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Feasibility Study of using Glass Fiber Reinforced Polymer rebars as Reinforcement in Concrete

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Abstract
Glass fiber reinforced polymer rebars are those materials made from the glass fibers in a polymeric matrix. The use of the glass fiber reinforced polymer rebars 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 rebars are light in weight and can be transported and handled easily with high factor of safety. The other mechanical characteristics of GFRP rebars 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 rebars than steel rebars they are considered to be cost effective product as not much maintenance is required. In this study the steel rebars and GFRP rebars 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.
The beams of cross section 100mm x 100mm of length 500mm with 12mm diameter of GFRP rebars and steel rebars are tested for flexural behavior. This paper also attempts to present the knowledge why the use of GFRP rebars is not common in some area's despite of their various advantages.
Keywords: *Glass Fiber Reinforced Polymer (GFRP), Rebars, Flexural Behavior Test.*

1. Introduction

This chapter discuss on feasibility of the use of glass fiber reinforced polymer rebars in concrete structures. It also deals with the need of the study of the GFRP rebars from the aspect of engineers. It also draws an outline of the manufacturing process of the GFRP rebars. It also explains the physical and mechanical characteristics of the GFRP rebars and the comparison made with the traditional steel rebars. This chapter also draws the growth of the GFRP rebars in the advanced world today [1, 2].

2. Literature Review

S.Sailey Sivaraja et.al (2013): Described mainly in terms of earthquake loading.The author constructed scaled masonry elements with and without the use of GFRP rebars. The experiment performed on the shaking table and elements subjected to base shock vibrations concluded that the simulation of the impact test for earthquake is reasonable [3].

Bogusław Jareka and Aleksandra Kubika (2015): Conducted examination on the GFRP rebars in RC with the static tensile test on three different manufacturers of the GFRP rebars. First manufacturer was glass fibers arranged in parallel and embedded in vinyl - ester resin finished with grooved ribs which results in discontinuity of fibers on the outer surface. Second manufacturer was prepared by the pultrusion method of glass fibers in epoxy resin and last manufacturer was also prepared by pultrusion method composed of continuous glass fiber embedded in thermosetting synthetic resin with grippy sand braiding surface. The sample prepared were mounted on the tensile machine and subjected to an axial force increasing at the constant of 10MPa/s at the temperature of 20°C. The result concluded that for different manufacturer of the GFRP rebars, the increasing load can change the Young modulus of elasticity which in fact changes the application in RC [4].

Sudeep Vyas and Danish Khan (2016): Discussed on the partial replacement of the cement in the

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concrete by different percentage of glass powder by the weight of cement. The sample prepared was arranged by various percentage of powder glass like 10%, 20%, 30% and 40%. The main objective being on the evaluation of the pozzolanic activity of the waste glass powder, various testing was done such as IST and FST of the sample and the compressive strength test. This paper resulted that 10% to 30% partial replacement by glass powder can be used because the compressive strength at 28 days is close to required strength but as a whole, they concluded that with increase in the percentage of powder glass the strength required decreases [5].

3. Properties of Materials

- Cement
- Fine Aggregate
- Course Aggregate
- Water
- Glass Fiber Reinforced Polymer

3.1. Cement

Ordinary Portland cement (OPC) is by far the most type of cement. As BIS requires the minimum, compressive strength of 43 grades OPC is 43 Mpa.
OPC shared the following usages;

- P.C.C works
- Brickworks
- Plastering works etc.,

3.2. Fine Aggregate

Manufactured sand is artificial sand obtained from crushing hard stones into small sand-sized angular-shaped particles, washed and finely graded to be used as construction aggregate. It is an alternative to River Sand used for construction purposes.

3.3. Coarse Aggregate

Coarse aggregate hare massive structure entirely crystalline of wholly, glassy of in combination in between, depending upon the rate at which they were cooled during formation. Aggregates are the important constituent in concrete. They give concrete to, reduce shrinkage of the concrete.

3.4. Water

Water is an important ingredient of concrete as its activity participated in the chemical reaction with cement. Since it helps to form the strength giving the cement get, the quantity and the quality of water is required to be looked into very careful.

3.5. Glass Fiber Reinforced Polymer

They present much higher life service in reinforced concrete than the steel reinforcement. Hence the use of GFRP rebars is more durable than the steel rebars. Apart from being corrosive resistance GFRP rebars is also economic. Being light in weight, transportation cost as well as storage and maintenance cost is much less than steel. Likewise, in extreme weather, heat and cold can be conducted by steel bars but on the other hand the GFRP bars cannot conduct electricity or heat and cold which can assist extra assurance for not causing issues especially in building structures such as hospital rooms [6-7].

4. Types of Tests

- Compressive Test
- Water Absorption Test
- Impact Test

4.1. Compressive Test

The given Table 1-3 shows the ultimate tensile strength of the steel rebars, GFRP rebars and sand-coated GFRP rebars. The compressive strength of each sample after 28 days curing is also shown. 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 [8].

Table 1 Compressive and Tensile Strength of the Samples after 28 days

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

Table 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

Table 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

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 [9, 10]. The following points are the conclusion concluded from the paper:

- 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.
- 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.
- 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.
- 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.
- The flexural strength value of sand-coated GFRP reinforced concrete and GFRP reinforced concrete are closer to the steel reinforced concrete beams hence, it can be suitable to use as an alternative for the steel reinforcement construction.

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