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Utilization of PET Fiber in Concrete

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ABSTRACT

In this study, the effectiveness of waste Polyethylene Terephthalate (PET) fibers in improving the properties of concrete was investigated. Recycling of waste PET bottles is a daunting task in developing countries due to inadequate recycling facilities. The main aim of this research paper is to investigate the mechanical behavior of the components by using PET fibers. This paper describes the performance of PET fiber reinforced concrete for two grades of concrete mix M20 and M30. An experimental work has been carried out on the specimens like cubes, cylinders and beams which were casted in the laboratory and their behavior under the test was observed. The PET fibers were replaced to the fine aggregate volume from 0.0% to 2.0%. The compressive strength, split tensile strength and flexural strength of concrete were determined after 28 days of curing period. The highest compressive, split tensile and flexural strength of concrete was observed at 1.5% fiber volume replacement to the fine aggregate. The study concludes that the replacement of waste PET fibers to fine aggregate in concrete serves as a means of utilizing the waste generated by PET bottles to increase the strength of concrete.

Keywords: PET, Coca Cola, Bisleri, Point Loading System, Flexural Test

I. INTRODUCTION

Concrete is a basic material for civil engineering construction. All basic ingredients of concrete are natural. But the properties of concrete can be change by adding some plastic fiber. The concrete has many advantageous properties such as good compressive strength, durability, specific gravity and fire resistance but tensile strength of the concrete is very much low means it can be neglected. But tensile property of the concrete can be increase by addition of plastic fiber. Research conducted for this to utilization of plastic bottles of various brands like coca cola, Bisleri, etc and mix them in the concrete. The use of plastic has increases substantially all over the world it leads to create large quantities of plastic-based waste. Plastic waste is the one of the challenges to dispose and manage as it is non-biodegradable material which is harmful to our beautiful environment. The PET bottles are recycled and used in concrete.

II. OBJECTIVES

The main objectives of this research proposal are as follows:

i. Determination of compressive strength of concrete block when plastic bottle fiber can be used as partial substitute for the fine aggregate in concrete composites.
ii. To investigate the mechanical behaviour of the components by using PET fiber.
iii. To determine the percentage of PET fiber which gives more strength when compared to control concrete.

III. MIX MATERIALS

The material details are as follows:

A. Cement

For this research, locally available cement which is of the ordinary Portland cement type (53 grade) was used throughout the work. Specific gravity of cement was 3.09.

B. Fine Aggregate

Locally available fine aggregate used was 4.75 mm size confirming to zone II with specific gravity 2.66. The testing of sand was conducted as per IS: 383-1970.Water absorption and fineness modulus of fine aggregate was 1.35% and 2.806 respectively.

C. Coarse Aggregate

Coarse aggregate used was 20mm and less size with specific gravity 2.76. Testing of coarse aggregate was conducted as per IS: 383-1970. Water absorption and fineness modulus of coarse aggregate was Nil and 6.203 respectively.

D. Water

The water used was potable, colourless and odourless that is free from organic impurities of any type.

E. Plastic PET Fibers

The post consumed PET mineral water bottles of single brand were collected from local restaurants. The fibers were cut after removing the neck and bottom of the bottle. The plastic fibers were used having water absorption 0.00 %.

Fig.1 PET Fiber

IV. EXPERIMENTAL WORK AND TEST

A. Mix Design

Mix design carried out for M20 grade of concrete by IS 10262:2009, having mix proportion of **1:1.90:2.96** with water cement ratio of 0.52. Mix design carried out for M30 grade of concrete having mix proportion of **1:1.60:2.49** with water cement ratio of 0.45. The partial replacement of fine aggregate by 0.5 % to 2.0 % of PET fiber. Chemical admixtures are not used in the work.

B. Compressive, Flexural and Split Tensile Strength

Concrete prepared with different percentage replacement of fine aggregate by 0.5 % to 2.0 % and cured under normal condition as per recommendations of IS and were tested at 28 days for determining the compressive, flexural and split tensile strength compared with the test results of conventional concrete.

