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Experimental Investigation of Recycled PET-Polypropylene hybrid Fiber Reinforced Concrete

[1]Tushar R. Shinde, [2]R.M.Jadhav, [3]V.A.Kuwar

[1]ME Structure, Department of Civil Engineering
[2,3]Assistant Professor, Department of Civil Engineering
Late G.N.Sapkal College of Engineering
Nashik, India

***Abstract*— The use of hybrid fiber reinforced concrete has attracted because cementitious material including different type of fibers in suitable combination performs better compared to mono fiber reinforced concrete. In this study I have investigated the performance of concrete containing Polyethylene Terephthalate (PET) bottle waste fibers along with polypropylene fibers as a hybrid fiber reinforced concrete. The PET fibers are obtained by simply cutting the bottles. PET bottle waste was chosen because it is being thrown after single use and cause environmental problem. In present investigation fresh properties as well as mechanical properties of individual fibers and hybrid fibers for various proportions of fibers are found out. The workability of fresh concrete is determined by slump cone and compaction factor test also results of compressive strength, split tensile strength and flexural strength were studied. The use of waste PET bottle fibers with polypropylene fibers in concrete has been shown interesting improvements in concrete performance.**

***Keywords*— Compressive Strength, Flexural Strength, Split Tensile Strength, Hybrid Fiber Reinforced Concrete, Polyethylene Terephthalate.**

I. INTRODUCTION

The construction material is continuously evolving. In plain concrete structural cracks (micro cracks) may be develop even before loading due to drying shrinkage or other causes of volume change. When loaded, the micro crack propagates and open up. additional cracks are developed at minor defects. It has been recognized that the addition of small, closely spaced and uniformly dispersed fibers to concrete would act as crack arrester and would substantially improve its static and dynamic properties. And this type of concrete is known as fiber reinforced concrete. In the field of concrete construction, the use of fibers has been steadily increasing over the past years in an effort to overcome the inborn tensile strength and toughness limitations of plain concrete. The ability to enhance flexural and tensile performance of the concrete matrix, together with the opportunity for improving its durability, pushed boundaries in developing new materials to be used as fibers. The major advantage of fiber reinforced concrete is to transform a brittle concrete into ductile material.

The environmental problems related to waste is one of the main challenge to dispose and manage. It has become one of the major environmental, economical and social issues. Recycling is the most promising waste management process for disposal of waste materials. The waste utilization in Civil Engineering construction has become an attractive alternative for disposal and protecting environment. Now a days fastest growth in generation of plastic. Collection and disposal of plastic waste causes an additional impact on environment. The present study highlights fibers are obtained by simply cutting the waste plastic bottles that is PET fibers reinforced concrete and results are compared with polypropylene fibers reinforced concrete for different proportion of fibers. Then combine performance of both fibers is evaluated.

II. LITERATURE REVIEW

Erlon Lopes Pereira [1], concluded that the load capacity of an ecological concrete produced with PET fibers is greater than the load capacity of conventional concrete. This is because the insertion of fibers from PET bottles into concrete improved the mechanical properties of the ecological concrete in terms of compression, tension and bending. The volume of fibers affects compression resistance of concrete while the fiber length does not affect this property.

Ruben Paul Borg [2], concluded that reduction in crack width for 1% fiber content, increase in flexural strength with increase in fiber content and deformed fibers gives better result than straight one. on other side slightly decrease in compressive strength as the fiber content increases also longer fibers are found effective.

Aswathy N. [3], reported that workability of plain PET fibers reinforced concrete was decreased with the increase in percentage of fibers volume fraction, The optimum strength was obtained at 1% of fibers content and change in nature of failure occur from brittle to ductile when plastic fibers were introduced into the concrete.

R. N. Nibudey et al. [4], concluded that workability measured with the slump and compaction factor decreases with increase in fiber content. Increase in compressive strength, split tensile strength upto 1% fiber content further increase in fiber content strength decreases.

