Behavior Of Concrete Using Shredded PET Bottle Fibre as Partial Replacement Of Fine Aggregate

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Abstract - *Concrete, being one of the most widely used construction materials globally, continually undergoes innovation to enhance its properties and sustainability. This study explores the viability of incorporating shredded PET (Polyethylene Terephthalate) bottle fibers as a partial replacement of fine aggregate in concrete mixes. The research aims to assess the mechanical, durability, and environmental aspects of such composite materials.*

The experimental investigation involves preparing concrete specimens with varying percentages of shredded PET fibers, replacing a portion of the fine aggregate. Mechanical properties such as compressive strength, tensile strength, and flexural strength are evaluated to understand the impact of PET fiber incorporation on the overall strength characteristics of concrete. Furthermore, durability aspects including resistance to chloride ion penetration, sulfate attack, and water absorption are examined to assess the durability performance of the composite.

Moreover, the environmental implications of utilizing shredded PET fibers in concrete are analyzed. This includes investigating the reduction in carbon footprint attributed to the use of recycled PET materials and assessing any potential benefits in terms of energy consumption and waste management.

The findings of this study aim to provide valuable insights into the feasibility and effectiveness of utilizing shredded PET bottle fibers as a sustainable alternative in concrete production. The outcomes could contribute to the development of environmentally friendly construction materials while addressing the challenges of waste management and resource conservation in the construction industry.

Key Words*: Concrete, Cement, Fine aggregates, Coarse aggregates, PET bottles.*

1.INTRODUCTION

Concrete is a fundamental construction material widely used in various infrastructure projects globally due to its versatility, durability, and strength. However, the production of conventional concrete involves significant environmental impacts, including high energy consumption and depletion of natural resources. In recent years, there has been growing interest in developing sustainable alternatives to conventional concrete by incorporating recycled materials to reduce environmental footprints and enhance the long-term sustainability of construction practices.

One such recycled material gaining attention is shredded PET (Polyethylene Terephthalate) bottle fibers, which are derived from post-consumer plastic waste. PET is commonly used in the production of beverage bottles, and its recycling presents an opportunity to mitigate plastic pollution while creating value-added products. The utilization of shredded PET fibers as a partial replacement of fine aggregate in concrete has emerged as a promising approach to address both environmental and engineering challenges in the construction industry.

The incorporation of shredded PET fibers in concrete offers several potential benefits. Firstly, it provides a sustainable solution for managing plastic waste by diverting PET bottles from landfills and utilizing them as reinforcement in concrete. Secondly, the use of recycled PET fibers can potentially improve the mechanical properties of concrete, such as enhancing flexural and tensile strength, as well as reducing shrinkage and cracking. Additionally, the lightweight nature of PET fibers may contribute to the overall density reduction of concrete, offering advantages in terms of structural design and transportation.

Despite the potential advantages, there are also challenges and uncertainties associated with the utilization of shredded PET fibers in concrete. These include concerns regarding the compatibility of PET fibers with cementitious materials, potential degradation over time, and the influence of fiber geometry and dosage on concrete properties. Therefore, comprehensive experimental investigations are essential to evaluate the behavior of concrete incorporating shredded PET fibers and to assess its suitability for various structural applications.

This research aims to contribute to the understanding of the behavior of concrete using shredded PET bottle fibers as a partial replacement of fine aggregate. Through systematic experimentation and analysis, the study seeks to assess the mechanical properties, durability performance, and environmental implications of such composite materials. The findings of this research endeavor are expected to provide valuable insights for the development of sustainable concrete solutions, fostering innovation in the construction industry towards a more environmentally conscious future.

1.1 PET Bottle Fibre

PET bottle fiber refers to fibers derived from recycling Polyethylene Terephthalate (PET) plastic bottles. PET is a commonly used polymer in the production of various plastic products, including beverage bottles, food containers, and polyester fabrics. PET bottles are widely consumed globally, leading to significant plastic waste generation.

To address the environmental challenges associated with PET bottle waste, recycling initiatives have been developed. One such initiative involves processing PET bottles into fibers for various applications, including reinforcing materials in concrete.

PET bottle fibers are typically obtained through a mechanical shredding and melting process, where discarded PET bottles are cleaned, shredded into small pieces, and then melted to form fibers. These fibers can vary in length, diameter, and aspect ratio, depending on the specific requirements of the application.

In the construction industry, PET bottle fibers are increasingly being explored as a sustainable alternative to conventional materials. When incorporated into concrete, PET fibers can act as reinforcement, improving the mechanical properties and durability of the composite material. Additionally, the use of recycled PET fibers helps reduce the environmental impact associated with plastic waste disposal.

