

A COMPARATIVE STUDY ON SUSTAINABLE FIBER-REINFORCED CONCRETE USING RECYCLED TIRE STEEL, PLASTIC, GLASS, AND COCONUT FIBERS

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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



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Section: 27(A)
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DECLARATION

This thesis is a presentation of our original research work. Wherever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature and acknowledgement of collaborative research and discussion. The work was done under the supervision of M.A. Bashar Bhuiyan, Lecturer, Department of Civil Engineering, Sonargaon University.

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Dedicated
To
“Our Parents
And
Our Honorable Teachers”

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Finally, we dedicate this work to our beloved parents for their unconditional love, constant encouragement, and sacrifices that have guided us to this point. We also extend our thanks to all the faculty members and staff of the Civil Engineering Department for their kind assistance.

ABSTRACT

This study examines the incorporation of recycled and renewable fibers—such as steel, plastic, glass, and coconut fibers—into concrete to enhance its mechanical properties and improve sustainability. The research focuses on the effects of these fibers on the compressive strength of fiber-reinforced concrete (FRC) at various curing periods (3, 7, 14, and 28 days). Results show that glass fibers significantly improve compressive strength, with a peak of 21.81 MPa at 28 days, followed by steel fibers and coconut fibers, which also contributed to strength gains, particularly at higher fiber contents. Plastic fibers, while enhancing the concrete's toughness, showed more moderate improvements. The study also highlights the environmental sustainability of using recycled fibers, particularly coconut and plastic fibers, as an eco-friendly alternative to synthetic materials. The findings suggest that the use of these fibers could lead to more durable, cost-effective, and environmentally sustainable concrete. However, further research is needed to explore long-term durability, economic feasibility, and the environmental impact of fiber-reinforced concrete under varying conditions. The study also recommends future research into hybrid fiber systems and life-cycle assessments (LCA) for a deeper understanding of the material's sustainability and performance.

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CHAPTER-1

INTRODUCTION

1.1 GENERAL OVERVIEW

FRC is defined as concrete in which fibers from waste or renewable sources are used to improve mechanical and durability performance while reducing reliance on virgin steel or synthetic fibers and lowering environmental impacts. Recent reviews emphasize that recycled tire steel, recycled plastics, waste glass, and natural fibers such as coconut coir can convert difficult-to-dispose solid wastes into value-added construction materials, supporting circular economy and life-cycle-based design of concrete.

Previous studies have shown that partial replacement of total volume of concrete with tire steel fiber, plastic fiber, glass fiber and coconut fiber can improve sustainability of concrete. While traditional concrete is well-known for its high compressive strength or pressure-bearing capacity, it is inherently brittle and possesses relatively low tensile strength. Using steel fibers, plastic fibers, glass fibers, and coconut fibers is to arrest internal micro-cracks within the concrete and to enhance the ductility (post-cracking flexibility) of the matrix.

1.2 BACKGROUND OF THE STUDY

Concrete is most widely used construction material worldwide. However, brittle nature and low tensile strength limit performance. Fiber reinforcement improve crack resistance, toughness and durability. Concurrently, waste materials such as rejected steel, plastics, glass, coconut pose serious environmental challenges. Utilizing these wastes as fibers in concrete can enhance sustainability while improving material performance.

1.3 RESEARCH OBJECTIVES

- To conduct a comprehensive comparative assessment of sustainable fiber-reinforced concrete incorporating recycled tire steel fibers, plastic fibers, recycled glass fibers, and coconut fibers, with respect to mechanical performance, environmental impact, and practical applicability.
- To determine the optimal fiber dosage and configuration for each type of fiber to achieve improved concrete performance.
- To evaluate the mechanical properties of fiber-reinforced concrete through standardized laboratory testing methods.
- To assess the environmental sustainability of recycled fiber-reinforced concrete based on lifecycle considerations.
- To analyze the economic feasibility of using recycled fiber-reinforced concrete, particularly for applications in developing countries.
- To develop recommendations for hybrid fiber systems that combine different fiber types for enhanced performance.
- To identify durability characteristics and evaluate the long-term performance of fiber-reinforced concrete.

1.4 ORGANIZATION

The thesis begins with **Chapter 1: Introduction**, which provides general knowledge, the background, research objectives, questions, and an overview of the study's structure. **Chapter 2: Literature Review**, presenting a review of existing research to highlight key findings and identify the gaps that the study aims to address. **In Chapter 3: Methodology**, the research design, data collection methods, and analysis techniques are detailed. **Chapter 4: Results and Discussion** presents the research findings, interpreting and comparing them. **Chapter 5: Conclusions** summarizes the findings, discusses their implications, and offers recommendations for future research. Lastly, **Chapter 6: References** lists all the sources cited throughout the thesis.

CHAPTER-2

LITERATURE REVIEW AND RESEARCH GAPS

2.1 INTRODUCTION

FRC is defined as concrete in which fibers from waste or renewable sources are used to improve mechanical and durability performance while reducing reliance on virgin steel or synthetic fibers and lowering environmental impacts. Recent reviews emphasize that recycled tire steel, recycled plastics, waste glass, and natural fibers such as coconut coir can convert difficult-to-dispose solid wastes into value-added construction materials, supporting circular economy and life-cycle-based design of concrete.

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2.2 LITERATURE REVIEW

Suthar & Patel (2021) investigated experimental studies on RCC columns with natural fibers. The results showed that rice bran fiber increased the load-bearing capacity of the column by 1.67 times, while coconut fiber was weak in terms of flexibility. However, the authors did not explore the environmental impact or cost-effectiveness of using natural fibers in RCC columns [1]. Sekar & Kandasamy (2019) investigated the durability properties of coconut shell concrete with coconut fibers. This shows that fully immersed curing increases the durability of conventional concrete, while in-situ curing increases the durability of CSC. However, the authors did not explore alternative methods to improve the durability of CSC without additional curing [2]. Yildizel et al. (2018) investigated the abrasion resistance and mechanical properties of waste-glass-fiber-reinforced roller-compacted concrete. The results showed that 2% waste glass fibers significantly increased the abrasion resistance of RCC. But the authors did not explore the effect of higher percentages of waste glass fibers or their long-term performance [3]. Patil (2014) investigated strengthening of RCC beams using different glass fibers. The results showed that GFRP beams showed predictable behavior, providing improved performance during bending, with stiffer GFRP bars significantly increasing load-bearing capacity. But the authors did not explore the long-term performance or environmental impact of GFRP in RCC beams [4]. Chen et al. (2021) investigated researchers on new anticaking glass-fiber-reinforced cement material and integrated composite technology with lightweight concrete panels. The results showed that the addition of fiber improved the flexural strength of GRC and reduced the drying shrinkage. The smooth connection between GRC and PLC reduced the shrinkage and improved the crack resistance. But the author did not explore the composite precast elements made of GRC and PLC in depth [5]. Sawant et al.

(2013) investigated the strengthening of RCC beams using different glass fiber wraps. The results showed that U-shaped GFRP wraps increased the beam strength by 66.66%, while single and double mat wraps showed less improvement. But the authors did not explore the cost-effectiveness or environmental impact of using GFRP wraps on RCC wraps [6]. Wagh et al. (2014) investigated a comparative study of RCC and steel-concrete composite structures. The result is that composite structures are more cost-effective, faster to construct, and have increased earthquake-resistant performance compared to RCC structures. But the authors did not explore the effects of different composite materials on long-term durability [7]. Patel (2017) investigated the maintenance of RCC beams by retrofitting using steel plates. This results in a 92-95% increase in beam strength when retrofitted with steel plates, especially when applied at the top and base. However, the authors did not explore the effects of different retrofitting materials beyond steel plates [8]. Almajeed & Abbas (2024) investigated the fabrication of sustainable roller-compacted concrete pavement containing plastic waste as fine and coarse aggregates. The results showed that 10% PVC substitution resulted in a reduction in compressive strength of up to 12.79%, but a minimal reduction was observed with 5% PET and HDPE substitution, with the coating material curing providing the best strength results. However, the authors did not explore the long-term durability of RCC with plastic waste [9]. Almajeed & Abbas (2024) investigated the fabrication of sustainable roller-compacted concrete pavement containing plastic waste as fine and coarse aggregates. The results showed that the strength of RCC mixtures containing 10% PVC decreased, while 5% PET and HDPE improved the performance. However, the authors did not investigate the long-term durability of RCC with plastic waste under extreme environmental conditions [9]. Adil Abed et al. (2018) investigated the effects of adding waste plastic fibers on some properties of roller compacted concrete. The result is the addition of 1% waste plastic fibers improved the compressive and flexural strength of RCC, but increased water absorption and reduced ultrasonic pulse velocity. However, the authors did not investigate the study didn't explore the long-term durability of roller-compacted concrete (RCC) with waste plastic fibers under extreme weather conditions [10].

