iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 Issue: VII Month of publication: July 2021

DOI: https://doi.org/10.22214/ijraset.2021.36272

Design and Analysis of Eco Car Chassis with Different Profiles

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Abstract: Formula Student Racing competitions are held at various Formula SAE circuits globally. Chassis serves as an important component in the race car design. Thus a solicitous analysis is expected out of the formula car. It is also noted that the weight of the car is inversely proportional to the performance of the car hence need for optimization. A high speed protection system plays a major role in the race car design such as front impact, rear impact, side impact and roll over analysis. Also, there exists a problem of the torsional rigidity as far the dynamics is considered. This paper aims at the design aspects and the analysis insights of the race car. The car is modelled according to the 95th percentile male that can fit inside the cockpit of the chassis. As the car travel at the high speed, the protection has been designed to the car in such a way that stresses are minimum and the performance is maximum. Finite element methods are used for the analysis and the design of experiments is created for the optimization of the chassis. To avoid any possibilities of failure of the structure and thus to provide enough supporting member to make the region stronger in term of deformation . Finite element analysis enables to predict the region that tends to fail due to loading, the distribution of stress and strain on the chassis, both component as well as the material costing. The main objective is to study the effect of the validations of the FEM result are given using the different profiles like RECTANGLE, CIRCULAR, AND I SHAPE convergence methods for car body and the equipment.
Keywords:-Chassis design; cross sections; Static analysis; Model analysis

I. INTRODUCTION

In the automobile industry there are three types of chassis available are ladder frame, monocoque, and space frame. In race cars space frame is used because it makes the chassis more rigid & strong; Forces acting on it are tension & compression rather than bending. Chassis can withstand all vehicle compartment interior include door/quarter panels, floor, roof, dash, door window strip, glass window strip, glass, vents and ducts, engine/transmission, mounts, exhaust hangers, suspension, control cables, body structural resonances, and cavity acoustic resonances, among others. & it has the ability to bear some unwanted loads acting on it. There are so many cross sections are available, each has a different nature; main purpose of cross sections is to increase the strength of the material.

II. LITERATURE SURVEY

Basically chassis is considered as a framework to support the body, engine & other parts which make up the vehicle. Chassis lends the whole vehicle support & rigidity. Chassis usually includes a pair of longitudinally extending channels & multiple transverse cross members that intersect the channels. The transverse members have a reduced cross section in order to allow for a longitudinally extending storage space. The chassis has to contain the various components required for the race car as well as being based around a driver's cockpit. The safety of the chassis is a major aspect in the design, and should be considered through all stages. The purpose of car chassis is to maintain the shape of the vehicle and to support the various loads applied to it. The structure usually accounts for a large proportion of the development and manufacturing cost in new vehicle programme and many different structural concepts are available to the designer. It is essential that the best one is chosen to ensure acceptable structural performance with in other design constraints such as cost, volume and method of production, product application and many more. Assessments of the performance of a vehicle structure are related to its strength and stiffness. A design aim is to achieve sufficient levels of these with as little mass as possible.

