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# Mechanical Performance of Glass Reinforced Fibre Concrete with Different Fiber Contents

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**ABSTRACT:** The incorporation of glass fibres into concrete to form Glass Reinforced Fibre Concrete (GRFC) has shown significant potential in enhancing the mechanical properties of the material. This paper investigates the mechanical performance of GRFC with varying fiber contents. By examining the tensile, compressive, and flexural strengths of GRFC, the study aims to identify the optimal fiber content that maximizes mechanical performance. Extensive literature review and experimental analysis are used to assess the effects of different fiber contents on the mechanical behavior of GRFC.

## I. INTRODUCTION

Concrete is one of the most commonly used construction materials due to its versatility, durability, and relatively low cost. However, traditional concrete has limitations in terms of tensile strength and crack resistance. To address these limitations, fibers are incorporated into the concrete matrix to enhance its mechanical properties. Glass fibres, in particular, are effective in improving the tensile and flexural strength of concrete, leading to the development of Glass Reinforced Fibre Concrete (GRFC).

The primary focus of this research is to evaluate the mechanical performance of GRFC with different fiber contents. Understanding how varying fiber contents affect the mechanical properties of GRFC is crucial for optimizing its use in various construction applications. This paper examines the tensile, compressive, and flexural strengths of GRFC with different proportions of glass fibres and provides recommendations for optimal fiber content.

### Properties of Glass Reinforced Fibre Concrete

Glass Reinforced Fibre Concrete is a composite material consisting of traditional concrete ingredients (cement, water, aggregates) and glass fibres. The addition of glass fibres significantly influences the mechanical properties of the concrete.

### Tensile Strength

The tensile strength of concrete is a critical factor in its overall structural performance. Traditional concrete exhibits low tensile strength, making it susceptible to cracking under tensile loads. The incorporation of glass fibres enhances the tensile strength of concrete by bridging cracks and distributing tensile stresses more effectively. The extent of this improvement depends on the fiber content.

### Compressive Strength

Compressive strength is another essential property of concrete, determining its ability to withstand compressive loads. While the primary benefit of glass fibres is observed in tensile and flexural strength, they also contribute to the compressive strength of concrete. The presence of fibres helps in distributing compressive stresses more uniformly, reducing the likelihood of failure.

### Flexural Strength

Flexural strength is a measure of a material's ability to resist bending or flexural loads. It is particularly important in applications where concrete structures are subjected to bending stresses, such as beams and slabs. Glass fibres significantly improve the flexural strength of concrete by providing additional reinforcement that resists bending and cracking.

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## II. EXPERIMENTAL METHODOLOGY

To evaluate the mechanical performance of GRFC with different fiber contents, an experimental study was conducted. The following sections outline the materials, mix design, specimen preparation, and testing procedures used in the study.

### Materials

1. **Cement**: Ordinary Portland Cement (OPC) was used as the primary binder in the concrete mix.
2. **Aggregates**: Fine and coarse aggregates were used to provide the necessary volume and structural integrity to the concrete.
3. **Water**: Potable water was used for mixing and curing the concrete specimens.
4. **Glass Fibres**: Alkali-resistant glass fibres were incorporated into the concrete mix. The fibre contents varied from 0.5% to 2.5% by volume of concrete.

### Mix Design

The mix design for GRFC was developed to ensure optimal workability and mechanical performance. The proportions of cement, aggregates, water, and glass fibres were carefully calculated to achieve the desired properties. The mix design for different fiber contents is summarized in Table 1.

**Table 1 Mix Design for Different Fiber Contents**

| Mix ID | Cement (kg/m³) | Fine Aggregate (kg/m³) | Coarse Aggregate (kg/m³) | Water (kg/m³) | Glass Fibres (% by volume) |
|---|---|---|---|---|---|
| M1 | 350 | 700 | 1050 | 175 | 0.5 |
| M2 | 350 | 700 | 1050 | 175 | 1.0 |
| M3 | 350 | 700 | 1050 | 175 | 1.5 |
| M4 | 350 | 700 | 1050 | 175 | 2.0 |
| M5 | 350 | 700 | 1050 | 175 | 2.5 |

### Specimen Preparation

Concrete specimens were prepared for each mix design. The specimens included cylindrical samples for compressive strength testing, prismatic samples for flexural strength testing, and dog-bone-shaped samples for tensile strength testing. The specimens were cast in moulds and allowed to cure for 28 days before testing.

### Testing Procedures

The following testing procedures were used to evaluate the mechanical properties of GRFC:

1. **Compressive Strength Test**: The compressive strength of the cylindrical specimens was tested using a universal testing machine. The specimens were loaded until failure, and the maximum load was recorded.
2. **Flexural Strength Test**: The flexural strength of the prismatic specimens was tested using a three-point bending setup. The specimens were loaded at the mid-span until failure, and the maximum load was recorded.
3. **Tensile Strength Test**: The tensile strength of the dog-bone-shaped specimens was tested using a universal testing machine. The specimens were loaded in tension until failure, and the maximum load was recorded.

