

An Experimental Investigation of Mechanical Properties of Chemically Treated Polyester Fibre Reinforced Concrete

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Abstract- Polyethylene terephthalate (PET) fibers have been used in fiber reinforced concrete, but poor dispersibility of PET, due to low wettability, cause reduce strength of the fiber reinforced concrete. However, the hydrophobic nature of PET surface results poor wettability with ionic surface of cement, sand and other concrete admixture, proper bonding between the hydrophobic PET and hydrophilic cement matrix is possible with surface modification of polyester fiber. In present work attempt to modify the PET fiber surface by chemical treatment at ambient temperature and see the effects on compressive strength, split tensile strength and flexural strength. A comparison will be drawn between all these materials.

In this project treated polyester fiber was used to prepare fiber reinforced concrete. The polyester fiber was used at different percentages (0%, 0.20%, 0.25%, & 0.30%) by weight of cement and comparison of strength of concrete for treated fiber reinforced concrete at different percentage was carried out. The concrete samples were prepared (cube, cylinder & beam) and cured in normal water for 7, 28 and 56 days.

The study was carried out to see the effect of acidic rain on fiber reinforced concrete. Acidic water was prepared by using the concentrated HCl in deionised water respectively. To see the environmental effect, the Concrete samples were cured in acidic for 56 days. The samples were tested for compressive strength, split tensile strength and flexural strength and found that 0.25% of PET fiber by weight of cement may be recommended for optimum dose. The studies indicate that the dispersion of treated fiber in concrete was better with respect to normal fiber. The fiber reinforced concrete was also more resistance against acidic environment with respect to normal concrete. In all aspects, the treated fibre reinforced concrete was found better than normal reinforced concrete.

I. INTRODUCTION

The concept of using fibre as reinforcement is not new. From ancient time fibres have been used as reinforcement. Historically, horsehair was used in mortar and straw in mud bricks. In the 1900s, asbestos fibres were used in concrete. In 1911 Porter found that fibre could be used in concrete. Nylon, the first synthetic fibre, was developed by Wallace Carothers, an American researcher at the chemical firm DuPont in the 1930s. The first polyester fibre was introduced by John Rex Whinfield and James Tennant Dickson, British chemists working at the Calico Printers' Association, in 1941

A composite material a non uniform solid consisting of two or more different materials that are mechanically bonded together. Each of the various components retain its identity in the composite and maintains its characteristic structure and properties. Generally, the structure of a composite consists of two phases, matrix and reinforcement. The matrix is a continuous phase and the reinforcement is a discontinuous one. The required property of reinforcements is to enhance the strength of the composite and the matrix has the ability of bonding the reinforcements. Composites are produced when two or more materials or phases are used together to give a combination of properties that cannot be achieved otherwise. Fibre-reinforced polyester composites provide improvements in strength, stiffness and toughness. They also could have corrosion resistance in different hostile environments. By using different glass fibres electrical resistivity is controllable also. So, the fibre is used as reinforced material.

II. LITRETURE REVIEW

M.Haghighatkishet. al. (1992) studied the structural effects on polyester fibre due to its alkakine hydrolysis. Partially oriented and fully drawn poly(ethylene terephthalate)

(PET) fibres were treated with aqueous solution of 10% sodium hydroxide at 30°C. The weight loss density, diameters and birefringence of fibres were measured. X-ray diffraction studies were carried out and SEM photomicrographs of fibres were obtained. Both yarn types showed progressive weight loss and reduction of diameters with increasing time of alkaline treatment. There were no changes in orientation and crystallinity of fibres. Surface morphology differed between partially oriented and fully drawn fibres. It is concluded that the reaction occurs preferentially in the region of low structural order on the surface of fibres.

Bing Chen et. al. (2005) investigated the mechanical properties of polymer-modified concretes containing expanded polystyrene beads. Styrene-butadiene rubber (SBR) latex as a polymeric admixture was applied in lightweight expanded polystyrene (EPS) concrete

Anita Singh et. al. (2008) studied about acid rain and its ecological consequences. Acidification of rain-water is identified as one of the most serious environmental problems of transboundary nature. Acid rain is mainly a mixture of sulphuric and nitric acids depending upon the relative quantities of oxides of sulphur and nitrogen emissions

III. OBJECT

The present work is aimed to investigate the effect of treatment of polyethyleneterephthalate (PET) fibre with NaOH on the strength of concrete.

