Comparison Between The Flexural Behavior of RCC Beam And Hybrid (Using GFRP) Concrete Beam

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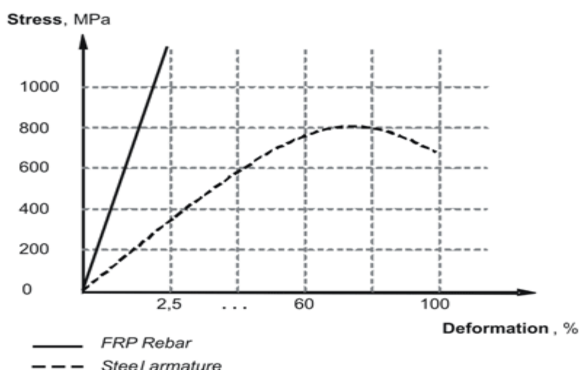
Abstract- *Fibre Reinforced Polymer bars are one of an alternative to steel rebar in many applications and to steel plate-bonding techniques for structural strengthening. Corrosion of steel reinforcement in concrete structures causes deterioration of concrete resulting in costly maintenance, repairs and shortening of the service life of structures. Glass Fibre Reinforced Polymer is one of the type under FRP bars which plays steel role in concrete structures.*

This project deals with the study of GFRP(glass) bar as a tensile reinforcement and/or shear reinforcement for a beam under loading. An attempt has been made to replace steel in concrete member by providing glass fibre reinforced polymer bars to attain better performance than steel. A control beam is designed as per code providence and casted using steel bars 6,8,10 mm diameter and the another hybrid beam is designed and casted using FRP bars 8 mm dia. Both having 1000mm length, breadth 200mm and depth 200mm with cover 20mm. Load test is conducted on these two specimen and compared.

Keywords- GFRP rebars; Steel rebars; Reinforced concrete; Mechanical properties

I. INTRODUCTION

The Fibre Reinforced Polymer bars (FRPs) are increasingly being used in the structures to overcome some of the problems were facing by using the traditional reinforcement steel bar. Primary ingredients to manufacture a GFRP bar are glass-fibre filament and a resin matrix which is generally polyester resin. These glass-fibre filaments are similar to the one's mixed directly in concrete mix to obtained GFRC sheets and members with the exception that Glass fibers meant for GFRC purposes have a special Alkali-resistant coating over their surface. These filaments are known to possess exceptional tensile strength and are the load bearing components of bar. The matrix or polyester resin is introduced as a binding agent enabling dimensional stability and to hold the fibers together.(1). The conventional concrete members such as beams are composed of concrete and steel reinforcement bars. The concrete is used in beam to resist compressive loads where the tensile and shear loads will be resisted by steel bars reinforced in concrete. Efficient structures are considered when the concrete extremely resists compressive load and the steel increases in tension and shear strength. The FRP bars properties, such as low self-weight, very good fatigue properties (assuming that the load acting parallel to the direction of the fibers) and high durability in aggressive environments contribute to the intensive development of possibility of using the FRP bars as main reinforcement of concrete structures.(2). However, reinforcing steel in RC elements is vulnerable to corrosion, especially the transverse reinforcement for which the concrete cover is thinner. The use of FRP stirrups has been hindered by their limited availability. Moreover, a 60% strength reduction factor at bends for various types of FRP is recommended, which makes them less appealing.(3). Researches have resulted in alternative reinforcing materials. GFRP is one of the material in alternating steel rebars commercially available in form of bars which can be bonded with concrete as a member. However, the problem dealing with corrosion in steel bars the GFRP bars are high in corrosion resistance and impervious to the action of salt ions, chemical, and the alkalinity inherit in concrete. Alkali attack could not be detaining the GFRP reinforcement material.(4). The elongated strain to failure that give enough time to alert before failure takes place. Good performance of FRP reinforced concrete requires adequate interfacial bond between bars and concrete, due to the tensile stress transfer from concrete matrix to reinforcement. But complete replacement of steel bars in a member is not efficient because GFRP is not good as steel in compression. Bending test results show that bending bearing capacity of GFRP rebars reinforced concrete beams is higher than that of steel rebars reinforced concrete beams(5) so it cannot be bended for development length. Even though it is having higher tensile strength than steel its failure is brittle in nature because of linear stress strain. The GFRP bars were anisotropic, and they were characterized by high tensile strength only in the direction of the reinforcing fibers. Tensile strength of GFRP bar is high, because they are anisotropic composite materials, GFRP rebar achieved yield tensile strength about 13% higher than that the steel rebar, while yield strain of GFRP is higher than steel about 58%.(6). The cross section dimensions didn't affect the GFRP bar modulus. The inclusion of FRP on concrete surface provides better crack control and deformation characteristic of beams.(7). In this paper two type of beams like conventional steel reinforced beam are casted and hybrid GFRP bars reinforced concrete beam are casted by providing the steel and GFRP rebars as main reinforcement or shear reinforcement in different ratios and compared each other to determine in which way the hybrid beam having higher flexural strength than the conventional beams. The contribution of steel rebars to GFRP/CFRP rebars in the top and bottom reinforcement of concrete beams provides ductility and stiffness improvement of beams and ensures the desirable ductile flexural behavior and avoids the unfavorable brittle failure.(8)



