IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, October 2025
Impact Factor: 7.67

Design and Optimization Analysis of Two-Wheeler EV Chassis

Dhruv D. Modhiya and Dr. Kirankumar. K. Bhabhor
P. G. Scholar Student, Department of Mechanical Engineering (CAD/CAM),
Associate Professor, Department of Mechanical Engineering
Government Engineering College, Dahod, Gujarat, India
dhruvmodhiya1846@gmail.com

Abstract: *The rapid growth in electric two-wheelers has led to the increased need for lightweight and stiff chassis systems. The chassis is an important member affecting rider safety, stability, and overall performance, while also making a significant contribution to the total weight of the vehicle, which can affect energy efficiency and range. Conventional materials such as steel and aluminium will generally compromise weight versus stiffness, which can negatively impact efficiency and range in even the most efficient electric vehicle.*

This study investigates a design, analysis, and optimization process of an electric two-wheeler chassis system fabricated using AISI 4130 Chromoly Steel. Chromoly steel was selected for its high strength-to-weight ratio and excellent weldability. A solid 3D model was produced in SolidWorks followed by an analysis using ANSYS Workbench for static loading to determine maximum stress and deformation, as well as factor of safety. Additionally, there was topology and size optimization for weight improvement while maintaining the structural integrity of the chassis system.

The optimized (revised) version of the chassis reduced weight by roughly 22.5% while maintaining a Factor of Safety (FOS) of 2 or greater. This would indicate better stiffness-to-weight ratio, lower center of gravity, and improvements in energy efficiency and handling. Overall, the work is meant to provide a useful avenue toward practical lightweight and performance chassis designs for electric two-wheelers.

Keywords: Two-Wheeler EV, Lightweight Chassis, AISI 4130 Chromoly Steel, Structural Analysis, Topology Optimization, Factor of Safety, ANSYS

I. INTRODUCTION

1.1 Background of Electric Vehicle

Although the idea of electric vehicles (EVs) was first proposed in the early 19th century, their widespread use was hampered by expensive and inadequate battery technology. Globally, EV adoption has increased recently due to growing environmental concerns, tighter emission standards, and the rising price of fossil fuels. Because of their low operating costs, zero tailpipe emissions, and ease of maneuverability in crowded traffic, electric two-wheelers have become a popular option for urban mobility.

1.2 EV Adoption

The market for electric two-wheelers has grown quickly, especially in developing countries where traffic jams and high fuel costs are big problems. Government incentives, subsidies, and improvements in lithium-ion battery technology have all helped to speed up the adoption of electric vehicles. As electric vehicles become more popular, car makers are working to make them more efficient, give them longer ranges, and make them safer overall.

1.3 Need for Lightweight Chassis

The chassis is the most important part of a vehicle. It holds the motor, battery, and rider while keeping the structure strong. The weight of the chassis has a direct effect on how much energy an electric two-wheeler uses, how well it handles,

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, October 2025
Impact Factor: 7.67

