Strength Development in Concrete Reinforced with Glass Fibre

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Abstract - *In the construction field, concrete is the most widely utilized material, followed by steel reinforcements. In today's world, the construction materials sector is undergoing in rapid transformation, with new technologies replacing traditional materials on a daily basis. Fibres, pozzolanic materials, and other admixtures are being used by researchers all around the world to improve properties of concrete. Steel is used on the tension face largely to counteract the concrete's weak spot, which is tension. Though it is thought to be the best for this job, it is nevertheless corroded by nature's action, which raises concerns of seeking a solution to this problem. Fibre reinforced polymer (FRP's) rebars are one of the most frequent steel substitutes. In this investigation, two processes are combined: the first one is the replacement of ordinary concrete with Glass Fiber Fiber Reinforced Concrete, and the second one is the replacement of ordinary steel rebars with Glass Fiber Polymer Rebars (GFRP's), and the effects on Compressive Strength and Ultimate Crushing Loads are studied.*

Keywords: FRP, GFRP, Glass fibre, Concrete, RCC

1.INTRODUCTION

One of the most frequently utilised building materials is concrete. It is the bedrock of the construction and real estate industries. It has a number of advantages, including high compressive strength, stiffness, temperature tolerance, and durability. It can be easily casted when and where needed, and its basic components are practically universally available. However, it has several drawbacks, such as being brittle and weak in tension. Though, in general, Reinforcements are provided in concrete, i.e., the concrete is reinforced with steel at the tension region to boost its tensile strength.

1.1 Glass Fibre Reinforced Concrete (GFRC)

Fibre Reinforced Plastic Concrete is created in the same method as ordinary concrete, but it comprises fibre material that is evenly distributed throughout the entire concrete matrix. The most prevalent alkali resistive fibres used in GFRC are alkali resistant fibres. It's a cutting-edge technology. It's basically blended in with the water that's used to make the mix. Once the fibre is distributed equally, it forms a mesh-like network in the concrete matrix. This results in a matrix of evenly mixed fibres that form a random distribution of high-tensile-strength fibres. The cracking strength of the concrete rises as a result of this mesh, and the fibres act as crack arresters.

Various percentages of fibre content in concrete have recently been researched, and it has been revealed that the higher the fibre concentration, the higher the cracking and tensile strengths.

In most situations, 5% of the total cementitious material's weight is used in the concrete mix. Glass fibres are formed by a process in which molten glass is pulled into the fibres. The molten glass is pulled into thin filaments, which are then split into 12 mm and 6 mm fibres to be used in the GFRC.

1.2 Glass Fibre Reinforced Polymers (GFRP):

In Reinforced Cement Concrete, steel bars are the most commonly used reinforcements. They are cost-effective and are not exposed to chloride ion attack or other natural attacks.

When moisture and other substances make contact with them, they oxidized. When this occurs, the bar's volume increases by 2 to 5 times because the concrete can't handle the tensile strains and cracks, eventually causing failure. As a result of this corrosion and loss, steel replacement is both costly and also impractical. Engineers have been drawn to GFRP because of its favourable qualities, including as superior resistance to corrosion and other chemical agents, high tensile strengths, and fatigue resistance.

GFRP rebar does have a high tensile strength and is resistant to both natural and chemical agents. Because their strengths are uniform and reproducible, they can be compared to steel bars. Beams incorporating GFRP bars as shear reinforcement may tolerate higher shear strengths, making them similar to steel bars.

Because GFRP bars are fragile, their stress-strain graph shows immediate failure, although beams cast with GFRP bars do not break immediately, making them safe and providing adequate notice before collapse. GFRP beams are still developed utilising the working stress method to mitigate catastrophic failures.

They come in a variety of sizes, just like steel bars, extending from 12 mm to 40 mm in diameter.

2. TECHNICAL SPECIFICATIONS

2.1 Glass Fibres :

- Filament diameter - 14µ
- Specific gravity- 2.62
- Length- 12 mm
- Density(t/m^3)- 2.60
- Elastic modulus- 73
- Tensile strength- 1700
- No of fibres (million/kg)-220

2.2 Glass Fibre reinforced polymer (GFRP):

- Guage Length (Lo) 80.0000 mm
- Final Guage Length 82.5000 mm
- Outer Dia 16.0000 mm.
- Cross sectional Area 201.1392 mm ^{2}
- Maximum Load 141.833 kN
- Strain 5.000 %
- U.T.S. Value 705.149 N / mm ^{2}
- Mod. of Elasticity 46630.000 N / mm ^{2}
- 0.2% Proof Load 94.380 kN
- Stress @ 0.2% Prf. Load 459.930 N I mm ^{2}
- Yield Load 19.986 kN
- Yield Stress 99.213 N/mm ^{2}

3. METHODOLOGY

3.1 Testing of material

The specific gravity of all materials, namely coarse aggregates, fine aggregates, and cement, was determined:

- Specific gravity of cement- 2.21
- Specific gravity of fine aggregate- 2.83

Specific gravity of course aggregate- 2.52.

3.2 Casting of beam and cubes

The same concrete mix is being used to cast the beams and cubes, ensuring that the results are comparable. The dimensions of the moulds used to cast the beams are 2000*260*240 mm. The cube moulds feature the dimensions of 150*150*150 mm. To make the erection process more efficient, the beams were reinforced with 16 mm primary reinforcement and 8 mm hanger bars.

In this experiment, four beams and a total of 12 cubes were cast, with six cubes composed of regular concrete and six cubes made of glass fibre reinforced concrete. Half of them were tested for 7-day testing and the other half for 28-day testing. After a proper curing period of 28 days, the beams were inspected.

