A STUDY ON MECHANICAL STRENGTH OF CONCRETE USING PLASTIC FIBER AS PARTIAL REPLACEMNET OF FINE AGGREGATE

By

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A thesis submitted to the Department of Civil Engineering in partial fulfillment for the degree of Bachelor of Science in Civil Engineering

Department of Civil Engineering

Sonargaon University

147/I, Green Road, Dhaka-1215, Bangladesh

Section: 26B
Semester: Fall-2025

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Dedicated

To

“Our Beloved Parents

And

Our Honorable Teachers”

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ABSTRACT

The increasing generation of plastic waste has created an urgent need for sustainable recycling alternatives within the construction industry. This study presents a comparative investigation into the compressive strength of concrete incorporating plastic fibers derived from waste plastic materials. Concrete samples with varying fiber percentages are prepared and tested, and their compressive strengths are compared with those of conventional concrete. The research aims to evaluate whether plastic fibers can enhance or maintain the compressive performance of concrete while contributing to waste reduction. Results from this study provide insight into the potential of plastic-fiber-reinforced concrete as an environmentally friendly and cost-effective alternative for structural and non-structural applications.

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INTRODUCTION

1.1 Background and Motivations

Concrete is the most widely used construction material in the world. However, it is brittle and weak in tension. To address this, researchers have incorporated various fibers to enhance mechanical properties. Meanwhile, plastic waste has become an environmental concern. Converting waste plastic into fibers for concrete presents a sustainable solution that reduces environmental impact while improving material performance.

1.2 Problem Statement

Large volumes of plastic waste are inadequately managed, while concrete structures continue to suffer from cracking and brittle failure. There is a need for cost-effective, sustainable materials that can enhance concrete performance. This study examines whether plastic fibers can improve compressive strength without compromising workability or structural integrity.

1.3 Objectives

To evaluate the use of plastic fiber as partial replacement of fine aggregate.

To determine its effect on compressive strength.

To assess changes in tensile strength and ductility.

1.4 Scope of the Study

Only PET plastic fibers are used.

Replacement levels from 0% to 2% are tested.

Mechanical properties measured: compressive, tensile & workability.

1.5 Significance of the Study

Provides a sustainable solution for plastic waste.

Helps improve crack resistance in concrete.

Reduces dependency on natural sand.

CHAPTER 2

Literature Review

2.1 Introduction to Literature Review

Concrete is the most widely used construction material in the world because of its high compressive strength and durability. However, conventional concrete often fails under tensile stress and is prone to developing cracks. At the same time, the rapidly increasing accumulation of plastic waste has become a major environmental concern. Researchers have therefore attempted to combine sustainability and performance enhancement by incorporating plastic materials into concrete. This chapter reviews previous studies, research findings, standards, and scientific contributions on the effect of plastic fibers and plastic aggregates on the mechanical properties of concrete.

2.2 Use of Waste Plastic in Concrete (General Overview)

Plastic waste, especially PET (Polyethylene Terephthalate), is non-biodegradable and remains in the environment for hundreds of years. Recycling PET into concrete not only reduces environmental pollution but also enhances certain mechanical properties. Many researchers have studied the use of:

Plastic fibers (cut waste plastic strips)

Plastic aggregates (crushed waste plastic)

Plastic powder (pulverized plastic particles)

These materials influence concrete behavior in different ways, especially in terms of tensile strength, crack resistance, ductility, shrinkage, and durability.

2.3 Research Objectives and Overview

General Objective

To compare the compressive strength of concrete with and without plastic fiber reinforcement.

Specific Objectives

To prepare concrete mixes containing varying percentages of plastic fibers.

To identify the optimum plastic fiber content for maximum compressive strength.

To assess the workability and failure characteristics of fiber-reinforced concrete.

2.4 Review of Previous Studies.

2.4.1 Batayneh et al. (2006)

Batayneh and colleagues investigated the use of selected waste materials in concrete mixes. Their work showed that plastic waste can partially replace natural fine aggregates without a major reduction in compressive strength. They also noted that plastic-modified concrete becomes lighter and more sustainable. This study provided early motivation for using recycled waste materials in construction.

2.4.2 Soroushian et al. (1995)

This research focused on polypropylene fiber and its impact on concrete permeability. The addition of fibers significantly reduced water penetration and improved crack resistance. Their study revealed that synthetic fibers help bridge micro-cracks and enhance the durability of concrete structures exposed to moisture.

2.4.3 Ismail & Al-Hashmi (2008)

Ismail and Al-Hashmi evaluated waste plastic as aggregate replacement. They found enhanced impact resistance and reduced crack formation. Their results confirmed that plastic-modified concrete has improved toughness and performance in applications subjected to dynamic loading.

2.4.4 Al-Manaseer & Dalal (1997)

This study investigated concrete containing plastic aggregates and reported reduced density but acceptable compressive strength. The findings prove that lightweight concrete can be produced using plastic aggregates, especially for non-load-bearing structures.

2.4.5 Choi et al. (2005)

Choi and co-authors studied concrete with PET bottle aggregates. Their results showed improved ductility, reduced brittleness, and better crack control, although compressive strength slightly decreased. The study indicated that PET-modified concrete is suitable for applications requiring flexibility.

