GLASSTO BARS

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ABSTRACT

Corrosion of steel reinforcement is one of the main problems facing the construction industries throughout the world. Many methods have been used to minimize the problem but without success. Thus, more durable reinforcements are highly needed to replace conventional steel. Researchers are desperate to find an alternative to steel so they came forward with a revolutionary idea of introducing glass fiber reinforced fiber in the concrete. Glass Fiber Reinforced Polymer (GFRP) bars provide a good alternative reinforcement due to its non-corrodible characteristic. The principal reason of introducing FRP bars is eradicate the losses incurred due to the corrosion of steel. Keeping in mind the above material i.e. GFRP. we are going to compare the beams casted with glass fiber rebar and steel reinforcement and applying sand coating on GFRP bars to obtain bond strength. The results will be studied for flexural strength and bond strength. The composition of both steel & glass fiber rebar and glassto bars (sand coated bars) will also be used and useful design will be developed.

Keyword: - *Glassto Bars, Sand Coated GFRP bars, Flexural Strength, Bond Strength and Conventional Steel Bars.*

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1. INTRODUCTION

Corrosion of steel is a major cause of infrastructure degradation. Solving this problem is a major challenge for the engineering community. Porous, concrete will allow water and corrosive agents such as salt to penetrate and reach reinforcing steel. Once exposed to those corrosive agents, steel will begin corroding.

Now a day due to availability of the glass fiber reinforced polymer (GFRP) or carbon fiber reinforced polymer (CFRP) rebar's can be installed in these cases. These bars have a higher tensile strength, good corrosion resistant, non-magnetic, easily machined and much lighter than steel. Glass Fiber Reinforced Polymers are a proven and successful alternative that have numerous advantages over traditional reinforcement methods, giving structures a longer service life. The GFRP rebar is a structural ribbed reinforcing bar made of high strength and corrosion resistant glass fibers that are impregnated and bound by an extremely durable polymeric epoxy resin. This combination equals an engineered material system resulting in unique attributes that replace and supersede typical materials such as galvanized, epoxy coated and stainless-steel rebar. Its characteristic properties are ideal for any harsh and corrosive environments.

1.1 Consequences due to corrosion

- High rehabilitation cost
- Health and Safety-hazard
- Shutdown due to corrosion failure
- Contamination
- Loss of efficiency

1.2 Solution

Several options have been explored, most notably the use of galvanized steel rebar, epoxy coated or stainless steel. The results, however, have been disappointing as these solutions have turned out to be less than effective or cost prohibitive. Glass Fiber Reinforced Polymer (GFRP) has proven to be the solution, a major evolution in reinforced concrete technology. Lightweight, non-existent corrosion, that offers excellent tensile strength and high mechanical performance. GFRP rebar is installed much like steel rebar, but with fewer handling, transportation and storage problems.

1.3 Pultrusion process

The pultrusion process starts with racks or creels holding rolls of fiber mat or doffs of fiber roving. Most often the reinforcement is fiberglass, but it can be carbon, aramid, or a mixture. This raw fiber is pulled off the racks and guided through a resin bath or resin impregnation system. Resin can also be injected directly into the die in some pultrusion systems.

The raw resin is almost always a thermosetting resin, and is sometimes combined with fillers, catalysts, and pigments. The fiber reinforcement becomes fully impregnated (wetted-out) with the resin such that all the fiber filaments are thoroughly saturated with the resin mixture.

As the resin rich fiber exits the resin impregnation system, the un-cured composite material is guided through a series of tooling. This custom tooling helps arrange and organize the fiber into the correct shape, while excess resin is squeezed out, also known as "debunking." This tooling is known as a "pre-former." Often continuous strand mat and surface veils are added in this step to increase structure and surface finish.

Once the resin impregnated fiber is organized and removed of excess resin, the composite will pass through a heated steel die. Precisely machined and often chromed, the die is heated to a constant temperature, and may have several zones of temperature through-out its length, which will cure the thermosetting resin. The profile that exits the die is now a cured pultruded Fiber Reinforced Polymer (FRP) composite.

