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# Design & Manufacturing of Formula Student Vehicle Chassis

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**ABSTRACT -** Designing a reliable chassis is at the heart of building a safe and high-performing Formula Student vehicle. This project focuses on creating a spaceframe chassis using AISI 1018 steel — chosen for its strength, ease of fabrication, and availability. With the help of SolidWorks for modelling and ANSYS for analysis, the chassis was engineered to balance stiffness and weight while meeting all the safety and design requirements set by SUPRA SAEINDIA and Formula Bharat rulebooks. Throughout the process, refinements were made to the rear suspension geometry, including adjustments to wishbone lengths, angles, and damper positioning, to enhance handling and load distribution. Driver ergonomics and turning radius were also factored into the design to improve control and comfort. Reference to research papers and previous competition vehicles guided development at each stage. The result is a chassis that not only supports dynamic performance but also reflects thoughtful integration of real-world driving and manufacturing considerations.

**KEY WORDS:** Formula Student, Chassis, Design, AISI 1018, Structural Analysis, Driver ergonomics, Suspension geometry.

## 1.INTRODUCTION:

The chassis plays a critical role in any vehicle, acting as the structural core that supports all major systems while ensuring safety, rigidity, and dynamic stability. In high-performance applications, such as formula-style vehicles, the challenge lies in designing a chassis that is lightweight yet strong enough to handle intense loads during acceleration, braking, and cornering. This project focuses on the design and manufacturing of a tubular spaceframe chassis using AISI 1018 steel, chosen for its good strength-to-weight ratio, weldability, and cost-effectiveness.

The design process involved detailed CAD modelling in SolidWorks and structural analysis in ANSYS to evaluate torsional rigidity, stress distribution, and deformation under real-world loading scenarios. Special attention was given to optimizing suspension mounting points, rear wishbone angles, and damper positions to improve load transfer and handling characteristics. Driver ergonomics, visibility, and turning radius were also considered to ensure comfort and control within a compact structural envelope.

By combining practical manufacturing methods with simulation-driven design, the project aims to develop a chassis that balances performance, safety, and manufacturability — all while operating within the constraints faced by student teams.

## 2. DESIGN METHODOLOGY:

The chassis was designed by following the safety and structural requirements specified in the SUPRA SAEINDIA and Formula Bharat rulebooks. The focus was on achieving a balance between strength, driver safety, and weight reduction. An initial layout was created by considering the ergonomic position of the driver and packaging of key subsystems.

The complete 3D model of the chassis was developed in SolidWorks, incorporating primary, secondary, and tertiary members. The model was then imported into ANSYS Workbench to perform structural analysis under various loading conditions. Based on the analysis results, several design iterations were carried out to improve torsional rigidity and reduce unnecessary material. Final geometry ensured proper suspension integration, driver comfort, and rulebook compliance.

| Tubes | Nomenclature | Dimensions (mm) | MOI (mm2) |
|---|---|---|---|
| Primary | Front Bulkhead | 25.4 x 2.5 | 11320 |
| | Front Hoop | | |
| | Main Hoop | | |
| Secondary | Front Hoop Bracing | 25.4 x 1.65 | 8509 |
| | Side Impact | | |
| | Main Hoop Bracing | | |
| Tertiary | Bracing Supports | 18 x 1 | 6695 |
| | Non-Structural Tubes | | |

**Table -1:** Chassis tube nomenclature & dimensions

### 2.1. Vehicle Design Parameters:

A] Wheelbase- Wheelbase is simply the distance between the front and rear wheels of the car. It plays a big role in how stable and balanced the vehicle feels, especially at high speeds or while cornering.

B] Track width: Track width refers to how far apart the left and right wheels are on the same axle. A wider track usually gives the car better grip and control during turns.

C] Ground Clearance: Ground clearance is the gap between the lowest part of the chassis and the ground. It

tells us how easily the vehicle can go over bumps or uneven surfaces without scraping the bottom.
D] Templates: In Formula Student, templates are standard shapes or guidelines provided in the rulebook. They help make sure that important parts like the cockpit, roll hoops, and headrest are designed safely and fit properly around the driver.

| Parameter | Length (mm) |
|---|---|
| Wheelbase | 1610 |
| Track Width | F-1043, R-1092 |
| Ground Clearance | 30 |
| Height | 1105 |
| Chassis Length | 2360 |
| Chassis Width | 630 |

**Table -2:** Dimension Parameter of Chassis

### 2.2. Material Selection:

Material selection plays a crucial role in chassis design, as the chassis must support all vehicle components while withstanding various forces during acceleration, braking, and cornering. The material should offer high strength, good stiffness, and a favorable strength-to-weight ratio to ensure performance and safety. It must also resist vibrations and deformation under load, while being suitable for processes like welding and forming. A well-chosen material ensures that the chassis remains lightweight, durable, and reliable throughout its operation.

