

# Design and Analysis of SAE BAJA Car Frame using ANSYS

Divyansh Uikey<sup>1</sup>, Prof. Vedansh Chaturvedi<sup>2</sup>

<sup>1</sup>UG Scholar, Department of Mechanical Engineering, MITS Gwalior, M.P. India

<sup>2</sup>Assistant Professor, Department of Mechanical Engineering, MITS Gwalior, M.P. India

\*\*\*

**Abstract:** The frame of SAE based BAJA Vehicle also referred as roll cage acts as structural incarnate for several type of Automated Vehicle. This Vehicle frame is subjected to various kinds of Load like Dynamic and Static Load seen in Front Load, Side Load, Roll Over Impact. This chassis is designed by rule specified by SAE India rulebook. Chassis plays important part in any vehicle that support entire body of the car. It also responsible for the protection and safety of the occupant in case of any accident (any side, front, back, roll over impact.) and it also give shape of the vehicle. This report contains Designing of the Chassis, selection of material, and analysis of chassis in different loading condition to determine the safety and post impact scenarios in ANSYS WORKBENCH 2021 R1 STUDENT VERSION. The overall result then taken into account to see whether the vehicle is safe enough for variety of load or not.

**Key Words:** BAJA, SAE, ANSYS, Analysis

## Introduction

Baja SAE India is an academic level competition. Engineering Students all over India participate as a team in this event. The main purpose of each team is to design and build a prototype of off-road vehicle that has to go through different impetration and then after it get ready for race.

All the consideration regarding design element, material selection, engine capacity, weight ratio all these major things is taken from the latest rulebook of SAE India.

## Material Selection

Material Selection of SAE BAJA vehicle is considered as important part of analysis. As it leads to greater influence on how vehicles performs and also about vehicles safety, reliability and performance. The qualities that were given due importance are yield strength, the power to weight ratio and good weldability property.

So as per the rulebook of SAE India the material should be American Iron and Steel Institute 1018, American Iron and Steel Institute 1020 and American Iron and Steel Institute with minimum Carbon percentage of .18%.

-Below table is given of composition of these material

So, because of low carbon content of 0.18% these chassis can be welded properly. Because if there is more carbon percentage then the material should have more strength it become harder which decrease the property of weldability. Although this is a complex structure therefore it should have gone under various welding process to complete that kind of structure. Therefore, we use low carbon content material which also shows high yield strength, high tensile strength, corrosion resistance as it contains chromium and molybdenum as strengthening agents.

## Modelling of SAE BAJA frame

This model is initially modelled in SOLIDWORK 2019 considering design requirement according to rulebook of SAE India.

## Cross Section Selection

The parameters however unable to defined by Solid Work. So, we have to use design modal in ANSYS to determine it. We import model in ANSYS design Modal and then select Line Body to generate a model where we can see point of intersection. And by selecting Circular Cross Section area of outer radius 12.5mm and inner radius of 11.6mm respectively. Then we apply these cross sections in overall joints of the model. After, all line bodies converted into single 1 part 1 body which is suitable for accurate analysis.

## Analysis of Frame on various Impacts and Meshing details

### Meshing Details

-Display Style: Use geometry setting

-Element size: 114.57 mm

-Element type: Beam

-No. of Elements: 139932

-No. of Nodes: 241864

-Analysis Type: Static

### 1. The Front Impact Analysis

Front Side is generally called most accident-prone area. It also responsible for driver and passenger's safety. Therefore, the front impact analysis should have been like this that it doesn't cause major fatal incident at all.

Let say, there is a race and car is going at 65kmph of speed. The mass of the car including driver is 265kg.

$$m = 265 \text{ kg}$$

$$v = 60 \text{ kmph} = 16.6 \text{ m/s (Max Velocity)}$$

$$\text{Acceleration} = a = (v_f - v_i)/t = (0 - 16.6)/0.15 = 110 \text{ m/s}$$

$$\text{Therefore, } F = m * a = 265 * 110 = 29.15\text{kN}$$

### 2. The Side Impact Analysis

Side impact can be dangerous for both occupant as well as car body. So, it also plays important role in safety

With Same condition as front impact calculations are as follows

$$m = 265 \text{ kg}$$

$$v = 60 \text{ kmph} \approx 17 \text{ m/s (Max Velocity)}$$

$$\text{Acceleration} = a = v_f - v_i/t =$$

$$0 - 17/0.30 = 56.66 \text{ m/s}$$

$$\text{Therefore, } F = m * a = 280 * 56.66 = 15.86\text{kN}$$

### 3. Roll over Impact

As it's a race and there is a chance that vehicle can flip over while in speed so roll over impact is also taken in consideration while talking about safety.

