Comparative study of flexural strength of GFRP Reinforced beam with Steel Reinforced beam

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***Abstract*- Steel being widely used material used to take tension in RCC. But the fact that it corrodes with time, and the structure gets deteriorated slowly. The aggressive environment faced by the structures like marine structure, chemical plants and waste water treatment facilities etc are susceptible to corrosion and increased volume of steel leads to cracking and spalling of concrete. Which increases the repair and maintence cost of structure to great extent. Glass Fibre Reinforced Polymer (GFRP) rebars have came out be as the alternative to steel. Various countries uses GFRP Bars as alternative to steel, and it has proved to be successful. In this paper we have studied the comparative study of both Steel and GFRP reinforced beams. Six beams of GFRP reinforced and six beams of Steel reinforced with steel being the shear reinforcement in all beams were taken, and tested for flexure, the result and conclusion of the test is tabulated below.**

***Index Terms*- Glass Fibre reinforced Polymer GFRP, Flexural strength, Tensile strength.**

1. INTRODUCTION

The corrosion problem occurs in the structures located in aggressive environments such as coastal and marine structures, chemical plants, water and wastewater treatment facilities and bridges. Corrosion of reinforcements can result in costly repairs and safety hazards. Rust from the corroded bar takes large volume than the iron from which it formed, resulting in expansive forces cracking and spalling of concrete and ultimately the failure of structure.

Millions of rupees are spent every year to replace or repair concrete structures that are deteriorated due to the corrosive effect of salt. This problem is more serious in cold climate countries, where de-icing salts accelerate the deterioration. Reported figures to repair and maintain concrete structures deteriorated by corrosion of reinforcements are horrible. The eighth annual report of the Secretary of Transportation to the Congress of the USA reported that 40% of the 575,607 inventoried highway bridges are either structurally or functionally deficient. In Quebec (Canada) half of the maintenance budget of the Ministry of Transports is spent in repairing the concrete structures damaged by corrosion of steel. Within Europe the annual cost of corrosion has been estimated to be 1000 million pounds per year.

In areas where low electric conductivity or electromagnetic neutrality is needed, use of steel as reinforcement results in complex construction layout. Some possible areas are structures supporting electronic equipment such as transmission towers, airport control towers, hospitals, and military structures (invisibility to radar). In above structures, other suitable material can replace steel to avoid health hazard or to protect electronic equipment.

Hence, GFRP can be proved to be good alternative to steel, which is anti rust as well as have good tensile strength.

II. OBJECTIVES

1. Better cost-effective materials are needed to maintain and improve the infrastructure.
2. To study and compare the flexural behavior of GFRP reinforced concrete beams, with Steel reinforced beams with a focus on evaluating current design code provisions relating to design with GFRP.
3. Alternatives to steels and alloys to combat the high costs of repair and maintenance of structures damaged by corrosion and heavy use.

III. UNITS

All the units given in this paper are mentioned next to the given parameter.

Load (KN), Deflection (mm), Bending Moment (KN.m), Compressive strength (MPa / N/mm^2), Modulus of Elasticity of GFRP bar (GPA), etc

IV. MIX DESIGN OF M30 CONCRETE

1. Water - 145.3 kg
2. Cement - 330 Kg
3. Fine Aggregates - 830 kg
4. Coarse Aggregates

A. 10 mm - 700 kg
B. 20 mm - 396 kg
M30 ratio is 0.44 : 1 : 2.5 : 3.32

V EXPERIMENTAL PROGRAMME

A. Casting of beams:

1. To study and compare the flexural strength of GFRP reinforced beams with the Steel reinforced beams, Total Nine beams were casted out of which Three beams were of steel as main and shear reinforcement and rest other Six beams were of GFRP as main reinforcement with steel as shear reinforcement in form of stirrups.
2. The size of the beams were 700 mm x 150 mm x 150 mm. The clear cover of 25 mm was provided on top ,bottom as well as on both the sides of the beam.
3. M30 grade concrete was used for casting beams.

B. Testing of Beams for Flexure:

4. All the Beams were simply supported on Universal Testing Machine (UTM) on a span of 650mm and were subjected to two equal loads at 200mm apart and symmetrical about midspan. The Load was applied gradually until the failure of the beam was observed.
5. The load verses deflection was recorded and the graph was plotted.
6. The final experimental results of both Steel and GFRP beams were compared with numerical results.

