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Design and Analysis of Go - Kart Chassis using Distinctive Materials

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Abstract: Go-Kart Chassis is the main supporting structure for Engine Mounting, Steering System, Wheels etc. It bears all the stresses on the go – kart in both static and dynamic conditions. As there is no suspension system in the go-kart, huge vibrations are produced by the shock due to direct contact of the wheel to the ground or from engine which is mounted on it. Due to this Vibrational behaviour, Cyclic loads act on it and result in a fatigue failure. The purpose of this study was to analyse vibrational behaviour of various materials and their mode shapes under natural frequency response. And to perform Impact Analysis for evaluating withstanding capacity of the chassis under dynamic conditions. In this research the go-kart chassis is designed in 3D-CAD modelling software CATIA V5 and finite element analysis is performed by using ANSYS 14.5 workbench on selected materials. Hence, using modal and impact analysis defects are detected and necessary modification like change in materials, geometry of stiffness is made. the analysis on go kart chassis are often extended further to know the modal behaviour under fracture condition.
Keywords: Numerical Simulation, Go-Kart Chassis, Vibrational Behaviour, Resonance, Structural Rigidity, Reliability, Explicit dynamics, Catia V5, ANSYS 14.5 Workbench.

I. INTRODUCTION

Go-kart chassis is a supporting structure and act as a load bearing framework of an object, which structurally supports the object and also embedding various components like braking system, steering mechanism, wheels, powertrain, body works and engine mounting.

Without chassis go-kart is incomplete. The structure of go kart chassis is available in different cross-section, in this interpretation circular cross-section is examined. Circular cross section is always selected because of its high resistance of twisting effect and possesses torsional rigidity, the round cross-sectional tube as ability of greater energy absorption than the square cross section tube or any other.

This higher energy absorption will retrieve from the impact on go-kart chassis. Crush force efficiencies (CFE) obtained is higher for circular cross-sectional tube in comparison to square cross-sectional tube so circular section is always preferred [1].

The designed chassis should possess enough strength to withstand the impact and protect the rider. This behaviour can be achieved by using high strength material and better cross section against to impact. As to overcome the difficulties circular cross section chassis is constructed with minimum dimension and strength requirements. If overall weight of chassis rises the performance decreases due to reduction in acceleration [2].

To understand the dynamic characteristics of the go-kart chassis and overcome the resonance modal analysis is carried out on structure of designed chassis.

As go-kart is suspension free the excitation frequencies obtained from the wheel and ground interface during motion matches with the natural frequency of go-kart geometry results in resonance. Similarly, from engine mounting on chassis. Due to vibration generated various components mounted on chassis may lose alignment and leads to failure. To overcome the problem modal analysis is performed.

The hypothetical deformation described by the chassis under specific excitation frequency are evaluated, defects are identified and change of design is analysed [3].

The main aspiration of the project is to construct a CAD model of go-kart chassis in CATIA software by approaching the Indian Karting Championship (INDKC) 4th edition rulebook, and to evaluate modal and impact analysis using ANSYS workbench on designed chassis using materials viz. AISI 1018, AISI 4130 and 2014 Al alloy and Ti -3Al-2.5V alloy. Comparison of results in done to make necessary modification in design to optimize the performance.

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A. Specification of the Problem

The objective of present work is to evaluate modal and impact analysis on Go-kart chassis. In this interpretation CAD model of chassis is designed in CATIA software, modal and impact analysis is performed by ANSYS (FEA) software using dissimilar materials. After analysis, a comparison is done between materials in terms of weight, factor of safety, deformation, and stress.

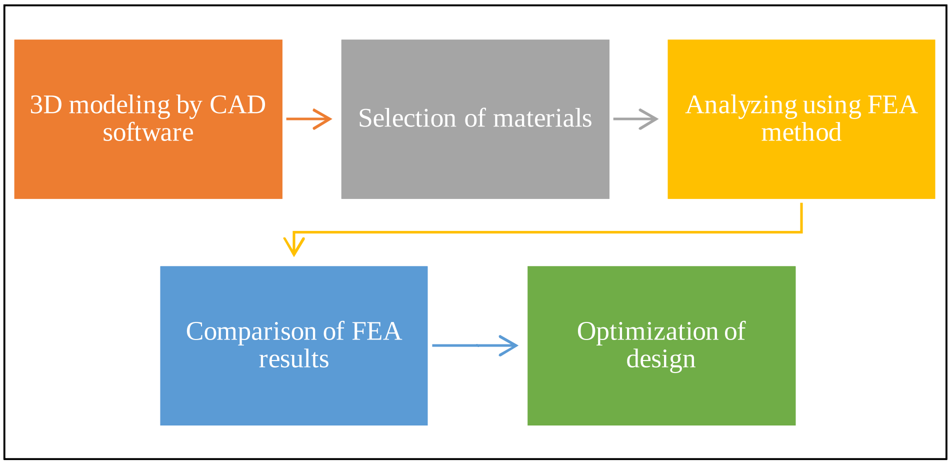

Fig. 1 Representation of the Procedure of the Research

II. MATERIAL SELECTION & METHODOLOGY

A. Material Selection

This work mainly emphasis on the selection and analysis of best material for the go kart chassis. The go kart frequently comes across various collusion and impacts during its services hence their impact analysis needed to be addressed. For this, the study includes 4 diverse materials such as AISI 1018, AISI 4130 and 2014 Al alloy and Ti -3Al-2.5V alloy, as in [4].

These materials were taken into consideration because of their dissimilarity to each other and contain distinct properties. These materials are selected because of their distinctiveness. These mainly are characterized into their alloy names such as Carbon Steels, 2000 Series Aluminium Alloy, Near Alpha Titanium Alloy.

1) *AISI 1018:* The carbon content in 1018 is approximately about 0.05–0.30% which makes it more malleable and ductile in nature. These carbon steels have a relatively low tensile strength, but it is cost efficient and easy to form, by carburizing the material surface hardness may increase.

Table II.I Chemical Composition of AISI 1018

Element	Content
Carbon	0.14 – 0.20 %
Iron	98.81 – 99.26 %
Manganese	0.6 – 0.9 %
Phosphorous	< 0.04 %
Sulphur	< 0.05 %

2) *AISI 4130:* These Materials include chromium and molybdenum and are often informally referred to as chromoly steel. They possess excellent strength to weight ratio and are considerably stronger and harder.

Table II.II Chemical composition of AISI 4130

Element	Content
Carbon	0.282 – 0.33 %
Manganese	0.40 – 0.60 %
Phosphorous	0.035 % Maximum
Sulphur	0.040 % Maximum
Silicon	0.20 – 0.35 %
Chromium	0.80– 1.10 %

3) *Aluminium 2014 Alloy:* These materials are easily machined, most commonly it can be extruded and forged. Which are strongest available aluminium alloys, and these alloys possess good corrosion resistance as well as having high hardness. As it contains slight amount of Copper which makes the material an excellent heat and electricity conductivity.

Table II.III Chemical composition of Aluminium 2014 Alloy

Element	Content
Aluminium	90.4 – 95 %
Chromium	0.1 % Maximum
Copper	3.9 – 5 %
Iron	0.7 % Maximum
Silicon	0.5 – 1.2 %
Manganese	0.4 – 1.2 %

4) *TI – 3Al – 2.5V:* Ti alloys are most commonly used for aerospace application. They have excellent withstanding ability even at extreme temperatures. These are lighter in weight, high tensile strength, durable and corrosion resistance they possess good mechanical properties.

Table II.IV Chemical composition of Ti – 3Al – 2.5V

Element	Content
Titanium	94.5 %
Aluminium	3 %
Vanadium	2.5 %

Following table gives the required mechanical properties of the distinctive materials used in the exploration. These were the properties which were used in the ANSYS 14.5 Workbench software to solve the modal and impact analysis.