2.3 CONTENT

Chen et al. (2021) investigated researchers on new anticracking glass-fiber-reinforced cement material and integrated composite technology with lightweight concrete panels. The result is the addition of fibers improved GRC's flexural strength and reduced drying shrinkage. The smooth connection between GRC and PLC minimized shrinkage and improved crack resistance. But author didn't explore composite precast components made of GRC and PLC in depth.

2.3.1 Steel Fiber in Concrete

- Previous studies on the use of Steel fiber as a partial replacement for the total volume of concrete.
- Effects of Steel fiber on tensile strength, toughness, durability and workability.
- Steel fiber reinforcement improve crack resistance.

- Benefits of steel fiber as a low cost material.

Steel fiber are collected from tires and used as steel fibers.

Characteristics of Steel Fiber :

- Source: Local area.
- Color: Metallic Silver, Dark Grey/Blackish.
- Nature: Metallic, flexible, irregular.

2.3.2 Plastic Fiber in Concrete

- Previous studies on the use of Plastic fiber as a partial replacement for the total volume of concrete.
- Effects of Plastic fiber on toughness, durability and workability.
- Plastic fiber reinforcement improves crack resistance.
- The benefits of Plastic fiber include low cost and availability.
- Limitations of using high percentages of Plastic fiber.

Plastic fibers collected from local market recycled plastics (mainly PET, PP, and HDPE) are processed into fibers through shredding or extrusion.

Characteristics of Plastic Fiber:

- Source: Local market
- Color: White, transparent, translucent.
- Nature: Lightweight, flexible, water resistant.

2.3.3 Glass Fiber in Concrete

- Previous studies on the use of Glass fiber as a partial replacement for the total volume of concrete.
- Effects of Glass fiber on compressive strength, toughness, durability and workability.
- Glass fiber reinforcement improves crack resistance.
- Limitations of using percentages of Glass fiber.

Glass fiber is available in rolls at industrial supply hardware stores or large chemical supply shops.

Characteristics of Coconut Fiber:

- Source: Glass fiber is available in rolls at industrial supply hardware stores.
- Color: White or Translucent.
- Nature: Lightweight, Inorganic, Amorphous.

2.3.4 Coconut Fiber in Concrete

- Previous studies on the use of Coconut fiber as a partial replacement for the total volume of concrete.
- Effects of Coconut fiber on compressive strength, toughness, durability and workability.
- Coconut fiber reinforcement improves crack resistance.
- Benefits of Coconut fiber as a low-cost and eco-friendly material.
- Limitations of using high percentages of Coconut fiber.

Coconut fiber was collected from local Coconut grove. Coconut fiber is naturally hydrophilic (water-absorbing), which can increase the water demand of concrete and reduce its flowability. For this reason, the fibers are pre-soaked to ensure the correct dosage and to prevent them from clumping together or trapping excess air within the concrete.

Characteristics of Coconut Fiber:

- Source : Local Coconut grove.
- Color : Deep brown
- Nature : Lightweight, fibrous.

CHAPTER-3

METHODOLOGY

3.1 MATERIALS USED

In this study, cement, fine aggregate, coarse aggregate and fresh water are used to produce the desired concrete mix. The mixer is mixed with various amounts of additional Tire Steel, Plastic, Glass, and Coconut Fibers. Sand was used as fine aggregate and stone chips were used as coarse aggregate and potable water was used in the investigations for both mixing and curing.

3.1.1 Cement

Ordinary Portland Cement (OPC) was used as the main binding material. A cement is a binder, a chemical substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together. Actually, two types of cement are primarily used, namely OPC and PCC. The most important of these is Portland cement.

Specifications of Cement

Name: Portland Composite Cement

Specific gravity of cement: 3.15

Setting time of cement: 1) Initial setting time 30 Minutes

2) Final setting time 10 Hours

Weight : 50 Kg/Bag

BDS EN : CEM-II/A-M (S-V-L) 42.5 N

Clinker: 70-79%

Other Materials: 21-30%



Fig 3.1: PCC Cement

3.1.2 Fine aggregate

Aggregate significantly influences the rheological and mechanical properties of 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. **Sylhet sand was used as the fine aggregate in this study**, as shown in the figure. Whose fineness modulus (FM) is 3.72. The sand was saturated with water and air-dried before being used to obtain the Saturated Surface (SSD) condition.



Fig 3.2: Fine Aggregate (Sylhet Sand)

3.1.3 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 them an indispensable ingredient in the construction and maintenance of rigid structures. Coarse aggregates are particulates that are greater than 4.75mm. The usual range employed is 20 mm in diameter. **In this study, we used black stone (Dubai LC stone).**



Fig 3.3: Black Stone Chips

3.1.4 Water

Water is critical in the making of concrete. Adding water to the mix sets off 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. In this study, we used water are potable standard.



Fig 3.4: Water

3.1.5 Additional Fibers

In this study, we used four additional fibers with different ratios to check the concrete strength and sustainability. Fibers are Tire Steel, Plastic, Glass, and Coconut Fibers. All fiber lengths were 1-2 inches. All fibers was dry condition when the concrete was mixed.



Fig 3.5: Additional Fibers

3.2 MATERIALS TESTS

We have conducted some tests to check the quality of the materials used, which are as follows.

3.2.1 Sieve Analysis

We tested sieve analysis on both coarse aggregates and fine aggregates. Sieve analysis is a laboratory procedure used for particle size distribution for both coarse and fine aggregates.

Apparatus for test:

- a) Sieve Set (with different mesh sizes)
- b) Sieve Shaker
- c) Balance/Weighing Scale
- d) Brush
- e) Pan
- f) Oven
- g) Containers

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 the specimen is already dried). Weigh 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 numbers and the particle sizes are provided below in a chart for further understanding. Keep the weight recorded specimen on the top sieve and then keep the complete sieve stack on the sieve shaker (Don't forget to keep the lid and receiving pan). Allow the shaker to work 10-5 minutes – use the clock here. Remove the sieve stack from the shaker and record the weight of each sieve and receiving pan separately.

Sieve Analysis Test Report

Table 3.2.1.1: Sieve Analysis of Fine Aggregate

Sieve Size (No)	Sieve Opening (mm)	Weight Retained (gm)	Cumulative Weight Retained (gm)	Cumulative Weight Retained (%)
4	4.75	1	1	0.10%
8	2.36	35	36	3.60%
16	1.19	225	261	26.10%
30	0.59	290	551	55.10%
50	0.3	344	895	89.50%

100	0.15	81	976	97.60%
PAN	0	24	1000	100.00%
	Total	1000		372.00%

FM =	3.72
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Table 3.2.1.2: Sieve Analysis of Coarse Aggregate

Sieve Size (No)	Sieve Opening (mm)	Weight Retained (gm)	Cumulative Weight Retained (gm)	Cumulative Weight Retained (%)
3/4 inch	19.05	224	224	22.40%
3/8 inch	9.5	689	913	91.30%
4	4.75	87	1000	100.00%
8	2.36	0	1000	100.00%
16	1.19	0	1000	100.00%
30	0.59	0	1000	100.00%
50	0.3	0	1000	100.00%
100	0.15	0	1000	100.00%
	Total	1000		713.70%

FM =	7.14
-------------	-------------



Fig 3.6: Sieve Analysis Test

3.2.2 Specific gravity

We tested **Specific gravity** on both coarse aggregates and fine aggregates. **Specific gravity** is a measure of the **density** of a material relative to the density of **water**. It is a dimensionless

quantity that helps determine the **compactness** of a material. In concrete, specific gravity is important because it affects the mix design and the overall performance of the concrete.

Apparatus:

- a) Pycnometer
- b) Balance/Weighing Scale
- c) Water

Test Procedure:

- a) Weighing in Air: Weigh the dry sample in air.
- b) Weighing in Water: Immerse the sample in water and weigh it again. Ensure no air bubbles are attached to the sample.
- c) Calculation: Use the formula to calculate the specific gravity by comparing the weight of the sample in air and the weight of the sample submerged in water.

Specific gravity Test Report

3.2.2.1 Specific gravity of fine aggregate

Found data form Test, A- 300 gm

B- 657 gm

C- 844 gm

S- 310 gm

Table 3.2.2.1: Specific Gravity of Fine Aggregate

Test	Formula	Result
Apparent Specific Gravity	$A/(B+A-C)$	2.65
Bulk Specific Gravity (Oven Dry Basic)	$A/(B+S-C)$	2.44
Absorption Capacity, D%	$((S-A)/B)*100$	1.52
Bulk SG (S.S.D. Basic), G	$S/(B+S-C)$	2.52

3.2.2.2 Specific gravity of Coarse aggregate

Found data form Test, A- 2020 gm

B- 2050 gm

C- 1295 gm

Table 3.2.2.2: Specific Gravity of Coarse Aggregate

Test	Formula	Result
Apparent Specific Gravity	$A/(A-C)$	2.79
Bulk Specific Gravity (Oven Dry Basic)	$B/(B-C)$	2.72
Bulk Specific Gravity (S.S.D. Basic), G	$A/(B-C)$	2.68
Absorption Capacity, D %	$(B-A)*100/A$	1.49



Fig 3.7: Specific Gravity Test

3.2.3 Unit Weight

We tested Unit weight on both coarse aggregates and fine aggregates. Unit weight refers to the weight of a material per unit volume. It is an important property in concrete mix design as it influences the amount of water, cement, and aggregates required to achieve a desired concrete mix.

