Glass Fiber Reinforcement Polymer Rebar's

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***Abstract*—Glass fiber reinforced polymer rebar's are those materials made from the glass fibers in a polymeric matrix. The use of the glass fiber reinforced polymer rebar's in modern world has proved to be advantageous in the civil infrastructures due to its corrosive resistant nature. Not only to this advantage, the GFRP rebar's are light in weight and can be transported and handled easily with high factor of safety. The other mechanical characteristics of GFRP rebar's such as non-conductive to electricity and heat makes them an ideal choice for specific infrastructures like hospitals and industries. Because they serve to be long lasting rebar's than steel rebar's they are considered to be cost effective product as not much maintenance is required. In this study the steel rebar's and GFRP rebar's are placed as reinforcement in the concrete cement and is compared with respect to the flexural property with each other for the feasibility of reinforcement.**

***Key Words*—Glass fiber reinforced polymer (GFRP) rebar's, flexural behavior test.**

I. INTRODUCTION

1.1Glass Fiber Reinforced Polymer rebar's

GFRP rebar, or Glass Fiber Reinforced Polymer rebar, is a composite material used in concrete construction as an alternative to traditional steel rebar. It's made by combining glass fibers with a polymer resin, providing a lightweight, strong, and corrosion-resistant reinforcement. GFRP rebar offers several advantages over steel, including higher strength-to-weight ratio, enhanced durability, and resistance to corrosion, making it suitable for various applications.

1.2Composition and Manufacturing:

GFRP rebar is created by embedding glass fibers within a polymer matrix, typically an epoxy resin. The glass fibers provide tensile strength, while the resin binds the fibers together and protects them from environmental factors.

1.3Advantages over Steel:

GFRP rebars being characteristically corrosion resistance and electromagnetically neutral they strengthen the RC structures and help compete against corrosion for long period of time. Corrosion is defined as the deterioration of the metal surfaces rapidly when exposed to the atmosphere where the reduction-oxidation reaction takes place. Hence the GFRP rebars is an ideal option due to the following properties:

FRP rebar does not rust or corrode, unlike steel, which is a significant advantage in harsh environments like coastal areas or those with high chemical exposure.

- The rebars are invulnerable to moisture and strong chlorides.
- They (GFRP rebars) do not react with the salts and other chemicals.

Figure 1: Glass Fiber Reinforced Polymer

II. LITERATURE REVIEW

1.Akhil raj .R, et.al (2017) discussed on using GFRP composite bars in RC flexural member. The test was prepared by arranging a beam of 200mm x 200mm with 700mm length set up on the single point loading applied at the mid span of the beam. To increase the bond between the concrete and the bars, sand coating was applied on the bars. The authors concluded that the ultimate load carrying capacity of the beam is the ultimate failure load of GFRP beam, resulted more than that of the steel reinforced concrete.

2.Aditya S. Rajput and Umesh K. Sharma (2017) dicussed the durability and the serviceability performance of GFRP rebar's on concrete reinforcement in which durability of GFRP rebar's were tested by exposing them to chemicals and serviceability was tested in terms of deflection and cracking. In the test the recording of reduction of the tensile strength was noted due to accelerated exposure and stress-strain graph was plotted. Total of 15 beams were prepared for the serviceability performance and flexural on two point loading set up was tested and load- deflection curve was plotted. The conclusion made was that durability performance of GFRP in carbonated concrete was better. They also concluded that crack propagation study indicates that GFRP reinforced beams when loaded results in wider cracks than steel reinforced beams.