Overall, PET bottle fibers represent a promising solution for recycling PET bottles and creating value-added products in various industries, contributing to efforts aimed at promoting sustainability and reducing plastic pollution

2. MATERIALS AND METHODS

2.1 Materials

- Cement: ordinary Portland cement 43 grade.
- Fine aggregate: M sand.
- Coarse aggregate: 20mm passing.
- Plastic fibres: PET Bottle fibres 4.75mm passing
- Water cement ratio: 0.55

Methodology

Collection and properties of materials
↓
Preliminary tests of materials
↓
Mix design
↓
Casting and curing of specimens
↓
Tests on concrete
↓
Analysis and result

In this experiment,0%,3%,6%, 9% and 12% of traditional fine aggregate were replaced in M25 grade concrete. The replacement percentage is by volume of total fine aggregate content derived from the mixture proportioned. Cube specimens of size 150 mm× 150 mm×150 mm, cylinder specimens of 100mm diameter and 200 mm height and prism specimens of size 100 mm×100 mm× 500 mm. Various Specimen types prepared are listed in Table 1.

Table 1: Various specimen types prepared

Sr no,	Specimen Type	No. of specimen prepared					
		PCC	3%	6%	9%	12%	Total
1	Cube	1	1	1	1	1	5
2	Cylinder	1	1	1	1	1	5
3	Beam	1	1	1	1	1	5
Total							15

The tests we performed on hardened concrete after 7days, 14days and 28 days of curing will be compression test, Split Tensile test and Flexural Test.

Experimental results

The parameters such as Compressive Strength, Splitting Tensile Strength and flexural strength test are discussed and Comparison between the conventional Concrete and PET added concrete is represented as follows

Compressive strength:

The cubes are usually size of 150 mm x 150 mm x 150 mm M25 grade. They're cast in molds and compacted properly to eliminate voids and ensure uniformity.

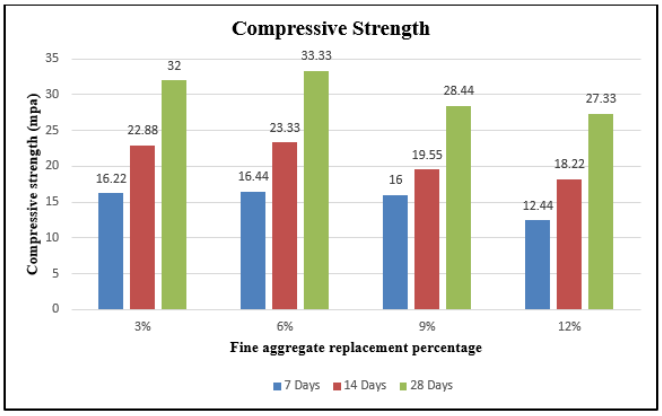
After casting, the cubes are cured in a controlled environment to simulate the conditions the concrete will experience in its intended application. This often involves immersion in water using curing compounds to maintain moisture and temperature levels.

After the designated curing period (7 days, 14 days, or 28 days), the cubes are removed from the curing environment and tested for compressive strength. This is typically done using a hydraulic press that applies a gradually increasing load to the cube until it fails. The maximum load at failure is recorded, and the compressive strength is calculated by dividing this load by the cross-sectional area of the cube.

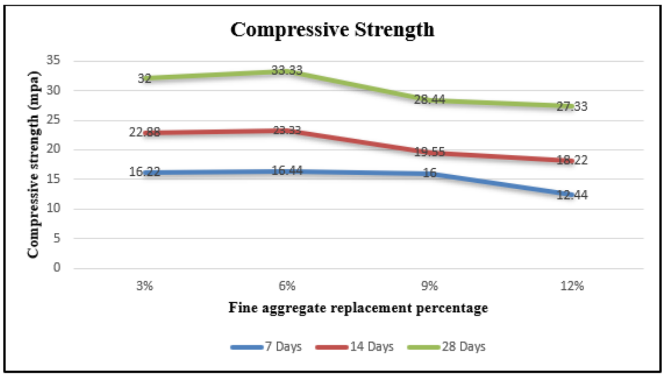
Fig -1: Cube after failure

Table 2: variation of 7 days, 14 days, and 28 days.