III. CHASSIS DESIGN

While designing a chassis, the driver's safety should be of prime importance. Hence, the design should be made such that any kind of impact forces do not reach the driver. Among various kind of chassis, space frame chassis was selected since it is easy to manufacture and is very cost efficient. Also a space frame chassis helps give proper triangulation since it is based on the working principle of truss. This makes the chassis stronger and more rigid on application of loads.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
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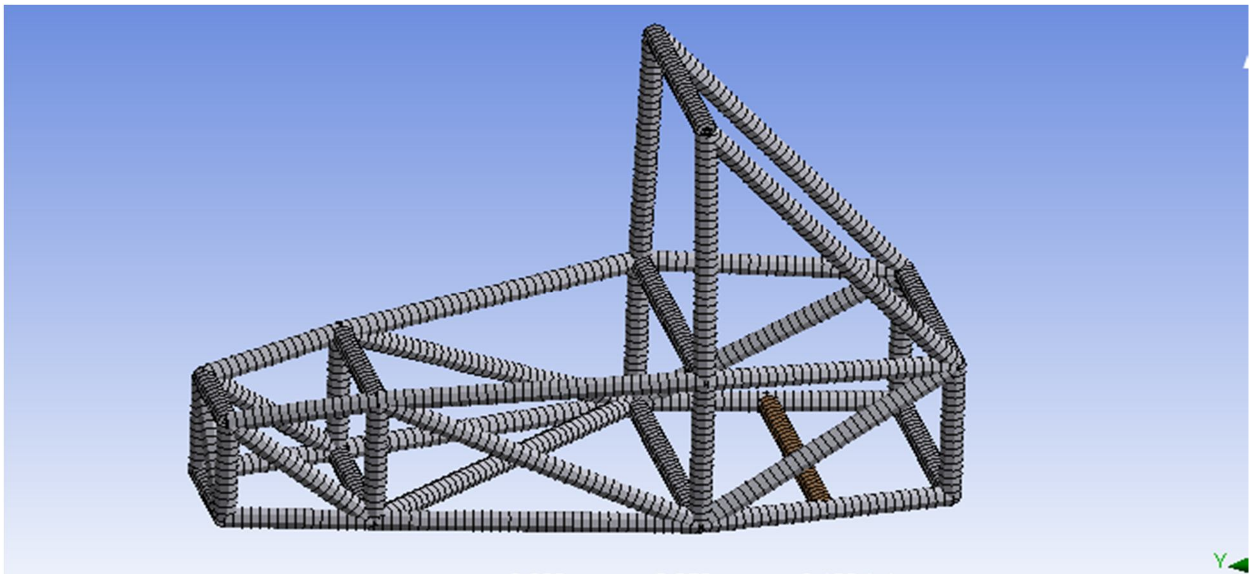
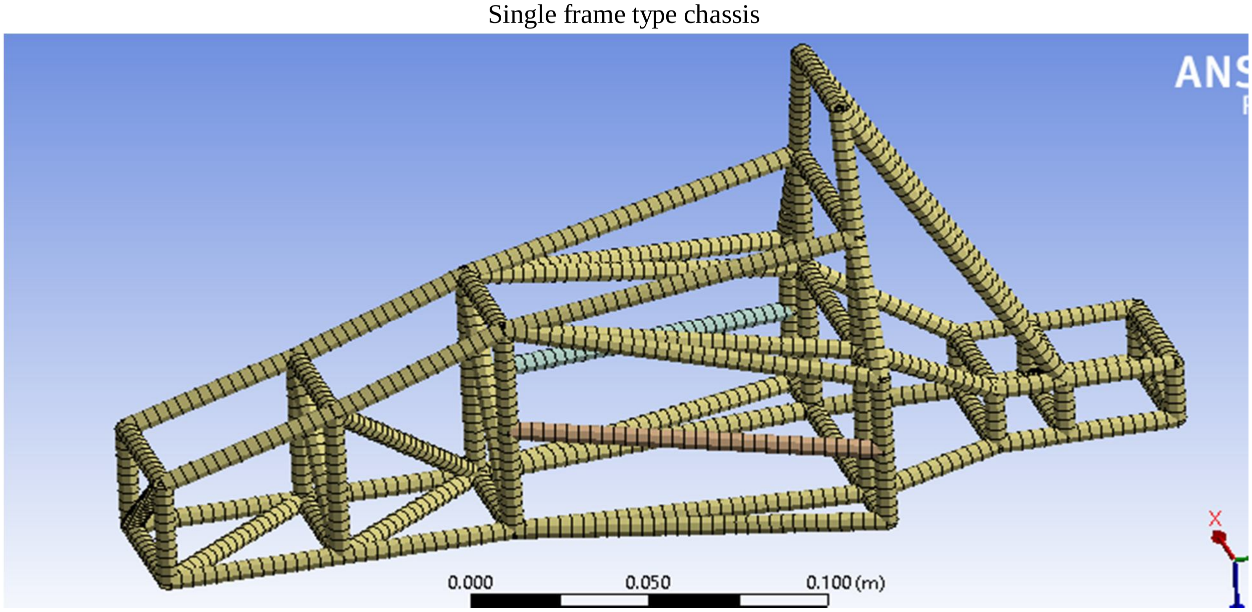
Main Hoop, Front Hoop, Side Impact Protection and Crush Zone are the various segments that constitute the structure of a chassis, the Main Hoop is meant to ensure the safety of the upper part of the driver's body, while the Front Hoop is tasked with the protection of the driver's arm in the event of rollover. The Side Impact Protection section, as the name suggests is meant to protect the driver in the event of a lateral collision with another car. Being frontally placed the crush zone is designed to absorb a significant proportion of energy during a head-on collision Reducing the Weight of the Chassis to a minimum was considered as a secondary objective during the designing process, while Safety of the driver was the primary objective. SPACE CLAIM was the Software used to construct the CAD design of the two types of Chassis. One is single frame chassis & another one is double frame chassis, along these we are adding three types of cross sections as I-section, RECTANGULAR-section, and CIRCULAR- section in the design stage.