V. TEST RESULTS

A. Compressive Strength

A cube compression test is performed on standard cubes of size 150 x 150 x 150 mm after 28 days of immersion in water for curing. The compressive strength of specimen is calculated by the following formula.

$$f_{cu} = \frac{P_c}{A}$$

Where,

P_c = Failure Load in Compression, KN

A = Loaded Area of Cube, mm^2

Table 1. Compressive Strength Test at 28 Days for M20

Sr. No.	% PET Fiber	Compressive Strength in N/mm²	Avg. Compressive Strength in N/mm²	Percentage Increased
1	0	26.13	26.28	0.00
		26.31		
		26.40		
2	0.5	26.48	26.57	1.10
		26.57		
		26.66		
3	1	26.75	26.85	2.16
		26.84		
		26.97		
4	**1.5**	**27.11**	**27.25**	**3.69**
		27.24		
		27.42		
5	2	27.02	27.04	2.89
		27.15		
		26.97		

Table 2. Compressive Strength Test at 28 Days for M30

Sr. No.	% PET Fiber	Compressive Strength in N/mm²	Avg. Compressive Strength in N/mm²	Percentage Increased
1	0	39.02	39.70	0.00
		40.15		
		39.94		
2	0.5	41.36	40.96	3.17
		40.95		
		40.58		
3	1	40.68	41.30	4.03
		41.26		
		41.96		
4	1.5	41.98	42.00	5.79
		41.85		
		42.18		
5	2	41.07	40.75	2.64
		41.03		
		40.16		

B. Spilt Tensile Strength

The cylindrical specimens of diameter 150 mm and length 300 mm were casted with PET bottle fibers in volume fraction 0.0%, 0.5%, 1.0%, 1.5%, and 2.0%. The split tensile strength test was carried out as per IS: 516-1979. This test was carried on specimens at the 28 days of curing. The split tensile strength of cylinder is calculated by the following formula:

$$f_t = \frac{2P}{\pi DL}$$

Where,

f_t= Split Tensile Strength in MPa

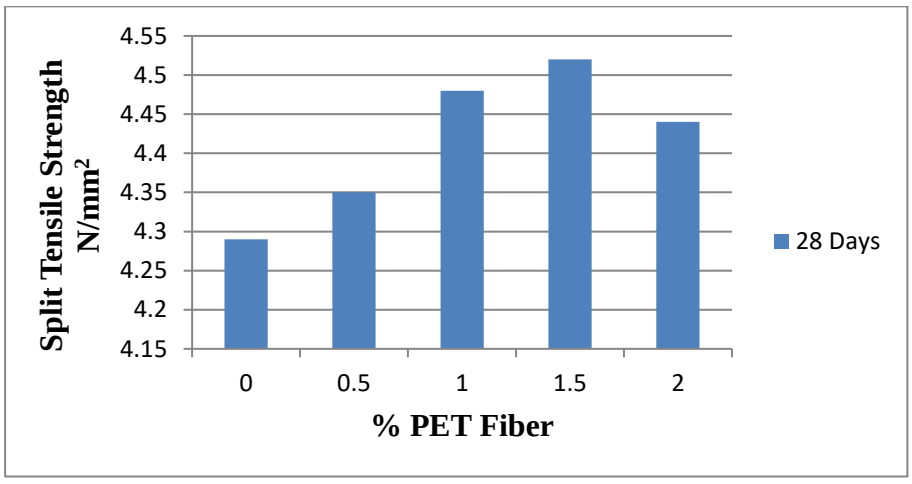
P = Load at Failure in N

L = Length of Cylinder in mm

D = Diameter of Cylinder in mm

Table 3. Split Tensile Test at 28 Days for M20

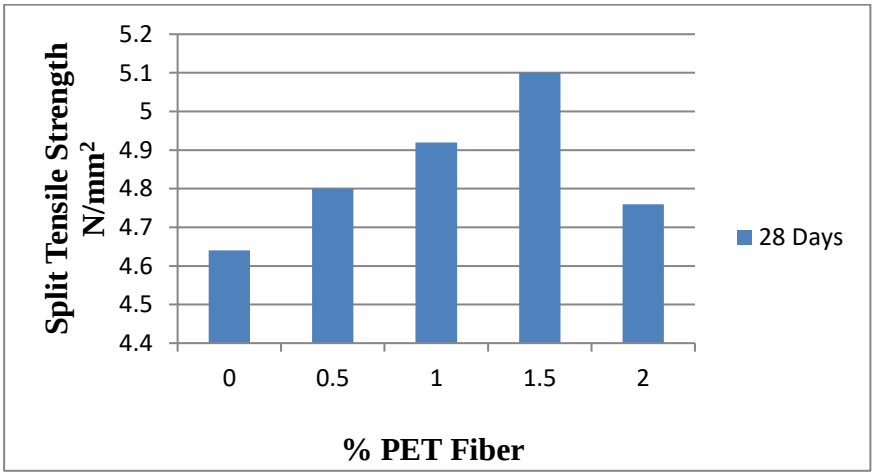
Sr. No.	% PET Fiber	Split Tensile Strength in N/mm²	Avg. Split Tensile Strength in N/mm²	Percentage Increased
1	0	4.27	4.29	0.00
		4.30		
		4.31		
2	0.5	4.33	4.35	1.39
		4.35		
		4.38		
3	1	4.45	4.48	4.42
		4.50		
		4.48		
4	1.5	4.52	4.52	5.36
		4.55		
		4.54		
5	2	4.45	4.44	3.49
		4.41		
		4.47		



Graph 1 Split Tensile Strength for M20

Table 4 Split Tensile Strength at 28 Days for M30

Sr. No.	% PET Fiber	Split Tensile Strength in N/mm²	Avg. Split Tensile Strength in N/mm²	Percentage Increased
1	0	4.93	4.64	0.00
		4.61		
		4.38		
2	0.5	4.59	4.80	3.44
		4.87		
		4.92		
3	1	4.83	4.92	6.03
		4.97		
		4.95		
4	1.5	4.91	5.10	9.91
		5.02		
		5.38		
5	2	4.89	4.76	2.59
		4.53		
		4.86		



Graph 2 Split Tensile Strength for M30

C. Flexural Strength

Three beam section of size 150x150x750mm were casted and cured for 28 days. The flexural strength is determined by using the formula,

