Evaluation of Physical Properties of Concrete Incorporating Pet Bottle Fibers

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Abstract—

The growing need for eco-friendly building materials has led researchers to look into new ways to use waste materials in making concrete. This study assesses the physical properties of conventional concrete infused with polyethylene terephthalate (PET) bottle fibers sourced from recycled plastic waste. Concrete reinforced with PET bottle fibers is seen as a good way to improve performance while also dealing with environmental problems caused by throwing away plastic. To improve the physical properties of the concrete, waste PET bottle fibers were cut into small strips and mixed with the concrete in different amounts. Experiments were done to test the physical properties of the material at different curing ages. These properties included workability, density, compressive strength, split tensile strength, and flexural strength. We looked at more things about how cracks form, how the concrete bonds, and how the structure responds. The results show that adding PET bottle fibers makes the material stronger and more flexible because they help control cracks and absorb more energy. This study shows that recycled PET fibers could be used in concrete, which would help with responsible construction and sustainable waste management.

Keywords—Concrete, PET fibers, Compressive strength, Flexural strength, Sustainable construction, Fiber reinforced concrete.

I. INTRODUCTION

The increasing accumulation of plastic waste, especially from PET bottles, has become a serious environmental issue affecting waste management systems. At the same time, improving the strength and durability of conventional concrete is a major objective in modern construction practices. The use of fibers derived from waste PET bottles in concrete offers an effective and sustainable solution to these challenges. PET fibers are obtained by processing discarded plastic bottles and incorporating them into the concrete mix. The addition of these fibers enhances the performance of concrete by increasing its resistance to cracking and improving its toughness and structural behavior. This study focuses on evaluating the physical properties of concrete mixed with PET bottle fibers, including workability, compressive strength, split tensile strength, and flexural strength.

II. LITERATURE REVIEW

Zhang and Wang (2020) examined the physical and mechanical properties of conventional concrete reinforced with recycled PET bottle fibers. The study focused on compressive, split tensile, and flexural strength. Results showed that compressive strength slightly varied, while tensile and flexural strengths increased. The inclusion of PET fibers improved crack resistance and enhanced structural performance while promoting environmental sustainability.

Singh et al. (2021) studied the effect of different percentages of PET fibers on the strength and durability of geopolymer concrete. Tests were conducted to evaluate compressive strength, split tensile strength, water absorption, and sorptivity. Optimum fiber content improved tensile strength, while excess fibers reduced workability.

investigated the physical and durability properties of PET fiberreinforced concrete under severe environmental conditions. Tests such as water absorption, permeability, and crack resistance were conducted. Results showed improved resistance to moisture penetration and reduced crack width. PET fibers enhanced bonding within the matrix, improving durability and reliability.The study highlighted sustainable benefits through effective recycling of plastic materials. context.

III. METHODOLOGY

IV. MATERIAL PROPERTIES AND MIX DESIGN

The polyethylene fibers, including UHMWPE, HDPE, and recycled PET fibers, are used for microreinforcement of M30 concrete mixes at 0.5- 1.5% volume fraction and 6-12mm lengths. UHMW PET fibers have excellent tensile strength of 2500- 3000 MPa, elongation of 3.5%, and hydrophobicity with a density of 0.97g/cm³. They provide excellent bridging of cracks smaller than 0.3mm and permeability. HD PET fibers. provide cost-effective water resistance, whereas PET fibers provide sustainability through waste bottles.framework.

Table:1 Material Properties of PET Bottle Fiber

S. No	Property	PET Bottle Fiber
1	Material Type	Polyethylene Terephthalate (PET)
2	Density	1.34 – 1.39 g/cm^3
3	Tensile Strength	300 – 600 MPa
4	Length of Fiber	10 – 20 mm
5	Diameter	0.2 – 0.4 mm
6	Water Absorption	Negligible

B) COARSEAGGREGATE

The coarse aggregate of concrete is usually rounded shape, well graded, and smaller in size than that of conventional concrete and geopolymer concrete. The size of coarse aggregate used for concrete is between 10mm to 20mm. Rounded and smaller coarse aggregate helps to achieve better flowability and deformability of concrete. It also helps to avoid segregation of concrete. Graded aggregate is also important to cast concrete in highly congested reinforcement or formwork of smaller dimensions.

Table:2 Materials and Properties for Coarse Aggregate

s.no.	Property	Normal Coarse Aggregate
1	Specific gravity	2.17
2	Bulk Density Loose compacted	1857.33 kg/m^3
3	Flakiness index	3%
4	Elongation index	0%
5	Bulk Density after compaction	2047 kg/m^3

C) CEMENT

Ordinary Portland Cement (OPC-43 grade) will serve as a binding agent for the M20 concrete mixes, which will comply with the IS: 8112-2013 specifications. The Ordinary Portland Cement has a specific gravity of 3.15, a fineness of more than 320m²/kg, an initial setting time of 180 minutes, and a 28-day compressive strength of 43 MPa.