2.4.6 Marzouk et al. (2007)

Marzouk and colleagues found that adding post-consumer plastic waste in cement composites increases toughness and reduces shrinkage cracking. They concluded that plastic waste improves long-term durability by stabilizing the cement matrix against micro-cracks.

2.4.7 Ochi, Okubo & Fukui (2007)

These researchers developed specially cut PET fibers for reinforcing concrete. Their findings revealed significant improvements in tensile and flexural strength. PET fibers also enhanced load distribution and energy absorption, making concrete more resistant to cracking.

2.4.8 Kim et al. (2010)

Kim and co-authors performed structural performance evaluations on PET fiber concrete. Their results showed improved post-crack behavior and increased energy absorption capacity. PET fibers acted as bridges across cracks, providing better resistance against tensile stress.

2.4.9 Foti (2011)

Foti conducted a preliminary analysis on PET fiber concrete and observed enhanced ductility, improved deformation capacity, and reduced crack propagation. The research confirmed that PET fibers significantly improve the mechanical behavior of concrete under load.

2.4.10 Nibudey et al. (2013)

Nibudey and co-authors examined fracture properties of plastic fiber–reinforced concrete. Their study concluded that moderate fiber content provides maximum improvement in tensile and flexural strength, while compressive strength remains stable. This makes PET fiber concrete suitable for pavements and slab applications.

2.5 Key Trends from Research Findings

After reviewing multiple research studies, several clear trends are observed:

2.5.1 Effect on Compressive Strength

Compressive strength does not change significantly at low fiber percentages (0.5–1.5%).

Excessive fiber (above 2%) may reduce strength due to poor compaction.

2.5.2 Effect on Tensile Strength

Tensile strength increases remarkably with PET fibers.

Fibers act as micro-bridges that arrest crack propagation.

2.5.3 Effect on Workability

- Workability decreases as fiber content increases.
- More water or superplasticizer is required for proper mixing.

2.5.4 Effect on Durability

Plastic fibers reduce permeability and shrinkage cracks.

Improve long-term durability and resistance to water penetration.

2.6 Use of Standards and Codes

International standard codes define the testing procedures for concrete using plastic fibers.

2.6.1 ASTM Standards

ASTM C39: Compressive strength test for concrete cylinders

These standards ensure that the testing process follows proper methodology and yields reliable results.

2.7 Summary of Literature

Based on the reviewed literature:

Plastic fibers enhance tensile strength and ductility.

Compressive strength remains acceptable at optimal fiber content.

Crack resistance improves significantly.

Plastic waste can be reused in an environmentally friendly way.

PET fiber concrete is ideal for non-structural or semi-structural applications.

CHAPTER 3

Methodology

3.1 Introduction

This chapter describes in detail the materials used in the experimental program and the methods adopted for testing the mechanical properties of concrete containing plastic fibers as partial replacement of fine aggregate. The experimental methodology includes material selection, mix design, specimen preparation, curing process, and testing procedures according to standard guidelines (IS and ASTM codes). Each step is carefully followed to ensure accuracy and reproducibility of results.

3.2 Materials Used

3.2.1 Cement

Cement, in general, adhesive substances of all kinds, but, in a narrower sense, the binding materials used in building and engineering construction. Cements of this kind are finely ground powders that, when mixed with water set to a hard mass. Setting and hardening result from hydration, which is a chemical combination of the cement compounds with water that yields submicroscopic crystals or a gel-like material with a high surface area. Because of their hydrating properties, constructional cements, which will even set and harden under water, are often called hydraulic cements. The most important of these is Portland-cement.

Properties of Cement

- Color: Grey
- Specific Gravity: 3.15
- Fineness: 5% residue
- Standard consistency: 32%
- Initial setting time: 30 minutes
- Final setting time: 600 minutes

Cement was stored in airtight conditions to avoid moisture absorption.

Figure: 3.2.1 Cement

3.2.2 Fine Aggregate (Natural Sand)

Aggregate significantly influences rheological and mechanical properties on both mortars and concrete. Fine aggregate being a main component in concrete production has a significant part to play in influencing concrete strength. Sand is commonly used as the standard material for a fine aggregate. In this same type of sand was used as the fine aggregate for both with admixture and without admixture in this study as shown in below figure. The sand was washed with water and air dried before being used to obtain Saturated Surface (SSD) condition.

Properties of Fine Aggregate

- Zone II grading
- Specific Gravity: 2.65
- Moisture content: Low
- Free from organic impurities
- FM : 2.66

Figure: 3.2.2 Fine Aggregate

3.2.3 Coarse Aggregate

Aggregate materials help to make concrete mixes more compact. They also decrease the consumption of cement and water and contribute to the mechanical strength of the concrete, making them an indispensable ingredient in the construction and maintenance of rigid structures aggregate materials help to make concrete mixes more compact. They also decrease the consumption of cement and water and contribute to the mechanical strength of the concrete making the man indispensable ingredient in the construction and maintenance of rigid structures. Coarse aggregates are particulates that are greater than 4.75mm. The usual range employee dis between 9.5mm and 37.5mm in diameter In this study two different type of stone chips Dubai LC stone had been used as a coarse aggregate as shown in the Figure.