Apparatus:

- a) Bucket
- b) Balance/Weighing Scale
- c) Tamping Rod
- d) Leveling Tool

Test Procedure:

- a) Weigh the container: Determine the weight of the empty container.
- b) Fill the container: Fill the container with a sample of the material (e.g., fine or coarse aggregate).
- c) Compact the material: Use a tamping rod to compact the aggregate in the container (if required).
- d) Weigh the sample: After filling and compacting, weigh the container with the material inside.
- e) Calculate unit weight: Subtract the weight of the empty container and divide the result by the volume of the material in the container.

Unit Weight Test Report

Table 3.2.3.1: Unit Weight of fine aggregate

Materials	Condition of Sample	Weight of Sample (gm.)	Bucket Area (MM)	Unit Weight (Kg/CuM)
Sand	Loose condition	4171	0.00278	1500.359712
	Tempering condition	4541	0.00278	1633.453237
	Jiggling condition	4636	0.00278	1667.625899

Table 3.2.3.2: Unit Weight of Coarse Aggregate

Materials	Condition of Sample	Weight of Sample (gm.)	Bucket Area (MM)	Unit Weight (Kg/CuM)
Stone	Loose condition	3831	0.00278	1378.05
	Tempering condition	4266	0.00278	1534.53
	Jiggling condition	4365	0.00278	1570.14



Fig 3.8: Unit Weight Test

3.2.4 Aggregate Impact Value (AIV)

We tested **Aggregate Impact Value (AIV)** on coarse aggregate. **Aggregate Impact Value (AIV)** measures the **toughness** of aggregates and their ability to resist impact. It is calculated as the percentage of fines generated when aggregates are subjected to impact.

Apparatus:

- Impact Test Machine (with a 12.5 kg hammer)
- Sieves
- Cylindrical Mold
- Balance

Procedure:

- a) Weigh a sample of aggregates and place it in the mold.
- b) Drop the hammer onto the sample 15 times.
- c) Sieve the material and calculate the percentage of fines passing through the 2.36 mm sieve.

Aggregate Impact Value (AIV) Test Report

Founded data form Test,
Sample Materials – Black Stone Chips
Total Weight (Mold and Aggregate)– 2623 gm.
Mold Weight (AIV Mold) – 1965 gm.
Total Sample Weight – 658 gm.
2.36mm sieve Passing – 23 gm.
Retain – 635 gm.

Table 3.2.4.1: Aggregate Impact Value (AIV)

Test	Formula	Result %
Aggregate Impact Value (AIV)	$(\text{Weight of material passing through 2.36 mm sieve (g)}/\text{Total weight of sample}) \times 100$	3.50



Fig 3.9: Aggregate Impact Value

3.2.5 Aggregate Crushing Value (ACV)

We tested **Aggregate Crushing Value (ACV)** on coarse aggregate. **Aggregate Crushing Value (ACV)** is a measure of the **strength** of aggregates, indicating how much they can withstand crushing under a compressive load. It is essential for assessing the suitability of aggregates for concrete used in structural applications where resistance to crushing is critical.

Apparatus:

- a) UTM
- b) Mold
- c) Sieves
- d) Balance/Weighing Scale
- e) Tamping Rod.

Test Procedure:

- a) Place the aggregate sample in the steel mold and compact it.
- b) Apply a compressive load using the test machine.
- c) After crushing, sieve the sample through a 2.36 mm sieve to separate the fines.
- d) Calculate the percentage of fines (material passing through the sieve) relative to the total weight of the sample.

Aggregate Crushing Value (ACV) Test Report

Founded data form Test,

Sample Materials – Black Stone Chips

Total Weight (Mold and Aggregate)– 15821 gm.

Mold Weight – 12124 gm.

Total Sample Weight – 3697 gm.

2.36mm sieve Passing – 400 gm.

Retain – 3295 gm.

Loss– 2 gm.

Table 3.2.5.1: Aggregate Crushing Value (ACV)

Test	Formula	Result %
Aggregate Crushing Value (ACV)	$(\text{Weight of material passing through 2.36 mm sieve (g)}/\text{Total weight of sample}) \times 100$	10.820



Fig 3.10: Aggregate Crushing Value (ACV)

3.3 CONCRETE MIX DESIGN

For this Research mixture proportion of concrete were determine in accordance with the following conditions: -

Mix Ratio: 1:1.5:3 (Cement: Fine Aggregate: Coarse Aggregate)

Water/Cement Ratio: 0.46

Cement: 1% by volume

Fine Aggregate: 1.5% by volume

Coarse Aggregate: 3% by volume

Additional Fibers: 0.5%, 2.5%, and 5% by volume of total concrete volume

3.4 CONCRETE MOULDING PROCEDURE

The concrete molding process involves several important steps to ensure proper preparation of concrete samples for testing. First, the ingredients—cement, fine aggregate (sand), coarse aggregate (stone chips), and fibers (steel, plastic, glass, or coconut)—are measured according to the mix design and thoroughly mixed in a concrete mixer. Water is then added based on the specified water-cement ratio. The concrete is poured into clean, dry molds in layers, each layer being compacted using a tamping rod or vibrating table to eliminate air voids. After the molds are filled, the surface is leveled and smoothed.



Fig 3.11: Concrete Mixing

3.5 CONCRETE CURING PROCEDURE

After 24 hours of casting, the concrete samples were removed from the mold and cured. Curing was done by soaking in water. Curing was done for 03, 07, 14, 28 days respectively.



Fig 3.12: Curing of Cylinder

3.6 COMPRESSIVE STRENGTH TEST

We tested the strength of concrete through compressive strength testing of RCC cylinders. We used a Universal Testing Machine (UTM) to perform the test.



Fig 3.13: Compressive Strength Test

CHAPTER-4 RESULT AND DISCUSSION

4.1 COMPRESSIVE STRENGTH TEST RESULTS

In this stage, we found comparative results for concrete strength against different amounts of different fibers.

Table 4.1.1: Compressive Strength Test for 03 Days

SL	Used Fiber	Added Fibers %	Height of Cylinder (mm)	Dia of Cylinder (mm)	Weight of Cylinder (gm)	Crushing Value (KN)	Strength (MPA)
1	Without Fiber	-	206	102.5	4010	68	8.25
2	Steel	0.50%	205	101.42	4009	65	8.05
3		2.50%	206	103.38	4103	65	7.74
4		5.00%	206	102.88	4106	72	8.66
5	Plastic	0.50%	206	102.39	4065	67	8.14
6		2.50%	205	101.06	3970	58	7.23
7		5.00%	206	103	4002	65	7.80
8	Glass	0.50%	205	101.79	4065	81	9.95
9		2.50%	207	102.47	4139	75	9.09
10		5.00%	206	101.46	3965	63	7.79
11	Coconut	0.50%	206	101.84	4007	60	7.37
12		2.50%	206	102.52	4100	77	9.33
13		5.00%	206	103	4063	75	9.00

