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Design And Analysis of Six-Seater Electric Vehicle Chassis

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Abstract

This research paper is focused on the analysis of six-seater electric vehicle chassis. The vehicle chassis serves as a framework for supporting the body and different parts of the vehicle. Also, it needs to withstand twist, shock, vibrations, and other stresses caused due to sudden acceleration and braking, road condition, centrifugal force while cornering and forces induced by its components. The investigation has been carried out, considering one grade material i.e., AISI 1018 EQUIVALENT. By utilizing data of all loads on in all possible direction are considered, for designing rigid and strong chassis. The design and analysis are done using software - SOLIDWORKS and ANSYS.

Keywords: AISI 1018 Equivalent; Solid works; Ansys; Chassis;

1. Introduction

The chassis is considered to be one of the significant structures of an automobile. It is the frame which holds both the car body and the power train. Various parts like the motor, battery, the suspension system, the brakes, the steering components, the axle assemblies are bolted onto the chassis. The chassis provides the strength needed for supporting the different vehicular components as well as the payload and helps to keep the automobile rigid and stiff. The chassis is also an important component of the overall safety system. Also, it ensures low levels of noise, vibrations, and harshness throughout the automobile. Chassis should be rigid enough to withstand the shock, twist, vibration, and other stresses. Along the strength, an important consideration is chassis design is to have adequate bending and torsional stiffness for better handling characteristics. So, strength and stiffness are two important criteria for the design of chassis. The load carrying structure is the chassis, so the chassis must be so designed that it has to withstand the loads that are coming over it.

2. Specification of Frame

According to our design of the chassis, inputs from other subsystems, and mechanical properties of the materials were considered. Hence, the design was finalized based on these parameters and was designed in SOLID WORKS. The analysis is done with the help of ANSYS. Based on the analysis, the modification was done, and the design was finalized.
The material chosen for the Chassis frame is AISI 1018 EQUIVALENT. We have chosen four different sizes pipes with the following dimensions of rectangular and square cross section.

Table 1: Dimensions of Pipes

S. No.	PIPES	UNIT
1.	60X40X2	mm
2.	40X40X2	mm
3.	20X20X1.5	mm
4.	20X20X1	mm

3. Design of The Chassis

By using SOLIDWORKS SOFTWARE, we design a suitable sustainable chassis design after numerous corrections.

