

Investigation of Properties of Fiber Reinforced Concrete Using Rubber Tyre Tube Wastage as Fibers

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Abstract

Fiber reinforced concrete (FRC) is widely used as construction material. Fibers increase the structural integrity of concrete. Steel fibers, glass fibers, synthetic fibers and natural fibers are types of fibers used in FRC. Waste deposition of vehicles tyre after its useful life became critical issue to dispose off. In the present study preliminary investigation is carried out to check the feasibility of waste tyre tube material as fiber material in concrete. Waste tyre tube collected from different sources and cutting to aspect ratio 40 and called Rubber Tyre Tube Fiber (RTTF). Dose of RTTF is decided from the literature pertaining to FRC as 0.5%, 1.00% and 1.5% with respect to volume of concrete. Fresh and hardened properties of concrete are investigated with utilization of RTTF as fiber. Hardened state performance of RTTF reinforced concrete improved over the control mix. RTTF reinforced concrete is more crack resistance than control mix. Flow ability or workability of the concrete decrease with increment of dose of RTTF fiber because of formation of flocks. These flocks in the fresh concrete decrease the workability of concrete.

Keywords

Fiber Reinforced Concrete (FRC), Rubber Tyre Tube Fiber (RTTF), Slump

Introduction

Fiber reinforced concrete (FRC) is a composite material made with Portland cement, aggregate, admixture and incorporating discrete discontinuous Fibers. Plain, unreinforced concrete is a brittle material, with a low tensile strength and a low strain capacity. Randomly distributed fibers in concrete bridge the propagation of crack and minimize the increment in the width of crack. Fibers in the concrete are increases strain carrying capacity of concrete. The main purpose of adding any of Fiber types to concrete is not to prevent cracking but to control it. Steel and polypropylene fibers two mains types of fibers used in worldwide. The recommended dose of the fibers lies in the range of 20-40kg/m³ or 0.25-1.5% by volume of the concrete. As the dose of fiber in the concrete increases then flexural strength of concrete also increases [11]. Inclusion of fibers in the concrete reduced the workability of the concrete. Fibers impart heterogeneity to the FRC. Addition of polypropylene fibers to the concrete is responsible for the balling effect and reduction of the slump. The inclusion of the Fibers into the concrete mix influences its workability, with increasing in the Fiber volume and aspect ratio leading to decreased workability (Hannat, 1978; Swamy, 1974). Fibers are used super plasticizers to minimize the slump reduction of concrete. Fibers delay and control of tensile cracking of FRC [14].

Addition of the fibers slightly affects the compressive strength of the concrete ranging from 0-15%. Tensile strength of concrete improved due to addition of fibers about 30-40% [1]. Area under stress-strain curve is more in FRC as compared to non-FRC. Area under stress-strain curve represents toughness (Newman et al, 2003). Steel FRC is more durable than plain cement concrete and control the shrinkage cracks of the concrete [13].

Comparative experimental investigation reported between plain cement concrete and SFRC for slab on grade. Load – carrying capacity of the slab on ground increase with the use of SFRC. Flexural toughness is the area under stress-strain graph. Flexural toughness of the SFRC is more than the plain cement concrete slab. It is proposed that friction between surface of slab of grade and the sub-grade is negligible effect on the load- carrying capacity [2]. Fiber improved the load- deflection property of the plain cement concrete. Tensile cracks in the FRC slab initiated at the same load irrespective of dose and type of fiber but well below the flexural cracking load. Slab flexural strength of slab is 1.8-2.2 times higher than flexural strength of beam. Flexural strength of the FRC is around 1.4 times flexural strength of the plain cement concrete. The flexural cracking load of the fiber reinforced slabs was 25 -55% higher than the plain concrete slab. Optimum doses of the various types of fibers are proposed for slab on grade [16]. Failure pattern of slab on grade similar is to all types of slab failed under uniform load. As the dose of the steel fiber increase then ultimate load carrying capacity increases [15]. Effect of fiber content and diameter of steel fiber studied on the SFRC slab on grade. Modulus of elasticity tend to decrease with the increment with fiber content.

Toughness of the concrete is mainly depends on the dose of the fibers [12]. Required thickness of the slab on grade depends on the magnitude of loading, modulus of sub-grade, reinforcement and grade of concrete [17].

In India, Rubber tube tyre waste is causing considerable damage to the environment. Rubber being a non-degradable material is difficult to dispose-off. The use of rubber will enhance quality of concrete it will surely reduce environmental pressure and hence an attempt has been made to understand whether they can be successfully used in concrete to improve some of the mechanical properties as in the case of the other fibers. Up till now the studies are being carried out on the various materials such as steel fibers, polypropylene fiber, synthetic fiber, glass fiber etc. In this study the bicycle tube tyre utilized in concrete as a substitute to other fibers which are available in the market.