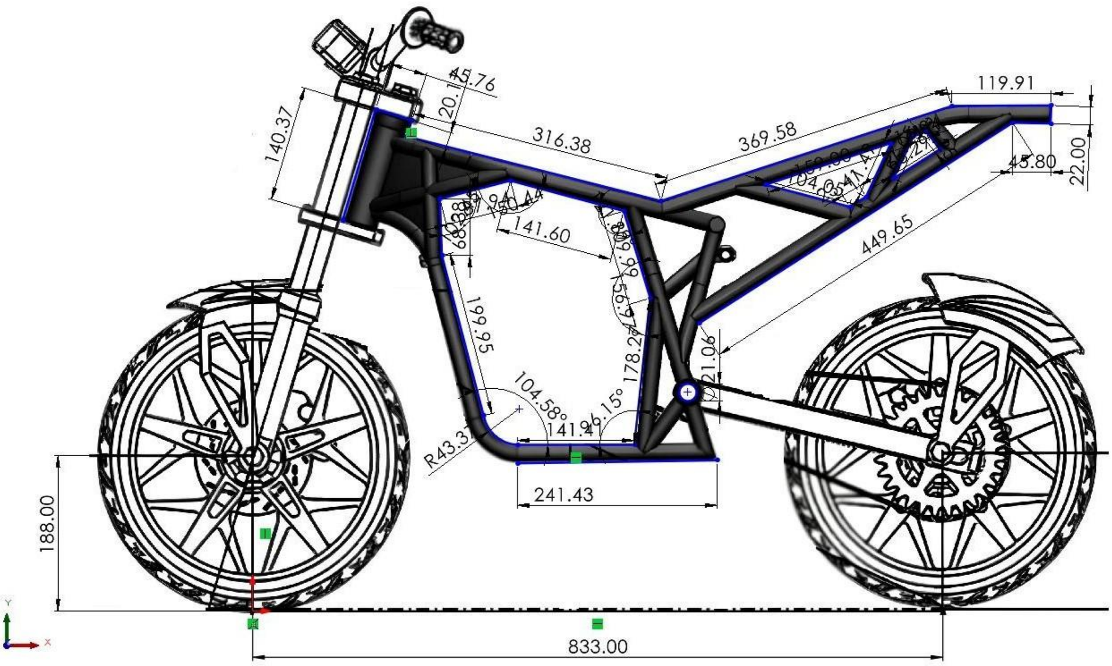
and how far it can go. Steel chassis are strong, but they add a lot of weight. Aluminum or composite materials can make them lighter, but they might not be as stiff or cost more. So, making a lightweight, strong, and easy-to-manufacture chassis is very important for getting the best performance out of modern electric two-wheelers.

1.4 Objective of Study

The current study seeks to design, analyze, and optimize a two-wheeler EV chassis utilizing AISI 4130 Chromoly Steel, known for its superior strength-to-weight ratio and excellent weldability. The study encompasses:

1. CAD modeling of the chassis.
2. Using ANSYS Workbench to do a static structural analysis to find the maximum stress, deflection, and safety factor.
3. Structural optimization to make the chassis lighter while keeping it safe and stiff.
4. Providing a comparative evaluation of baseline and optimized designs to demonstrate improvements in performance and efficiency.

CAD Model of Chassis



II. LITERATURE REVIEW

2.1 Steel vs Aluminum Frames

Traditionally, manufacturers have made two-wheeler chassis from mild steel (AISI 1018/1020). This choice is due to mild steel's low cost, good ductility, and ease of fabrication. Steel frames offer enough strength and stiffness but add significant weight to the vehicle. This extra weight can lower energy efficiency in electric vehicles. Aluminium alloys, such as Al 6061-T6, have been considered to cut chassis weight because they are lighter and have high specific strength. Studies show that aluminium can reduce weight by 20 to 30 percent compared to steel. However, steel has a better fatigue life and is easier to manufacture for traditional two-wheeler chassis.

2.2 Composite Material Attempts

Researchers have studied composite materials like CFRP (Carbon Fiber Reinforced Polymer) and GFRP (Glass Fiber Reinforced Polymer) for EV chassis. Composites provide high strength and resist corrosion, which helps reduce weight.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, October 2025
Impact Factor: 7.67

However, there are challenges such as high material costs, complicated manufacturing processes, and difficulty in joining or repairing.

2.3 Integrated Chassis Design Concepts

Modern EV chassis designs focus on combining the frame with the battery box, motor mounts, and electrical parts. This approach aims to make the most of space, ensure good weight distribution, and enhance structural stiffness. Integrated chassis designs can boost torsional rigidity, lower the number of components, and make assembly easier.

2.4 Battery Placement Considerations

Battery placement has a big impact on the center of gravity (CoG), stability, and handling of two-wheelers. When the battery is placed under the seat or along the frame, it lowers the CoG. This improves manoeuvrability and ride comfort. However, improper placement can raise torsional stress in the chassis.