Single frame type chassis



Double frame type chassis

IV. MATERIAL SELECTION

Given the forces a chassis experiences during locomotion, its material property needless to say is a key criterion that influences its design. A material with greater stiffness and higher resistance to yielding coupled with low temperature sensitivity ideally makes the cut to be a proper material of choice for a chassis. Two of the materials primarily used in manufacturing the space frame of a chassis are Structural steel4340 and Titanium alloy.

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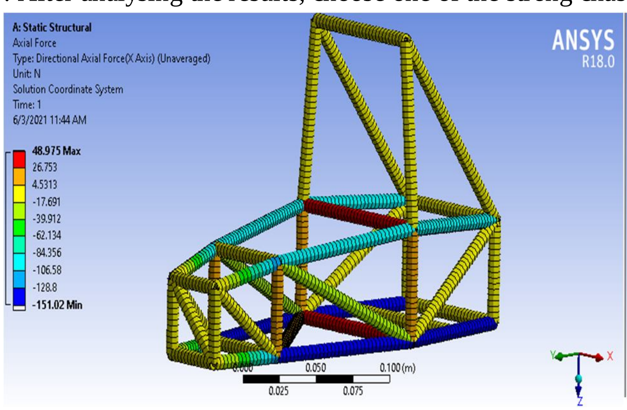
V. FINITE ELEMENT ANALYSIS

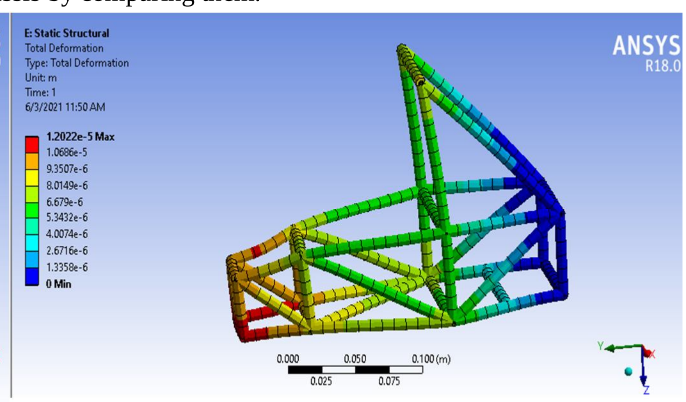
The finite element method (FEM) is the most widely used method for solving problems of engineering and mathematical models. Typical problem areas of interest include the traditional fields of structural analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential. The FEM is a particular numerical method for solving partial differential equations in two or three space variables (i.e., some boundary value problems). To solve a problem, the FEM subdivides a large system into smaller, simpler parts that are called finite elements. This is achieved by a particular space discretisation in the space dimensions, which is implemented by the construction of a mesh of the object: the numerical domain for the solution, which has a finite number of points. The finite element method formulation of a boundary value problem finally results in a system of algebraic equations. The method approximates the unknown function over the domain. The simple equations that model these finite elements are then assembled into a larger system of equations that models the entire problem. The FEM then uses variational methods from the calculus of variations to approximate a solution by minimizing an associated error function. Studying or analyzing a phenomenon with FEM is often referred to as finite element analysis (FEA).

