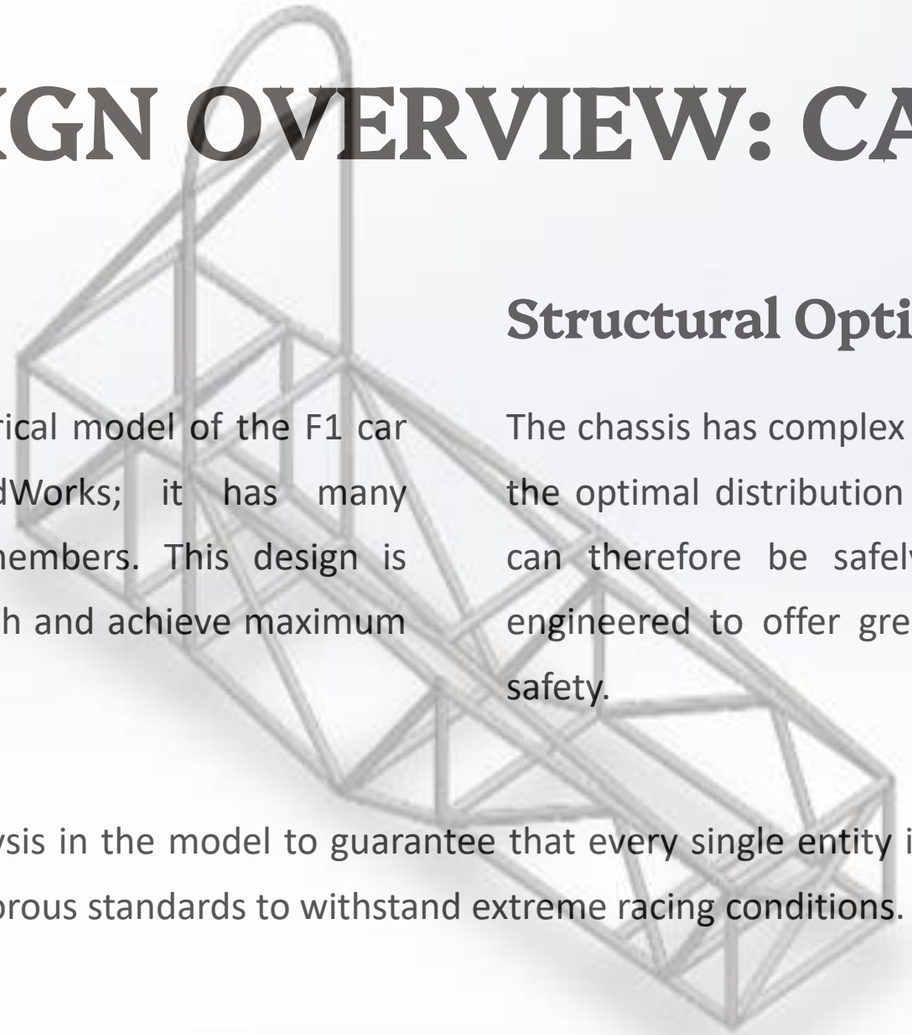
F1 CAR CHASSIS DESIGN: STRUCTURAL ANALYSIS AND MATERIAL SELECTION

This presentation sheds light on key aspects of how an F1 car chassis is designed or better still how one can analyze an F1 car chassis. The main objectives of the design of the chassis are to provide support to structural framework, protection of the driver and the aspiration to make it perform well. We will discuss main characteristics, materials, mass characteristics, and the simulation results of the chassis which will show that it can protect from high impact loads and at the same time it will be relatively lightweight. Specifically, emphasis will be made on AISI 4130 steel for its use and the methods which were utilized in the models' validation.

