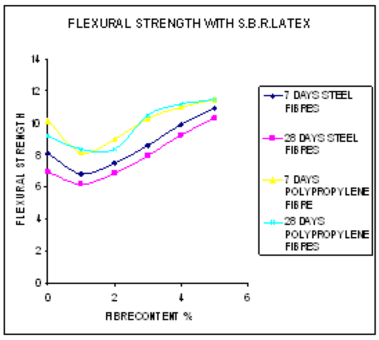

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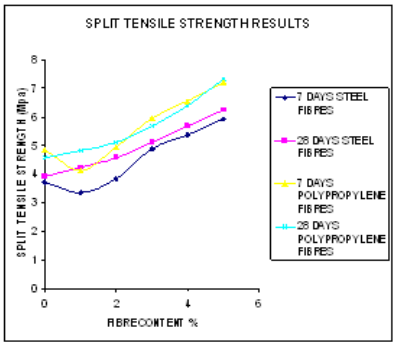

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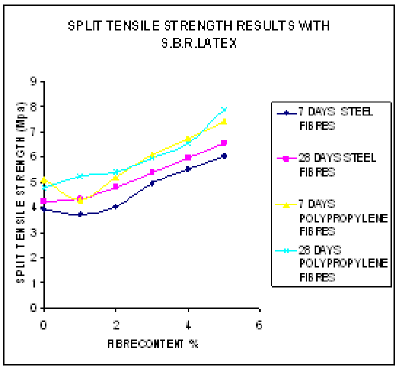

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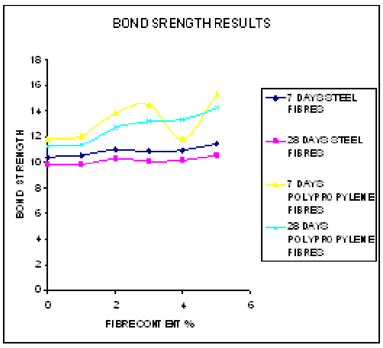
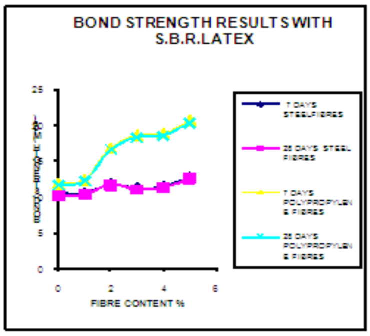


Graph: 7



Conclusion:

1) Average Comp. Strength of Polypropylene FRC is increased by @ 10% over PCC for 7 days & 2.5% for 28 days, so it can be concluded that Avg. Comp. Strength in creases with increases in fibre contact.

2) Maximum Comp. Strength for polypropylene fibre is obtained at 0.3% of fibre content i.e. 14.47% for 7 days & 8.36% for 28 days.

3) There is no increase in flexural strength initially but there is substantial increase in flexural strength by the increase in fibre content & polymer content.

4) It is also observed that split tensile strength is increased by 58.08% with & without polymer content.

5) Bond strength increases after 0.2% increase in fibre content.

6) It is observed during testing that fibre embedded in concrete specimen prevent it from specialty into pieces.

7) The crack holding capacity of concrete is increased by the addition of fibres to the concrete.

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Comp.Test Results with Fibres:

Sr. No.	Fibre contact in percentage	Avg.Comp.Strength After 7 days for steel fibres N/mm^2	Avg.Comp strength After 7 days for Polyprolelen fibres Mpa	Avg. Compos After 28 days for steel fibres	Avg. Com strength after 28 days for polypropelen fibres.
1	0	30.88	28.90	42.40	40.23
2	1.0	31.70	29.45	40.23	39.94
3	2.0	32.52	30.20	40.48	40.29
4	3.0	33.13	30.85	42.66	41.26
5	4.0	34.42	30.39	43.51	40.99
6	5.0	35.40	30.12	44.12	40.81
Comp.Test Result S.B.R. Latex (7.5%)					
1	0	31.22	30.94	43.20	41.37
2	1.0	32.92	31.33	41.45	41.80
3	2.0	34.66	32.62	42.62	42.30
4	3.0	34.82	30.42	44.35	44.83
5	4.0	35.86	33.14	44.95	43.92
6	5.0	37.40	32.84	45.86	43.32

Flextured Strength test Results:

Sr. No.	Fibre contact	For 7 days steel fibres	For 7 days Polypropylene fibres	For 28 days steel fibres	For 28 days polypropylene fibres.
1	0	7.52	6.32	9.02	8.46
2	1.0	7.23	6.10	8.67	8.0
3	2.0	7.50	6.30	9.0	8.44
4	3.0	7.94	6.64	9.53	8.84
5	4.0	8.46	7.02	9.80	9.04
6	5.0	8.94	7.34	10.0	9.19

Flextured Strength with SBR letex (Polyer 7.5%):

Sr. No.	Fibre contact	For 7 days steel fibres	For 7 days Polypropylene fibres	For 28 days steel fibres	For 28 days polypropylene fibres.
1	0	8.10	6.88	10.12	9.20
2	1.0	6.80	6.16	8.16	8.34
3	2.0	7.48	6.84	8.97	8.35
4	3.0	8.59	7.95	1.30	10.48
5	4.0	9.88	9.24	10.97	11.15
6	5.0	10.92	10.28	11.46	11.48

Split Tensile Strength:

Sr. No.	Fibre contact	For 7 days steel fibres	For 7 days Polypropylene fibres	For 28 days steel fibres	For 28 days polypropylene fibres.
1	0	3.72	3.92	4.85	4.56
2	1.0	3.35	4.23	4.12	4.83
3	2.0	3.83	4.56	4.93	5.12
4	3.0	4.87	5.10	5.95	5.67
5	4.0	5.37	5.68	6.55	6.37
6	5.0	5.93	6.23	7.20	7.32

Split Tensile Strength with SBR latex:

Sr. No.	Fibre contact	For 7 days steel fibres	For 7 days Polypropylene fibres	For 28 days steel fibres	For 28 days polypropylene fibres.
1	0	3.92	4.23	5.12	4.78
2	1.0	3.72	4.36	4.32	5.23
3	2.0	4.03	4.78	5.21	5.43
4	3.0	4.98	5.37	6.12	5.98
5	4.0	5.53	5.98	6.72	6.56
6	5.0	6.02	6.56	7.42	7.88

Bond Strength in MPa:

Sr. No.	Fibre contact	For 7 days steel fibres	For 7 days Polypropylene fibres	For 28 days steel fibres	For 28 days polypropylene fibres.
1	0	10.42	9.82	11.84	11.21
2	1.0	10.55	9.86	12.09	11.39
3	2.0	11.00	10.26	13.84	12.71
4	3.0	10.83	10.06	14.52	13.22
5	4.0	10.93	10.15	11.84	13.31
6	5.0	11.42	10.52	15.35	14.22

Bond Strength with 7.5% SBR letex (Polymer):

Sr. No.	Fibre contact	For 7 days steel fibres	For 7 days Polypropylene fibres	For 28 days steel fibres	For 28 days polypropylene fibres.
1	0	10.72	10.21	11.92	11.58
2	1.0	10.57	10.37	12.47	12.21
3	2.0	11.90	11.69	16.84	16.58
4	3.0	11.28	11.07	18.56	18.30
5	4.0	11.54	11.33	18.85	18.59
6	5.0	12.76	12.65	20.63	20.37