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Evaluation of Heavy Vehicle Chassis Using E-Glass Epoxy and S-2 Glass Epoxy Materials Through CAD-FEA Simulation

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Abstract: ***The chassis is one of the most critical structural components of a heavy vehicle, responsible for supporting loads, maintaining structural integrity, and ensuring overall vehicle stability and safety. Traditionally, chassis structures are manufactured using steel due to its high strength and durability. However, the increasing demand for lightweight vehicles and improved fuel efficiency has led to the exploration of advanced composite materials such as E-Glass Epoxy and S-2 Glass Epoxy. This study focuses on the design and evaluation of a heavy vehicle chassis using these composite materials. A 3D model of the chassis is developed and analyzed using Finite Element Analysis (FEA) to assess parameters such as stress distribution, deformation, and factor of safety under various loading conditions. E-Glass Epoxy is known for its cost-effectiveness and good mechanical properties, while S-2 Glass Epoxy offers higher strength, stiffness, and improved fatigue resistance. The performance of both materials is compared to determine their suitability for heavy vehicle chassis applications. The results aim to highlight the advantages of composite materials in reducing weight while maintaining structural performance. This study provides valuable insights into material selection for modern automotive chassis design, contributing to enhanced efficiency, durability, and sustainability.***

Keywords: Heavy vehicle chassis, E-Glass Epoxy, S-2 Glass Epoxy, Composite materials, Finite Element Analysis, Structural analysis, Lightweight design.

I. INTRODUCTION

The chassis is the backbone of a heavy vehicle, providing structural support to all major components such as the engine, transmission, suspension system, and payload. It is designed to withstand various static and dynamic loads during operation, including bending, torsion, and impact forces. Traditionally, heavy vehicle chassis structures are manufactured using steel due to its high strength, stiffness, and durability. However, steel structures significantly increase the overall weight of the vehicle, leading to higher fuel consumption and reduced efficiency. In recent years, the automotive industry has focused on reducing vehicle weight without compromising structural performance. This has led to the increasing use of advanced composite materials such as E-Glass Epoxy and S-2 Glass Epoxy. These materials offer high strength-to-weight ratios, corrosion resistance, and improved fatigue performance compared to conventional metals. E-Glass Epoxy is widely used due to its cost-effectiveness and satisfactory mechanical properties, whereas S-2 Glass Epoxy provides superior strength, stiffness, and enhanced durability, making it suitable for high-performance applications. This study aims to design and evaluate a heavy vehicle chassis using these composite materials. By employing modern design tools and Finite Element Analysis (FEA), the structural behavior of the chassis under various loading conditions is analyzed. Key parameters such as stress distribution, deformation, and factor of safety are examined to assess performance. The comparison between E-Glass Epoxy and S-2 Glass Epoxy helps in identifying the most suitable material for achieving lightweight, strong, and efficient chassis design.

The outcomes of this study are expected to contribute to the development of advanced lightweight vehicle structures, improving fuel efficiency, load-carrying capacity, and overall performance of heavy vehicles.

II. LITERATURE REVIEW

Raj Kumar et al. (2019) This study focuses on the design and analysis of a heavy vehicle chassis using composite materials such as E-Glass Epoxy and S-2 Glass Epoxy. The research highlights that composite materials significantly reduce the weight of the chassis while maintaining required strength and stiffness. The results show that S-2 Glass Epoxy performs better in terms of load-carrying capacity and deformation resistance compared to E-Glass Epoxy.

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Patel and Sharma (2018) This study investigates the use of polymer matrix composites in automotive structures. The authors emphasize that composites offer high strength-to-weight ratio, corrosion resistance, and improved fatigue life. The findings support the replacement of conventional steel chassis with composite materials for improved efficiency.

Reddy et al. (2020) This research analyzes the mechanical properties of E-Glass Epoxy composites. The study shows that E-Glass provides good tensile strength, impact resistance, and cost-effectiveness, making it suitable for moderate load applications in vehicle structures.

Suresh et al. (2021) This study evaluates the performance of S-2 Glass Epoxy composites under high loading conditions. The results indicate that S-2 Glass has superior strength, stiffness, and fatigue resistance compared to conventional glass fiber composites, making it ideal for heavy-duty applications.

Kumar et al. (2017) This research focuses on weight reduction in heavy vehicle chassis using composite materials. The study concludes that composite chassis can achieve significant weight savings while maintaining structural integrity and safety under different loading conditions.

Singh and Gupta (2022) This study uses Finite Element Analysis (FEA) to analyze chassis structures made of composite materials. The results highlight that stress distribution and deformation can be effectively predicted using simulation tools, enabling optimized design.

Verma et al. (2019) This research compares steel and composite chassis structures. The findings show that composite materials reduce overall weight and improve fuel efficiency without compromising strength and performance.

Arun et al. (2021) This study examines the effect of fiber orientation and layering on the mechanical properties of composite materials. It concludes that proper fiber alignment significantly enhances strength and stiffness of the chassis.

Mehta et al. (2020) This research investigates fatigue behavior of glass fiber reinforced composites. The study reveals that composite materials exhibit good fatigue resistance, making them suitable for long-term automotive applications.

Das and Rao (2023) This recent study reviews the application of advanced composite materials in automotive structures. It highlights that S-2 Glass Epoxy offers better performance in high-load conditions, while E-Glass Epoxy remains a cost-effective alternative for medium-duty applications.

III. OBJECTIVE

1) To design a heavy vehicle chassis model using suitable CAD software based on standard dimensions and loading conditions.
2) To perform structural analysis of the chassis using Finite Element Analysis (FEA).
3) To analyze and compare the performance of composite materials—E-Glass Epoxy and S-2 Glass Epoxy—under identical loading conditions.
4) To study the effect of material properties on weight reduction, strength, and stiffness of the chassis.

