

Experimental Investigation on Strength and Flexural Behaviour of Glass Fiber Reinforced Concrete Using M40 Grade Concrete

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Abstract

Concrete is one of the most widely used construction materials due to its high compressive strength and versatility. However, conventional concrete exhibits brittle behaviour and low tensile strength, which limits its performance under flexural loading. Fiber reinforcement has emerged as an effective method to enhance the mechanical properties and crack resistance of concrete. This study investigates the strength and flexural behaviour of Glass Fiber Reinforced Concrete (GFRC) using M40 grade concrete. Alkali-resistant glass fibers were incorporated at varying dosages of 0.25%, 0.50%, 0.75%, and 1.00% by volume of concrete. Fresh concrete properties were evaluated using slump tests, while hardened concrete properties were assessed through compressive strength, split tensile strength, and flexural strength tests at different curing ages. The experimental results indicated that the addition of glass fibers significantly improved tensile and flexural strength, while compressive strength showed marginal improvement. The optimum fiber dosage was observed at 0.75%, which provided the best overall performance in terms of strength and crack control. The study demonstrates that GFRC can be effectively used in structural applications where improved flexural performance and crack resistance are required.

Keywords: Glass Fiber Reinforced Concrete, M40 Concrete, Flexural Strength, Split Tensile Strength, Fiber Reinforced Concrete.

1. Introduction

Concrete is the most widely used construction material in the world due to its availability, adaptability, and relatively low cost. It plays a critical role in infrastructure development including buildings, bridges, pavements, and dams. Despite its advantages, conventional concrete has inherent limitations such as low tensile strength and brittle failure behaviour. Under

tensile and flexural loading, cracks develop in concrete even at relatively low stress levels, which eventually leads to structural failure.

To overcome these limitations, the concept of Fiber Reinforced Concrete (FRC) has been introduced. In FRC, discrete fibers are uniformly distributed within the concrete matrix to improve its tensile strength, crack resistance, and post-cracking behaviour. The fibers act as crack arresters, bridging micro-cracks and preventing their propagation into larger cracks.

Among different types of fibers, glass fibers have gained significant attention due to their high tensile strength, lightweight nature, and resistance to corrosion. Glass Fiber Reinforced Concrete (GFRC) has been widely used in architectural panels, façade elements, and precast components. In recent years, researchers have explored its potential for structural applications due to its improved flexural behaviour and crack resistance.

The present study focuses on evaluating the strength characteristics and flexural behaviour of GFRC using M40 grade concrete. The effect of varying fiber content on compressive strength, split tensile strength, and flexural strength has been investigated experimentally.

2. Literature Review

Several researchers have studied the performance of glass fiber reinforced concrete. Kumar and Srinivas (2024) investigated the flexural behaviour of GFRC beams and reported increased first crack load and ultimate load due to fiber addition. The study observed that fiber reinforced beams exhibited ductile behaviour with multiple crack formation.

Rao et al. (2024) evaluated the mechanical and durability properties of high-strength GFRC and reported improvements in tensile strength and reduced water absorption at optimum fiber dosage. The study

concluded that glass fibers enhance both strength and durability characteristics of concrete.

Sharma and Jain (2023) studied the influence of glass fibers on M30 and M40 concrete and observed that flexural strength increased by nearly 30% at optimum fiber content. However, workability decreased with increasing fiber dosage.

Singh and Verma (2022) investigated the tensile behaviour of GFRC and reported improved crack resistance and delayed crack initiation in fiber reinforced specimens.

Previous studies clearly indicate that the addition of glass fibers enhances the mechanical performance and crack control of concrete. However, identifying the optimum fiber dosage remains an important research objective.

3. Materials and Methodology

3.1 Materials

The materials used in this study include cement, fine aggregate, coarse aggregate, water, glass fibers, and chemical admixture.

- **Cement:** Ordinary Portland Cement (OPC 53 grade) conforming to IS 12269 was used.
- **Fine Aggregate:** Natural river sand conforming to Zone II of IS 383 was used.
- **Coarse Aggregate:** Crushed granite aggregate with maximum size of 20 mm was used.
- **Water:** Potable water free from impurities was used for mixing and curing.
- **Glass Fibers:** Alkali-resistant glass fibers of 12 mm length were used.
- **Superplasticizer:** Polycarboxylate ether based superplasticizer was used to improve workability.

3.2 Mix Design

Concrete mix design was carried out for **M40 grade concrete** as per **IS 10262:2019**.

Mix Proportions

Material	Quantity
Cement	400 kg/m ³
Fine Aggregate	650 kg/m ³
Coarse Aggregate	1200 kg/m ³
Water	160 litres
Water Cement Ratio	0.40

Glass fibers were added in the following proportions:

Mix ID	Fiber Content
GF0	0%
GF0.25	0.25%
GF0.50	0.50%
GF0.75	0.75%
GF1.00	1.00%

3.3 Experimental Program

The following tests were conducted:

- Slump test
- Compressive strength test
- Split tensile strength test
- Flexural strength test

Tests were conducted at **7, 28, and 56 days curing periods**.

4. Results and Discussion

4.1 Workability

The slump test results showed that workability decreased with increasing fiber content due to increased internal friction and obstruction to flow.

Mix	Slump (mm)
GF0	95
GF0.25	85
GF0.50	75
GF0.75	65
GF1.00	55

4.2 Compressive Strength

Mix	7 Days	28 Days	56 Days
GF0	31.2	41.5	43.8
GF0.25	32.4	42.8	45.1
GF0.50	33.6	44.5	46.9
GF0.75	34.1	45.2	47.6
GF1.00	33.0	44.0	46.0

Compressive strength increased slightly with fiber addition up to 0.75%.

4.3 Split Tensile Strength

Mix	28 Days Strength (MPa)
GF0	3.20
GF0.25	3.55
GF0.50	3.90
GF0.75	4.20
GF1.00	4.05

The results show significant improvement due to fiber crack-bridging action.

4.4 Flexural Strength

Mix	28 Days Strength (MPa)
GF0	5.1
GF0.25	5.8
GF0.50	6.5
GF0.75	7.1
GF1.00	6.8

Flexural strength increased by nearly **35%** at optimum fiber content.

5. Conclusions

The following conclusions can be drawn from the experimental investigation:

1. Workability of concrete decreases with increasing glass fiber content.
2. Compressive strength shows slight improvement with fiber addition.
3. Split tensile strength increases significantly due to crack-bridging action of fibers.
4. Flexural strength improves substantially with glass fiber incorporation.
5. Optimum fiber content was found to be **0.75%**.

6. Glass Fiber Reinforced Concrete exhibits improved crack resistance and ductility compared to conventional concrete.

GFRC can therefore be effectively used in structural elements where enhanced flexural performance and crack control are required.

References

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