Analysing Textile-Reinforced Concrete to Strengthen Reinforced Concrete Beams with ANSYS

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***Abstract*—One of the challenges engineers are facing today is reinforcement of reinforced concrete beams. Although there are several ways of going about it, textile-reinforced concrete has gained momentum in engineering. In comparison to conventional methods of reinforcement, the benefits developed by TRC are immense and can therefore be used for various purposes. The reinforcing of textiles with glass or carbon fibers makes them a combination suitable for generating strong material superior to that of conventional concrete. This is because it enables the construction of structures such as foundations, bridges, and beams among others with high strength. This article looks at how TRC material can be used to reinforce existing beams and analyzes the performance gains using ANSYS.**

***Keywords*— Textile-Reinforced Concrete (TRC), Reinforced Concrete Beams, Structural Strengthening, Finite Element Analysis (FEA), ANSYS Simulation, Flexural Behaviou, Load–Deflection Response**

I. INTRODUCTION

The reinforced concrete beams are some of the most widely used structural elements in civil engineering constructions and bridges. However, their susceptibility to easy deterioration whenever they bear compressive and shear forces means engineers should always look for ways of strengthening these elements. Such elements can be strengthened by use of a new form of material known as textile-reinforced concrete. It is a special type of concrete mixed with fabric reinforcement to produce a very strong and durable material.

Textile-reinforced concrete was developed as a means to combine tensile strength from steel with the durability of concrete into a new, innovative construction solution. This composite material, developed in the early 2000s, has been shown to greatly improve the load-carrying capacity of reinforced concrete beams. In retrofitting and strengthening reinforced concrete beams, TRC could serve as an alternative or complement to the traditional methods. For replacing the use of steel bars or mesh in some structures, TRC depends on laying a layer of high-strength textile reinforcement on either side of the beam, making it essentially a sandwich structure that holds superior load-carrying advantages. This also contributes to an increased life span and to the improved strength and stability performance of beams made with reinforced concrete.

Benefits of Using Textile-Reinforced Concrete

First, textile-reinforced concrete has increased strength as compared to conventionally reinforced concrete. This is so because the fibrous structure of the textile material disperses forces imparted on the beam, making it hardier and helping it bear heavier loads.

This reinforcement is ideal for sustainability in that, without the steel fibers inside, it can avoid any corrosion that might have taken place with any steel reinforcement bar whenever coming into contact with water or any moist surroundings; it means longer life for your infrastructure with fewer repairs over some time.

Finally, there is also an economic benefit to be seen with this type of augmentation. Because of the stability within the structure, it has shown to be cost-effective both in the long run and without the need for repairs, so any savings you may seek to find in the short run will only be amplified further down the line.

II. PROPOSED METHODOLOGY

In reinforced concrete beams, TRC strengthening is a new technology that features pretensioned steel strands in a matrix of synthetic fibers. Compared to previously tested beams, this reinforcement increases the tensile strength of the beam to allow a greater weight and load. This paper aims to support the use of ANSYS in modeling the mechanical behavior of textile-reinforced concrete in reinforced beams. The simulation through ANSYS offered information on how the load was distributed across the beams and allowed a visualization of how the textile reinforcement affected the beams' performance. The finite element analysis requires the "finite elements," a collection of elements that are all connected through a finite set of nodes.

GFRP BARS with MODELING OF BEAMS

In the last couple of decades, there has been an increased usage of glass fiber-reinforced polymer reinforcement in beams based on GFRP bars. Increased corrosion resistance and light weight are two major advantages that make them preferable in case of comparison with traditional steel reinforcement. However, their behavior under some kinds of loading was not well understood up until now, and the modeling of their behavior often presumes some sort of simplification. Material properties should be considered when it comes to modeling beams with GFRP bars, including stiffness, strength, and modulus of elasticity. Further, the interaction between GFRP bars and concrete beams is considered, including such issues as bond characteristics, shear transfer, and confinement. Simultaneously, the impact of environmental conditions cannot be underestimated for the GFRP bars in case of such factors like temperature, humidity, and UV exposure. Totally, three full-size GFRP beams were modeled in which the set consisting of 3 models for grade beams reinforced with 16mm, 20mm, and 24mm GFRP bars.

After setting the material properties and specifying the environmental condition, it is now possible to model beams containing GFRP bars using numerical techniques. The FE method is presently the most widely used among the numerical techniques available. Under FE methods, one can study beams against different kinds of loading conditions: axial, bending, and shear forces.