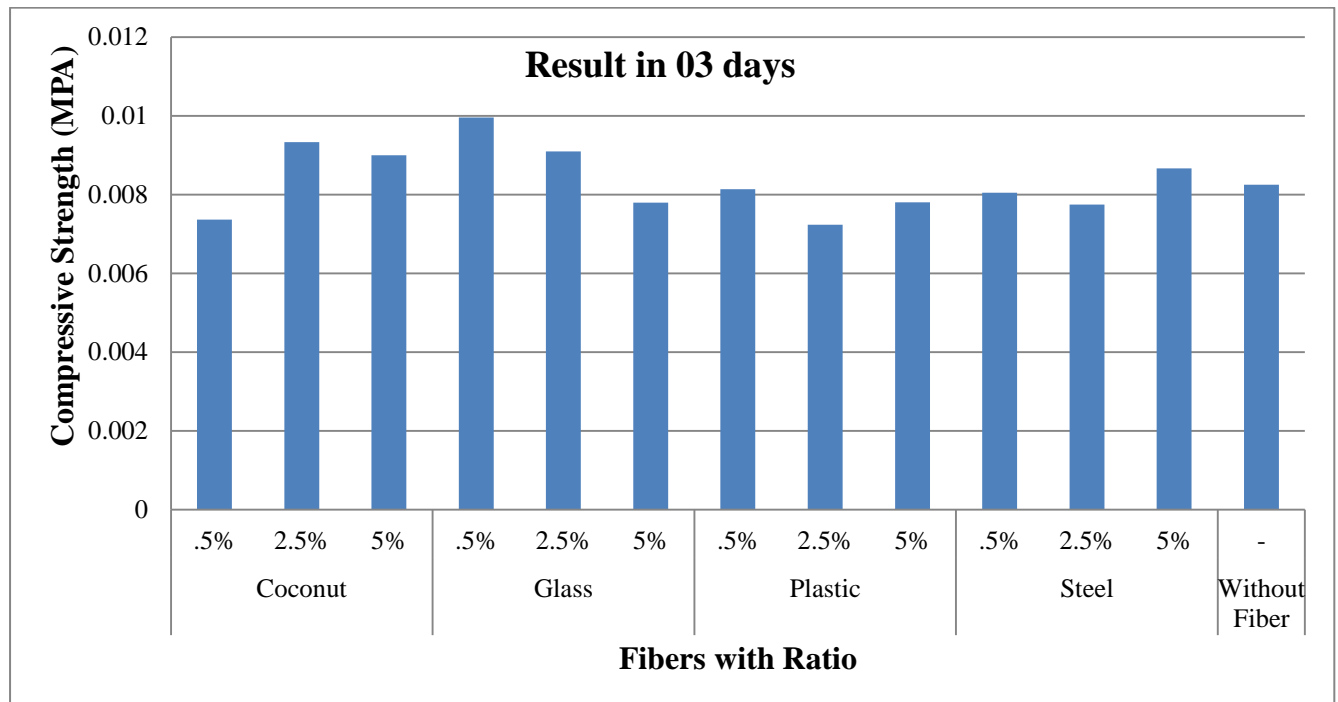


Fig: 4.1: Compressive Strength Test (03 Days)

Table 4.1.2: Compressive Strength Test for 07 Days

SL	Used Fiber	Added Fibers %	Height of Cylinder (mm)	Dia of Cylinder (mm)	Weight of Cylinder (gm)	Crushing Value (KN)	Compressive Strength (MPA)
1	Without Fiber	-	206	102.5	4010	90	10.91
2	Steel	0.50%	206	101.98	4142	93	11.39
3		2.50%	206	102.07	4071	75	9.17
4		5.00%	205	102.1	4048	98	11.97
5	Plastic	0.50%	206	102	4070	75	9.18
6		2.50%	206	102.87	3958	75	9.02
7		5.00%	205	103	3971	80	9.60
8	Glass	0.50%	206	102	3993	110	13.46
9		2.50%	205	102.07	4051	100	12.22
10		5.00%	206	103	4123	77	9.24
11	Coconut	0.50%	205	103	4016	85	10.20
12		2.50%	206	102.27	4077	100	12.17
13		5.00%	206	101.89	3941	107	13.12

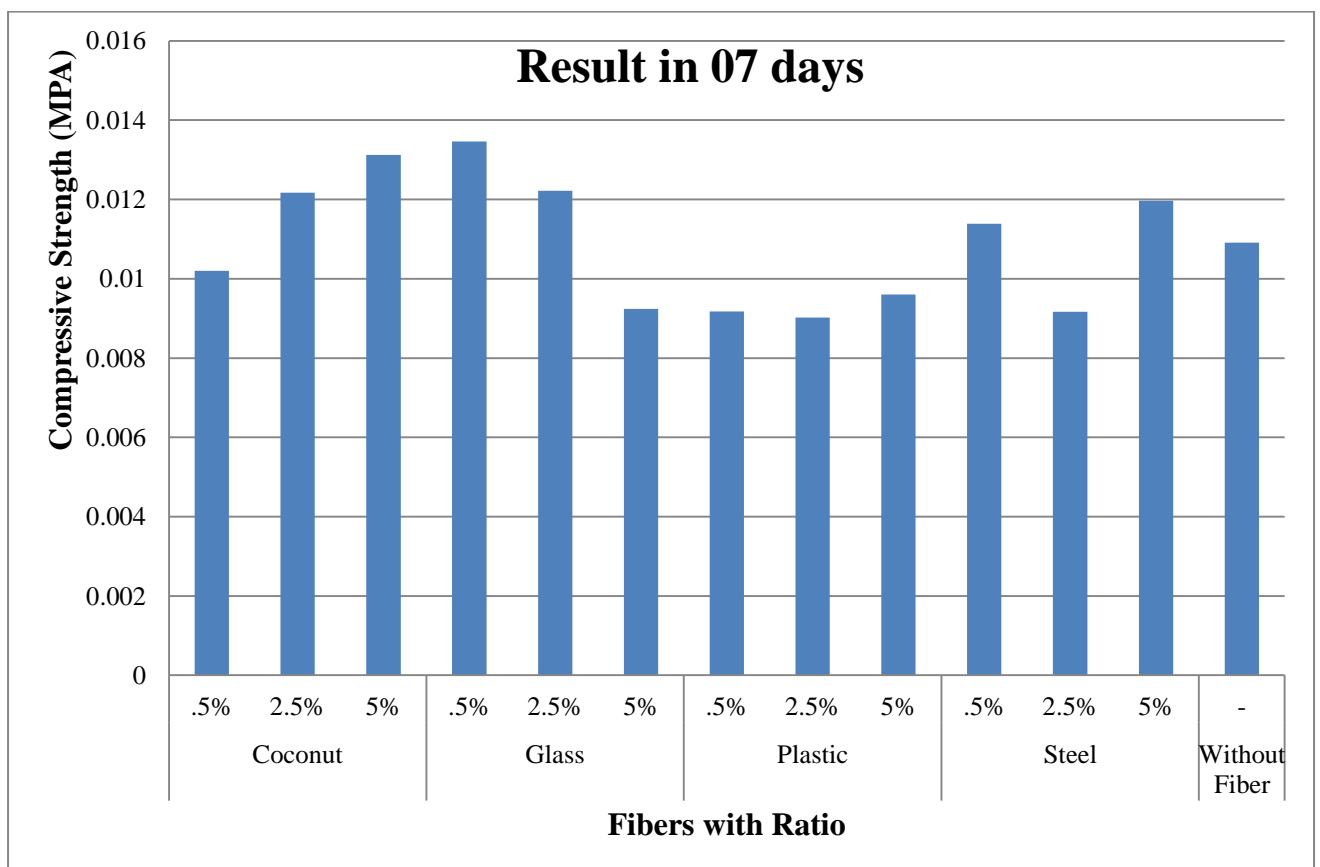


Fig: 4.2: Compressive Strength Test (07 Days)

Table 4.1.3: Compressive Strength Test for 14 Days

SL	Used Fiber	Added Fibers %	Height of Cylinder (mm)	Dia of Cylinder (mm)	Weight of Cylinder (gm)	Crushing Value (KN)	Compressive Strength (MPA)
1	Without Fiber	-	206	102.5	4010	125	15.15
2	Steel	0.5%	207	103.1	4138	125	14.97
3		2.5%	207	102.06	4129	120	14.67
4		5.0%	206	102.41	3953	125	15.18
5	Plastic	0.5%	205	102.2	3962	105	12.80
6		2.5%	204	101.28	4050	96	11.92
7		5.0%	207	101.96	4038	100	12.25
8	Glass	0.5%	205	102.5	4048	155	18.78
9		2.5%	205	103.4	4104	130	15.48
10		5.0%	206	102.3	4139	112	13.63
11	Coconut	0.5%	205	101.9	3992	127	15.57
12		2.5%	206	102.5	4109	133	16.12
13		5.0%	207	102.7	3950	140	16.90