3.Doo Yeol Yoo, Nemkumar Banthia and Young Soo Yoon (2016) researched on the flexural behavior of the GFRP rebar's and steel rebar's in ultra-high performance fiber reinforced concrete (UHPFRC) beams. Three GFRP rebar beams and four hybrid (steel + GFRP rebar's) of different ratio reinforcement beams were fabricated and tested through sectional analysis based on the AFGC/SETRA and JSCE recommendations. From the test they concluded that all UHPFRC beams displayed very stiff load-deflection curve after cracking due to excellent fiber bridging capacity on the crack surfaces. They also said that higher the reinforcement ratio of GFRP rebar's higher the post cracking stiffness and ultimate moment capacity. They also resolved that the maximum moment capacity was underestimated based on the sectional analysis by AFGC/SETRA and overestimated by JSCE recommendations.

4.Benmoktane, 0. Chaallal and R. Masmoudi (2019) discussed the use of theglass fiber reinforced plastic in concrete structures. The authors prepared sample of two types of GFRP rebar's and compared it to the conventional steel reinforced concrete. The beams casted were of three different depths i.e. 300mm, 450mm and 500mm with equal width of 200mm and length of 3m. The beams were tested on the flexural testing setup. Hence, the authors concluded that even if the GFRP rebar's were manufactured by two different companies under different manufacturing process and factors, they behaved in similar manner during flexural test. They also claimed that GFRP rebar's can be used as an alternative in the concrete structures dues to its various properties discussed in the paper and that they have higher scope in future.

III. METHODOLOGY

As per the Indian standard codes' recommendation, concrete mix used for the prepared beams was of M30 grade (fck=30MPa) as shown in Table 1.

To improve the bond strength between the concrete and GFRP rebar's, sand was coated over GFRP rebar's with the help of resins i.e. 1 part of resin in 2 parts of sand

Mix preparations

Three different types of total nine concrete beams of dimensions 50cm x 10cm x 10cm samples were prepared which included a) three samples of steel reinforced plain concrete beams(S- type), b) three samples of glass fiber reinforced polymer reinforced concrete beams(G- type II) and c) three sample of sand coated glass fiber reinforced polymer concrete beams (SG- type III).

All the samples were subjected to third point loading flexure test as per the procedure mentioned in codes after 28 days of curing period, individually on the ultimate testing machine at a constant rate of strain. The load-displacement readings were noted at a regular intervals and load- displacement curves were plotted.

The following mathematical expression was used for the calculations of the modulus of rupture for the samples tested.

$$f_b = \frac{3 * P * a}{b *}$$

Where:

Fb = modulus of rupture, MPa ;

P = maximum load, N;

b = width of beam, mm;

d = depth of beam, mm;

a = distance between line of fracture and nearest support, mm;

Table 1.1: Concrete mix design for singly reinforced beams

Concrete grade –M30 (all quantities for 1m3 volume of concrete)					
Requirements	Cement	Water	FA	CA	w/c ratio

Content	350	140	890	1110	0.40
Unit	Kg/m^3	Kg/m^3	Kg/m^3	Kg/m^3	-
Design mix	1: 2.54: 3.17				

Table 1.2: Details of singly reinforced concrete beams

Specimen	Reinforcement dimension,		Clear cover cm	No. of stirrups
	Length, cm	Diameter, mm		
S-1	46	12	2.0	-
S-2	46	12	2.0	-
S-3	46	12	2.0	-
G-1	46	12	2.0	-
G-2	46	12	2.0	-
G-3	46	12	2.0	-
SG-1	46	12	2.0	-
SG-2	46	12	2.0	-
SG-3	46	12	2.0	-

IV.RESULT AND DISCUSSION

Compressive strength and Tensile strength of reinforcements:

The given Table 3 shows the ultimate tensile strength of the steel rebar's, GFRP rebar's and sand-coated GFRP rebar's. The compressive strength of each sample after 28 days curing is also shown.

Table 2.1: Compressive and tensile strength of the samples after 28days

Sample	Compressive strength (MPa)	Tensile strength (MPa)	% of tensile strength (MPa)
S-1 (standard sample)	29.25	585	-
G-1	29.65	593	1.36
SG-1	29.85	597	2.05

The chart plotted below also shows the comparison of the three samples for compressive strength and tensile strength.

