

Glass Fibre Reinforcements in Concrete

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Abstract: Concrete is the most primarily used material in the construction field followed by steel as reinforcements. The present day scenario is witnessing a fast change in the building material industry and day by day new technologies are replacing the conventionally used materials. Researchers all over the world are working hard to improve concrete by the use of fibres, pozzolanas and other admixtures. Steel is provided in the compression side primarily so as to counter act the weak zone of concrete that is Tension. Though it is considered to be the best for this work but still it gets corroded by the action of the nature thus, arises the topic of looking for a alternative. One of the most common alternatives is Fibre reinforced polymer rebars (FRP's). In the present experimental investigation two processes are combined (I) replacement of Ordinary Concrete with Glass fibre Reinforced Concrete and (II) replacement of ordinary steel rebars with Glass fibre polymer rebars(GFRP's) and thus studied on the changes of Compressive Strength and Ultimate Crushing loads.

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

1. Introduction

Concrete is on the most commonly used building material. It is basically the foundation of real estate and infra industry. It has various strengths such as high compressive strength, stiffness, temperature endurance and durability. It can be easily casted when and where required and also its raw materials are easily available. On the other hand it is brittle and weak in tension which is considered to be the shortcomings of the concrete. Though generally Reinforcements are used concrete that is the concrete is reinforced by steel in the tension region in order to increase its strengths in tension.

1.1 Glass Fibre Reinforced Concrete (GFRC)

Fibre Reinforced Concrete is a concrete made in the same manner as the ordinary concrete but it contains fibre material which is spread evenly in the complete concrete mix. Alkali resistant fibres are most commonly used for GFRC. It is a new technology. It is basically added in to water used for making the mix. Once the fibre is properly spread it forms a mesh like network. This forms a matrix of evenly mixed fibres forming a random distribution of fibres having high tensile strength. Due to this mesh the cracking strengths of the concrete increases and thus the fibres acts as crack arresters.



Figure 1: Glass fibres 12 mm long

Various percentages of fibre content in the concrete had been studied on lately and it was observed that more the fibre content more will be the cracking and tensile strengths.

Generally 5 % fibre content is used, that is 5% of the weight of total cementitious material. Glass fibres are produced in process in which the molten glass is drawn into the this fibres. The molten glass is drawn into thin filaments with are later cut into 12 mm and 6 mm fibre which are then used in the GFRC.

1.2 Glass Fibre Reinforced Polymers (GFRP):

Steel bars are the commonly used reinforcements in the RCC. They are cost efficient and effective only if they are not subjected to chloride ion attack and other attacks of nature. They are subjected to oxidation when exposed to moisture and other chemicals. When such corrosion occurs the volume of the bar increases up to 2 to 5 times, as the concrete cannot withstand this tensile stresses it cracks ultimately causing failure. Thus, this deterioration and loss leads to steel replacement which is expensive and not feasible. The advantageous property of GFRP like high resistance to corrosion and other chemical agents, high tensile strengths and fatigue resistance have grabbed the attention of the engineers.

The GFRP rebar have high tensile strength and are extremely resistant to natural and chemical agents. There strengths are reliable and repeatable and thus, it is comparable to steel bars. The beams having GFRP bars as shear reinforcement are able to withstand more shear strengths and thus it is comparable to steel bars.

The GFRP bars are brittle in nature thus there stress-strain graph shows immediate failure but the beams casted using GFRP bars do not fail suddenly thus it is safe and gives proper warning before collapsing. Still to avoid catastrophic failures GFRP beams are designed using working stress method.

They are available in various sizes just like steel bars from 12 mm to 40 mm dia.



Figure 2: Glass fibre reinforced concrete

2. Technical Specifications

2.1 Glass Fibres

- Filament diameter - 14 μ
- Specific gravity- 2.6
- Length- 12mm
- Density(t/m³)- 2.6
- 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
- Inner Dia 0.0000 mm
- Outer Dia 16.0000 mm.
- Area 201.1392 mm²
- Maximum Load 141.831 kN
- Strain 5.000 %
- U.T.S. Value 705.139 N / mm²
- Mod. of Elasticity 46620.000 N / mm²
- 0.2% Proof Load 94.420 kN
- Stress @ 0.2% Prf. Load 469.430 N I mm²
- Yield Load 19.966 kN
- Yield Stress 99.263 N/mm²