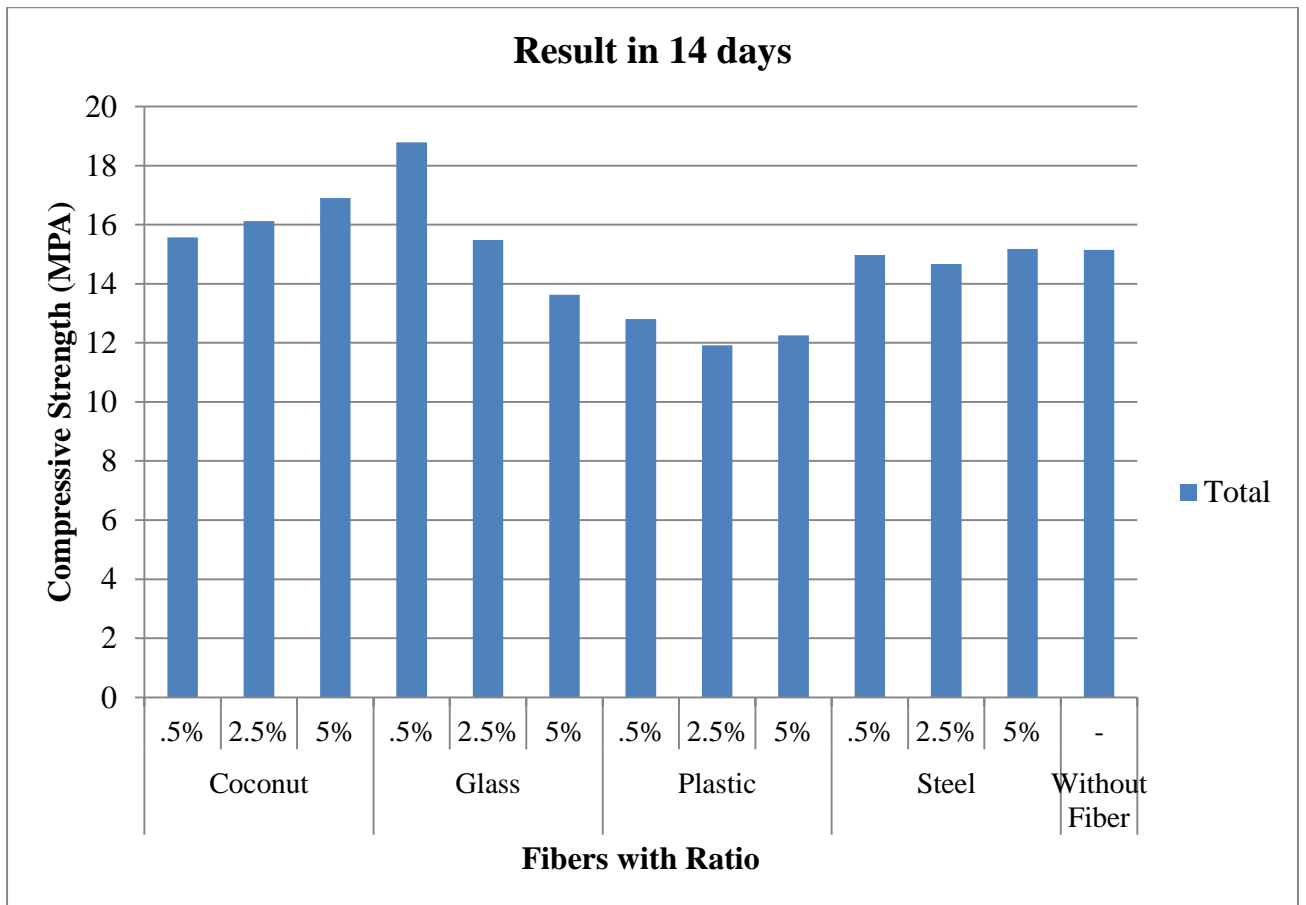


Fig: 4.3: Compressive Strength Test (14 Days)

Table 4.1.4: Compressive Strength Test for 28 Days

SL	Used Fiber	Added Fibers %	Height of Cylinder (mm)	Dia of Cylinder (mm)	Weight of Cylinder (gm)	Crushing Value (KN)	Compressive Strength (MPA)
1	Without Fiber	-	206	102.5	4010	170	20.60
2	Steel	0.50%	206	101.4	3977	140	17.34
3		2.50%	207	102.8	4125	125	15.06
4		5.00%	206	101.9	4133	115	14.10
5	Plastic	0.50%	206	102.9	4031	109	13.11
6		2.50%	205	101.7	3953	115	14.16
7		5.00%	207	102.48	4094	120	14.55
8	Glass	0.50%	205	102.5	4048	180	21.81
9		2.50%	205	103.4	4104	160	19.05
10		5.00%	206	102.3	4139	138	16.79
11	Coconut	0.50%	205	101.9	3992	150	18.39
12		2.50%	206	102.5	4109	160	19.39
13		5.00%	207	102.7	3950	165	19.92

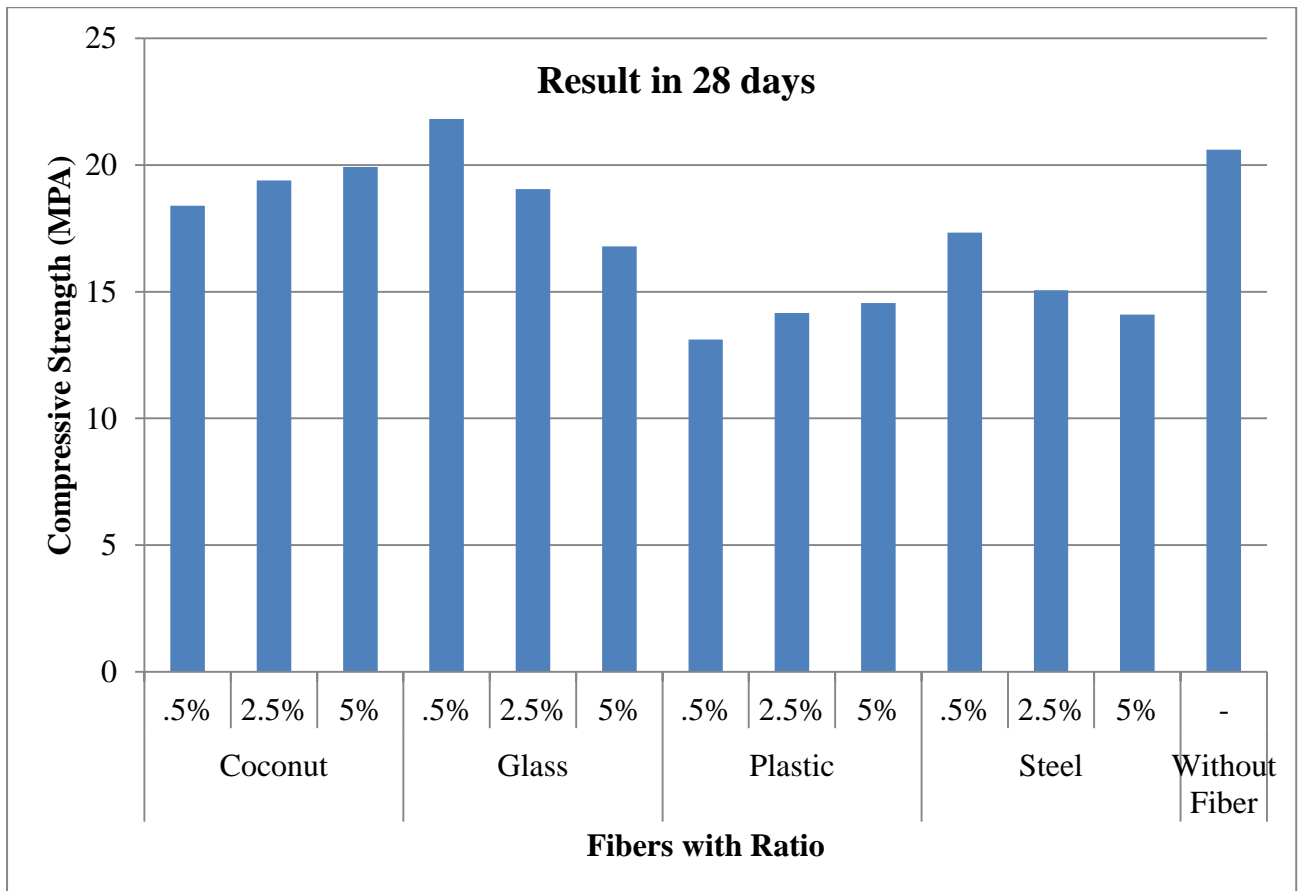


Fig: 4.4: Compressive Strength Test (28 Days)

Table 4.1.5: Compressive Strength Test Summary

Fiber	Added Fiber %	Compressive Strength In 03 days (MPA)	Compressive Strength In 07 days (MPA)	Compressive Strength In 14 days (MPA)	Compressive Strength In 28 days (MPA)
Without Fiber	-	8.25	10.91	15.15	20.60
Steel	0.50%	8.05	11.39	14.97	17.34
	2.50%	7.74	9.17	14.67	15.06
	5%	8.66	11.97	15.18	14.1
Plastic	0.50%	8.14	9.18	12.8	13.11
	2.50%	7.23	9.02	11.92	14.16
	5%	7.8	9.6	12.25	14.55
Glass	0.50%	9.95	13.46	18.78	21.81
	2.50%	9.09	12.22	15.48	19.05
	5%	7.79	9.24	13.63	16.79
Coconut	0.50%	7.37	10.2	15.57	18.39
	2.50%	9.33	12.17	16.12	19.39
	5%	9	13.12	16.9	19.92