CHASSIS DESIGN OVERVIEW: CAD MODEL



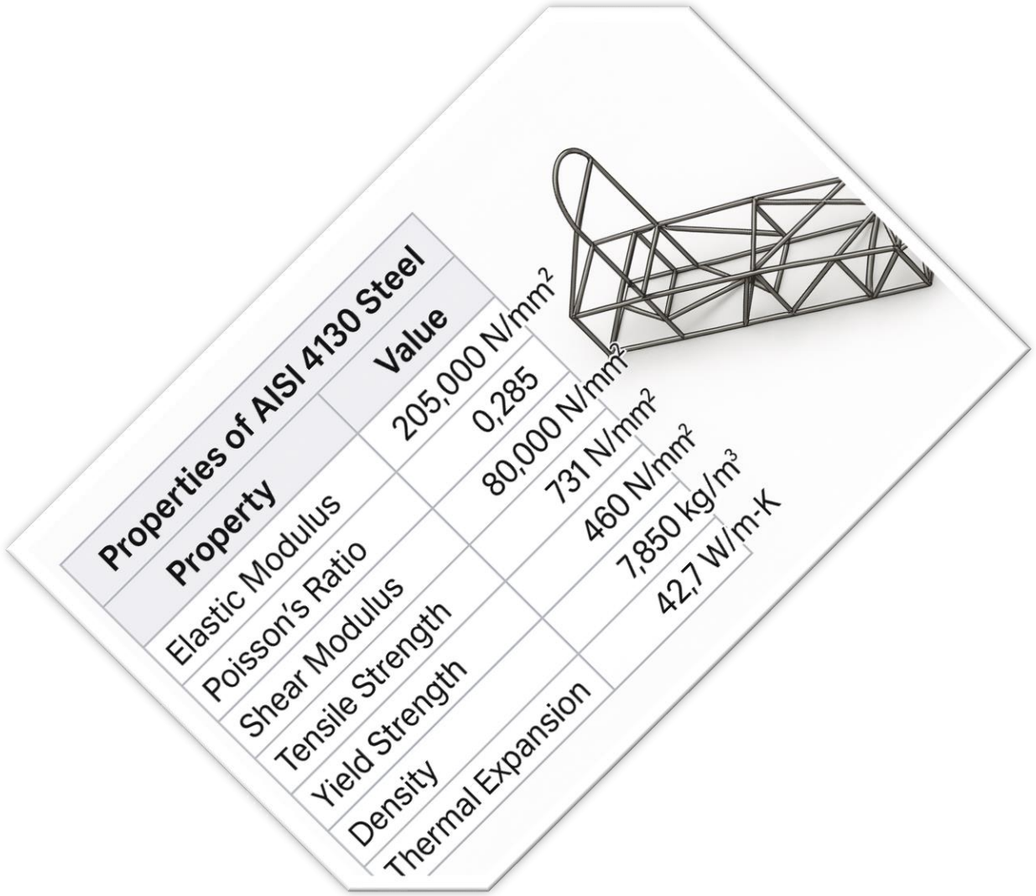
Visual Representation

Here, it is necessary to note the geometrical model of the F1 car chassis have been created in SolidWorks; it has many interconnected beams and structural members. This design is explicitly weighed to make certain strength and achieve maximum protection in case of impacts.

Structural Optimization

The chassis has complex composite elements layout which ensures the optimal distribution weight and high-resistance to impacts. It can therefore be safely stated that all components are well engineered to offer great performance with equal emphasis on safety.

The CAD facilitates visualization and analysis in the model to guarantee that every single entity is useful in strengthening and forming the vehicle. The chassis' design adheres to rigorous standards to withstand extreme racing conditions.



Material Selection: AISI 4130 Steel Properties

High Strength-to-Weight Ratio

AISI 4130 steel is preferred for its mechanical properties relative to density, which is a critical factor in an F1 car design.

Resistance to Deformation

High strength and resistant to deformation of the material guarantees that the car's chassis does not deform when making high speed turn or an impact.

Elastic Modulus	205,000 N/mm^2
Poisson's Ratio	0.285
Shear Modulus	80,000 N/mm^2
Tensile Strength	731 N/mm^2
Yield Strength	460 N/mm^2
Density	7,850 kg/m^3
Thermal Expansion	42.7 W/m·K