Table II.V Mechanical Properties of the Distinct Materials

Properties	AISI 1018	AISI 4130	AL 2014-T6	TI-3AL-2.5V
Density (g/cc)	7.87	7.85	2.8	4.48
Young's Modulus (GPa)	205	205	72.4	100
Poisson's Ratio	0.29	0.29	0.33	0.3
Tensile Strength Yield (Mpa)	370	435	414	500
Tensile Strength Ultimate (MPa)	440	670	483	620

B. Design

1) *Dimensioning:* Dimensioning is a significant part in the structure since it ensures that the plan of the Chassis is at acceptable stable condition. The selected dimensions are taken into consideration and are similar to the certified dimensions which were used in Annual Go-Kart Sporting Event - Indian Karting Championship (INDKC) 4th Edition. Fig. 2 portrays the dimensions of the chassis.

Table II.VI Dimensions of the Chassis

Content	INDKC Dimensions[R]	Preferred Dimensions
Wheelbase	>1016 mm	1040 mm
Track Width	>612.8 mm	726 mm
Diameter of Tube	>25.4 mm	26 mm
Thickness of Tube	>1.5 mm	1.8 mm

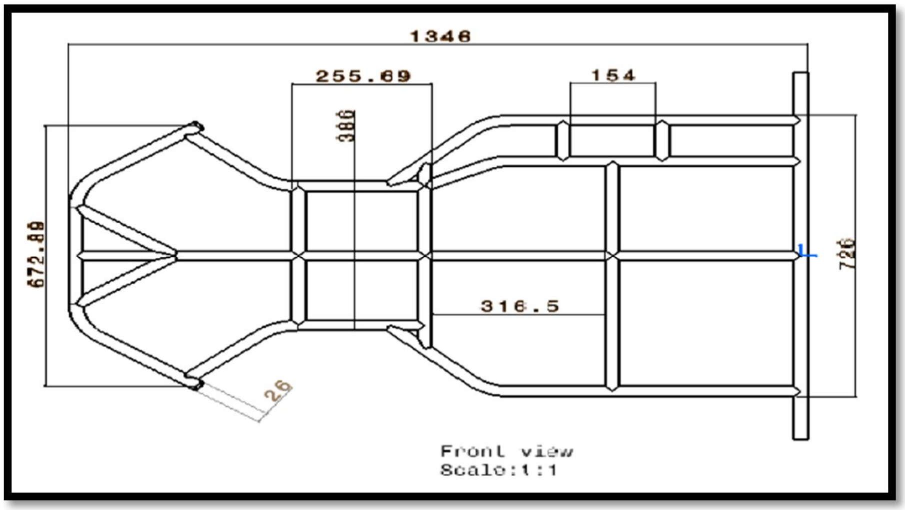

Fig. 2 Chassis Dimensions

2) *Modelling:* The 3D CAD Model is created by the use of CATIA V5 software which represents the conceptual design and layout of chassis as shown in the Fig. 3. The intention is to show the early structure in a visual representation as the real model should be seen first. The possibility of the structure should be communicated as specialized drawing. The structure needs to have usefulness and innovation to the eyes of the consumer. Without the function, the plan is inappropriate. Straightforward is better when structuring go-kart to facilitate the work when we are fabricating the chassis.

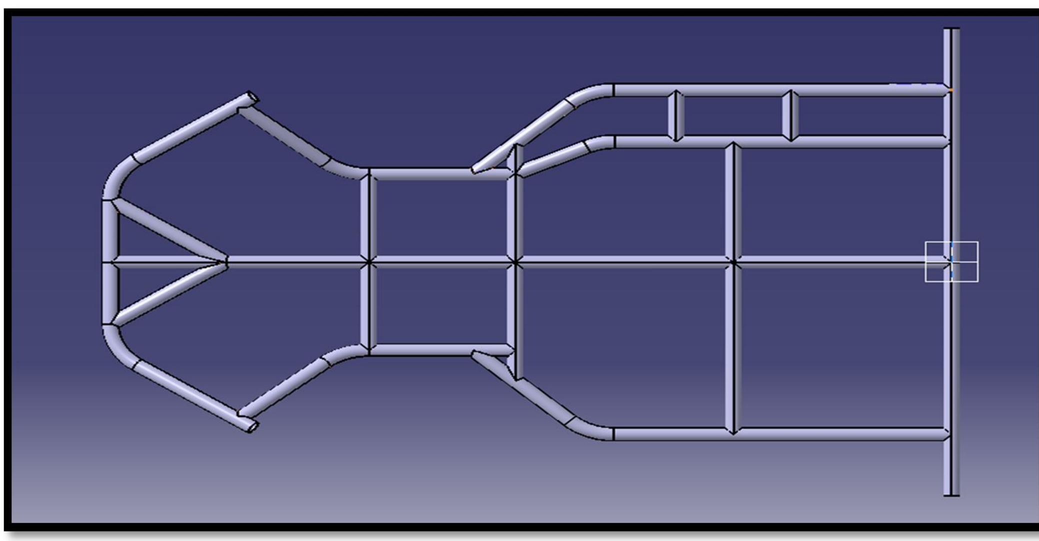

Fig. 3 Pictorial Representation of CAD Model

III. RESULTS AND DISCUSSION

A. *Meshing*

Meshing is an essential part of engineering analysis where complex geometries are divided into various nodes and elements, which are uniformly distributed throughout the material to improve the results. The meshing impacts the precision, convergence, and speed of the simulation, as in [5]. The Element size is taken as 2 mm, as shown in Fig. 4.

Table III.I Nodes and Elements

Elements	317353
Nodes	634847

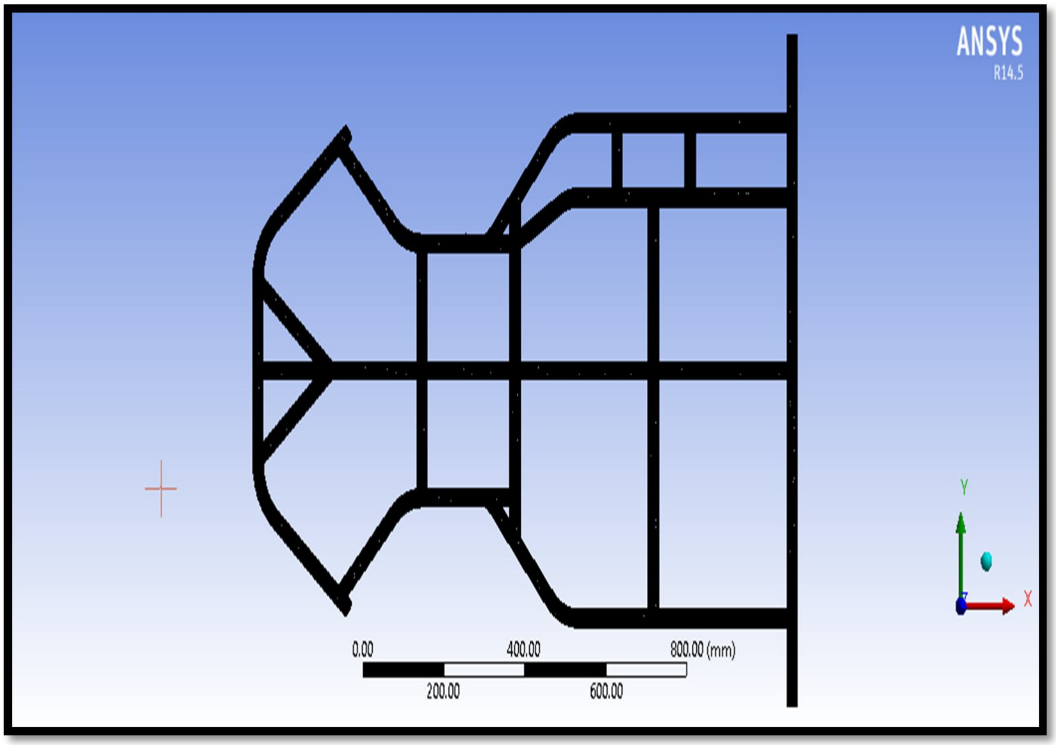

Fig. 4 Meshing of the Chassis

B. Boundary Conditions

Boundary conditions are the limitation or constrains provided to chassis geometry. In modal analysis hypothetical deformation of system is allowed to oscillate at infinite degrees of freedom. Here the result is completely depending on boundary conditions and structure of system. Four regions of fixed points were chosen for boundary condition, it demonstrates where the front and back axle will be put as appeared in Fig. 5.

