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Research Paper

MECHANICAL PERFORMANCE OF RECYCLED PET FIBER REINFORCED CONCRETE WITH LOW VOLUME FRACTION

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This paper focuses on the experimental investigation on mechanical behavior of fibrous concrete reinforced with Recycled Polyethylene Terephthalate (RPET) fiber and steel fiber up to a volume fraction of 0.5% were found (Sivakumar and Manu Santhanam, 2007). The mechanical properties were studied compressive strength, split tensile strength and flexural strength. The volume fraction of fibers are started from 0% to 2% and the improved value of compressive strength is achieved at the 1.5% of steel fibers (metallic fiber) and RPET fibers (non-metallic fibers) are 0.1%, 0.2%, 0.3%, 0.4% and 0.5% and using of M40 grade recommended as per IS 10262-2009 are studied. Compared to the optimized value of fiber reinforced concrete specimens with the control specimens. The experimental work on specimens has been extensively searched for getting platform for the research on the Flexural behavior of Hybrid fibre (steel and RPET) reinforced concrete beam is to be discussed briefly. Finally, general concluding remarks are made along with possible suggestions for future directions of research.

Keywords: Fiber reinforced concrete, Hybrid Fiber Reinforced concrete, Recycled Polyethylene Terephthalate fiber, Polypropylene fiber, Split tensile strength

INTRODUCTION

It is known that concrete is a relatively brittle material. Reinforcement of concrete with randomly distributed short fibers may improve the toughness of cementitious matrices by preventing or controlling the initiation, propagation, or coalescence of cracks (Alberto Meda *et al*., 2012; Albano *et al*., 2009; Eswari *et al*., 2008; Ramadevi *et al*., 2012; Ravichandran *et al*., 2009). Poor toughness, a serious shortcoming of high strength concrete, can be overcome by reinforcing with short discontinuous fibres. Fibres primarily control the propagation of cracks and limit the crack width. In Fibre Reinforced Concrete (FRC), fibres can be effective in arresting cracks at both macro and micro levels. The addition of steel fibres at high dosages, however, has potential disadvantages in terms of poor workability and increased cost. In addition, due to the high stiffness of steel fibres, micro-defects such as voids and honeycombs could form during placing as a result of improper consolidation at

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low workability levels (Ravichandran *et al.*, 2008). A compromise to obtain good fresh concrete properties (including workability and reduced early-age cracking) and good toughness of hardened concrete can be obtained by adding two different fibre types, which can function individually at different scales to yield optimum performance (Sivakumar and Manu Santhanam, 2007).

The reason for using fiber blends is to enhance the properties of concrete by combining the benefits that each particular fiber type can impart. Fiber blends – Concrete can be reinforced with conventional steel bars, and/or blends of steel and/or synthetic and /or/cellulose fibers (Kim *et al.,* 2010).

There is no fiber type that can encompass all the desired properties of fresh and hardened concrete in terms of, for example, providing load bearing capacity at cracked sections, crack control, spalling resistance at elevated temperatures, improved abrasion, impact and frost resistance. However, appropriate blends of fibers, with or without, traditional reinforcing bars can lead to synergetic effects, i.e., combinations of different fiber types can enhance concrete in both its fresh and hardened states (Vikrant *et al.,* 2012).

In this investigation explains the mechanical behaviors using fiber reinforced concrete is analyzed. Also, experimental study of the comparative strength and failure mode for the conventional mix specimens and combinations of fibers reinforced specimens were obtained below.

Fibre reinforced concrete is the composite material containing fibres in the cement matrix in a orderly manner or randomly distributed would obviously, depend upon the efficient transfer of stress between matrix and the fibres, which is largely dependent on the type of fibre, fibre geometry, fibre content, orientation and distribution of the fibre, mixing and compaction techniques of concrete and size and shape of the aggregate.

MATERIALS AND METHODS

Materials Used

The properties of materials used in concrete mixes are as given below,

Cement

Portland Pozzalano Cement (PPC) is the basic Portland cement and is best suited for use in general concrete construction. It is of three types, 33 grade, 43 grade, 53 grade. One of the important benefits is the faster rate of development of strength. The properties of cement is given inTable 1.

Table 1: Properties of Cement

Property of Cement	Values
Grade Of Cement	PPC 53
Specific Gravity	3.15
Initial Setting time	28 min
Final Setting Time	600 min

Fine Aggregate

The most important function of the fine aggregate is to provide workability and Uniformity in the mixture. The fine aggregate also helps the cement paste to hold the coarse aggregate particle in suspension. Locally available clean and dry river sand passing through IS 4.75 mm sieve is used for casting the specimens. The sand has the following properties. The sand has the following properties in the Table 2.

Table 2: Properties of Fine Aggregate

Properties	Values
Specific Gravity	2.65
Fineness Modulus	2.25

Coarse Aggregate

Coarse aggregate 20 mm sieve passing and 12.5 mm sieve retained and having specific gravity 2.77 is used for casting all specimens and the properties of coarse aggregate is given in Table 3.

