# Structural Analysis of Go-kart Chassis using different materials to find the suitable material for the given model

**Atharva Kondhare, Sandesh Pawar, Anisa Diwan**

*Atharva Kondhare, Dept. of Mechanical Engineering, VIIT College, Maharashtra, India*
*Sandesh Pawar, Dept. of Mechanical Engineering, VIIT College, Maharashtra, India*
*Anisa Diwan, Dept. of Mechanical Engineering, VIIT College, Maharashtra, India*

---------------------------------------------------------------------***---------------------------------------------------------------------

**Abstract -** *In the present work, the chassis of the go-kart is designed and simulated for different impact positions such as front impact, side impact, & rear impact tests for four different materials. Initially, the chassis was designed using 3D CAD software and then simulations is carried out in ANSYS Workbench. The work shows the failure criteria based on von-mises stress for selected materials. The work aims to get the perfect materials for chassis that can withstand the range of force that the drivers experience while driving low-ground clearance go-karts. The reason to carry out a range of force analysis is that the kart should have maximum value for the factor of safety. The same range of a force is carried out on all the impact positions. For the current analysis, the strength of materials and structural rigidity are the main consideration.*

***Key Words***: **Chassis; Go-Kart; CAD Modelling; AISI: Simulation.**

## 1. INTRODUCTION

The Chassis is the metallic frame or Rigid Structure onto which all other components of a body are fixed. The work of the chassis is to carry the load of the vehicle and its passenger and resist the torque and thrust loads from the engine and gearbox, as well as those from stopping and accelerating, surviving the centrifugal force when turning. The chassis' construction is made up of thick tubing and tubes with different cross sections that support the different vehicle parts and protect the driver [1]. This work's discussion and result are based on the design and structural analysis of kart chassis under different loading conditions. The go-kart has an extremely low ground clearance compared to other cars and is specifically made for racing. The engine, wheels, steering, tires, axle, and chassis are the typical components of a go-kart. Go-karts cannot be equipped with suspensions because of their low ground clearance. [2].

Now, computer-aided engineering tools are used to design land vehicles [3]. Computer dynamic simulation techniques are frequently used to examine how those vehicles behave under various input situations [4]. Finite element analysis is used for the structural analysis of different types of vehicles. The FEA is used to calculate the generated stresses and strains from different input scenarios that have been applied as boundary conditions. [5]. Internal and external loads are acting on a Body. The internal load is brought on by the mass of the vehicle and payloads, while the external loads are brought on by the wheel-ground interface, moving through the suspension mechanism and its elastic components, and from the aerodynamic field surrounding the car body [1].

## 2. Methodology

### 1. Material Selection

The concerns of the manufacturer regarding laws and regulations, as well as some customer demands, determine an automotive chassis. Most producers favor affordable, secure, lightweight, and reusable materials. The primary considerations for choosing a material, particularly for the body, involve a wide range of properties like resilience, production effectiveness, and

thermal, chemical, or mechanical resistance. Mainly two materials are considered while constructing chassis & they are steel and aluminum. Aluminum is corrosion-resistant, however, due to its low flexibility modulus, it is not able to replace steel parts. As a result, such components must be redesigned to adopt the same mechanical strength. It is utilized as wheels, brackets, brake parts, suspension parts, steering parts, and instrument panels in chassis applications. Steel is the material of choice for producers because it has all the necessary qualities. Steel is now stronger, lighter, and more rigid than it was in the past thanks to advancements made in the steel industry. Steel's inherent capacity to absorb the impact energy created in a crash makes it ideal for body structures. So, for better material Selection in Go-kart chassis, we take AISI Steel Standards. The selected materials are AISI 1018, AISI 1026, AISI 4130, and AISI 1020.