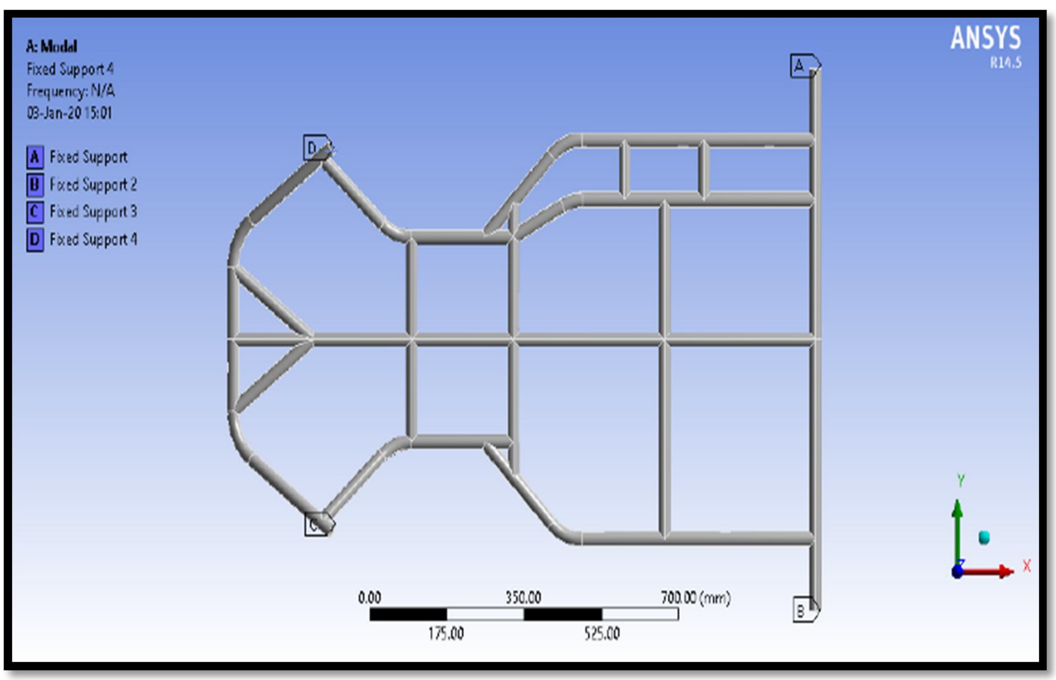

Fig. 5 Boundary Conditions of the Chassis

C. Modal Analysis

It It is used to find out the resonating frequencies and mode shapes of a go-kart chassis so that we can analyse the resonance and keep the structure of chassis far away from resonance which results in stability of the go-kart and possesses good vibrational absorptivity. For the safety point of view of the driver, ergonomic considerations are carried out and vibrational behaviour their mode shapes need to be evaluated, as in [6]. In present analysis stiffness of the chassis structure, ability to minimize resonance, strength and reliability are primary considerations. Mainly, it is centred around extracting a material which has great natural frequencies that at last outcomes in less vibrations and maintains a strategic distance from resonance. The Modal Analysis stimulation is conducted for the four materials i.e., AISI 1018, AISI 4130, AL-2014-T6, TI-3AL- 2.5V by giving six mode shapes. The stimulations obtained good performance results for both AISI 4130 and AL-2014-T6.