This FRP profile is pinched and pulled by a "gripper" system. Either caterpillar tracks or hydraulic clamps are used to pull the composite through the pultrusion die on a continuous basis. At the end of this pultrusion machine is a cut-off saw. The pultruded profiles are cut to the specific length and stacked for delivery.

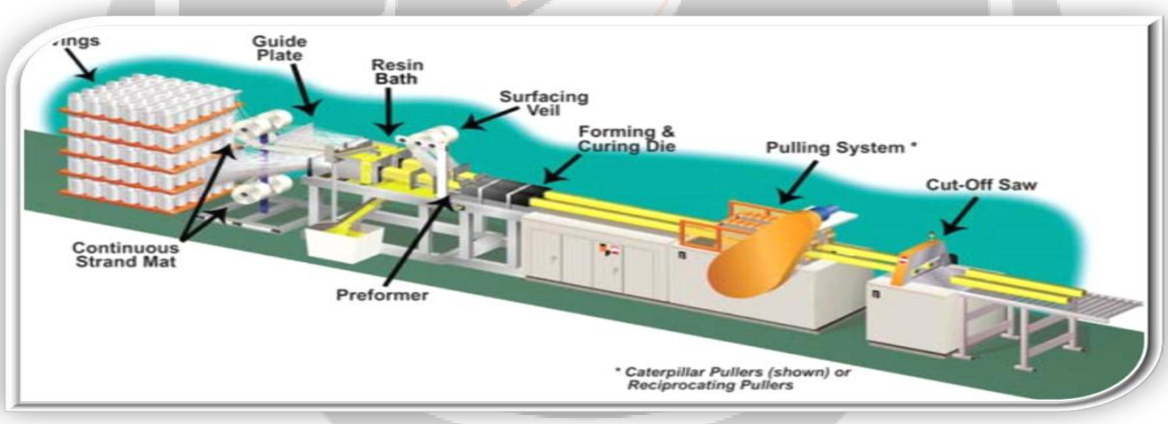


Fig -1: Pultrusion Process

2. RESEARCH METHODOLOGY

Aim of this project is to compare different mechanical properties of FRP rebar with that of the HYSD rebar when concrete is reinforced with it.

Different mechanical test that we are going to conduct are: -

- Flexural behavior of FRP reinforced beam

- Bond strength of FRP

Flexural Behavior of FRP Beam: -

- Researches done on concrete reinforced members with FRP show that, no yield stress was seen, bearing in mind the liner relation between stress and strain in FRP bars.
- Deflection of concrete beams with FRP also is very bigger than similar samples of RC beams with steel, around 4 times, and the diagram of their load-deflection is in a straight line.
- In some compressive rupture of these beams at ultimate loading, a descent of the neutral axis (N.A.) has been seen with an increase in loading.
- For the design of the flexural concrete reinforced members with FRP, various relations are presented with the basic assumptions of achieving these relations, and as such, they are used for the reinforced concrete members with steel bars, and the properties of FRP are used as a replacement of the steel properties.

Bond strength of FRP rebar: -

- The bond characteristic of FRP rebar is one of the most important parameters that control the design of FRP-reinforced concrete members.
- Pull-out and splitting are the two dominate bond failure modes expected between FRP rebar's and concrete.
- The occurrence of each one depends on the confinement around the bars, concrete cover and strength, and the bar embedment length.
- FRP bent bars are being needed in many applications such as concrete bridge barrier.
- In this case, the bond and the bar embedment length are become more critical.
- The problem is attributed to the significant reduction of the tensile strength at the bend portions of the FRP rebar.
- This paper presents an experimental investigation on the strength behavior of FRP-rebar’s with new developed end anchorages to be used as alternative to the bent FRP-rebar’s

2.1 Material used and its properties

Material	Type
Cement	Ultratech OPC 53 Grade
Coarse Aggregates	25mm Down
Grit	10mm Down
Fine Aggregate	White Sand
Steel	Fe500 (Balbir Company)