The Table 1. Shows mechanical properties of selected materials.

| properties | Materials | | | |
|---|---|---|---|---|
| | AISI 1080 | AISI 1026 | AISI 4130 | AISI 1020 |
| Young's Modulus (GPa) | 200 | 200 | 210 | 205 |
| Poisson's Ratio | 0.29 | 0.3 | 0.3 | 0.29 |

| | | | | |
|---|---|---|---|---|
| Yield Tensile Strength(MPa) | 370 | 415 | 435 | 297.79 |
| Density (Kg/m3) | 7850 | 7858 | 7850 | 7870 |

**Table -1:** Properties of selected materials

## 2. Modelling

The 3D model of the chassis is designed with the help of Solidworks. SolidWorks is a software mainly used to develop mechatronics systems from beginning to end. Using the 3d sketch option initially chassis sketch is formed in XY, YZ & XZ planes. Then using the weldments method hollow pipes are created on the sketch. The hollow pipe is ISO 26.9 x 3.2 diameter. The chassis is formed by using hollow pipes as they result in less weight as compared to the solid pipe

For CAD Modelling

Scale: $1m = 600mm$

*Chassis Length= 2m*

*Chassis Width= 0.66m*

*Diameter Of pipe= ISO 26.9 * 3.2*

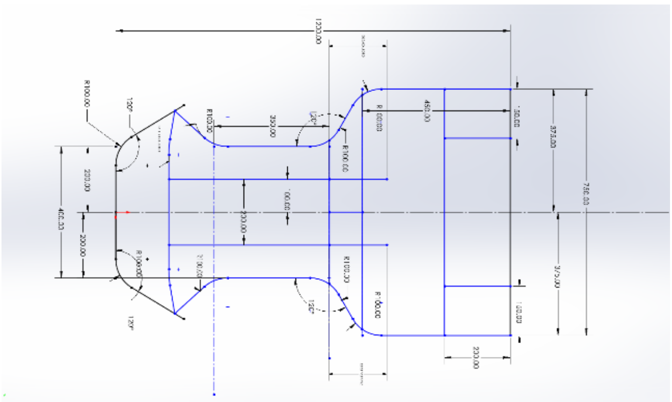

**Figure 1.1:** Top view Sketch with dimensions (mm)

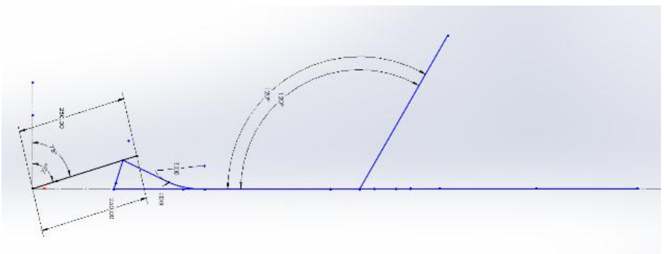

**Figure 1.2**: Side View

SolidWorks makes it simple to create a pipe structure using the weldment method or option Feature. Solid Works also Offers a 3d sketching method Therefore it is easy to sketch the chassis in a three-dimensional way