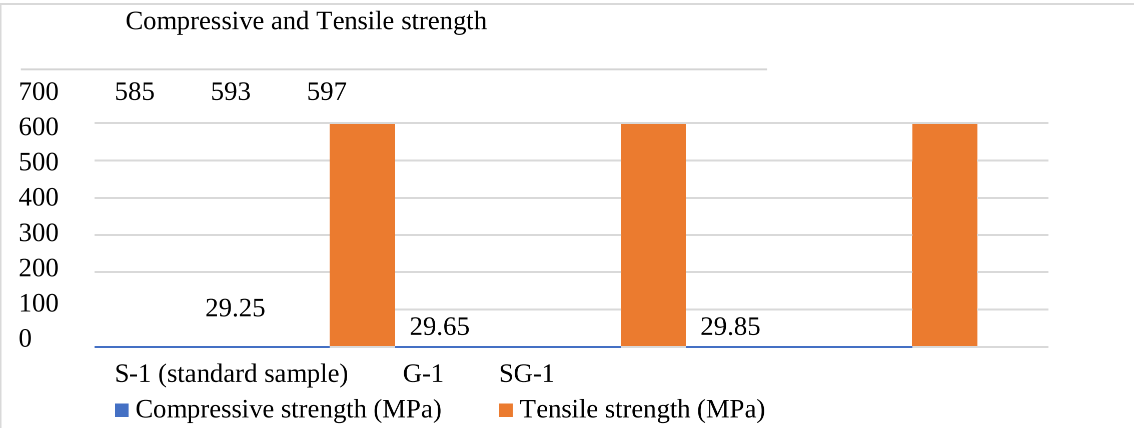

Fig 2.1: Compressive and Tensile Strength

From the given chart result, the compressive strength of the three samples that is steel rebar, GFRP rebar and sand-coated GFRP for mix design of M30 grade is obtained as 29.25MPa, 29.65MPa and 29.85MPa respectively.

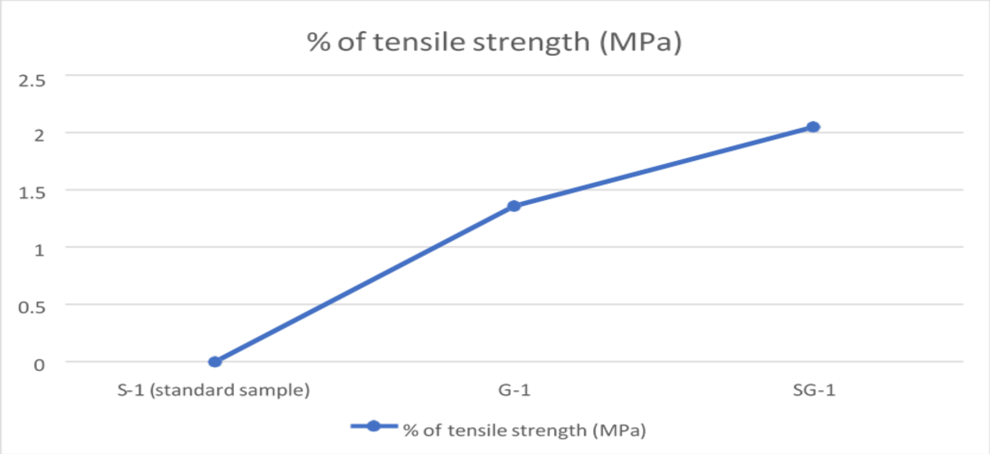

Fig 2.2: Percentage of Tensile Strength

From the given chart result the highest tensile strength of the sample is about 2.05% observed in sand-coated GFRP rebar with respect to the standard sample that is steel reinforcement. The GFRP rebar is about 1.36% respectively. The tensile strength of the sand-coated GFRP reinforcement is found high because of the improved bonding between the rebar and concrete. The bonding was increased by using a coarser sand coated on the rebar with the help of resin and hardener.