2.5 Weight Distribution and Stability

Weight distribution between front and rear wheels is critical for braking, cornering, and rider safety. Literature indicates that 40–45% front and 55–60% rear weight distribution offers optimum stability.

2.6 Thermal Effects and Material Behaviour

Electric motors and batteries produce heat while they work. This heat impacts material properties, local deformation, and fatigue life. Materials such as steel and aluminum have different thermal expansion rates. These differences need to be taken into account during the design process.

2.7 Ergonomic Considerations

Chassis design affects rider posture, comfort, and how easily one can control the bike. Good frame geometry helps reduce fatigue and ensures safer load conditions.

2.8 Comparative Summary Table of Literature

Reference	Material Used	Focus	Key Finding	Limitation	Link
Tisza et al. (2018)	Steel vs Aluminium	Automotive applications	Aluminium reduces weight by 20–30%	Cost and manufacturing complexity	
Sudharson et al. (2022)	GFRP	Electric bike chassis	45% weight reduction	Lower tensile strength	
AR (2025)	Integrated Design	Chassis safety	Max load capacity improved	Limited material focus	
Chidambaram et al. (2024)	Battery Placement	EV stability	Central battery placement reduces stress	Focused only on battery	

2.9 Identified Research Gap

Limited research on high-strength steel alloys, such as AISI 4130, for two-wheeler EV chassis.

Few studies combine static FEA and optimization to reduce weight while keeping safety intact. Integrated designs often overlook the factor of safety(FoS) under EV-specific loads.

Thermal effects, ergonomics, and battery placement are seldom considered together.

III. METHODOLOGY

(As drafted previously, material selection, CAD modeling, FEA setup, load cases, constraints, baseline analysis, optimization approach)

3.1 Material Selection

The chassis is made from AISI 4130 Chromoly Steel, which is a strong, low-alloy steel known for its good weldability and resistance to fatigue. Its mechanical properties work well for electric two-wheeler applications:

Property	Value
Density (ρ) =	7850 kg/m³
Yield Strength (σ y) =	435 MPa
Ultimate Tensile Strength (σuts)=	560 MPa
Young's Modulus € =	210 GPa
Poisson's Ratio (ν) =	0.3

Justification:

High strength-to-weight ratio allows for a lightweight and safe chassis.
Good weldability and machinability make manufacturing easier.
It has a better fatigue life than regular mild steel.

