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Design and Development of an Electric Racing Motorcycle Chassis

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ABSTRACT

This project presents the design and fabrication of a motorcycle chassis developed by our team for an electric bike application. The work focuses on creating a structure that is not only strong and durable but also lightweight enough to support high-performance requirements. Since the electric motorcycle includes a battery pack along with the rider and other components, the chassis is designed to safely handle both static and dynamic loads occurring during real riding conditions. We have adopted a perimeter-type chassis configuration and developed it using a combination of plate and tubular members. The idea behind this approach was to use plates in regions where higher stiffness is required, while tubular members help in reducing weight and maintaining structural efficiency. This hybrid design allowed us to achieve a better balance between rigidity and weight, which is essential for stability and handling. The complete chassis model was created in CAD and further analyzed using Finite Element Analysis (FEA) to understand how the structure behaves under different loading conditions. The results showed that the stresses developed are within safe limits and the deformation is minimal, which validates the reliability of our design. From a practical standpoint, the chassis was designed keeping manufacturing feasibility in mind. Standard fabrication processes such as cutting, bending, and welding were considered during the design stage itself to ensure that the model could be built accurately. Overall, this project reflects our effort in developing a functional and efficient chassis system from scratch, combining design, analysis, and manufacturing aspects. The final outcome demonstrates a structure that meets the required strength and performance criteria for an electric motorcycle.

Keywords: *Electric racing motorcycle; Chassis design; Finite element analysis (FEA); Lightweight frame; Structural optimization; Material selection; Torsional rigidity; Vehicle dynamics.*

1.0 Introduction

1.1 Overview

The chassis frame forms the backbone of a motorcycle, serving as the primary load-bearing structure that supports all essential components, including the rider, battery pack, motor, and auxiliary systems. In an electric racing motorcycle, the importance of the chassis becomes even more significant due to the presence of a relatively heavy battery pack and the requirement for high structural performance.

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The main objective of this project is to design and manufacture a chassis that can safely withstand static and dynamic loads while maintaining high strength, durability, and lightweight characteristics. The frame must support the combined weight of the rider (approximately 75 kg), battery pack, and vehicle components, along with additional forces generated during braking, acceleration, and cornering.

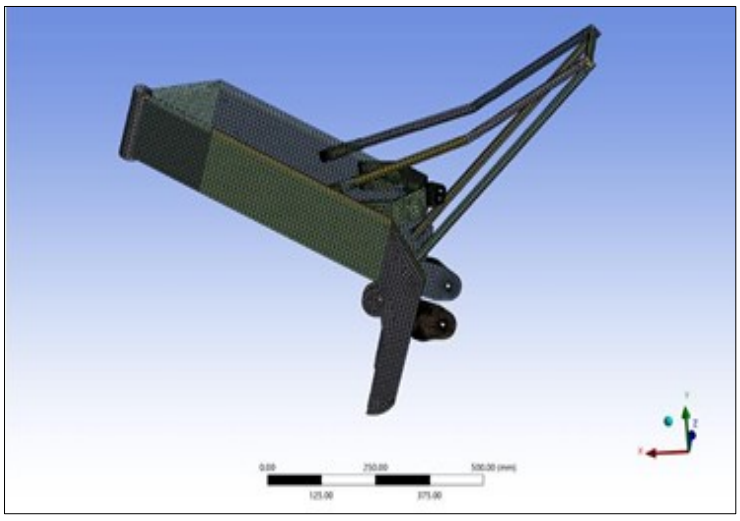
Figure 1: Chassis Design and Development Illustration



A well-designed chassis ensures proper load distribution across the structure and minimizes deformation under stress. This directly affects the stability, handling, and safety of the motorcycle. Therefore, the design approach focuses on achieving an optimal balance between strength, stiffness, and weight reduction.

In this project, the chassis is developed considering real-world operating conditions and racing requirements. The design is validated through analytical calculations and simulation techniques to ensure that it performs reliably under critical loading conditions. According to the project analysis, the structure demonstrates low deformation and acceptable stress levels, ensuring safe operation.

Figure 2: Chassis Design and Development Illustration



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Motorcycle chassis can be classified into different types based on their structural design and load-carrying mechanism. The most common types include backbone frame, trellis (tubular space frame), perimeter (twin-spar) frame, and monocoque frame.

The backbone frame is simple and lightweight but offers limited stiffness, making it suitable for low-performance applications. The trellis frame uses interconnected tubular members arranged in triangular patterns, providing good strength and rigidity with relatively low weight.

Figure 3: Chassis Design and Development Illustration



Figure 4: Chassis Design and Development Illustration



Figure 5: Chassis Design and Development Illustration.

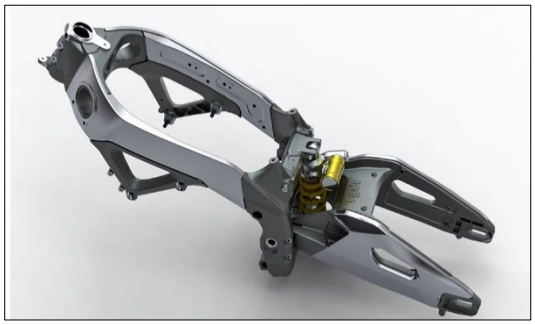


The perimeter frame, also known as the twin-spar frame, is widely used in high-performance motorcycles due to its ability to provide a direct load path between the headstock and swingarm pivot, resulting in improved stiffness and handling stability. The monocoque frame integrates the body and chassis into a single unit, offering high rigidity but requiring complex manufacturing processes.

Figure 6: Chassis Design and Development Illustration



Figure 7: Chassis Design and Development Illustration

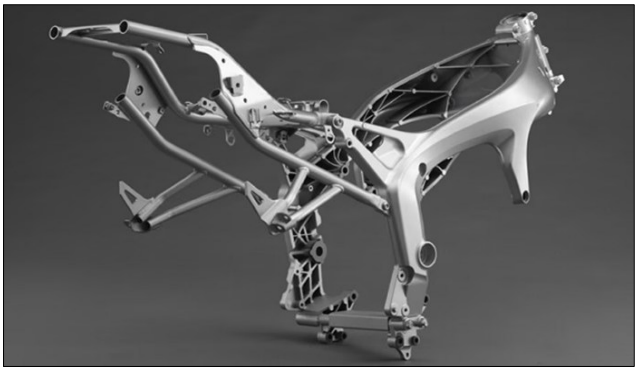


In this project, a perimeter-type chassis with a combination of plate and tubular construction is selected, as it provides an optimal balance between strength, stiffness, weight, and manufacturability, making it suitable for electric racing motorcycle applications.

A tubular space frame design has been selected because it offers an effective balance between rigidity and ease of fabrication. The geometry is arranged in such a way that loads are distributed efficiently across the frame, especially between critical regions like the headstock, seat mount, and swingarm pivot. This helps in reducing unwanted deflection and improving overall stability.

For material selection, mild steel is used due to its good welding properties, availability, and sufficient strength for the application. To further enhance durability, additional reinforcements are provided at high-stress areas to prevent failure under repeated loading conditions.

Figure 8: Chassis Design and Development Illustration



To ensure that the design performs as expected, Finite Element Analysis (FEA) is carried out. The results indicate that the stresses developed in the frame remain within safe limits and the deformation is minimal under applied loads, confirming the structural reliability of the design .

From a manufacturing perspective, the chassis is fabricated using standard processes such as cutting, bending, and welding. Proper alignment and fixture-based assembly are used to maintain dimensional accuracy and consistency.

In summary, the developed chassis frame meets the key requirements of strength, durability, and load-bearing capability, making it suitable for supporting the electric motorcycle system while ensuring safe and stable operation under racing conditions.

1.2 Problem formulation

The problem addressed in this project is the design and development of a motorcycle chassis capable of handling the combined load of the rider, battery pack, and vehicle components under dynamic conditions such as braking, acceleration, and cornering. The challenge lies in achieving a structure that is both lightweight and strong, while ensuring minimal deformation and safe stress levels. Additionally, efficient load transfer between critical regions like the headstock and swingarm pivot must be maintained to ensure stability and performance. Therefore, a perimeter-type chassis using plate and tubular construction is developed and analyzed to meet these requirements.