- To know the optimum dosage of treated polyester fibre in concrete.
- Selection of mix design for M25 grade of concrete mix.
- To study the properties of hardened concrete (compressive strength, split tensile strength and flexural strength).
- To study the environmental effect (acidic environment) on the characteristic strength of fibre reinforced concrete.

IV. MATERIAL AND METHODS

Table 1 Material used

Sno.	Name of the material	Source of the materials
1	Cement	PSC manufactured by ACC
2	Fine aggregate	Local from Bilaspur
3	Coarse aggregate	Local from Bilaspur
4	Polyester Fiber	Shree Yamuna Ji enterprises Bilaspur
5	NaOH	Saraswati enterprises Dayal and Bilaspur
6	HCL	Saraswati enterprises Dayal and Bilaspur
7	Distilled Water	Filter Wala CMD Chowk Bilaspur
8	Water	Tap water

1. Treatment of polyester fibre and addition of fibre

Normal or untreated fibre was not able to disperse uniformly in concrete. So, the fibres were treated with 1.8% NaOH (alkaline) solution to see dispersion effect.

For the treatment of fiber the following steps were taken:-

- Preparation of 1.8% NaOH solution (by weight):- 1.8% NaOH solution was prepared by dissolving 1.8gm of NaOH in 20-30ml of distilled water and make up the volume of 100 ml.
- Fibers were immersed in 1.8% NaOH solution for 24 hours.
- Then after Washed the alkaline treated fiber subsequently 2 to 3 times using distilled water until no alkaline was present in the wash.
- Then the fiber was oven dried at a temperature of 110-120°C for 2-3 hours after the wash. We observe that FTIR Spectra was obtained in each case.

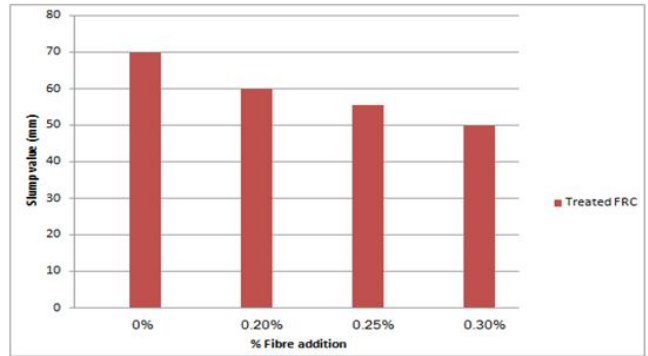
Polyester fibre (12mm length) was added in concrete at percentages of 0%, 0.20%, 0.25%, and 0.30% by weight of cement. This addition was carried out with treated fibre.

Physical and mechanical properties of cement

Properties	Results	Standard Limits (IS: 455)
Consistency	30%	-
Soundness	Expansion 3mm	<10mm
Initial setting time (min)	110 minutes	>30 min
Final setting time	280 minutes	<600 min
Specific gravity	3.20	-
Fineness	3% Retain on 90 micron sieve	<10%
Compressive strength	N/mm ²	N/mm ²
1.3 days	18.10	>16
2.7 days	22.30	>22
3.28 days	33.50	>33

Properties of fine aggregate

S. No.	Test	Fine Aggregate
1	Zone	III
2	Moisture content	0.21%
3	Specific gravity	2.638%
4	Fineness Modulus	2.31%
5	Water Absorption	1.18%