Graph 1. Stress Strain curve between steel and GFRP

II. PURPOSE OF THE WORK

The purpose of this research is to show how the Hybrid Glass fibre reinforced polymer (GFRP) reinforced concrete behaves better than conventionally used steel reinforced concrete. This study will provide evidence to show that the hybrid GFRP concrete structure performs good in flexural strength which is higher than the steel reinforced concrete structure. There are different specimens are used to deterimine the better replacement of steel in a beam. However, one conclusion that seems to have got in all these years of research is GFRP reinforcement should be not relied on to resist compression. The flexural strength of a reinforced concrete (RC) beam has been increased by using fiber reinforced polymer (FRP) to the tension face where GFRP handles more tensile load than steel. These part discuses on flexural behavior of FRP bars as a reinforced in concrete beams. (9). International tested data show the compression modulus of GFRP bars is lower that its tensile modulus. Due to the combined effect of this behavior and the relatively lower modulus of GFRP compared with steel, the maximum contribution of compression FRP reinforcement calculated at crushing of concrete is small. Therefore, these should neither consider FRP reinforcement as reinforcement in columns nor other in compression members, nor as compression reinforcement in flexural members. Although all of them indicate that the compressive strength of GFRP rods should not be disregarded, requiring further research in this area. This is the basic point of this work, study the behavior of reinforced concrete with GFRP bar under loading. Though GFRP bars are light weight, no-corrosive, exhibit high specific strength and specific stiffness, are easily constructed, and can be tailored to satisfy performance requirements. It does reduce some considerable cost in construction and easy transportable to the construction site.

III. METHODOLOGY

3.1 Mixing method

1. Grade of concrete= M 20
2. Type of cement grade= OPC 53
3. Max size of aggregate= 20 mm
4. Min cement content= 300 kg/m^3
5. Max cement content= 450 kg/m^3
6. Max water cement ratio= 0.55
7. Degree of workability= 75 to 10 mm
8. Exposure condition= mild
9. Specific gravity of cement = 3.15
10. Specific gravity of coarse aggregate = 2.8
11. Specific gravity of fine aggregate= 2.65
12. Water absorption for C.A = 0.35 %
13. Free moisture of F.A= 1 %

Weight of the materials used in casting beam

- Cement= 358.47 kg/m^3
- Sand= 657.2 kg/m^3
- Coarse Aggregate= 1232 kg/m^3
- Water= 197.16 lit/m^3

The mixing proportion of concrete (1:1.5:3) was used. The cement and fine aggregate were taken in a pan as per estimated and it is thoroughly mixed in a pan and then the coarse aggregate was combined and mixed with the entire batch by shovel until the materials are uniformly distributed throughout the batch. Then the water was poured and blended with the materials for specific duration until the concrete is homogenous in appearance and the consistency is attained. The mixing process was paused and then returned for a few minutes and the open end or top of the pan was covered to prevent evaporation during the rest period. This step was repeated in two cycles to insure the homogeneity for mixture. The total mixing time was about 15 min.