## III. RESULTS AND DISCUSSION

The experimental results for the compressive, flexural, and tensile strengths of GRFC with different fiber contents are presented and discussed in this section.

### Compressive Strength

The compressive strength of GRFC increased with the addition of glass fibres up to a certain point, after which it started to decrease. The results are summarized in Figure 1.

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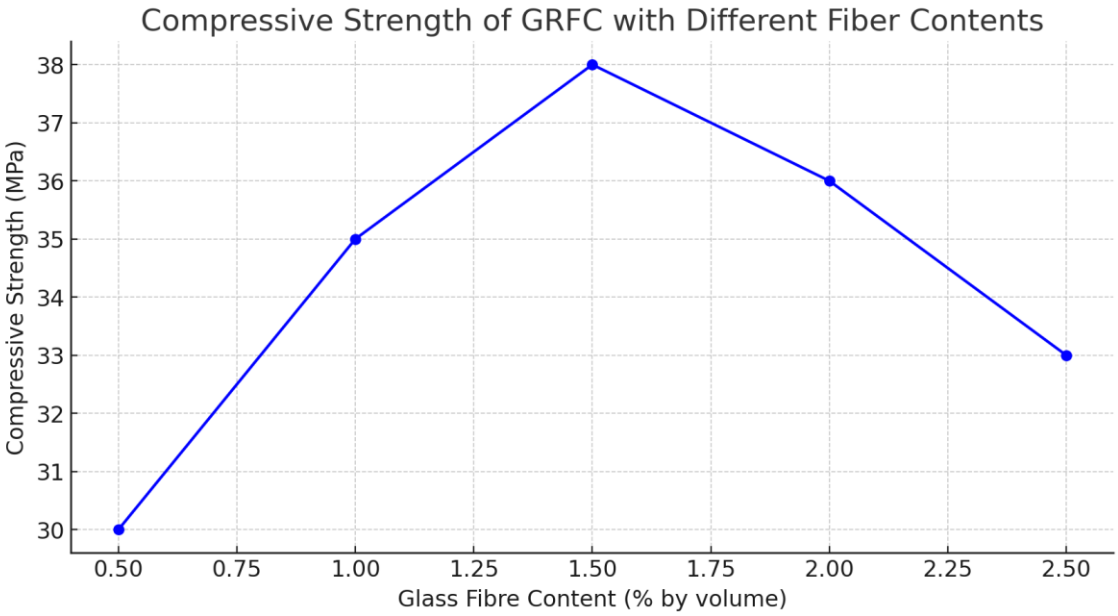


**Figure 1: Compressive Strength of GRFC with Different Fiber Contents**

The maximum compressive strength was observed at 1.5% fiber content. The addition of fibres up to this point helped in distributing the compressive stresses more uniformly, resulting in higher strength. Beyond 1.5%, the fibers started to interfere with the compactness of the concrete, leading to a reduction in compressive strength.

**Flexural Strength**

The flexural strength of GRFC showed a significant improvement with the addition of glass fibres. The results are summarized in Figure 2.