A. Static Structural

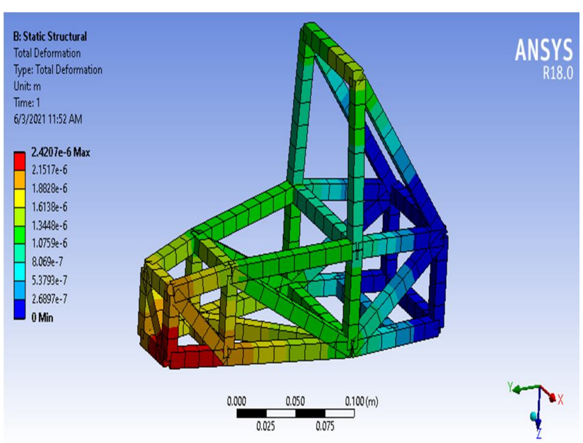
For obtaining a convincing and optimised all the chassis designs, static structural analysis was performed. Various impact forces such as front impact forces, minimum combined stress, & maximum combined stress were calculated and the analysis was done in ANSYS software. At first, we apply load of 500N on the front side of the chassis in static analysis for finding the results shown below. After analysing the results, choose one of the strong chassis by comparing them.



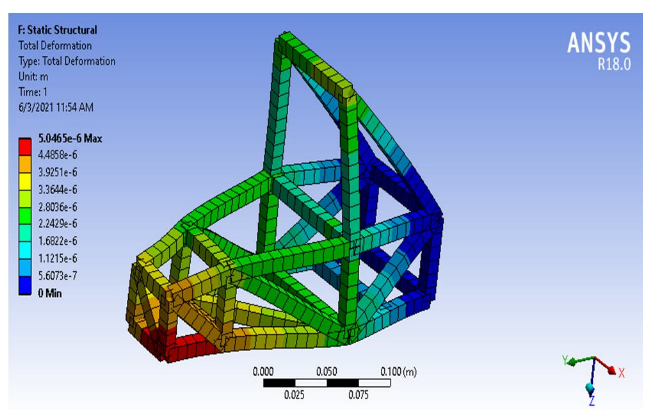
A) Single frame chassis-Circular cross section-Steel material



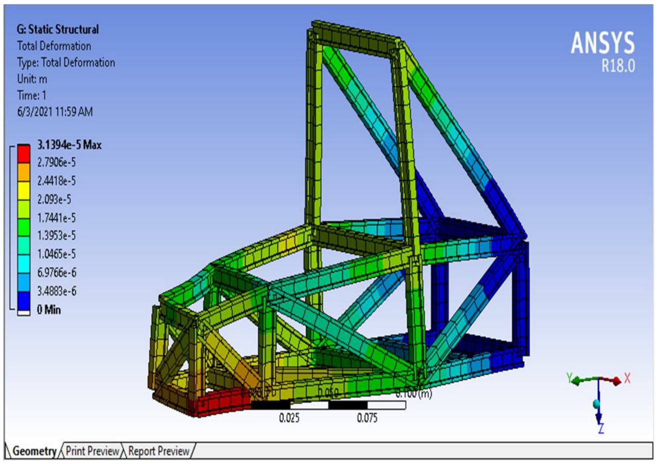
B) Single frame chassis-Circular cross section-Titanium



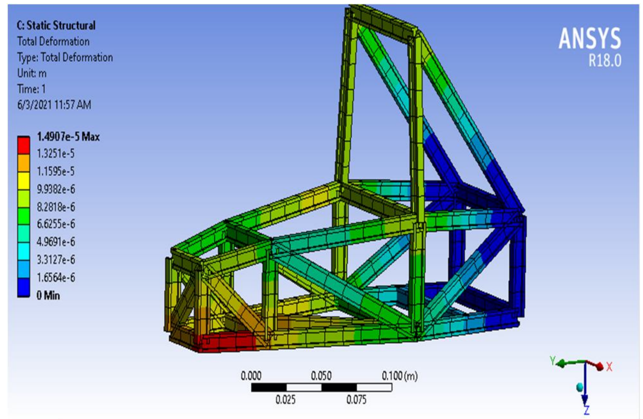
A) Single frame chassis-Rectangular cross section-Steel material



