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"DESIGN AND DEVELOPMENT OF ROLL CAGE FOR ALL-TERRAIN VEHICLE (ATV)"

Mr. Atharva Vishnu Kakad¹, Mr. Deepak Gokul Sangamnere², Mr. Krishna Kailash Kalal³, Mr. Shubham Raju Deore⁴, Guide : Prof. A. S. Yadav⁵, Prof. P. P. Bhirud⁶

¹(Student of LoGMIEER, Nashik Diploma)

²(Student of LoGMIEER, Nashik Diploma)

³(Student of LoGMIEER, Nashik Diploma)

⁴(Student of LoGMIEER, Nashik Diploma)

⁵(Lecturer at LoGMIEER, Nashik Diploma)

⁶(H.O.D. Mech. At LoGMIEER, Nashik Diploma)

ABSTRACT

The roll cage is a critical structural component of an All-Terrain Vehicle (ATV), ensuring the safety of the driver and maintaining the vehicle's structural integrity during rollovers or impacts. This paper presents the design and development of an optimized roll cage using CAD modeling and Finite Element Analysis (FEA). The study evaluates various materials and geometric configurations to achieve an optimal balance between strength, weight, and cost. The roll cage was designed considering SAE BAJA standards, and its structural behavior was validated under static and dynamic load conditions using ANSYS. The results confirm that a well-designed roll cage ensures maximum driver protection while maintaining vehicle performance and cost-effectiveness.

1. Introduction

The roll cage of an ATV functions as a protective skeleton, shielding the driver from injuries in the event of a rollover or crash. A well-designed roll cage not only enhances safety but also contributes to the structural strength of the vehicle. This research aims to develop a lightweight yet durable roll cage that complies with international safety standards and performance requirements.

2. Objectives

- To design a safe and efficient roll cage for an ATV based on SAE BAJA specifications.
- To select appropriate materials based on mechanical and physical properties.
- To analyze the roll cage using Finite Element Analysis for structural integrity.
- To validate the design under various loading conditions such as front, rear, side, and rollover impacts.

3. Literature Review

A review of prior research shows that chromoly steel, AISI 1018, and AISI 4130 are commonly used for roll cage construction due to their high strength-to-weight ratio. Several studies have employed CAD tools for design and FEA tools for simulation under impact conditions. Results indicated that the correct geometry and material significantly reduce the risk of failure under high loads.

4. Design Considerations

- **Driver Ergonomics:** Adequate headroom and ingress/egress space.
- **Safety Standards:** Based on SAE BAJA India regulations.
- **Material Selection:** AISI 1018 steel pipe (mild steel) due to cost-effectiveness and sufficient strength.
- **Pipe Diameter:** 1-inch OD with 2 mm wall thickness.



Fig, CAD Model

5. Methodology

1. CAD Design:

- Software: SolidWorks
- Considerations: Five-point harness mountings, foot protection, center of gravity, and load paths.

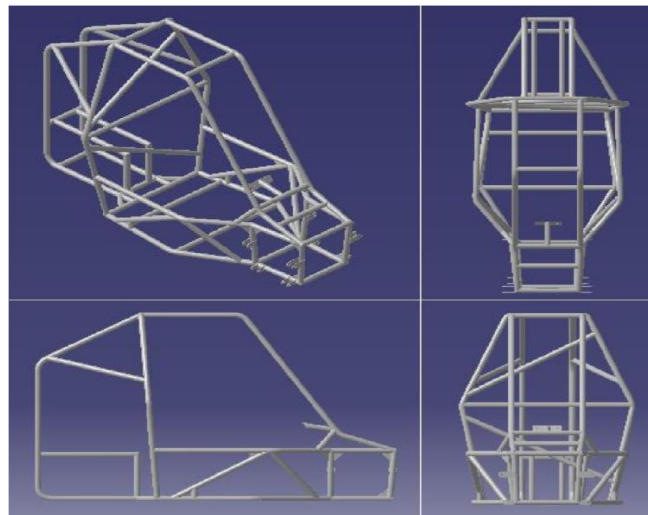


Fig. CAD Model

2. Material Properties (AISI 1018 Mild Steel):

- Density: 7.85 g/cm³
- Yield Strength: 370 MPa
- Ultimate Tensile Strength: 440 MPa

3. FEA Analysis:

- Software: ANSYS Workbench
- Boundary Conditions: Fixed at suspension points
- Load Cases:
 - Frontal impact: 1000 N
 - Side impact: 800 N
 - Rollover: 1200 N

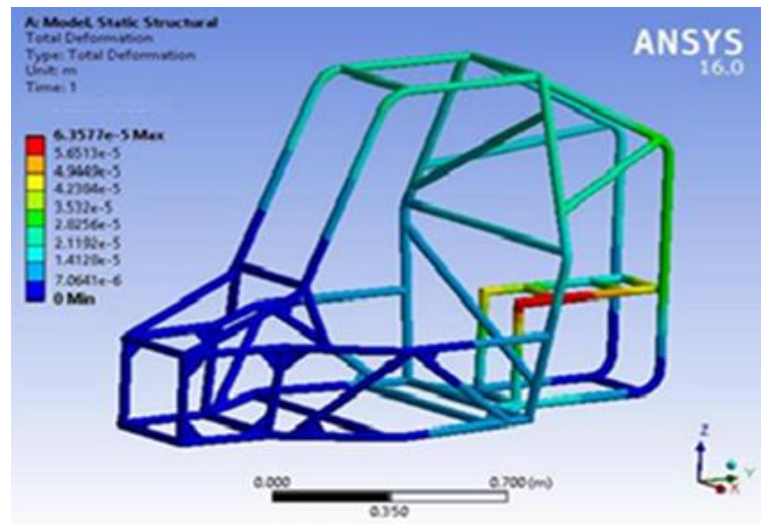


Fig. FEA Analysis

6. Results and Discussion

Loading Condition	Max Stress (MPa)	Deformation (mm)	Factor of Safety
Frontal Impact	220	2.5	1.68
Side Impact	180	2.1	2.05
Rollover	260	3.0	1.42

- **Observation:** All maximum stress values are well within the yield strength of the material.
- **Conclusion:** The structure is safe for all tested load cases.

7. Advantages

- Lightweight and low-cost design.
- High structural integrity and safety.
- Easy to manufacture and assemble.

8. Conclusion

The designed roll cage successfully meets the safety requirements for an ATV operating in rugged terrains. Using AISI 1018 steel ensures affordability without compromising on strength. The roll cage exhibits high durability under simulated impact conditions, making it suitable for practical applications in off-road racing and transport.

9. Future Work

- Physical crash testing of the roll cage prototype.
- Weight optimization using topology optimization.
- Exploring composite or hybrid materials for further weight reduction.

10. REFERENCES

1. SAE BAJA India Rulebook, 2025 Edition.
2. Ramesh, T., "Design and FEA of Roll Cage for SAE BAJA ATV", *IJERT*, 2021.
3. Sharma, V., "Crash Analysis of ATV Roll Cage", *Elsevier Procedia Engineering*, 2019.
4. AISI Steel Manual, 2020 Edition.
5. Patil, A., "FEA of ATV Structures", *IJAERD*, 2022.