1.4 Structural Analysis & Simulation Results

Our structural simulation process, a critical step in validating the CAD design, was conducted using **Ansys**. This iterative process aimed to assess the chassis' structural integrity, performance characteristics, and safety under various loading conditions. To ensure accurate and reliable results, we established a robust simulation framework that involved defining appropriate boundary conditions, applying realistic loading scenarios, selecting appropriate material properties, and performing a mesh convergence study to ensure mesh independence, thus balancing accuracy with computational efficiency.

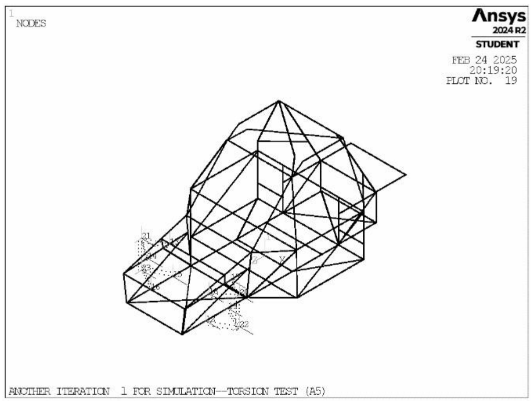

Figure 1.8: *Nodes of the Meshed Chassis*

1.4.1 Validating Torsional Rigidity

A simulation was conducted to assess how well the chassis resists twisting, as torsional rigidity is critical for handling performance.

Loading and Boundary Conditions:

A torque of **1175.9 N.M** was applied to the front axle mounting points, simulating forces experienced during cornering. The rear suspension mounting points were fixed to prevent movement. The torque value was determined based on expected peak cornering forces.

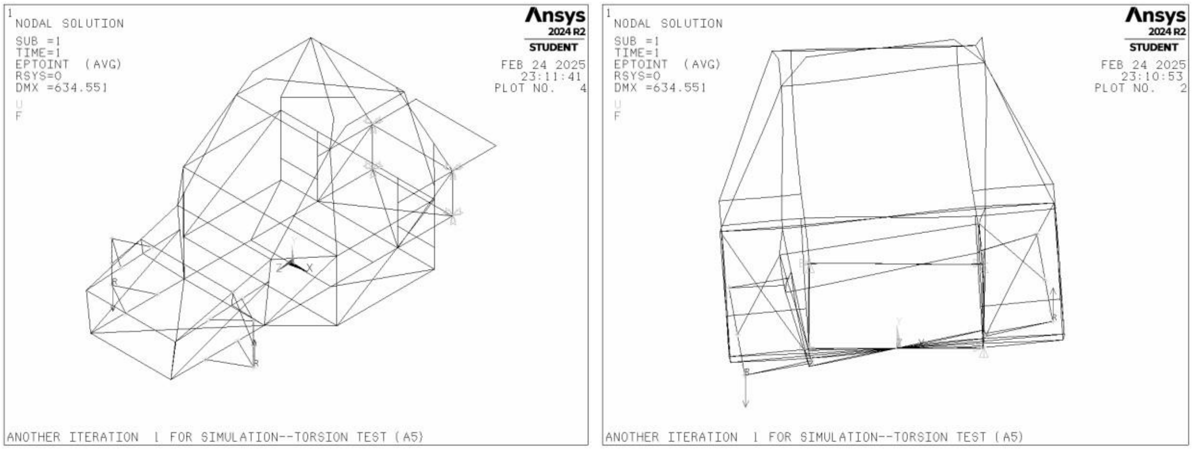

Figure 1.9: *Analysis of Cornering Loads*

Results and Discussion:

The simulation revealed a torsional rigidity of **1678.57 N.m/deg**, exceeding the target of **>1650 N.M/deg**. This confirms the effectiveness of the chassis design in resisting torsional forces, contributing to improved handling and stability.

1.4.2 Validating Bending Stiffness

Bending stiffness is essential to minimize vertical deflection under load. A simulation was performed to determine the chassis' resistance to bending forces.

Loading and Boundary Conditions:

A force of **1101.02 N** was applied at the front suspension mounting points to simulate the weight transfer due to aggressive deceleration. The rear suspension mounting points were fixed. This force represents the worst-case scenario for braking loads.