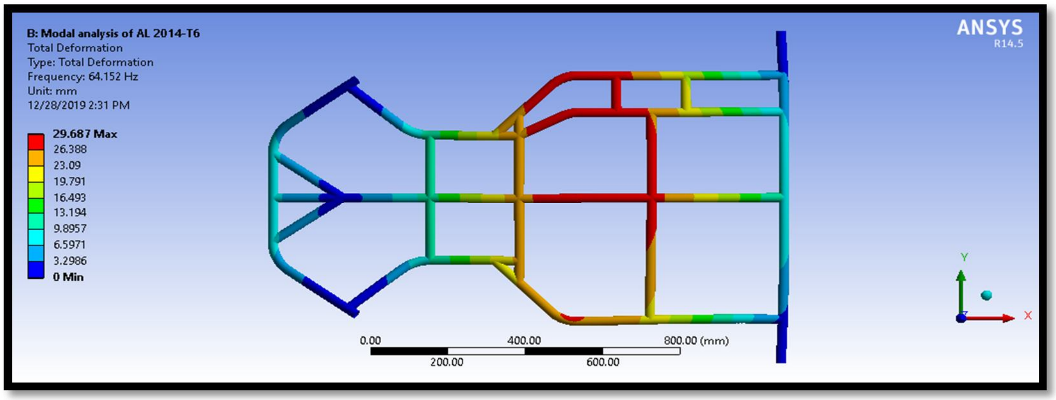

Fig. 6 1ST Mode Shape of the Chassis

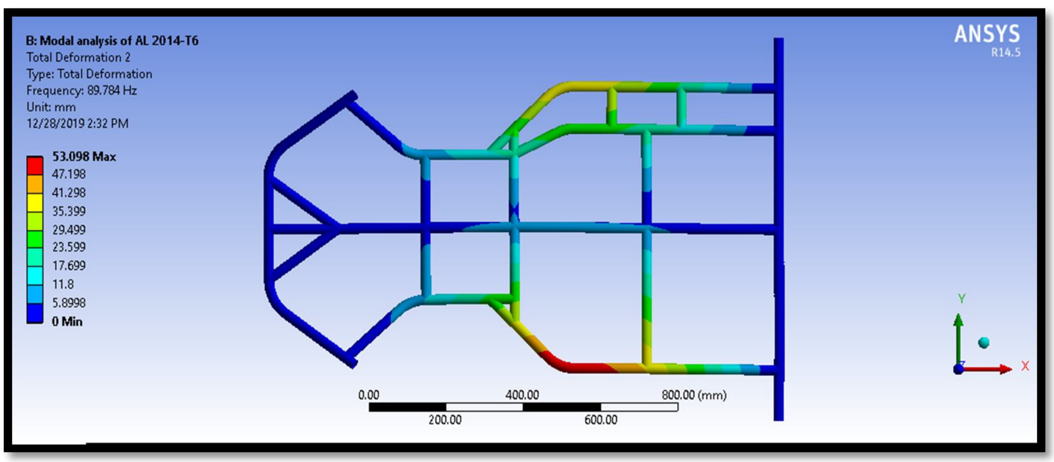

Fig. 7 2ND Mode Shape of the Chassis

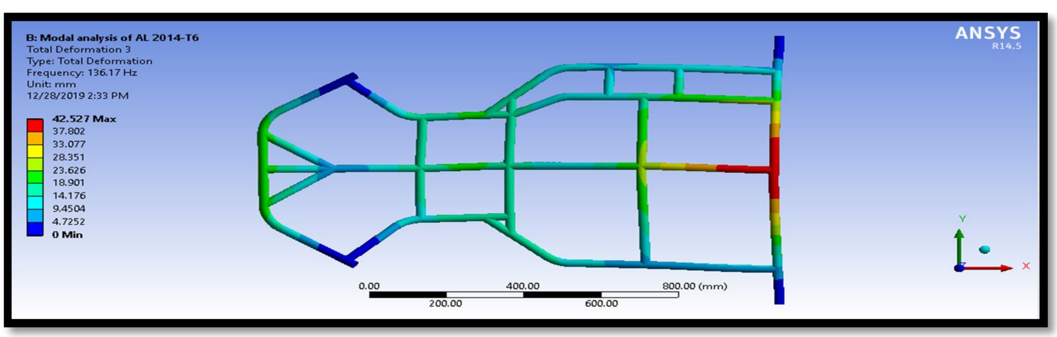

Fig. 8 3RD Mode Shape of the Chassis

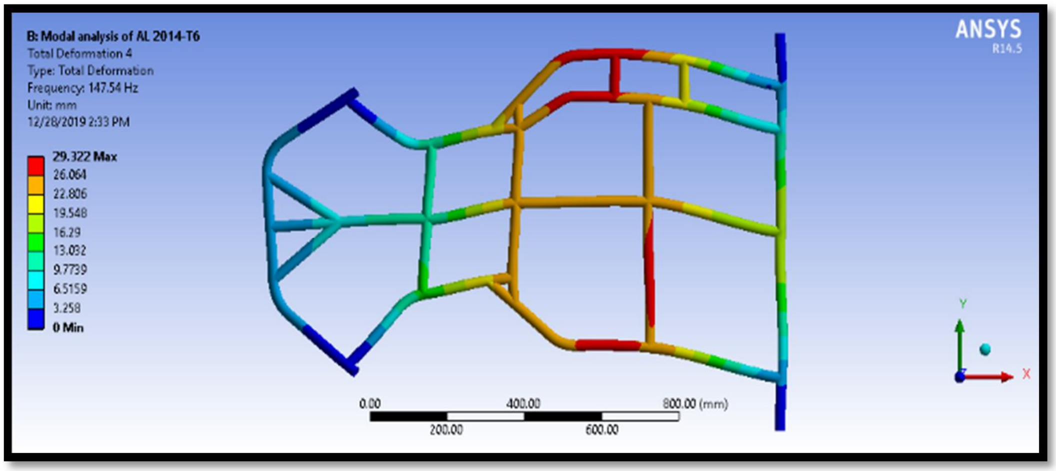

Fig. 9 4TH Mode Shape of the Chassis

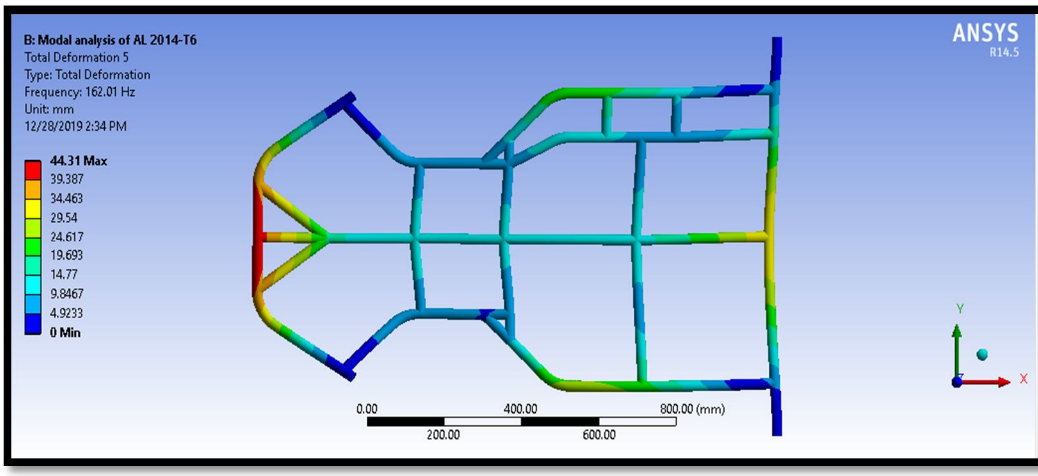

Fig. 10 5TH Mode Shape of the Chassis

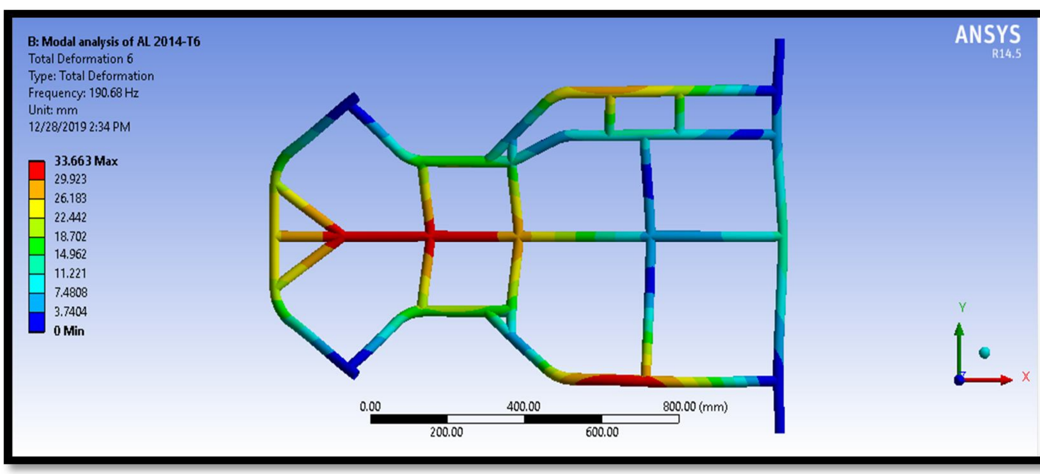

Fig. 11 6TH Mode Shape of the Chassis

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D. Natural Frequencies

The resonating frequencies obtained by performing modal analysis for different material on go-kart chassis as above displayed are tabulated below. Representation through graphs is done to compare the evaluated results. The following Table III.II consists of the natural frequencies of the materials including different modes of shapes.

Table III.II Natural Frequencies of the Materials

Mode Shape	Materials			
	AISI 1018	AISI 4130	AL-2014-T6	TI-3AL-2.5V
	Natural Frequencies (Hz)			
1	63.75	65.30	64.15	59.65
2	89.51	91.62	89.78	83.69
3	135.13	138.48	136.17	126.49
4	146.09	149.78	147.54	136.82
5	160.78	164.75	162.01	150.49
6	189.25	193.93	190.68	177.14