Properties of coarse aggregate

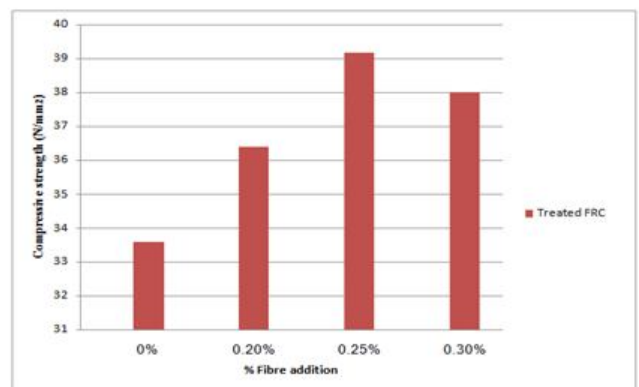
S. No.	Test	Coarse Aggregate
1	Moisture content	0.2%
2	Water absorption	0.60%
3	Specific gravity	2.854%
4	Crushing value	23.86%
5	Impact value	15.89%

Compressive strength test data for fibre reinforced concrete after 7 days

Concrete Mix	Sample	Failure load (kN)	Compressive strength (N/mm ²)	Avg. Compressive Strength (N/mm ²)	Variation of compressive Strength w.r.t F ₀
F ₀	1	518	23.02	23.46	0%
	2	538	23.91		
F _{0.20}	1	552	24.53	24.86	+5.96%
	2	567	25.20		
F _{0.25}	1	600	26.07	26.22	+11.76
	2	580	25.77		
F _{0.30}	1	578	25.68	25.90	+10.40%
	2	588	26.13		

Mix proportion of concrete

S.No.	Mix	w/c ratio	Mix proportion	Mix (mm)	Compressive strength (N/mm ²)	
					7 days	28 days
1	M ₁	0.44	1:1.38:2.77	77	21.43	29.74
2	M ₂	0.46	1:1.40:2.95	70	24.10	34.37

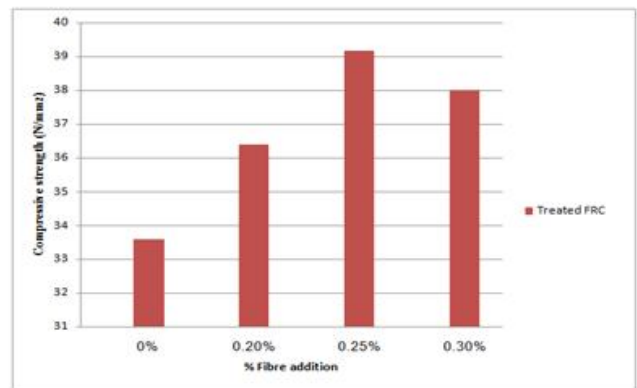


Slump value of fibre reinforced concrete

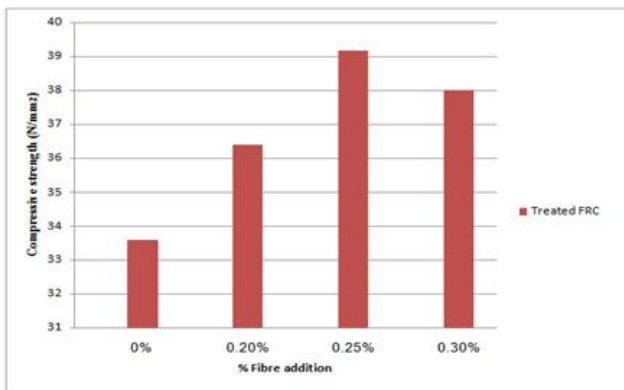
Concrete Mix	Slump(mm)	Variation of slump w.r.t F ₀
F ₀	70	0%
F _{0.20}	60	-14.28%
F _{0.25}	56	-20%
F _{0.30}	50	-27.14%

Compressive strength test data for fibre reinforced concrete after 28 days

Concrete Mix	Sample	Failure load (kN)	Compressive strength (N/mm ²)	Avg. Compressive Strength (N/mm ²)	Variation of compressive Strength w.r.t F ₀
F ₀	1	753	33.46	33.79	0%
	2	768	34.13		
F _{0.20}	1	825	36.66	36.33	+7.51%
	2	810	36.00		
F _{0.25}	1	916	40.70	39.15	+15.86
	2	846	37.60		
F _{0.30}	1	850	37.77	37.99	+12.42%
	2	860	38.22		