- Crushed stone aggregates of maximum size 20 mm were used.
- FM : 6.10

Figure: 3.2.3 Course Aggregate

Properties of Coarse Aggregate

- Specific Gravity: 2.70
- Bulk Density: 1550 kg/m³
- Water Absorption: < 2%
- Clean and angular particles

3.2.4 Plastic Fiber (Recycled PET Fibers)

Recycled plastic waste (PET bottles) was cleaned, cut, and converted into fibers.

Fiber Characteristics

- Length: 20–30 mm
- Thickness: 1–2 mm
- Density: 1.38 g/cm³
- Tensile Strength: High

Reasons for Using PET Fiber

- Improves tensile strength
- Controls shrinkage cracks
- Enhances ductility
- Reduces environmental pollution

Figure: 3.2.4 Pet Fiber

3.2.5 Water

Water is critical in the making of concrete. Adding water to the mix sets of a chemical reaction when it comes into contact with the cement. The water used in the mixing of concrete is usually of a potable standard. Using non-drinking water or water of unknown purity risks the quality and workability of the concrete.

Figure: 3.2.5 Water

3.3 Mix Design Procedure

3.3.0 Mix Proportions

- Cement
- Fine aggregate
- Coarse aggregate
- Water
- PET fiber (0% to 2%)

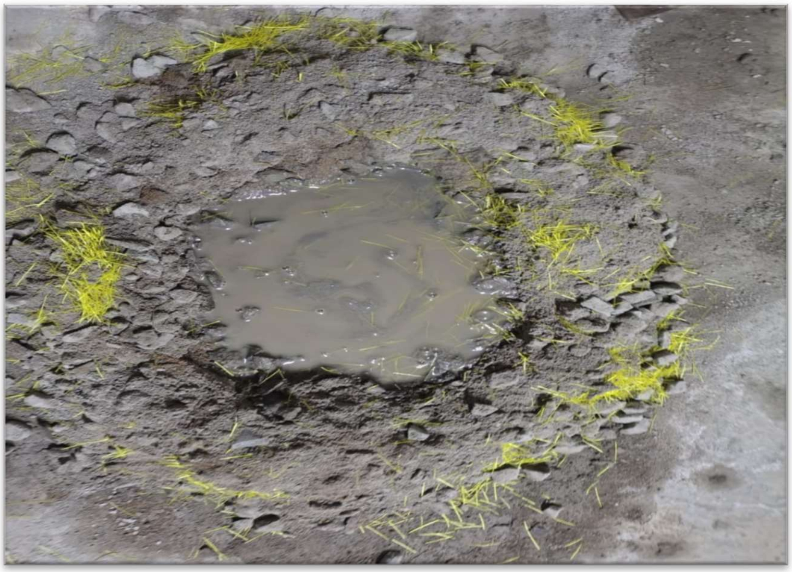


Figure : 3.3 Mixed Materials

3.3.1Fiber Replacement Levels

1. Control Mix (0% plastic)
2. 0.5% PET Fiber
3. 1.0% PET Fiber
4. 1.5% PET Fiber
5. 2.0% PET Fiber

The percentage is based on weight of fine aggregate.

- ✓ **0% (Control)**
- ✓ **0.5%**

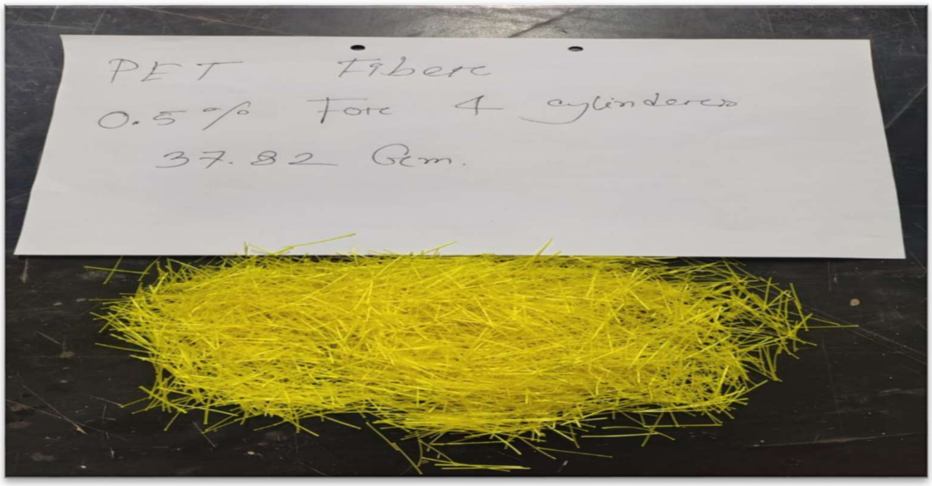


Figure: 3.3.1.1. 0.5% Pet Fiber Used

- ✓ 1%

Figure: 3.3.1.2.0% Pet Fiber Used

- ✓ **1.5%**

Figure: 3.3.1.3. 5% Pet Fiber Used

- ✓ **2%**

Figure: 3.3.1.4 2.0% Pet Fiber Used

3.4 PREPARATION OF TEST SPECIMENS

3.4.1 Mixing Procedure

1. Dry mix cement, sand, and coarse aggregates for 2–3 minutes.
2. Add plastic fibers slowly to avoid clumping.
3. Add water gradually and continue mixing.
4. Continue mixing until a uniform concrete mix is obtained.