% Granules added	Weight (kg)			Peak load (KN)			Compressive strength (MPa)		
	7^{th} day	14^{th} day	28^{th} day	7^{th} day	14^{th} day	28^{th} day	7^{th} day	14^{th} day	28^{th} day
0%	8.90	8.92	8.95	390	550	745	17.33	24.44	33.11
3%	8.91	8.93	8.96	365	515	720	16.22	22.88	32
6%	8.92	8.94	8.95	370	525	750	16.44	23.33	33.33
9%	8.53	8.55	8.58	360	440	640	16.00	19.55	28.44
12%	8.28	8.31	8.33	280	410	615	12.44	18.22	27.33



Graph1:Bar Chart of Compressive Strength



Graph2:Line Chart of Compressive Strength

We concluded that, compressive strength of concrete increases with increase in the percentage of PET bottle fibre upto 6% in 7 days,14 days and 28 days. The compressive strength decreases with increase in the percentage of PET bottle fibre after 6 % in 7 days,14 days and 28 days. Peak compressive strength was at 6 % i.e. 16.44Mpa, 23.33Mpa, 33.33Mpa for 7 days, 14 days,28 days respectively.

Split tensile test

The cylinders are usually size of 100 mm (Diameter) x 200 mm (Height) M25 grade. They're cast in molds and compacted properly to eliminate voids and ensure uniformity.

After casting, the cylinders are cured in a controlled environment to simulate the conditions the concrete will experience in its intended application. This often involves immersion in water using curing compounds to maintain moisture and temperature levels.

After the designated curing period (7 days, 14 days, or 28 days), the cylinders are removed from the curing environment and tested for split tensile strength. This is typically done using a hydraulic press that applies a gradually increasing load to cylinders until it fails. The maximum load at failure is recorded, and the split tensile strength is calculated by 2L/πdh. (L = Load on cylinder, d = diameter of cylinder, h = height of cylinder).

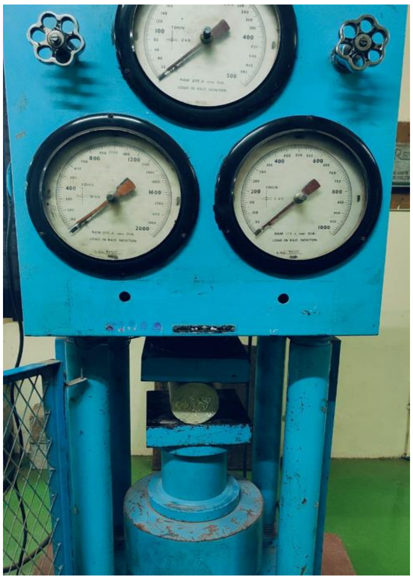
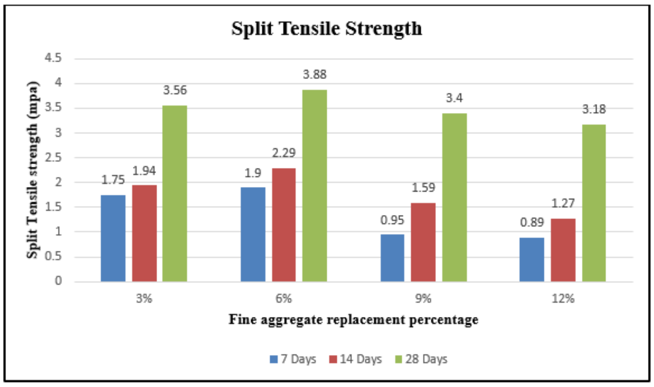


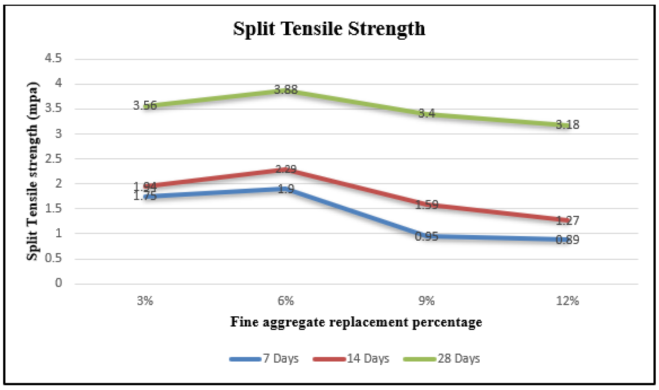
Fig -2: Cylinder for Split tensile strength

Table 3: variation of 7 days, 14 days, and 28 days.

% Granules added	Weight (kg)			Peak load (KN)			Tensile strength (MPa)		
	7th day	14th day	28th day	7th day	14th day	28th day	7th day	14th day	28th day
0%	4.10	4.12	4.15	62	81	110	1.97	2.57	3.50
3%	4.12	4.13	4.16	55	61	112	1.75	1.94	3.56
6%	4.15	4.17	4.18	60	72	122	1.90	2.29	3.88
9%	4.01	4.03	4.07	30	50	107	0.95	1.59	3.40
12%	3.97	3.99	4.01	28	40	100	0.89	1.27	3.18



Graph 3:Bar Chart of Split Tensile Strength



Graph 4:Line Chart of Split Tensile Strength

We concluded that, Split tensile strength of concrete increases with increase in the percentage of PET bottle fibre upto 6% in 7 days,14 days and 28 days. The Split tensile strength decreases with increase in the percentage of PET bottle fibre after 6 % in 7 days,14 days and 28 days. Peak Split tensile strength was at 6 % i.e. 1.90Mpa, 2.29Mpa, 3.88Mpa for 7 days, 14 days,28 days respectively.