Table 3: Properties of Coarse Aggregate

Properties	Values
Specific Gravity	2.77
Size of Aggregates	20 mm Passing Through and 12.5 mm Sieve retained
Fineness Modulus	5.96

Super Plasticizer

Superplasticizers are added to reduce the water requirement by 15 to 20% without affecting the workability leading to a high strength and dense concrete. These can be added to concrete mix having a low to-normal slump and water cement ratio to produce high slump flowing concrete. The effect of Superplasticizers lasts only for 30 to 60 min, depending on composition and dosage and is followed by rapid loss in workability.

Steel Fiber

The properties of steel fiber has given in Table 4.

Table 4: Properties of Steel Fiber

Specification	Values
Length(mm)	50
Diameter(mm)	0.5
Aspect ratio	60
Tensile strength(GPa)	1.7
Elasticity modulus(GPa)	200
Specific gravity(g/cm3)	7.48

Recycled Polyethylene Terephthalate Fiber (RPET)

The properties of Recycled polyethylene Terephthalate Fibre (RPET) is given in Table 5.

CONCRETE MIX DESIGN

Concrete mix of grade M40 has been designed based on Indian standard Recommended Guidelines IS: 10262-2009. The proportions and quantities of various materials for the concrete mix have been presented in Table 6.

Figure 1: Steel Fiber (crimped)

Figure 2: Recycled Polyethylene Terephthalate Fiber (RPET Fiber)

Table 5: Physical Properties of RPET Fiber

Specification	Values
Length(mm)	38
Diameter(mm)	0.02
Aspect ratio	1900
Tensile strength(GPa)	1.7
Elasticity modulus(GPa)	200
Specific gravity(g/cm3)	7.48

Table 6: Quantities of Materials Used

Details	By Ratio	By weight
Cement	1	395 kg/m^3
Fine Aggregate	1.66	717 kg/m^3
Coarse Aggregate	2.84	1153kg/m^3
Water	0.45	157 l/m^3

Table 7: Dimensions of Specimens

Specimens	Description
Cubes(mm)	150X150X150
Cylinders(mm)	150 diameter, 300 height
Prisms(mm)	100X100X500

TEST SPECIMENS

Cubes of size 150 mm X 150 mm X 150 mm, cylinders with 150 mm diameter X 300 mm height and prisms of size 100 mm X 100 mm X 500 mm were prepared using the standard moulds. The samples are casted using the four different waste materials. The samples are demoulded after 24 h from casting and kept in a water tank for 28 days curing. A total of 45 specimens are casted for testing the properties such as compressive strength, split tensile strength and flexural strength. The details of the specimen and their notations are given below in Table 7.

Recycled Polyethylene Terephthalate fibers will be added in harden concrete for various volume fractions such as 0.1%, 0.2%, 0.3%, 0.4% and 0.5% with 0.5% of steel fiber by total volume of concrete. The fiber reinforced concrete of the specimens details are as given below:

Table 8: Details of Specimens

S. No.	Shape of Specimen	Properties to be Studied	% of RPET fiber	No. of Specimens	Days of Testing	Size of Specimen (mm)
1	Cube	Compressive strength	0.1	3	28	150X150X150
			0.2	3		
			0.3	3		
			0.4	3		
			0.5	3		
2	Cylinder	Split Tensile strength	0.1	3	28	150mm dia
			0.2	3		300mm high
			0.3	3		
			0.4	3		
			0.5	3		
3	Prism	Flexural Strength	0.1	3	28	100X100X500
			0.2	3		
			0.3	3		
			0.4	3		
			0.5	3		

RESULTS AND DISCUSSION

After the detailed investigation on different strength parameters has been done, the following result has been achieved and shown in Table 9.

1. The specimens added with the RPET fiber have a significant result over the compressive strength. The compressive strength for the specimens ST0.5RPET0.1%, ST0.2RPET 0.2%, ST0.5RPET 0.3%,ST0.5RPET0.4% and ST0.5RPET0.5% are founded by the results are greater than that of the conventional concrete, as shown in Figures 3, 4 and 5 respectively.

Compressive Strength on Concrete Cubes

The comparative results for compressive strength of concrete cube between control specimen and FRC specimens are shown in the graph in Figure 3.

The comparison of the 28 days cube compressive strength results shows that FRC1, FRC2,FRC 3, FRC 4 and FRC5 shows an increase in compressive strength for percentage of RPET fibres 0.1%, 0.2%, 0.3% and then gradually decrease and may remains constant after 0.4%, 0.5% Aspect ratio respectively when compared to CC (Control specimen) For M40 grade concrete.