1.3 Objectives

- To design a lightweight yet strong perimeter-type chassis capable of supporting the rider, battery pack, and vehicle components.
- To ensure efficient load distribution and minimal deformation under dynamic conditions like braking, acceleration, and cornering.
- To validate the structural performance using Finite Element Analysis (FEA) while maintaining a safe factor of safety.
- To develop a chassis that is durable and easy to manufacture using standard fabrication processes.

2.0 Research and Designing

2.1 Introduction

The research and design phase is a crucial part of this project, as it defines the structural layout and performance capability of the motorcycle chassis. In this work, the focus was on

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developing a chassis that is strong, lightweight, and suitable for an electric motorcycle application. The presence of a battery pack along with the rider introduces additional loading conditions, which makes it necessary to carefully study existing designs and select an appropriate configuration.

The design process involved understanding real-world requirements, studying different chassis types, selecting suitable materials, and validating the design through simulation. The approach was practical and iterative, where improvements were made based on analysis results and manufacturability considerations.

2.2 Literature study and existing designs

The design of a motorcycle chassis is a complex and iterative process that requires a balance between strength, stiffness, weight, and handling performance. Before developing the proposed chassis, an extensive literature study was carried out by referring to research papers, journals, and standard books such as *"Motorcycle Handling and Chassis Design" by Tony Foale*. This study helped in understanding the theoretical background as well as practical challenges involved in chassis design. [1], [2]

A motorcycle chassis acts as the primary load-bearing structure, supporting components such as the engine, battery pack, suspension system, and rider. It must not only withstand static loads but also dynamic forces generated during braking, acceleration, and cornering. As highlighted in previous research, the chassis must ensure structural integrity, rider safety, and proper handling characteristics under all operating conditions. [1], [2]

2.2.1 Review of existing research work

Several researchers have worked on improving chassis design by focusing on weight reduction, stress distribution, and structural optimization.

A study on two-wheeler chassis design emphasizes that the design process is not linear but involves continuous iterations and refinements, where different design concepts are evaluated and improved step by step . It also highlights that factors such as material selection, geometry, and load conditions play a crucial role in determining the performance of the chassis. [1], [2]

Another research work on modal analysis explains that the chassis behaves like a vibrating structure, and its performance is influenced by parameters such as natural frequency, damping, and mode shapes . If the natural frequency of the chassis matches the excitation frequency, resonance may occur, leading to excessive vibrations and possible structural failure. Therefore, it becomes essential to design the chassis in such a way that vibration effects are minimized. [2], [5]

Further studies also show that Finite Element Analysis (FEA) is widely used for validating chassis designs. It helps in predicting stress distribution, deformation, and critical failure zones before actual manufacturing. Most researchers have used CAD tools like CATIA and SolidWorks for modeling and ANSYS for analysis, which aligns with the methodology followed in this project.[3],[5]

In addition, research on material optimization suggests that while steel is commonly used due to its strength and cost-effectiveness, alternative materials like aluminium, titanium, and composites can reduce weight while maintaining structural performance. However, cost and manufacturability remain key constraints in material selection. [3]

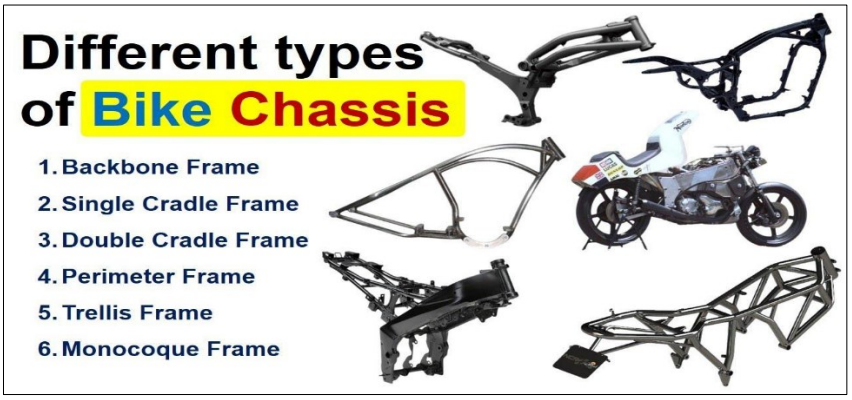
2.2.2 Study of chassis types

Different types of chassis designs have been developed over time, each with its own advantages and limitations.

- Backbone Frame: Simple and economical, but lacks stiffness for high-performance applications.
- Trellis Frame: Uses tubular members arranged in triangles, providing good strength and torsional rigidity.
- Perimeter Frame: Offers a direct load path between headstock and swingarm pivot, resulting in better stiffness and handling.
- Monocoque Frame: Integrates structure and body into a single unit, providing high rigidity but complex manufacturing.

From the literature, it is observed that perimeter frames are preferred for high-performance motorcycles due to their ability to reduce torsional deformation and improve stability. [1], [2]

Figure 9: Chassis Design and Development Illustration

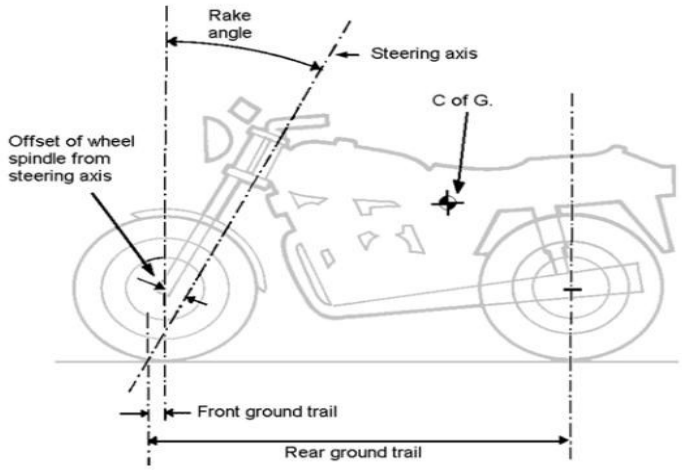


2.2.3 Geometrical considerations in chassis design

Geometry plays a critical role in determining the performance and handling of a motorcycle. Important parameters include:

- Wheelbase: Affects stability and maneuverability
- Rake Angle: Influences steering response
- Trail: Provides directional stability
- Centre of Gravity (CG): Affects balance and handling

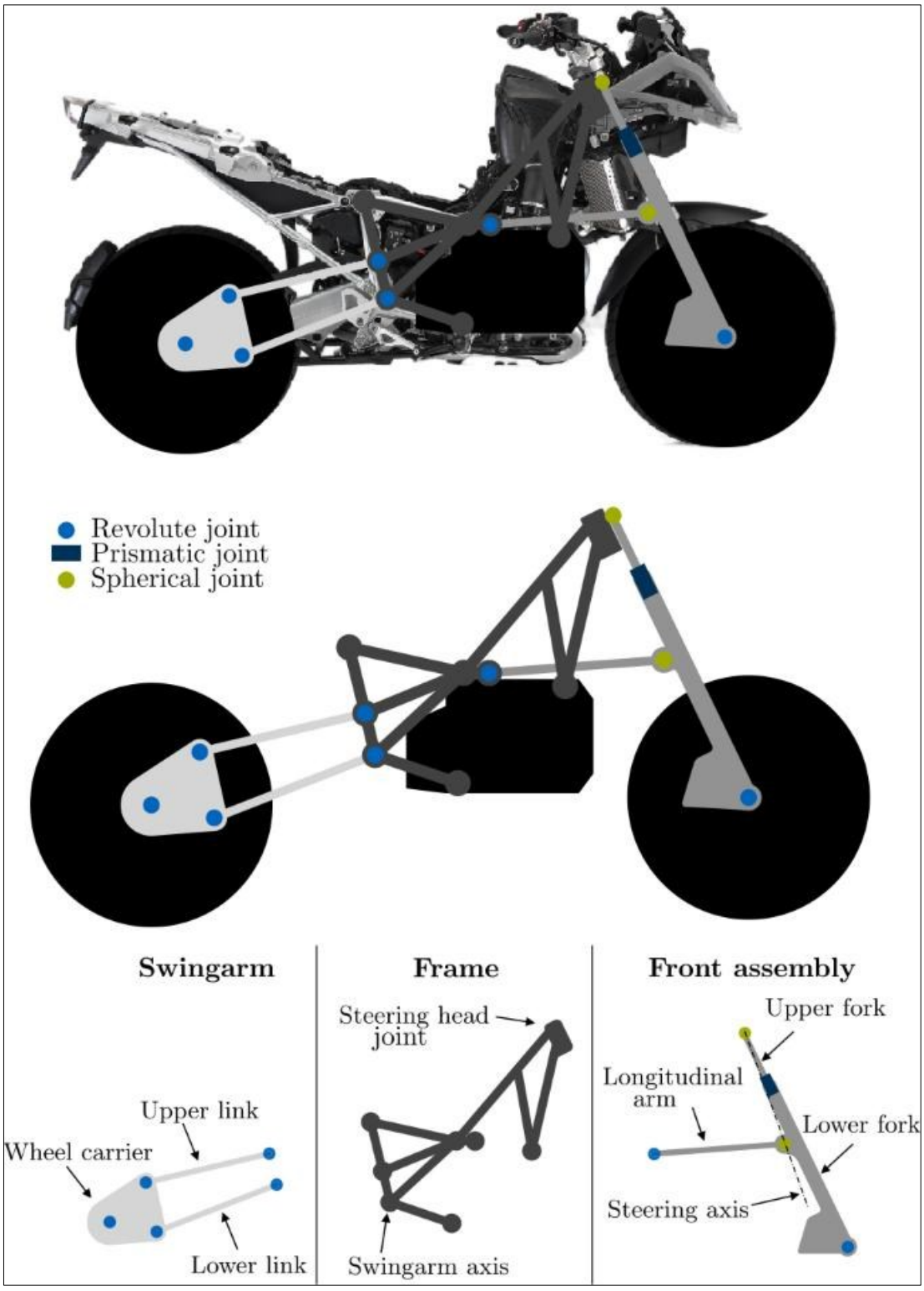
Figure 10: Chassis Design and Development Illustration