Table 2: Dimensions of Chassis

S. No.	SPECIFICATIOS	VALUES
1.	Length	3000mm
2.	Breadth	1320mm
3.	Height	645mm
4.	Wheelbase	2315mm

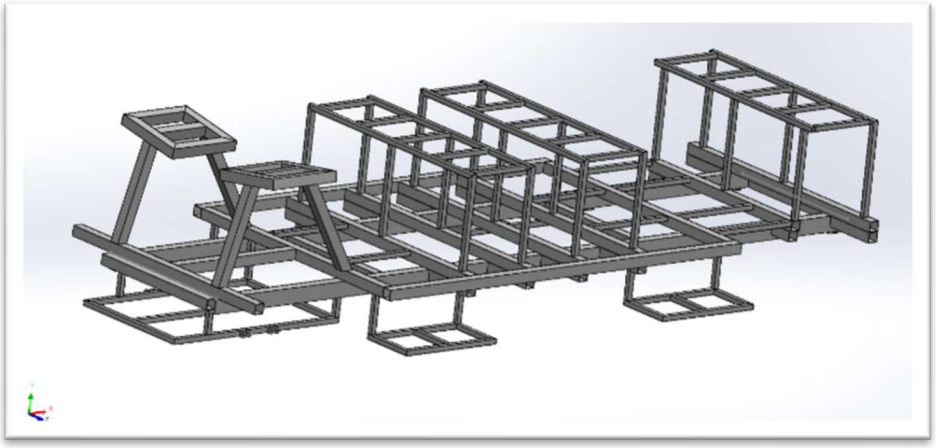

Figure 1: ISOMETRIC VIEW OF CHASSIS

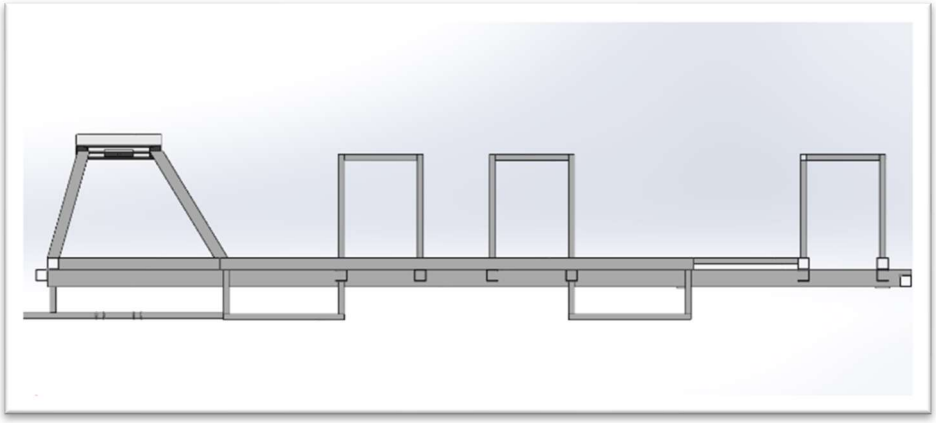

Figure 2: SIDE VIEW OF CHASSIS

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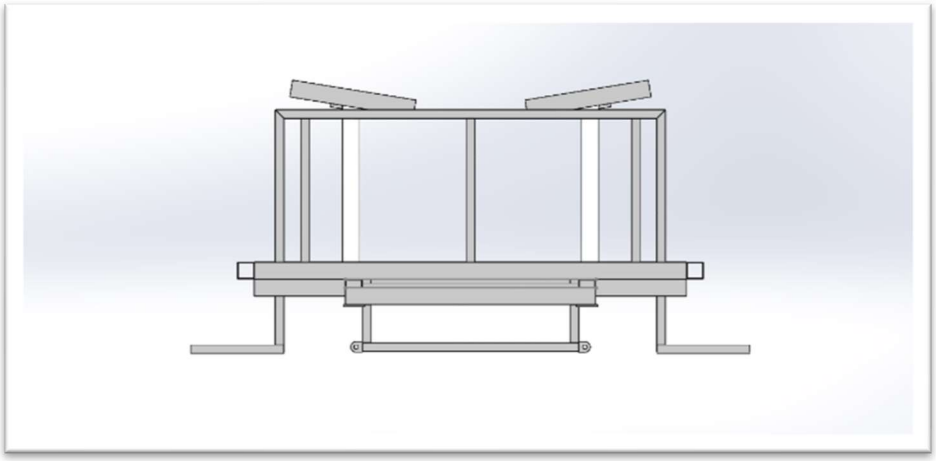