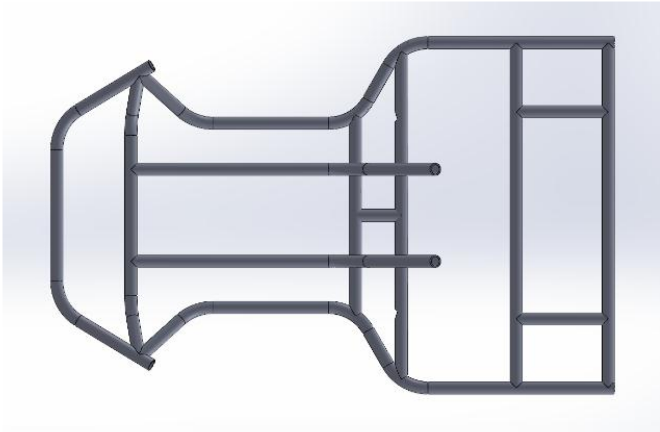

**Figure 1.3**: Chassis top view

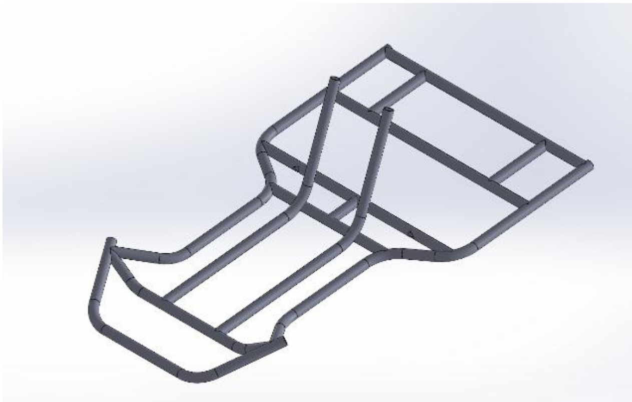

**Figure 1.4:** Chassis isometric View

**Figure 1.5**: Chassis side View

## 3. Fine Element Analysis (FEA)

The chassis behavior under actual physical force is understood using finite element analysis (FEA) [6]. To ensure safety when operating the go-kart, the chassis' structure must be strong and able to bear the forces applied to it. Static analysis is necessary to ensure that the chassis complied with the specifications [1]. For Finite Element Analysis, Ansys Software is used.

### 2.3.1.Meshing

Meshing helps to divide a complicated object into clearly defined cells where the general equation can be assigned so that the solver can easily simulate physical behavior. Highly accurate simulations are made possible by the 3D CAD model's increased accuracy and processing time as the mesh becomes more precise [6].

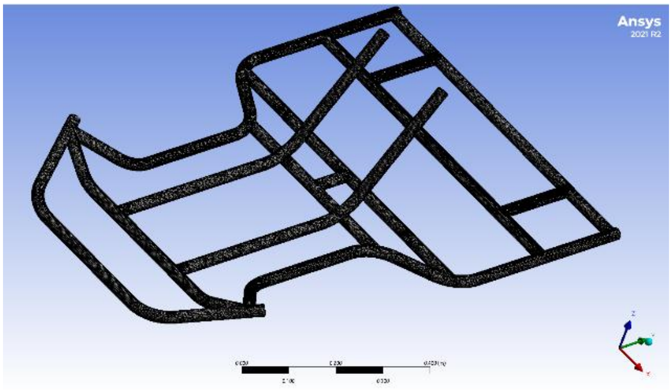


**Figure 2.1**: Go-Kart Chassis After meshing

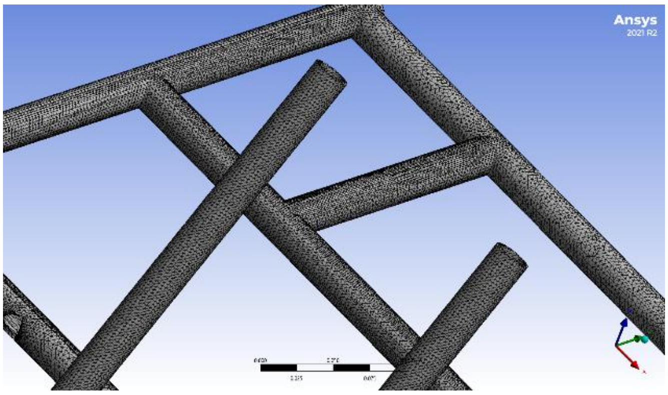


**Figure 2.2**: Close look at the quality of the chassis

The geometry used for mesh is tetrahedral and the element size is kept to 3mm. Total nodes are 2,20,000 and elements are 8,04,100 physics preference is kept CFD, & Solver Preference is Fluent And Element Order is Linear.