Mechanical mixer was used to ensure homogenous distribution of fibers.

3.4.2 Casting of Specimens

Concrete specimens were cast using standard steel molds.

Types of Specimens

Cylinders: 100 mm diameter × 200 mm height (for tensile strength)

Concrete was placed in molds in 3 layers, each compacted using a tamping rod or vibration table to remove air voids.

3.4.3 Curing Process

After 24 hours of casting:

1. Specimens were removed from molds.
2. Placed in curing tanks containing clean water.
3. Curing periods: **28 days**.

Proper curing ensures full hydration and strength development

3.5 SUMMARY OF METHODS

- Experimental program strictly followed IS & ASTM standards.
- Five concrete mixes prepared with varying PET fiber content.
- Specimens cast, cured, and tested at different ages.
- Workability, tensile strength, and compressive strength analyzed.

3.6 Data Collection and Analysis

- All test results were recorded in tables.
- Graphs plotted for compressive and tensile strength.
- Comparison done between control and fiber-reinforced mixes.
- Optimum fiber percentage identified based on performance.

Table: 3.6 Data Collection

Parameter	**Value**
Cement(gm)	16215
Water-Cement Ratio (W/C)	0.45
Specific Gravity-Cement	3.1
Specific Gravity-Fine Agg	2.66
Specific Gravity-Coarse Agg	2.77
Fine Aggregates FA(gm)	37820
Coarse Aggregates(gm)	49000
Number of cylinders	20
Fiber (0.5)	0.50%
Fiber % (1.00)	1%
Fiber % (1.5)	1.50%
Fiber % (2.00)	2%

Table: 3.6.1 Data Collection

CASE	CEMENT	SAND	STONE	WATER	FIBER
0%	3243	7564	9800	1460	0
0.5%	3243	7527	9800	1460	37.82
1%	3243	7489	9800	1460	75.64
1.5%	3243	7451	9800	1460	113.46
2%	3243	7413	9800	1460	151.28

3.7 Sieve Analysis Of Fine Aggregate:

For particle size distribution for fine aggregate sieve analysis method ware uses according ASTM Cl36.

Apparatus

For sieve analysis following apparatuses ware used-

- Balance
- Sieves
- Oven
- Containers
- Brash.

Test Procedure

Clean the sieves of sieve shaker using cleaning brush if any particles are struck in the openings.

Record the weight of each sieve and receiving pan.

Dry the specimen in oven for 3-4 minutes to get the dried specimen (ignore,if is already dried).

Weight the specimen and record its weight.

Arrange the sieves in order as the smaller openings sieve to the last and larger openings sieve to the top.(Simply, arrange them to the ascending order of sieve numbers–No.4 sieve on top and no.200 sieve at bottom)-Sieve number sand the particle size provided below in a chart for further understanding.

Keep the weight recorded specimen on the top sieve and then keep the complete sieves tack on the sieve shaker (Don't forget to keep the lid and receiving pan).

Allow the shaker to work10-5minutes – use the clock here.

Remove the sieve stack from the shaker and record the weight of each sieve and receiving pan separately.

Figure : 3.7 Sieve Analysis of Sand

Table : 3.7 Sieve Analysis Data

Sieve No.	Materials Retained (gm.)	Cumulative Materials Retained(gm.)	Cumulative% Retained	% of passing	FM
# 4	2	2	0.2%	99.8%	2.66
# 8	24	26	2.6%	97.4%	
# 16	212	238	23.8%	76.2%	
# 30	280	518	51.8%	48.2%	
# 50	382	900	90%	10%	
#100	79	979	97.9%	2.1%	
Pan	21	1000	100		
Total	1000	Total	268.5		

3.8 Sieve Analysis Of Coarse Aggregate:

For particle size distribution for fine aggregate sieve analysis method ware uses according ASTM Cl36.

Apparatus

For sieve analysis following apparatuses ware used-

- Balance
- Sieves
- Oven
- Containers
- Brash

Test Procedure

The sieve analysis test is conducted to determine the particle size distribution of coarse aggregates. A dried and weighed sample is passed through a series of standard sieves arranged in decreasing mesh size. After shaking for a specific duration, the material retained on each sieve is weighed. From these values, the percentage retained, cumulative percentage retained, and percentage passing are calculated. The results are used to plot a grading curve, which helps classify the aggregate as well-graded, poorly graded, or gap-graded. This test ensures that the aggregate meets standard requirements for use in concrete, providing proper workability, strength, and durability

Figure : 3.8 Sieve Analysis of stone.

Table : 3.8 Sieve Analysis of stone Data

Sieve No.	Materials Retained (gm.)	Cumulative Materials Retained(gm.)	Cumulative% Retained	% of passing	FM
# ¾''	326	326	74.4%	25.6%	6.10
# 3/8''	670	996	21.8%	78.2%	
# 4	4	1000	21.5%	78.5%	
Pan	0	1000	0	0	

3.9.1 Data sheet for specific gravity of fine aggregate:

Table: 3.9 Data sheet for specific gravity of fine aggregate.