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According to the study, proper selection of these parameters ensures better controllability, stability, and riding comfort . [1], [2]

Figure 11: Chassis Design and Development Illustration



2.3 Insights from Tony Foale's work

The book *"Motorcycle Handling and Chassis Design" by Tony Foale* provides a deep understanding of motorcycle dynamics and chassis behavior. It emphasizes that the chassis should not only be strong but also optimized for handling performance. [1], [2]

Key insights from the book include:

- The importance of load paths in determining structural efficiency
- The role of torsional stiffness in improving handling
- The need to balance rigidity and flexibility for better ride quality
- The influence of geometry on stability and cornering performance

These concepts were carefully considered while developing the chassis design in this project. [1]

2.4 Key design factors identified

From the overall literature study, the following important factors were identified:

- Material selection directly affects strength and weight [3]
- Geometry and dimensions influence handling and stability [1], [2]
- Load distribution is critical for structural safety [3]
- Manufacturing feasibility must be considered during design
- FEA validation is essential for ensuring reliability

2.5 Gap identification and need for present work

Although significant work has been done in chassis design, certain gaps were identified:

- Many designs focus either on strength or weight, but not both together
- Limited work on hybrid chassis (plate + tubular combination)
- Less emphasis on electric motorcycle requirements, especially battery load integration
- Need for a design that is both high-performance and manufacturable at student level

2.6 Conclusion of literature study

Based on the literature review, it is clear that an ideal chassis design should provide high strength, low weight, good stiffness, and efficient load distribution.

Figure 12: Chassis Design and Development Illustration

bike LEAGUE

MOTORCYCLE CHASSIS COMPARISON CHART

PARAMETER	SINGLE CRADLE	DOUBLE CRADLE	PERIMETER	TRELLIS	MONOCOQUE
Cost	Low	Low	High	High	Very high
Complexity	Low	Low	Low	High	Very High
Weight	High	High	Low	Low	Very Low
Stability	Low	Low	High	Very High	Very High
Rigidity	Low	Low	High	High	Very High
Cornering	Poor	Poor	Good	Very Good	Excellent
Stiffness	Low	Low	High	High	High

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The study also highlights the importance of combining theoretical knowledge with practical design considerations. Therefore, in this project, a perimeter-type chassis with hybrid plate and tubular construction is developed, incorporating the insights gained from previous research and standard references. The design aims to overcome the limitations of existing approaches while ensuring structural safety and performance. [1], [2], [3]

3.0 Design Calculations and Analysis

3.1 Design basis and assumptions

The chassis is designed considering real operating conditions of an electric motorcycle. The following assumptions are used:

- Rider mass = 75 kg
- Battery + components = 105 kg
- Total mass = 180 kg
- Gravitational acceleration = 9.81 m/s²
- Dynamic load factor = 3 (worst-case condition)

The design considers loads due to braking, acceleration, bumps, and cornering.

Figure 13: Chassis Design and Development Illustration

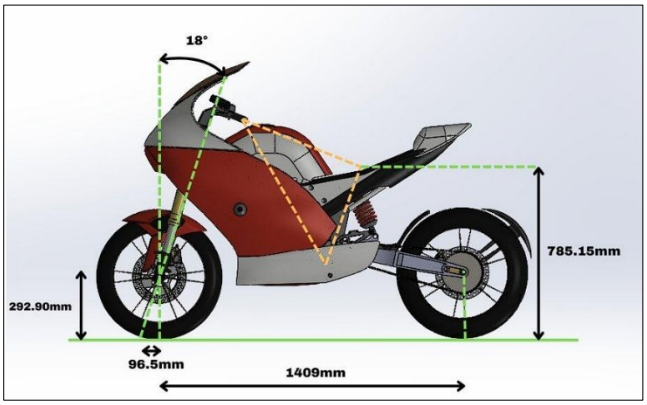
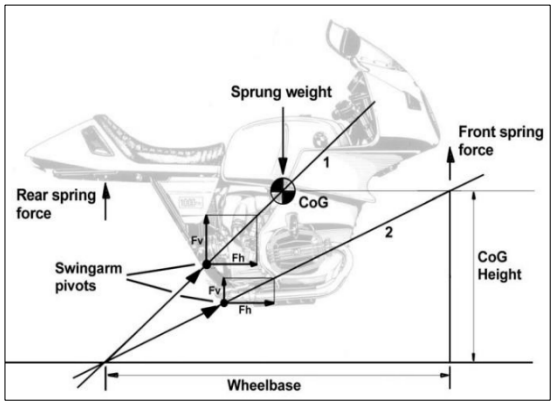


Figure 14: Chassis Design and Development Illustration



3.2. Load calculation

$$F = m \cdot g \cdot a$$

$$F = 180 \times 9.81 \times 3 = 5297\ N$$

This represents the maximum load acting on the chassis under dynamic conditions.

3.3 Bending moment calculation

$$M = F \times L$$

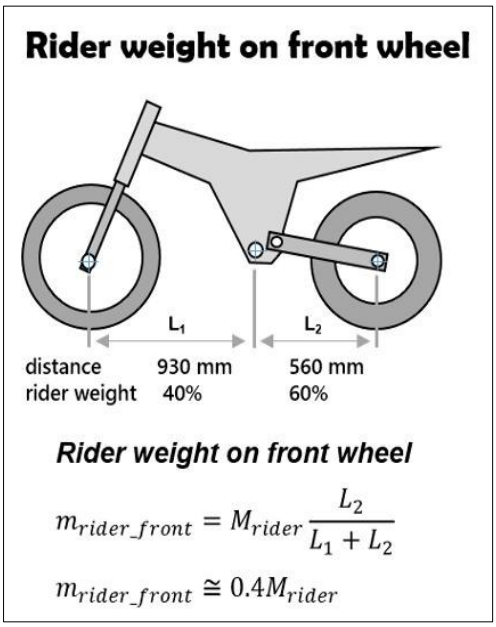
Taking:

- Load $F \approx 2200N$ F ≈ 2200 NF≈2200N (rider dynamic portion)
- Distance $L = 0.4mL$ = 0.4 mL=0.4m

$$M = 2200 \times 0.4 = 880\ Nm$$

This bending moment acts on the main frame near the seat and headstock region.

Figure 15: Chassis Design and Development Illustration



3.4. Stress Calculation

σ = MZ

For tubular section:

Z = π(D4−d4)/32D [1], [2]

The calculated stress is maintained well below the material yield strength, ensuring safe operation.