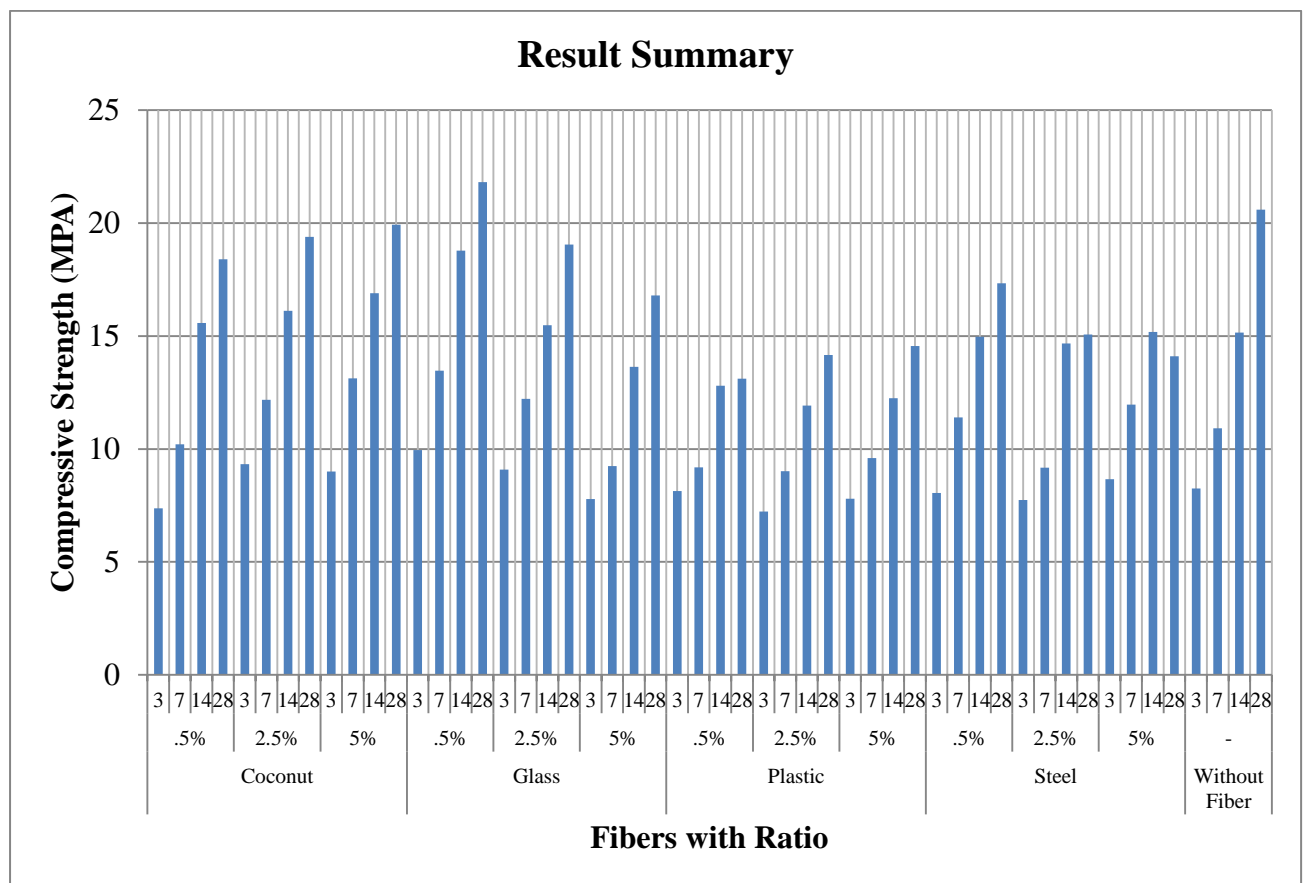


Fig: 4.5: Compressive Strength Test Summary Result

4.2 COMPRESSIVE STRENGTH TEST ANALYSIS

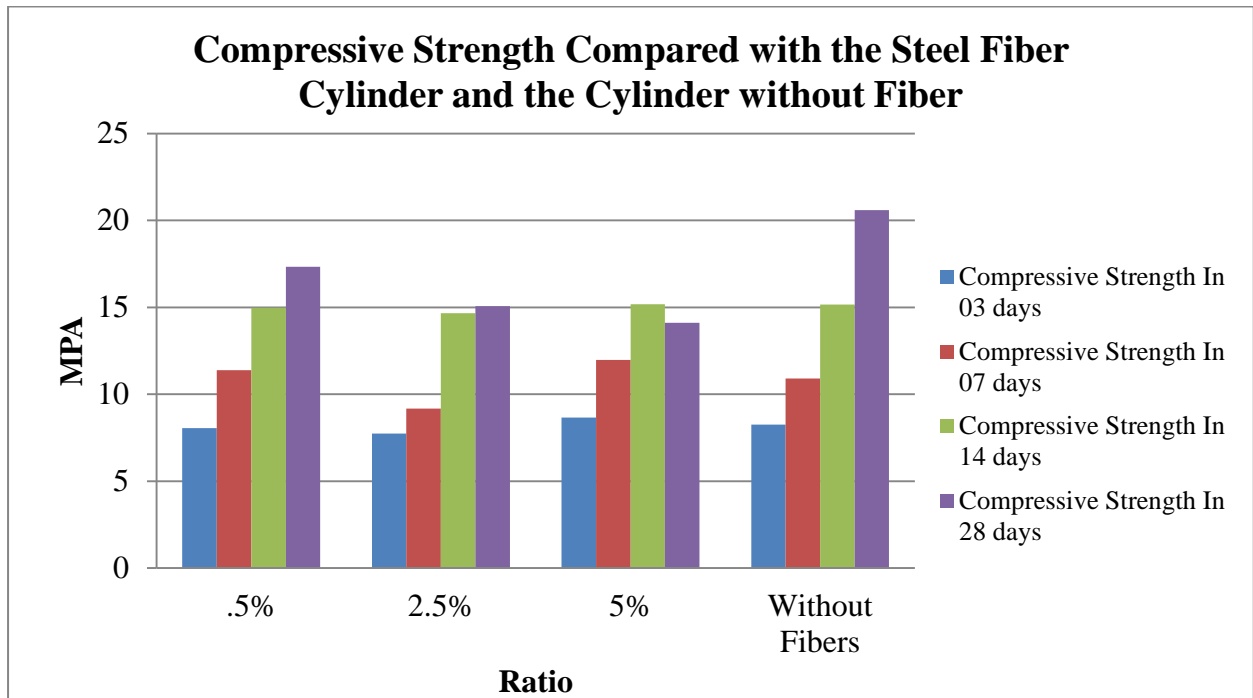


Fig: 4.6: Compressive Strength Curve Compared with the Steel Fiber Cylinder and the Cylinder without Fiber

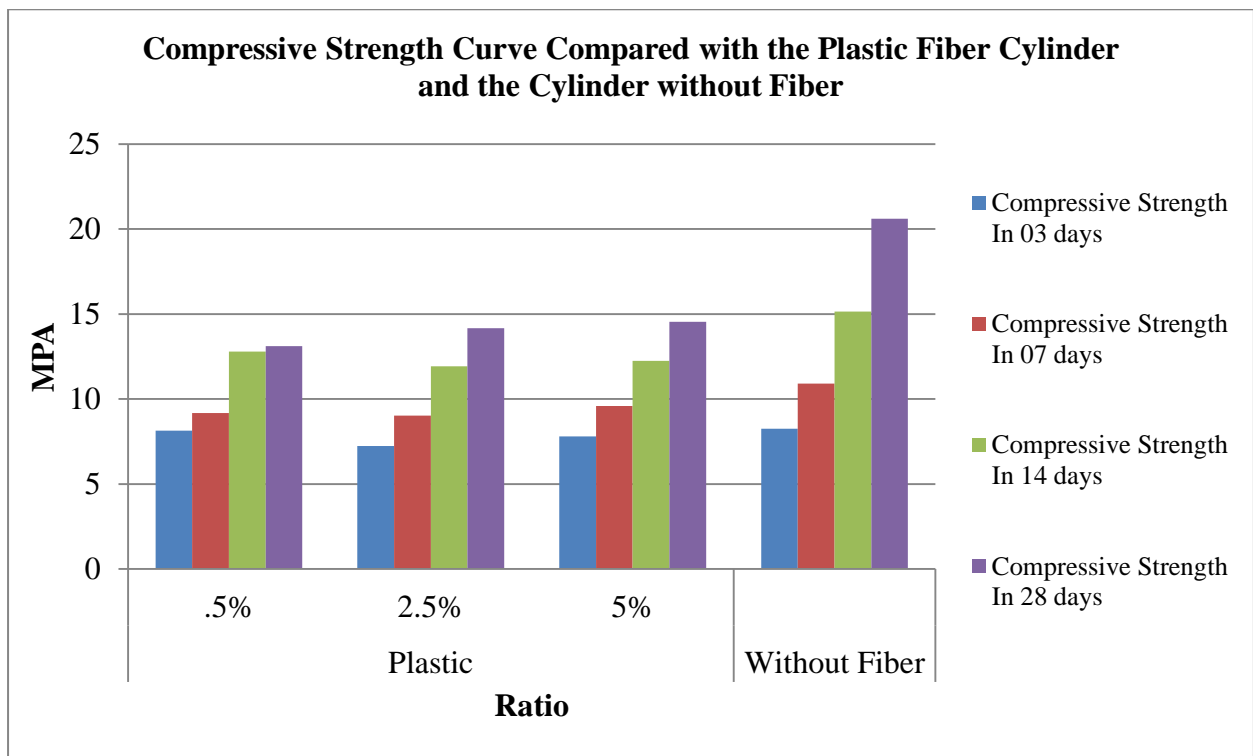


Fig: 4.7: Compressive Strength Curve Compared with the Plastic Fiber Cylinder and the Cylinder without Fiber