Figure 3: REAR VIEW OF CHASSIS

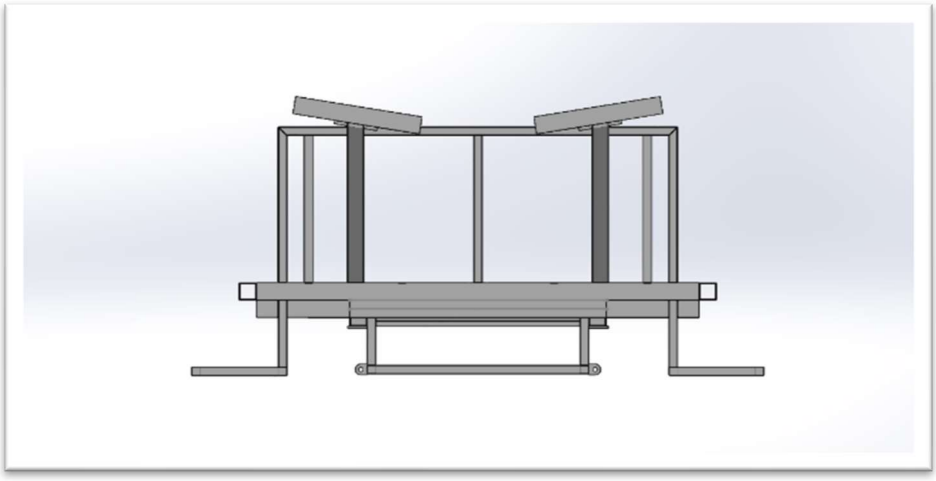


Figure 4: FRONT VIEW OF CHASSIS

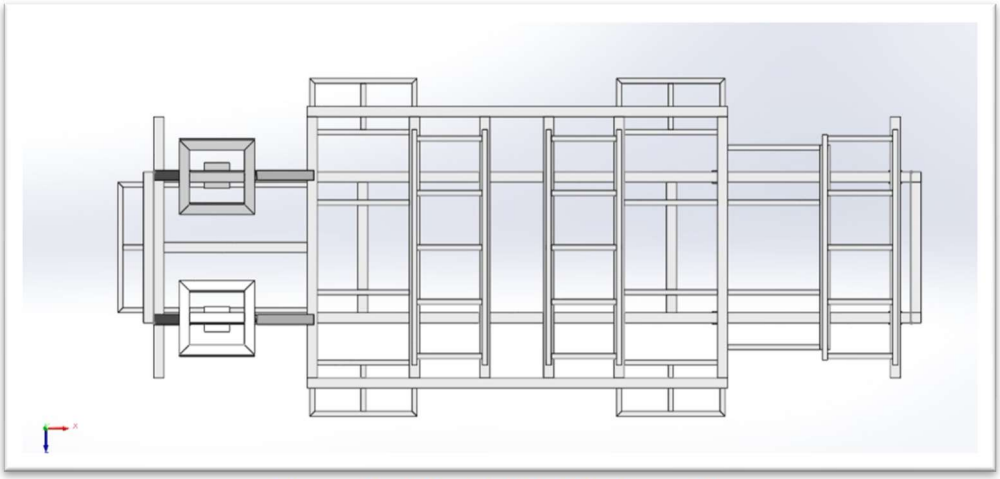


Figure 5: TOP VIEW OF CHASSIS

4. Material

We choose AISI 1018 Equivalent material based on material mechanical properties, chemical composition and cost.

Table 3: Chemical composition

S. No.	ELEMENT	CONTENT (%)
1	Carbon	0.15-0.20
2	Manganese	0.60-0.90
3	Phosphorous	0.04 Max
4	Sulphur	0.05 Max
5	Iron	Balance

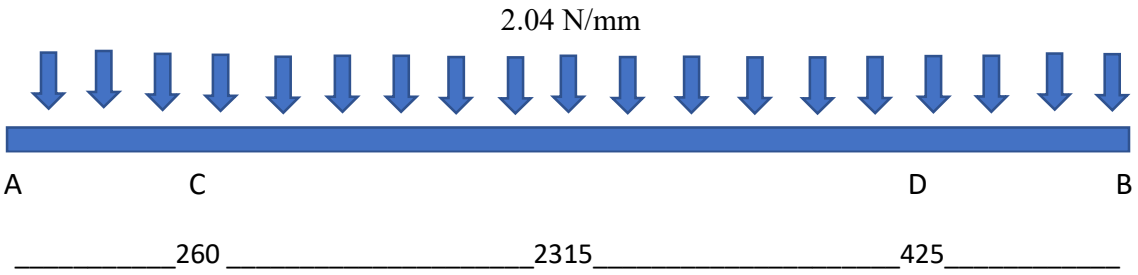
Table 4: Mechanical properties

S. No.	PROPERTIES	METRIC
1	*Tensile Strength*	*440 MPa*
2	Yield Strength	370 MPa
3	Young's Modulus	205 GPa
4	Shear Modulus	80 GPa
5	Poisson's Ratio	0.29
6	Hardness	126
7	Density	7.87 g/cm^3
8	Thermal Conductivity	51.9

5. Theoretical Calculation

For the design purpose of the chassis,
calculate the strength of the chassis.