Methodology

The primary objective of this investigation is to study experimentally the properties of fiber reinforced concrete containing rubber tube tyre fibers. The said material was inserted in the proportions of 0.5%, 1.00% and 1.5% in the concrete mixture with respect to the cementitious material. The properties of concrete, namely, Compressive strength, split tensile Strength and flexural strength were studied on the concrete produced by utilizing the fiber reinforcement concrete mixture. The rubber tyre tube was converted to fiber. Rubber tyre tube was collected from the waste yard of commercial area of Nagpur and were washed and shredded manually to the cross sectional dimension of 1.5 mm by 1.5 mm and length of 60 mm keeping the aspect ratio of 40.

Portland Pozzolana Cement (Fly ash Based)	Fine Aggregate (Natural Sand)	Coarse Aggregate
Fineness = 5%	Fineness Modulus = 2.4	Fineness Modulus = 6.8
Standard Consistency = 29%	Silt Content = 0.75%	Silt Content = 0.25%
Compressive Strength of PPC cubes 7 Days = 18 N/mm ² 28 Days = 48 N/mm ²	Water Absorption = 1.7%	Water Absorption = 0.8%
Soundness of Cement = 4 mm	Specific Gravity = 2.67	Specific Gravity = 2.72

Table 1: Details of Material Properties [5,6,7]



Figure 1: Methodology of Investigation of Properties of RTTF Concrete

Proportioning of M20 grade of concrete as a control mix assessed as per IS : 10262 - 2009. Slump requirement is 100mm. Admixture is not used for casting of M25 grade of control mix.

Sr. No	Name of Test	Specimen	No of specimen	% of fiber added	Days of curing
1.	Compression test	Cube : 150x150x150mm	12 Nos	CM,0.5%,1.00%,1.50%	07 days
			12 Nos		28 days
2.	Split tensile test	Cylinder : 100x200mm	12 Nos	CM,0.5%,1.00%,1.50%	07 days
			12 Nos		28 days
3.	Flexural test	Beam : 150x150x700mm	06 Nos	CM,0.5%,1.00%,1.50%	07 days
			06 Nos		28 days

Table 2: Details of Specimens

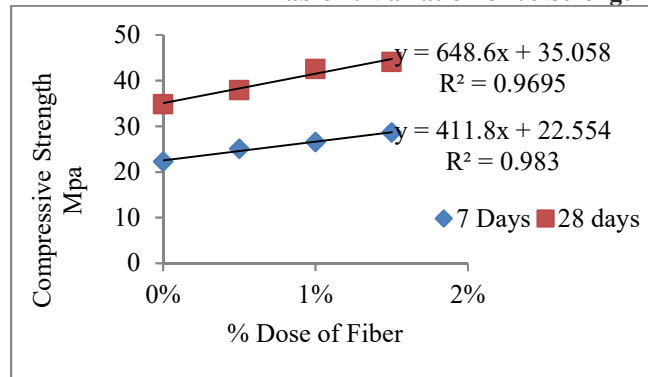
Results and Discussion

SN	% of fiber	Compressive strength (MPa)		Split Tensile Strength (MPa)		Flexural Strength (MPa)		Slump mm
		7 days	28 days	7 days	28 days	7 days	28 days	
1	0%	22.26	34.9	1.47	3.762	1.591	3.762	110
2	0.50%	25.12	38	1.62	4.235	1.687	4.514	98
3	1.00%	26.54	42.62	1.87	4.505	2.024	4.658	72
4	1.50%	28.65	44.17	2.41	4.65	2.451	4.827	60

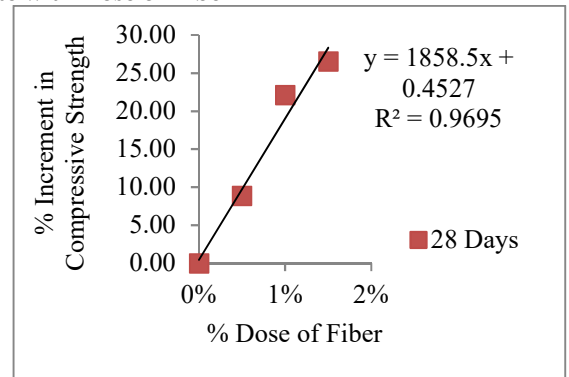
Table 3: Variation of Strength Properties of Concrete with Dose of Fiber [8,9,10]

SN	% of fiber	Compressive strength (MPa)	Flexural Strength (MPa)	Split Tensile Strength (MPa)	Slump mm	% Increment in Compressive Strength	% Increment in Split Tensile Strength	% Increment in Flexural Strength	% Decrement in Slump
		28 days	28 days	28 days	mm				
1	0%	34.9	3.762	3.762	110	0.00	0.00	0.00	0.00
2	0.50%	38	4.235	4.514	98	8.88	12.57	19.99	-10.91
3	1.00%	42.62	4.505	4.658	72	22.12	19.75	23.82	-34.55
4	1.50%	44.17	4.65	4.827	60	26.56	23.60	28.31	-45.45