2.2 Third-point loading Flexural test on cement concrete beams of singly reinforced with various types of rebar's:

As said flexural strength is also termed as Modulus of rupture or bend strength, is a maximum bending stress applied to a material before it yields. The flexural test is done by three-point loading in which two points loads are placed at third points along the span of the beam.

The following table shows the load at failure, deflection of mid-section and flexural strength values of the specimen tested.

Table 2.2: Testing of the specimen

Specimen	Curing period	Load at failure, KN	Displacement of mid-section at failure, mm
Steel reinforced beam	28 days	15.70	2.30
GFRP reinforced beam	28 days	52.30	0.095
Sand-coated GFRP reinforced beam	28 days	75.85	0.057

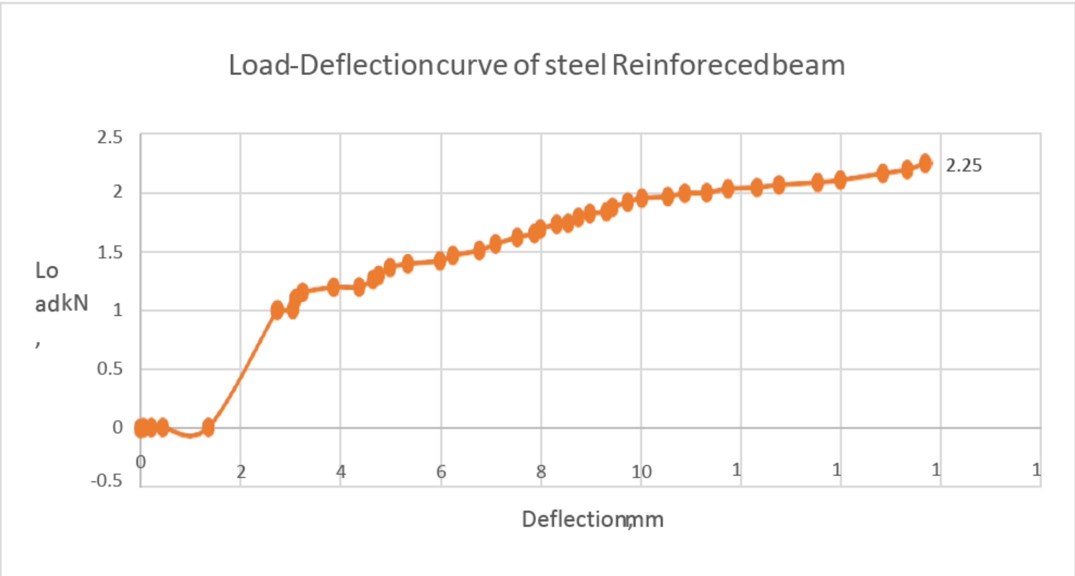

Fig 2.3: Load-Deflection curve of Steel Reinforced Beam

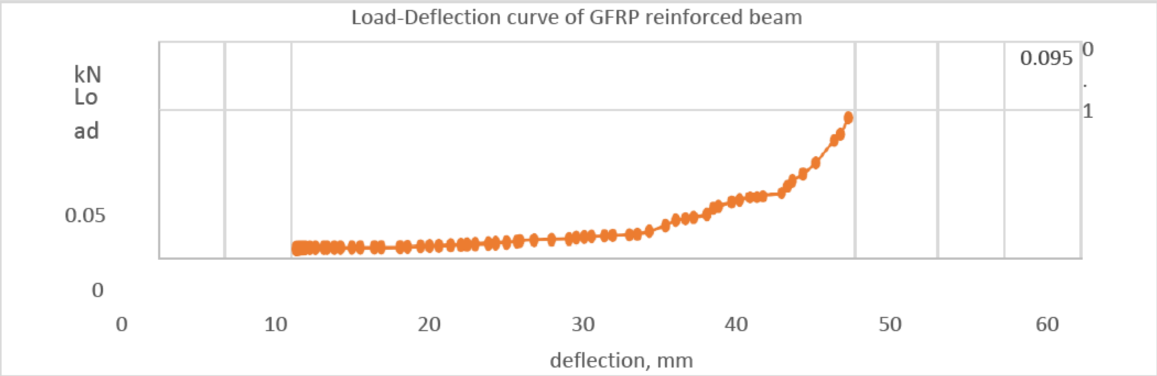

Fig 2.4: Load-Deflection curve of GFRP Reinforced Beam

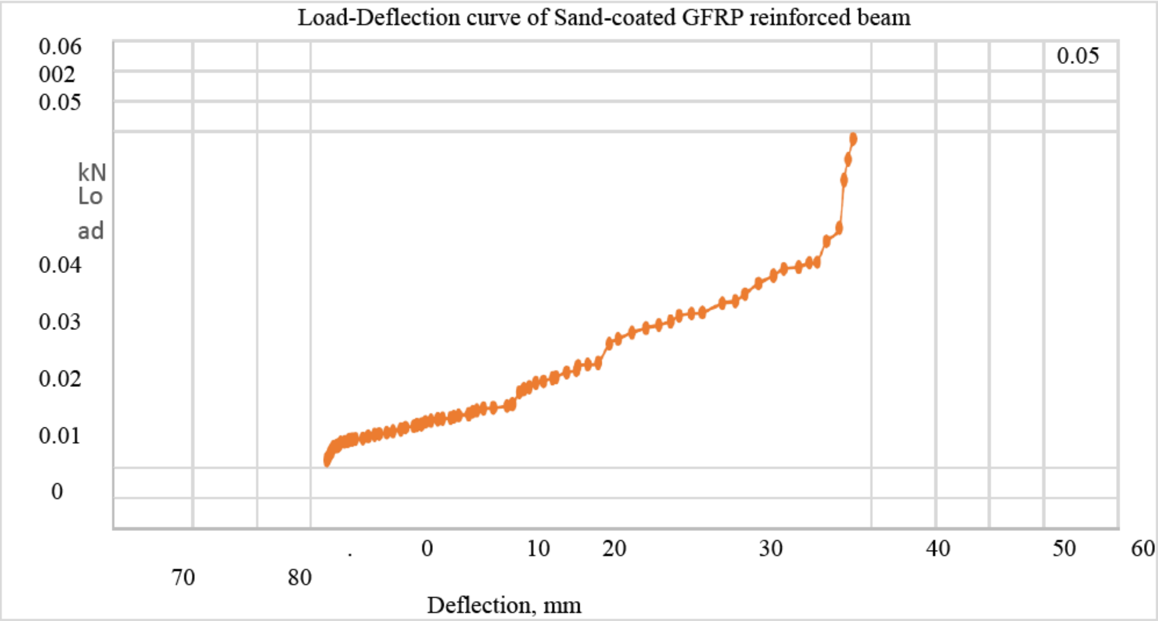

Fig 2.5: Load-Deflection curve of Sand-coated GFRP Reinforced Beam

From the curve shown above, we can conclude that the variation is followed by a straight-line until the first crack. In load-deflection curve of the steel reinforced beam there is an exhibition of local breakage in the profile after the disruption of the linearity. In GFRP reinforced beam and sand-coated reinforced beam, the curve explains the ductile behaviour of the rebar's. Therefore, by this property of GFRP reinforced beam it can provide ample of time to be alerted for the failures to take place. Therefore, GFRP is suitable to be used as an alternative for the steel reinforcement beam.

Table 2.3: Specification of the Specimens

Specimen	Flexural strength, MPa	Strain	Modulus of elasticity, MPa
Standard specimen, S-1	17.5	9	15000
G-1	12.8	16	500
SG-1	15.3	10.5	1000

The above graph shows the flexural strength of the specimens tested. The flexural strength of the standard specimen that is steel reinforced beam has a flexural strength value of 17.5MPa. whereas the decrease in flexural strength of GFRP reinforced concrete flexural strength is about 26.85% and sand-coated RC flexural strength is about 12.57% less than the standard steel RC.