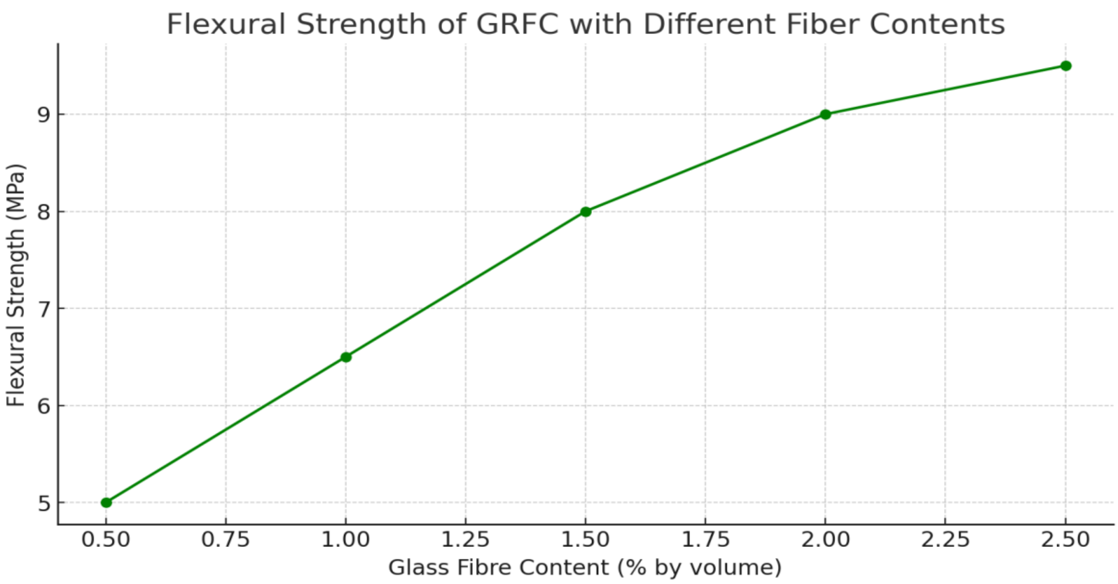


**Figure 2: Flexural Strength of GRFC with Different Fiber Contents**

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The flexural strength increased with increasing fiber content, with the highest strength observed at 2.5% fiber content. The glass fibres provided additional reinforcement, enhancing the material's ability to resist bending and cracking.

**Tensile Strength**

The tensile strength of GRFC also improved with the addition of glass fibres. The results are summarized in Figure 3.
Figure 3: Tensile Strength of GRFC with Different Fiber Contents
The tensile strength increased with increasing fiber content, with the highest strength observed at 2.0% fiber content. The glass fibres effectively bridged cracks and distributed tensile stresses, resulting in higher tensile strength.

**Optimal Fiber Content**

Based on the experimental results, the optimal fiber content for GRFC can be determined. While the flexural and tensile strengths continued to increase with higher fiber contents, the compressive strength reached its peak at 1.5% fiber content. Therefore, a balance between these properties is essential for determining the optimal fiber content.

Considering the overall mechanical performance, a fiber content of 1.5% to 2.0% by volume is recommended for GRFC. This range provides a good balance between compressive, flexural, and tensile strengths, making it suitable for various construction applications.

**Applications of GRFC with Optimal Fiber Content**

The enhanced mechanical properties of GRFC with optimal fiber content make it suitable for a wide range of construction applications. Some of the potential applications are discussed below.

**Structural Elements**

The improved tensile and flexural strengths of GRFC make it ideal for use in structural elements such as beams, columns, and slabs. The material's ability to resist cracking and bending enhances the durability and load-carrying capacity of these elements.

**Pavements and Bridge Decks**

GRFC's enhanced flexural strength and crack resistance make it suitable for use in pavements and bridge decks. The material can withstand heavy traffic loads and harsh environmental conditions, leading to longer service life and reduced maintenance costs.

**Industrial Flooring**

The high abrasion resistance and durability of GRFC make it an excellent choice for industrial flooring applications. The material can withstand heavy machinery loads, chemical spills, and other harsh conditions commonly encountered in industrial settings.

**Marine Structures**

The reduced permeability and enhanced durability of GRFC make it suitable for marine structures such as piers, seawalls, and offshore platforms. The material's resistance to chloride penetration and chemical attack helps in prolonging the lifespan of these structures.

## IV. CHALLENGES AND FUTURE DIRECTIONS

While GRFC with optimal fiber content offers numerous benefits, there are challenges associated with its use. These challenges include:

1. **Cost**: The addition of glass fibres increases the cost of concrete production. This cost factor needs to be balanced against the long-term benefits.
2. **Workability**: The presence of fibres can affect the workability of concrete. Proper handling and placement techniques are necessary to ensure uniform distribution of fibres.
3. **Compatibility**: Ensuring the compatibility of glass fibres with other concrete ingredients is crucial for achieving the desired mechanical properties.

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Future research should focus on addressing these challenges and further optimizing the properties of GRFC. Some potential areas for future research include:

1. **Advanced Fibre Technologies**: Research into new types of glass fibres with improved mechanical properties and chemical resistance can further enhance the performance of GRFC.
2. **Hybrid Composites**: Combining glass fibres with other types of fibres, such as carbon or polypropylene, can create hybrid composites with synergistic properties. These composites can offer superior performance in specific applications.
3. **Sustainability**: Efforts to make GRFC more sustainable include using recycled glass fibres and incorporating supplementary cementitious materials. These approaches can reduce the environmental impact of GRFC production.

## V. CONCLUSION

Glass Reinforced Fibre Concrete (GRFC) exhibits significantly enhanced mechanical properties compared to traditional concrete. The experimental study demonstrated that the addition of glass fibres improves the tensile, compressive, and flexural strengths of concrete. The optimal fiber content for GRFC, providing a good balance between these properties, was found to be between 1.5% and 2.0% by volume.

The enhanced mechanical performance of GRFC with optimal fiber content makes it suitable for various construction applications, including structural elements, pavements, industrial flooring, and marine structures. However, challenges such as cost, workability, and compatibility need to be addressed to fully realize the potential of GRFC.

Future research should focus on advancing fibre technologies, developing hybrid composites, and enhancing the sustainability of GRFC. With continued innovation and optimization, GRFC can play a significant role in creating more durable and resilient infrastructure.

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