Table:3 Material Properties of PET Bottle Fiber

S. No	Property	Cement (OPC)
1	Type	Ordinary Portland Cement (OPC 53 Grade)
2	Specific Gravity	3.15
3	Standard Consistency	30 – 35 %
4	Initial Setting Time	30 minutes (minimum)
5	Final Setting Time	600 minutes (maximum)
6	Fineness	225 – 300 m²/kg

FINEAGGREGATE

Fine aggregate, which can be granular material or crushed stones, is a primary constituent of concrete. The quality of fine aggregate and density of fine aggregate have a significant influence on the properties of hardened concrete.

Table:4 Materials and Properties for Fine Aggregate

S.No.	Property	Fine Aggregate
1	Specific gravity	2.67
2	Water absorption	1.27%
3	Moisture content	0.8%
4	Sieve analysis (Material status) IS:383/1970	Passes the requirements for zone II

D) WATER

Water has a very huge role in the concrete mix. The role of water in the concrete mix can be broken down as follows: as a main thing, bonding: water in the ingredient in the concrete mixes with cement, forming a bind

FIGURE:1 Materials

MIX DESIGN

a) Grade Designation =M30
b) Type Of Cement: Opc 53 Grade
c) Max Nominal Size of Aggrate:20mm
d) Workability: 100-120mm Slump
e) Exposure Condition: Moderate
f) Types Og Aggregate: Crushed **Angular Aggregates**
g) Max Water Cement Ratio: 0.45
h) Max Cement Content: 360 kg /m^3
i) Addition of Polyethylene Fibers

I. TEST DATA FOR MATERIALS

a) cement used: opc 53 grade
b) specific gravity of cement: 3.15
c) specific gravity of
1) coarse aggregate 20mm :2.67
2) fine aggregate :2.65
d) sieve analysis
1) coarse aggregate = 3.26
2) fine aggregate =4.41

III. SELECTION OF WATER CEMENT RATIO

Adopted max water amount ratio
= 0.44

IV. SELECTION OF WATER CONTENT

Max water content for 20mm aggregate
= 186 litre (for 25 to 50 mm slump range)
Estimate water content for 100 mm slump
= 186 (6/186)
= 197 litres

V. CALCULATION OF CEMENT CONTENT

Adopted w/c ratio = 0.44 Cement content = 158/0.44
=359 kg /m^3 > 340 kg/m^3 hence ok.

VI. PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE

From table 3 of (IS 1062:2009)

Volume of Coarse aggregate corresponding to 20 mm Size aggregate and fine aggregate (zone 11) for water cement ratio of 0.50

II. TEST DATA FOR MATERIALS

The largest mean compressive strength of 28 days given by
fck'= fck + 1.65 s
from IS10262:2000
S= 5 N / mm2
fck'= 30 + (1.65 x 5)
=38.25 mpa
fck'=38.25 N / mm2

a) volume of water
= 0.62
Volume of Coarse aggregate = 0.64 x 0.9
= 0.57
Volume of fine aggregate = 1- 0.546
= 0.424

MIX CALCULATION

The mix calculation per unit volume if concrete shall be as follows

b) Volume of concrete = 1 m3

c) Volume of cement = mass of cement / (specific gravity of cement x1000)

= 359/3.15 x 1000

= 0.114 m3

d) mass of Coarse aggregate

= e x volume of Coarse aggregate x Coarse aggregate of specific gravity x 1000

= 0.724 x 0.576 x 2.67 x 1000

=1118 kg /m3

e) mass of fine aggregate

= e x volume of fine aggregate x specific gravity of fine aggregate x1000

= 0.724 x 0.424 x 2.60 x 1000

= 798 kg /m3

f) Addition of PET fibers

fiber = 0.00236 kg /m3

0.5% = (0.5/100) x 0.00236 x 1.4

0.5% = 0.0214 kg /m3

1% = 0.024 kg /m3

1.5% = 0.0322 kg /m3

MIX PROPORTION

Cement = 340 kg /m3

Water = 158 L/m3 Coarse aggregate = 1113 kg /m3 Fine aggregate =798 kg /m3

Fiber (0.5%) = 0.0107Kg/m3

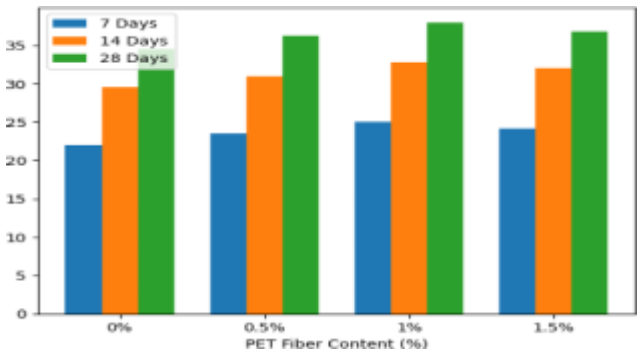
V TEST RESULTS AND DISCUSSIONS

TEST ON FRESH CONCRETE

A) Slump Cone Test

The Slump Cone Test was conducted to find out the workability of the fresh concrete mixes. In this test, a concrete mix is filled into a cone-shaped mold, which is then raised vertically.