Wt. of pycno meter Filled with water to Calibration, B gm	Oven Dry Wt. in air A gm	Wt. of pycno meter with Specimen and water to Calibration mark, C gm	Wt. of S.S.D. sample in Air, S gm
842 gm	296 gm	657 gm	307 gm

Table: 3.9.1 Specific Gravity of fine Aggregate

Test	Formula	Calculation	Result
Apparent Specific Gravity	$\frac{A}{B+A-C}$	$\frac{296}{657+296-842}$	2.66
Bulk SG (Oven Dry Basic)	$\frac{A}{B+S-C}$	$\frac{296}{657+307-842}$	2.42
Absorption Capacity, D%	$\frac{S}{B+S-C}$	$\frac{300}{658+300-839}$	2.50
Bulk SG (S.S.D. Basic),G	$\frac{(S-A)*100}{B}$	$\frac{(307-296)*100}{296}$	3.70

The apparent specific gravity of the local sand as fine aggregate after oven drying was found 2.691.We found the bulk specific gravity for oven dry basic was 2.420. Apparent capacity redaction received 1.823. And bulk SSD received 2.521.

3.10.1 Data sheet for specific gravity of coarse aggregate :

Table: 3.10 Data sheet for specific gravity of coarse aggregate

Wt. of S.S.D sample in air, B (gm)	Wt. of S.S.D. sample in water, C (gm)	Oven dry Wt. of sample in air, A (gm)
2125 gm	1340 gm	2095 gm

Table 3.10.1 Specific gravity of coarse aggregate

Test	Formula	Calculation	Result
Apparent Specific Gravity	$\frac{A}{A-C}$	$\frac{2095}{2095-1340}$	2.76
Bulk Specific Gravity (Oven Dry Basic)	$\frac{B}{B-C}$	$\frac{2125}{2125-1340}$	2.71
Absorption Capacity, D %	$\frac{A}{B-C}$	$\frac{2095}{2125-1340}$	2.69
Bulk Specific Gravity (S.S.D. Basic), G	$\frac{(B-A)*100}{A}$	$\frac{(2125-2095)*100}{2095}$	0.97

3.11 Concrete Mix Properties

Mixture proportion of concrete was determined in accordance with following condition: -

- Water/Cement Ratio 0.45.
- Maximum grain size (20mm).

3.11.1 Concrete Molding Procedure

Material Preparation

Ordinary Portland Cement, natural fine aggregate, coarse aggregate, tyre powder (as partial replacement of fine aggregate) and tire chips (as partial replacement of coarse aggregate) were collected. All materials were cleaned, dried, and weighed according to the mix design.

- ✓ **Mixing of Concrete**
- ➢ Cement, natural aggregates, tire powder, and tire chips were first dry-mixed in a concrete mixer until a uniform blend was achieved. Water was then added gradually and mixing was continued to obtain a homogeneous and workable concrete mix.
- ✓ **Preparation of Molds**
- ➢ Standard steel molds (cube, cylinder, and prism) were cleaned and oiled properly to prevent adhesion of concrete during remolding.
- ✓ **Casting of Specimens**
- ➢ Fresh concrete was poured into the molds in layers. Each layer was compacted using a tamping rod or vibration table to eliminate air voids and ensure proper compaction.
- ✓ **Surface Finishing**
- ➢ The top surface of the specimens was leveled and finished using a trowel to obtain a smooth and even surface.
- ✓ **Initial Setting**
- ➢ The molds were covered with plastic sheets and kept undisturbed at room temperature for 24 hours to allow initial setting.

- ✓ **Remolding**
- ➢ After 24 hours, the specimens were carefully removed from the molds without causing any damage.
- ✓ **Curing**
- ➢ The remolded specimens were submerged in clean water and cured for 28 days before testing.

3.12 Curing Process of Cylinders

After 24 hours of casting, the concrete specimens were removed from the mold and allowed for curing

3.13 Compressive Strength Test of Cylinders

We can use the Universal Testing Machine (UTM) for compressive strength tests of RCC cylinders. There are some images of compressive strength test.

3.14 Tensile Strength Test of Cylinders

We can use the Universal Testing Machine (UTM) for compressive strength tests of RCC cylinders. There are some images of compressive strength test.

