

# An Experimental Study on Glass Fibre Reinforcement Concrete

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**Abstract**—Concrete is the most widely used building materials, which are prized for their high compressive strength (fck) and longevity. With the increasing growth of urbanization, the demand of concrete has grown drastically. To satisfy the increasing demand for economical building materials, a lot of research has centred on the inclusion of advanced materials in traditional concrete. One such material is glass fibre, whose bright future as a material for enhancing concrete has been demonstrated. With the fast rate of urban growth, there is increasing demand for high-strength concrete that can be manufactured at an efficient rate. Glass fibre is especially good at fulfilling this requirement. Composed of very fine fibres of glass, it has excellent mechanical properties such as high strength, flexibility, stiffness, thermal resistance, and chemical resistance. Whereas glass fibre has similar mechanical properties to polymers and carbon fibre, it is much cheaper and less brittle, and thus ideal for numerous applications across the world. The present investigation is aimed at studying the strength properties of Glass Fibre Reinforced Concrete (GFRC). The mix design of concrete was done as per IS 10262:2009, employing M25 grade concrete, 0.40 water-cement ratio, and Conplast as a super plasticizer. Glass fibres (GF) were added to the mixture in different percentages—0%, 0.5%, 1%, and 1.5% by weight. The performance of GFRC was tested and compared with control concrete (fibres-free) by studying major mechanical properties like compressive strength, flexural strength, and split tensile strength.

**Index Terms**—Fiber Reinforced Concrete (FRC), Glass Fibers (GF), Compressive Strength(fck), Flexural Strength (fcr), Split Tensile Strength (f<sub>ct</sub>).

## I. INTRODUCTION

### 1.1 Introduction

Concrete is a composite material made of water, cement, and aggregates, often enhanced with additives and reinforcements like steel for improved

performance. It starts as a moldable fluid and hardens into a strong, stone-like substance. As the second most used material globally after water, concrete has been the backbone of durable structures for centuries.

Advancements in material science since the 1950s have significantly improved concrete through the development of specialized additives. While concrete has high compressive strength and is cost-effective, it lacks tensile strength and is prone to cracking and shrinkage. Adding glass fiber during mixing enhances its tensile strength and reduces cracking, combining the strengths of both materials for better overall performance.

### 1.2 Glass Fibre Reinforced Concrete (GFRC) –

Glass Fibre Reinforced Concrete (GFRC) is a composite made from cement, sand, water, admixtures, and randomly dispersed short glass fibres. This combination improves the mechanical and physical properties of concrete.

GFRC is commonly used for non-structural elements like façade panels, pipes, and decorative components due to its lightweight, strength, fire resistance, and aesthetic appeal.

This study tested concrete samples with and without glass fibres to compare compressive and flexural strength. Results showed that glass fibres enhance concrete performance by improving resistance to tension, bending, and crack formation.

However, adding fibres can reduce workability, making the mix harder to pour. To counter this, a super plasticizer was added to improve flow. The research focuses on evaluating how different fibre contents and the use of a super plasticizer affect the strength and workability of GFRC.

## II. LITERATURE REVIEW

### 2.1 Introduction

Glass Fibre Reinforced Concrete (GFRC) is a composite material that combines the strength and flexibility of glass fibres with traditional concrete. It offers improved mechanical properties like higher tensile strength, flexural strength, and impact resistance. Being lightweight and durable, GFRC is suitable for various construction applications.

### 2.2 Use of Different Fibres in Concrete

Adding different types of fibres—such as steel, polypropylene, glass, and synthetic—enhances concrete's strength, ductility, and durability. Each fibre type affects properties like compressive strength, tensile strength, and crack resistance differently, making them useful for a range of structural and non-structural purposes.

#### Steel Fibre

Steel fibres significantly improve concrete's ductility, tensile strength, and energy absorption. They are especially effective in ultra-high strength and recycled aggregate concrete, enhancing compressive and flexural strength. For example, 0.5–3% steel fibres can boost compressive strength by over 66% and flexural energy by 65%. Closed steel fibres further increase tensile strength by 46%. However, excessive fibre content may reduce performance due to poor bonding.

#### Polypropylene and Polyolefin Fibres

These synthetic fibres enhance concrete's compressive strength, toughness, and crack resistance. Polyolefin fibres can improve compressive strength by up to 30%, while polypropylene fibres limit crack growth and improve tensile strength. They also enhance post-cracking behavior and reduce micro-voids, making the concrete more durable under environmental stress.

#### Glass Fibres

Glass fibres boost tensile, flexural, and compressive strength, improve crack resistance, and reduce shrinkage. They are especially beneficial in sustainable concrete mixes using recycled or geopolymer materials. Optimal content ranges from

0.5% to 2%, with 1.25% often yielding the best results in strength and sustainability.