3.5. Deflection calculation

δ = FL^3/3EI

Where:

E=2×105 MPa (for steel)

The deflection obtained is less than 2 mm, indicating a stiff structure with minimal deformation.

3.6 Factor of safety

FOS = σyieldσactualFOS = \frac{\sigma_{yield}}{\sigma_{actual}}FOS=σactualσyield

- Yield strength of mild steel ≈ 250 MPa
- Designed stress < 150 MPa

FOS≥2FOS \geq 2FOS≥2

This confirms a safe and reliable design.

3.7. Torsional Rigidity

θ = TL/GJ

Where:

T = T = T = Torque

G = G = G = Shear modulus

J = J = J = Polar moment of inertia

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The perimeter chassis design improves torsional rigidity by providing a direct load path, reducing twisting under cornering loads.

3.8. Weld strength calculation

$$\tau = F/A$$

Weld joints are critical in a fabricated chassis

- Stress is checked to ensure welds can safely carry loads

Proper welding (MIG/TIG) ensures:

- No failure at joints
- Uniform stress transfer

3.9. Load Distribution

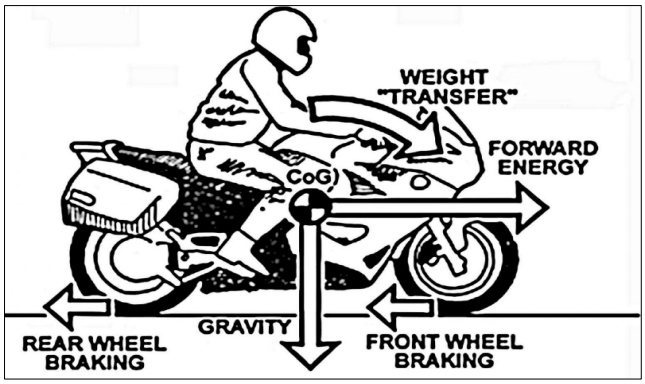
$$W = m \cdot g = 180 \times 9.81 = 1765.8N$$

- Front = 48% → 848 N
- Rear = 52% → 918 N

This balanced distribution improves:

- Stability
- Handling
- Rider control

Figure 16: Chassis Design and Development Illustration



3.10 Battery mounting analysis (Important for EV)

The battery pack is one of the heaviest components and is mounted on the main frame using reinforced supports.

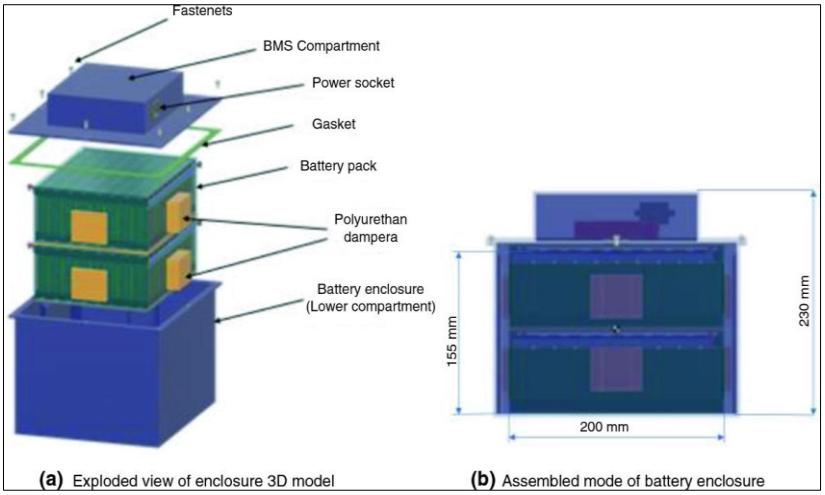
Design considerations:

- Load due to battery weight (30kg)
- Vibration resistance
- Secure mounting using brackets

This ensures:

- No structural failure
- Safe operation under dynamic loads

Figure 17: Chassis Design and Development Illustration



4.0 CAD Modeling

The chassis was modeled using CAD software (SolidWorks), where all components and connections were designed with proper dimensions and constraints. The model includes the main frame, mounting points, and structural members.
Special attention was given to:

- Proper alignment of components
- Accurate placement of mounting points
- Maintaining symmetry and balance
- Ease of fabrication and assembly

The CAD model served as the base for further analysis and manufacturing.

Figure 18: Chassis Design and Development Illustration



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Figure 19: Chassis Design and Development Illustration