Table -1: Material Details

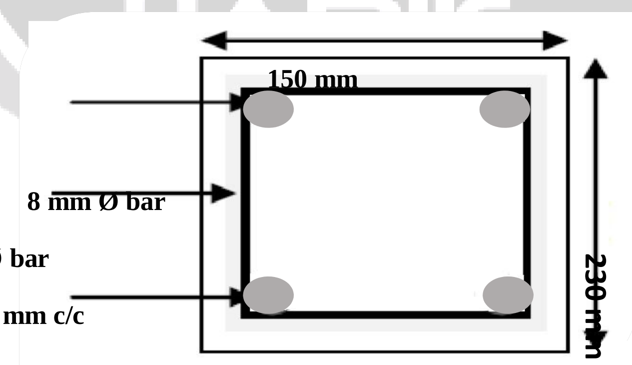
2.2 Concrete Mix Design

Quantity for 6 Cubes (0.02025 m^3)

Properties	Material	Trial mix-1	Trial mix-2
Specific Gravity	25mm Down	2.835	
	10mm Down	2.805	
	Sand	2.738	
	Cement	3.15	
W/C ratio	-----	0.5	0.49
Quantity (kg)	10mm Down	17.84	17.72
	25mm Down	16.82	16.71
	Cement	9.49	9.75
	Sand	16.31	16.20
	Water	4.75	4.78
Slump (mm)	---	26	38

Table -2: Concrete Mix Design

2.3 Reinforcement detail of beam



8 mm Ø bar

@ 150 mm c/c

10 mm & 12mm Ø bars

2, 8 mm Ø bars as

Top reinforcement **1000**

2, 10 mm & 12mm Ø bars as

Bottom reinforcement **Stirrups 8mm Ø bars @ 150 mm c/c**

Fig -2: Reinforcement Details

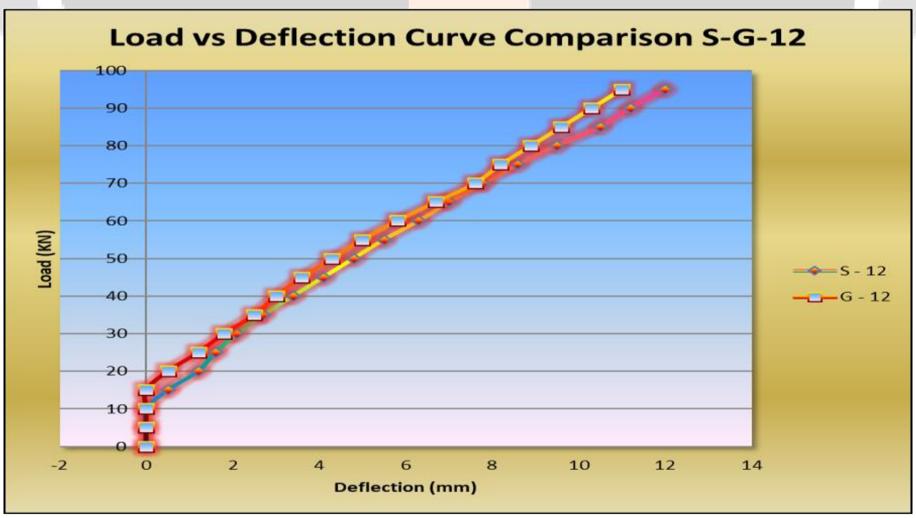
2.4 Beam combination

Sr. No.	No. of Specimen	Particulars	Notation
1	**2**	**10 mm steel bars in tension**	**T - S - 10**
2	**2**	**12 mm steel bars in tension**	**T – S – 12**
3	**2**	**10 mm GFRP rebars in tension**	**T – G -10**
4	**2**	**12 mm GFRP rebars in tension**	**T – G – 12**
5	**2**	**One 12 mm bar of steel and one 12 mm bar of GFRP in tension**	**T – S – G – 12**