IV. METHODLOGY

This study focuses on the design and evaluation of a heavy vehicle chassis using composite materials—E-Glass Epoxy and S-2 Glass Epoxy. The chassis model is designed using standard dimensions and analyzed using Finite Element Analysis (FEA). The structural performance is evaluated based on stress, deformation, and factor of safety, and results are compared to determine the best material.

Flow Process

Selection of Chassis Type (Heavy Vehicle)

↓

Collection of Design Parameters (dimensions, load conditions)

↓

3D Modeling of Chassis (CAD Software)

↓

Material Selection (E-Glass Epoxy & S-2 Glass Epoxy)

↓

Import Model into FEA Software (ANSYS)

↓

Meshing of Chassis Model
↓
Application of Boundary Conditions (Loads & Constraints)
↓
Static Structural Analysis
↓
Evaluation of Stress and Deformation
↓
Comparison of Results for Both Materials
↓
Performance Assessment (Strength, Weight, Stiffness)
↓
Conclusion and Material Recommendation

V. CONCLUSION

The study concludes that composite materials are effective alternatives to conventional steel for heavy vehicle chassis design. Both E-Glass Epoxy and S-2 Glass Epoxy offer significant weight reduction, which improves fuel efficiency and vehicle performance. However, S-2 Glass Epoxy demonstrates superior strength, stiffness, and fatigue resistance compared to E-Glass Epoxy, making it more suitable for high-load applications.

On the other hand, E-Glass Epoxy is more cost-effective and can be used where moderate strength is sufficient. The use of Finite Element Analysis (FEA) helps in accurately predicting structural behavior and optimizing the design. Overall, the selection of material depends on the balance between performance requirements and cost considerations, with S-2 Glass Epoxy being the better choice for high-performance chassis applications.

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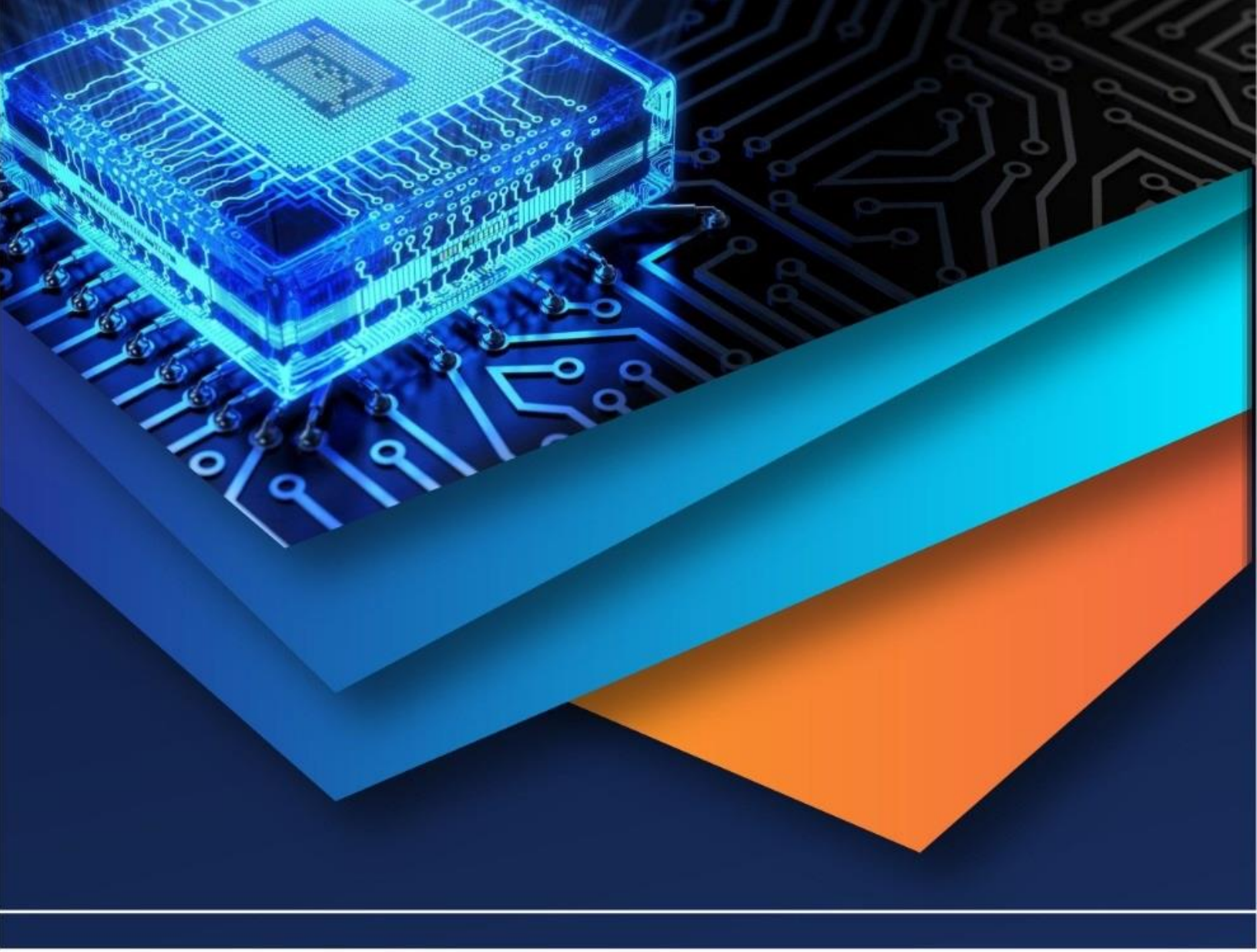

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