Flexural Behaviour of Hybrid Reinforcement By Using GFRP

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Abstract- *This investigation deals with the flexural strength behaviour between conventional reinforced concrete members and hybrid reinforcement of concrete members prepared by coating of glass fibre reinforced polymers (GFRP) on steel reinforcement. For testing purpose, We made a reinforced concrete specimen and a hybrid reinforced GFRP specimen having a size 150mmX150mmX1000mm. The concrete prism specimen tested in loading frame assembly for maximum load carrying capacity and deformation under a certain age limit of 7 days, 14 days and 28 days. The members are prepared by using concrete grade of* M_{30} *and steel grade of Fe 415. the members are designed as per limit state design method. The adding of GFRP will gives the concrete to be non -corrosive, high strength and light weight.*

Keywords- Concrete; Hybrid reinforcements with GFRP; Beams; Flexure; Corrosion.

I. INTRODUCTION

Corrosion of the steel reinforcement in a cold and saline environment leads to the overall deterioration of reinforced concrete structures. To avoid such deterioration, fiber-reinforced polymers (FRP) rebars are used in place of steel reinforcement. The physical properties of FRP are to resist the corrosion but it as brittle in nature. To overcome this problem the new hybrid bars has been introduced.

Harry G. Harriset.al.,1998[6] reported experimental investigation that the creation of a hybrid composite by combining two or more different reinforcing fibers to produce a bilinear ductile stress-strain behavior however such efforts have thus far resulted in limited practical developments. It describes the ductile behavior of beams reinforced with the new FRP and with steel bars.D. A. Bournas et.al. 2011[4] investigated the old-type reinforced concrete (RC) columns confined with composite material [fiber-reinforced polymer (FRP). The interaction between jacket (or concrete cover for unconfined concrete) and embedded longitudinal reinforcement of bar buckling was determined through strain measurements of the compression reinforcement. Based on the experimental investigations, the postbuckling behavior of columns was related to the stiffness. Angelo D'Ambrisi et.al. 2011[1] reported that the previous decade, fiber-reinforced polymers (FRP) have been widely used to improve the capacity of flexural and shear of reinforced concrete (RC) beams and columns. The way in which the nature of fibers and matrices and the number of layer the strengthened can be controlled.

The effect of Hybrid Reinforcements System on the flexural capacity, crack width, strain curves was discussed. The results revealed that can increase the flexural capacity, durability, and first crack load, strain. This present paper presents that the hybrid reinforcements wrapped with GFRP are placed in tension zone.

II. METHODOLOGY

- Collection and of Materials
- Material Test
- Mix Design
- Beam Details
- Casting and curing of Specimens
- Testing Arrangement
- Results and Discussion
- Conclusion

2.1. Materials used

2.1.1. Aggregates and cement

Fine and coarse aggregates were used in this study. The fine aggregate was sieved using the 4.75 mm sieve to remove avoiding unwanted materials. The specific gravity of the fine grained aggregate was found to be 2.72 respectively IS383-1987[9]. Coarse aggregates with the maximum size of 20 mm, having a specific gravity of 2.60 are used. In this study the ultra tech cement of grade 33 has been used. The specific gravity was found to be 3.15.

2.1.2 REINFORCEMENT

The longitudinal reinforcements used were high-yield strength deformed bars of 10 mm diameter. The stirrups were made from TMT bars with 8 mm diameter. The yield strength of steel reinforcements is determined by standard tensile test of three specimens. The values are given in Table 1,

Table 1: Properties of TMT Bar

F_{max} [KN]	UTS [Mpa]	ELONGATION [%]	YIELD STRESS [Mpa]
50.99	645.57	19.80	548.96

2.1.3 HYBRID REINFORCEMENTS

The steel reinforcement of diameter 10mm is wrapped with bidirectional GFRP sheet at one layer. The diameter should be increased while wrapping .The yield strength of hybrid reinforcements was determined by standard tensile test, respectively from ACI 440.1R-06[2]. The values are given in Table 2,

Table 2: Physical Properties of TMT with Glass fiber

F_{max} [KN]	UTS [Mpa]	ELONGATION [%]	YIELD STRESS[Mpa]
52.32	662.47	2.32	544.91

2.2 SPECIMEN DETAILS

To achieve ductility in reinforcement concrete structures without using on conventional steel rebar, a new design methodology was introduced by the writers to identify suitable fiber composite material that mimic the stress-strain characteristic of steel. Taking advantage of the design flexibility and the wide availability of manufacturing capacity in the industry. The beams were reinforced Glass fibers with two numbers of 10 mm diameter bars at the bottom, and the two numbers of 10mm diameter HYSD bars at the top, with the 8mm diameter stirrups at 150mm center to center.. All beams were tested under the two-point loading. All tested beam had 150mm wide, 1000mm length, and 150mm thickness. The dimensions, reinforcement and details of supports common total slab.