The test was conducted according to ASTM C-143 and IS-1199 norms, which gave valuable insights into the workability of the concrete mixes with the inclusion of recycled aggregate, and PET fibers.



B). Compaction Factor Test

The compacting factor test is intended mainly for laboratory use, although it may be employed in the field. It is more accurate and sensitive than the slump test.

TEST ON HARDENED CONCRETE

For testing concrete in the hardened state, it is necessary to prepare different molds like cubes, cylinders, and beams. It is cured 24 hours after the required time.

A) Compressive Strength

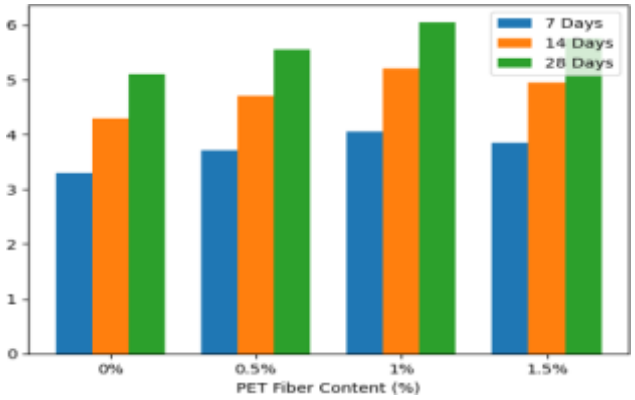
Theresults of the mechanical properties (according to IS: 516) obtained based on the samples tested according to Indian standard testing procedures are discussed.

PET FIBER CONTENT (%)	NO. OF DAYS		
	7 DAYS	14 DAYS	28 DAYS
0%	22.00 N/mm^2	29.50 N/mm^2	34.50 N/mm^2
0.5%	23.50 N/mm^2	31.00 N/mm^2	36.20 N/mm^2
1%	25.00 N/mm^2	32.00 N/mm^2	38.00 N/mm^2
1.5%	24.20 N/mm^2	32.00 N/mm^2	36.80 N/mm^2

B) Flexural Strength Test

The results of the flexural strength test (according to IS: 516) obtained from the tested samples are discussed based on Indian standard testing procedures.

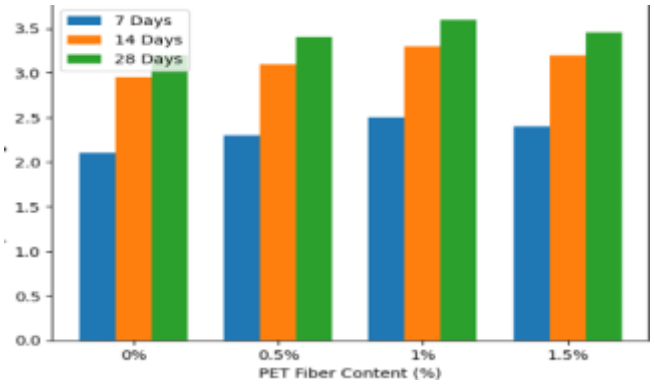
PET FIBER CONTENT (%)	NO. OF DAYS		
	7 DAYS	14 DAYS	28 DAYS
0%	3.30 N/mm^2	4.30 N/mm^2	5.10 N/mm^2
0.5%	3.70 N/mm^2	4.70 N/mm^2	5.55 N/mm^2
1%	4.05 N/mm^2	5.20 N/mm^2	6.05 N/mm^2
1.5%	3.85 N/mm^2	4.95 N/mm^2	5.75N/mm^2



C) Split Tensile Strength Test

The results of the split tensile strength test obtained from the tested samples are discussed based on standard testing procedures.

PET FIBER CONTENT (%)	NO. OF DAYS		
	7 DAYS	14 DAYS	28 DAYS
0%	2.10 N/mm^2	2.95 N/mm^2	3.20 N/mm^2
0.5%	2.30 N/mm^2	3.10 N/mm^2	3.40 N/mm^2
1%	2.50 N/mm^2	3.30 N/mm^2	3.60 N/mm^2
1.5%	2.40 N/mm^2	3.20 N/mm^2	3.45 N/mm^2



VI. CONCLUSION

The project titled Evaluation of Physical Properties of Concrete Incorporating PET Bottle Fibers concluded that the addition of PET fibers improves strength and reduces crack formation. The fibers enhance durability and performance of concrete. This approach reduces plastic waste and supports eco-friendly and sustainable construction practices effectively today globally in practice.

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