Flexural Behaviour of Concrete Beams with Glass Fiber Reinforced Polymer Rods

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***Abstract* - The objective of this study is to present the effectiveness of usage glass fiber reinforced polymer GFRP as reinforcement bars in concrete beams. The GFRP reinforced beams indicated higher ductility than the steel reinforced beams. GFRP bars due to their excellent corrosion resistance, high tensile strength, and good non magnetic properties have been proposed for reinforcing concrete structures instead of traditional steel. Therefore, four beams are casted by M30 concrete. The GFRP provided as main reinforcement and HYSD bars provided as hanger bars for two beams. And the GFRP provided as main reinforcement and also hanger bars for next two beams. Analyze and calculate the load and deflection for casted beams. The beams are casted by M30 concrete and investigation for M30 grade of concrete having mix proportion 1:2.03:2.96 with water cement ratio 0.45 to study the compressive strength, flexural strength, split tensile strength. Result data clearly shows the 7 days and 28 days compressive strength, split tensile strength, flexural strength for M30 concrete.**

Keywords - GFRP, Flexural Strength, Compressive Strength, Split Tensile Strength &Deflection

1. INTRODUCTION

1.1 FRP Reinforcements

Fibre reinforced polymers used as an alternative reinforcement material to steel for new construction. It is used for strengthening and repairing of existing concrete structures. Fiber reinforced polymer sheets and strips are most commonly used techniques. And this is also used for currently flexural and shear strengthening of concrete beams, slabs and columns. Externally bonded fiber polymer reinforcements are high susceptible to damage from fire and temperature, ultraviolet rays, and moisture absorption, collision.

Insufficient protection may reduce the life and durability of the structure.

For structural application, we can use as FRP in two ways.

- First ways FRP used as a sheet or plate which is to strengthen damage structural member by application of FRP. Retrofitting and strengthening structure member such as beam, column and slab used with external application of FRP are one of the effective method use over a world.
- Second way FRP used as bars in reinforced concrete member instead of steel bar.

1.2 Flexural Strength

Flexural strength is known as fracture strength and modulus of rigidity and also known as bends strength. Flexural strength is a material property. In a flexure test, it is defined as the stress in a material before it yields. The transverse bending test is most frequently used to flexural strength. Which a specimen can either a circular or rectangular cross-section. In three point flexural test technique, the specimen is bent until fracture or yielding. The material at its moment of rupture, the flexural Strength represents the highest stress experienced.

1.3 Glass Fiber

The filaments are converted into larger diameter threads are called as Roving process. These threads are used for woven reinforcing glass mats and fabrics. It is also commonly used in spray applications. Fiber fabrics are fabric reinforcing material in web form that have both warped and also in weft directions. Mats are manufactured with chopped fibers in cut direction and in continuous mats, these are using continuous fibers.

The lengths of glass threads are lies between 3 and 26 mm. It is used in plastics and most commonly used for moulding processes. Glass fiber short strands are short between 0.2–0.3 mm. The strands of glass fibers that are used to reinforced thermoplastics. And it is most commonly used for injection molding.

2. EXPERIMENTAL RESULTS

2.1 Cement

Ordinary Portland cement (OPC) of grade Conforming IS 12269-1987 shown in Table 2.1.

Physical Property	Results
Finess	91%
Normal Consistency	31%
Vicat initial setting time (minutes)	32 min
Vicat final setting time (minutes)	565 min
Specific gravity	3.1

Table 2.1 Properties of Cement

2.2 Fine Aggregate

The properties of Fine aggregate are given in below Table 2.2.

2.3 Coarse Aggregate

The properties of coarse aggregate are given in below Table 2.3.

S.no	Property	Results
1	Particle size, shape	Round , 4.75mm down
2	Fineness Modulus	4.14%
3	Silt content	1.67%
4	Specific Gravity	2.73
5	Bulking of Sand	4.16%
6	Bulk Density	1793 Kg/m^3
7	Water absorption	0.28

Table 2.2 Properties of Fine aggregate

S.no	Property	Results
1	Particle size, shape	Angular, 12mm
2	Fineness Modulus of 20mm Aggregates	7.13%
3	Specific Gravity	2.66
4	Water Absorption	0.62%
5	Bulk Density of 20mm Aggregates	1497 Kg/m^3
6	Flakiness index	21.16%
7	Elongation index	38.22%

Table 2.3 Properties of coarse aggregate

2.4 High Yield Strength Deformed Bars

The properties of HYSD bars were given in Table 2.4.

S.no	Property	Results
1	Diameter	12 mm
2	Area	113 mm^2
3	Load For Yield	48.8 KN
4	Yield Strength	431.4 N/mm^2
5	Ultimate Load	64.8 KN
6	Ultimate Stress	573.5 N/mm^2
7	Changing Length	86mm
8	Original Length	600mm
9	Strain	0.14
10	Neck dia	7mm
11	%reduction in area	65.9%
12	% of Elongation	14%

Table 2.4 Properties of HYSD bars

2.5 Glass Fiber Reinforced Polymer Bars

The properties of HYSD bars were given in Table 2.5.

S.no	Property	Results
1	Diameter	12 mm
2	Area	113 mm^2
3	Load For Yield	52.7 KN
4	Yield Strength	466 N/mm^2
5	Ultimate Load	72.5 KN
6	Ultimate Stress	642 N/mm^2
7	Change in Length	62mm
8	Original Length	600mm
9	Strain	0.10
10	Neck dia	8mm
11	%reduction in area	55.52%
12	% of Elongation	10%

Table 2.5 Properties of GFRP bars

2.6 Tests of Concrete

Tests of concrete are

1. Compressive strength test
2. Flexural strength test
3. Split tensile strength test

2.6.1 Compressive Strength Test

7 days and 28 days compressive strength Was given in Table 2.6.