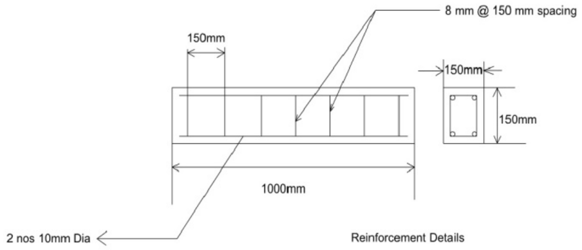

Figure 2: Longitudinal profile and cross section

2.3 BEAM CASTING AND CURING

The concrete is poured in the timber moulds of size 1000mmx150mmx150mm dampened properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water.

Figure 3: concrete in mould

Figure 4: curing of mould

2.3 TEST ARRANGEMENT

The beams were tested in the Loading Frame, 40 ton in capacity. All beams were tested up to ultimate load, under two-point loading over a simply supported. The load was applied in 1 ton increments until the yield of the tensile reinforcement. The beam was tested to failure by applying the load in increments, and the observations such as mid-span deflections at each load step, first crack load, and ultimate load, were carefully recorded.

Figure 5: Test Setup

III. RESULTS AND DISCUSION

3.1 Mechanical Properties

The average compressive strength, split tensile test of M_{30} grade concrete at 28 days resulted to 25N/mm^2, 2.32N/mm^2, respectively.

3.2 First Crack and Ultimate Load

It can be observed that all beams exhibited some delay in the formation of first crack, when compared to that of the control beam. It can be seen that in both groups of beams, the beams with GFRP wrapping exhibits the maximum load carrying capacity when compared to other beams. This shows that the ultimate load carrying capacity increases with the number of GFRP layers.

Table 3: First Crack and Ultimate Load

Beam ID	First crack load [kN]	Deflection at first crack load [mm]	Ultimate load [kN]	Deflection at ultimate load [mm]
Control 1	1.50	1.4	5.56	13.9
Control 2	1.5	2.0	6.08	12.2
Control 3	1.40	1.6	4.13	10.6
A1	1.45	1.9	5.05	11.3
A2	1.5	1.0	8.67	14.2
A3	3.04	2.4	8.83	15.2

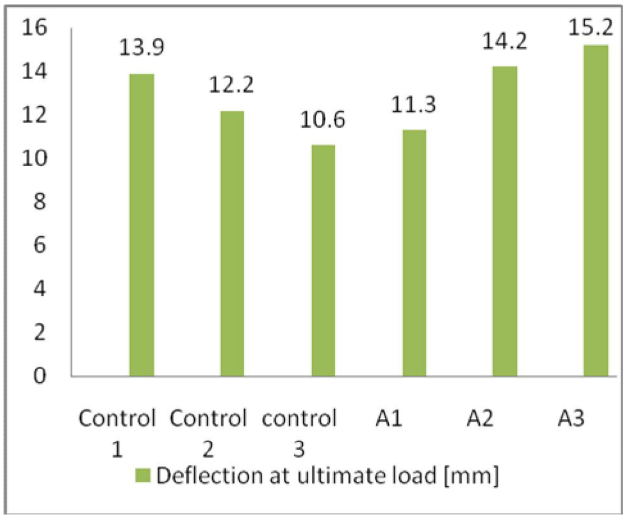

Figure 6: Deflection at Ultimate Load

3.3 FLEXURAL STRENGTH TEST RESULTS

The load deflection response of the Group A beams is compared with that of the control beams. The load deflection response of the A1, A2, and A3 beams, along with the response of the control beam.

Table 4: FLEXURAL STRENGTH TEST RESULTS

S. No	Type of Specimen	Size of Beam (mm)	Flexural Strength (N/mm^2)		
			7 Days	14 Days	28 Days
1	Conventional Reinforced Concrete	1000x150x 150	2.98	5.75	8.62
2	GFRP Reinforced Concrete	1000x150x 150	6.88	8.62	11.68

