IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

"GLASS FIBER REINFORCED POLYMER REBARS: A SUSTAINABLE ALTERNATIVE FOR CONCRETE REINFORCEMENT"

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Abstract: This study compares the flexural properties of concrete beams reinforced with GFRP and steel rebars. Beams with a 100mm x 100mm cross-section and 500mm length, each using 12mm diameter rebars, are tested to assess GFRP's viability as a reinforcement material. The paper also explores why GFRP rebars, despite their advantages, are still underused in some area

Index Terms - GFRP, Flexural Strength, rebars & composites.

I.INTRODUCTION

Benmoktane, 0. Chaallal and R. Masmoudi (2019) discussed the use of glass fiber reinforced plastic in concrete structures. The authors prepared a sample of two types of GFRP rebars 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 rebars 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 rebars 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.

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.

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.

Renata Kotyniaa, Damian Szczecha and Monika Kaszubsk (2017) researched on the bond behavior of GFRP bras to concrete in beam test. The authors prepared 12 rectangular concrete beams with cross section 150mm x 200mm of length 800mm. The beams were tested on the four point loading by the displacement control system with hydraulic jack of 200kN capacity. The system consisted of linear variable differential transducer

(LVDT) and one strain gauge to record bar slip. The result concluded that the bond failure developed partially along the surface of the bar and in surrounding concrete by peeling off the external fibers of the bars.

In the present paper I have used glass fiber as a substitute for steel reinforcement to enhance the strength.

I. RESEARCH METHODOLOGY

- **MATERIALS AND METHOD**

- **CEMENT**

Ordinary Portland Cement (OPC) is the most widely used cement in construction. According to BIS standards, the minimum compressive strength for 43-grade OPC is an impressive 43 MPa, making it a reliable choice for various structural applications.(1)

- **SAND**

a. Fine Aggregate

Manufactured sand is a high-quality artificial sand created by crushing hard stones into angular, sand-sized particles. It undergoes washing and precise grading, making it an excellent alternative to river sand for construction. Durable and eco-friendly, Manufactured sand is reshaping modern construction practices.(1)

b. Coarse Aggregate

Coarse aggregates are robust, solid materials with structures ranging from entirely crystalline to glassy, depending on their cooling rate during formation. As a key component of concrete, they provide strength, stability, and volume while minimizing shrinkage. These aggregates are the backbone of durable and long-lasting concrete structures.(1)

- **WATER**

Water plays a crucial role in concrete production, actively participating in the chemical reaction with cement to form strength-giving compounds. The strength and durability of concrete directly depend on the quality and quantity of water used, making careful selection and monitoring essential for optimal results.(1)

- **GLASS FIBER REINFORCED POLYMER**

Glass Fiber Reinforced Polymers (GFRP) are crafted through a process called fiberization. Molten glass is delicately extruded through fine openings in a platinum alloy bushing, forming ultra-thin fibers. These fibers are rapidly cooled, collected, and drawn into filaments with high-speed winders. To ensure durability and prevent breakage, the filaments are coated and bundled, ready to revolutionize construction and engineering applications.

II. PREPARATION OF SAMPLE

The sample for this study is prepared by using following materials, (all quantities for 1m3 volume of concrete)The methodology section outline the plan and method that how the study is conducted. This includes Universe of the study, sample of the study,Data and Sources of Data, study's variables and analytical framework. The detailsare as follows;

Requirement	**Cement**	**Coarse aggregate**	**Fine aggregate**	**Water**
Content	355	895	1115	145
Unit	Kg/m^3	Kg/m^3	Kg/m^3	Kg/m^3
Design mix : 1:2.54: 3.17 **Concrete grade -M30**				

Table 1: Material content

III. MANUFACTURING PROCESS

GFRP rebars are produced using the advanced pultrusion method, where fiberglass filaments are carefully infused with resin. These filaments are then drawn through a heated mold, where they are shaped and cured to form durable rebars. This continuous process ensures high strength, consistency, and precision, making GFRP rebars a game-changer in modern construction(3).