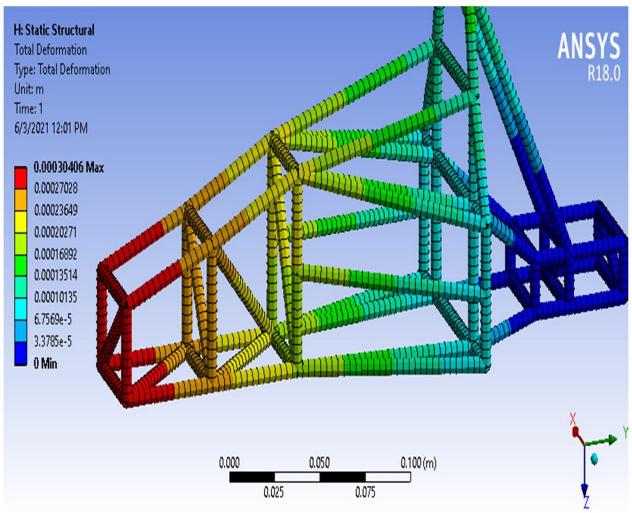
B) Single frame chassis-Rectangular cross section-Ti



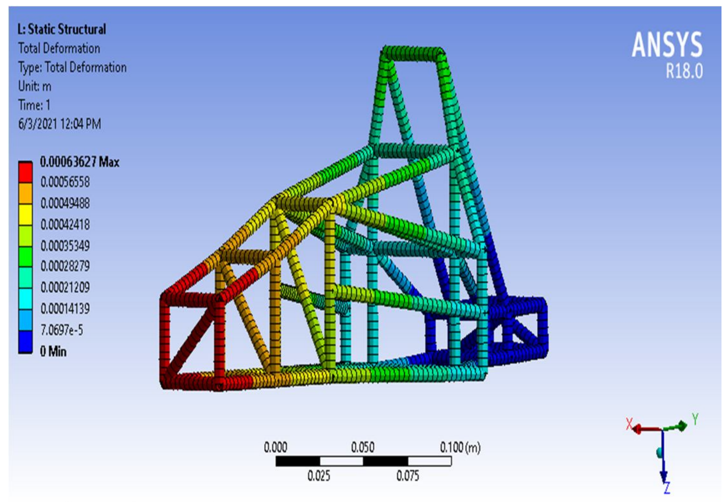
A) Single frame chassis-I cross section-Steel material



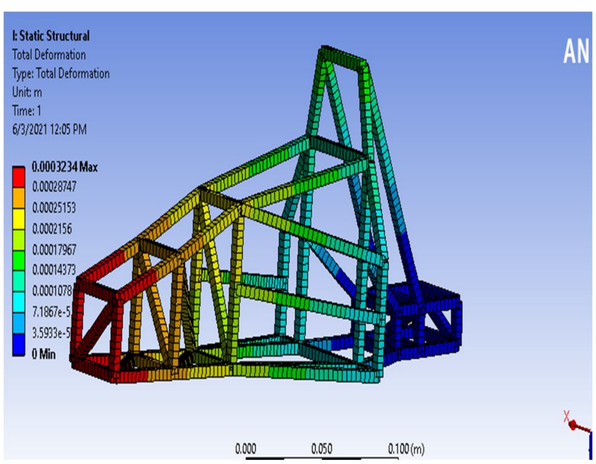
B) Single frame chassis-I cross section-Titanium material



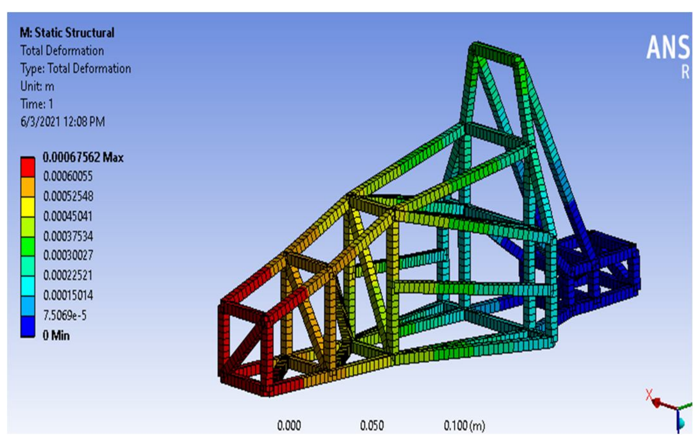
A) Double frame chassis-Circular cross section-Steel material