| Material Nme | Tensile strength (N/mm2) | Yield strength (N/mm2) | Mass density (kg/m2) | Cost (rupees/m) |
|---|---|---|---|---|
| AISI 1018 | 440 MPa | 370 MPa | 7870 kg/m3 | 390 |
| AISI 1020 | 420.5 MPa | 351.5 MPa | 7900 kg/m3 | 375 |
| AISI 4130 | 731 MPa | 460 MPa | 7850 kg/m3 | 450 |

**Table-3:** Material Selection

AISI 1018 was selected for this project because it offers a good balance of mechanical properties, affordability, and ease of manufacturing. Compared to AISI 1020, AISI 1018 provides slightly better strength and is equally weldable and machinable, making it a more suitable option for structural applications like a chassis.
While AISI 4130 has much higher strength and a better strength-to-weight ratio, it requires additional processes such as heat treatment and precision welding techniques to fully utilize its properties. These extra steps not only increase fabrication complexity but also raise the overall cost significantly. Considering the design goals of safety, stiffness, and cost-effectiveness, AISI 1018 stands out as the most practical and efficient choice for this project.

### 3. ERGONOMICS:

While designing the chassis, driver comfort and control were given high priority. The goal was to ensure that the driver could sit comfortably, reach the pedals and steering wheel easily, and maintain good visibility — all without compromising on safety or vehicle packaging.
To begin with, we referred to the templates provided in the rulebook and used the dimensions of a 95th percentile male to make sure the cockpit could comfortably fit a wide range of drivers.
An ergonomic jig was built to simulate the seating position, and real drivers were asked to sit and give feedback. Based on this, adjustments were made to the seat angle, steering wheel height, and pedal distance. These changes helped achieve a natural and relaxed driving posture, which is important during endurance events. The final layout also ensured smooth entry and exit for the driver, proper harness mounting, and clear visibility — all of which are crucial for safety and performance on track. Overall, the ergonomic setup was designed to give the driver a confident and fatigue-free experience while racing.

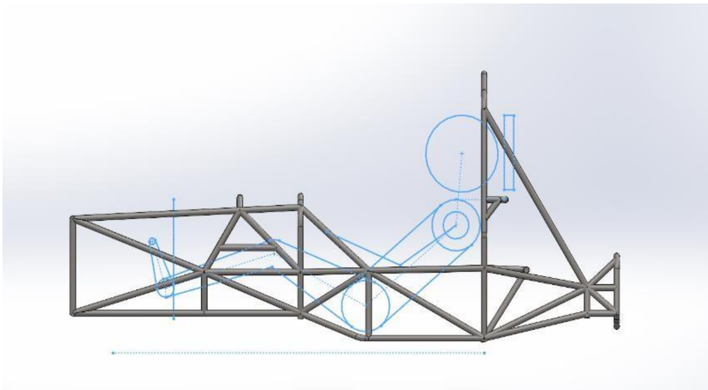

**Fig -1:** Driver Ergonomics & Vehicle Envelope

| Driver Position (reclined) | Main Roll Hoop height (mm) | Total Frame length (mm) | Driver visibility | Driver Rating (out of 5) |
|---|---|---|---|---|
| 35° | 1187.9 | 2159.63 | Better | 4.5 |
| 40° | 1149.56 | 2193.55 | Good | 4 |
| 50° | 1062.74 | 2253.94 | Moderate | 3 |
| 60° | 965.91 | 2302.93 | Bad | 2 |

**Table-4:** Driver Position Comparison

## 4. FINITE ELEMENTAL ANALYSIS:

To ensure the chassis could handle real-world racing conditions, Finite Element Analysis (FEA) was performed on the 3D CAD model using ANSYS Workbench. The main focus was on checking torsional rigidity, stress distribution, and deformation under various loading conditions like cornering, braking, and bumps. The chassis was simulated with fixed points at suspension mounts, and loads were applied to replicate actual forces during dynamic events. The results helped us identify weak zones and make design changes to improve strength while keeping the structure lightweight. This analysis gave us the confidence that the final chassis design would perform safely and reliably on track.

### 4.1: Front Impact Test

The front impact test was done to check how the chassis would behave in a frontal collision. A simulated force was applied to the front bulkhead area in ANSYS to see how the structure absorbs and distributes the impact. The goal was to make sure the front section doesn't deform excessively and keeps the driver safe. The results showed that the design could handle the expected load while staying within the safety limits defined by the rulebook.

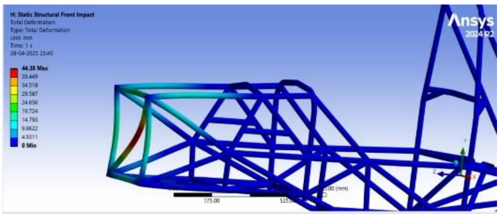


**Fig-2:** Front Impact Test

### 4.2: Side Impact Test

The side impact test was carried out to check how well the chassis protects the driver from lateral collisions. A load was applied to the side impact zone, especially near the driver's seating area, using FEA in ANSYS. The aim was to ensure the side members could absorb the force without collapsing or causing harm to the driver. The simulation results confirmed that the side structure had enough strength and stiffness to handle the impact safely, meeting the required safety standards.