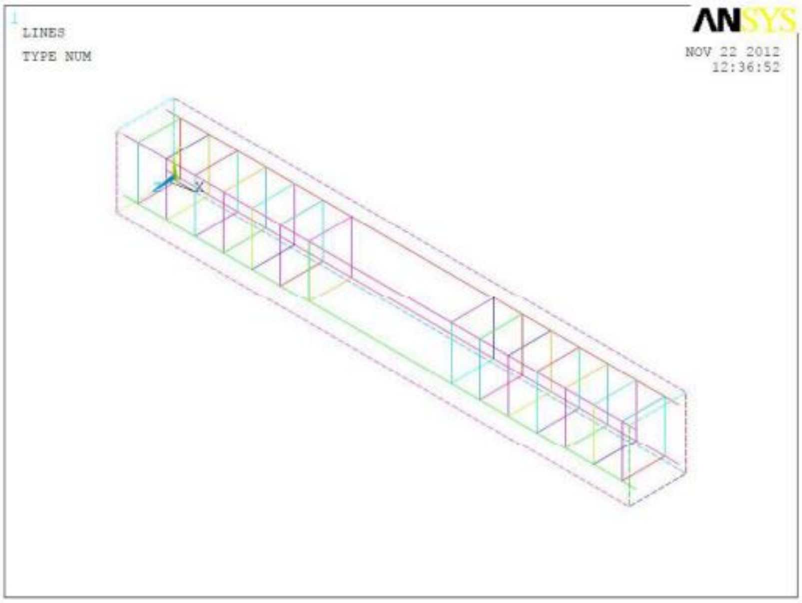

Figure 1. GFRP Beam Reinforcement Model

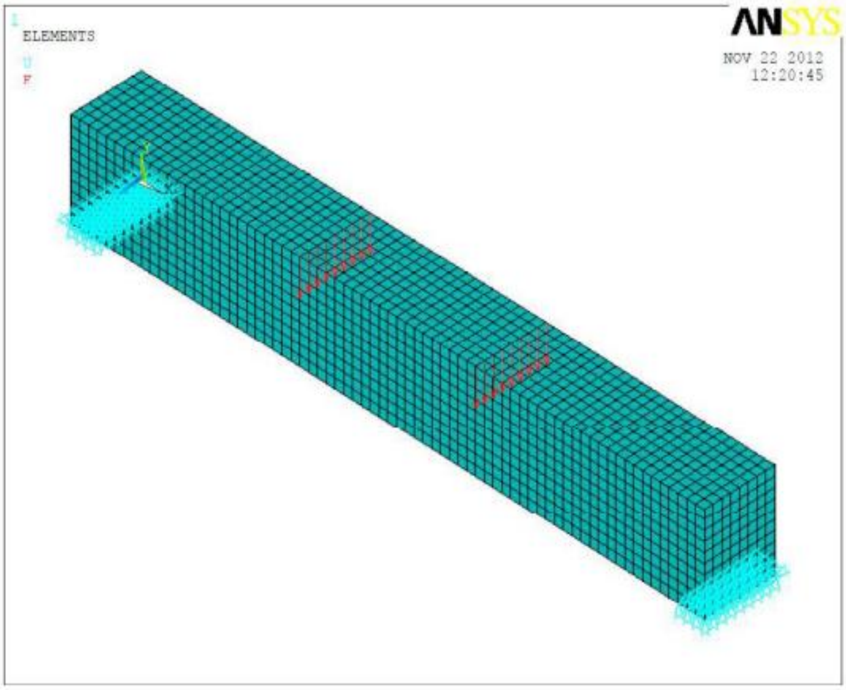

Figure 2. Condition of Support and Loading

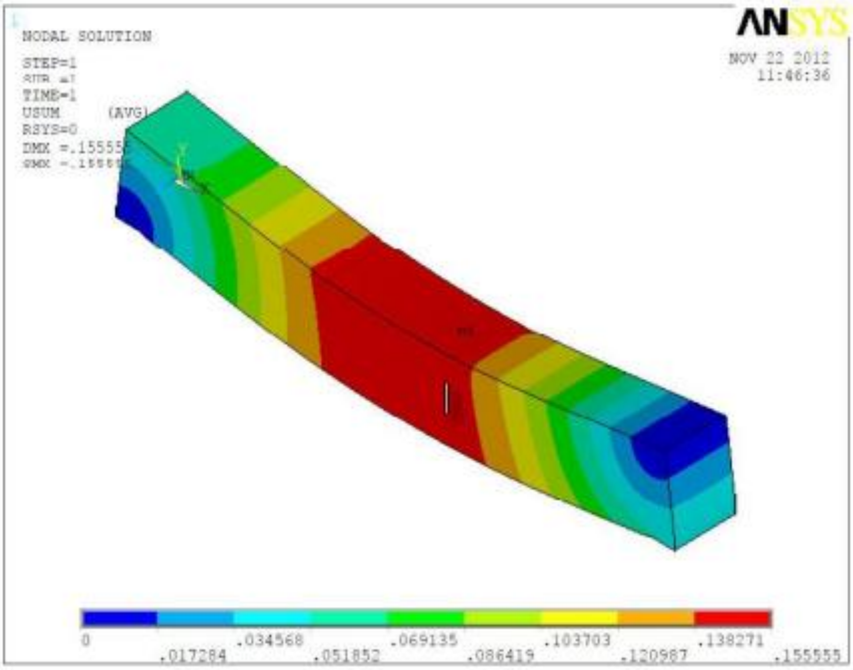

Figure 3. Deflection of the beam

III. RESULT AND DISCUSSION

Below is the graph showing deflection of beams that were without stirrups against an increase in the load applied. It was observed that from the analytical results, deflection increased proportionally with an increase in