**2.3.2.Boundary Conditions**

Three conditions were imposed depending on the front, side, and Rear impact tests. For the Front impact test, the rear section was fixed and a force was applied to the front section, as shown in Figure 3.1. For the side impact test, One side of the chassis is fixed, and on the other side, the force was applied, as shown in figure 3.2. And for the Rear side impact test the front section was fixed, and force was applied to the rear section of the chassis, as shown in figure 3.3

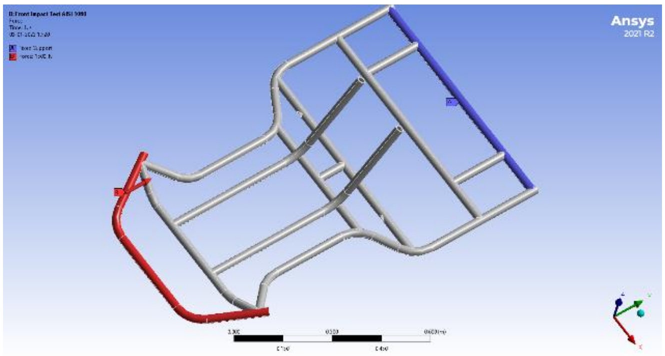


**Figure 3.1:** Condition for Front Impact test

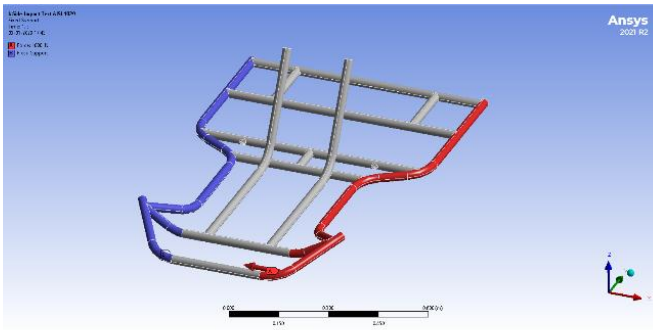


**Figure3.2**: Condition for Side Impact Test

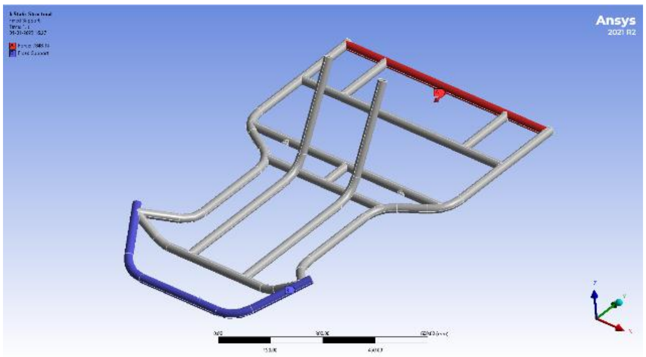


**Figure 3.3**: Condition for rear impact test

**2.3.3.Solution**

Analysis of all selected materials was performed using ANSYS to determine the factor of safety and deformation that the built chassis experiences when a load is applied to it in front static impact and Side static impact [6].

Front Impact Test

Let us consider for the front analysis test, that the maximum weight of the driver is 100 kg, and the maximum weight of the Go-Kart is considered 100 kg; therefore, Assuming the vehicle is struck by the applied load for a brief period at a velocity of 70 km/hr during the front section of the chassis, the go kart's weight with the operator is assumed to be 200 kg. Analysis of the impact load's impact varies depending on the driver's perception of safety and is done for a range where loads are measured at 4g, 6g, and 8g.