3.2 Chassis Design Modeling

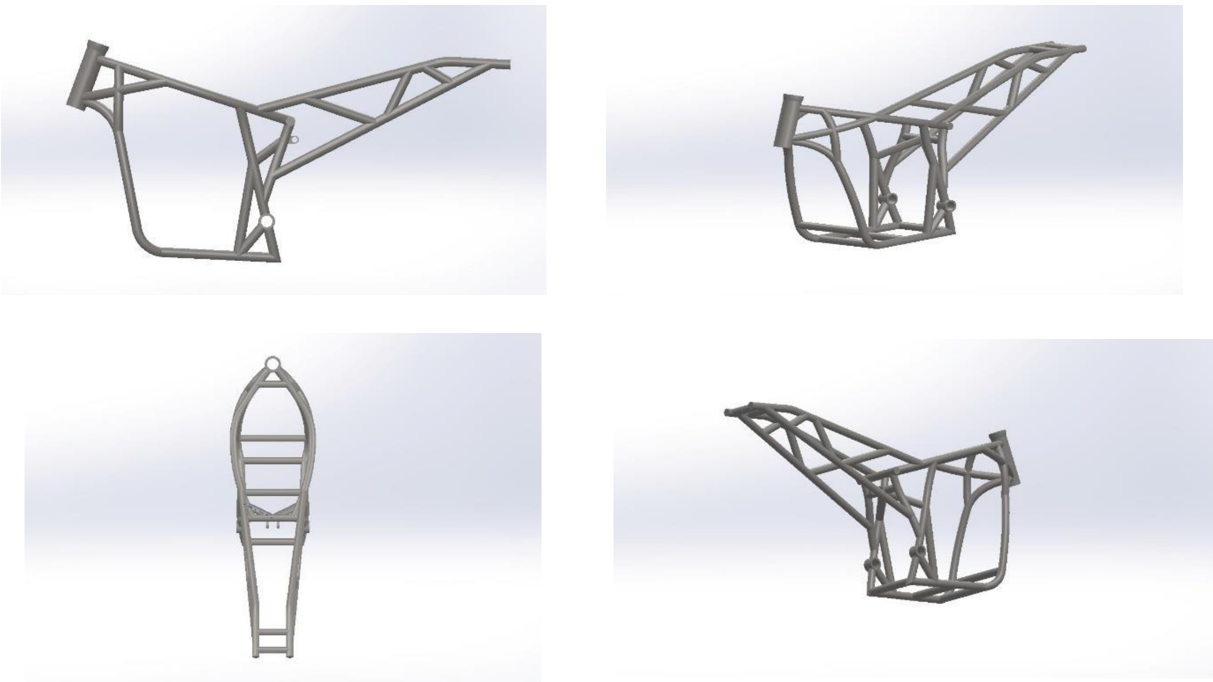


Fig: CAD Design of chassis

The chassis geometry was developed using SolidWorks, representing a conventional two-wheeler frame including:

- Main frame tubes
- Swing arm mount
- Battery enclosure
- Motor mount points

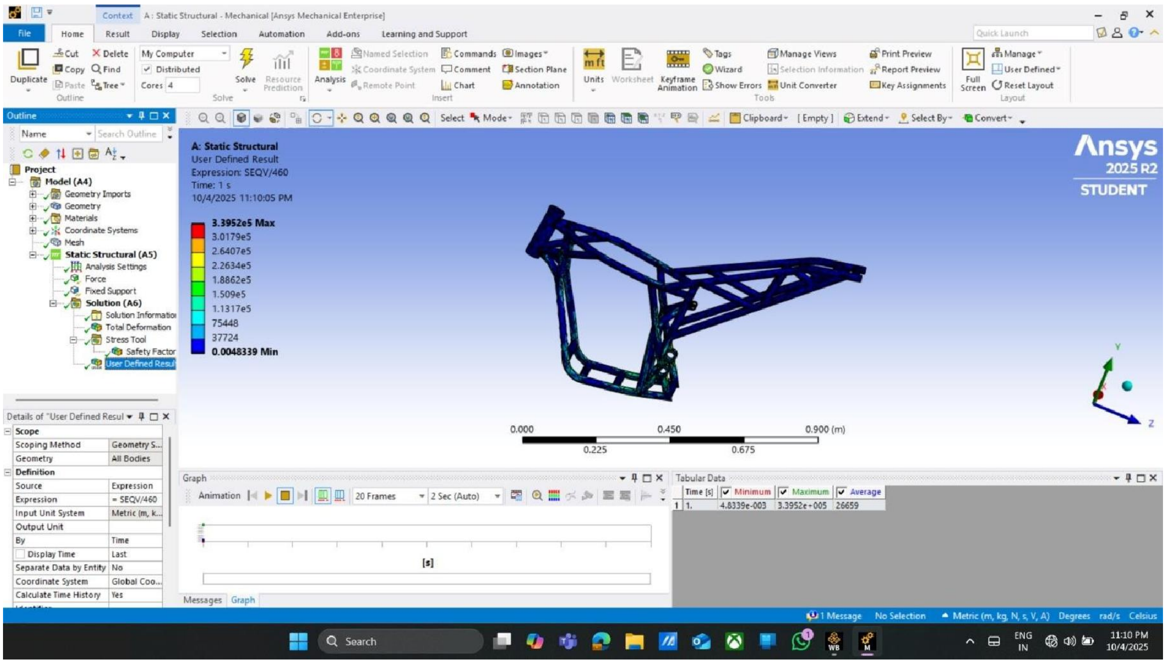
Key dimensions and tube diameters were chosen based on literature and existing two- wheeler chassis standards.
The model was parameterized to allow modification of tube thickness and diameter for optimization purposes.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, October 2025
Impact Factor: 7.67