Flexural strength test

The beams are usually size of 100 mm x 100mm x 500 mm M25 grade. They're cast in molds and compacted properly to eliminate voids and ensure uniformity.

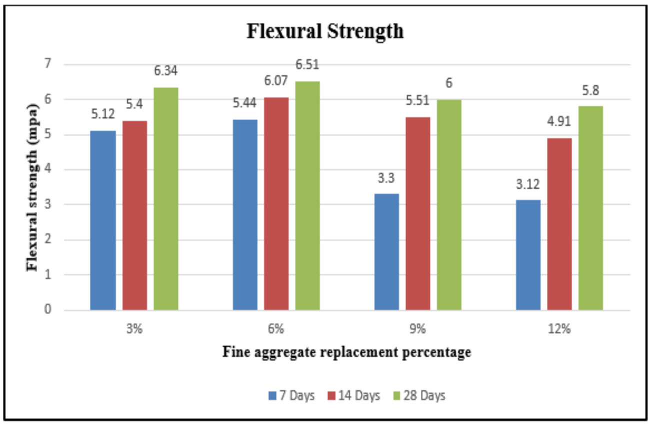
After casting, the beams are cured in a controlled environment to simulate the conditions the concrete will experience in its intended application. This often involves immersion in water using curing compounds to maintain moisture and temperature levels.

After the designated curing period (7 days, 14 days, or 28 days), the beams are removed from the curing environment and tested for Flexural strength test. This is typically done using a hydraulic press that applies a gradually increasing load to beams until it fails. The maximum load at failure is recorded, and the Flexural strength test is calculated by PL/bd^2.

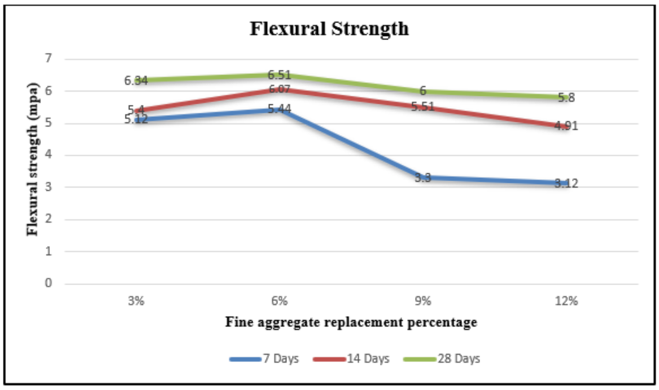
Figure 3:Flexural Strength Test

Table 4: variation of 7 days, 14 days, and 28 days.

% Granules added	Weight (kg)			Peak load (KN)			Flexural strength (MPa)		
	7th day	14th day	28th day	7th day	14th day	28th day	7th day	14th day	28th day
0%	13.15	13.22	13.25	6	8	10.2	2.52	4.95	5.11
3%	13.20	13.21	13.24	6.6	9	13	5.12	5.40	6.34
6%	13.18	13.22	13.23	8.5	9.2	10.5	5.44	6.07	6.51
9%	12.91	12.93	12.96	5	9.5	10	3.30	5.51	6.00
12%	12.85	12.86	12.88	4	7	9.8	3.12	4.91	5.80



Graph 5:Bar Chart of Split Tensile Strength



Graph 6:Line Chart of Split Tensile Strength

We concluded that, Flexural strength of concrete increases with increase in the percentage of PET bottle fibre upto 6% in 7 days,14 days and 28 days. The Flexural strength decreases with increase in the percentage of PET bottle fibre after 6 % in 7 days,14 days and 28 days. Peak Flexural strength was at 6 % i.e. 5.44 MPa, 6.07 MPa, 6.51 MPa for 7 days, 14 days,28 days respectively.

Conclusion

The conclusion based on obtained results is as follows:

- The inclusion fibre content increases flow properties of concrete.
- The maximum compressive strength , split tensile strength and flexural strength were at usage of 6% of PET bottle as replacement of fine aggregate .After that reduction in strength were observed as increasing of PET bottle fibre as fine aggregate,
- The concrete with PET Bottle fibre was shown lower weights as compared conventional concrete. This can achieve lightweight concrete properties.
- PET bottle fibre can be used without affecting the properties of concrete.
- From our observations we concluded that, PET Bottle fibres can be replaced as fine aggregate resulting in cost reduction and solving issues of solid wastes.

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