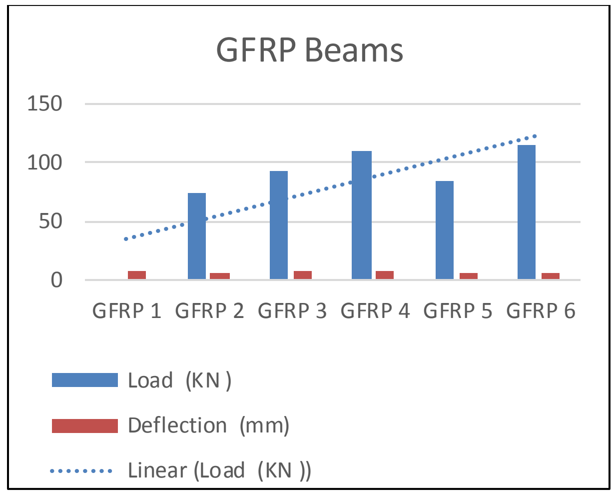
C. Results:

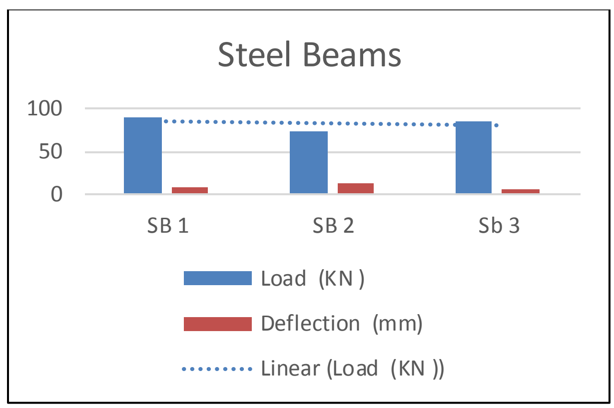
Table no.1 - Load vs Deflection of GFRP beams

Beam	Load (KN)	Deflection (mm)
GFRP 1	108 .4	8.6
GFRP 2	75	6.9
GFRP 3	93.12	7.0
GFRP 4	110.06	8.5
GFRP 5	85	6.9
GFRP 6	115.26	6.7

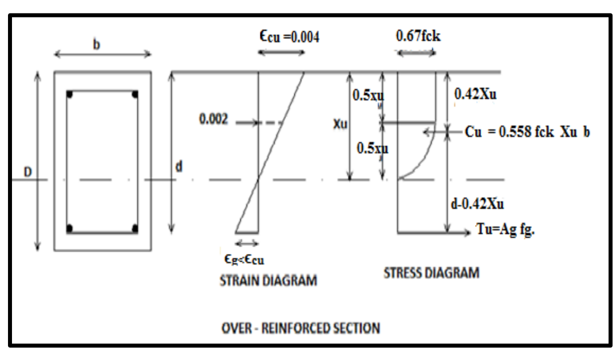
Table no.2 - Load vs Deflection of Steel beams

Beam	Load (KN)	Deflection (mm)
STEEL B 1	89	8.27
STEEL B 2	85	8.1
STEEL B 3	74	12.4





VI. ANALYTICAL CALCULATIONS



Diameter of Bars = 10 mm ϕ, Tensile stress (fgu) = 600 MPa , Modulus of elasticity (Eg) = 50 GPa, fck = 30 MPa , b = 150 mm , D = 150 mm , d = 130mm , L= 700 mm.

From eqn. We get Xu, as follows,

$$\frac{0.558 \times fck \times b}{0.004 \times Ag \times Eg} \times Xu^2 + Xu - d = 0$$

Xu =34.56 mm

And from eqn.

$$Xu \max = \frac{0.004 \times d}{0.004 + [\frac{fgu}{Eg}]} = 32.5 \text{ mm}$$

Xu>Xumax, Over reinforced Section.

Ultimate Moment Mu = Cu x Zu = 0.558 fck x Xu x b x (d - 0.42 Xu)

Mu= 10021789.42 kN.m

From Experimental setup,

$$BM = \frac{w(L-a)}{4}$$

$$w = \frac{BM \times 4}{(L-a)}$$

w=80.17 KN

VII. RESULTS

1. The results indicate that the load carrying capacity of GFRP reinforced beams is more as compared to the Steel beams.
2. The load is directly proportional to deflection. As the load increases the deflection also increases.
3. The experimental values of ultimate load carrying capacity of beam have come out to be greater than that of analytical values.
4. The result clearly shows that the load carrying capacity of the GFRP reinforced beam is more than the typical steel reinforced beam of same diameter bars.
5. The deflection of steel beams is greater and varies higher than those of GFRP beams.

VIII. CONCLUSION

1. Observed cracks in beam were approximately at 45^o to the horizontal axis of the beam near the ends. This shows that the beams failed due to shear failure.
2. Shear strength is less than flexural strength then there will be a shear failure.
3. After ultimate load, load-carrying capacity reduces and constant for certain deflection then again it reduces and continued for a certain deflection thus after maximum load beams load-carrying capacity did come to end suddenly thus we can conclude the ductility of the beam is improved.
4. The study indicates that great potential exist for use of GFRP rebars in concrete structures, especially in areas where corrosion is a problem.
5. As it is clear from the results that the deflection of Steel beams are somewhat greater than that of GFRP beam, hence we can conclude that the steel beam shows more ductility.

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