3.2.1 Different types of Beams

Four distinct types of test beams were cast in order to assess all of the conceivable combinations using the materials available. The following were the various cases:

- Beam1: Plain concrete with Steel rebars.
- Beam2: Glass fibre reinforced concrete with steel rebars.
- Beam3: Plain concrete with glass fibre reinforced polymer rebars.
- Beam4: Glass fibre reinforced concrete with glass fibre reinforcedpolymer rebars.

3.2.2 Types of concrete

- **Ordinary concrete**

The standard mix design for M25 Grade concrete was established in accordance with IS10262:2009 and then tweaked to account for the moisture content of the raw material batches.

- **Glass fibre reinforced concrete:**

Up to 5% of the total weight of cementitious material was added in the form of glass fibres. The fibres are mixed with water and agitated until a mesh forms. This water is then used to make concrete.

4. TEST RESULTS

4.1 Compression test

After 7 days as well as after 28 days of cure, the cubes were evaluated for compressive strength.

Compressive strength: Compressive strength is the ability of a mass to resist loads, which causes it to shrink in size.

Figure 1: Compression Testing Machine

Table 1: Test Results for compression test

Sample No.	*Type of concrete*	*Curing period (Days)*	*Comp. stress*	*Mean*
1	ORD	7	17.679	16.889
2	ORD		15.757	
3	ORD		17.231	
1	GFRC	7	20.239	20.178
2	GFRC		19.925	
3	GFRC		20.372	
1	ORD	28	34.316	32.238
2	ORD		31.112	
3	ORD		31.287	
1	GFRC	28	42.658	41.9
2	GFRC		41.687	
3	GFRC		41.328	

ORD- Ordinary Concrete

GFRC- Glass Fibre Reinforced Concrete

4.2 Flexure Test (Static Bending Test)

Flexural strength: It is the tensile strength of concrete beams that is measured accordingly. It represents the resistance of the beams under bending situations.

Figure 2: 4 Point Flexure Testing Machine

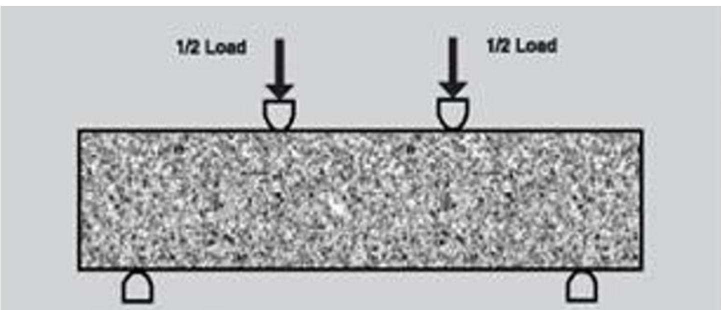


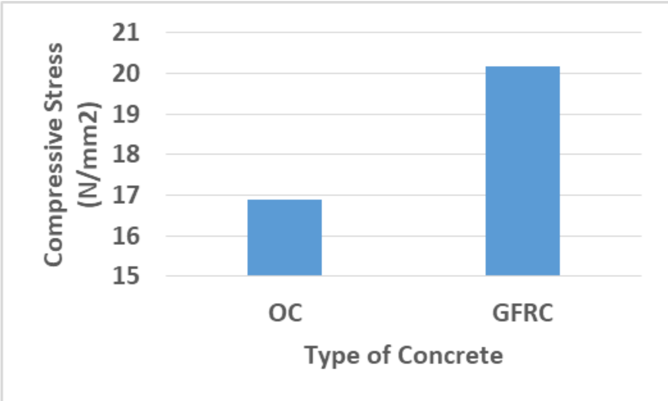
Figure 3: Graphical representation of Loading

Table 2: Test results for 4 point flexure test

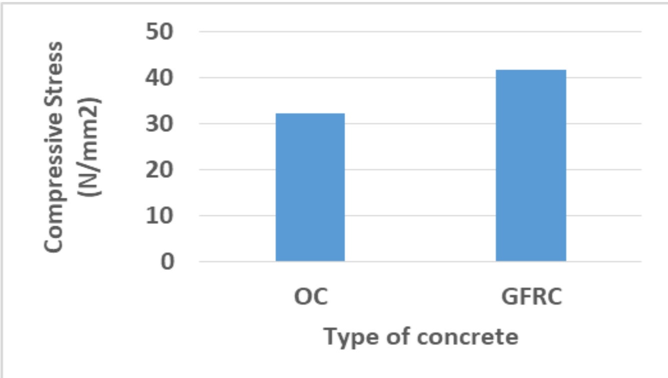
Type of reinforcement	Type of concrete	Cracking load	Ultimate load
STEEL	NORMAL	52	150
STEEL	GFRC	58	124
GFRP	GFRC	68	186
GFRP	NORMAL	48	218

5. GRAPHS

5.1 Compressive stress at 7 days curing period:



5.2 Compressive stress at 28 days curing period:



6. CONCLUSIONS

6.1 Glass Fibre Reinforced concrete:

- Glass fibres in concrete were examined for bleeding .
- The 7-day compressive strength as well as the 28-day compressive strength enhanced sufficiently.
- The concrete's voids were also decreased..
- Concrete's tensile strength improves as a result of mesh development.
- Glass fibres prevent concrete cracks from shrinking.
- The water-to-cement ratio falls drastically.

- Air entrainment is drastically decreased.

6.2 Glass Fibre Reinforced Polymer Bars

- There was no rust found upon it.
- This material is chemically stable.
- Tensile strength is enhanced.
- Being light in weight in nature.
- In comparison to conventional reinforcement, the ultimate load was extremely high.
- There was more allowable deflection observed.
- Flexural strength, and also shear strength and bending moment resisting capacity, are all improved.

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