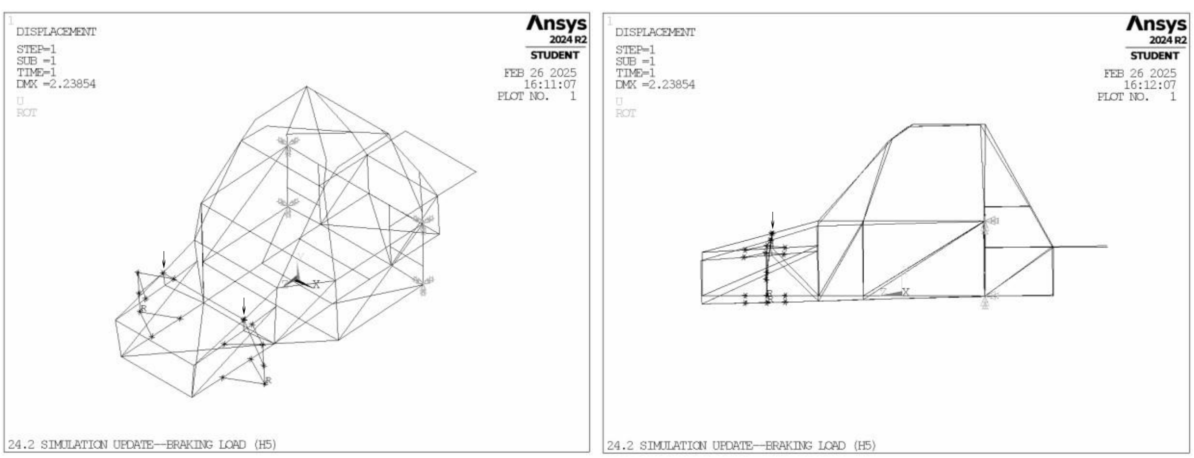

Figure 1.10: *Analysis of Braking Loads*

Results and Discussion:

The simulation showed a maximum vertical deflection of **2.1651 mm, resulting in a bending stiffness of 6928.09 N/mm**, which meets the target of **> 6100 N/mm**. This ensures minimal deflection and prevents ground contact.

1.4.3 Assessing Front Impact Performance

Front impact simulations were conducted to assess the chassis' ability to withstand frontal collisions, prioritizing driver safety.

Loading and Boundary Conditions:
An impact force of **38,940 N** was applied to the front of the chassis, simulating a collision. This force complies with regulatory standards for front-impact testing.

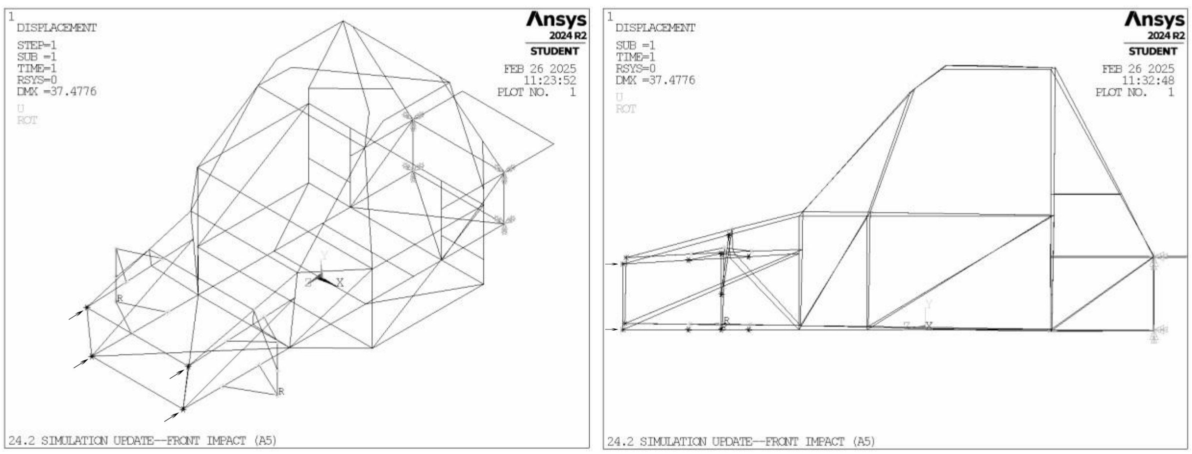

Figure 1.11: *Analysis of Front Impact*

Results and Discussion:
The maximum stress observed was **23.357 MPa**, which is below the yield strength of the material. The Factor of Safety (FOS) exceeding **3.0**, indicating that the chassis can withstand significant frontal impacts without failure, ensuring driver safety.

