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HYBRID REINFORCEMENT BY USING GFRP

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Abstract - *The steel reinforcements are corroded easily in saline and cold environment leads to deterioration of concrete structures. Hybrid reinforcements wrapping with glass fibers (GFRP) are used in steel reinforcements is to reduce the corrosion. In the present paper, test results of 8 concrete beams with reinforced with steel, GFRP rods and hybrid reinforcements, the stirrups are placed at different spacings of 150mm and 300mm. The use of hybrid reinforcements resulted in increasing the flexural behavior and corrosion resistance.*

***Key Words*: Concrete; Hybrid reinforcements with GFRP; Beams; Flexure; Strain; Corrosion.**

1. INTRODUCTION

Corrosion of the steel reinforcement in a cold and saline environment leads to the overall deterioration of reinforced concrete structures. To avoid this condition, 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 over the steel reinforcement.

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 post buckling 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 layers the strengthened can be controlled.

2. EXPERIMENTAL PROGRAM

2.1 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 avoid unwanted materials. The specific gravity of the fine grained aggregate was found to be 2.60 respectively IS383-1987[9]. Coarse aggregates with the maximum size of 20 mm, having a specific gravity of 2.80 are used. In this study the Portland pozzolanic cement of grade 53 has been used. The specific gravity was found to be 3.11.

2.2 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.

Table -1: Properties of TMT Bar

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

2.3 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: Properties of TMT Bar With GFRP

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

2.4 Epoxy Resin

The properties of Epoxy Resins are relatively low molecular weight capable of being under a variety conditions. The well cured resins have high chemical, corrosion resistance good mechanical and thermal properties. The properties of epoxy are given in Table 3,

Table -3: Properties of Epoxy Resins

PROPERTY	EPOXY
Viscosity at 250^{0}c	12600
Density	1.16

3. SPECIMEN DETAILS

A total of 8 beams were casted and tested until failure. The beams were divided into two groups, viz, GROUP A and GROUP B, based on the type of reinforcing layer. The Group A consisted of 2 beams which were GFRP bars at different spacings of 150 and 300mm. The Group B consisted of another 4 beams wrapped with GFRP sheet at different lengths and spacings viz, 400mm,800mm and 1400mm and spacings at 150mm and 300mm. In addition to this, 19 cubes measuring 150mmx150mmx150mm,3 cylinder of 150mm in diameter and 300mm in height, were also cast and tested in order to find the compressive strength, and split tensile strength. The split tensile strength of concrete was determined using cylinder specimens. For ease identification, the beams with GFRP bars were named as A1,A2 and the beams with hybrid reinforcements were named as B1,B2,B3,B4. The control beam with steel reinforcements was designed, which is common for both groups. The glass fiber is wrapped with one layer above the steel reinforcements. The beam geometry is shown in Figure 2. The beams were reinforced Glass fibers with two numbers of 10mm diameter bars at the bottom, and the two numbers of 10mm diameter HYSD bars at the top, with the 8mm diameter stirrups at 150mm and 300mm center to center. The beams are mounted with strain gauges, the three strain

All beams were tested under the two-point loading, with a support to support distance of 1.3m. The loads were applied 500mm away from each support of the beam.

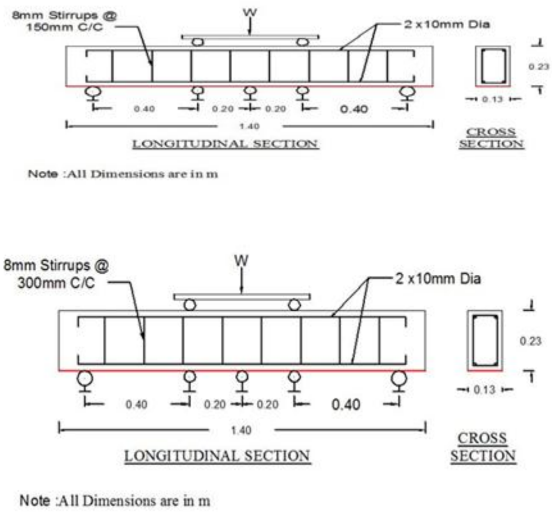

Fig -1: Longitudinal Profile and Cross sections

3.1 Test Arrangement

The beams were tested in the Loading Frame, in Figure 3, 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.

Fig -2: Test Arrangements

Table -3: Types of Reinforcements

Beam ID	Type Of Reinforcements	Spacings of strippus
A1	BG150	150
A2	BG300	300
B1	400mm wrapped with GFRP	150
B2	800mm wrapped with GFRP	150
B3	1400mm wrapped with GFRP	150
B4	1400mm wrapped with GFRP	300

4. TEST RESULT AND DISSCUSSION

The load deflection response of the Group A beams is compared with that of the control beams in Figure 5. The load deflection response of the Group B beams, along with the response of the control beam in Figure 6,

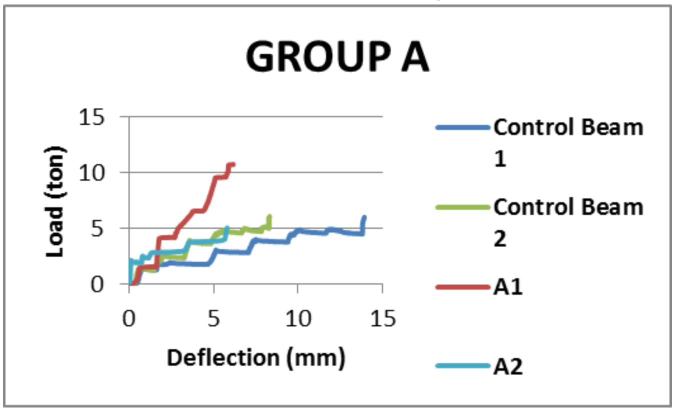

Chart -1: Load Vs Deflection for Group A

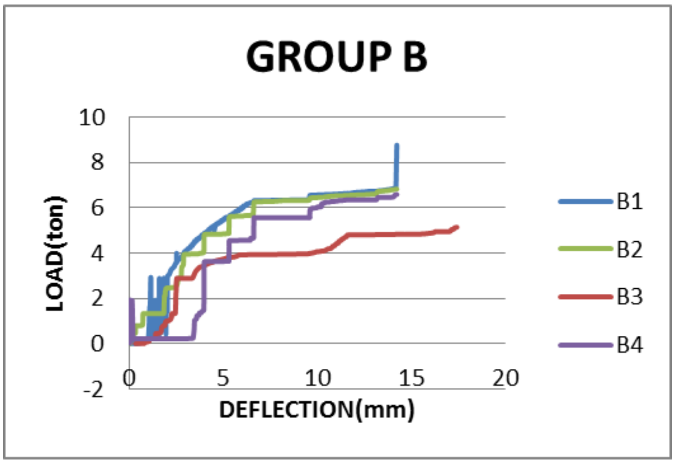

Chart -2: : Load Vs Deflection for Group B Behaviour

4.1 Test Results

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. The beam carried practically no load after failure. All the same value of applied load, all strengthened beams exhibited smaller mid-span deflections, compared to the corresponding control beam.

Table -4: Test Summary

Beam ID	First crack load [Ton]	Deflection at first crack load [mm]	Ultimate load [Ton]	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
A1	1.40	1.6	4.13	10.6
A2	1.45	1.9	5.05	11.3
B1	1.5	1.0	8.67	14.2
B2	3.04	2.4	8.83	15.2
B3	2.02	2.8	5.15	17.4
B4	1.75	2.9	6.53	18.8

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