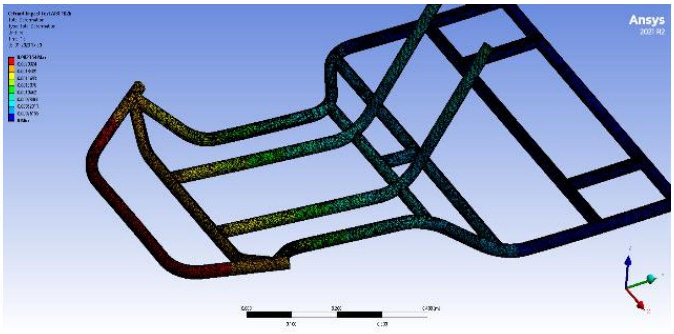


**Figure 5.1:** maximum deflection in chassis for front

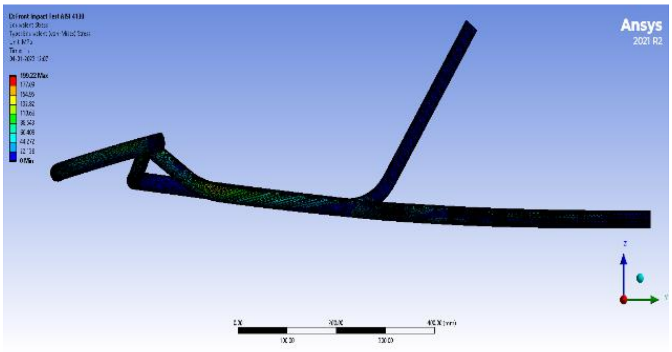


**Figure 5.2:** Maximum Von-mises stress for front impact

<u>Side Impact Test</u>

Let us consider for the Side Analysis test, that the maximum weight of the driver is 100 kg, and the maximum weight of the go-Kart is considered 100 kilograms; therefore, the total weight of the go-kart with the Operator is taken as 200 kg. assuming that the vehicle is briefly hit by the applied load while traveling at 70 km/hr in the selected section of the chassis. Analysis of the impact load's effect varies depending on the driver's perception of safety and is done for a range where loads are measured at 4g and 6g.