Table -3: Beam Combination

3. EXPERIMENTAL RESULTS

3.1 Load vs Deflection Curve comparison of Steel & GFRP 12mm in Tension Zone: -



Graph -1: Load vs Deflection Curve

3.2 Flexural strength calculation: -

P_{total} = 95 kN

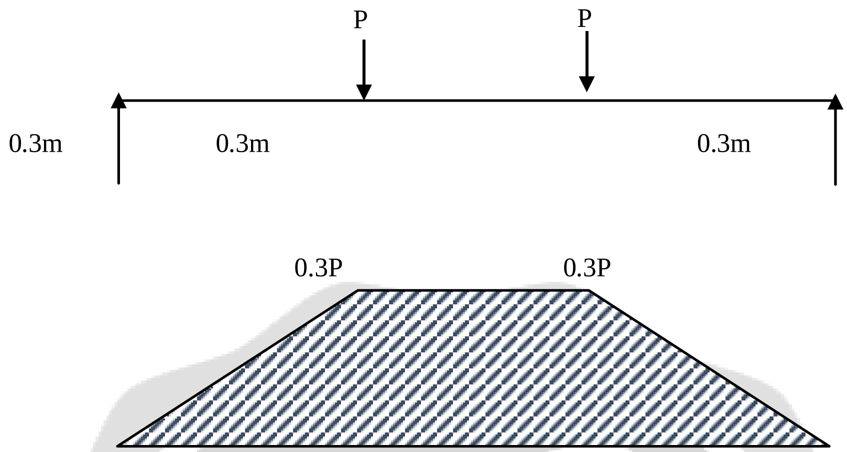


Fig -3: Bending moment diagram

Hence,

P = 95/2

= 42.5 kN (The total load gets distributed at two points due to two-point loading system).

M_u = 42.5 * 0.3

=12.75 kN.m

3.2 Bond stress calculation

As per IS 2770.1 – 1967

The average bond strength shall be the value obtained for each specimen, by dividing the applied load at the slip specified, by the surface area of the embedded length of the bar; and then taking the average value for the group of each type of bar in the test series.

Sr. No.	No. of Samples	Material	Dia. (mm)	Surface Area (mm2)	Slip Avg. Load (N)	Bond Stress = L / S. A.
1	2	Steel Fe-500	10	4712.4	25600	5.4
2	2	Steel Fe-500	12	5654.9	37000	6.6
3	2	GFRP	10	4712.4	23500	5
4	2	GFRP	12	5654.9	33750	6
5	2	GFRP Sand Coated	10	4712.4	25000	5.3

Table -4: Bond Stress

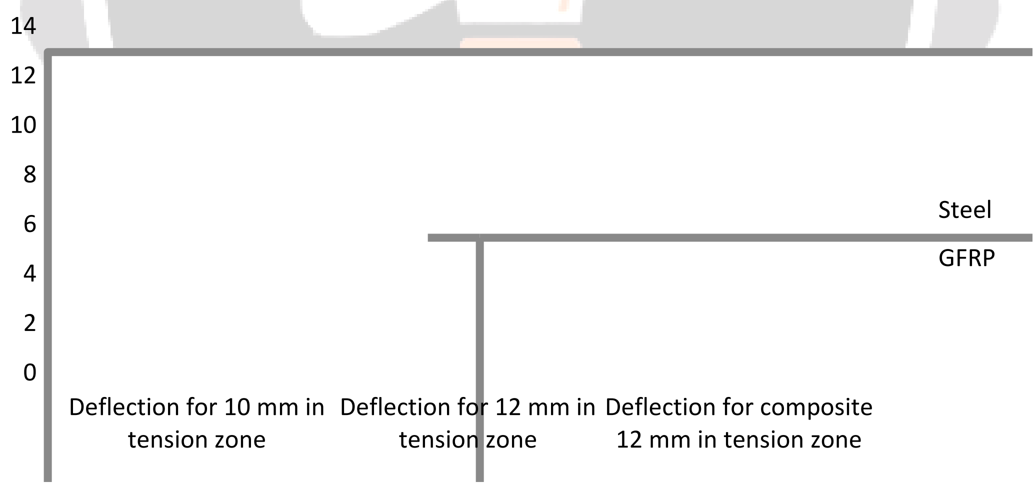
4. CONCLUSIONS

4.1 Flexural behavior: -

- The test carried out for the flexure of steel and GFRP beams were not carried out up to the failure load so the ultimate capacity of both the material was not been noticed. But the deflection in GFRP beams was observed lesser at the initial loads as compared to the steel beams.
- The limitation of GFRP beams would be that it would fail directly on the ultimate load and won't give any yield position so the steel beams are better in comparison to them.
- The result of composite beam was quite satisfactory in case of deflection. So, the GFRP bars could be used in concrete with the steel in combination to get good results.