3.2 Reinforcement detailing

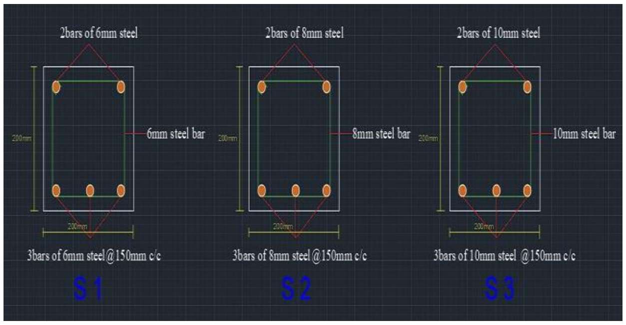


Fig 1. Reinforcement detailing of Steel RCC beam

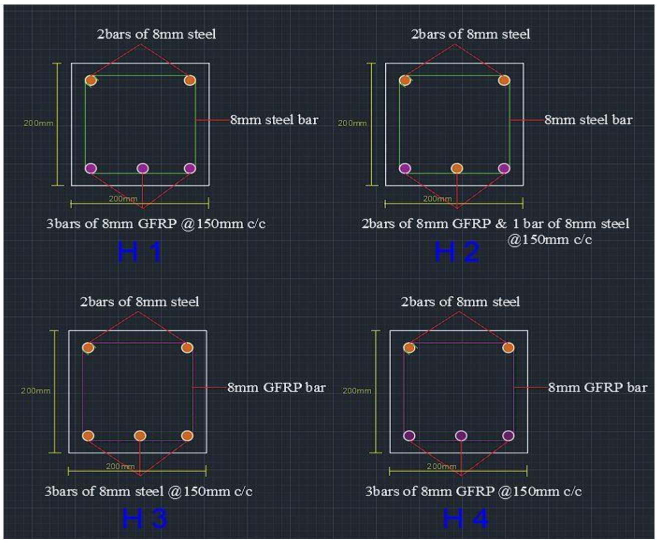


Fig 2. Reinforcement detailing of Hybrid beam

3.3 Beam casting

Wooden mold for compressive strength and flexural strength was used throughout this investigation. Prismatic specimens of 1000 x 200 x 200 mm for flexural strength. The molds were softly coated with oil or grease before use, per ASTMC-192 concrete casting was performed in different layers, each layer of 50 mm. Each layer was compacted by using Tamping Rods until no air bubbles emerged in the concrete, and the surface of concrete was leveled off fully to the upper of the molds by using steel trowel. Concrete is reinforced by GFRP and steel bars evenly distributed with specific distance in the mold. The GFRP bars indicated good bond behavior to concrete, mainly due to the ribs on the bar surface.(10). The basic conditions that must be supplied to continue a reaction is the appropriate temperature, and adequate moisture. The green concrete contains enough water to complete the hydration process of cement, but in most conditions a large quantity of water is evaporated by heat. Moisture curing method was utilized to compensate for the water that evaporates during the casting process. Specimens were completely submersed in water tanks until the time of measurements (28 days) as a curing age.

3.4 Result

S.NO	SPECIMEN	TYPE OF FAILURE	INITIAL CRACK OCCURS IN (KN)	ULTIMATE LOAD IN (KN)
1.	STEEL BEAM 1	SHEAR FAILURE	112.6	184.7
2.	STEEL BEAM 2	SHEAR FAILURE	120.5	185.6
3.	STEEL BEAM 3	SHEAR FAILURE	128.6	187.8
4.	HYBRID BEAM 1	SHEAR FAILURE	74.8	210.5
5.	HYBRID BEAM 2	CRUSHING FAILURE	65.2	178.6
6.	HYBRID BEAM 3	CRUSHING FAILURE	47.6	186.9
7.	HYBRID BEAM 4	CRUSHING FAILURE	48.3	198.2

IV. CONCLUSION

1. GFRP reinforcing bar has higher tensile strength and higher corrosion resistance than steel rebar in addition, moderate flexural strength, these properties make GFRP is good alternative of steel in foundations application.
2. In hybrid GFRP/steel reinforced concrete beams, the steel reinforcement improved the beam stiffness, ductility and load resistance after cracking.
3. The GFRP bars indicated good bond behavior to concrete, mainly due to the ribs on the bar surface.
4. Using FRP bars in high strength concrete will give us better cracks, as we know, FRP bars have low modules of elasticity and this, can considered as the main reason.
5. The increase in the bar diameter caused the decrease in the shear bond stress in both cases of the concrete cover thickness;
6. The decrease in the concrete cover thickness led to the decrease in the shear bond stress in both cases of the bar diameter
7. The higher the amount of GFRP reinforcement, the less the rate of increase of the ultimate capacity of the concrete beam.
8. The higher the percentage of the GFRP bars with respect to the steel bars, the lower beam strength
9. It is better to use steel bars as top reinforcement in concrete beams with hybrid GFRP/steel bars as lower reinforcement. The contribution of steel rebars to GFRP rebars in the top and bottom reinforcement of concrete beams provides ductility and stiffness improvement of beams and ensures the desirable ductile flexural behavior and avoids the unfavourable brittle failure.
10. In hybrid beams, stiffness slightly decreased and a noticeable increase in the beams deflection after the initiation of first crack and yielding of steel

reinforcement is noticed. So the shear reinforcement can be placed closer to the end supports for decreasing the deflection in hybrid GFRP reinforced concrete beams.

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