The production of GFRP rebars begins with high-quality fiberglass filaments, resin (such as polyester, polyurethane, vinyl ester, or epoxy), and cutting-edge machinery. Fiberglass filaments are unspooled, tensioned, and dipped into a resin bath, ensuring perfect impregnation. Excess resin is carefully removed, and the fibers are fed into a specialized mold where they form a ribbed surface for added grip. The fibers are then shaped and undergo polymerization, resulting in strong, durable, and precisely crafted GFRP rebars that are ready to withstand the test of time.

- **WHY GFRP REBARS OVER STEEL REINFORCEMENT BARS**

GFRP rebars stand out for their remarkable corrosion resistance and electromagnetic neutrality, making them the perfect choice for reinforcing concrete structures. Unlike traditional steel, which succumbs to corrosion from environmental factors, GFRP bars offer a long-lasting, corrosion-resistant solution that significantly boosts the durability of reinforced concrete. As an increasingly popular alternative to steel reinforcement, GFRP bars tackle corrosion challenges head-on, ensuring concrete structures maintain their strength and integrity for years to come(4).

- **THE GROWTH OF GFRP REBARS**

In recent years, the demand for GFRP (Glass Fiber Reinforced Polymer) rebars has soared, driven by their unmatched benefits in marine construction, including bridges and highways. As a superior alternative to steel rebars, GFRP offers outstanding durability, reduced maintenance costs, and increased longevity. This transformative material is revolutionizing the construction industry, leading the way toward more sustainable, resilient, and cost-effective infrastructure solutions. GFRP rebars are not just changing how we build—they are shaping the future of construction itself.

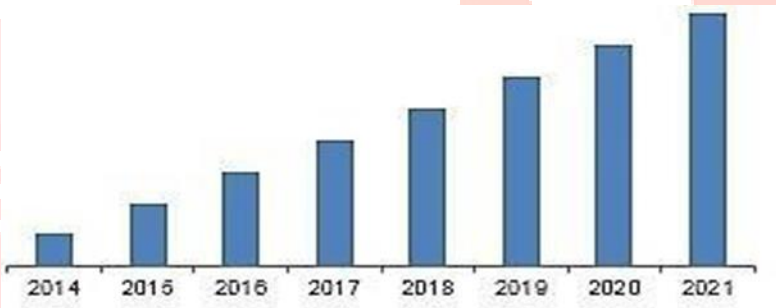

Fig.1: Graph showing increase of GFRP rebars in market. (source by industry ARC Analysis and expert Insight

- **SIGNIFICANCE OF STUDY**

While concrete is strong under compression, it falls short in tensile strength, necessitating reinforcement rebars to improve its performance under stress. GFRP (Glass Fiber Reinforced Polymer) rebars, much like traditional steel, offer the same essential reinforcement—but with remarkable benefits. These advanced rebars bring superior durability, corrosion resistance, and long-lasting performance, making them a game-changing alternative to steel in modern concrete construction.

As steel rebars are known for their elasticity, ductility, and impact resistance, they face serious drawbacks in harsh environments—corrosion that leads to concrete cracks and potential structural failure, as well as vulnerability to high temperatures (2). GFRP rebars offer a breakthrough solution, with exceptional resistance to corrosion from alkaline and sulfur attacks, superior tensile strength, and a high modulus of elasticity that ensures they won't crush under pressure. These advanced features not only enhance the durability and safety of structures but also provide a more cost-effective, reliable, and long-lasting reinforcement option for modern construction(5).

CONCLUSION

- **Corrosion Resistance:** GFRP rebars excel in marine and harsh environments, offering superior resistance to corrosion and extending the service life of structures far beyond that of steel reinforcement.
- **Cost-Effective:** With a longer lifespan and reduced maintenance needs, GFRP rebars provide excellent long-term value, making them more cost-efficient over time.
- **Lightweight and Easy to Handle**: Their lightweight nature lowers transportation, storage, and handling costs, providing an economic advantage for construction projects.
- **Enhanced Safety:** Unlike steel, GFRP rebars do not conduct heat or electricity, offering added safety—particularly in sensitive environments such as hospitals and power plants.
- **Versatile Applications:** Among various Fiber Reinforced Polymers (FRP), GFRP is the most widely used due to its affordability, high tensile strength, and excellent insulating properties.

GFRP rebars are reshaping the construction industry, offering sustainable, durable, and safe solutions for modern infrastructure.

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