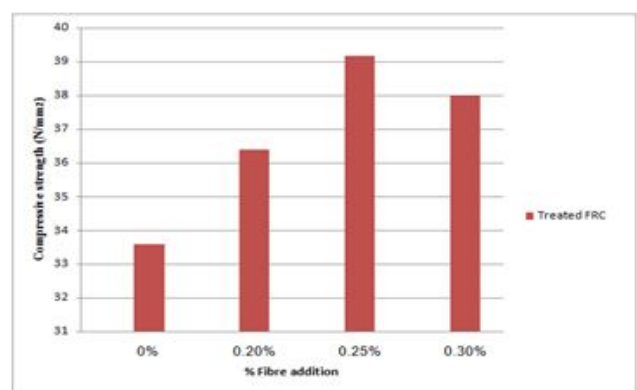


Compressive strength test data for fibre reinforced concrete after 56 days normal water curing



Compressive strength test data for fibre reinforced concrete after 28 days

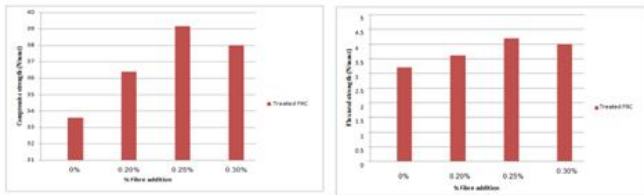
Concrete Mix	Sample	Failure load (kN)	Compressive strength (N/mm ²)	Avg. Compressive Strength (N/mm ²)	Variation of compressive Strength w.r.t F ₀
F ₀	1	814	36.17	36.52	0%
	2	830	36.88		
F _{0.20}	1	905	40.22	39.82	+9.03%
	2	887	39.42		
F _{0.25}	1	1002	44.53	44.08	+20.70%
	2	982	43.64		
F _{0.30}	1	943	41.91	42.31	+15.85%
	2	961	42.71		



Flexural strength test data for fibre reinforced concrete after 7 days

Concrete Mix	Sample	Failure load (kN)	Compressive strength (N/mm ²)	Avg. Compressive Strength (N/mm ²)	Variation of compressive Strength w.r.t F ₀
F ₀	1	753	33.46	33.79	0%
	2	768	34.13		
F _{0.20}	1	825	36.66	36.33	+7.51%
	2	810	36.00		
F _{0.25}	1	916	40.70	39.15	+15.86
	2	846	37.60		
F _{0.30}	1	850	37.77	37.99	+12.42%
	2	860	38.22		

Concrete Mix	Size of beam (mm x mm x mm)	Span (mm)	Failure load (KN)	Flexural strength(N/mm ²)= Pl/bd ²	Variation of flexural strength w.r.t F ₀
F ₀	500 x 100 x 100	400	5.50	2.20	0%
F _{0.20}	500 x 100 x 100	400	6.50	2.60	+16.66%
F _{0.25}	500 x 100 x 100	400	7.50	3.00	+36.36%
F _{0.30}	500 x 100 x 100	400	7.00	2.8	+27.27%

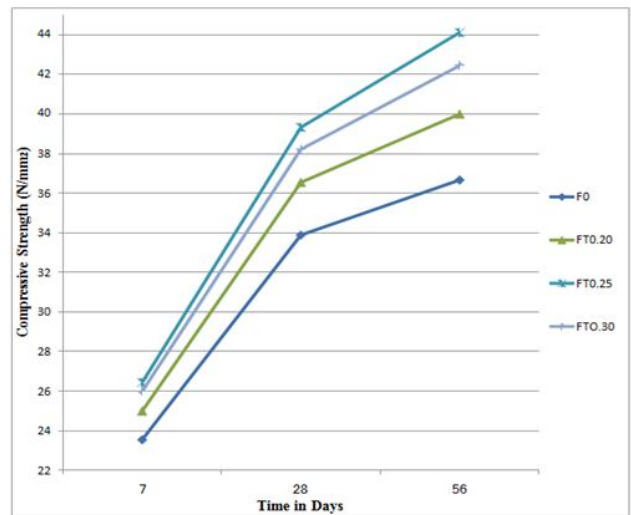


Flexural strength test data for fibre reinforced concrete after 28 days

Concrete Mix	Size of beam (mm x mm x mm)	Span (mm)	Failure load(KN)	Flexural strength(N/mm ²)= Pl/bd ²	Variation of flexural strength w.r.t F ₀
F ₀	500 x 100 x 100	400	8.00	3.20	0%
F _{0.20}	500 x 100 x 100	400	9.00	3.60	+12.5%
F _{0.25}	500 x 100 x 100	400	10.50	4.20	+31.25%
F _{0.30}	500 x 100 x 100	400	10.00	4	+25.00%