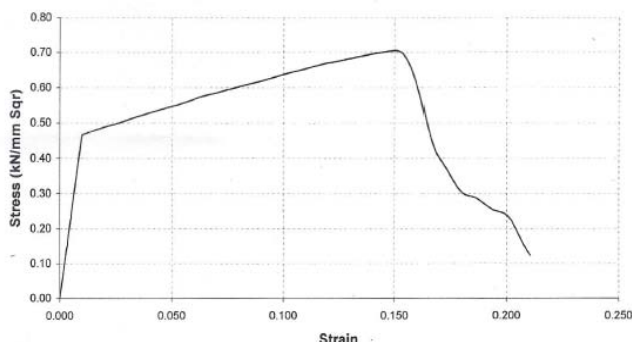


Figure 3: Stress-Strain graph of GFRP

3. Methodology For Experimentation

3.1 Testing of material

All the materials such as course aggregates, fine aggregates and cement were tested for their specific gravity.

- Specific gravity of cement- 2.2
- Specific gravity of fine aggregate- 2.8
- Specific gravity of course aggregate- 2.54

3.2 Casting of beam and cubes

Beams and cubes are casted from the same concrete mix so that the results obtained are comparable. The moulds used to cast beams are of size 2000*260*240 mm in dimensions. And the moulds for cubes are 150*150*150mm in dimensions. The beams were reinforced with 16mm main reinforcement and 8 mm hanger bars are provided to facilitate the erection process.

4 beams and total 12 cubes were casted, 6 cubes from the normal concrete and 6 cubes from glass fibre reinforced concrete. Out this half were used for 7 day testing and half for 28 days testing. The beams were checked after 28 days of proper curing.

3.2.1 Different types of Beams

Four different types of test beams were casted so as to study all the types of combinations possible with the available material. The different cases were:

- Plain concrete with Steel rebars (Beam1)
- Glass fibre reinforced concrete with steel rebars (Beam2)

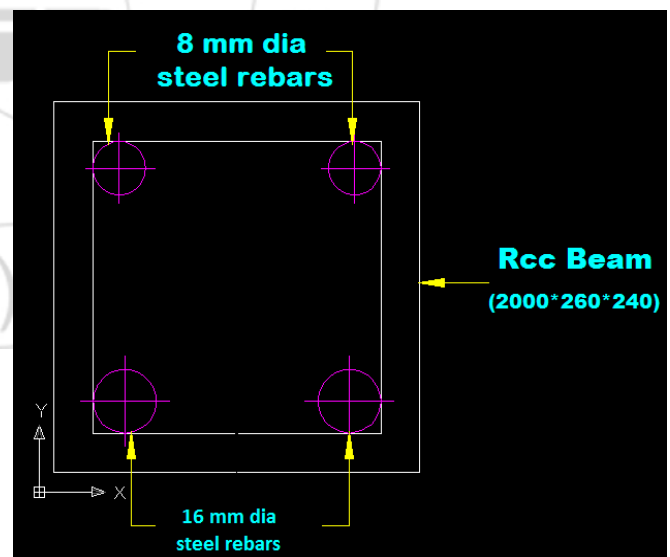


Figure 4: Drawing of r/f provided in beam 1&2

- Plain concrete with glass fibre reinforced polymer rebars (Beam3)
- Glass fibre reinforced concrete with glass fibre reinforced polymer rebars (Beam4)

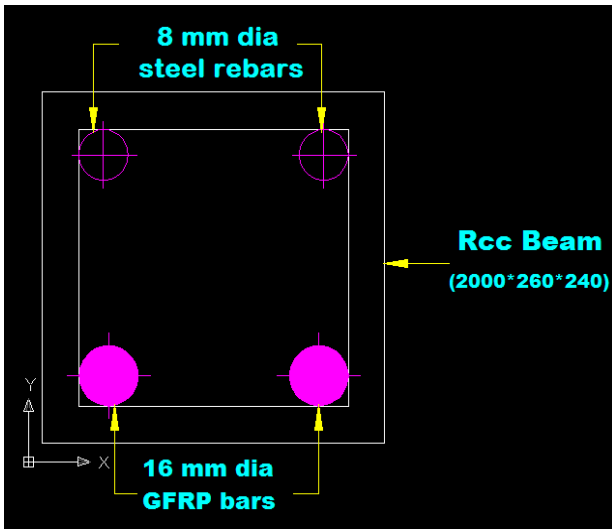


Figure 5: Drawing of r/f provided in beam 1&2



Figure 7: Glass fibre forming mesh when added to water

3.2.2 Types of concrete

- **Ordinary concrete**

Standard mix design for M25 was properly designed according to IS10262:2009 and was further adjusted according to prevailing moisture content of the raw material batch.