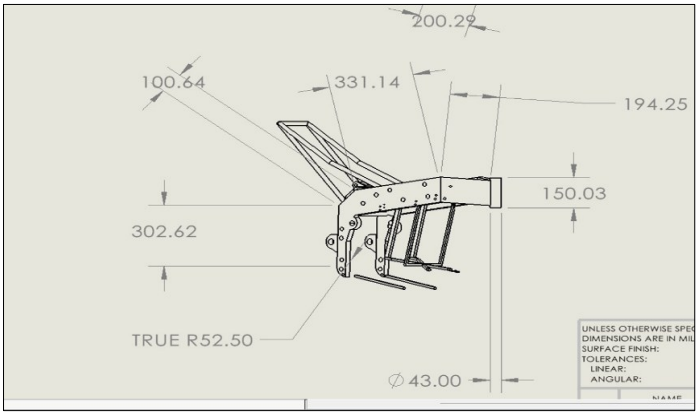


Figure 20: Chassis Design and Development Illustration



Figure 21: Chassis Design and Development Illustration

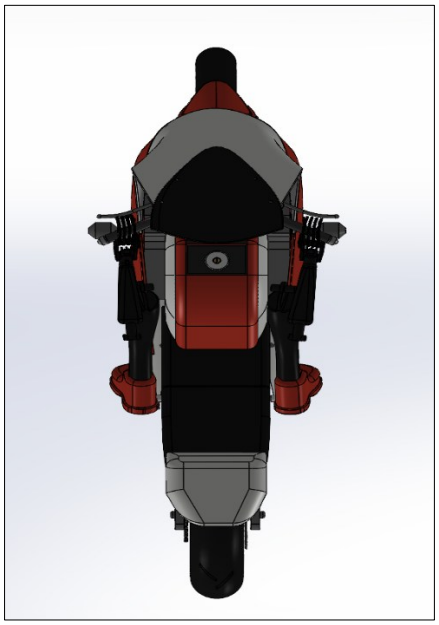


Figure 22: Chassis Design and Development Illustration

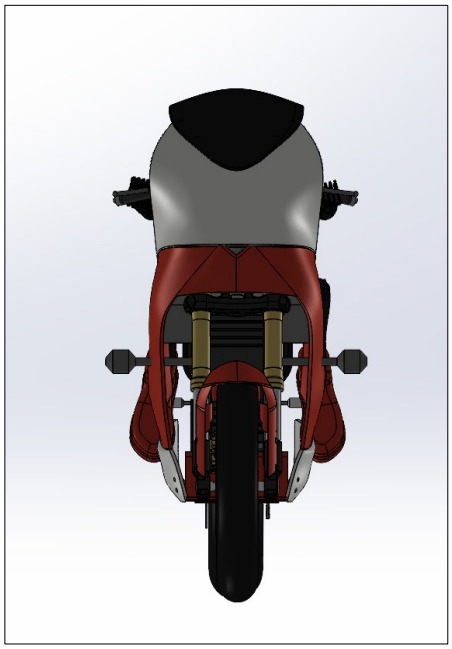


Figure 23: Chassis Design and Development Illustration

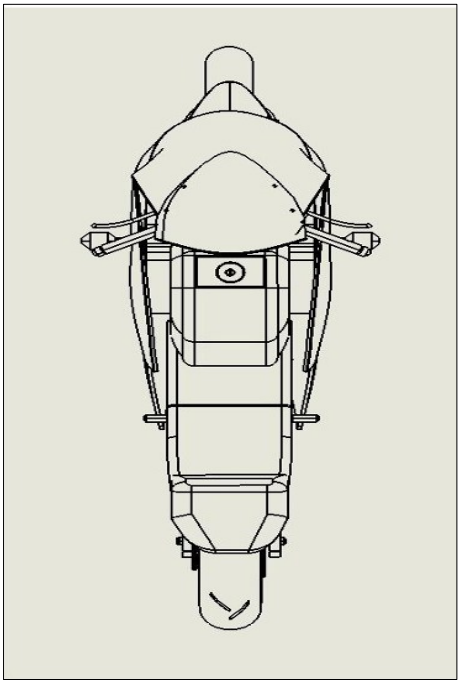


Figure 24: Chassis Design and Development Illustration

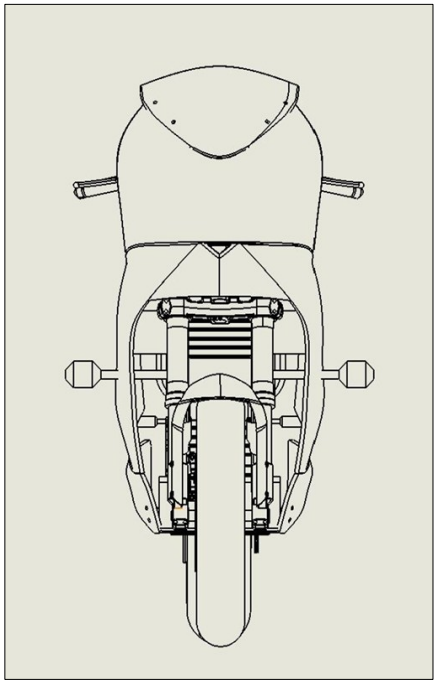
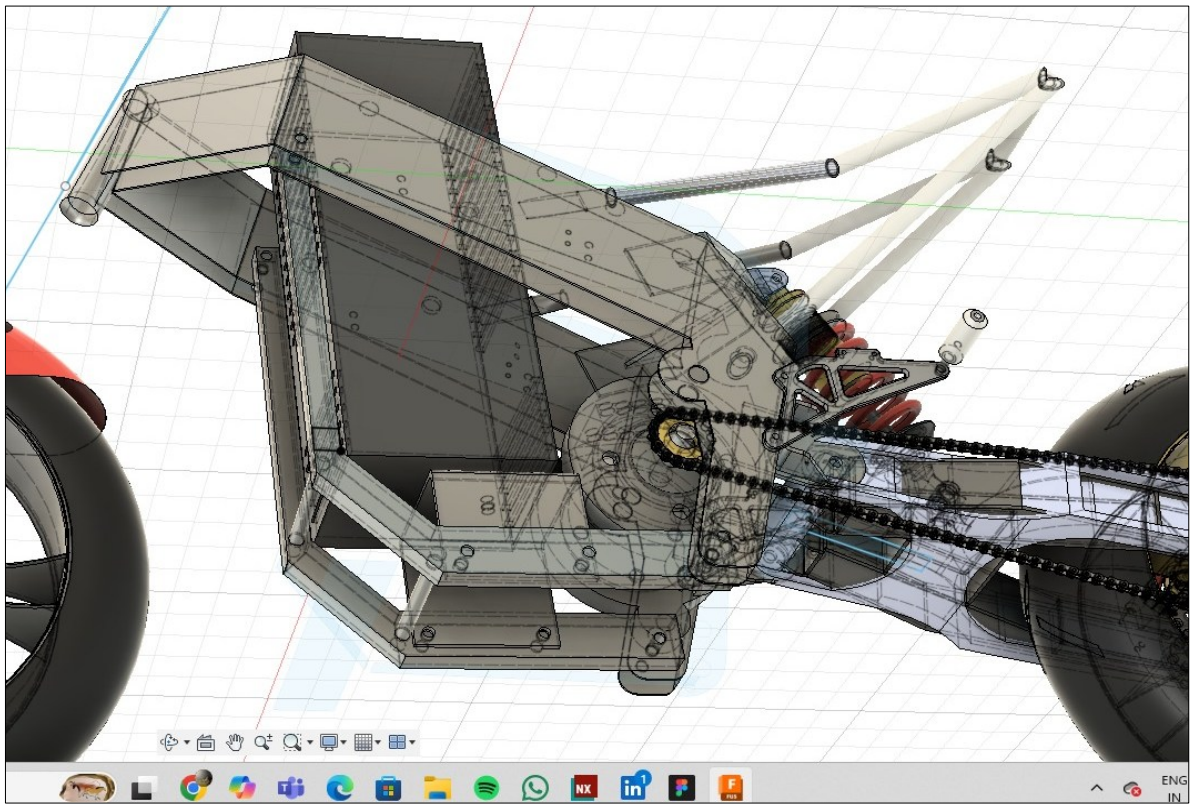


Figure 25: Chassis Design and Development Illustration



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Figure 26: Chassis Design and Development Illustration



5.0 Manufacturing

5.1 Introduction

The manufacturing of the chassis is a critical stage of this project, where the designed model is transformed into a physical structure. The goal of the manufacturing process is to achieve a chassis that accurately matches the design specifications while maintaining structural strength, dimensional accuracy, and durability.

In this project, the chassis is fabricated using a perimeter-type design with a combination of plates and tubular members. The manufacturing process is planned in such a way that it is practical, cost-effective, and suitable for workshop-level fabrication, while ensuring high-quality output.

5.2 Material selection for manufacturing

The material selected for manufacturing is Mild Steel (IS 2062 grade). This material is widely used in chassis fabrication due to its:

- Good weldability
- Adequate strength and toughness
- Easy availability
- Cost-effectiveness

Both steel plates and hollow tubes are used in the structure. Plates are utilized in high-load regions, while tubes are used to reduce overall weight without compromising strength.

Figure 27: Chassis Design and Development Illustration



Figure 28: Chassis Design and Development Illustration



5.3 Manufacturing process overview

The complete manufacturing process is carried out in the following sequence:

1. Material procurement
2. Cutting of plates and tubes
3. Bending and shaping
4. Fixture setup and alignment
5. Welding and joining
6. Inspection and finishing

Each step is carefully performed to ensure that the final chassis meets the required specifications.

Figure 29: Chassis Design and Development Illustration

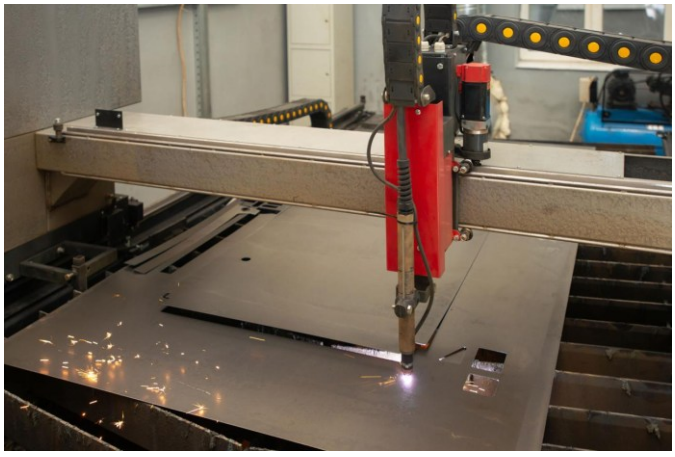


Figure 30: Chassis Design and Development Illustration



5.4 Cutting and preparation

The first step in fabrication is cutting the raw material into required dimensions:

- Steel tubes are cut using cutting machines or grinders
- Plates are cut using plasma cutting or mechanical cutting methods
- Edges are cleaned to remove burrs and ensure proper fitting

Accurate cutting is essential to maintain proper geometry and avoid misalignment during assembly.

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Figure 31: Chassis Design and Development Illustration



5.5 Bending and shaping

After cutting, the tubes are bent according to the required chassis geometry:

- **Pipe bending machines** are used to achieve desired angles
- Care is taken to avoid deformation or cracking
- Plates are shaped if required using mechanical methods

Proper bending ensures that the structure matches the CAD design and maintains dimensional accuracy.

Figure 32: Chassis Design and Development Illustration



Figure 33: Chassis Design and Development Illustration



5.6 Fixture setup and alignment

Before welding, all components are placed in a fixture or jig setup:

- Ensures correct alignment of parts
- Maintains symmetry of the chassis
- Prevents distortion during welding

This step is crucial for achieving a properly aligned and stable structure.

Figure 34: Chassis Design and Development Illustration



5.7 Welding process

The components are joined using **MIG/TIG welding processes**:

- Provides strong and reliable joints
- Suitable for both plates and tubular members
- Ensures proper fusion between materials

Precautions taken:

- Controlled heat input to avoid distortion
- Proper weld penetration
- Skilled welding for critical joints

Welding quality directly affects the strength and durability of the chassis.