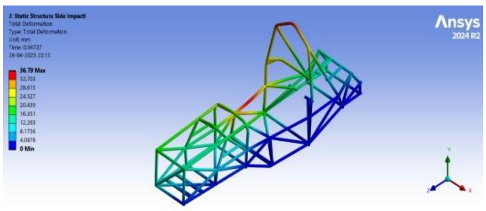


**Fig-3:** Side Impact Test

### 4.3: Rear Impact Test

The rear impact test was done to evaluate how the chassis responds to a collision from the back, especially around the engine and differential mount area. Using FEA in ANSYS, a force was applied to the rear section to simulate an impact scenario. The goal was to ensure that the structure could absorb the load without major deformation and protect the drivetrain components. The results showed that the rear members maintained their integrity, confirming the chassis is safe and reliable under rear impact conditions.

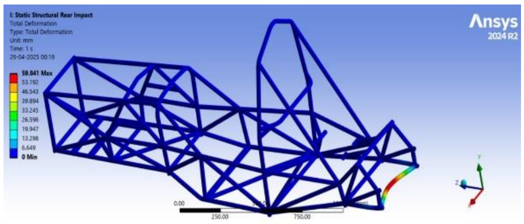


**Fig-4:** Rear Impact Test

### 4.4: Roll Over Analysis:

The roll-over analysis was performed to check if the chassis could protect the driver in case the car flips upside down. In this simulation, forces were applied to the top of the main roll hoop and front roll hoop to replicate the load during a roll-over. The aim was to make sure these structures could take the impact without collapsing. FEA results showed that both roll hoops stayed within the allowable deformation limits, ensuring the driver remains safe during a roll-over situation, as required by the competition rulebook.

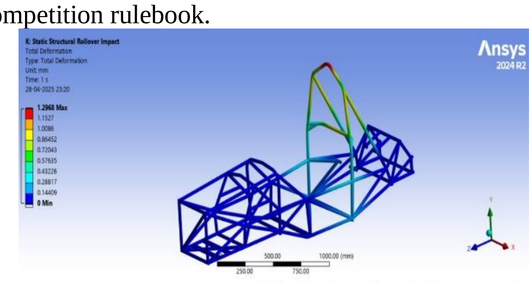


**Fig-5:** Roll Over Analysis

### 4.5: Static Load Analysis:

Static load analysis was carried out to understand how the chassis behaves under normal operating loads, like the weight of the driver, engine, suspension, and other components. Using ANSYS, loads were applied at key mounting points to simulate the weight and forces acting on the chassis while the car is stationary. The goal was to check for stress concentration and ensure there's no excessive deformation. The results confirmed that the chassis could safely support all static loads with good strength and stability.

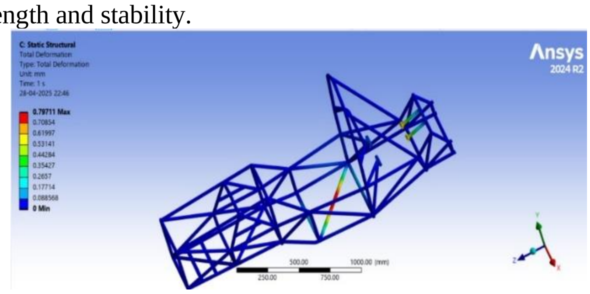


**Fig-6:** Static Load Analysis

## 5. MANUFACTURING:

The manufacturing process begins with the creation of a prototype to validate the profile and fitment of the chassis pipes. This initial step ensures that the designed geometry aligns correctly with the physical components and helps identify any necessary adjustments before final fabrication. Once the prototype is approved, the actual manufacturing starts with the preparation of chassis pipes, which are cut and bent as per the design specifications. Spot welding is first carried out using the MIG welding process to temporarily hold the structure in position and maintain alignment. After all spot welds are completed and verified, full welding of the chassis is performed using the TIG welding process. TIG welding is chosen for its precision and cleaner weld finish, which is crucial for the structural integrity and aesthetic of the final chassis. Throughout the process, care is taken to ensure accuracy, proper joint strength, and compliance with safety standards.

**Fig-7:** Prototype Manufacturing

**Fig-8:** Fixture Assembly And Tube Positioning

**Fig-9:** Final Chassis

## 6. CONCLUSION:

The objective of this project was to establish a practical and systematic approach to the design and manufacturing of a Formula Student chassis. Emphasis was placed on performance, safety, and manufacturability through a structured design process that included CAD modeling, torsional stiffness analysis, and FSAE rule compliance. The use of AISI 1018 steel and a validation prototype allowed for early correction of design flaws and improved fitment accuracy.

Ergonomics played a key role in chassis layout, with a more reclined seating position lowering the center of gravity and improving vehicle dynamics. This adjustment led to dimensional changes in the cockpit and roll hoop geometry, ultimately improving driver comfort and handling balance.

Manufacturing decisions, such as working with a wooden jig and combining MIG for spot welding with TIG for final welds, enhanced alignment and build precision. This project provided valuable hands-on experience, highlighting the importance of design validation, fixture planning, and real-world fabrication constraints in the development of a competitive student-built race car chassis.

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