$$f_{cr} = \frac{P_f L}{bd^2}$$

Where,

f_{cr}= Flexural Strength in MPa

P_f = Central Load through Two Point Loading System in N

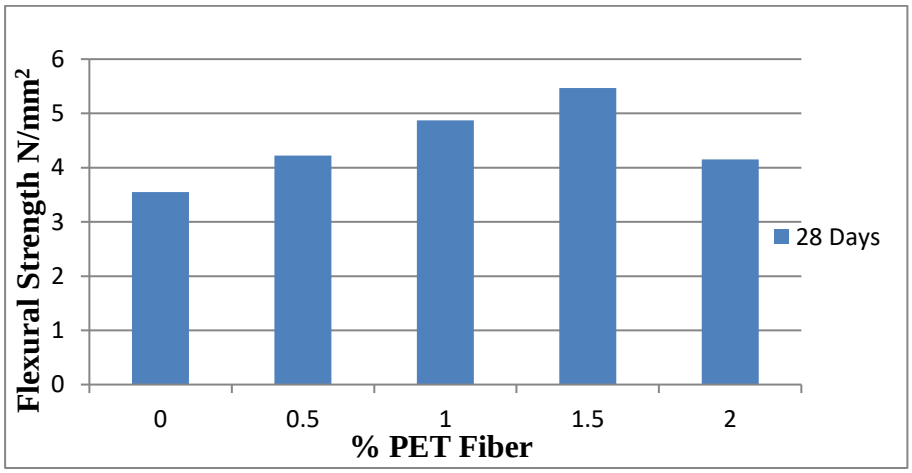
L = Span of Beam in mm

b = Width of Beam in mm

d = Depth of Beam in mm

Table 5 Flexural Test at 28 Days for M20

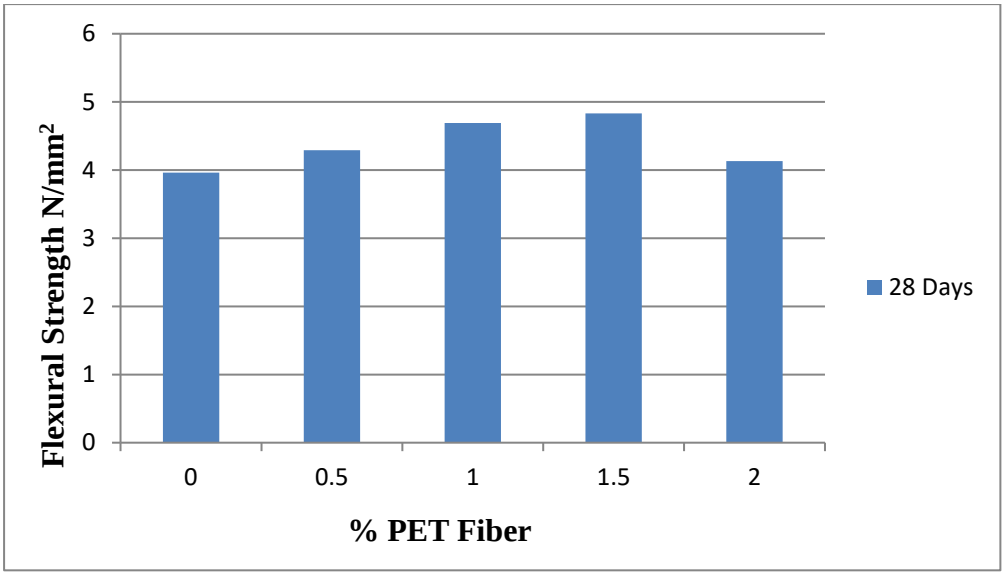
Sr. No.	% PET Fiber	Flexural Strength in N/mm²	Avg. Flexural Strength in N/mm²	Percentage Increased
1	0	3.34	3.55	_
		4.00		
		3.32		
2	0.5	4.23	4.22	18.87
		4.00		
		4.43		
3	1	4.66	4.87	37.18
		5.11		
		4.89		
4	1.5	5.34	5.47	54.08
		5.55		
		5.54		
5	2	4.22	4.15	16.90
		4.00		
		4.23		



Graph 3 Flexural Strength for M20

Table 6 Flexural Strength at 28 Days for M30

Sr. No.	% PET Fiber	Flexural Strength in N/mm²	Avg. Flexural Strength in N/mm²	Percentage Increased
1	0	3.95	3.96	0.00
		3.97		
		3.95		
2	0.5	3.98	4.29	8.42
		4.22		
		4.67		
3	1	4.54	4.69	18.43
		4.91		
		4.63		
4	1.5	4.82	4.83	21.96
		4.77		
		4.89		
5	2	3.87	4.13	4.29
		4.15		
		4.38		



Graph 4 Flexural Strength for M30

VI. CONCLUSION

1. The compressive strength for 1.5% PET FRC specimens increased as compared to normal concrete for 28 days whereas the compressive strength of PET FRC specimens at 2% decreases slightly.

2. Split tensile strength and Flexural strength test result demonstrates that inclusion of 1.5% PET fiber volume fraction enhanced Split tensile strength and Flexural strength maximum for both grades of concrete.
3. It was observed during experimentations that normal concrete specimens were suddenly broken into two pieces either cubes or cylinders but for PET FRC specimens the failure (rupture) was not sudden.
4. The introduction of PET fiber in concrete helps to hold concrete ingredients unite.
5. This experimental work deals with PET fiber content used as partial substitute for the fine aggregate in concrete, therefore from above positive results it is concluded that the consumption of fine aggregate in concrete can be reduced.
6. It is counted as one of the foundations for green project through reduces land and air pollution.

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