load. However, from the experimental results, load increased exponentially with deflection. The discrepancy of the results obtained analytically and those obtained experimentally were blamed on the existence of the stirrups in the beam. Figures 4, 5, and 6 show the results.

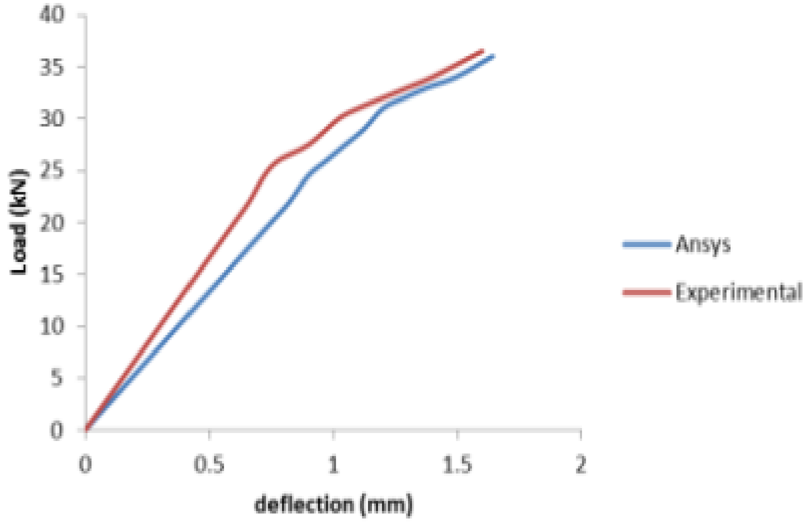

Figure 4. Control Beam's Deflection vs Load graph

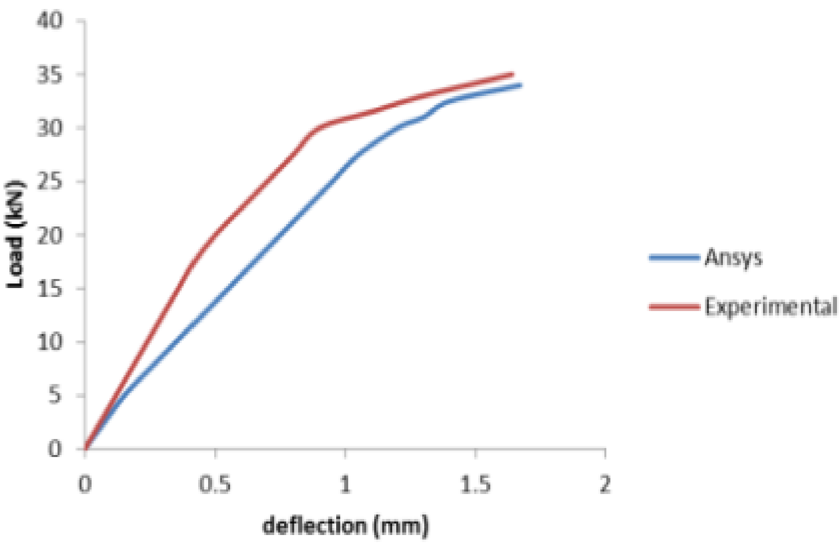

Figure 5. Deflection vs Load graph of Composite beam with 15% replacement of aggregate