Antonia Caggiano et al. [5], concluded that fiber reinforced specimens exhibited a post peak response more ductile than reference ones also FRC specimens made of only polypropylene fibers exhibited an excellent post cracking toughness for small crack opening.

Pentea Rashiddadash et al. [6], concluded that combination of steel and polypropylene fibers decreased the mechanical properties in comparison to FRC containing only steel fibers. Also adding pozzolona to concrete mixture has no effect on load versus deflection diagram that mainly depends on the percentage of steel and polypropylene fibers.

Machine Hsie et al. [7], in this investigation the mechanical properties of PP hybrid fiber reinforced concrete are calculated. Two forms of Polypropylene fibers one is macro monofilament and second is microfiber in different percent are added to cementitious matrix. The results show that hybrid fiber improved the toughness index of composite. Furthermore, the compressive strength, splitting tensile strength and modulus of rupture of hybrid FRC are increased.

III. EXPERIMENTAL WORK

A. Materials

1. Cement

Cement used in the investigation was 53 Grade ordinary Portland cement. The physical properties of cement are as given in table1.

Table 1:The properties of cement

Sr. No	Properties	Results
1	Fineness	4.22 %
2	Specific Gravity	3.12
3	Normal Consistency	31 %
4	Initial Setting Time	45 Min.
5	Final Setting Time	240 Min.

2. Fine Aggregate

The river sand was used as fine aggregate confirming to zone II of IS 383-1970. Table 2 shows the physical properties of fine aggregates.

3. Coarse Aggregate

Locally available crushed stone aggregates with nominal size 20 mm was used. Table 2 shows the physical properties of coarse aggregates.

Table 2: Properties of coarse aggregate and fine aggregate

Sr. No	Properties	Fine aggregate	Coarse aggregate
1	Specific Gravity	2.73	2.69
2	Water Absoption	0.3	0.4
3	Fineness Modulus	3.24	6.87

4. Water

Potable water was used for mixing and curing as per IS 456:2000.

5. Fibers

a) PET Fibers: The waste PET mineral water bottles were collected and the fibers were cut after removing the neck and bottom of the bottle. The length of fiber was kept 50 mm and breadth was 2 mm for this experiment having aspect ratio 75.

Fig. 1. PET fibers

b) Polypropylene Fibers: For this study monofilaments fine polypropylene fibers were used. The fibers were supplied by reliance industry by name Recron 3s having length 12 mm, Tensile strength 4000-6000 Kg/cm^2**,** Melting point > 250ºC.

Fig. 2. Polypropylene fibers

6. Plasticizer

Emceplast BV Plasticizer was used 0.2% by weight of cement for present investigation. It may be use 0.15 to 0.3 percent by weight of cement depending upon application.

B. Experimental Methodology

1. Mix Design

The design mix of 1:1.66:2.78 (M30) with plasticizer 0.20% by weight of cement with cement content of 413 kg/m^3

is adopted for normal concrete. The mix were designed by using IS 10262-2009. The individual PET fibers and Polypropylene fibers were added 0%, 0.5%, 1.0%, 1.5%, 2.0% by weight of cement. Then combination of PET and Polypropylene fibers with a constant total amount of fibers equal to 2% by cement weight. (1.5%/0.5%, 1.0%/1.0%, 0.5%/1.5%)

2. Workability test

The workability of concrete was determined with the help of slump cone and compaction factor test for each percentage of PET fibers, Polypropylene fibers and combination of both fibers.

3. Compressive strength test

Concrete cubes specimens (150 mm x 150 mm x150 mm) were tested for computing compressive strength.