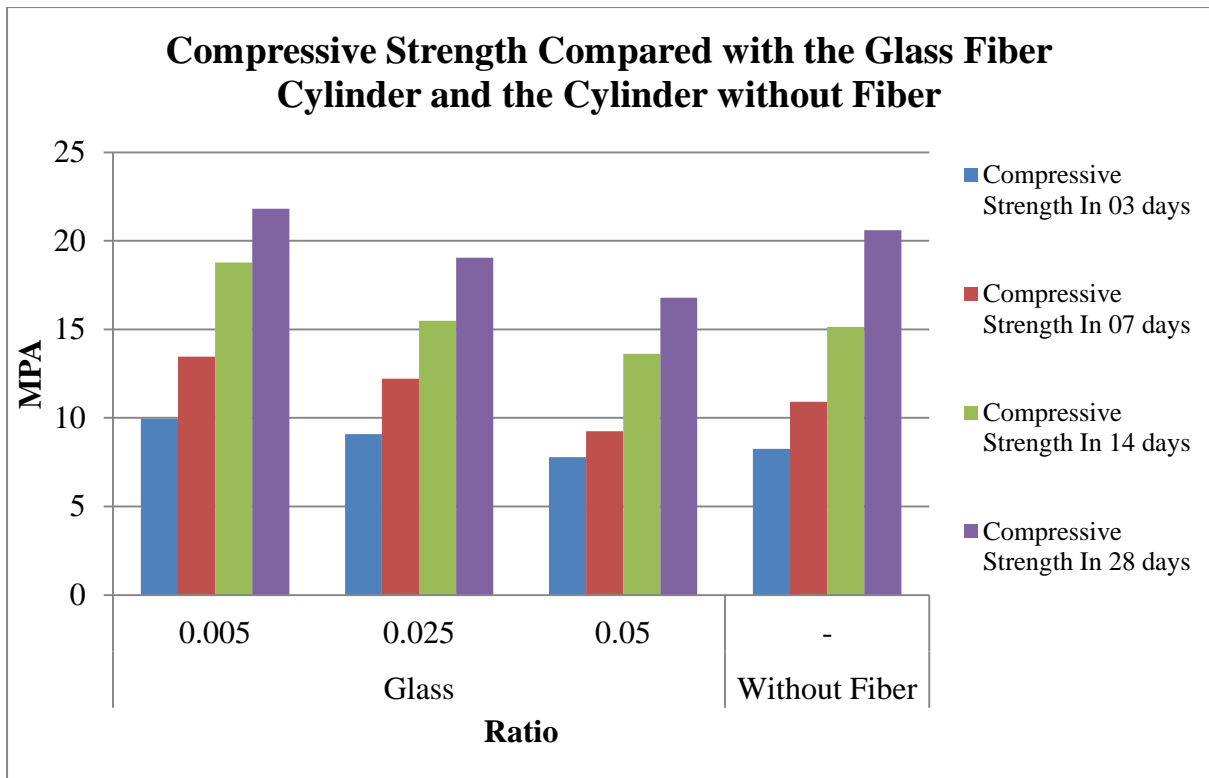


Fig: 4.8: Compressive Strength Curve Compared with the Glass Fiber Cylinder and the Cylinder without Fiber

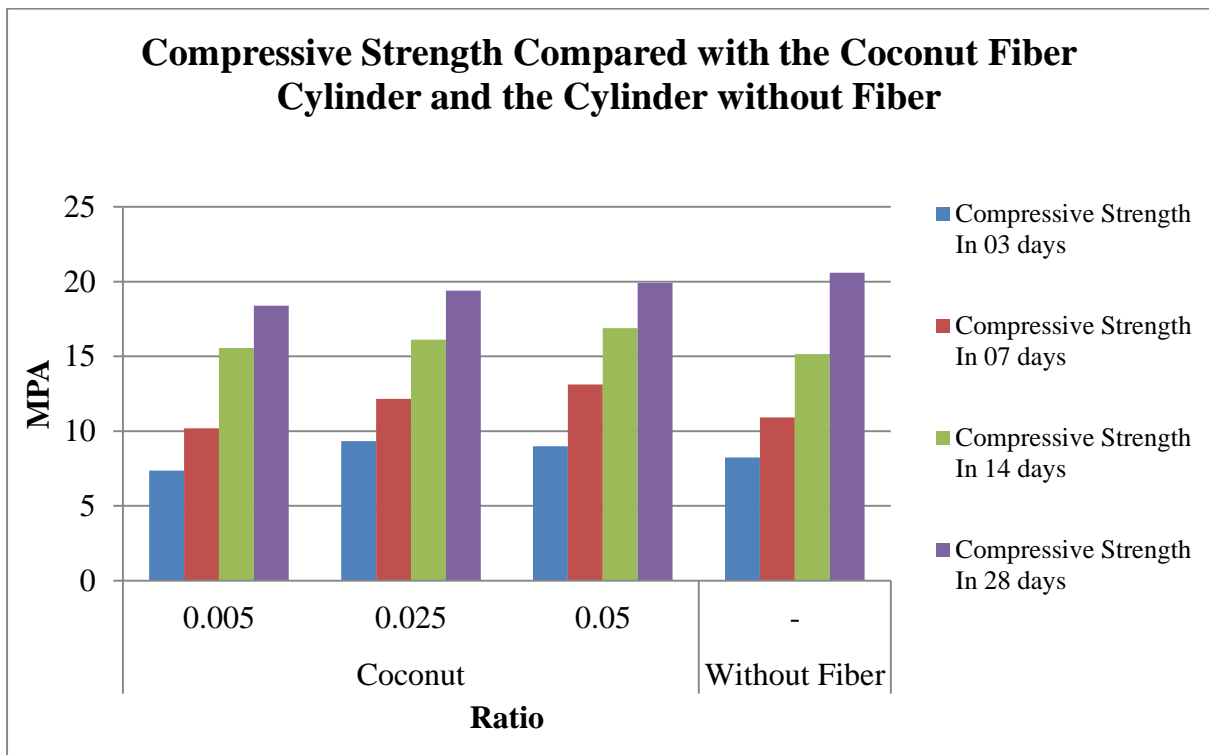


Fig: 4.9: Compressive Strength Curve Compared with the Coconut Fiber Cylinder and the Cylinder without Fiber

