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An Experimental Study on Glass Fiber Reinforced Geopolymer Concrete

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ABSTRACT: The production of Ordinary Portland Cement (OPC) concrete has high environmental impact due to significant CO₂ emissions. Geopolymer Concrete (GPC), made using industrial waste like fly ash from thermal power plants, offers a sustainable alternative with excellent strength and durability. Fly ash reacts with alkaline solutions (NaOH, Na₂SiO₃) to form a binding gel, but GPC's brittleness limits its structural use. This study investigates Glass Fiber-Reinforced GPC (GFRGPC) with fiber volume fractions of 0%, 0.1%, 0.2%, 0.3%, and 0.4%, and lengths of 6 mm, 12 mm, and 25 mm, using M30 grade GPC with 100% fly ash binder. Mechanical properties (compressive, flexural, and split tensile strength) were compared to plain GPC to evaluate the effectiveness of glass fibers in improving performance.

I. INTRODUCTION

Geopolymer concrete (GPC) presents a sustainable alternative to conventional Portland cement concrete, offering lower carbon emissions and effective use of industrial by-products such as fly ash. Despite its durability and strength, the brittle nature of GPC limits its ductility and cracking resistance. Fiber reinforcement—specifically glass fibers—offers a potential solution due to their high tensile strength, corrosion resistance, and cost-effectiveness. This study explores the effect of varying glass fiber content and length on the mechanical and durability properties of GPC.

II. LITERATURE REVIEW

Prior studies have demonstrated the benefits of glass and polymer fibers in conventional and geopolymer concretes. However, research predominantly focused on shorter fibers (≤ 6 mm). There remains a gap regarding the performance of longer fibers (12 mm and 25 mm) in GPC. This study addresses that gap through a comprehensive experimental evaluation.

- Geopolymer concrete's highest compressive strength observed at 60°C.
- 0.3% glass fiber volume fraction results in an 11.62% increase compared to conventional concrete.
- Tensile strength in geopolymer concrete shows a linear variation.
- Peak strength at 60°C with 0.3% glass fiber, exhibiting a 3.64% gain over conventional concrete.
- Maximum flexural strength for geopolymer concrete found at 60°C with 0.3% glass fiber.
- Strength surpasses normal concrete by 2.65% at the same volume fraction.
- Geopolymer concrete achieves maximum strength at 60°C with 0.3% glass fiber volume fraction.
- Noteworthy that concrete strength can be increased without cement, promoting an eco-friendly approach.

Objectives

1. To investigate the mechanical, durability, and fracture properties of glass fiber-reinforced geopolymer concrete (GFRGPC).
2. To optimize mix design to achieve high performance and sustainability.
3. To enhance strength, toughness, and resistance to environmental factors.
4. To contribute to advancements in sustainable construction technology.

Scope of Work

To study effect of glass fibres of geo polymer concrete. To compare the fly ash-based geo polymer concrete with addition of glass fibres geopolymer concrete.

Problem Statement

To study the strength parameters of geopolymer concrete with addition of glass fibers on strength of concrete. i.e. (0%, 0.1%, 0.2%, 0.3%, & 0.4%) with Varying length of Glass fiber 6 mm, 12 mm & 25 mm.

III. METHODOLOGY

Non-Destructive Test Methods

- Rebound Hammer Test: Measures surface hardness to estimate concrete strength. Higher rebound values = stronger concrete. Quick and useful for preliminary quality checks.
- Ultrasonic Pulse Velocity (UPV) Test: Measures speed of ultrasonic pulses in concrete. Higher velocity = denser, more uniform, and better-quality concrete.

Destructive Test Methods

- Compressive Strength Test: Cube specimens are loaded in a compression testing machine until failure.
Formula: $F_c = P / A$
- Split Tensile Strength Test: Cylindrical specimens tested per IS:516-1989.
Formula: $F_{sp} = 2P / (\pi \times D \times H)$
- Flexural Strength Test: Beam specimens tested for modulus of rupture.