Table 9: Different Strength Values After 28 Days Curing

S. No.	Mix Proportions	Compressive Strength, N/mm²	Split Tensile Strength, N/mm²	Flexural Strength, N/mm²
1	CC	42.3	2.356	5.86
2	FRC 1 ST0.5RPET0.1	42.5	2.450	5.72
3	FRC 1 ST0.5RPET0.2	42.22	2.933	5.96
4	FRC 1 ST0.5RPET0.3	42.67	3.067	5.67
5	FRC 4 ST0.5RPET0.4	41.96	2.885	5.6
6	FRC 1 ST0.5RPET0.5	40.67	2.045	5.21

Figure 3: Compressive Strength of Concrete Vs. Various % of ST, RPET Fiber

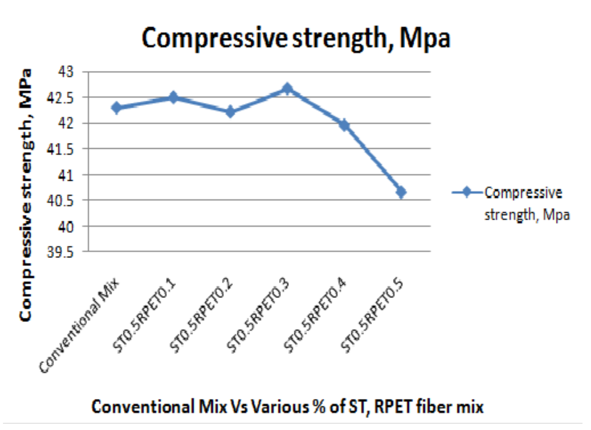
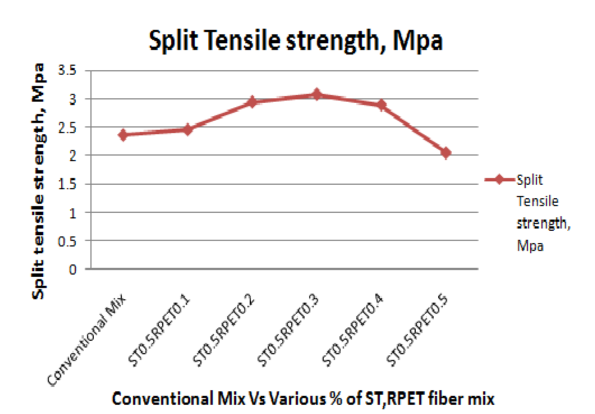


Figure 4: Split Tensile Strength of Concrete Vs. Various % of ST, RPET Fiber



Split Strength on Concrete Cylinders

The comparative results for split tensile strength of concrete cube between control specimen and FRC specimens are shown in the graph in Figure 4.

The comparison of the 28 days cube split tensile strength results shows that FRC1, FRC2, FRC3, FRC4 and FRC5 shows an increase in split tensile strength for percentage of RPET fibres 0.1%, 0.2%, 0.3% and then gradually decrease and may remains constant after 0.4%, 0.5% Aspect ratio respectively when compared to CC (Control specimen) For M40 grade concrete.

Figure 5: Flexural Strength of Concrete Vs. Various % of ST, RPET Fiber

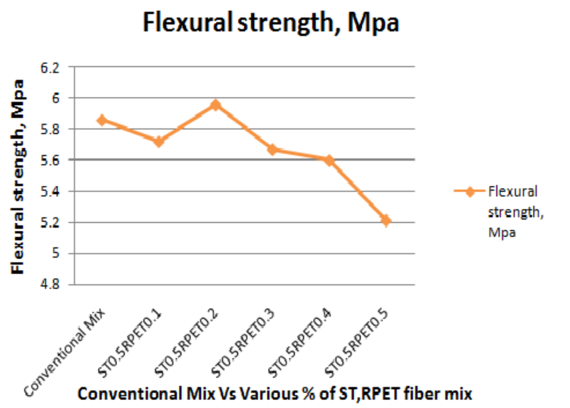


Figure 6: Failure Mode of Specimens

Figure 6 (Cont.)

Flexural Strength on Concrete Prisms

The comparative results for split tensile strength of concrete cube between control specimen and FRC specimens are shown in the graph in Figure 5.

The comparison of the 28 days cube flexural strength results shows that FRC1, FRC2,FRC 3, FRC 4 and FRC5 shows an increase in flexural strength for percentage of RPET fibres 0.1%, 0.2%, 0.3% and then gradually decrease and may remains constant after 0.4%, 0.5% Aspect ratio respectively when compared to CC (Control specimen) For M40 grade concrete.

CONCLUSION

The following conclusions have been made based on the results obtained from the experimental investigation and the failure mode of specimens are shown in Figure 6.

1. The specimen with Recycled polyethylene Terephthalate fiber was found to be good in compression which had the compressive strength of 41.25% more than the conventional concrete.
2. Better split tensile strength was achieved with the addition of the Recycled polyethylene Terephthalate in concrete. The strength has increased up to 40.87% when compared to that of the conventional concrete specimen.
3. In flexure the specimen with Recycled polyethylene Terephthalate fiber was found to be good. While adding the Recycled polyethylene Terephthalate fiber the flexural strength increased by 25.88% that of the conventional concrete.

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