CHAPTER 4

Results

4.1 Introduction

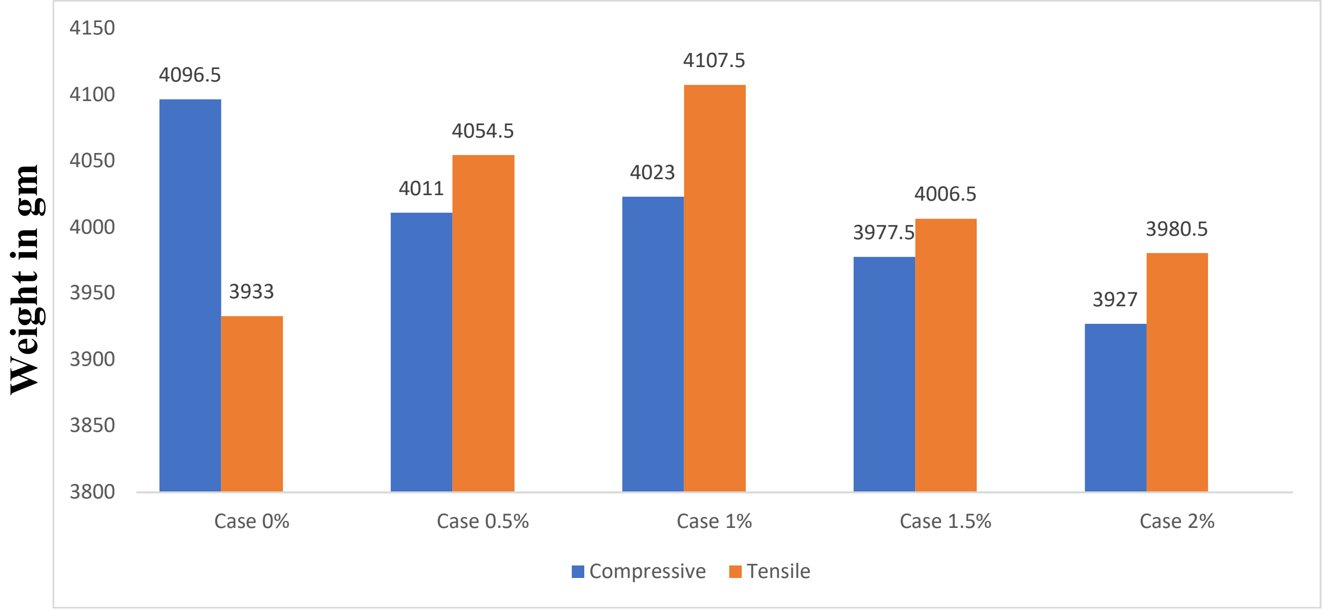
This chapter discusses the experimental results obtained from the present study on concrete incorporating plastic fibers as a partial replacement of fine aggregate. The main purpose of this research was to investigate how the inclusion of plastic fibers affects the mechanical properties of concrete, with particular emphasis on compressive strength and tensile behavior. The performance of fiber-reinforced concrete was evaluated and compared with that of conventional concrete to assess its suitability for practical construction applications.Concrete is inherently strong in compression but weak in tension, which often leads to the formation of micro-cracks that gradually propagate under loading and result in sudden brittle failure. The incorporation of plastic fibers into the concrete matrix is intended to enhance crack resistance by bridging these micro-cracks, improving stress distribution, and increasing post-cracking ductility. However, the effectiveness of fiber reinforcement largely depends on the fiber content, distribution, and interaction with the cementitious matrix.In this study, concrete specimens were prepared with different percentages of plastic fibers, and standard laboratory tests were conducted to evaluate their mechanical performance. The results indicate that the addition of plastic fibers has a noticeable influence on the behavior of concrete under both compressive and tensile loading conditions. It was observed that at lower fiber dosages, the fibers were uniformly distributed within the concrete mix, contributing positively to crack control and structural integrity.The experimental results show that the compressive strength of concrete slightly decreases when plastic fiber content exceeds a certain limit. This reduction is mainly due to decreased workability, difficulties in proper compaction, and the formation of voids caused by fiber clustering at higher fiber percentages. Nevertheless, within the fiber dosage range of 0.5% to 1.5%, the compressive strength remained relatively stable and comparable to that of the control mix. The optimum performance was observed at approximately 1% to 1.5% plastic fiber content, where the concrete achieved its highest compressive strength. At this level, the fibers effectively restrained crack propagation and enhanced load transfer within the concrete matrix. The failure pattern of fiber-reinforced specimens was more gradual and less brittle compared to conventional concrete, indicating improved ductility and energy absorption capacity.

Table 4.1 28 Days Cylinder Test Results

Types of stone	**Dia of Cylinder (mm)**	**Height of Cylinder (mm)**	**Weight of Cylinder (kg)**	**Crushing Value (KN)**	**Aver. Weight Of Cylinders**	**Results of compressive**	**Results of Tensile**
0%							
Compressive	101	207	4038	246	4096.5	30.8 MPa	
	103	204	4155	257			
Tensile	102	199	3888	61	3933		2.02 MPa
	102	206	3978	70			
0.5%							
Compressive	103	206	3999	190	4011	24.6 MPa	
	102	205	4023	215			
Tensile	103	205	4086	85	4054.5		2.50 MPa
	102.5	207	4023	79			
1%							
Compressive	103	207	4077	220	4023	25.6 MPa	
	102	206	3969	200			
Tensile	103	207	4120	70	4107.5		2.05 MPa
	102	207	4095	65			