This analysis obtained from the parameters of front impact and side impact analysis.

The load required for the roll-over impact loading use 25% of frontal impact load.

Therefore,

force,  $f^*$  front load

$$- 0.25 * 16.66\text{kN} \approx 8.333 \text{ kN}$$

### 4. Torsional Loading Analysis

As this is a off road vehicle and vehicles mean to be driven in any terrain or any driving condition so it's required that the frame should be stiff enough to sustain dynamic suspension loads.

Torsional Impact should be greater than 3.5knm/degree

Calculation

$$F = 2915 \text{ N}$$

$$L = \text{Distance between diagonally opposite wheel} = 490\text{mm}$$

$$\theta = \text{angular deformation}$$

$$\text{Tan}(\theta) = D/(L/2)$$

$$\text{Torsional stiffness} = (F \times L) / \theta.$$

Stiffness comes out to be 4.8knm/degree

Thus, it satisfies the torsional stiffness requirement.

### Conclusion

The frame of BAJA vehicle is designed as per the specifications of BAJA SAE India rulebook. AISI 1020 material was selected because it has high yield strength and good power to weight ratio as compared to others. Circular cross section was selected for distribution of forces which results in improving strength of the chassis. A preliminary design of the chassis is made using SOLIDWORKS software. The stress analysis results from ANSYS workbench indicate that the chassis is indeed secure enough to sustain the impact and protect the driver and frame of the vehicle.

### Reference

1.Rulebook BAJA SAE INDIA 2021

2.<https://bajasaehindia.org>

3.Denish S. Mevawala, Mahesh P. Sharma, Devendra A. Patel, Darshan A. Kapadia "Stress Analysis of Roll Cage for an All-Terrain

4.Vehicle", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)

5.Engineering Research and Applications (2012), 2(4), 126-128.

6.Static Analysis and Optimisation of Chassis and Suspension of an All-Terrain Vehicle by Thanneru Raghu Krishna Prasad et.al

7.<https://grabcad.com/library/tutorial-ansys-analise-estrutural-em-um-chassi-de-mini-baja-da-categoria-sae-1>

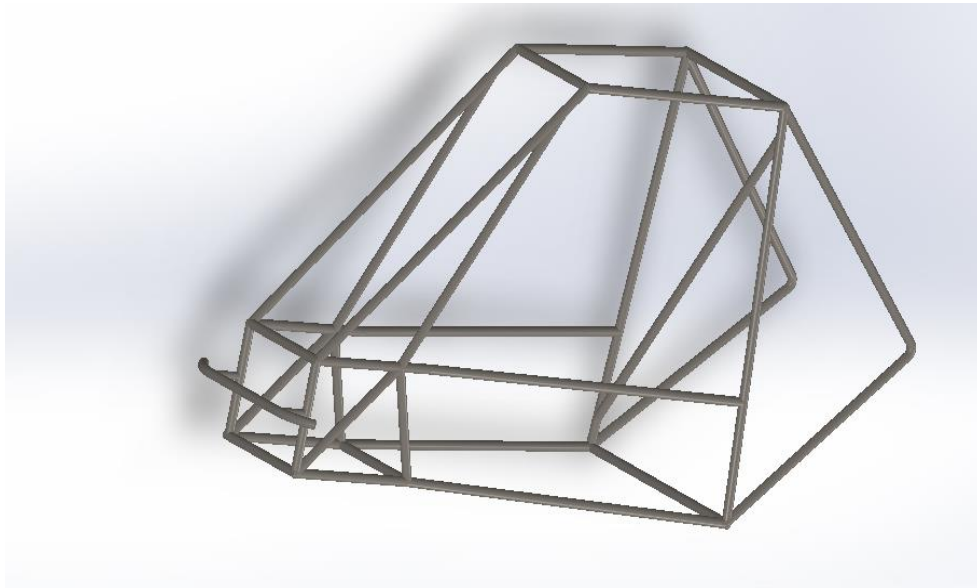
**Tables & Figure**

Element (%)	AISI 1018	AISI 1020	AISI 4130
Carbon, C	0.15 – 0.20	0.17 – 0.230	0.28 – 0.33
Iron, Fe	98.81 – 99.26	99.08 – 99.53	97.03 – 98.22
Manganese, Mn	0.60 – 0.90	0.30 – 0.60	0.40 – 0.60
Phosphorous, P	≤ 0.04	≤ 0.04	0.035
Sulfur, S	≤ 0.05	≤ 0.05	0.04
Chromium, Cr	–	–	0.80 – 1.10
Molybdenum, Mo	–	–	0.15 – 0.25

