

Original Article

Impact Behaviour of Graphene Coated Reinforcement Bars

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Abstract: The performance of reinforcement bars is critical in ensuring the strength and durability of structural systems. Conventional steel reinforcement bars, although widely used for their high tensile strength and ductility, are highly susceptible to corrosion and mechanical damage when exposed to harsh environmental conditions. This deterioration reduces structural efficiency and increases maintenance costs over time. To overcome these limitations, advanced surface modification techniques such as graphene coating have been introduced to enhance the properties of reinforcement bars. In this study, the behaviour of graphene-coated reinforcement bars is investigated with a focus on their mechanical and impact performance. Graphene, known for its exceptional strength and corrosion resistance, forms a thin protective layer on the steel surface, preventing the penetration of moisture and harmful chemicals. Experimental observations indicate that graphene-coated bars exhibit improved strength, higher impact resistance, and enhanced durability compared to conventional bars. Thus, graphene coating presents a promising solution for developing long-lasting and high-performance reinforcement materials

Keywords: Reinforcement Enhancement, Graphene Coating, Nanomaterials, Impact Behavior.

I. INTRODUCTION

The integration of advanced nanomaterials into traditional engineering processes has dramatically reshaped the landscape of materials science. In particular, graphene—a single layer of carbon atoms arranged in a two-dimensional hexagonal lattice—has emerged as one of the most transformative materials of the 21st century. Owing to its exceptional mechanical, electrical, thermal, and chemical properties, graphene has garnered significant attention across various industries. Among these, the steel industry stands to benefit immensely from graphene integration, especially in applications requiring durability, light weight, and corrosion resistance. This paper explores the potential of graphene in manufacturing high-quality, cost-effective steel and evaluates its applications in offshore design where environmental and mechanical demands are particularly severe.

II. LITERATURE REVIEW

Graphene has a mechanical strength 200 times greater than that of steel, it is an excellent material for strengthening metal matrices. It significantly increases tensile strength, hardness, fatigue resistance, and ductility when added to steel. Incorporation of Graphene with Reinforcement bars can improve the strength and durability of the reinforcement compared to the conventional one. Graphene allows the production of high-strength steel with lower alloy content, making it cost-effective without compromising quality. Graphene's high thermal conductivity enables better heat dissipation during fabrication processes like welding. Integration of graphene can help in weight reduction by allowing thinner steel sections without loss of strength. The anti-corrosive and high-strength nature of graphene-enhanced steel is ideal for offshore platforms, floating structures, and underwater pipelines. Graphene-steel composites offer longer service life, reduced need for replacements, and lower environmental footprint.

III. METHODOLOGY

- Material Characterization and Procurement: Collection and verification of Fe550D steel bars and reduced graphene oxide (rGO) materials.
- Surface Preparation of Steel Samples: Cleaning, polishing, and pre-treatment of rebar surfaces to ensure effective graphene adhesion.
- Graphene Coating Process: Application of rGO coating using a controlled surface coating technique (spray or dip-coating).
- Mechanical Testing: Conducting Drop Weight impact test and bend test to evaluate Impact Behaviour of the Rebar

IV. RESULTS AND DISCUSSION

A. Drop Weight Impact Test

In the Drop Weight Impact Test, the capacity for energy absorption and resistance to impact by a reinforcement bar is evaluated by dropping a known mass from a predetermined height onto a rebar sample.



Figure 1: Drop Weight Impact Test

The resulting response (deformation or failure) is recorded so that it can be correlated to the toughness and post-impact behaviour of rebar. The test is intended to simulate both accidental loading, and those due to impacts, that occur when using reinforced concrete. The number of blows required to crack initiation and number of blows required to specimen failure has shown in Table 1.

Table 1: Drop Weight Impact Test Result

Sample	Specimen Type	Number of Blows to Bend Initiation	Number of Blows to Deform
1	CRSB	18	32
2		17	30
3		19	33
1	GCRSB	25	45
2		26	47
3		24	44

Table 2: Impact Energy Absorbed by the Specimen

Sample	Impact Energy Absorbed by the Specimen at Failure
CRSB - 1	720.32
CRSB - 2	675.3
CRSB - 3	742.83
GCRSB - 1	1012.95
GCRSB - 2	1057.97
GCRSB - 3	990.44

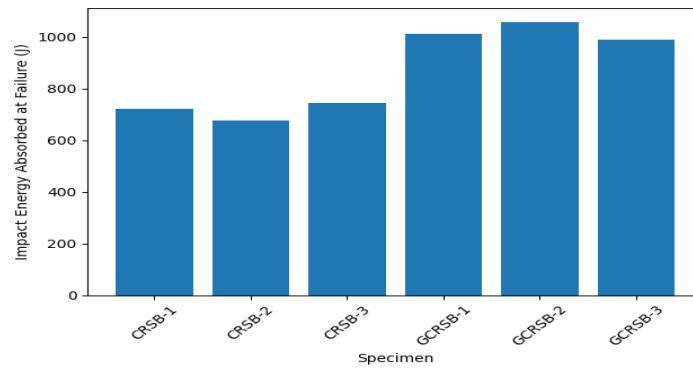


Figure 1: Bar Chart of Impact Energy Absorbed at Deformed Stage

a) Bend Test

The bend test evaluates the ductility and flexibility of the reinforcement bar by bending it through a specified angle without cracking or fracturing. It helps verify the steel’s capacity to withstand bending during handling and placement.



Figure 2: Bend Test Conducted on UTM

Table 3 shows that the behaviour of control specimen and the graphene coated specimen under bend test, at the end the specimens are bent to 180° and the changes has been noted down.

Table 3: Bend test results of CRSB and GCRSB

Sample	Specimen Type	Crack Formation at 180°	Remarks
1	CRSB	No Visible Cracks	Passed
2		No Visible Cracks	Passed
3		No Visible Cracks	Passed
1	GCRSB	No Visible Cracks	Passed
2		No Visible Cracks	Passed
3		No Visible Cracks	Passed

The bend test was carried out on CRSB and GCRSB, both of which were bent to an angle of 180 Degrees, in order to evaluate ductility and surface integrity. All CRSB and GCRSB in Table 3 had no visible cracks upon bending to 180 Degrees. All samples passed the test indicating that both types of reinforcement bars contain sufficient ductility and meet the standard requirements for the bend test.

V. CONCLUSION

Available data shows significant improvements that could occur from the application of Graphene Coating on conventional forms of steel rebar. Results from drop weight impact testing and bending tests support the fact that graphene coated rebar GCRSB exhibit higher levels of toughness or ability to withstand impact and significantly more energy

absorption capabilities than traditional rebar CRSB. The total number of blows required to deform both types of rebar, along with total energy values recorded during drops, provides clear evidence that the toughness and durability of the rebar is improved with the application of a graphene coating.

In addition, in regards to the bending tests performed between both types of rebar, neither the coated nor uncoated exhibited any reduction in ductility as both types were able to bend 180° without showing signs of cracking. The findings indicate that the strength and durability provided by the coating is favorable for both types of rebar (i.e., coated and uncoated) with no accompanying reduction in flexibility. As such, applying graphene coatings to rebar offers an excellent opportunity for the use of surface modification to provide enhanced mechanical performance, impact loading resistance, and long-term service life. Improved performance when applied to reinforced concrete structures will have a significant impact on future construction projects requiring durability and resistance to the elements. Future research on this type of surface modification should include long-term durability testing, testing in additional application areas beyond the normal stay-at-home use, and methods to optimize cost to promote practical use within the building and construction profession.

VI. REFERENCES

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