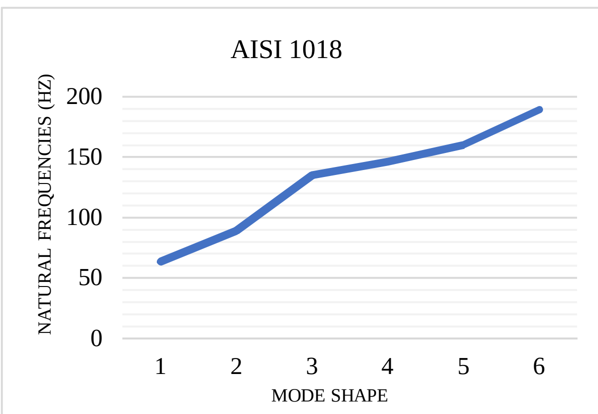

Fig. 12 Natural Frequencies Graph of AISI 1018

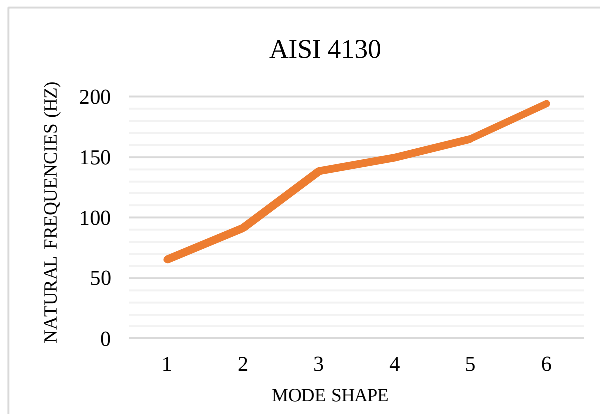

Fig. 13 Natural Frequencies Graph of AISI 4130

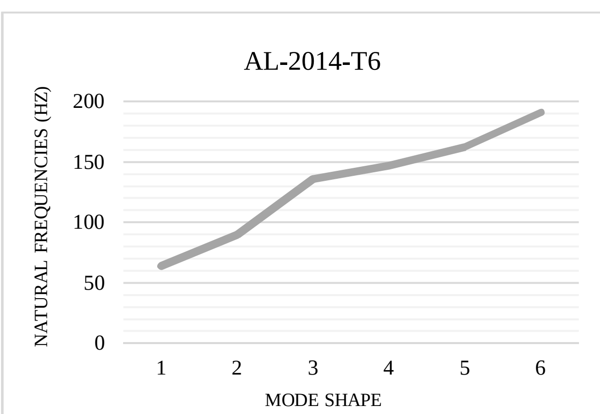

Fig. 14 Natural Frequencies Graph of AL-2014-T6

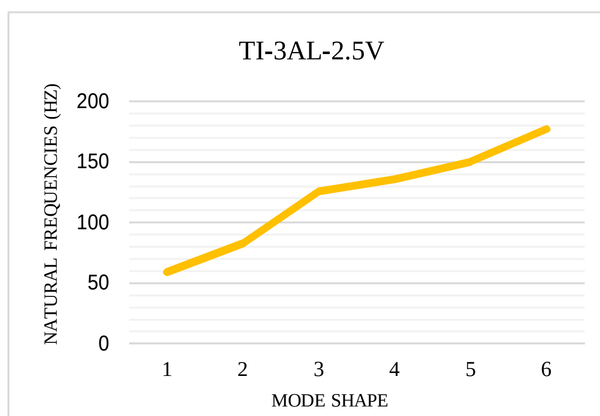

Fig.15 Natural Frequencies Graph of TI-3AL-2.5V

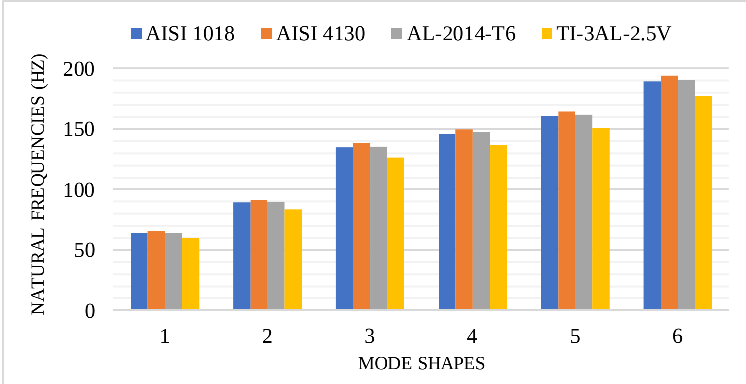

Fig. 16 Comparison of Natural Frequencies of Different Materials

From the results shown in Fig. 16, both AISI 4130 and AL-2014-T6 have high rate of natural frequencies compared to other materials, but AL-2014-T6 IS selected due to low weight to body ratio which is very essential while designing a go-kart.

E. Impact Analysis

It is an explicit dynamics form of analysis that gives us the withstanding capacity of the chassis. in this operation, we provide different forms of loads on the various direction to check the internal resistance offered by the chassis to the external loads applied to it. We can also obtain forces between two or more colliding bodies and the resultant deformation or damage. Explicit dynamics generally is used for high-speed interactions or complex contact, as in [7], [8]. The static structural analysis has been conducted on the chassis to find out the deformations and with- standing capacity for applied impact force. It is calculated by using Newton's mass moment equation, i.e. F=M×A

Where,

A = $\Delta v/t$ in m/s^2

F = Impact Force in Newtons

M = Mass of the overall go-kart in Kg's

Δv = Change in Velocity ($v_f - v_i$) in m/s

t = time taken to decelerate in seconds

The total mass of the go-kart is taken as 160 kg (including weight of the engine, drive system, brake unit, body kits and mass of the driver) and total time taken for the go-kart to decelerate varies with respect to impact and comes to rest in 0.78 seconds.

1) *Front Impact Analysis:* The impact force is applied at the front bumper, to study the deformation efforts. The go-kart change in speed is taken as 64 kph.

F= (160) *(22.79)