Table 1.1 Chemical composition of material

Parameter	AISI 1018	AISI 1020	AISI 4130
Tensile Strength (MPa)	440	395	560
Yield Strength (MPa)	370	295	460
Poisson Ratio	0.290	0.290	0.295
% Elongation	15	36.50	21.50
Strength to Weight Ratio	55-70	65-85	90-120
Modulus of Elasticity (GPa)	205	200	210

Table 1.2 Mechanical Properties of materials



Solid work Model

Analysis with ANSYS

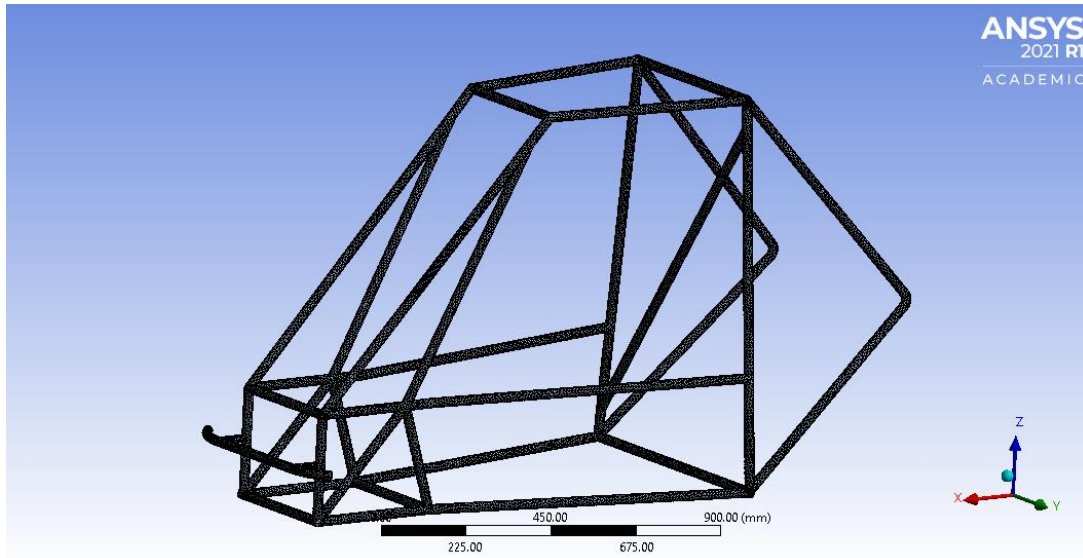


Fig 1.1 Meshed Model

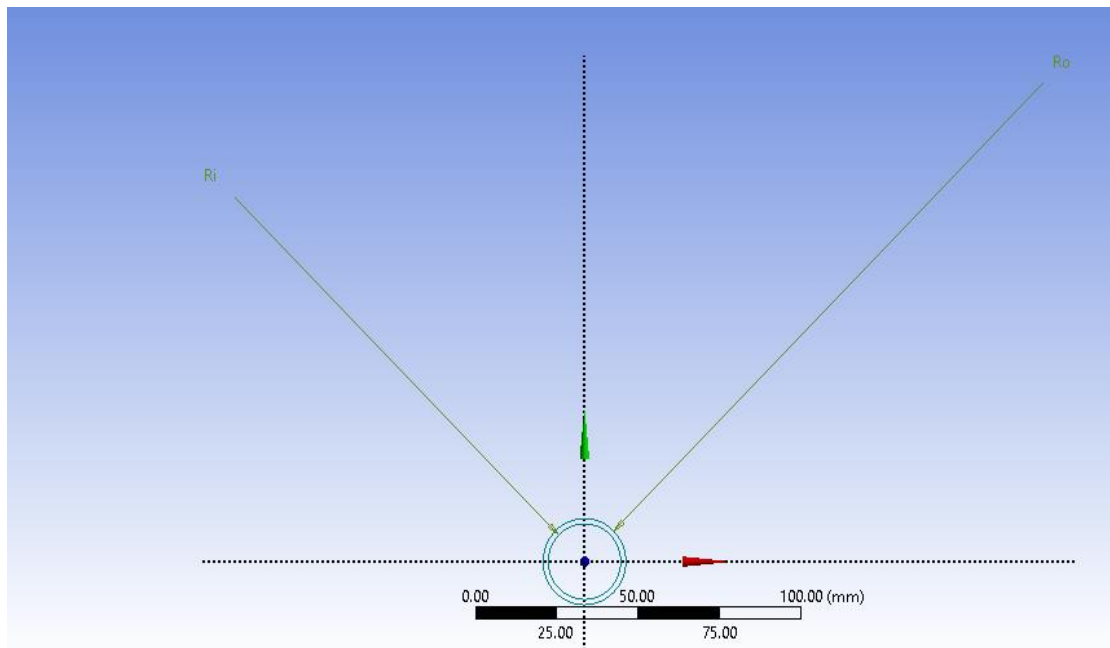