Mass Properties of the Chassis

Total Mass

36,489.12 grams

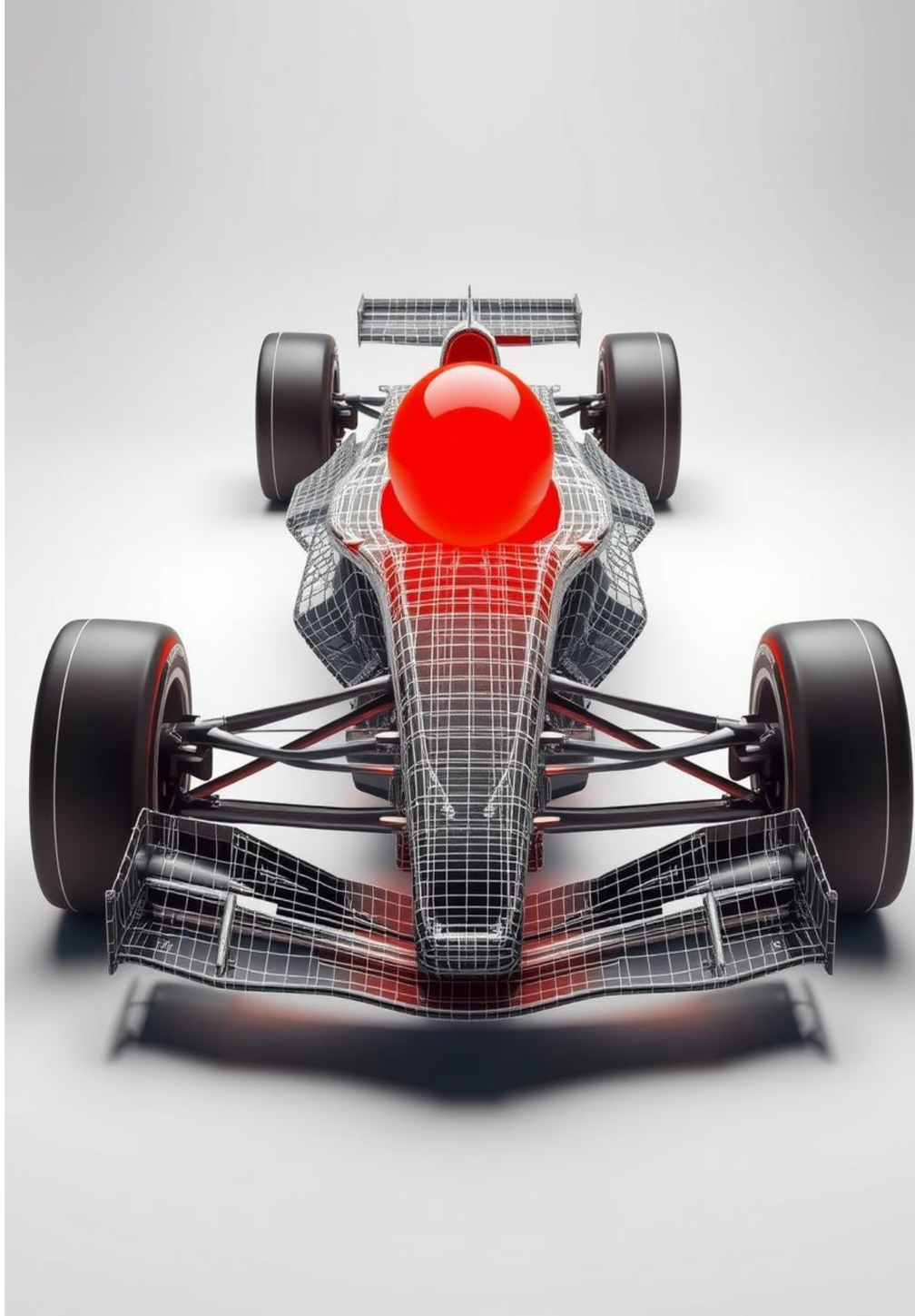
Volume

464,829.13 cubic millimeters

Center of Mass

(0.99, -0.13, 0.00) mm

The mass properties include mass, moment of inertia, roll static, pitch static, yaw static, roll couple coefficient, pitch couple coefficient and yaw couple coefficient which all play the overall stability role during high-speed maneuvering of the chassis. One must clearly know the center of mass location with the aim of positioning it in a manner that would help it be in a position of control and ton detect movements in other parts of the object. Every single moment of inertia is examined much to the details with the purpose of enhancing the stability of the chassis as much as it is possible in any conditions.



Simulation Setup: Impact Analysis in SOLIDWORKS

1

Static Analysis

Yielding the stress analysis of the chassis under impact loads through SOLIDWORKS Simulation.

2

Material Properties

It is used normalized at 870°C and thus to ensure real life precision, AISI 4130 Steel is used in the analysis.