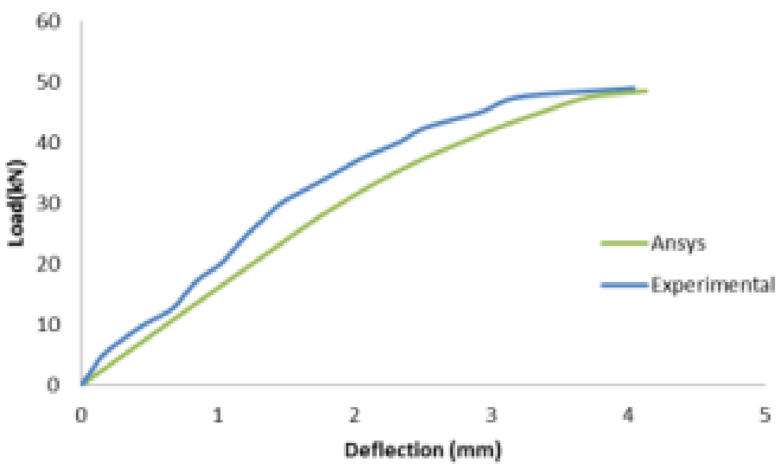

Figure 6. Load vs Deflection graph of Control Beam

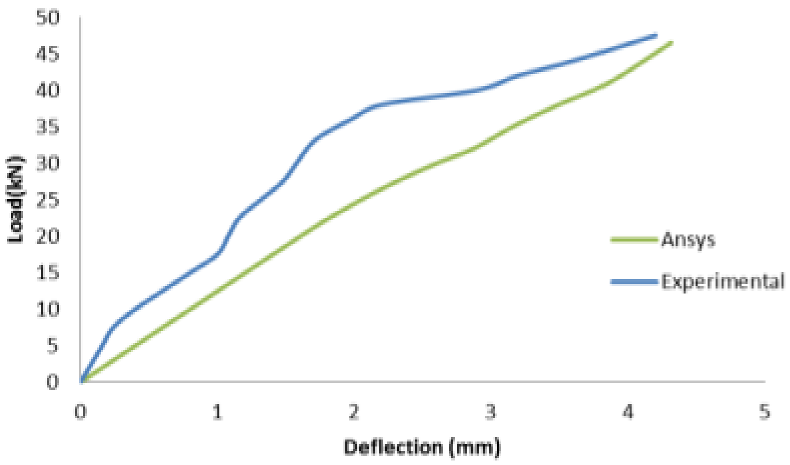

Figure 7. Deflection vs Load graph of Composite beam with 15% replacement of aggregate

IV. DISCUSSION

The experimental and the analytical results, on comparison, demonstrated minor differences. The analytical result was also found to have poorer load deflection characteristics and load bearing capabilities compared to what was recorded in the experiment.

V. CONCLUSIONS

The load deflection relationship for the control beams and the composite beams from the experimental and analytical analysis came out to be similar. Similarly, the experimental and analytical beam gave the same load bearing capacity for both the control beam and the composite beam. From the results obtained in this analysis of textile-reinforced concrete, enhancement of durability, strength, and safety is possible in reinforced concrete beams.

Declarations

Availability of Data and Material
The data generated and analyzed during this study, including numerical simulation results and analytical observations, are presented within the manuscript. Additional supporting data, finite element modeling details, and simulation inputs are available from the corresponding author upon reasonable request for academic and research purposes.

Competing Interests
The authors declare that they have no competing financial or non-financial interests that could have influenced the research outcomes or the preparation of this manuscript.

Funding
This research did not receive any specific grant from public, commercial, or not-for-profit funding agencies. The work was carried out as part of the authors' academic research activities.

Authors' Contributions
Salla Arun Tejadhar Reddy carried out the conceptualization of the study, numerical modeling using ANSYS, data analysis, and preparation of the manuscript. Prashant S. Lanjewar contributed to research supervision, methodological guidance, interpretation of results, and critical revision of the manuscript. Both authors read and approved the final manuscript.

Ethical Consideration
This study is based on numerical modeling and analytical investigation and does not involve human participants, animals, or clinical experimentation. All analyses were conducted in accordance with standard ethical and academic research practices applicable to civil engineering research.

Acknowledgements
The authors gratefully acknowledge the support and facilities provided by the Department of Civil Engineering, Dr. A. P. J. Abdul Kalam University, Indore (M.P.), India, for carrying out this research. The authors also thank colleagues and laboratory staff for their technical support and constructive discussions during the course of the study.

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