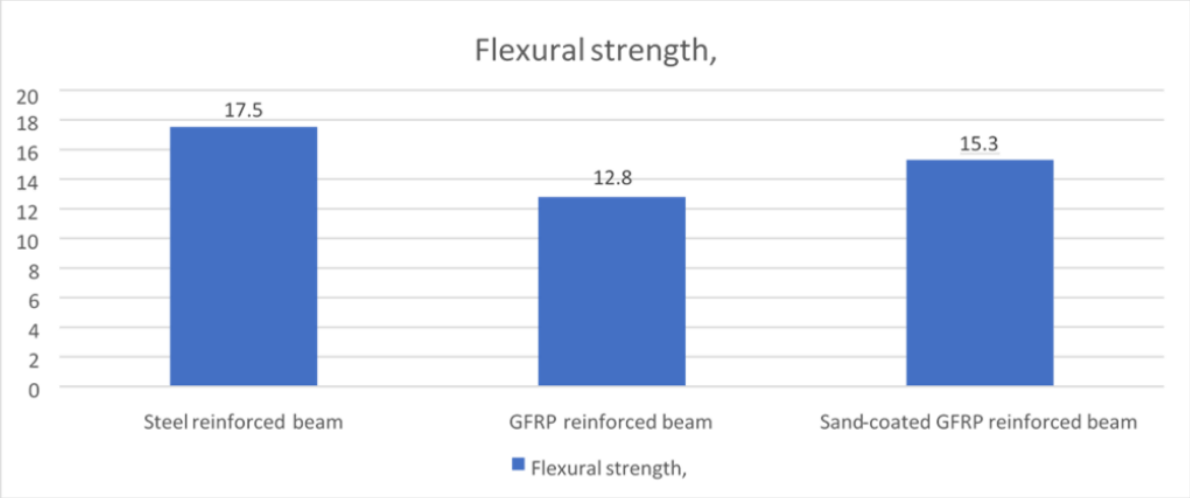

Fig 2.6: Flexural Strength, MPa

It can also be concluded that the flexural strength of sand-coated GFRP reinforced concrete are closer to steel reinforced concrete beam because it has higher strain as compared to the steel RC at the expense of the flexural modulus. The strength of the GFRP reinforced concrete is lower than sand-coated GFRP RC, as a result of lower flexural modulus. The strength in sand coated GFRP RC is also increased which is caused by the sand grains and in fact increases the brittleness of the GFRP rebar's.

V. CONCLUSION

As this paper presents the results on the flexural strength experiment of the three reinforced concrete specimens done by three-point flexural loading test, the following chapter discuss on the conclusion drawn.

The following points are the conclusion concluded from the paper:

1. The compressive strength of the three specimens after 28days of curing are 29.25MPa, 29.65MPa and 29.85MPa of steel reinforced concrete, GFRP reinforced concrete and sand- coated GFRP reinforced concrete respectively. Hence the required compressive strength of M30 grade concrete is obtained for the experiment
2. The tensile strength of GFRP reinforced concrete and sand-coated GFRP reinforced concrete are found to be 593MPa and 597MPa respectively due to its composite nature, thereby they are stronger in tension and can provided premature warning of the failure which can alert the engineers.
3. The highest tensile strength is observed in sand-coated GFRP reinforced concrete and then in GFRP reinforced concrete of 2.05% and 1.36% respectively with respect to steel reinforced concrete beams.
4. The failure of GFRP reinforced are seen higher than the steel reinforced hence they can provide ample of time to alert for the failures to take place.
5. The flexural strength value of sand-coated GFRP reinforced concrete and GFRP reinforced concrete are closer to the steel.

VI. REFERENCES

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