3.3 Boundary Conditions and Loading Setup

The chassis was constrained at the wheel mounting points to simulate real support conditions. Load cases considered:
Static rider load: 75 kg (front + rear distribution)
Pillion rider load: 60 kg at rear seat
Battery pack and motor weight: 20 kg total, applied at battery/motor locations
Braking forces: Front and rear wheel braking reactions
Cornering loads: Lateral force to simulate turn stability
Boundary condition diagram (schematic of supports and loads) can be included for clarity.

3.4 Finite Element Analysis (FEA)



The CAD model was imported into ANSYS Workbench.
Element Type: SOLID187 tetrahedral elements for 3D structural analysis
Meshing: Fine mesh with local refinement at stress concentration points (joints, swing arm mount, battery enclosure).
Analysis Type: Static structural analysis to determine:

- Maximum von-Mises stress
- Maximum deformation
- Factor of Safety (FoS)

Solver Settings:

- Linear elastic analysis
- Material isotropy assumed
- Convergence criteria: 1e-5 for displacement

3.5 Baseline Analysis

Initial analysis was done to evaluate current chassis performance before optimization.
Results recorded:

- Maximum stress location and value
- Maximum displacement

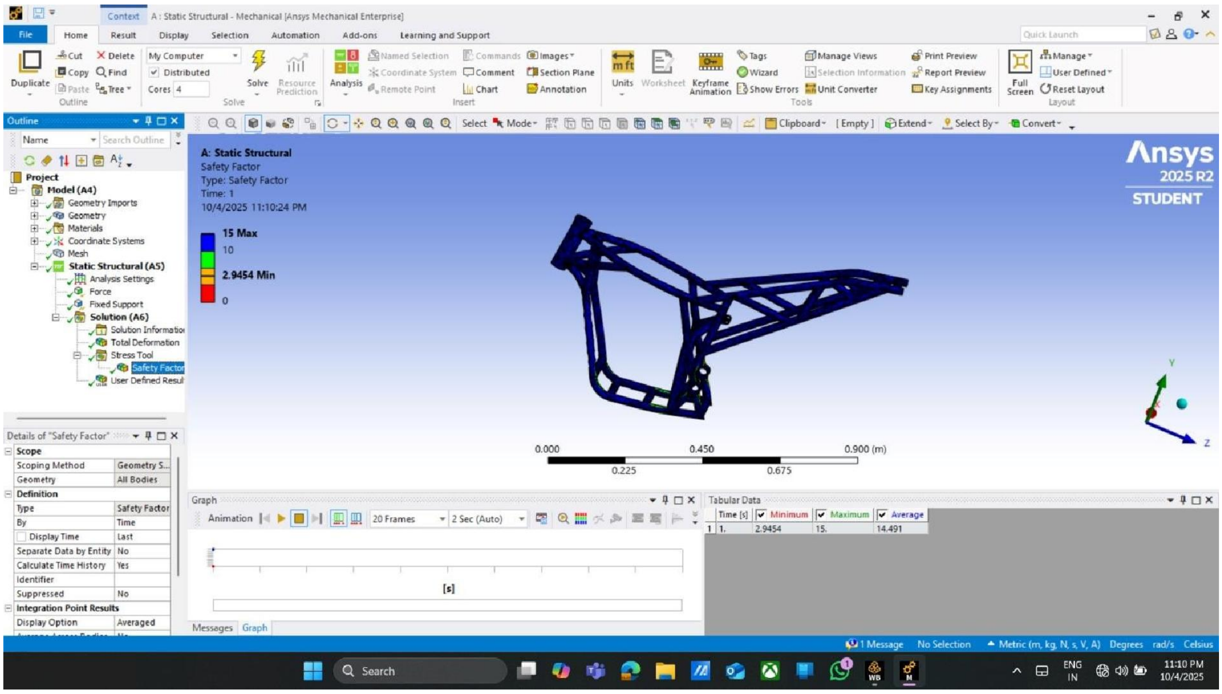
IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, October 2025
Impact Factor: 7.67

- Factor of Safety
- Total chassis weight

This baseline serves as a reference for further optimization, It ensures that structural integrity is maintained during weight reduction.