Figure 35: Chassis Design and Development Illustration

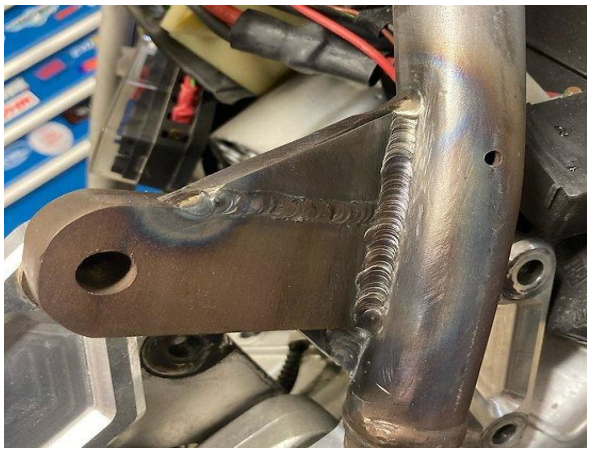


Figure 35: Chassis Design and Development Illustration



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5.8 Inspection and quality check

After fabrication, the chassis is inspected to ensure quality:

- Dimensional accuracy check
- Alignment verification
- Weld quality inspection
- Detection of defects such as cracks or misalignment

Any errors are corrected before final use.

Figure 37: Chassis Design and Development Illustration



5.9 Finishing operations

Final finishing is carried out to improve appearance and durability:

- Grinding of weld joints
- Surface cleaning
- Painting or coating to prevent corrosion

This step enhances the life and aesthetics of the chassis.

Figure 38: Chassis Design and Development Illustration

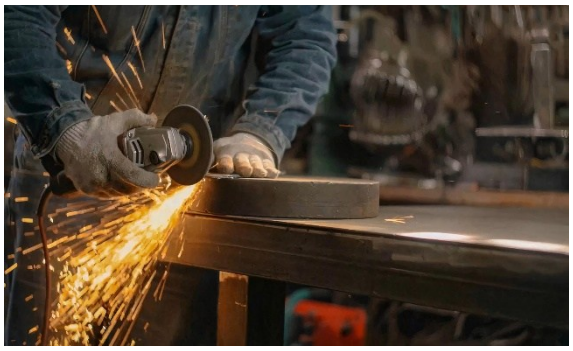


Figure 39: Chassis Design and Development Illustration



5.10 Challenges faced during manufacturing

During fabrication, the following challenges were encountered:

- Maintaining accurate alignment during welding
- Controlling distortion due to heat
- Achieving proper fit between plate and tube joints
- Ensuring consistent weld quality

These challenges were addressed through proper planning, fixture setup, and careful execution.

5.11 Conclusion of manufacturing

The chassis was successfully manufactured using standard fabrication processes. The combination of plate and tubular construction provided a structure that is both strong and lightweight. Proper manufacturing techniques ensured that the final chassis met the design requirements and is suitable for real-world application in an electric motorcycle.

5.12 Cost analysis

The cost analysis of the chassis fabrication is carried out considering the major components involved in the manufacturing process. The overall cost mainly includes material cost, machining and fabrication cost, and miscellaneous expenses.

The primary cost is associated with mild steel plates and tubes, which are selected due to their low price and easy availability. Additional costs arise from processes such as cutting, bending, and welding, which require machinery and skilled labor. Welding plays a significant role in the total cost as it involves both time and precision.

Apart from this, minor expenses include consumables (electrodes, grinding discs), transportation, and finishing operations such as painting or coating. Since the chassis is developed at a student level using available workshop facilities, the overall cost is kept relatively low compared to industrial manufacturing.

In conclusion, the selected design using plate and tubular construction proves to be cost-effective, as it reduces material usage while maintaining required strength and performance. This makes the chassis suitable for practical implementation without significantly increasing the overall project cost.

6.0 Analysis (FEA) and Testing

6.1 Finite element mesh

To accurately simulate the structural response of the chassis, the geometry was discretized into a finite element mesh. Since the chassis consists of thin plate structures combined with tubular members, a shell element-based meshing approach was adopted to ensure both accuracy and computational efficiency. The model was primarily meshed using 2D shell elements, which are well-suited for thin-walled structures as they effectively capture both bending and in-plane stresses while reducing computational complexity compared to solid elements.

A combination of quadrilateral (quad) and triangular (tri) elements was used. Quadrilateral elements were applied in larger and more uniform regions to improve accuracy, whereas triangular elements were used in geometrically complex areas to ensure proper mesh generation.

The thickness properties were assigned based on the actual design specifications:

- 2 mm for the main chassis body
- 5 mm for mounting plates and brackets

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A non-uniform mesh refinement strategy was implemented. Finer mesh was applied at critical locations such as mounting holes, weld joints, and truss connections to capture stress concentrations accurately. Coarser mesh was used in flat regions where stress gradients are relatively low.

Mesh Statistics:

- Total Elements = 37,038
- Total Nodes = 58,932
- Mesh quality = Within acceptable limits