#### Synthetic Fibre

Synthetic fibres like polypropylene, polyacrylonitrile, and polyvinyl alcohol improve tensile strength, toughness, and fire resistance. They also enhance concrete's structural performance and can partially replace steel fibres in high-performance applications. New types, including textile and cardboard fibres, contribute to sustainability and are being explored for 3D-printed concrete.

### 2.3 Use of Glass Fibre in Concrete

Glass Fibre Reinforced Concrete (GFRC) is formed by adding glass fibres to concrete, enhancing its strength, durability, and resistance to cracking, shrinkage, and impact. Due to its lightweight and mold ability, GFRC is widely used in architectural applications like facades and decorative elements.

#### Key Benefits of GFRC:

- Higher tensile strength – resists cracks from pulling forces
- Reduced cracking – better resistance to shrinkage and impact
- Increased durability – withstands weather, fire, and chemicals
- Lightweight – reduces structural load

#### Applications:

- Architectural – facades, panels, decorative forms
- Precast elements – wall panels, custom shapes
- Infrastructure – pavements, sidewalks, etc.

#### Production Methods:

- Glass fibres can be mixed directly or applied via spray-up techniques with the cement mix.
- Alkali-resistant glass fibres (ARGF) are commonly used to prevent corrosion.

#### Cost-effectiveness:

GFRC is often more economical due to its strength, durability, and ease of installation compared to conventional concrete.

## III. MATERIALS AND METHODS

### 3.1 Introduction

Glass Fibre Reinforced Concrete (GFRC) enhances toughness, energy absorption, and crack resistance by dispersing short glass fibres in a cementitious mix.

These fibres improve tensile strength—one of plain concrete’s main weaknesses.

However, bonding between glass fibres and cement is often poor due to their smooth, water-resistant surfaces. To address this, researchers explore methods like coating, chemical treatment, and surface roughening to improve fibre-cement adhesion.

This study also examines extruded polypropylene fibres, evaluating their mechanical performance using a single-fibre pull-out test. This test helps measure bonding strength and fibre resistance to being pulled from the cement matrix.

### 3.2 Materials Used

The primary materials included cement, fine aggregate, coarse aggregate, water and glass fibre.

#### 3.2.1 Cement

UltraTech OPC 53-grade cement, conforming to IS: 12269–2013, was used. It provided good early strength and ensured durability in the concrete mix.

S.NO.	Test	Average Value	Recommended Value
1.	Fineness Test	2.3%	<10%
2.	Standard Consistency Test	285%	27% - 33%
3.	Initial Setting Time	1 hour 53 min	>30 minute
4.	Final Setting Time	5 hours 9 min	<10 hours
5.	Soundness Test	1.67mm	<10 mm
6.	7days Compressive Strength Test	32.38 N/mm <sup>2</sup>	>30.1 N/mm <sup>2</sup>
7.	28 days Compressive Strength Test	45.47 N/mm <sup>2</sup>	>43 N/mm <sup>2</sup>

#### 3.2.2 Fine Aggregate

Well-graded, clean river sand passing through a 4.75 mm sieve (as per IS 383:2016) was used as the fine

aggregate, selected for its bonding properties and local availability.

S.N O.	Type of Test	U nit	Requirement	Resul t
1.	Water Absorption	%	Max 3	1.635
2.	Bulk Specific Gravity	gr/ c m <sup>3</sup>	Min 2.5	2.650
3.	Apparent Specific Gravity	gr/ c m <sup>3</sup>	Min 2.5	2.770
4.	Sand Equivalent	%	Min 50	80.40

#### 3.2.3 Coarse Aggregate

Crushed angular aggregate (maximum size 20 mm), free from impurities and compliant with IS 383:2016, was used. Its interlocking properties enhanced the strength and workability of the concrete.

S.NO.	Type of Test	Unit	Requirement	Result
1.	Los Angeles Abrasion Test	%	Max 40	29.5
2.	Asphalt Absorption	%	Min 95	98
3.	Water Absorption	%	Max 3	1.6
4.	Bulk Specific Gravity	gr/ cm <sup>3</sup>	2.5	2.6
5.	Apparent Specific Gravity	gr/ cm <sup>3</sup>	2.5	2.7

#### 3.2.4 Water

Clean, potable water was used for both mixing and curing, in accordance with IS 456:2000, ensuring no adverse effect on concrete strength or setting time.

#### 3.2.5 Glass Fibre

The glass fibre utilized in this research was a high-quality, alkaline-resistant glass fibre specifically designed for reinforcing cement and other alkaline

matrices. This type of fibre enhances the mechanical properties and the durability of concrete.

S.NO.	Character	Glass Fibres
1.	Number of Fibres	212million/kg
2.	Aspect Ratio	857:1
3.	Typical Addition Rate	0.6 to 1.0 kg/m <sup>3</sup> of Concrete
4.	Tensile Strength	1700 Mpa
5.	Modulus of Elasticity	73 Gpa
6.	Corrosion Resistance	Excellent
7.	Specific Gravity	2.6
8.	Density	26 KN/m <sup>3</sup>
9.	Filament Diameter	14 micro
10.	Filament Length	12 mm

### 3.3 Concrete Mix Design

M25 grade concrete (mix ratio 1:1:2) was used, as it is commonly recommended for structural elements such as beams. The mix was designed in accordance with IS 456:2000 guidelines. A consistent water-cement ratio of 0.45 was maintained to ensure adequate workability and the desired target strength.