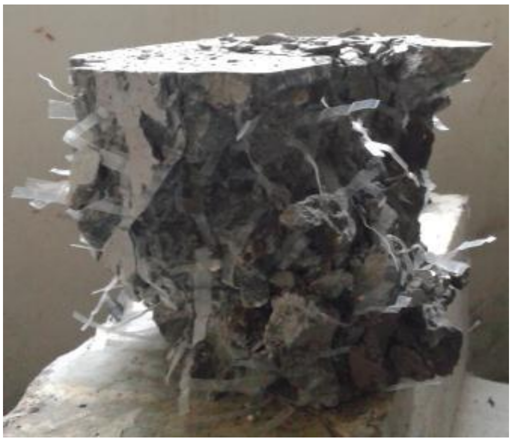

Fig. 3. PET fiber reinforced cube after failure

4. Split tensile strength

The cylindrical specimens (Diameter- 150 mm and length- 300 mm) to determine spilt tensile strength of concrete.

Fig. 4. Split tensile strength test setup

5. Flexural strength

Beam specimens (150 mm x 150mm x 700mm) for computing Flexural strength.

Fig. 5. Flexural strength test setup

IV. Results And Discussion

1. Test results of fresh concrete

Table 3: Workability of fiber reinforced concrete

% Fibers	PET fiber reinforced concrete		Polypropylene fiber reinforced concrete	
	Slump (mm)	Compaction factor	Slump (mm)	Compaction factor
0.0	85	0.890	85	0.890
0.5	82	0.884	79	0.887
1.0	71	0.873	66	0.868
1.5	64	0.850	53	0.849
2.0	53	0.839	46	0.836

Table 4: Workability of hybrid fiber reinforced concrete

% Fibers		Hybrid fiber reinforced concrete	
% PET Fibers	% Polypropylene Fibers	Slump (mm)	Compaction factor
1.5	0.5	55	0.856
1.0	1.0	52	0.843
0.5	1.5	48	0.839

2. Test results of compressive strength

Table 5: Compressive strength of fiber reinforced concrete

% Fibers		Compressive strength in N/mm^2	
% PET Fibers	% Polypropylene Fibers	7 days	28 days
-	-	24.96	39.40
0.5	-	25.12	39.86
1.0	-	25.89	40.64
1.5	-	26.61	41.95
2.0	-	25.42	40.32
-	0.5	25.80	41.52
-	1.0	27.34	43.86
-	1.5	25.14	41.62
-	2.0	23.54	38.17
1.5	0.5	27.12	42.94
1.0	1.0	27.10	42.84
0.5	1.5	25.20	41.52

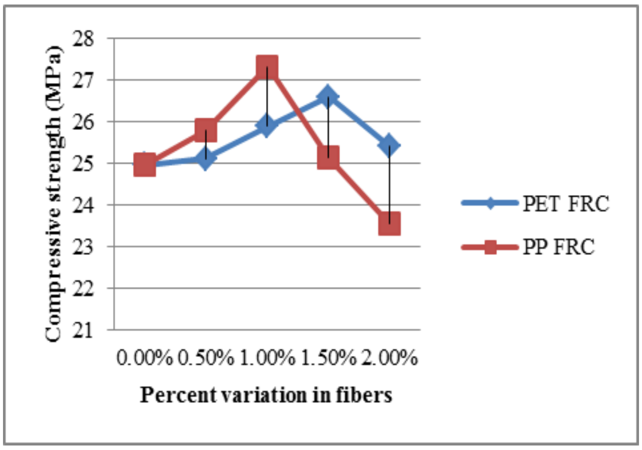

Fig. 6. 7 days Compressive strength of PET and Polypropylene FRC at various proportion of fibers