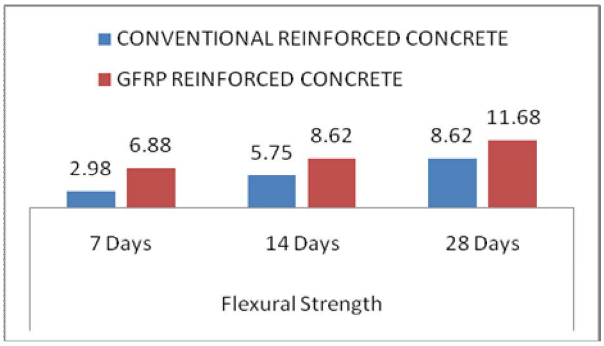

Figure 7: flexural strength

3.4 Failure Modes

All beams are tested until failure so that the data can be acquired about the influence of wrapped GFRP fiber on the flexural behavior of reinforced concrete beams. The control beam failed in flexure, while the behavior of failure is ductile. All the same value of applied load, all strengthened beams exhibited smaller mid-span deflections, compared to the corresponding control beam. This mode of failure was not prevented even if more than one layer was used. Cracks that occurred are smaller and more evenly distributed in both beams group tested.

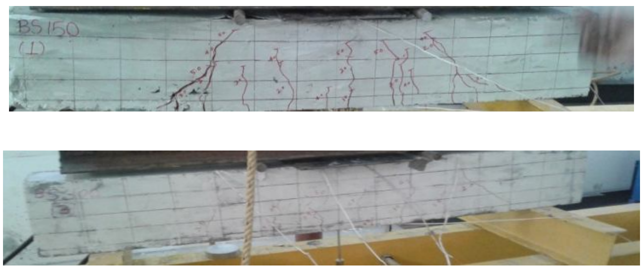

Figure 8: conventional beam & A1 Beam

IV. CONCLUSIONS

Based on the experimental investigation described in this study, the following conclusions are drawn:

- Based on the experimental investigation described in this study, the following conclusions are drawn:
- In the case of hybrid reinforcement concrete members gives high Ultimate Load carrying capacity, and gives less deflection when compared to the control beam specimen.
- The load carrying capacity of GFRP beam member increases 2.70% more than the conventional beam RC member at an age of 28 days.
- The flexural strength of GFRP beam member increases 26.80% more than the conventional beam RC member at an age of 28 days.
- The deflection of GFRP beams member's decreases 87% lesser than conventional RC beam member. And it gives lesser deformation of member and resists live load of the structure.

REFERENCES

[1] Angelo D'Ambrisi et.al, (2011), "Flexural Strengthening of RC Beams with Cement-Based Composites", Journal of Composites for Construction, Vol.15, No.5.

[2] ACI 440.1R-06" Guide for the design and construction of structural concrete reinforced with FRP bars".

[3] ChakibKassem et.al (2011),"Evaluation of Flexural Behavior and Serviceability Performance of Concrete Beams Reinforced with FRP Bars", Journal of composites for construction.,Vol.15, No.5.

[4] D.A.Bournas et.al (2011),"Bar Buckling in RC Columns Confined with Composite Materials", Journal of composites for construction, Vol.15, No.3.

[5] D.H. Deitz et.al (2003),"Physical Properties of Glass Fiber Reinforced Polymer Rebars in Compression", Journal of Composites for Construction,Vol.7, No.4.

[6] Harry G. Harris et.al, (1998),"New Ductile Hybrid FRP Reinforcing Bar For Concrete Structures", Journal Of Composites for Construction,Vol.2, No.1.

[7] IS 456:2000 "Code of practice for plain and reinforcement concrete", Bureau of Indian Standards, New Delhi.

[8] IS 10262:2009 "concrete mix proportioning", Bureau of Indian Standards, New Delhi.

[9] IS 383:1970 "Specification for coarse and fine aggregate from source for concrete" Bureau of Indian Standards, New Delhi.

[10] IS 2770-1(1967)"Methods of testing bond in reinforced concrete", Bureau of Indian Standards, New Delhi.

[11] Maurizio Guadagnini et.al, (2006),"Shear Resistance of FRP RC Beams: Experimental Study", Journal of Composites for Construction, Vol.10, No.6.

[12] Michele Theriault et.al (1998), "Effects of frp reinforcement ratio and concrete strength on flexural behavior of concrete beams", Journal of composites for construction, Vol.2, No1.

[13] N. B. Accord et.al (2006), "Use of Fiber-Reinforced Polymer Composite Elements to Enhance Structural Steel Member Ductility, "Journal of Composites for Construction, Vol.10, No.4.

[14] RonaldasJakubovskis et.al (2014)," Serviceability Analysis of Concrete Beams with Different Arrangements of GFRP Bars in the Tensile Zone", Journal of Composites for Construction.

[15] Taketo Uomoto, et.al, (2002), "Use of Fiber Reinforced Polymer Composites as Reinforcing Material for Concrete", Journal of Materials in Civil Engineering, Vol. 14, No.3.