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COMPARATIVE STUDY ON CONVENTIONAL STEEL BEAM WITH GFRP NON-PRISMATIC BEAM USING ETABS

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Abstract –*This study presents a comparative analysis between conventional steel beams and glass fiber reinforced polymer (GFRP) Non-prismatic beams using E-Tabs software. The investigation focuses one evaluating the structural performance and behavior of these two types of beams under various loading conditions. The study involves modeling the beams in E-Tabs, incorporating realistic material properties and cross-sectional geometries. Analysis is conducted to assess factors such as deflections, crack formations, and overall load – bearing capacity. Through this comparative study, insights into the advantages and limitations of GFRP Non-prismatic beams and limitations of GFRP Non-prismatic beams compared to conventional steel beams are gained, providing valuable information for structural design and engineering practices. Through a detailed parametric study, the effects of key design parameters such as beam geometry, material properties, and support conditions on the performance of both types of beams are systematically investigated. Additionally, considerations are given to practical aspects such as construction feasibility, cost-effectiveness, and sustainability implications associated with the adoption of GFRP non-prismatic beams in real-world structural projects. The findings of this study aim to provide valuable insights into the comparative advantages and limitations of conventional steel beams and GFRP non-prismatic beams, thereby assisting structural engineers, architects, and decision-makers in making informed choices regarding material selection for structural design and construction projects. Moreover, the research contributes to the ongoing efforts towards advancing sustainable and resilient infrastructure practices in the construction industry.*

Key Words: Deflections, GFRP, Geometries, ETABS.

1.INTRODUCTION

The use of Glass fiber-reinforced polymer GFRP beams in structural engineering has garnered significant attention due to light-weight corrosion-resistant, and high strength properties. In comparison, Conventional steel beams have long been the staple in structural design, known for their durability and liability.

This study aims to conduct comparative analysis between conventional steel beam and GFRP non-prismatic beams using E-Tabs software. By evaluating structural performance of this two materials under various loading conditions. This research seeks to provide valuable insights to the advantages and limitations of GFRP non-prismatic beams. In comparison to conventional steel beams.

The introduction of GFRP beam presents an opportunity to explore innovative solutions for sustainable and resilient in structure designs and this study aims to contribute to the growing body of knowledge in this field.

The ETABS software, renowned for its robust finite element analysis capabilities, serves as the primary tool for conducting this comparative study. Through detailed modeling and simulation, the software enables the examination of various structural parameters, including deflection, bending moment, shear forces, and stress distribution, allowing for thorough assessment of the performance of both beam types.

Furthermore, this study takes into account practical consideration such as construction feasibility, cost effectiveness, and sustainability implication associated with the adoption of GFRP non-prismatic beams. By addressing these factors, the research aims to offer holistic insights into the viability of GFRP as potential substitute for conventional steel in structural applications, contributing to the advancement of sustainable and resilient infrastructure practices.

In summary, this comparative structural analysis seeks to elucidate the comparative advantages and limitations of conventional steel beams and GFRP non-prismatic beams, providing valuable knowledge to inform material selection decision and drive innovation in structural engineering practice.

1.1 Conventional Steel Beam

Conventional steel beams are widely used structural elements of composed of steel, known for their strength, durability and versatility. This beams are commonly manufactured from Hot rolled or welded steel sections, offering excellent load bearing capacity and resistance to deformation. They are extensively utilized in various constructions projects, including buildings, bridges and industrial facilities. Conventional steel beams are preferred for their ease of fabrication, availability and cost-effectiveness.

However, they may be susceptible to corrosion in certain environments, requiring maintenance or protective coatings steel beams remain a fundamental component in modern construction due to their reliability and widespread applicability.

Conventional steel beams are fundamental components in structural engineering, embodying a rich blend of material strength, versatility and extensive practical application. Fabricated primarily from carbon steel, these beams boast a formidable array of mechanical properties that underpin their structural integrity. High tensile strength ensures their ability to withstand significant loads, while ductility allows for controlled deformation under stress, providing crucial warnings of impending failure and enhancing overall safety.

Central to the versatility of conventional steel beams is the diversity of cross-sectional shapes available, each meticulously engineered to optimize load distribution and resistance to various forces. The selection of an appropriate cross-sectional shape is guided by meticulous adherence to established engineering codes and standards such as Indian Standard Codes.