- Rear overhang = 425mm
- Front overhang =260mm
- Wheelbase =2315mm.
- Vehicle weight = 450 kg.
- Gross vehicle weight = 1000kg
- Total load to be applied = 1000×9.81=9810N
- Considering an overload of 1.25 of total load=9810×1.25=12262.5N
- As the chassis frame has two members. Therefore, load acting on each side member is half of the total load.
- Load acting on each of member frame = $\frac{12262.5}{2}$=6131.25N
- Beam considered is a simply supported at C and D with uniformly distributed load.
- Load acting on the whole beam=6131.25N
- Length of the beam =3000mm
- Uniformly distributed load =$\frac{6131.25}{3000}$=2.04375N/mm



A. Calculation of Reaction Forces

Taking moment at C (positive as clockwise and negative as anti-clockwise):

$= 2.04375\times260\times \frac{260}{2} = (2.04375\times2315\times \frac{2315}{2})-(R_D \times2315)+(2.04375\times2575\times425)$

$= 69078.75 = 54764580.47- R_D \times2315 + 2010794.531$

$= R_D = 3204.39$N

Similarly

$R_C + R_D = 6131.25$

$R_C = 2926.86$N

The reaction force at point C and D are 2926.86*N* and 3204.39*N*

B. Calculation of bending moment

Let M_A, M_B, M_C, M_D be the moment at point A, B,C and D respectively.

$M_A = 0$ Nmm

$M_B = 0$ Nmm

$M_C = (2.04375\times260\times\frac{260}{2})$

= 69078.75 Nmm

$M_D = (2575\times\frac{2575}{2}\times2.04375) +(2726.86\times2315)$

= -6775669.922+6312680.9 = -462989.022 Nmm

Maximum bending moment acting on the beam = 462989.022 Nmm

C. Calculation of Shear Force

$V_1 = W\times A = 2.04375\times425 = 531.375$N

$V_2 = R_C - V_1 = 2926.86-531.375 = 2395.485$N

$V_3 = R_D - V_4 = 3204.39-868.593 = 2335.8$N

$V_4 = W\times B = 2.04375\times425 = 868.593$N

D. Calculation of Bending Stress

I. Hollow Rectangular Cross-Section

d= 60mm

b= 40mm

t= 2mm (thickness)

Calculating moment of inertia about XX-axis by using formula

$I = \frac{bd^3}{12} - \frac{b_1 d_1^3}{12} = \frac{40\times60^3}{12} - \frac{38\times58^3}{12} = 102145.3\ mm^4$

To calculate deflection(δ), by using deflection formula on the beam given as

$\delta = \frac{W(b-x)}{24EI}(x(b-x)+b^2 -2(c^2 + a^2)-\frac{2}{b}(xc^2 + a^2(b-x)))$

where,

W = 6131.25N

b (wheelbase) = 2315mm

$x = \frac{Total\ len}{2}$ = 1500mm

a (front overhang) = 260mm

c (rear overhang) = 425mm

I (moment of inertia) = 102145.3mm

Young's modulus of elasticity of AISI 1018 EQUIVALENT, E=205000N/mm^2

By putting all the values in above deflection equation, we get maximum deflection on the beam.

Deflection on the beam, δ = 57.3mm

I. Hollow square cross-section

d= 40mm

b= 40mm

t= 2mm (thickness)

Calculating moment of inertia about XX-axis by using formula

$I = \frac{bd^3}{12} - \frac{b_1 d_1^3}{12} = \frac{40\times40^3}{12} - \frac{38\times38^3}{12} = 39572\ mm^4$

To calculate deflection(δ), by using deflection formula on the beam given as

$\delta = \frac{W(b-x)}{24EI}(x(b-x)+b^2 -2(c^2 + a^2)-\frac{2}{b}(xc^2 + a^2(b-x)))$

where,

W = 6131.25N

b (wheelbase) = 2315mm

$x = \frac{\text{Total length}}{2}$ = 1500mm

a (front overhang) = 260mm

c (rear overhang) = 425mm

I (moment of inertia) = 39572mm^4

Young's modulus of elasticity of AISI 1018 EQUIVALENT, E = 205000N/mm^2

By putting all the values in above deflection equation, we get maximum deflection on the beam.

Deflection on the beam, δ = 148mm

6. Analysis

Analysis of the chassis is performed in the ANSYS 2021 R2 SOFTWARE.