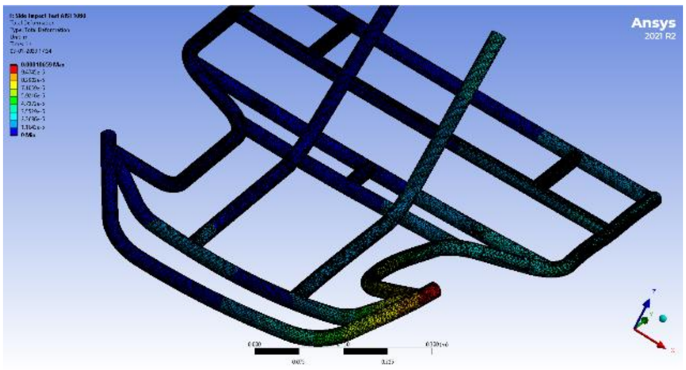


**Figure 5.3:** maximum deflection in chassis for side impact

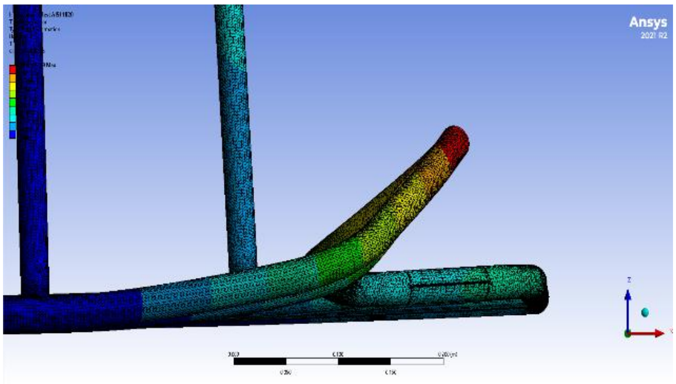


**Figure 5.4**: maximum deflection in chassis for side impact

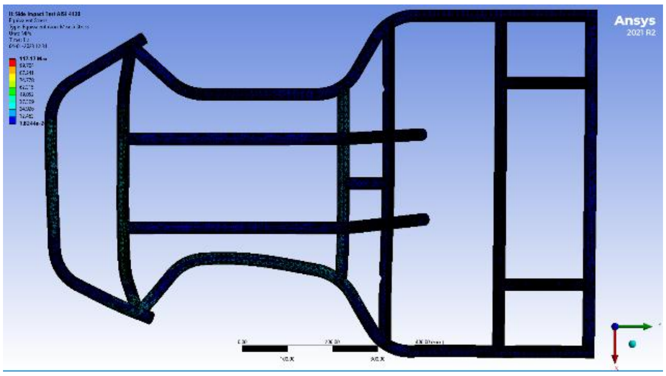


**Figure 5.5:** Max Von-mises stress for side impact

<u>Rear Impact Test</u>

Let us consider for the rear analysis test, that the maximum weight of the driver is 100 kilograms, and the greatest possible weight of the Go-Kart is considered 100 kilograms; therefore, the total weight of the go-kart with the operator is taken as 200 kg. assuming that the load strikes the car at the velocity of 70 km/hr in the selected section of the chassis for a brief period. Analysis of the impact load's impact varies depending on the driver's perception of safety and is done for a range where loads are measured at 4g, 6g, and 8g

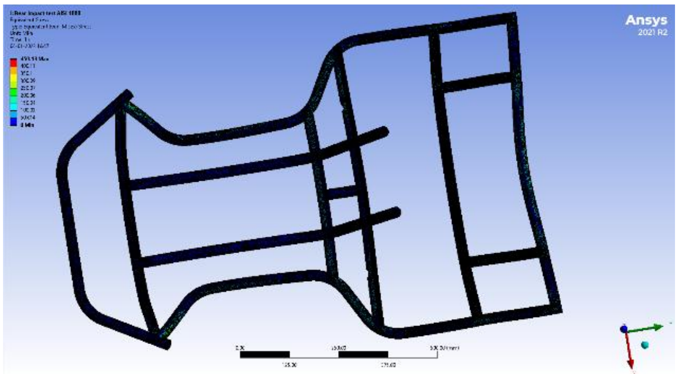


**Figure 5.6:** Maximum deflection in chassis for rear impact

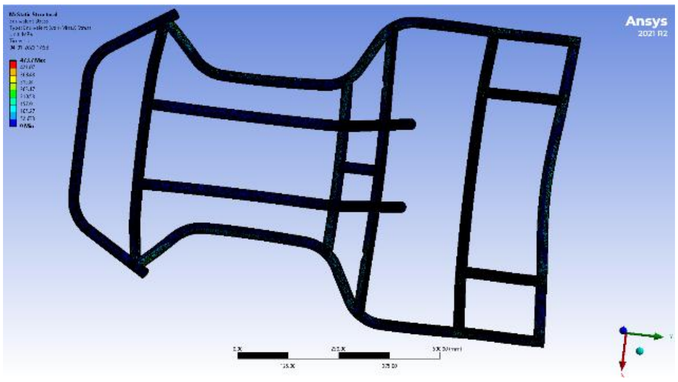

**Figure 5.7**: Maximum Von-mises stress for rear impact

$$F.O.S = \frac{Yield\ Tensile\ stress}{Von - mises\ stress}$$

**For safe design**

**F.O.S** ≥ 1

## 3. Result and Discussions

For results, the calculations are done by using the F.O.S formula. If the factor of safety is greater than or equal to one, then this design is said to be safe. The loads used in impact tests, the maximum deflection, and the induced Von Mise stress is displayed in the tables

| Front Impact Test AISI 1080 | | | | | | |
|---|---|---|---|---|---|---|
| Load Criterion | Force (N) | Max stress (MPa) | Deformation (mm) | Yield strength (MPa) | FOS | Remark |
| 4g | 7848 | 186.99 | 14.664 | 370 | 1.97 | Safe design |
| 6g | 11772 | 280.49 | 21.997 | | 1.31 | Safe design |
| 8g | 15696 | 373.98 | 29.329 | | 0.98 | Failure |

Table 1. Front Impact Test AISI 1080

| Side Impact Test AISI 1080 | | | | | | |
|---|---|---|---|---|---|---|
| Load Criterion | Force(N) | Max stress (MPa) | Deformation (mm) | Yield strength (MPa) | FOS | Remark |
| 4g | 7848 | 94.569 | 0.83722 | 370 | 3.91 | Safe design |
| 6g | 11772 | 141.85 | 1.2558 | | 2.6 | Safe design |