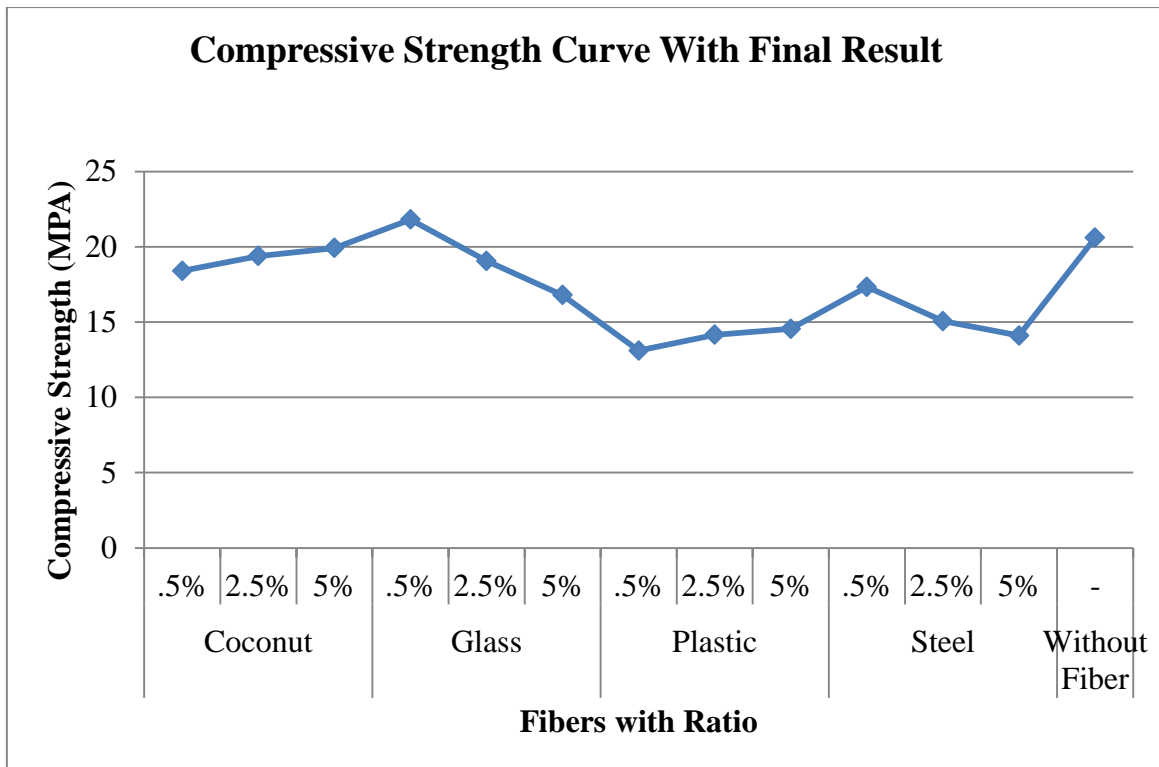


Fig. 4.10: Compressive Strength Curve With Final Result

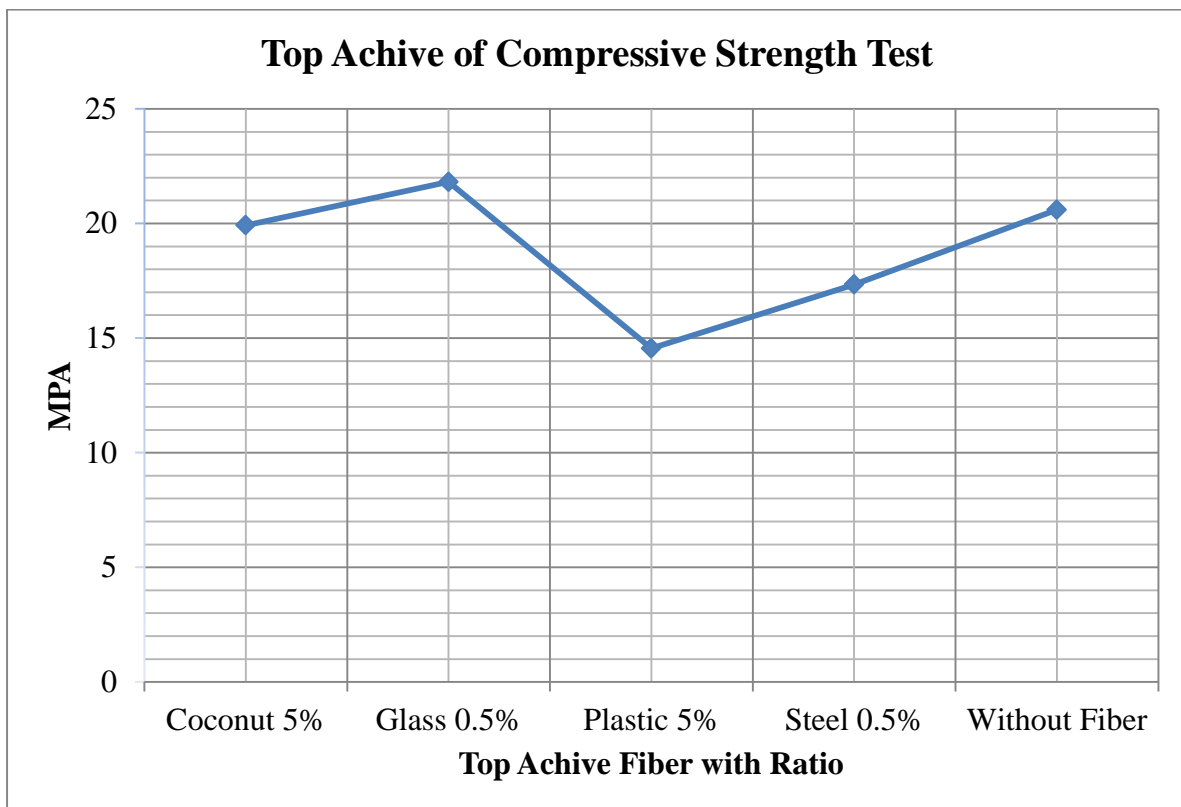


Fig. 4.11: Compressive Strength Curve Compared with Top Achieve Fiber's Ratio

4.3 DISCUSSION

The summary of the compressive strength test provides a clear comparison of the effect of different types of fibers (steel, plastic, glass and coconut) on the compressive strength of concrete at different curing stages: 3 days, 7 days, 14 days and 28 days. The data reveal significant changes in strength development depending on both the type and percentage of fibers added to the mix.

Steel fibers: Concrete with steel fibers showed improved compressive strength at all curing times. With 0.5% fiber content, the compressive strength increased from 8.05 MPa at 3 days to 17.34 MPa at 28 days, while 2.5% and 5% fiber reached 15.06 MPa and 14.1 MPa at 28 days, respectively. The M20 mix ratio typically provides 20 MPa, yet the strength changed slightly with the addition of steel fibers, with 0.5% fiber providing the highest value. Steel fibers reduce brittleness and increase durability, making 0.5% the ideal choice for improved concrete performance.

Plastic fibers: Plastic fiber concrete showed a moderate increase in compressive strength compared to steel fiber, with a maximum value of 14.55 MPa at 5% fiber content. Although the strength of plastic fiber concrete increases gradually with higher fiber content, its relative strength is lower than that of steel fiber concrete. However, plastic fibers offer cost reduction and environmental benefits, making them suitable for applications where high strength is not a primary requirement.

Glass Fiber: Concrete with glass fibers demonstrated the highest compressive strength, particularly with 0.5% fiber content, achieving 21.81 MPa at 28 days, the highest among all tested fiber types. At 2.5% and 5% fiber content, the compressive strength reached 19.05 MPa and 16.79 MPa, respectively. Glass fibers not only enhance strength but also improve durability, making them ideal for concrete exposed to aggressive environmental conditions. The use of 0.5% to 2.5% glass fibers is recommended for optimal concrete performance, as they reduce brittleness and increase durability.

Coconut fibers: Coconut fibers had the most significant impact on compressive strength among the tested fibers, with 5% fiber content achieving 19.92 MPa at 28 days, comparable to mixtures with higher percentages of plastic and glass fibers. At 2.5% and 0.5% fiber content, the compressive strength reached 19.39 MPa and 18.39 MPa, respectively. As a sustainable and environmentally friendly alternative to synthetic fibers, coconut fibers contribute positively to strength development, particularly when used in moderate amounts (0.5% to 5%).

CHAPTER-5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This study investigates the effects of different fibers—steel, plastic, glass, and coconut—on the compressive strength and sustainability of fiber-reinforced concrete (FRC). The findings reveal significant improvements in compressive strength with the addition of fibers, particularly glass fibers, which demonstrated the highest compressive strength at 28 days (21.81 MPa). Steel fibers also showed consistent performance, providing notable strength improvements, particularly at 0.5% content. Coconut fibers had a comparable impact on strength, with a maximum value of 19.92 MPa at 5% fiber content, while plastic fibers offered moderate improvements, reaching 14.55 MPa at 5%.

The study also highlights the durability benefits of fiber addition, particularly for glass and steel fibers, which significantly enhance concrete's resistance to brittleness and cracking. Coconut fibers, as an eco-friendly and sustainable alternative, showed promising results, suggesting their potential for use in environmentally conscious construction practices.

5.2 LIMITATIONS

- **Short-Term Testing:** Focused only on compressive strength over curing periods of 3, 7, 14, and 28 days, without evaluating long-term durability under environmental stressors.
- **Fiber Dosage Variations:** Limited range of fiber dosages (0.5%, 2.5%, and 5%) tested, with no exploration of optimal dosage or impact at higher/lower amounts.
- **Limited Environmental Assessment:** No detailed life-cycle assessment (LCA) conducted to evaluate the environmental impact of incorporating recycled fibers.
- **Geographical Scope:** Study conducted using locally available fibers and materials, limiting generalization to other regions with different fiber types.
- **Economic Analysis:** No in-depth economic feasibility analysis for large-scale use of recycled fibers, particularly in developing countries

5.3 FUTURE RESEARCH RECOMMENDATIONS

- Investigate the **synergy between different fiber types** and their combined effects on concrete's mechanical properties.
- Conduct **life-cycle assessments (LCAs)** to evaluate the overall **environmental sustainability** of recycled and natural fibers in concrete.
- Explore **economic viability** for large-scale use of fibers in developing countries and optimize fiber dosage to balance performance and cost.
- Examine the **long-term durability** of FRC under diverse environmental conditions, including exposure to chemicals, temperature fluctuations, and moisture.

CHAPTER-6

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