Formulas:

- $F_r = M / S$
- $S = (b \times d^2) / 6$
- $M = P \times L / 4$ (for third-point loading)

IV. RESULTS AND DISCUSSION

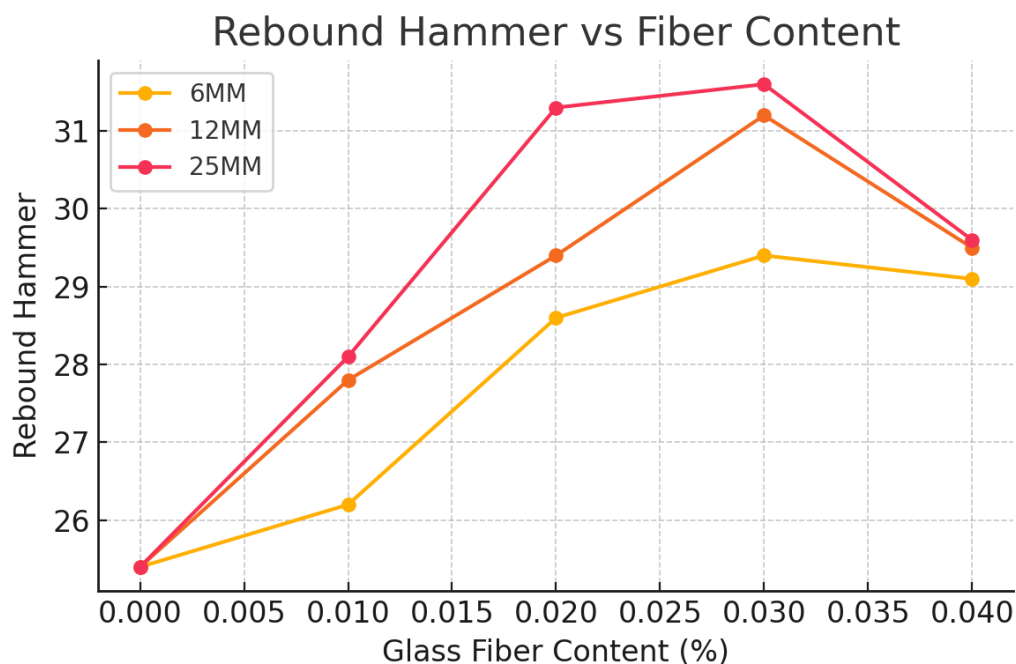
Rebound Hammer: Values increased up to 0.3% fiber content, peaking at ~31.6 MPa with 25 mm fibers.