Fig 1.2 Cross Section with dimension of Ro and Ri

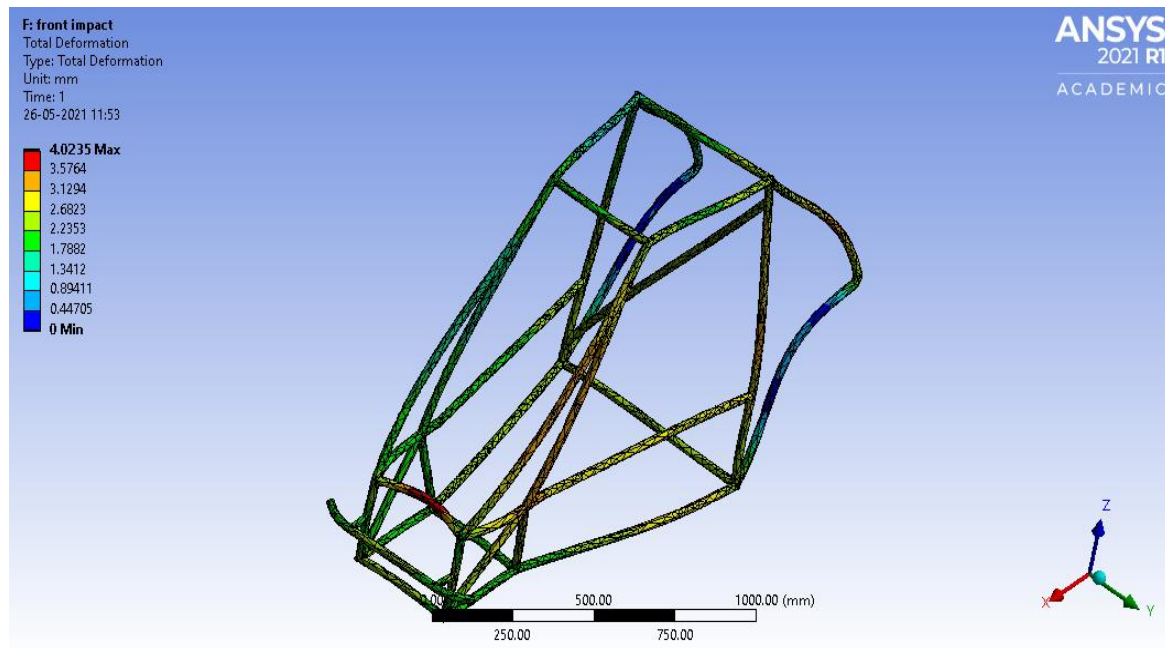


Fig1.3 Stress in Front impact Loading

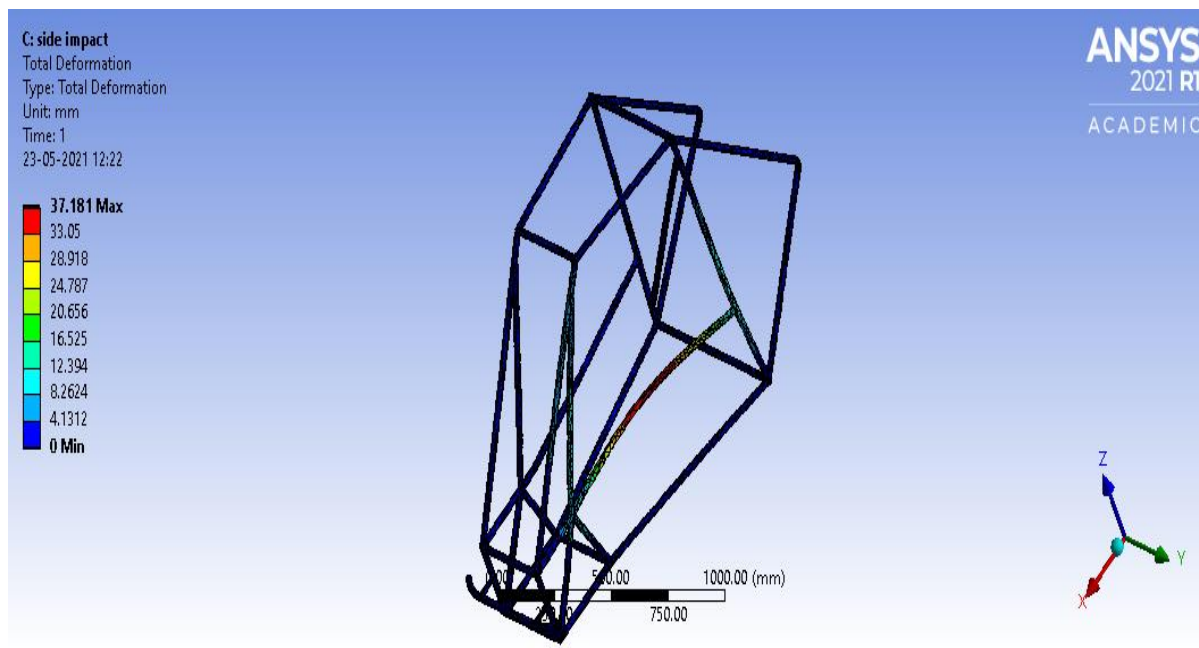


Fig 1.4 Maximum combined Stress in Side Impact Loading



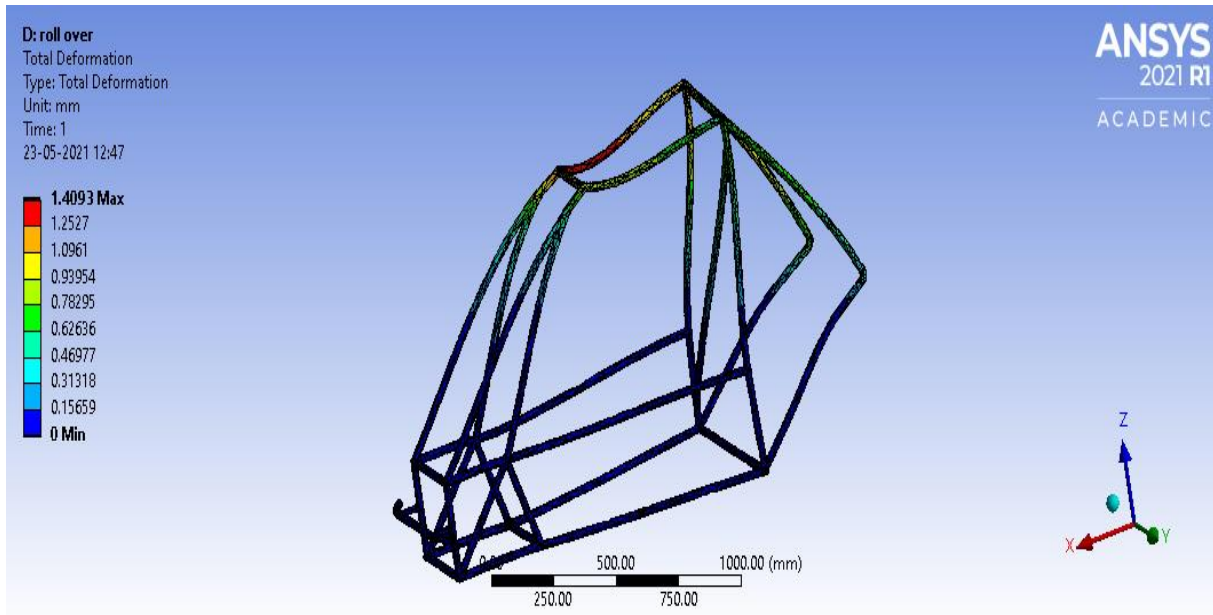