1.4.4 Assessing Side Impact Performance

Side impact simulations were conducted to evaluate the chassis' ability to withstand side collisions and protect the driver.

Loading and Boundary Conditions:
An impact force of **38,940 N** was applied to the side of the chassis, simulating a collision. This force complies with regulatory standards for side-impact testing.

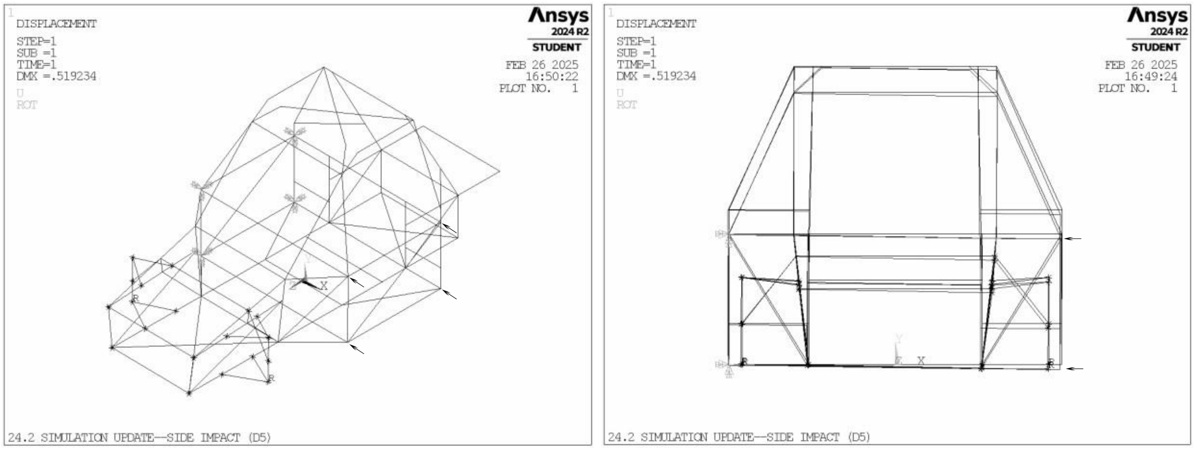

Figure 1.12: *Analysis of Side Impact*

Results and Discussion:

The maximum stress observed was **22.544 MPa**, which is below the yield strength of the material. The FOS exceeds **2.5**, confirming that the side-impact structure provides adequate protection to the driver.

1.4.5 Assessing Rear Impact Performance

Rear impact simulations were conducted to evaluate the chassis' ability to withstand rear collisions and ensure driver safety.

Loading and Boundary Conditions:

An impact force of **38,940** N was applied to the rear of the chassis, simulating a collision. This force complies with regulatory standards for rear-impact testing.