F= 3650.282 N

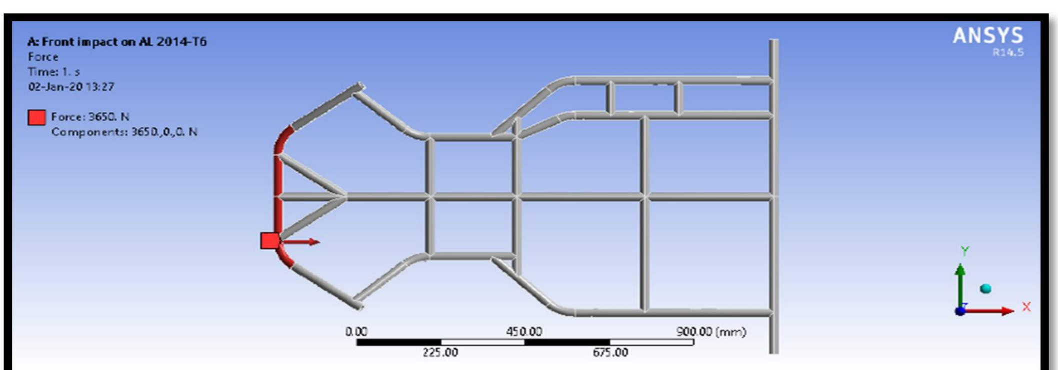

Fig. 17 Representation of Force Applied

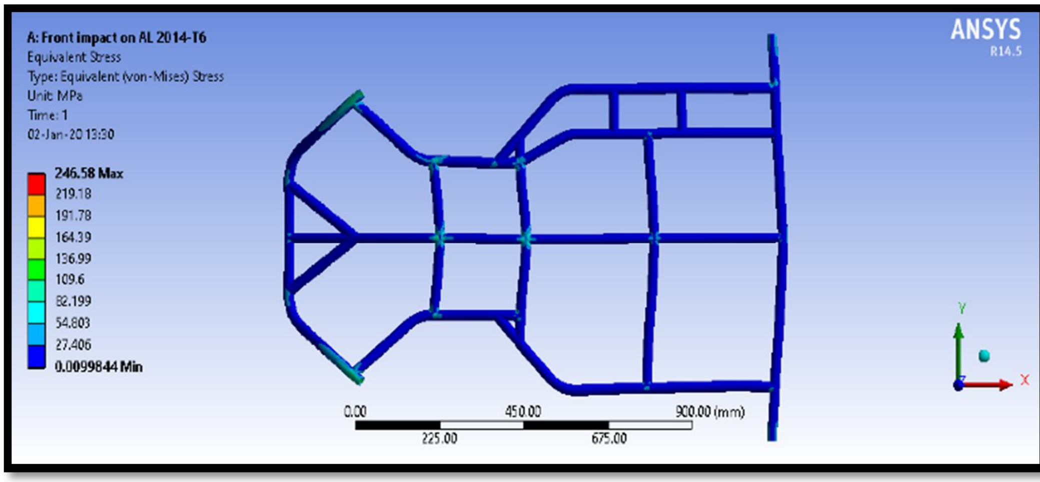

Fig. 18 Equivalent Stress

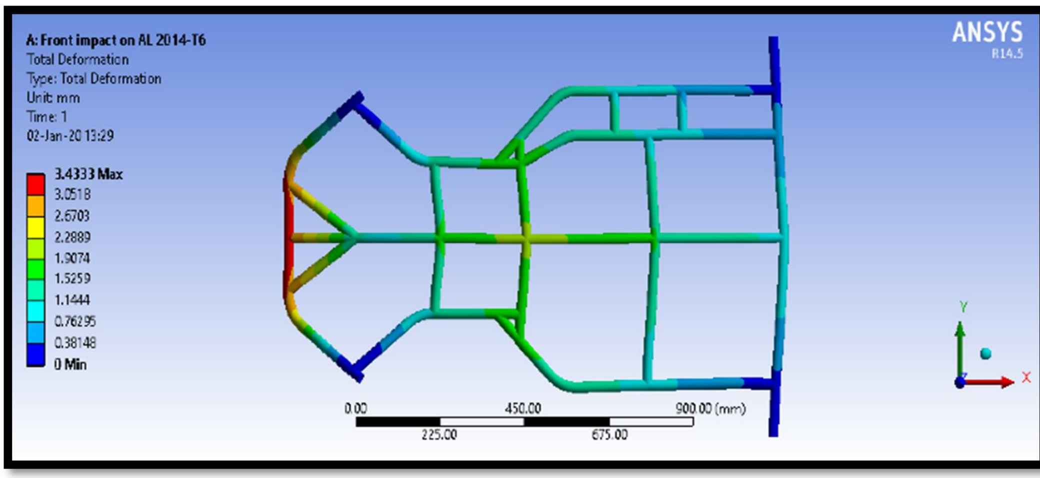

Fig. 19 Total Deformation

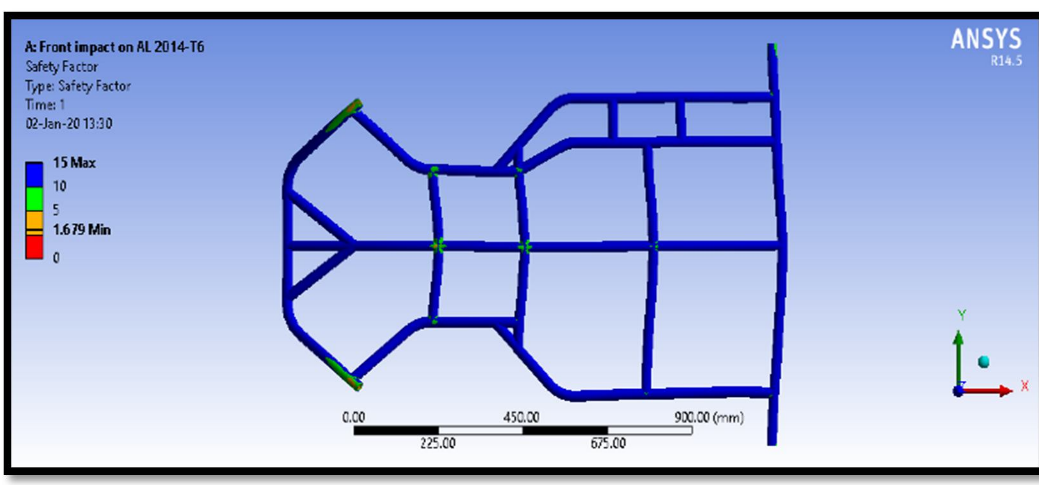

Fig. 20 Factor of Safety

Table III.III Front Impact Results

Equivalent Stress	246.58 Mpa
Total Deformation	3.43 mm
Factor of Safety	1.67

2) *Side Impact Analysis:* The impact force is applied at the side bumper, to study the deformation efforts. The go-kart change in speed is taken as 34 kph.

F= (160) *(12.1)