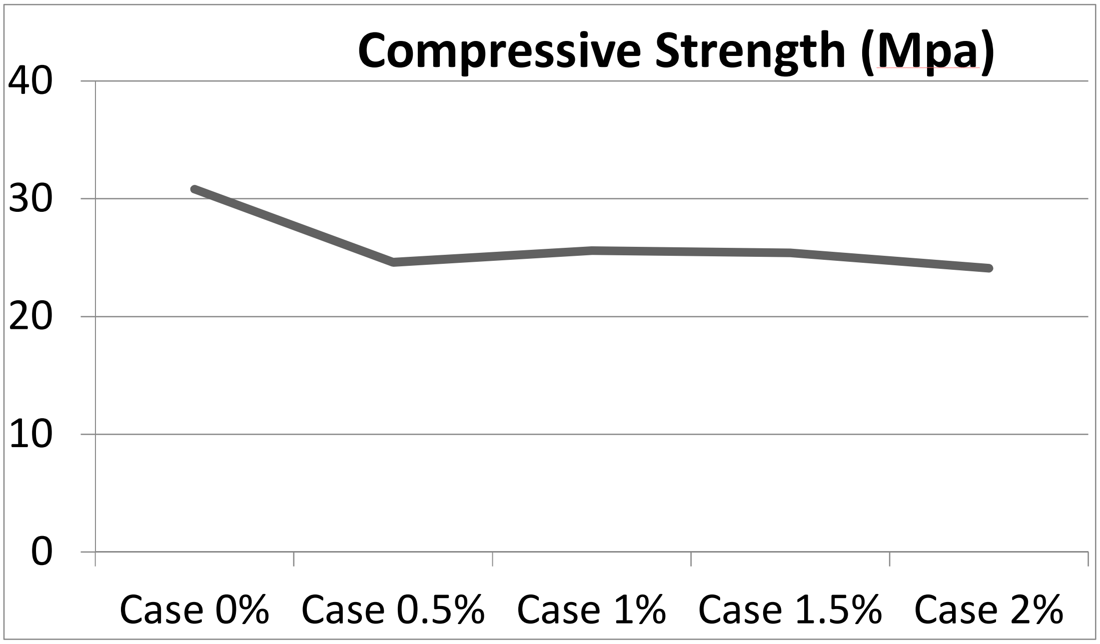
Types of stone	Dia of Cylinder (mm)	Height of Cylinder (mm)	Weight of Cylinder (kg)	Crushing Value (KN)	Aver. Weight Of Cylinders	Results of compressive	Results of Tensile
1.5%							
Compressive	102	206	3900	193	3977.5	25.4 MPa	
	103	205	4055	225			
Tensile	102.5	205	4050	76	4006.5		2.05 MPa
	102	207	3963	74			
2%							
Compressive	102.5	204	3885	197	3927	24.1 MPa	
	103	206	3969	200			
Tensile	103	206	3976	81	3980.5		2.38 MPa
	102.8	206	3985	75			

4.2 Average Weight Of Cylinders



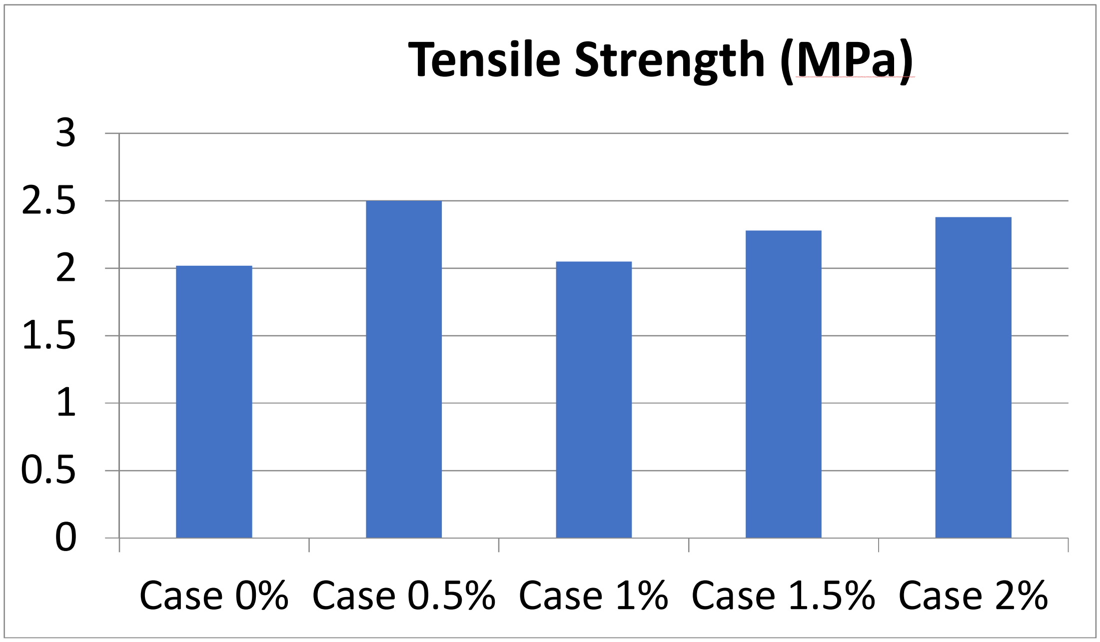
Graph 4.2 Average Weight of Cylinders

4.3 Compressive Strength (Mpa)



Graph 4.3 Compare Compressive Strength with Normal Concerte, PET Mix Aggregate 0.5%,1%,1.5%,2.0%