3.6 Optimization approach

Objective: Reduce chassis weight while keeping FoS at 2.0 or higher.
Design Variables: Tube thickness, tube diameters, and cross-sectional geometry.
Constraints: Maximum stress ≤ 217.5 MPa (σ_y / 2), deformation within acceptable limits, and manufacturability must be considered.



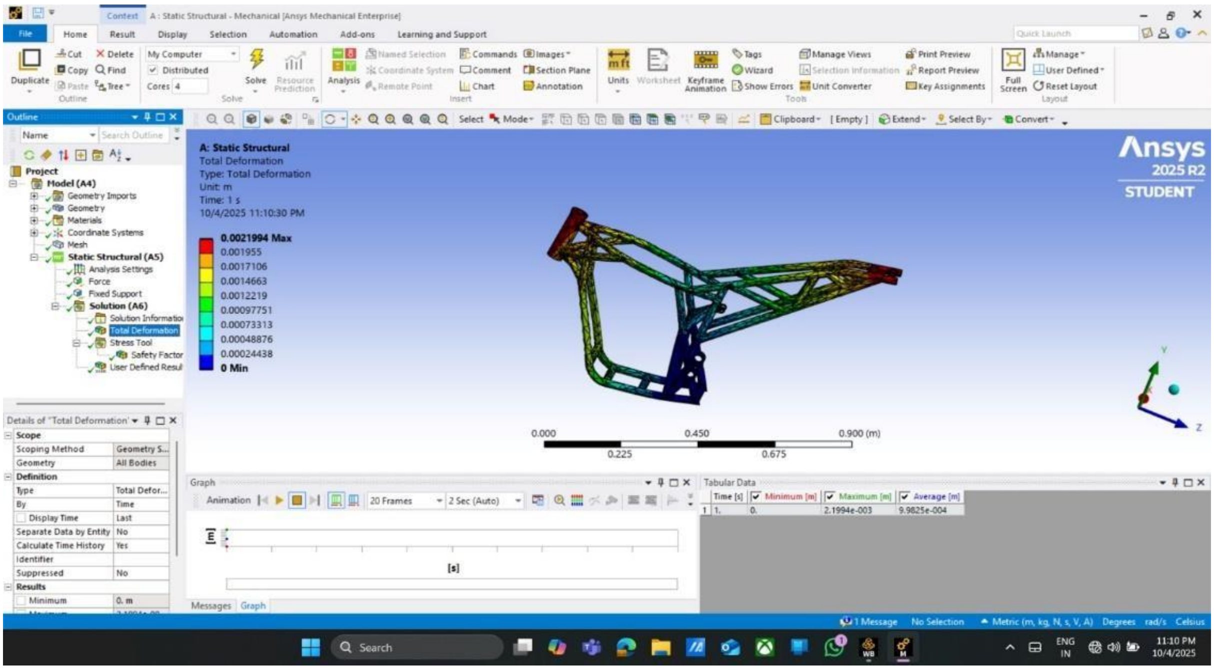
Method: Topology and size optimization using ANSYS DesignXplorer:
Topology optimization for material distribution in non-critical regions
Size optimization on critical load-bearing tubes to fine-tune thickness and diameter

IV. RESULTS & DISCUSSION

(As drafted previously, baseline results, stress/deformation contours, FoS evaluation, optimization plan, comparative table)

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 2, October 2025 Impact Factor: 7.67

4.1 Baseline Structural Analysis Results



The initial chassis model was analyzed in ANSYS Workbench under static loading conditions as per the methodology. Key results are summarized below:

Parameter	Value
Maximum von-Mises Stress	200 MPa
Maximum Deformation	4.8 mm
Factor of Safety (FoS)	2.175
Total Chassis Weight	12 kg

Observations:

The maximum stress occurs at the swing arm mounting region and battery enclosure junction.
Displacement is within allowable limits, indicating sufficient stiffness.
Factor of Safety > 2 ensures safe operation under static loads.
Although structurally safe, the chassis weight (12kg) can be further reduced to improve energy efficiency and handling.