Fig 1.5 Maximum combined Stress in Roll over Impact Loading

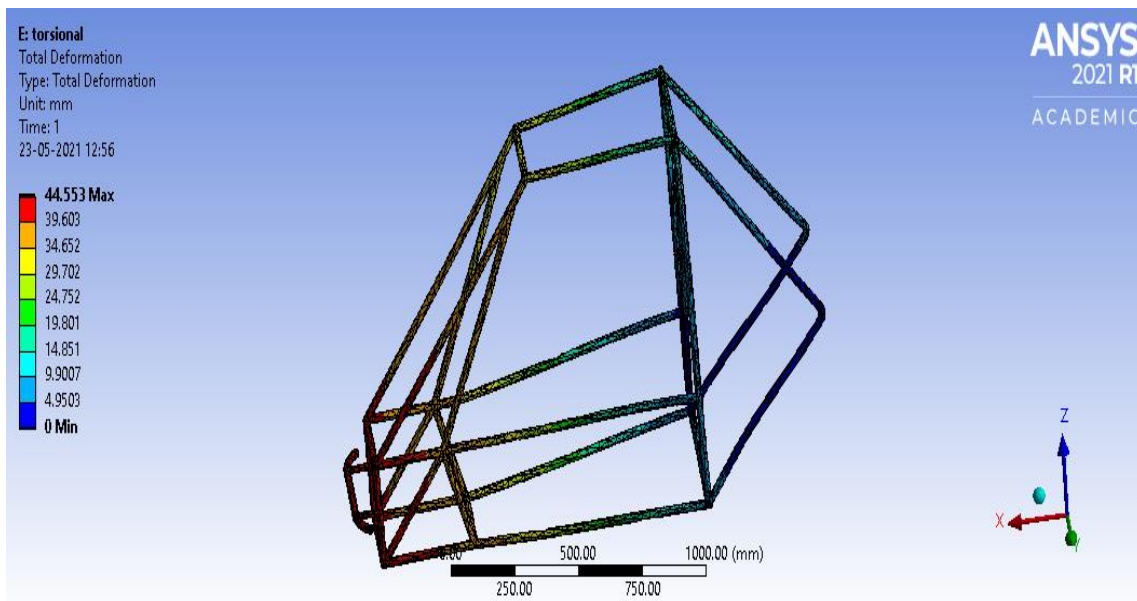


Fig 1.6 Maximum combined stress under torsional loading

### Factor of Safety

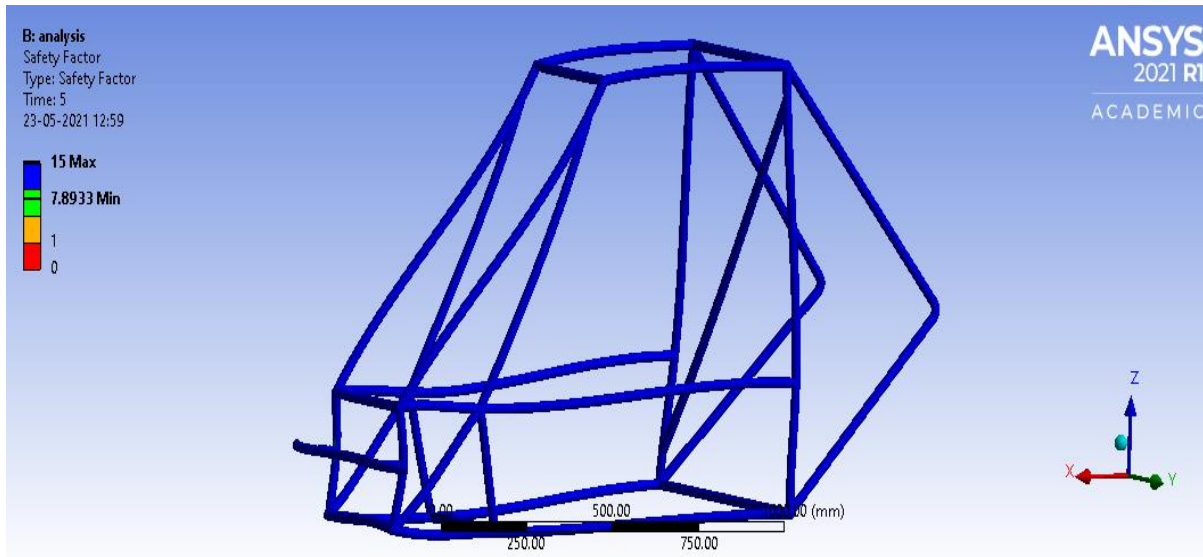


Fig 1.7 Safety Factors