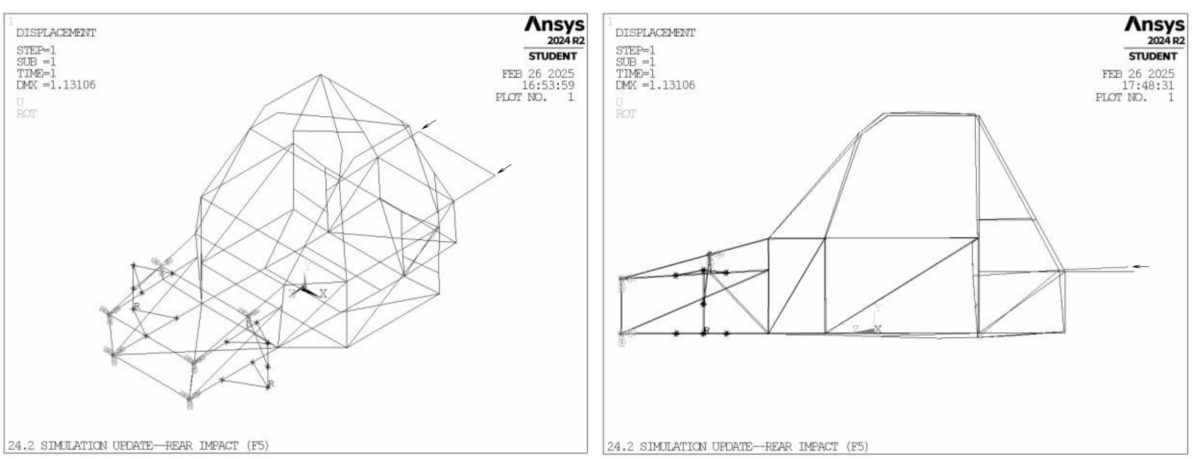

Figure 1.13: *Analysis of Rear Impact*

Results and Discussion:

The maximum stress observed was **43.9 MPa**, which is below the yield strength of the material. The FOS exceeds **1.5**, verifying that the rear impact structure is capable of withstanding significant rear collisions while ensuring driver safety.

1.4.6 Chassis Properties & COG

final chassis design achieved a centre of gravity height of **194.87 mm** and a weight distribution of **41.3% Front** and **58.7% Rear**. These values represent a compromise between stability, handling, and traction.

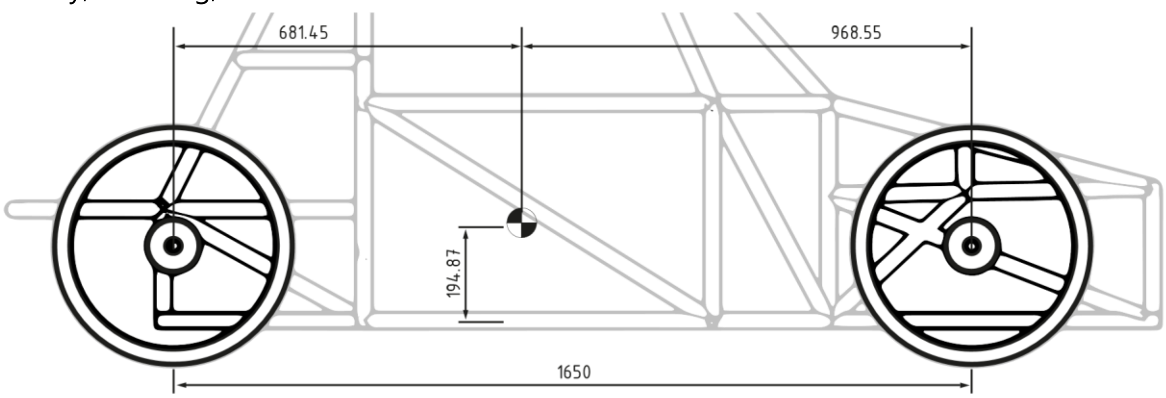

Figure 1.14: *Chassis **COG** location shown with key dimensions.*

1.5 Manufacturing & Assembly Considerations

To ensure accurate and repeatable chassis construction, a comprehensive **jigging system** was developed. **Figure 1.15** provides an overview of this system, illustrating the spatial relationship between the chassis frame and the key jigs used during assembly. Dedicated jigs are employed for the Main Hoop, Front Hoop, Front Suspension Mounts, and Rear Suspension Mounts, as labelled in the figure. The precise placement of these jigs facilitates accurate alignment and secure retention of chassis tubes during the welding process, minimizing distortion and contributing to the overall structural integrity of the chassis.