## IV. RESULT AND DISCUSSION

### 4.1 Compressive Strength Test Results

Compressive strength (f<sub>ck</sub>) tests were performed on cured concrete cube specimen at 7 days and 28 days of age using a compression testing machine with a capacity of 200 KN. The cube specimens were carefully positioned at the centre of the machine, ensuring proper alignment. The load was gradually applied to the cube until failure occurred, and the corresponding load values were recorded.

The compressive strength(f<sub>ck</sub>) of concrete is the capacity of a concrete specimen to withstand axial loads before failure.

Sr. N	Mix (days)	Fibre Content	Cube (Compressive Strength N/mm <sup>2</sup> )
1.	7	0 %	29.8
		0.5 %	35.2
		1.0 %	40.9
		1.5 %	33.9
2.	28	0 %	33.5
		0.5 %	38.5
		1.0 %	45.6
		1.5 %	36.1



Figure.4.1: Compressive Strength Test

### 4.2 Split Tensile Strength Test

Split tensile strength of concrete is usually found by testing concrete cylinder of size 100mm × 200mm. The specimens were tested for its strength as per IS: 516-1959 using a calibrated compression testing machine of 2000KN capacity. The tensile strength of the specimen was calculated by using the formula  $f_t = (2P) / (\pi \times d \times l)$  N/mm<sup>2</sup>

Where,

P = Maximum load in N applied to the specimen

d = Measured length in cm of the specimen

l = Measured diameter in cm of the specimen

f<sub>t</sub> = Tensile strength N/mm<sup>2</sup>



Sr. N	Mix (days)	Fibre Content	Cylinder (Split Tensile Strength N/mm <sup>2</sup> )
1.	7	0 %	1.41
		0.5 %	2.83
		1.0 %	2.62
		1.5 %	2.43
2.	28	0 %	3.4
		0.5 %	3.92
		1.0 %	3.57
		1.5 %	3.42

Table 4.2.2 Split Tensile Strength Values

4.3 Flexural Strength Test

Flexural strength is a measure of concrete’s ability to resist bending (tensile strength).

It is tested on a beam specimen of size 100×100×500 mm. After casting, the specimen is remolded after 24 hours and cured for 7, 28, and 60 days. Before testing, it is air-dried for a few hours.

The test is done as per IS: 516-1959 using a flexural testing machine. Rollers are placed 50 mm from each end for a 100 mm wide specimen.

$$fb = Pl / bd^2 \text{ N/mm}^2$$

Where,

P = Load at which specimen fails in N

l = Effective span in mm

b = Breadth of the specimen in mm

d = Depth of the specimen in mm



Sr. N	Mix (days)	Fibre Content	Beam (Flexural Strength N/mm <sup>2</sup> )
	7	0 %	2.40
		0.5 %	2.46
		1.0 %	2.65

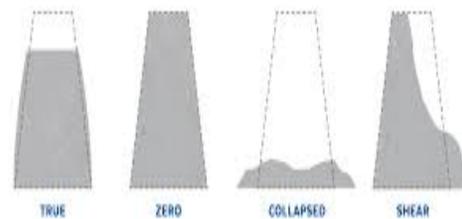
1.		1.5 %	2.51
2.	28	0 %	2.82
		0.5 %	3.09
		1.0 %	3.4
		1.5 %	3.24

Table 4.2.3 Flexural Strength Values

4.4 Slump Test

The concrete slump(fall) test is a straightforward and widely used method to assess the consistency and workability of fresh concrete before placement. It helps ensure uniformity across different batches and detect potential issues in the mixture.

The concrete slump(fall) test is a fundamental procedure used to evaluate the workability and consistency of fresh concrete before placement. It's widely adopted due to its simplicity, cost-effectiveness, and the immediate results it provides.



V. CONCLUSION AND FUTURE SCOPE

5.1 Conclusion Based on Experimental Investigation

The addition of glass fibres to reinforcement concrete significantly enhances its mechanical strength and durability characteristics.

- Initially, as the percentage of glass fibres increases, compressive strength, flexural strength, and split tensile strength( $f_{ct}$ ) also show a gradual improvement.
- The greatest strength measured for all 3 parameters are achieved at 1.0% glass fibre content by volume of concrete.
- Beyond this optimum value (i.e., >1.0%), a gradual decline in strength is observed, likely due to issues such as poor workability or non-uniform fibre distribution.
- In terms of durability, the performance of concrete continues to improve with increasing glass fibre content, as the fibres help control

crack propagation and enhance resistance to environmental effects.

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