3

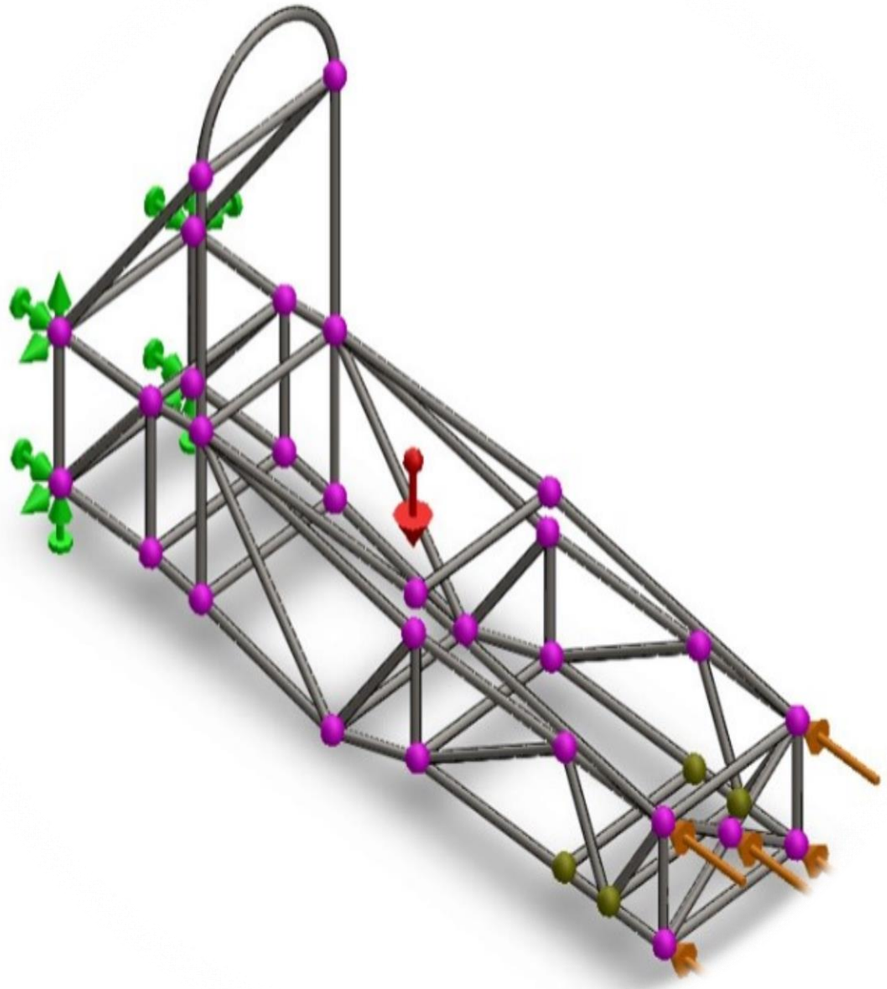
Mesh Information

Mixed Mesh with 10,017 elements and 19,977 nodes for high-quality results.

4

Fixtures and Loads

Applying a fixed geometry and implementing a force called 6000 N for impact force.



The nature of the simulation can be described as static because it is carried out to determine the specific behavior of the chassis under impact loads. It means that fine division of the meshes leads to high accuracy and fixed geometric boundaries and applied force represent actual crash conditions. The simulation is on stress points and displacement level aspects.

Simulation Results: Stress, Displacement, and Strain

1

Maximum von Mises Stress

1.827e+05 N/m^2 at Node 14837, within tensile strength.

2

Maximum Displacement

3.801 mm in Y direction, indicating minimal deformation.