Meshing has been carried out for material in ANSYS SOFTWARE.

Table 5: Mesh Data

COMPONENTS	VALUE
MESH SIZE	4
MESH METHOD	Quadrilateral
NO. OF ELEMENTS	875291
NO. OF NODES	6069721

Static Structural Analysis

In static structural analysis on chassis the total force applied in downward direction on chassis is 15000N

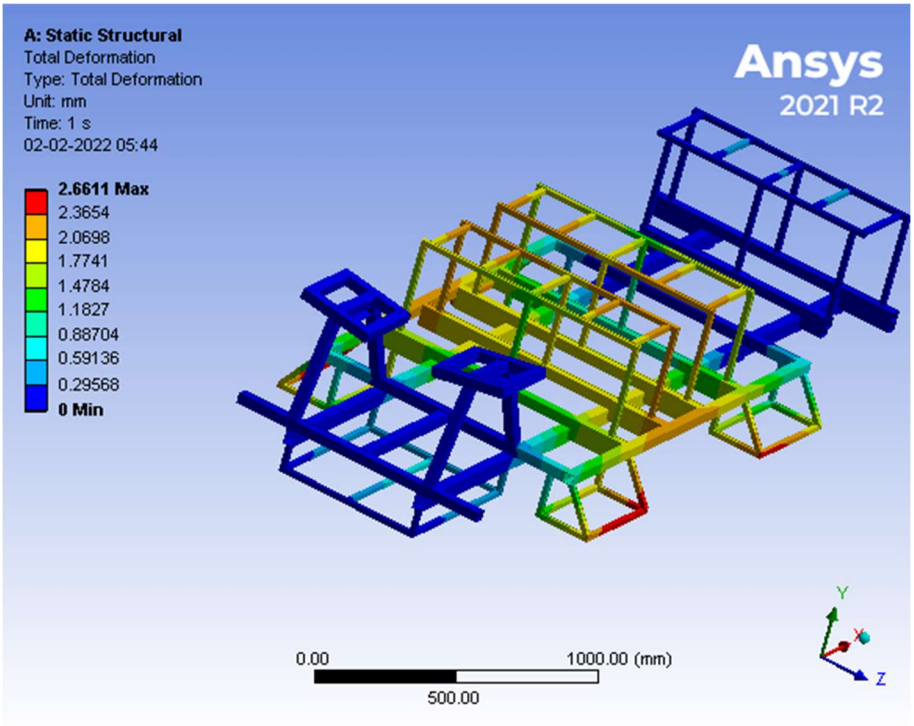


Figure 6: Total Deformation (Static Structural)