S.NO	Load (KN)	7 Days (N/mm^2)	Load (KN)	28 Days (N/mm^2)
1	466	20.71	730	32.44
2	474	21.06	662	29.4
3	458	20.35	680	30.22

Table 2.6 Compressive strength test

2.6.2 Split Tensile Strength Test

28 days Split tensile strength was given in Table 2.7.

S.NO	Load (KN)	28 Days
1	171	2.42
2	157	2.22
3	166	2.35

Table 2.7 Split tensile strength test

Fig 2.1 Compression test for first specimen

Fig 2.2 Compression test for second specimen

2.6.3 Flexural Strength Test

Flexural strength was given in Table 2.8.

Days	Flexural Strength(N/mm2)
28 Days	2.8

Table 2.7 Flexural strength test

Fig 2.3 Split tensile test for first specimen

Fig 2.4 Split tensile test for first specimen

Fig 2.5 Specimen arrangement for Flexural strength test

Fig 2.6 Flexural strength test

3. Design Of Beam

Total length of the beam is 1500 mm with a rectangular cross section of width 150 mm and depth 200 mm. The beams design is based on IS456. 4 Nos of 12 mm dia bars provided as main reinforcement and 2 Nos of 10 mm dia bars provided as Hanger bars. The stirrups are provided at 125 mm C/C distance. The using grade of concrete is M30 and the grade of steel is fy 500.

4. Experimental Set Up

The deep beams to be tested were placed in the loading frame of capacity 10 tons under two point loading and test set is shown in figure. The end condition of the beam was kept as a simply supported. The load cell was placed in the centre of the beam. Finding the deflection under the one third loading points, the deflectometers were

Placed and dial gauge was placed in the centre of the beam measure the mid deflection.

5. Results And Discussion

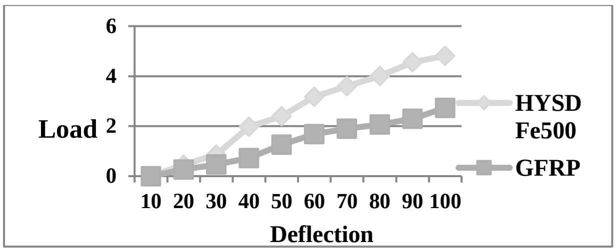
Based on the experimental studies conducted on beam reinforced with High yield strength deformed bars and Glass fiber reinforced bars. The following observations can be summarized. It is observed in beam with Glass fiber reinforced bars has a lesser deflection than the normal Fe 415 High yield strength bars. The maximum load has given that is 100 KN for both beams. The two point under loading condition is to be applied.

The load deflection values of both the beams were recorded. The mid span deflection of beam was compared with that of their respective control beams. It was noted that the behaviour of the flexure deficient beam when bonded with GFRP were better than the corresponding control beams. The use of GFRP rods had effect in delaying the growth of crack formation.

The comparison between glass fibre reinforced polymer bars and high yield strength deformed bars were given in Table 2.8.

Load	Deflection (mm)	
	HYSD Fe500	GFRP
10	0	0
20	0.45	0.26
30	0.87	0.47
40	1.98	0.73
50	2.4	1.26
60	3.18	1.68
70	3.6	1.9
80	4.01	2.06
90	4.56	2.3
100	4.81	2.73

Table 5.1 Load and deflection values for HYSD and GFRP bars



Graph 5.1 Load and Deflection curve

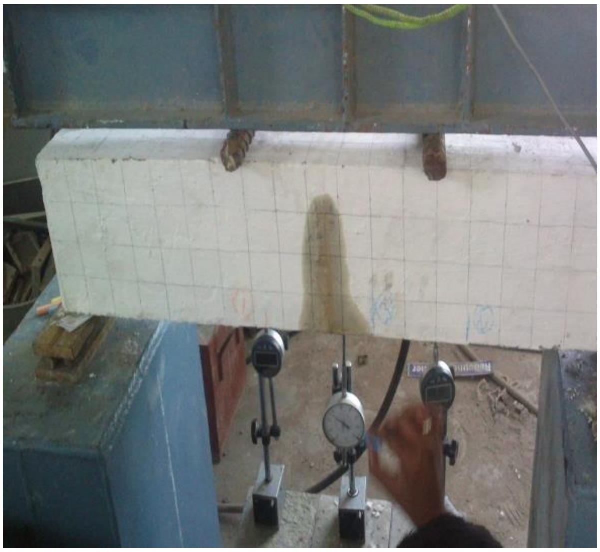


Fig 5.1 Beam arrangement for load deflection test

CONCLUSION

1. Basic properties of cement Fine aggregate, Coarse aggregate and GFRP bars were tested and the values were discussed.
2. In cement, finess, normal consistency, initial setting time, final setting time and specific gravity tests were conducted and the results of tests were adequate.
3. In fine aggregate, finess modulus, specific gravity, bulk density, bulking sand, silt content and water absorption tests were conducted and the results of tests were adequate.
4. In fine aggregate, finess modulus, specific gravity, bulk density, bulking sand, water absorption, flakiness index, elongation index and angularity number tests were conducted and the results of tests were adequate.
5. In concrete, cubes, cylinders ad prisms were casted and compressive strength, tensile strength and flexural strength were calculated.
6. GFRP bars tensile strength was calculated by UTM machine. GFRP bars tensile strength more than the HYSD bars. Poisson's ratio and tensile modulus values are within the permissible limits.
7. Deflection values are low for Glass Fiber reinforced polymer bars compared to normal High Yield strength bars of Grade 500 depends upon the Load by using loading frame machine.
8. 7 days and 28 days strength were calculated and compared the strengthened beams. GFRP reinforced beams have more strength than HYSD reinforced beams.

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