Table 2. Side Impact Test AISI 1080

| Rear Impact Test AISI 1080 | | | | | | |
|---|---|---|---|---|---|---|
| Load Criterion | Force(N) | Max stress (MPa) | Deformation (mm) | Yield strength (MPa) | FOS | Remark |
| 4g | 7848 | 225.06 | 3.1652 | 370 | 1.64 | Safe design |
| 6g | 11772 | 337.6 | 4.7477 | | 1.09 | Safe design |
| 8g | 15696 | 450.13 | 6.3303 | | 0.82 | Failure |

Table 3. Rear Impact Test AISI 1080

| Front Impact Test AISI 1026 | | | | | | |
|---|---|---|---|---|---|---|
| Load Criterion | Force(N) | Max stress (MPa) | Deformation(mm) | Yield strength (MPa) | FOS | Remark |
| 4g | 7848 | 214.45 | 12.316 | 415 | 1.93 | Safe design |
| 6g | 11772 | 321.68 | 18.474 | | 1.29 | Safe design |
| 8g | 15696 | 428.9 | 24.632 | | 0.96 | Failure |

Table 4. Front Impact Test AISI 1026

| Side Impact Test AISI 1026 | | | | | | |
|---|---|---|---|---|---|---|
| Load Criterion | Force(N) | Max stress (MPa) | Deformation(mm) | Yield strength (MPa) | FOS | Remark |
| 4g | 7848 | 109.26 | 0.98472 | 370 | 3.38 | Safe design |
| 6g | 11772 | 163.89 | 1.4771 | | 2.25 | Safe design |

Table 5. Side Impact Test AISI 1026

| Rear Impact Test AISI 1026 | | | | | | |
|---|---|---|---|---|---|---|
| Load Criterion | Force(N) | Max stress (MPa) | Deformation(mm) | Yield strength (MPa) | FOS | Remark |
| 4g | 7848 | 236.4 | 3.1717 | 415 | 1.75 | Safe design |
| 6g | 11772 | 354.59 | 4.7576 | | 1.17 | Safe design |
| 8g | 15696 | 472.79 | 6.3435 | | 0.87 | Failure |

Table 6. Rear Impact Test AISI 1026

| Front Impact Test AISI 4130 | | | | | | |
|---|---|---|---|---|---|---|
| Load Criterion | Force(N) | Max stress (MPa) | Deformation(mm) | Yield strength (MPa) | FOS | Remark |
| 4g | 7848 | 199.22 | 10.063 | 415 | 2.08 | Safe design |
| 6g | 11772 | 298.83 | 15.095 | | 1.38 | Safe design |
| 8g | 15696 | 398.45 | 20.126 | | 1.04 | Safe design |

Table 7. Front Impact Test AISI 4130

| Side Impact Test AISI 4130 | | | | | | |
|---|---|---|---|---|---|---|
| Load Criterion | Force (N) | Max stress (MPa) | Deformation (mm) | Yield strength (MPa) | FOS | Remark |
| 4g | 7848 | 112.17 | 0.93769 | 415 | 3.69 | Safe design |
| 6g | 11772 | 168.25 | 1.4065 | | 2.46 | Safe design |

Table 8. Side Impact Test AISI 4130

| Rear Impact Test AISI 4130 | | | | | | |
|---|---|---|---|---|---|---|
| Load Criterion | Force (N) | Max stress (MPa) | Deformation(mm) | Yield strength (MPa) | FOS | Remark |
| 4g | 7848 | 229.58 | 3.021 | 435 | 1.89 | Safe design |
| 6g | 11772 | 344.37 | 4.5315 | | 1.26 | Safe design |
| 8g | 15696 | 459.16 | 6.0419 | | 0.94 | Failure |