Conventional steel beams offer a host of advantages. The widespread availability of steel from a multitude of suppliers further enhances its appeal, simplifying procurement processes and facilitating efficient project execution. Despite their numerous advantages, conventional steel beams are not without challenges. Foremost among these is the susceptibility to corrosion when exposed to moisture and harsh environmental conditions, necessitating the applications of protective coatings or the exploration of alternative corrosion-resistant materials. Moreover, the environmental impact of steel production, including energy consumption and greenhouse gas emission, underscore the pressing need for sustainable alternatives in contemporary construction practices.

In the forthcoming comparative structural analysis utilizing ETABS software, the behavior and performance of conventional steel beams will be meticulously scrutinized and juxtaposed against GFRP (Glass Fiber Reinforced Polymer) non-prismatic beams under a myriad of loading scenario. This rigorous examination aims to provide engineers and designers with comprehensive insights into the relative merits, limitations, and applicability of conventional steel beams. GFRP beams, thereby empowering informed decision-making and facilitating the adoption of sustainable, resilient structural solution in modern construction endeavors.

1.2 GFRP (Glass Fiber-Reinforced Polymer)

- Glass fiber-reinforced polymer (GFRP) Beams are structural elements composed of a matrix of polymer resin reinforced with glass fibers.
- These beams offer several advantages over traditional materials like steel, including high strength-to-weight ratio, corrosion resistance and electromagnetic neutrality.
- GFRP beams are light-weight, making them easier to handle and transport during construction.
- They are commonly used in application where corrosions are concern, such as marine structures, bridges and parking garages.
- Additionally, GFRP beams are non-conductive and non-magnetic, making them suitable for environments where electro-magnetic interference is a consideration.
- Overall, GFRP beams provide a durable and sustainable solution for various structural engineering need.

1.2 ETABS

ETABS (Extended Three-Dimensional Analysis of Building System) software stands as a cornerstone in structural engineering, renowned for its advanced capabilities in modeling and analyzing complex structural system. Developed by Computers and Structures, Inc. (CSI), ETABS offers a comprehensive platform for conducting detailed comparative analyses, such as the proposed study between conventional steel beams and GFRP non-prismatic beams.

At the core of ETABS lies its sophisticated finite element analysis (FEA) engine, which enables precise simulation of structural behavior under diverse loading scenarios. This entails predicting key parameters including deflection, bending moments, shear forces, and stress distribution with a high degree of accuracy. By leveraging FEA techniques, engineers can gain invaluable insights into the performance of structural systems, aiding in informed decision-making during the design process.

One of the software's standout features is its robust support for 3-dimensional modeling. ETABS facilitates the creation of intricate 3D models that faithfully capture the geometry, material properties and boundary conditions of structural elements such as beams, columns and slabs. This capability allows engineers to represent complex architectural and structural configurations accurately, ensuring a comprehensive analysis of the system behavior

Furthermore, ETABS offers extensive flexibility in defining material properties, critical for conducting comparative analyses involving different materials like steel and GFRP. Engineers can specify material parameters such as modulus of elasticity, yield strength and density, tailoring the analysis to the specific characteristics of each material. This capability enables a detailed examination of how variations in material properties impact the structural response, facilitating a nuanced comparison between conventional steel beams and GFRP non-prismatic beams.

Overall, ETABS serves as a powerful ally in the comparative structural analysis, empowering engineers to explore the intricacies of structural behavior and make informed decisions regarding material section, design optimization and performance assessment. Through its advanced features and intuitive interface, ETABS continues to be a preferred choice for engineers seeking to push the boundaries of structural design and innovation.

2.PLAN DISCRIPTION

The structure features a hybrid design incorporating both Glass Fiber-Reinforced Polymer (GFRP) and conventional steel beams. The ground floor layout includes a spacious entrance, the design optimizes natural light and ventilation, creating a comfortable living environment. Additionally, the ground floor includes reinforced areas to support heavy loads and accommodate structural elements.

The incorporation of GFRP beams ensures enhanced durability and resistance to corrosion, particularly in areas prone to moisture or environmental factors. Conversely conventional steel beams offer robust support and structural integrity. Complementing the overall design. Together, these beam systems provide a balanced approach to structural stability and longevity, contributing to the longevity and sustainability of the structure.