Description	Units	CA1	CA2	FA	Water	Cement	Remarks
Wt. of wet sample	Gms.	1000	1000	1000			
Wt. of dried Sample	Gms.	994	995	955			
Wt. of Moisture	%	6	5	45			
Moisture	%	0.60	0.50	4.71			
Absorption	%	0.32	0.34	0.66			
Free Moisture	%	0.28	0.16	4.05			
Batch Wt.	Kgs.	215	92	188	40	85	
Free Moisture	Kgs.	0.61	0.15	7.62	8.38		
Adjusted Wt.	Kgs.	215.61	92.15	195.62	31.62	85	
Wt. Adopted	Kgs.	216	92	196	32	85	

Figure 6: Parameters used in the mix design

- **Glass fibre reinforced concrete:**

Glass fibres are added up to 5% of the total weight of cementitious material. The fibres are mixed with water and stirred till the form a mesh like look. Later this water is used in making concrete.

4. Test Results

4.1 Compression test

The cubes were tested for their compressive strength after 7 days and also after 28 days of curing.

Compressive strength: it is that strengths which enables a mass to resist the loads tending to reduce sizes.



Figure 8: Compression Testing Machine

Table 1: Test Results for compression test

Sample No.	Type	Days	Ultimate Load (KN)	Comp. Stre. (N/mm ²)	Mean
1	ORD	7	398	17.689	
2	ORD	7	357	15.867	16.8
3	ORD	7	385	17.111	
1	GFRC	7	452	20.089	
2	GFRC	7	448	19.911	20.1
3	GFRC	7	461	20.489	
1	ORD	28	771.3	34.280	
2	ORD	28	697.6	31.004	32.2
3	ORD	28	704.3	31.302	
1	GFRC	28	962.9	42.796	
2	GFRC	28	934.6	41.538	41.8
3	GFRC	28	927.2	41.209	

ORD- Ordinary Concrete

GFRC- Glass Fibre Reinforced Concrete

4.2 Flexure Test (Static Bending Test)



Figure 9: 4 Point Flexure Testing Machine

Flexural strength: it is the measure of a tensile strength of the concrete beam. It tells us the resistance offered by the beam under bending conditions.

The RCC beams were properly cured for 28 days before being tested upon the 4 point flexure test machine. The beam was subjected to 2 loadings from the upper end at distance of L/4. L/4 distance is used for this purpose so that true flexural strength can be obtained and rotational torque can be avoided.

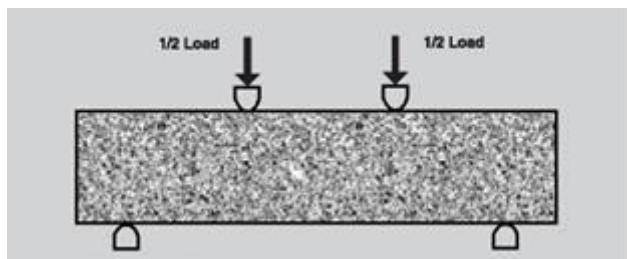


Figure 10: Graphical representation of Loading

Table 2: Test results for 4 point flexure test

Type of reinforcement	Type of concrete	Cracking load	Ultimate load
STEEL	NORMAL	50	145
STEEL	GFRC	55	120
GFRP	GFRC	66	199
GFRP	NORMAL	45	212

5. Observations

5.1 Glass Fibre Reinforced concrete:

- Glass fibres checked on the bleeding in concrete.
- The 7 day compressive strength and also the 28 day compressive strength increased by an adequate amount.
- The voids in the concrete were reduced.
- The tensile strength of concrete also increases due to mesh formation.
- Glass fibres prevent shrinkage cracks.
- Water-cement ratio decreases.
- Air entrainment decreases.
- First cracking load is high in case of beams.

5.2 Glass Fibre Reinforced Polymer Bars

- No rust was found
- Chemically stable material.
- Tensile strength considerable increased
- Light weight in nature.
- Ultimate load was very high as compared to conventional reinforcement.
- More allowable deflection.
- Not only flexural strength is increased but also shear capacity and bending moment resisting capacity increases.



Figure 11: 15mm crack termed as first crack

6. Future Aspects

- GFRP can be easily used as a replacement of steel reinforcements.
- GFRC claddings are very famous these days.
- GFRC cladding n designs can be easily repaired and replaced
- Hollow GFRP bars can be used to transmit oil
- GFRP bars can also be used as cooling ducts if required.
- Since being resistant to chemicals and nature's effect they are active replacements
- Sewer pipe lines can be designed and casted using both GFRC and GFRP
- High strength concrete can be worked upon and mixed with GFRC to bring about drastic change in the compressive strength.

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