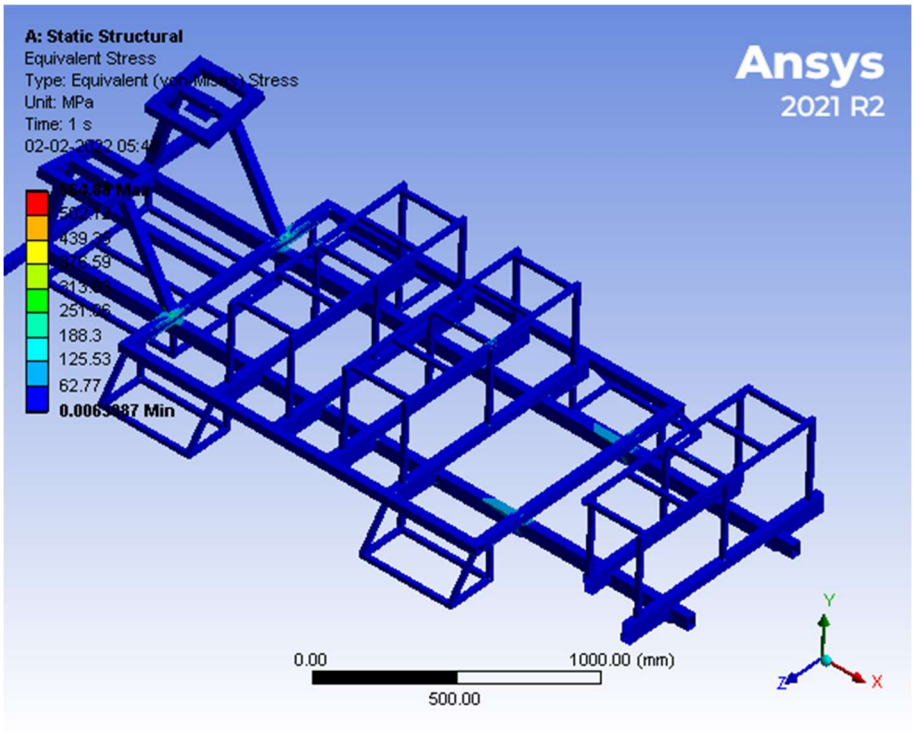


Figure 7: Equivalent Stress (Static Structural)

Total Deformation of static structural of chassis is 2.6mm.

Impact Test Analysis

In impact test analysis the total force applied is 15000N in front, rear and side of the chassis.

Front Impact Analysis

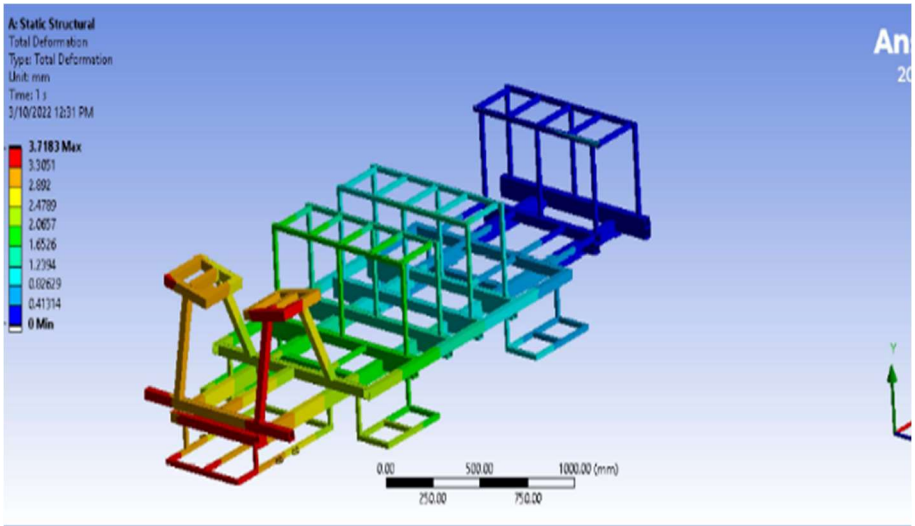


Figure 8: Total Deformation (Front Impact)

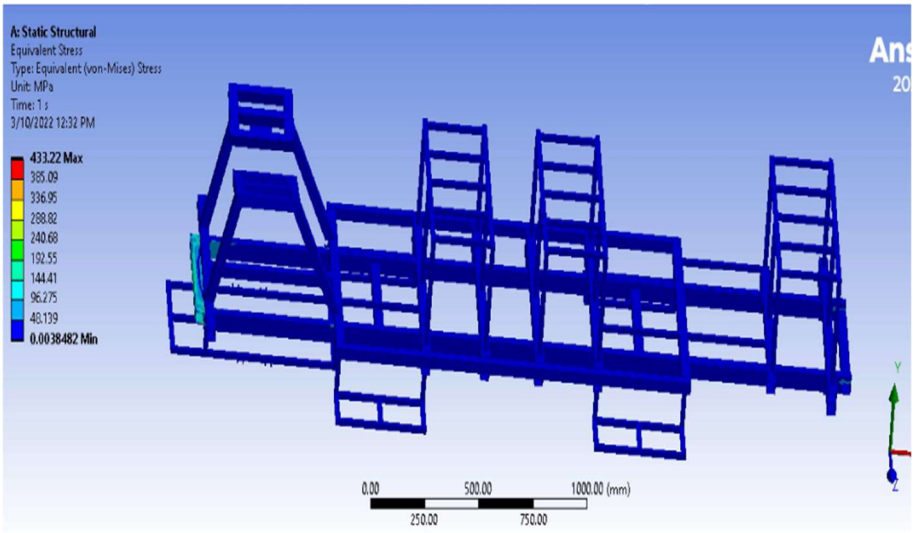


Figure 9: Equivalent Stress (Front Impact)

Total Deformation of Front Impact Test of chassis is 3.7mm.