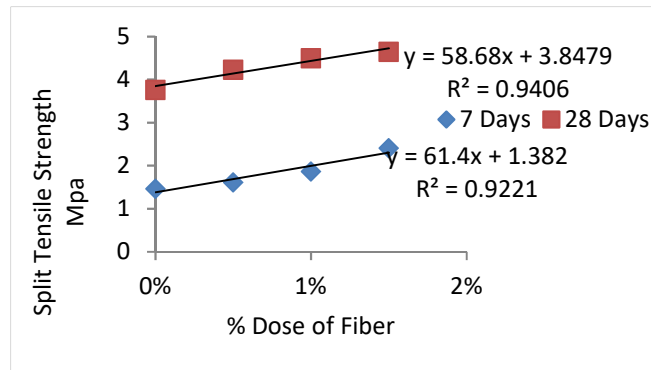
Table 4: Variation of % Strength of Concrete with Dose of Fiber



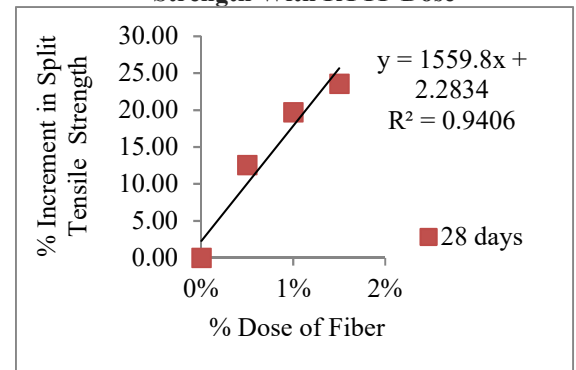
Graph 1 : Compressive Strength Variation With RTTF Dose



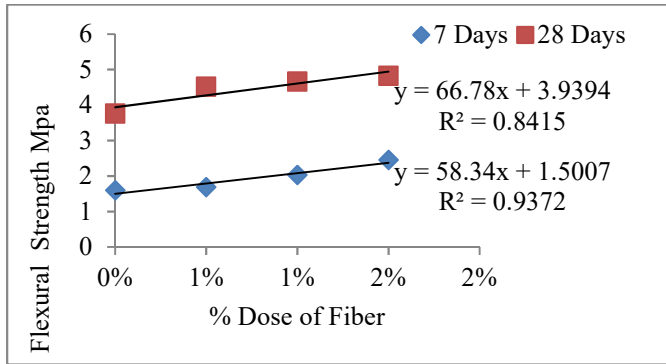
Graph 2 : Incremental Increase in Compressive Strength With RTTF Dose



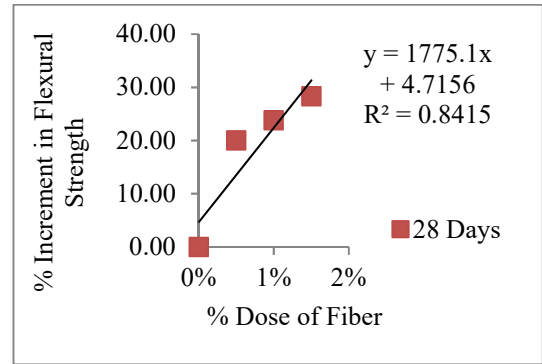
Graph 3 : Split Tensile Strength Variation With RTTF Dose



Graph 4 : Incremental Increase in Split Tensile Strength With RTTF Dose



Graph 5 : Flexural Strength Variation With RTTF Dose



Graph 6 : Incremental Increase in Flexural Strength With RTTF Dose



Figure 2: Compressive Failure



Figure 3: Tensile Failure



Figure 4: Flexural Failure

From based on experimental results following points are concluded:

1. With increment in the dose of the RTTF, the compressive, flexural and slit tensile strength increases considerable. This increment in the strength could be arresting the cracks propagation through the fibers distributed in the body of specimens.
2. From the experimental investigation, time for failure of for compression testing is increases with increment of the dose of RTTF. This is concluded than the post crack increment in deflection of the concrete. Post crack increment in the deflection of concrete responsible for the increment in the peak load of RTTF concrete failure.
3. Incremental increase in compression, split tensile and flexural strength of RTTF concrete increases with the increment of the dose of the concrete.
4. Retention of concrete or slump of concrete decreases with the increment of concrete. Addition of fiber causes balling effect i.e. formation of the flocks of fresh concrete and these flocks creates resistances to the flow ability of concrete.

Conclusion

Based on the preliminary experimental investigation, it is concluded that addition of RTTF improved the hardened properties of concrete i.e. compressive strength, split tensile strength and flexural strength. RTTF could be use as fiber in fiber reinforced concrete. Addition of RTTF to the concrete reduced the workability of concrete because of balling effect. To counterbalance this balling effect, it is necessary to use the plasticizers or super plasticizer. Again it is necessary to study stress-strain behaviour of the RTTF concrete with load deflection curve.

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