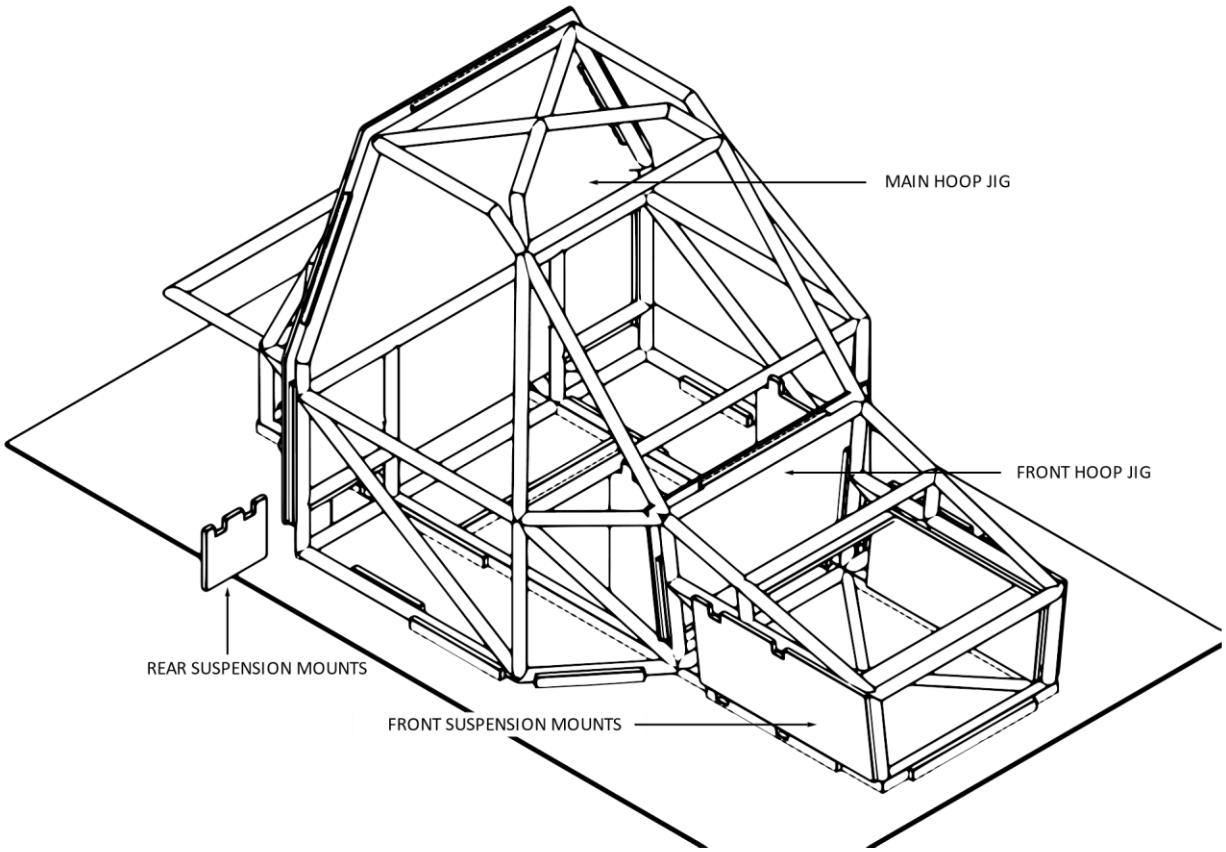

Figure 1.15: *Chassis Assembly Jig*

1.6 Key Performance Metrics & Results

Metric	Unit	Target	Acceptable	Theoretical
Torsional Rigidity	N.m/deg	>1650	>1476	**1678.57**
Bending Stiffness	N/mm	>6100	>5230	**6928.09**
Weight	kg	<28.3	<31.8	**25.78**
Weight Distribution	%	40F 60R	45F 55R	**41.3F 58.7R**
Vertical Location of CG	mm	<183	<205	**194.87**
Front Impact FOS	-	>3.0	>2.5	**3.13**
Rear Impact FOS	-	>3.0	>2.5	**1.66**
Side Impact FOS	-	>2.5	>2.0	**3.24**

The table below summarizes the key performance metrics and results obtained from the simulation iterations. The target values represent the ideal goals set for each metric, which were slightly higher than the acceptable values derived from the initial iterations as feasible benchmarks. The theoretical results listed in the final column correspond to the outcomes of the last iteration of simulations.

These results demonstrate significant improvements, with most metrics meeting or exceeding the acceptable thresholds. However, the rear impact factor of safety (FOS) fell slightly below the target. This progression highlights the iterative refinement process used to optimize performance.