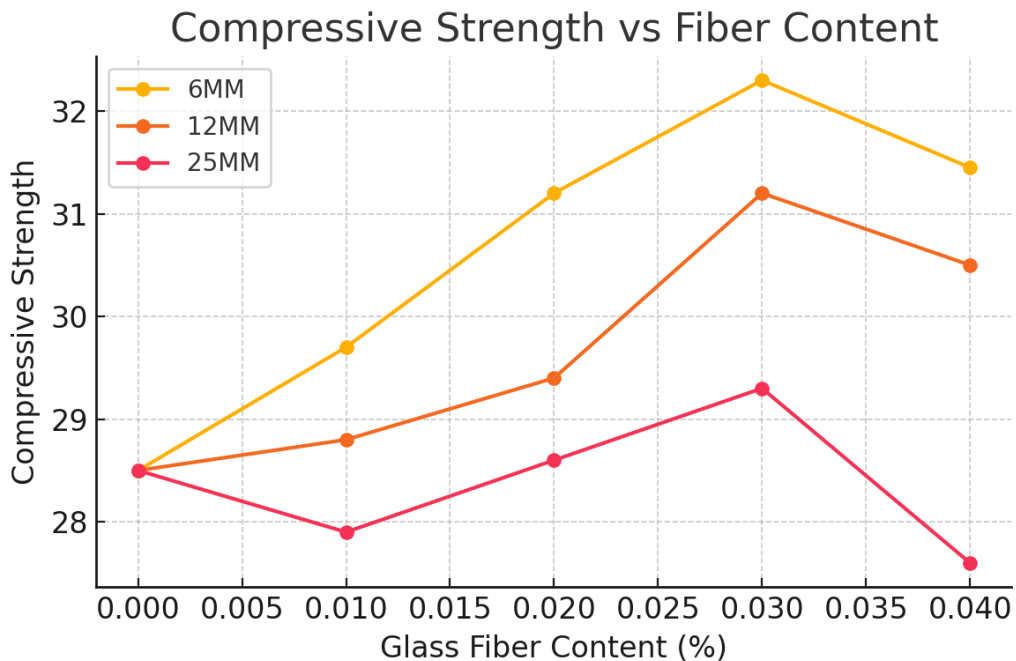
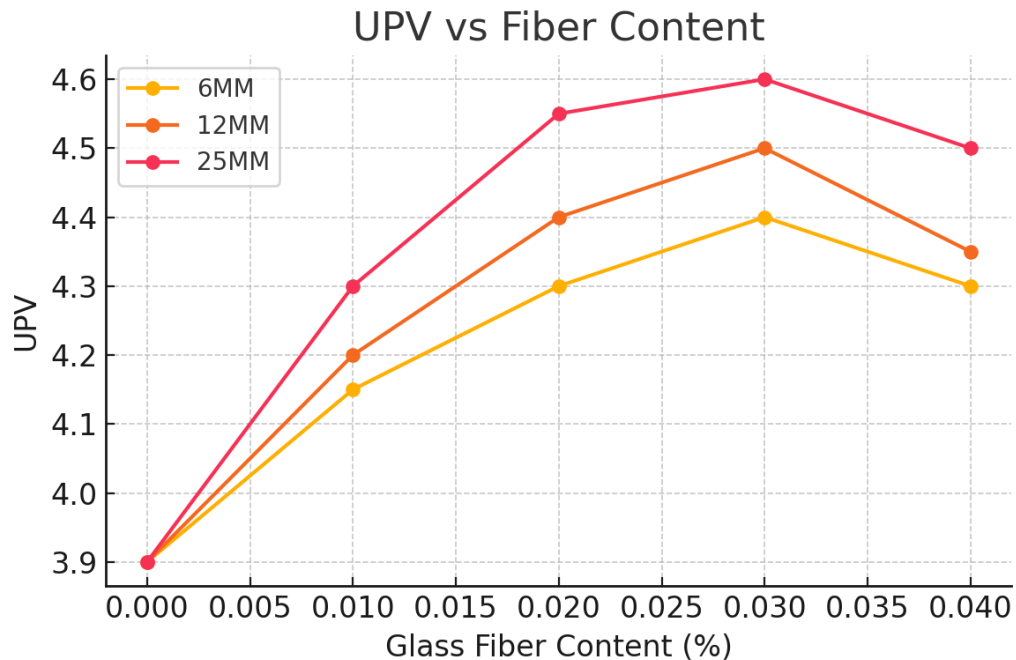
UPV: Peak velocity of 4.6 km/s at 0.3% fiber (25 mm).

Compressive Strength: Maximum of 32.3 MPa at 0.3% fiber (6 mm).

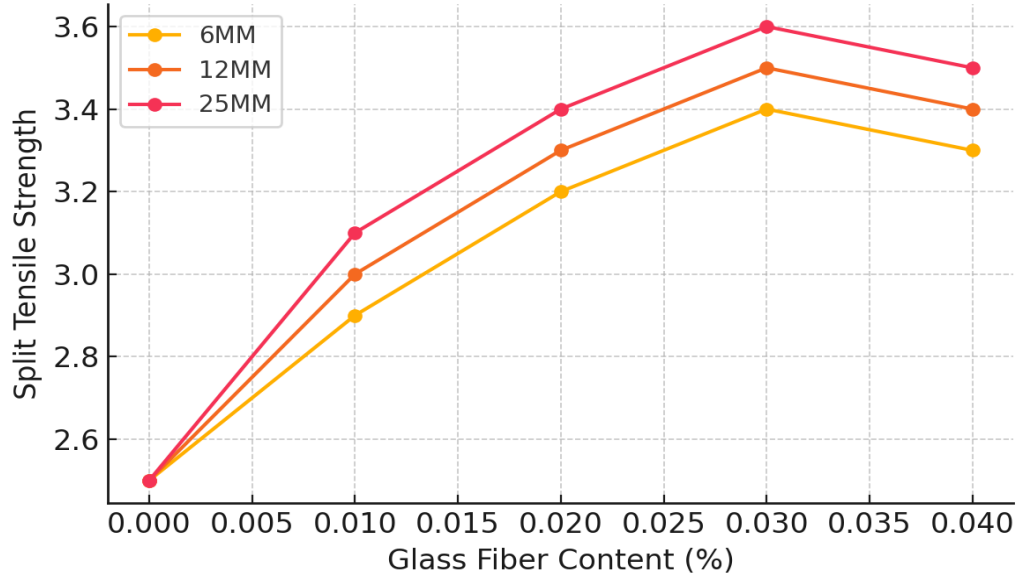
Split Tensile Strength: Increased from 2.5 MPa (control) to 3.6 MPa at 0.3% fiber (25 mm).