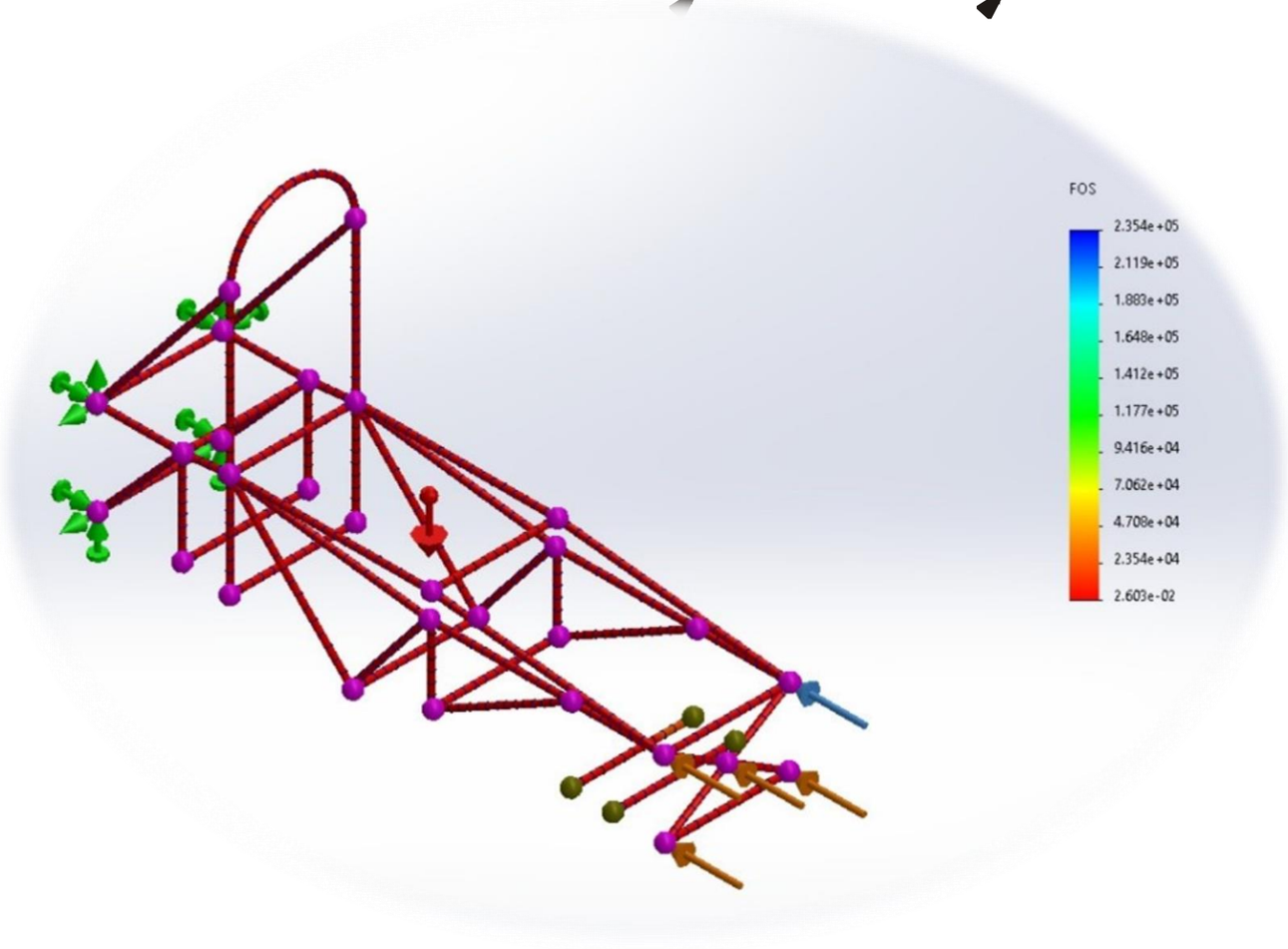
3

Maximum Equivalent Strain

3.827e-07 at Element 6230, within elastic limits.

From the analysis of data collected from simulation analysis, it could be deduced that maximum von Mises stress was not exceeded the tensile strength of the material of the chassis. Low displacement and strain reading also demonstrates that the chassis does not experience any excessive deformation as well as no beyond elastic limit force is applied to it even in the presence of extreme force and impact. Increase in the value of facts of safety indicates that the given design is quite safe and a minimum factor of safety of 2.354e+05 supports this argument as well.

Factor of Safety Analysis



1. Safety Margin

The design is safe under applied loads.

2. Minimum Factor of Safety

2.354e+05 at Node 9906.

3. Material Strength

AISI 4130 steel provides necessary strength.

The factor of safety that has been discussed correlates with the simulation as far as occupant impact condition of the F1 car chassis is concerned. The minimum factor of safety calculated at node 9906 reveals clearly that the chassis is capable of withstanding force which is much higher than those exerted at the time of simulation. This makes it highly safe for the driver and brings assurance of the overall strength of the vehicle.

Conclusion: Structural Integrity and Safety Validation

Excellent Structural Integrity

In the study, the AISI 4130 steel chassis also exhibits good structural response under the impact loads as depicted in the simulation.

Within Safety Margins

It is sufficient to say that it is well within the design’s safety parameters and protects the driver’s chassis.

Safe Performance

The findings of an automobile simulation reveal that the chassis will be safe during races with the impact loads incurred.

The F1 car chassis is made of AISI 4130 steel which described impressive structural and safety features of the car’s structure. The simulation results on this aspect indicate that the chassis is capable of withstanding great impact loads in the safe operating limits. This not only justifies the choice and design of material employed for the chassis fabrication that forms the body of the car but also the general design procedure to promote a more reliable and sustainable car unit for adoption to competitive racing.