

Study on Mechanical Performance of Graphite with GFRP in Structural Engineering

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Abstract—The usage of composite reinforcement in civil engineering has increased due to growing interest in durable, corrosion-free, and ecologically friendly building materials. Because they are lightweight, have a high tensile capacity, and do not corrode, Glass Fiber Reinforced Polymer (GFRP) and graphite-based reinforcing bars are becoming more popular alternatives to conventional steel. The mechanical response and structural contributions of these composite systems are investigated in this paper, with a particular emphasis on GFRP and graphite fiber reinforcements. The study examines their basic material characteristics, manufacturing processes, and suitability for elements of reinforced concrete. Tensile performance, stiffness, bond interaction with concrete, and overall structural capacity under load are all assessed in the experimental component.

Results indicate that both graphite reinforcement and GFRP offer good strength-to-weight properties, robust durability, and significant environmental exposure tolerance. Surface modification techniques can greatly increase adhesion, even though their bond with concrete is usually less than that of steel. According to the research, employing composite reinforcement may help concrete structures last longer and require less upkeep. In order to assist the creation of more dependable and sustainable infrastructure, these materials seem to be well suited for usage in bridges, buildings, and systems that need increased seismic resistance. To improve material configurations and gain a better understanding of long-term performance under various service situations, more research is advised.

Index Terms—Graphite with Glass Fiber Reinforced Polymer, High Yield Strength Deformed, Reinforced Cement Concrete, fiber-reinforced polymer

I. INTRODUCTION

The investigation of cutting-edge composite materials for structural applications has been prompted by growing worries about the robustness and susceptibility to corrosion of traditional reinforcing. Excellent mechanical strength, chemical stability, and long-term dependability are provided by graphite reinforcement, which is made up of carbon fibers bonded within a polymer matrix. In a similar vein, within the last two to three decades, glass fiber reinforced polymer (GFRP) bars have become more well-known as environmentally friendly alternatives to steel reinforcement. The corrosion of HYSD steel bars is a recurring problem in reinforced cement concrete (RCC) systems that reduces structural strength, speeds up deterioration, and reduces service life. This research is motivated by the need to determine reinforcement strategies that can more successfully handle these difficulties. The main objective is to assess and contrast the behavior of RCC beams reinforced with HYSD steel and those reinforced with graphite fiber bars.

Flexural strength, load-deflection patterns, material properties, and crack formation under applied loads are all examined in this study. The theoretical background, experimental program, results analysis, and findings and recommendations are the sections that make up this study.

II. LITERATURE REVIEW

Rehabilitation and retrofitting methods for old structures have been the focus of extensive research over the past few decades. Researchers from all

around the world have looked into problems with the production, use, and long-term maintenance of carbon fiber materials in order to facilitate their use in highly loaded civil engineering systems. Many academics and organizations are still working to create carbon fiber-based infrastructure solutions that are more effective, long-lasting, and energy-efficient. The main conclusions of previous research on carbon fiber as a strengthening material are compiled in this chapter. Glass Fiber Reinforced Polymer (GFRP) reinforcement has become a competitive alternative to conventional steel bars in tandem with this endeavor. GFRP rebars are prized for their strength- to-weight qualities, corrosion resistance, and lower maintenance needs (Bank et al., 2003).

GFRP bars have a high tensile capacity and stiffness and exhibit no signs of corrosion-related deterioration, according to extensive mechanical testing (Micelli et al, 2005). Strong resistance to fatigue, impact loading, and environmental exposure has been found in studies on the durability of GFRP reinforcement (El-Sayed et al., 2007). Although this restriction can be lessened by surface treatments like sandblasting or chemical modification, research on bond behavior has shown that the bond strength between concrete and GFRP bars is generally lower than that of steel (Bank et al., 2007). Bridges, building renovations, and seismic retrofitting projects have all effectively used GFRP reinforcement (El-Sayed et al., 2010). According to research on seismic conditions, GFRP bars preserve structural performance without showing any signs of deterioration (El-Sayed et al., 2012).

III. METHODOLOGY

A. SUBSECTION 1 -

Due to the increasing demand in the modern construction industry, fabrication techniques for Fiber Reinforced Polymer (FRP) composites are continuously being improved. Advanced manufacturing methods help reduce production cost, processing time, and component weight while improving strength and durability. Techniques such as contact molding and matched-die molding are widely used for producing GFRP and CFRP components with better quality and efficiency.

B. SUBSECTION 2 -

Material Preparation and Fabrication Process

1. Material Preparation

Graphite in powder or sheet form is prepared according to the required size and fineness. Glass fibers such as mats or rovings are cut and arranged based on the laminate design. The polymer resin, commonly epoxy, polyester, or vinyl ester, is mixed with a suitable hardener before use.

2. Mixing Process

Graphite powder is added to the resin in a measured proportion and mixed thoroughly to achieve uniform dispersion and reduce air voids.

3. Laminate Construction

A layer of glass fiber is placed on the mold surface and impregnated with the graphite-resin mixture. Additional layers are added sequentially until the required thickness and strength are achieved.

4. Curing Process

The laminate is cured either at room temperature or under controlled heating conditions using an oven or autoclave. Post-curing may also be performed to improve mechanical properties.

5. Finishing Operations

After curing, the composite is removed from the mold and finished by trimming, sanding, or machining. Surface coatings may also be applied for improved durability and appearance.

IV. RESULTS AND DISCUSSION

Material	Di a of mm	Max Force kN	Maxi Displac e ment mm	Tensile Strength N/mm ²
HYSD Bar	10	42.80	11.50%	545.00
GFRP Bar	10	60.45	2.32	769.697
Graphite GFRP Bar	10	102.9	4.39	1310.41

Interpretation of Results

The tensile test results indicate that the Graphite GFRP bar exhibited the highest tensile strength among all the reinforcement materials tested. The tensile strength of the Graphite GFRP bar was found to be 1310.41 N/mm², which is significantly higher than that of the conventional HYSD steel bar and normal GFRP bar. This demonstrates the superior load-carrying capacity and enhanced mechanical performance of Graphite GFRP reinforcement under tensile loading.

The GFRP bar also showed better tensile performance compared to the HYSD steel bar, with a tensile strength of 769.697 N/mm². However, the maximum displacement of the HYSD bar was greater, indicating higher ductility and deformation capacity before failure. In contrast, the FRP bars exhibited lower displacement values due to their brittle nature.

Overall, the experimental results confirm that Graphite GFRP bars possess excellent tensile properties and can be considered as an effective alternative reinforcement material in reinforced concrete structures, especially where high strength and corrosion resistance are required.

V. CONCLUSION

The present study investigated the tensile performance of HYSD steel bars, GFRP bars, and Graphite GFRP bars used as reinforcement materials in RCC structures. The experimental results showed that the Graphite GFRP bar exhibited the highest tensile strength of 1310.41 N/mm², which was significantly greater than that of conventional HYSD steel and normal GFRP bars. The GFRP bar also demonstrated better tensile capacity compared to HYSD steel reinforcement. The study confirmed that composite reinforcement materials possess excellent strength-to-weight ratio, corrosion resistance, and durability properties. Although HYSD steel bars showed higher ductility and displacement before failure, FRP bars exhibited superior strength characteristics under tensile loading. The lightweight nature of GFRP and Graphite GFRP bars also makes handling and transportation easier in construction applications. These materials are suitable for structures exposed to aggressive environmental conditions such as marine and chemical environments. Overall, Graphite GFRP reinforcement can be considered a promising and sustainable alternative to conventional steel reinforcement in modern reinforced concrete

construction.

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