Table 2.1 Modelling Details

Building detail	Parameters
Plan dimension	8mx8m
Each bay dimension	8m
Earthquake zone	3
Response Reduction factor	5
Framing Type	SMF
Importance factor	1
Soil type	MEDIUM
Number of stories	G+1
Height of stories	3m
Height of building	3m
Beam size	Beam 1: -300x600mm Beam 2: - 300x1200
Column size	Circular Column1: - 400mm Circular Column 2: - 900mm Rectangular Column 1: - 400x400mm Rectangle column 2:- 800x800mm
Characteristic strength of concrete	40Mpa
Live load	UDL on Beam: -1.6kn/m2 UDL on Joint: -1.6 kn/m2 UDL on Column:-7 kn/m2
Dead load	UDL on Beam: -2.8kn/m2 UDL on Joint: -2.8kn/m2 UDL on Column:-16 kn/m2

3.MODELLING AND ANALYSIS

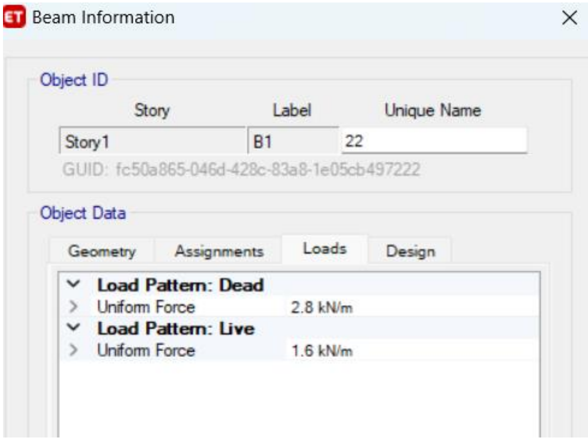

Figure 1: - Load Information

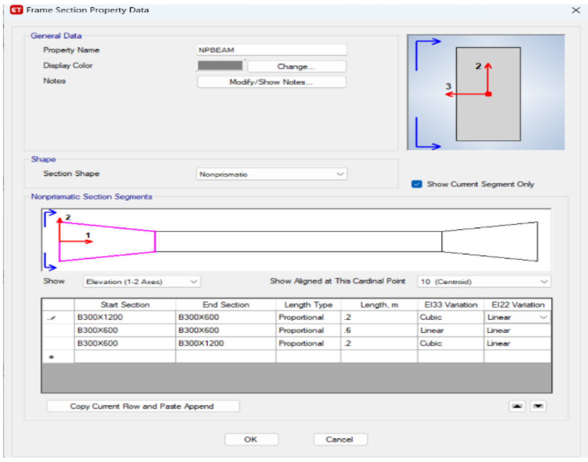

Figure 2:-Non-Prismatic Beam Dimensions

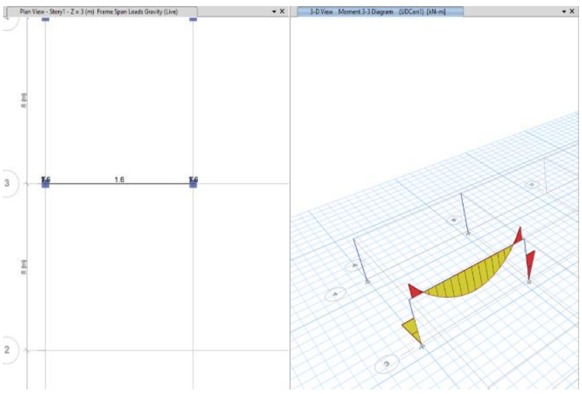

Figure 3: - Moment Diagram

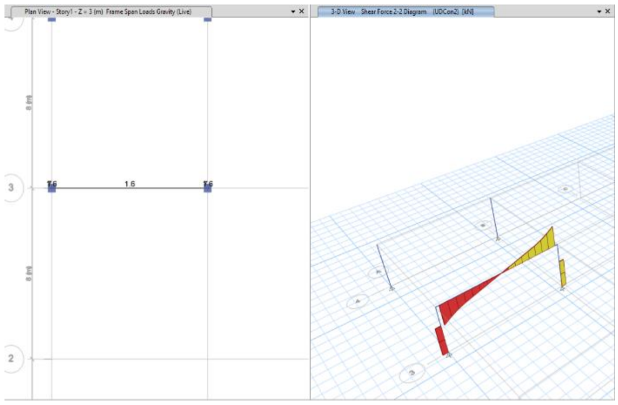

Figure 3: -Shear Force diagram

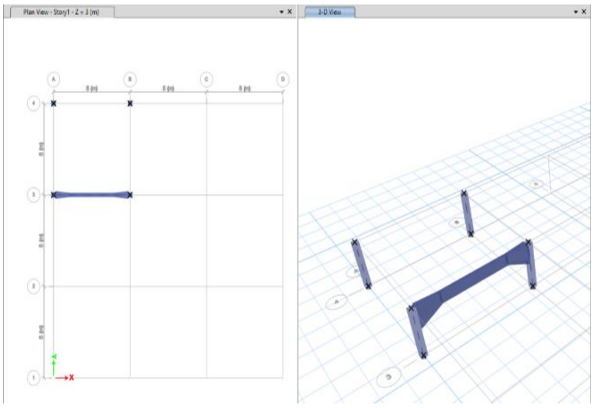

Figure 4: - 3-D Plan in E-Tab.

4. RESULT AND DISCUSSION

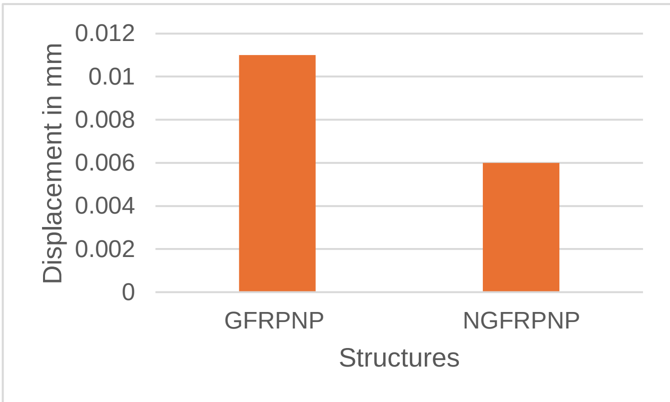

Fig.no. 4.1 Dead Load Graph.

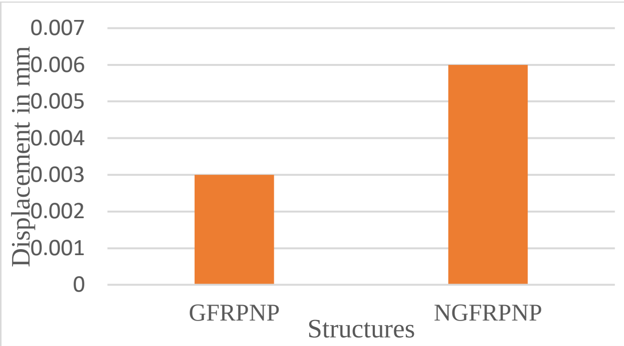

Fig. no.4.2 Displacement in live load

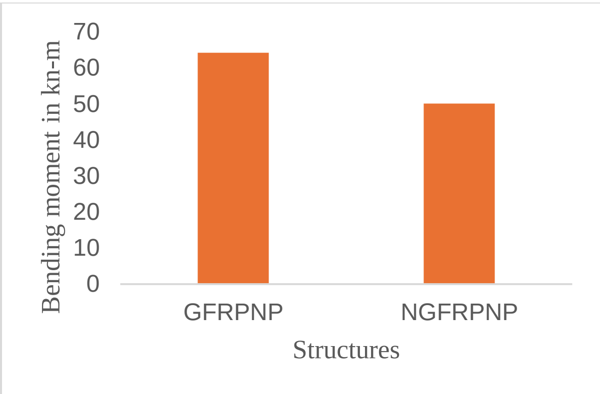

Fig. no.4.3 Maximum bending moment Graph.

Fig.no. 4.4 Maximum Shear Force Graph

5.CONCLUSION

In conclusion, the comparative study between conventional steel beams and GFRP non-prismatic beams using E-tabs software has provided valuable insights into the performance and behavior of these two materials in structural engineering application. Through detailed analysis of factors such as deflection, crack formations and load bearing capacity, it was observed that GFRP non – prismatic beams exhibit favorable characteristics such as corrosion resistance and high strength-to-weight ratio. However, challenges such as material cost and limited availability of standardize design codes for GFRP beams were also identify. Nonetheless, the findings of this study underscore the potential of GFRP beams as a viable alternative to conventional steel beams in certain structural applications, particularly in environment prone to corrosion. Moving forward further research and development efforts are warranted to addresses the challenges and capitalize on advantages offered by GFRP beams paving the way for more sustainable and resilient structural designs in future.

6.REFERENCES

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7.BIOGRAPHIES

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