Rear Impact Analysis

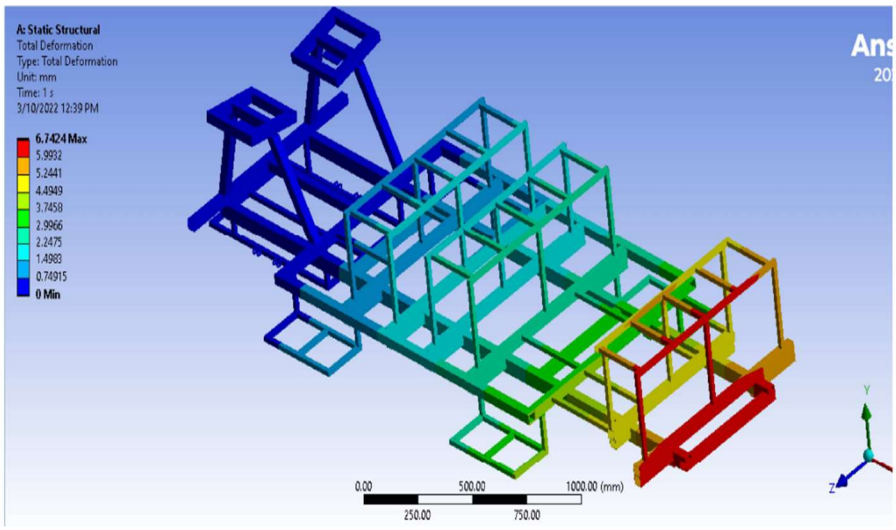


Figure 10: Total Deformation (Rear Impact)

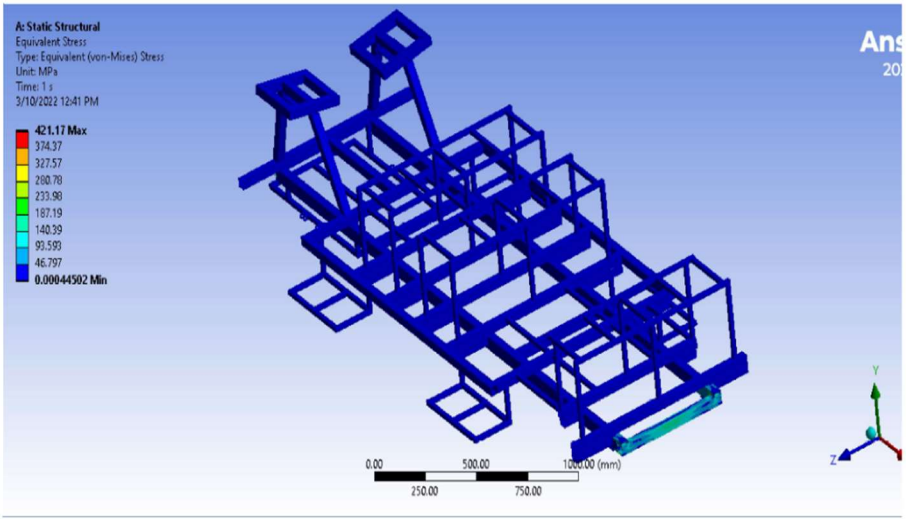


Figure 11: Equivalent Stress (Rear Impact)

Total Deformation of Rear Impact Test of chassis is 6.7mm.