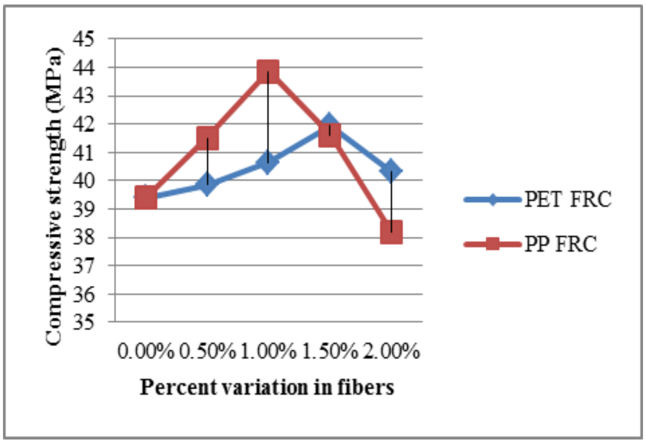

Fig. 7. 28 days Compressive strength of PET and Polypropylene FRC at various proportion of fibers

The figure 6 and 7 shows the graphical representation of 7 & 28 days compressive strength of PET and Polypropylene fiber reinforced concrete. The maximum strength was observed at 1% in case of polypropylene fibers and 1.5 % in case of PET fiber reinforced concrete.

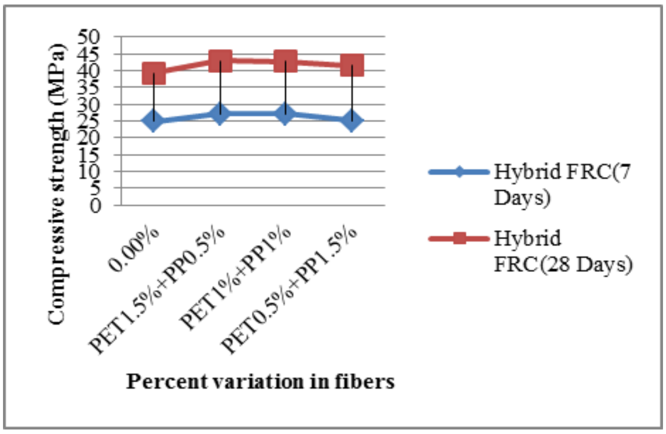

Fig. 8. 7 and 28 days Compressive strength of PET and Polypropylene hybrid FRC at various proportions of fibers

The figure 8 shows the graphical representation of 7 & 28 days compressive strength of PET and Polypropylene hybrid fiber reinforced concrete. The maximum strength was observed at 1.5% PET fibers and 0.5% Polypropylene hybrid fiber reinforced concrete.

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3. Test results of Split tensile strength

Table 6: split tensile strength of fiber reinforced concrete

% Fibers		Split tensile strength in N/mm^2
% PET Fibers	% Polypropylene Fibers	28 days
-	-	3.57
0.5	-	3.98
1.0	-	4.20
1.5	-	4.73
2.0	-	4.44
-	0.5	3.91
-	1.0	4.12
-	1.5	4.65
-	2.0	4.57
1.5	0.5	4.94
1.0	1.0	4.86
0.5	1.5	4.20

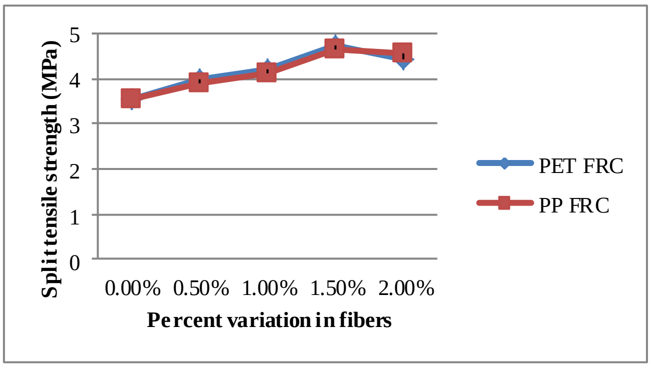

Fig. 9. 28 days Split tensile strength of PET and Polypropylene FRC at various proportion of fibers

The figure 9 shows the graphical representation of 28 days Split tensile strength of PET and Polypropylene fiber reinforced concrete. The maximum strength was observed at 1.5% in case of polypropylene fibers and also in case of PET fiber reinforced concrete.