Sr. No.	Dia. of bar in tension zone	Deflection in GFRP beams	Deflection in Steel beams	%age decrease in deflection in GFRP beams
1	10 mm Φ	10.8	11.9	11 %
2	12 mm Φ	11	12	11.1 %
3	Composite section 12 mm Φ	10.9		

Table-5: Percentage decrease in deflection in GFRP beams

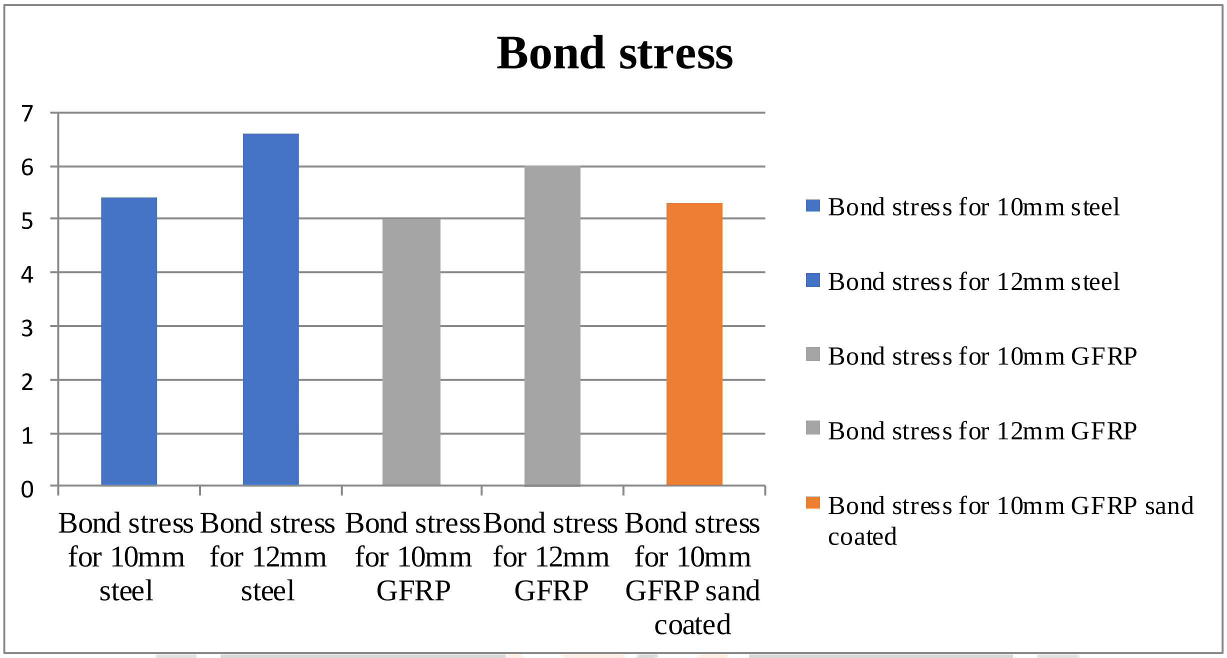


Graph: 2- Comparative deflection graph

4.2 Bond strength: -

- The bond strength of GFRP rebar is less comparative to the steel bars due to threading on rebar were less as compared to the steel bars. The GFRP rebar must be deep threaded to get the good bond with inner concrete.

- The sand coated GFRP rebar was impressive with the results as compared to the normal rebar. The sand coated on the rebar gives more friction to the concrete so that the strength increases. The sand coating would increase the cost of rebar.



Graph:3 - Comparative bond stress graph

5. REFERENCES

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- **Standard codes**

- IS 10262-1982 for mix-design
- IS 456-2000 for plain and reinforced concrete
- IS 383-1970 for coarse and fine aggregate

- ACI – 440.3r
- IS 2770.1 - 1967