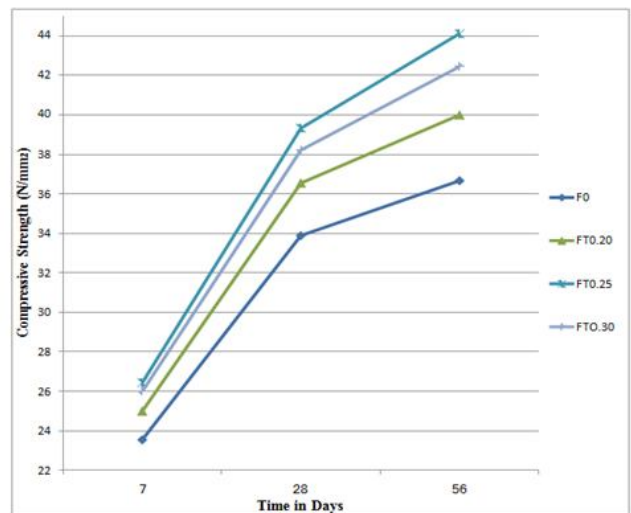
Compressive strength test result for fibre reinforced concrete after 7, 28 and 56 days in normal water curing (NWC)

Concrete Mix	Avg Comp. Strength (N/mm ²) After 7 days	%age Variation of comp.st. w.r.t. F ₀ After 7 days	Avg Comp. Strength (N/mm ²) After 28 days	%age Variation of comp.st. w.r.t. F ₀ After 28 days	Avg Comp. Strength (N/mm ²) After 56 days	%age Variation of comp.st. w.r.t. F ₀ After 56 days
F ₀	23.46	0%	33.79	0%	36.52	0%
F _{0.20}	24.86	+5.96%	36.33	+7.51%	39.32	+9.03%
F _{0.25}	26.22	+11.76%	39.15	+15.86%	44.08	+20.70%
F _{0.30}	25.90	+10.40%	37.99	+12.42%	42.31	+15.85%



Flexural strength of treated fibre reinforced concrete after 7, 28 and 56 days in normal water curing (NWC)

Concrete Mix	Avg Flexural Strength (N/mm ²) After 7 days	%age Variation of Flexural.st. w.r.t. F ₀ After 7 days	Avg Flexural Strength (N/mm ²) After 28 days	%age Variation of strength w.r.t. F ₀ After 28 days	Avg flexural Strength (N/mm ²) After 56 days	%age Variation of strength w.r.t. F ₀ After 56 days
F ₀	2.2	0%	3.20	0%	3.80	0%
F _{0.20}	2.60	+18.88%	3.60	+12.5%	4.60	21.05%
F _{0.25}	3.0	+36.36%	4.20	+31.25%	5.30	39.47%
F _{0.30}	2.8	+27.27%	4	+25.00%	5.10	34.21%



V. CONCLUSION

- The compressive strength, & flexural strength of PET fiber reinforced concrete increases with increase in percentage PET (treated) up to 0.25% fiber by weight of cement and then decrease with increase in percentage fiber.

(a) The compressive strength and flexural strength of treated FRC increased by 16.05%, 50% and 29.41% respectively with respect to 0% addition of fiber, after 28 days of normal water curing.

(b) The compressive strength and flexural strength of treated FRC increase 20.32%, 53.62% and 38.46% respectively after 56 days of normal water curing.

- The workability of treated fiber reinforced concrete was found to be Greater.
- In all cases in this study the treated FRC was found better than normal reinforced concrete.
- With this study, it may be recommend to use 0.25% by weight of cement treated PET FRC for better results.

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