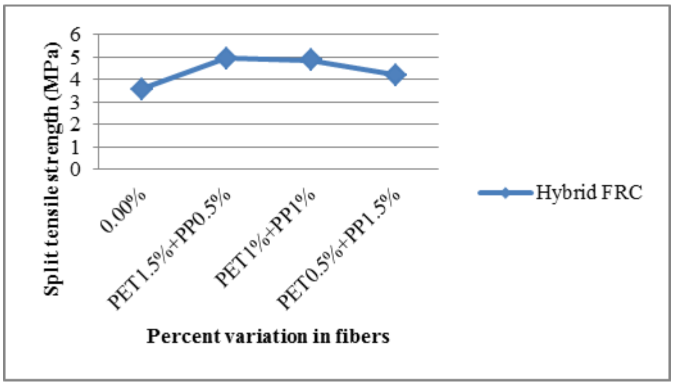

Fig. 10. 28 days Split tensile strength of PET and Polypropylene hybrid FRC at various proportions of fibers

The figure 10 shows the graphical representation of 28 days Split tensile strength of PET and Polypropylene hybrid fiber reinforced concrete. The maximum strength was observed at 1.5% PET fibers and 0.5% Polypropylene hybrid fiber reinforced concrete.

4. Test results of Flexural strength

Table 7: Flexural strength of fiber reinforced concrete

% Fibers		Flexural strength in N/mm^2
% PET Fibers	% Polypropylene Fibers	28 days
-	-	6.34
0.5	-	6.45
1.0	-	6.54
1.5	-	6.98
2.0	-	6.80
-	0.5	6.56
-	1.0	6.97
-	1.5	6.86
-	2.0	6.69
1.5	0.5	7.21
1.0	1.0	7.17
0.5	1.5	6.90

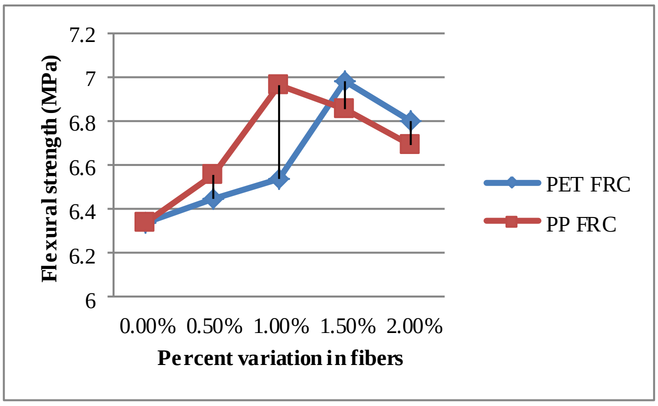

Fig. 11. 28 days Flexural strength of PET and Polypropylene FRC at various proportions of fibers

The figure 11 shows the graphical representation of 28 days flexural strength of PET and Polypropylene fiber reinforced concrete. The maximum strength was observed at 1% in case of polypropylene fibers and 1.5 % in case of PET fiber reinforced concrete.

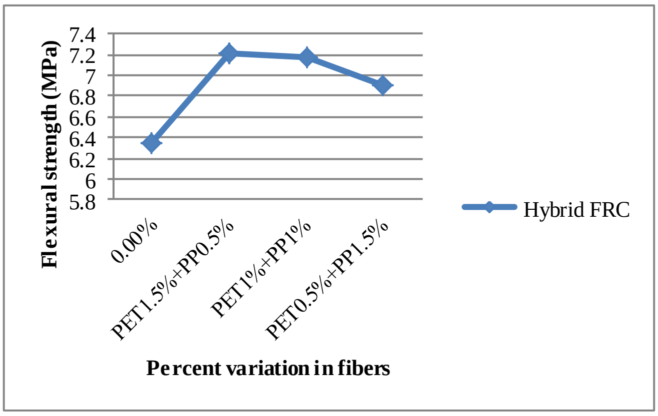

Fig. 12. 28 days Flexural strength of PET and Polypropylene hybrid FRC at various proportions of fibers

The figure 12 shows the graphical representation of 28 days flexural strength of PET and Polypropylene hybrid fiber reinforced concrete. The maximum strength was observed at 1.5% PET fibers and 0.5% Polypropylene hybrid fiber reinforced concrete.