Flexural Strength: Peaked at 5.1 MPa at 0.3% fiber (25 mm).

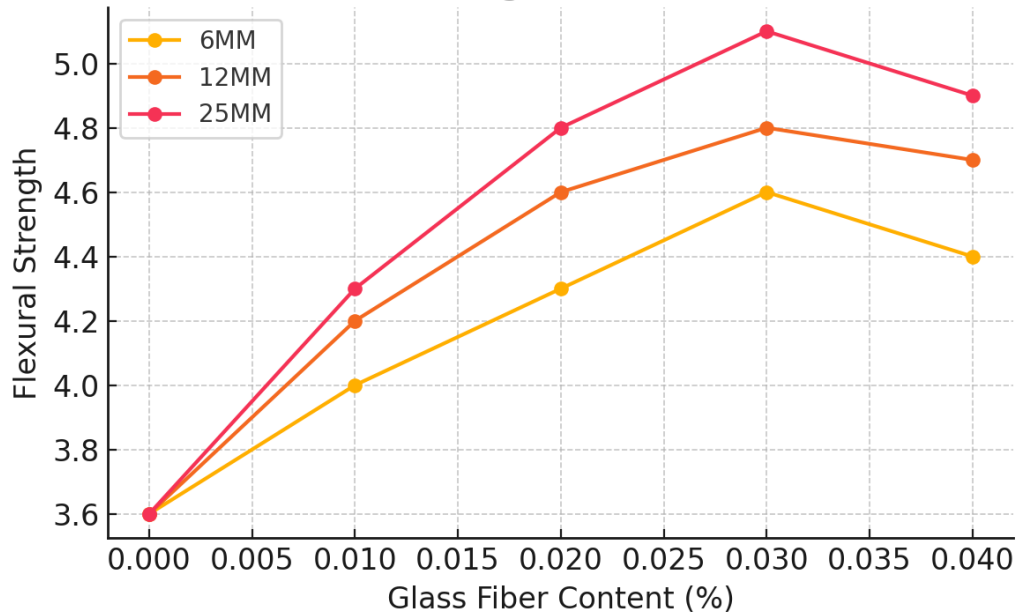




Split Tensile Strength vs Fiber Content



Flexural Strength vs Fiber Content



V. CONCLUSION

1. Rebound Hammer: Increased with fiber addition; peak ~31–32 at 0.3–0.4% (25 mm fiber) → higher surface hardness & durability.
2. UPV: Improved for all cases; peak ~4.6–4.7 km/s at 0.3% (25 mm fiber) → excellent internal quality, fewer voids/microcracks.
3. Compressive Strength: Increased up to 0.3% fiber (peak ~37–39 MPa at 6 mm length); higher dosages gave marginal gains or slight reduction.

4. Flexural Strength: Rose with both fiber content & length; best (~5.0–5.3 MPa) at 0.3% (25 mm) due to crack bridging & ductility.
5. Split Tensile Strength: Improved with fibers; max (~3.6–3.8 MPa) at 0.3–0.4% (25 mm), indicating better crack resistance.³

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