F= 1954.321 N

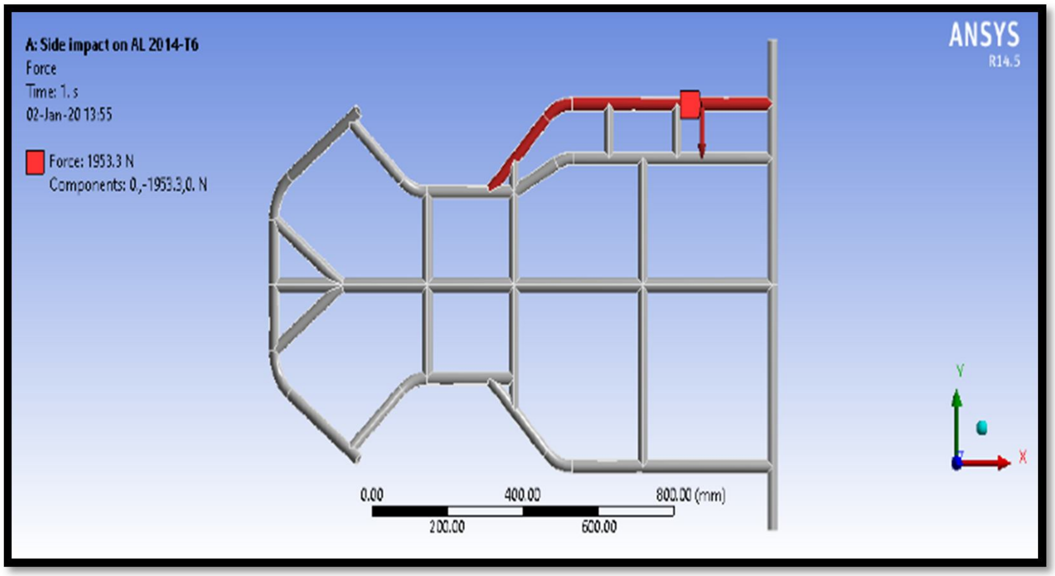

Fig. 21 Representation of Force Applied

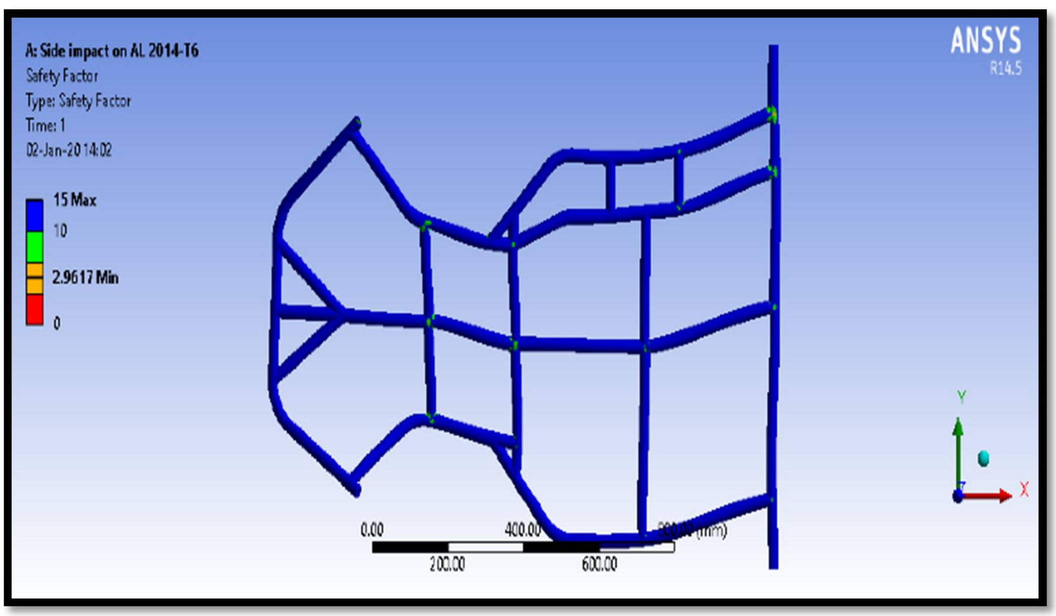

Fig. 22 Equivalent Stress

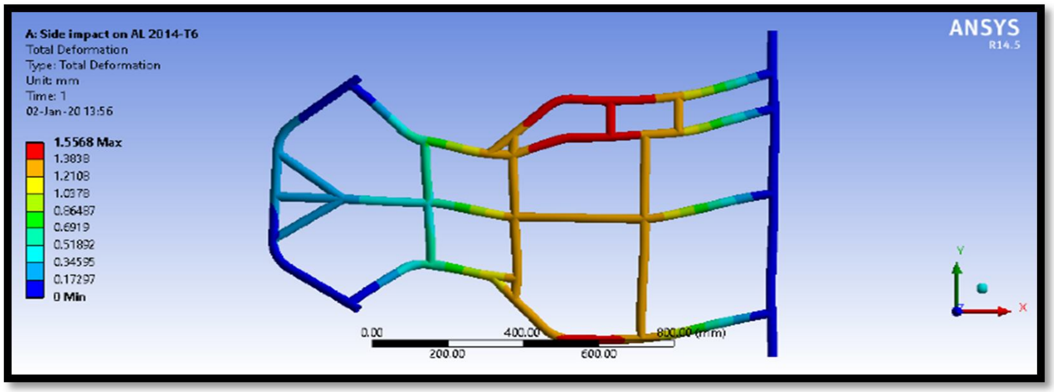

Fig. 23 Total Deformation

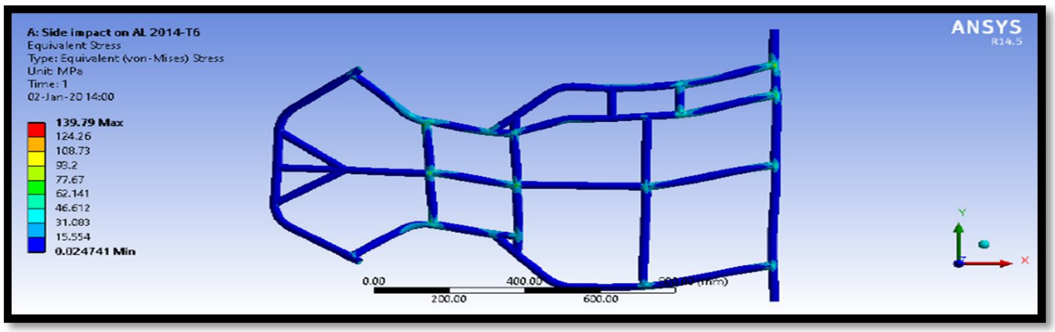

Fig. 24 Factor of Safety

Table III.IV Side Impact Results

Equivalent Stress	139.79 Mpa
Total Deformation	1.55 mm
Factor of Safety	2.96

3) *Rear Impact Analysis:* The impact force is applied at the rear bumper, to study the deformation efforts. The go-kart change in speed is taken as 54 kph.

F= (160) *(19.2)