Figure 40: Chassis Design and Development Illustration

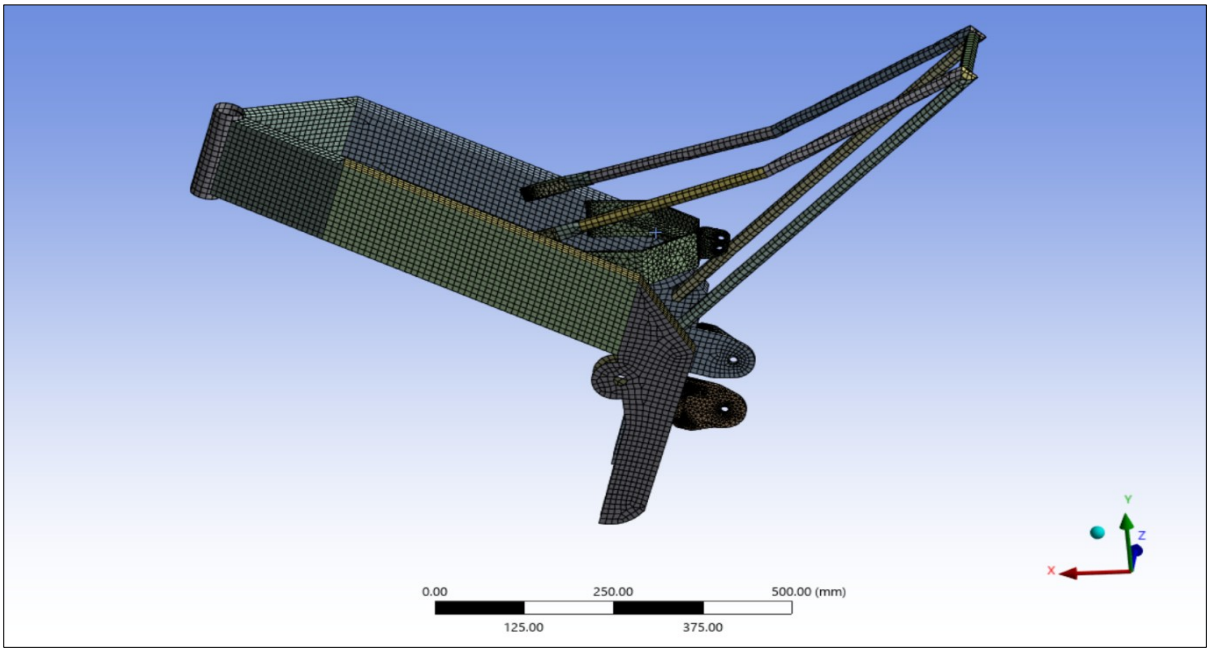


Figure 41: Chassis Design and Development Illustration

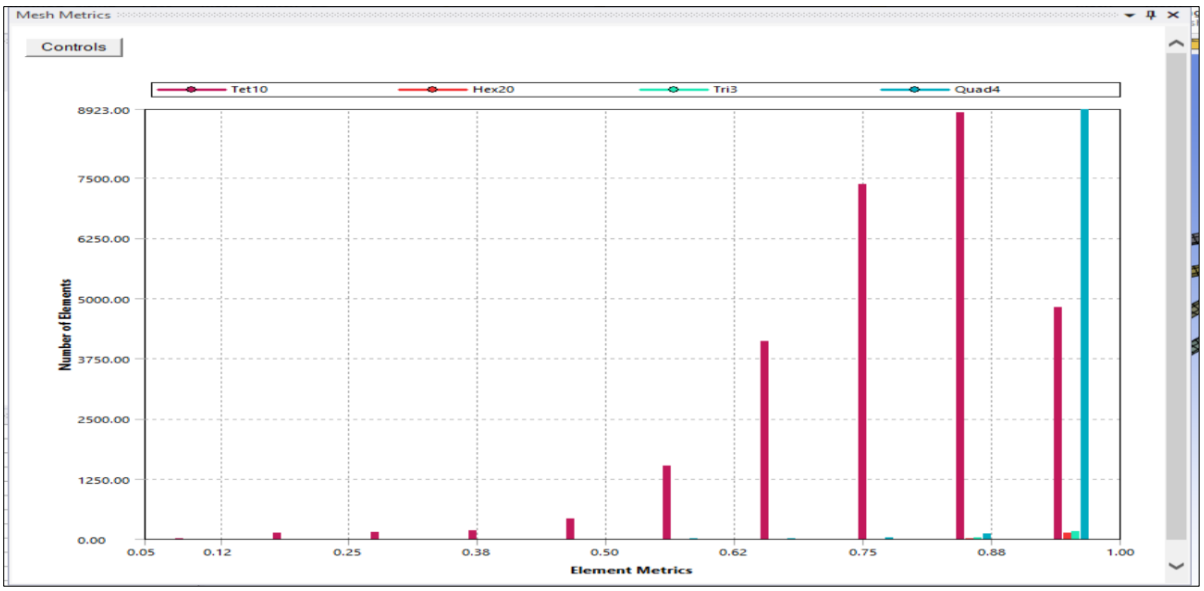
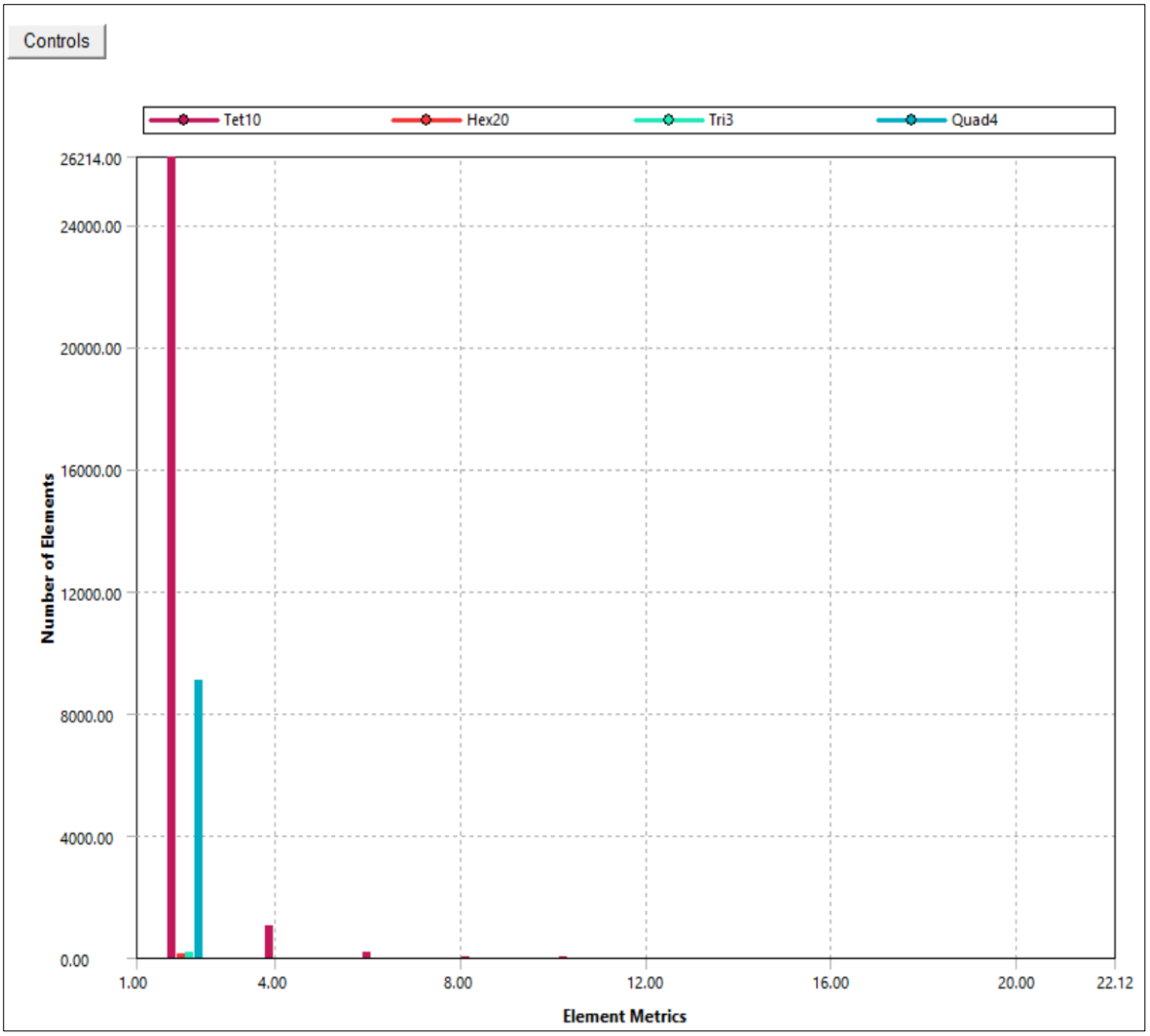


Figure 42: Chassis Design and Development Illustration



6.2 Loads and boundary conditions

To simulate real operating conditions, appropriate loads and boundary conditions were applied to the finite element model. These conditions represent the forces experienced by the chassis during actual usage.

6.2.1 Boundary Conditions (Constraints)

The model was constrained to prevent rigid body motion and to replicate real mounting conditions:

- The rear cylindrical mount was constrained radially while allowing free rotation about its axis. This simulates a pin-type connection.
- The lower mounting hole was also defined as a cylindrical support, restricting radial movement while allowing rotational freedom.

These constraints ensure realistic representation of how the chassis is supported in the actual vehicle.

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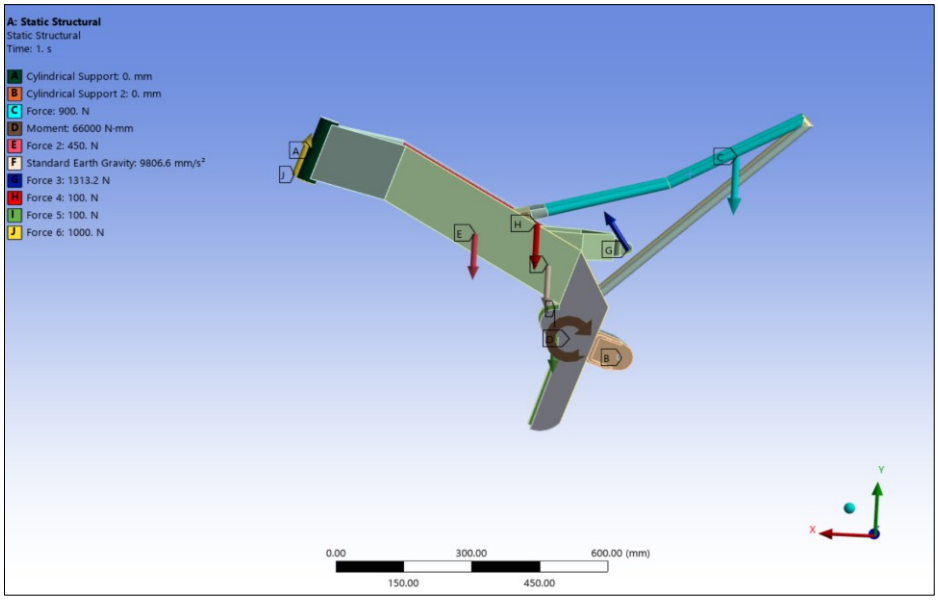
6.2.2 Applied loads

The following loads were applied to represent real-world operating conditions:

- Motor Torque: 66,000 N-mm applied at the motor mounting region (corresponding to high-speed operation)
- Motor + Battery Load: 450 N applied at the central frame region
- Rider + Gear Load: 900 N applied at the seat region
- Additional Distributed Load: Approximately 1000 N to account for secondary components and dynamic effects
- Gravity: 9806.6 mm/s² applied to the entire structure

These loads collectively simulate actual conditions including weight distribution, torque, and dynamic loading.