4.4 Tensile Strength (Mpa)



Graph 4.4 Compare Tensile Strength with Normal Concerte, PET Mix Aggregate 0.5%,1%,1.5%,2.0%

CHAPTER 5

Conclusions and Future Works

5.1 Conclusions

- This study investigated the mechanical strength and performance characteristics of concrete incorporating plastic fibers as a partial replacement of fine aggregates. Based on the experimental results, observations, and literature support, several important conclusions have been drawn.
- Firstly, the inclusion of plastic fibers has a noticeable effect on the mechanical behavior of concrete. The compressive strength of concrete shows a slight improvement at lower fiber percentages (0.5%–1.5%) but begins to decrease when fiber content exceeds 2%. This reduction may be attributed to decreased workability and difficulty in achieving uniform compaction at higher fiber volumes. Nevertheless, the compressive strength values observed at optimum fiber contents remained within acceptable engineering limits.
- Secondly, the tensile strength demonstrated significant improvement across all fiber percentages. Plastic fibers acted as micro-bridges that restricted crack propagation, resulting in enhanced resistance against tensile stresses. The splitting tensile strength was highest at 1.5% fiber content, indicating this is likely the most beneficial dosage for improving ductility and crack resistance.
- Thirdly, the addition of PET fibers reduced shrinkage cracking and enhanced toughness, providing better performance under impact and cyclic loading. The fiber-reinforced concrete displayed superior post-crack behavior compared to conventional concrete, which typically fails suddenly and in a brittle manner.
- Fourth, the workability of concrete decreased with increasing fiber content. This is primarily due to the fibrous texture of PET, which increases internal friction and reduces the matrix flow. As a result, mixes with higher fiber percentages require a superplasticizer or adjustments in water-to-cement ratio to maintain acceptable workability.
- Fifth, environmental benefits were clearly observed. Plastic fibers offer a sustainable solution for reusing waste PET materials, thereby reducing environmental pollution and minimizing the volume of plastic waste disposed of in landfills or waterways. This research demonstrates that recycled plastic can be transformed into a useful construction material rather than contributing to environmental degradation.
- Overall, the study successfully concludes that plastic fiber can be used as a partial replacement of fine aggregate in concrete, improving tensile strength, reducing cracks, and enhancing ductility without significantly compromising compressive strength. The optimum fiber percentage lies between **1.0% and 1.5%**, offering the best balance between mechanical performance and workability. This confirms that PET fiber–reinforced concrete is suitable for various non-structural and semi-structural applications in modern construction

5.2 Recommendations for Future Works

5.2.1 Optimum Fiber Content

Use **1% to 1.5% PET fiber** for the best combination of tensile strength, ductility, and workable consistency. Exceeding 2% should be avoided unless chemical admixtures are used.

5.2.2 Use of Superplasticizer

Due to reduced workability with fibers, a **superplasticizer** is recommended instead of adding additional water. This ensures consistent strength without increasing water-to-cement ratio.

5.2.3 Application Areas

Plastic fiber–reinforced concrete (PFRC) is recommended for:

- Pavement blocks
- Floor slabs
- Footpaths and walkways
- Partition walls
- Precast panels
- Repair and patchwork concrete

These applications benefit from improved crack resistance and flexibility rather than extremely high compressive strength.

5.2.4 Fiber Size Standardization

Fibers must be cut uniformly (20–30 mm length, 1–2 mm width) to ensure homogeneous distribution in the concrete mix and to avoid clumping during mixing.

5.2.5 Proper Mixing Technique

Fibers should be added gradually during mixing.
A mechanical mixer is recommended to ensure proper dispersion of fibers throughout the concrete matrix.

5.3 Recommendations for Quality Control

5.2.6 Follow Standard Guidelines

All procedures should follow IS 383, IS 10262, IS 516, and ASTM C39 standards to ensure reliability and accuracy of test results.

5.2.7 Proper Curing

Specimens must be cured for a minimum of 7–28 days to achieve full hydration. Improper curing can lead to reduced strength and durability.

5.2.8 Temperature and Moisture Control

Avoid placing PFRC in environments with extreme temperature fluctuations during curing, as plastic fibers change behavior in heat.

5.3 Recommendations for Future Research

5.3.1 Long-Term Durability Studies

More research is needed on:

- Water absorption
- Chemical resistance
- Freeze–thaw durability
- Carbonation depth

These properties determine long-term performance in real environments.

5.3.2 Flexural Strength and Load Testing

Flexural behavior of PFRC should be studied under:

- Repeated loading
- Fatigue
- Impact loading

This would help determine suitability in highway pavements and industrial floors.

5.3.3 Economic Feasibility Analysis

Cost–benefit analysis should be conducted to compare:

- Cost of production
- Availability of plastic waste
- Long-term savings from reduced maintenance

5.3.4 Use of Hybrid Fibers

Mixing PET fibers with other fibers (steel, glass, polypropylene) may further enhance performance and should be explored.

5.4.5 Automation and Industry Implementation

Development of automated fiber-cutting and mixing systems can help industries apply PFRC at large scale efficiently

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