Table 9. Rear Impact Test AISI 4130

| Front Impact Test AISI 1020 | | | | | | |
|---|---|---|---|---|---|---|
| Load Criterion | Force(N) | Max stress (MPa) | Deformation(mm) | Yield strength (MPa) | FOS | Remark |
| 4g | 7848 | 199.07 | 11.142 | 297.79 | 1.49 | Safe design |
| 6g | 11772 | 298.61 | 16.713 | | 0.99 | Failure |
| 8g | 15696 | 398.15 | 22.284 | | 0.74 | Failure |

Table 10. Front Impact Test AISI 1020

| Side Impact Test AISI 1020 | | | | | | |
|---|---|---|---|---|---|---|
| Load Criterion | Force(N) | Max stress (MPa) | Deformation(mm) | Yield strength (MPa) | FOS | Remark |
| 4g | 7848 | 112.55 | 0.95971 | 297.79 | 2.64 | Safe design |
| 6g | 11772 | 168.82 | 1.4396 | | 1.76 | Safe design |

Table 11. Side Impact Test AISI 1020

| Rear Impact Test AISI 1020 | | | | | | |
|---|---|---|---|---|---|---|
| Load Criterion | Force(N) | Max stress (MPa) | Deformation(mm) | Yield strength (MPa) | FOS | Remark |
| 4g | 7848 | 236.85 | 3.0915 | 297.79 | 1.25 | Safe design |
| 6g | 11772 | 355.27 | 4.6373 | | 0.83 | Failure |
| 8g | 15696 | 473.7 | 6.183 | | 0.62 | Failure |

Table 12. Rear Impact Test AISI 1020

## 4. CONCLUSIONS

1. According to the findings of this study, for front impact tests, AISI 4130 material performs well under 4 g, 6 g, and 8 g loads, with the highest factor of safety when compared to the selected material.
2. In the side impact test, all selected materials performed well under 4 and 6 g loads, but AISI 1080 is safer than other materials.
3. For the rear impact test, again, AISI 4130 is a safer material.
4. From the overall result, AISI 4130 is the most effective material among the selected materials under 4 g, 6 g, and 8 g loads.

## REFERENCES

[1] Jafri, Mohamad & Marwan, Shahrul & Lazim, Muhammad & Anuar, Nurul. (2019). FINITE ELEMENT ANALYSIS OF GO-KART CHASSIS. e-Academia Journal. 7. 10.24191/e-aj.v7iSI-TeMIC18.5397.

[2] Raghunandan, D., et al. "DESIGN AND ANALYSIS OF GO-KART CHASSIS." *INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY*, Nov. 2016, https://doi.org/10.5281/zenodo.164912.

[3] Raphael, Benny & Smith, Ian. (2013). Engineering Informatics: Fundamentals of Computer-Aided Engineering.

[4] Mike Blundell, Damian Harty, Chapter 3 - Multibody Systems Simulation software, Editor(s): Mike Blundell, Damian Harty, The Multibody Systems Approach to Vehicle Dynamics (Second Edition), Butterworth-Heinemann, 2015, Pages 87-184,ISBN 9780080994253, https://doi.org/10.1016/B978-0-08-099425-3.00003-0.

[5] Saheb, H. S.; Kona, R. K.; Hameed, M. (2016). Design report of a go-kart vehicle, International Journal of Engineering Applied Sciences and Technology, Vol. 1, No. 9, 95-102.

[6] Sanjeet Ramteke, and Vaishnavi Nambiar. "Material Selection Methodology for a Go-kart Chassis Using Weighted Decision Matrices." Turkish Journal of Computer and Mathematics Education, vol. 13, No. 2, 2022, pp. 539–50.

## BIOGRAPHIES

SANDESH PAWAR

Dept. of Mechanical Engineering, VIIT College, Maharashtra, India.

Atharva Kondhare

Dept. of Mechanical Engineering, VIIT College, Maharashtra, India

ANISA DIWAN

Dept. of Mechanical Engineering, VIIT College, Maharashtra, India.