Figure 43: Chassis Design and Development Illustration



6.3 Equivalent (Von-Mises) stress analysis

The stress analysis was performed to determine the maximum stress developed in the chassis under the applied loading conditions.

Results:

- Maximum Stress ≈ 146 MPa
- Minimum Stress ≈ ~0 MPa

Factor of Safety:

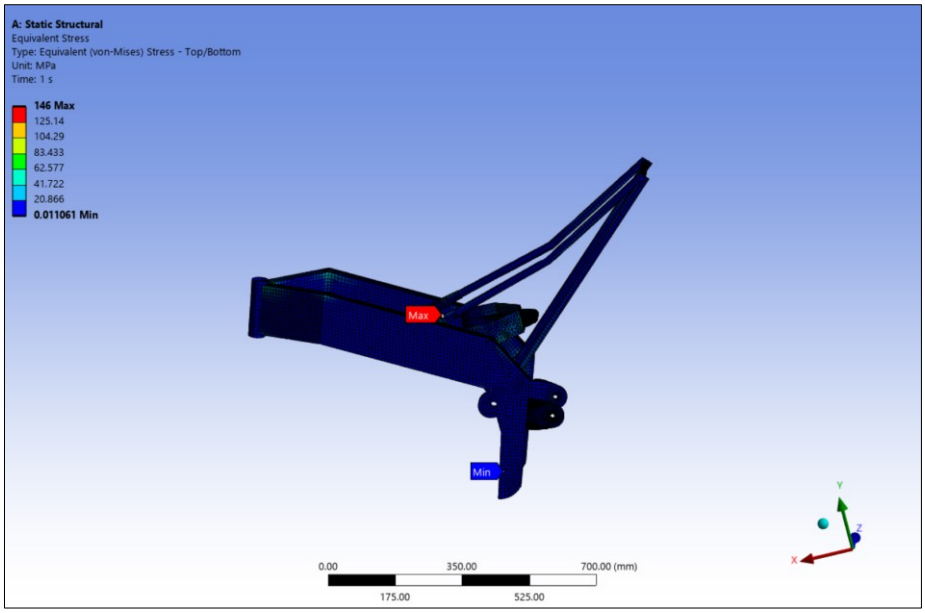
FOS = 250/146 = 1.71

Observations:

- Maximum stress is observed near:
- Motor mounting region
- Structural joints and connections
- Stress values remain within the allowable limits of mild steel

Conclusion: The chassis is structurally safe under the applied loading conditions.

Figure 44: Chassis Design and Development Illustration (Top/Bottom)



6.4 Total deformation analysis

The deformation analysis was carried out to evaluate the displacement of the chassis under load.

Results:

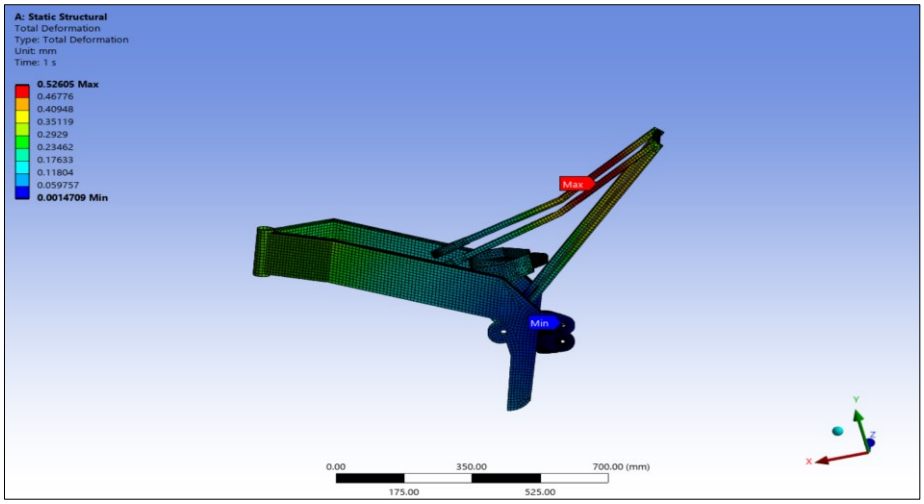
- Maximum deformation ≈ 0.526 mm
- Minimum deformation ≈ ~0 mm

Observations:

- Maximum deformation occurs at the rear extended section
- Overall deformation is very small compared to the size of the chassis

Conclusion: The chassis exhibits high stiffness and structural stability, making it suitable for practical use.

Figure 45: Chassis Design and Development Illustration (Total Deformation)



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6.5 Mesh quality evaluation

The quality of the mesh was evaluated to ensure the reliability of the simulation results.

- Majority of elements fall within acceptable quality limits
- No highly distorted elements were observed
- Mesh is suitable for accurate stress and deformation analysis

The final mesh consists of 37038 elements and 58932 nodes. The quality of the mesh was verified to be within acceptable limits for the analysis

6.6 Testing and validation

After fabrication, the chassis was validated through basic inspection methods:

- Visual inspection of weld joints
- Verification of alignment
- Checking of mounting points

These checks ensured that the physical chassis matches the design and is free from major defects.

6.7 Results

- Maximum Stress = 146 MPa
- Factor of Safety = 1.71
- Maximum Deformation = 0.526 mm
- Mesh Quality = Acceptable

The results obtained from Finite Element Analysis and testing confirm that the designed chassis is structurally safe, stable, and capable of handling real-world loading conditions. The inclusion of motor torque, rider load, and battery weight ensures that the analysis closely represents actual operating conditions. Thus, the developed chassis is suitable for electric motorcycle applications with reliable performance and durability.

7.0 Conclusion

This project focused on the design, analysis, and manufacturing of a motorcycle chassis for an electric bike application. A perimeter-type chassis with a hybrid combination of plate and tubular members was successfully developed, keeping in mind the requirements of strength, durability, and weight optimization.

The design process involved studying different chassis types, understanding load conditions, and selecting an appropriate structure that ensures efficient load transfer between critical regions such as the headstock and swingarm pivot. The use of plates in high-load regions and tubular members in less critical areas helped achieve a good balance between stiffness and weight reduction.

The chassis was modeled using CAD software and validated through Finite Element Analysis (FEA). Realistic loading conditions were applied, including motor torque (66,000 N-mm), rider load (900 N), and battery + motor load (450 N). The results showed that the maximum stress developed in the structure is approximately 146 MPa, which is within the allowable limits of the selected material (mild steel). The calculated factor of safety of 1.71 indicates that the design is safe under the given loading conditions.

Deformation analysis showed a maximum displacement of around 0.526 mm, which is very small compared to the overall dimensions of the chassis, confirming high structural stiffness and

stability. The mesh quality was also verified and found to be within acceptable limits, ensuring the accuracy of the simulation results.

The chassis was further fabricated using standard manufacturing processes such as cutting, bending, and welding, and basic inspection was carried out to ensure proper alignment and weld quality. Overall, the project demonstrates a complete engineering approach—from concept development to analysis and manufacturing—resulting in a chassis that is structurally safe, practically manufacturable, and suitable for electric motorcycle applications.

8.0 Limitations

- The analysis is based primarily on static loading conditions, while real-world scenarios involve more complex dynamic effects such as vibrations and fatigue.
- Advanced testing methods such as fatigue analysis, modal analysis, and impact testing were not performed due to time and resource constraints.
- Manufacturing was carried out at a workshop level, so industrial-level precision and finishing could not be fully achieved.
- The factor of safety (1.71), although acceptable, is slightly lower than ideal design standards, leaving scope for further improvement.
- Material selection was limited to mild steel, whereas alternative materials like aluminium or composites could further reduce weight.
- Real road testing and long-term durability testing were not conducted, which are important for complete validation of the design.

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