F= 3076.9 N

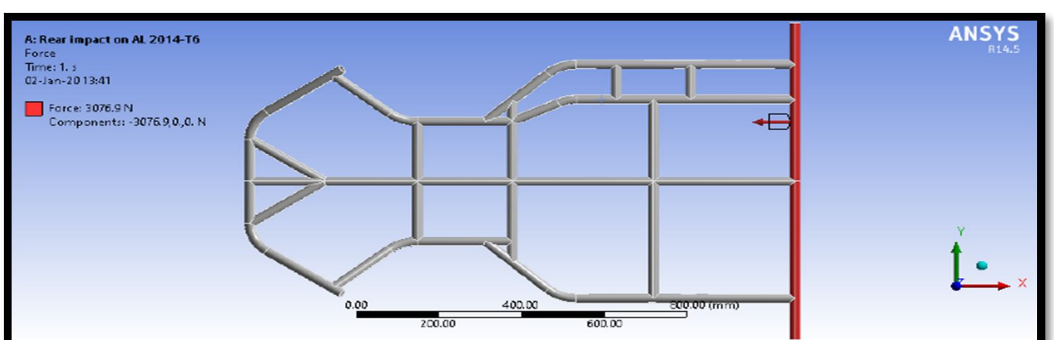

Fig. 25 Representation of Force Applied

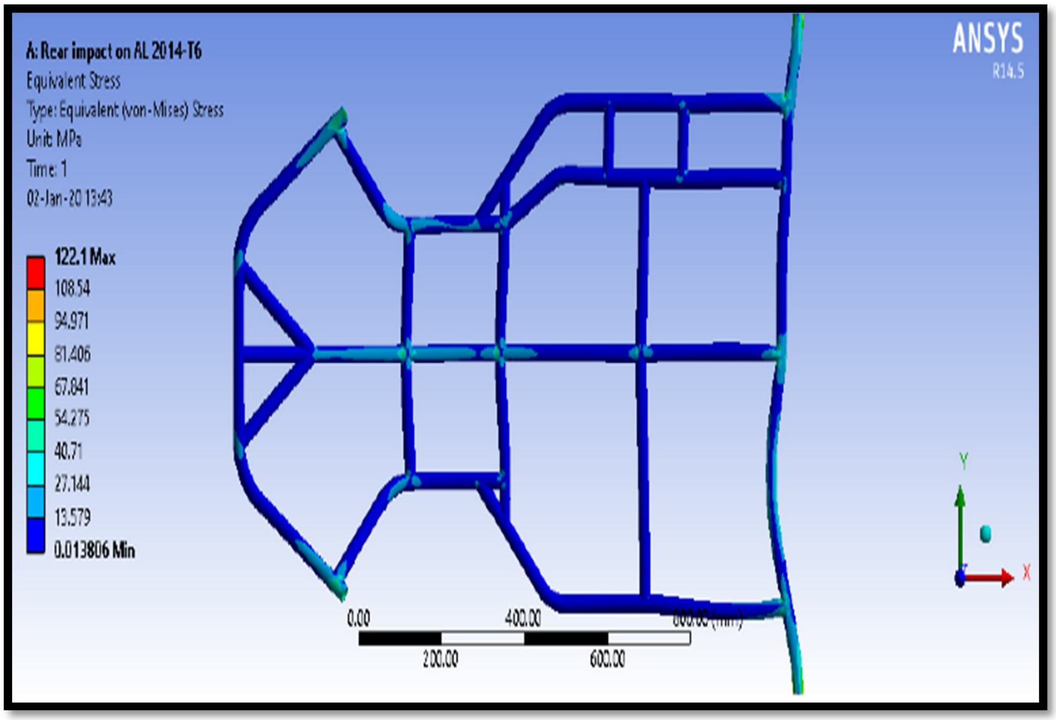

Fig. 26 Equivalent Stress

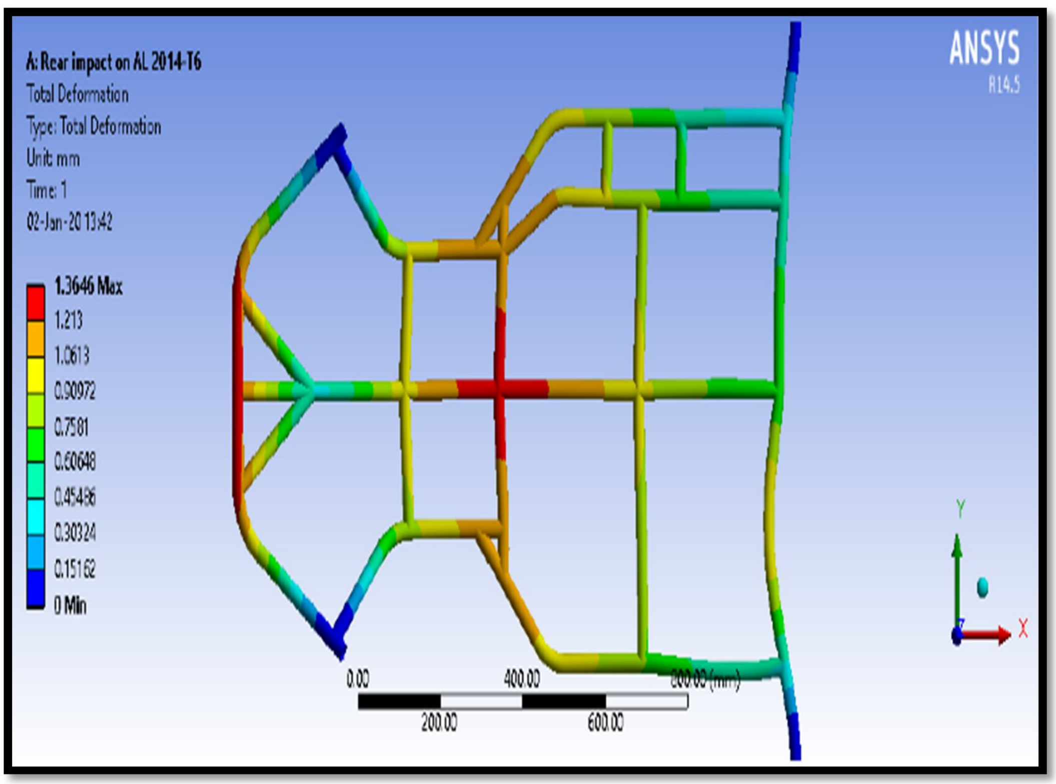

Fig. 27 Total Deformation

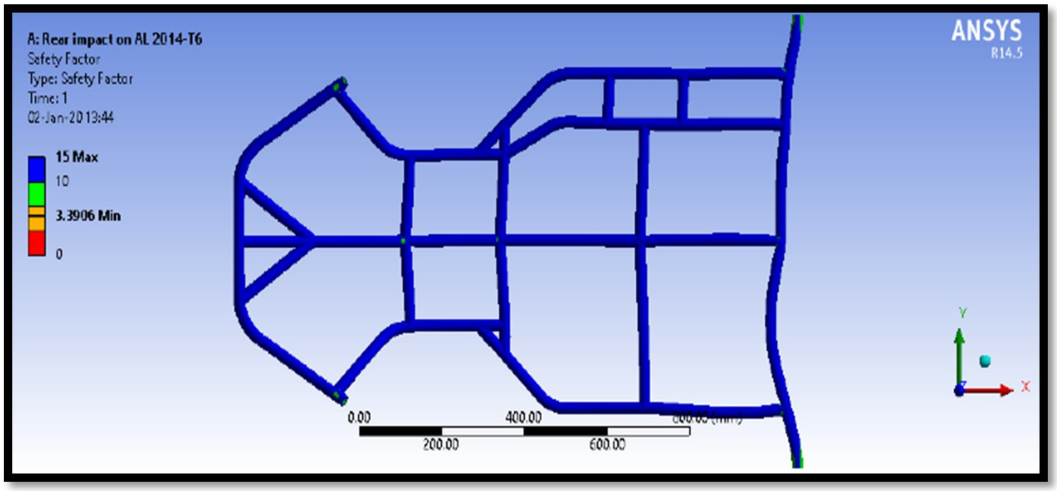

Fig. 28 Factor of Safety

Table III.V Rear Impact Results

Equivalent Stress	122.1 Mpa
Total Deformation	1.364 mm
Factor of Safety	3.39

IV. CONCLUSION

Model of chassis is structured in 3D CAD Modeling software which gives extraordinary adaptability to the creator and it is very easy to import for analysis in ANSYS or some other simulation software. In this study, it is clearly seen that the natural frequencies of AISI 4130 and AL-2014-T6 are higher in comparison with different materials and it helps to maintain a strategic distance away from resonance.

AL-2014-T6 was selected on account of less density and high yield strength when compared to AISI 4130 along these lines, to design a go-kart, it is basic to think about the body to weight proportion. Optimize the power of acceleration upgrade the performance and to get better outcomes. As we can see in this static structural analysis the factor of safety and deformation are worthy which brings about a decent withstanding limit to the go-kart.

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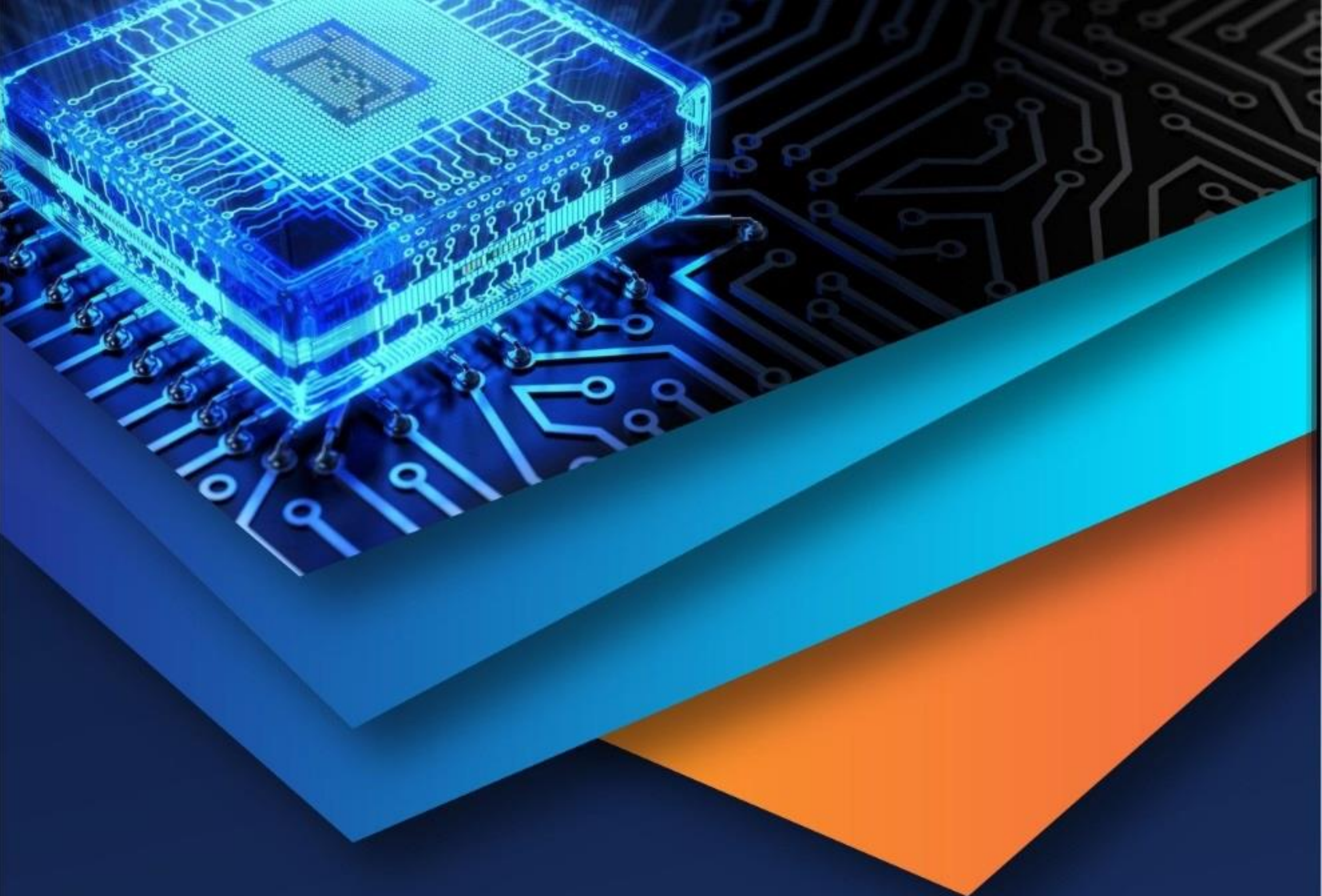

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