V. CONCLUSIONS

1) The workability of Waste PET bottle fiber reinforced concrete decreases as we increase percentage of fibers in concrete under slump cone and compaction factor tests.
2) The workability of Polypropylene fiber reinforced concrete decreases as we increase percentage of fibers in concrete under slump cone and compaction factor tests.
3) The decrease in workability in both fiber types is due to resistance to movement of aggregates offered by the fibers.
4) The workability of Polypropylene fiber reinforced concrete is less compared to PET fiber reinforced concrete for same percentage of fibers addition due to water absorption of polypropylene fibers.
5) Improvement in compressive strength, Split tensile strength and Flexural strength of concrete is observed for 0.0% to 1.5% of PET fibers by weight of cement.
6) Improvement in compressive strength, Flexural strength of concrete is observed for 0.0% to 1% of Polypropylene fibers and optimum split tensile strength for 1.5% of Polypropylene fibers by weight of cement.
7) The performance of hybrid fiber reinforced concrete is better than that of single fiber reinforced concrete.
8) 1.5% PET fibers and 0.5% Polypropylene fibers in combination gives best results than other combination.
9) The fibers obtained from waste PET bottles, helps to improve compressive strength, Split tensile strength and Flexural strength of concrete which is one of the innovative material having low cost that can be used in construction field also use of such material solve problem of solid waste disposal and prevents environmental pollution also.

REFERENCES

[1] Erlon Lopes Pereira et al., “Optimization of mechanical properties in concrete reinforced with fibers from solid urban wastes (PET bottles) for the production of ecological concrete”, Construction and Building Materials 149 (2017) 837–848.

[2] Ruben Paul Borg et al., “Early age performance and mechanical characteristics of recycled PET fiber reinforced concrete”, Construction and Building Materials 108 (2016) 29–47.

[3] Aswathy N., “Experimental study on concrete with straight and crimped plastic fibers”, International Journal of Science and Research (2015) ISSN (Online): 2319-7064.

[4] R.N. Nibudey et al., “Strengths prediction of plastic fiber reinforced concrete (M30)”, International Journal of Engineering Research and Applications, Vol. 3, pp.1818-1825, 2013.

[5] Antonia Caggiano et al., “Experimental characterization of the post cracking response in Hybrid Steel/Polypropylene Fiber Reinforced Concrete”, Constr. Build. Mater. 125 (2016) 1035–1043.

[6] Pentea Rashiddadash et al. “Experimental investigation on flexural toughness of hybrid fiber reinforced concrete (HFRC) containing metakaolin and pumice”, Constr. Build. Mater. 51 (2014) 313–320.

[7] M. Hsie et al. “Mechanical properties of polypropylene hybrid fiber reinforced Concrete”, Mater. Sci. Eng., A 494 (2008) 153–157.

[8] IS:456-2000, Plain and Reinforced Concrete- Code of Practice, Bureau of Indian Standards, New Delhi, 2000.

[9] IS:383-1970, “Indian standards specification for coarse and fine aggregates from natural sources for concrete.” Bureau of Indian Standard Institution, New Delhi.

[10] IS: 10262:2009. “Recommended guidelines for concrete mix design”, Bureau of Indian Standard Institution, New Delhi.

[11] M.S. Shetty, “Concrete Technology Theory and Practice”, S. Chand & Company Ltd., New Delhi, 2005.

[12] M.L. Gambhir, “Concrete Technology”,The Mc Graw-Hill companies.