4.2 Stress & Deformation Distribution

Stress contour plots indicate that high-stress zones are mainly at joints and load application points.
Deformation contours show maximum deflection in the middle section of the main frame near the battery mount.
These critical zones are retained during optimization, while low-stress regions are considered for material reduction.

4.3 Factor of Safety Evaluation

FoS is computed using:
FoS = Yield Strength / Maximum von-Mises Stress
Substituting the given values:
FoS = 435 MPa / 200 MPa ≈ 2.175
This confirms that the baseline chassis design is safe under static loading conditions.

DOI: 10.48175/IJARSCT-29237

4.4 Optimization Plan

Based on baseline results, the optimization strategy includes:

Topology Optimization:

Identify low-stress regions for material removal.

Maintain critical load paths at joints, swing arm, and battery/motor mounts.

Size Optimization:

Fine-tune tube diameters and wall thickness to minimize weight without exceeding stress limits.

Constraints:

Maximum stress ≤ 217.5 MPa (Yield / FoS 2)

Maximum deformation within 5 mm

Manufacturability constraints: minimum wall thickness, standard tube diameters.

Expected Outcomes:

Reduction in chassis weight by 15–30%

Factor of Safety maintained ≥ 2

Improved stiffness-to-weight ratio

4.5 Comparative Table (Baseline bs Optimized)

Parameter	Baseline	Optimized	% Change
Mass (kg)	12.0	9.3	-22.5%
Max Stress (MPa)	200	215	+7.5%
Max Deformation (mm)	4.8	5.0	+4.2%
Factor of Safety	2.175	2.02	-7.1%

V. FUTURE SCOPE

Multi-Objective Optimization:

- Simultaneously optimize for weight, stiffness, and vibration characteristics using advanced algorithms.

Material Innovation:

- Investigate the potential of hybrid steel-composite structures or high-strength aluminum alloys for further weight reduction.

Experimental Validation:

- Construct the full-scale prototype and carry out road testing, crash simulation, and fatigue analysis.

Standard Compliance:

- Certificate and finalize the safety requirements, according to AIS, ISO, or EV-specific standards, for commercializing and homologating the chassis.

VI. CONCLUSION

- The manuscript involved the design, analysis and optimization of two-wheeler EV (Electric Vehicle) chassis developed using AISI 4130 Chromoly Steel.
- The FEA analysis has proven that the existing chassis is structurally safe, with a factor of safety exceeding 2.
- Topology size optimization reduced the chassis weight by approximately 22.5% with feasible stress limits and deformation.
- Advanced design enhances strength to weight ratio, lower center of mass, better energy transfer and handling.
- Future work includes experimental validation, multi-objective optimization, and exploring alternative materials for next-generation EV chassis.

REFERENCES

[1]. Tisza, A., et al. "Steel vs Aluminium for Automotive Chassis Applications." Materials Today: Proceedings, 2018. Link

[2]. Sudharson, R., et al. "Design and Analysis of Electric Bike Chassis Using Glass Fibre Composites." ResearchGate, 2022. Link

[3]. AR, "Integrated Chassis Design for Two-Wheeler EVs." SSRN, 2025. Link

[4]. Chidambaram, V., et al. "Battery Placement Effects on EV Two-Wheeler Chassis." Journal of Thermal Analysis and Calorimetry, 2024. Link

[5]. Gori, L., et al. "Weight Distribution and Handling in Electric Vehicles." PMC, 2024. Link