Side Impact Analysis

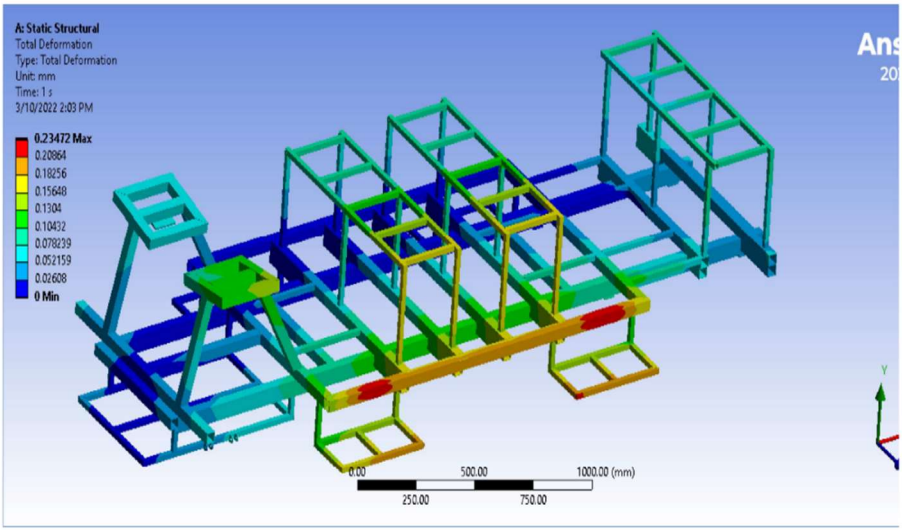


Figure 12: Total Deformation (Side Impact)

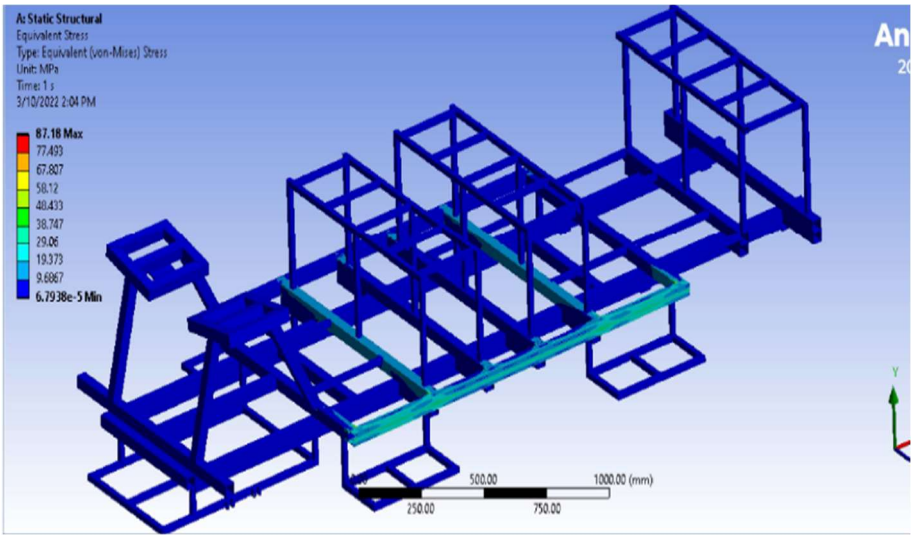


Figure 13: Equivalent Stress (Side Impact)

Total Deformation of Side Impact Test of chassis is 0.23mm.

7. Results and Discussion

Our chassis which is design in material of AISI 1018 Equivalent can withstand the load of 15000N in both Static structure and Impact test in Ansys.
In Ansys;

- Total Deformation of Static Structural of chassis is 2.6mm
- Total Deformation of Front Impact Test of chassis is 3.7mm
- Total Deformation of Rear Impact Test of chassis is 6.7mm
- Total Deformation of Side Impact Test of chassis is 0.23mm

Theoretical calculation on a single main member(beam) of chassis to find the deflection or deformation due to total load on the member of 6131.25N and uniform load of 2.04N/mm with the FOS of 1.25
Deflection of cross section;

- Hollow rectangular cross section
  Deflection due bending stress: 57.3mm
- Hollow square cross section
  Deflection due to bending stress: 148mm

8. Conclusions

This paper focuses on design and analysis of six-seater electric vehicle chassis. The material we used for the chassis is AISI 1018 EQUIVALENT, which is perfect for our chassis. The chassis is capable of bearing the maximum static load of 15000N.The maximum deformation of our chassis in ANSYS SOFTWARE is 6.7mm (In Rear Impact).

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