B) Double frame chassis-Circular cross section-Titanium



A) Double frame chassis-Rectangular cross section-Steel material



B) Double frame chassis-Rectangular cross section-Ti

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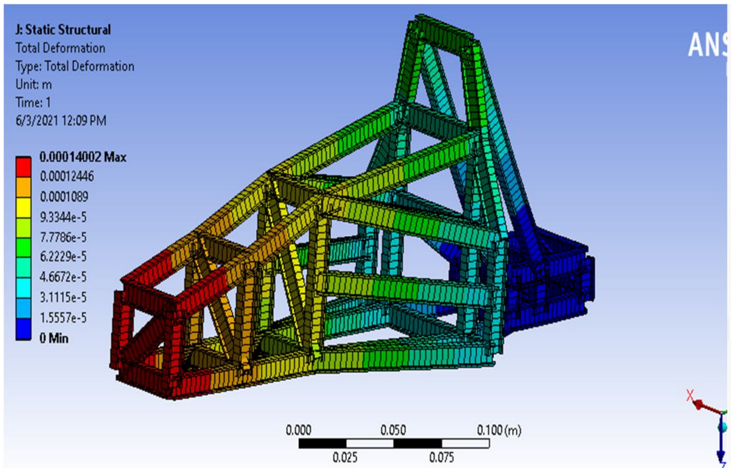
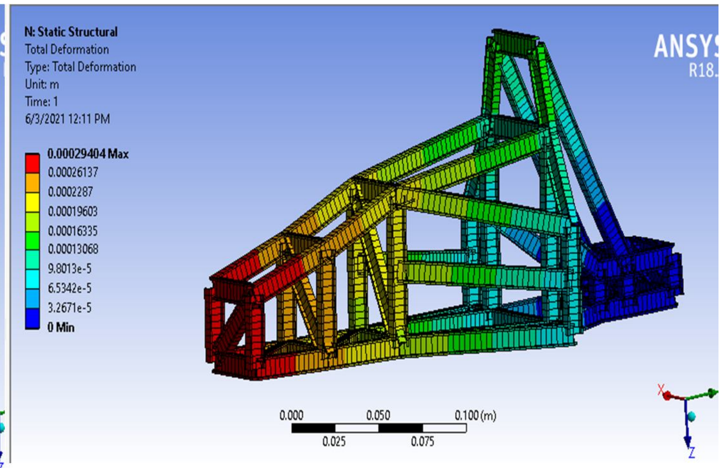


A) Double frame chassis-I cross section-Steel material



B) Double frame chassis-I cross section-Titanium material

1) Result Analysis

SINGLE FRAME CHASSIS
CIRCULAR CROSS SECTION

MATERIAL	TOTAL DEF.	MIN. STRESS	MAX. STRESS
STRUCTURAL STEEL	5.7E-6	1.2E6	1.6E6
TITANIUM ALLOY	1.2E-5	1.2E6	1.5E6

RECTANGULAR CROSS SECTION

MATERIAL	TOTAL DEF.	MIN. STRESS	MAX. STRESS
STRUCTURAL STEEL	2.4E-6	5E5	7.5E5
TITANIUM ALLOY	5E-6	5E5	7.8E5

I – CROSS SECTION

MATERIAL	TOTAL DEF.	MIN. STRESS	MAX. STRESS
STRUCTURAL STEEL	1.5E-5	1.3E6	3.7E6
TITANIUM ALLOY	3.1E-5	1.3E6	3.5E6

DOUBLE FRAME CHASSIS
CIRCULAR CROSS SECTION

MATERIAL	TOTAL DEF.	MIN. STRESS	MAX. STRESS
STRUCTURAL STEEL	0.0003	1.8E6	4.1E7
TITANIUM ALLOY	0.0006	1.8E6	4.1E7

RECTANGULAR CROSS SECTION

MATERIAL	TOTAL DEF.	MIN. STRESS	MAX. STRESS
STRUCTURAL STEEL	0.0003	1.5E6	4E7
TITANIUM ALLOY	0.00067	1.5E6	4E7

I-CROSS SECTION

MATERIAL	TOTAL DEF.	MIN. STRESS	MAX. STRESS
STRUCTURAL STEEL	0.0002	2E6	1.8E7
TITANIUM ALLOY	0.0001	2E6	1.88E7

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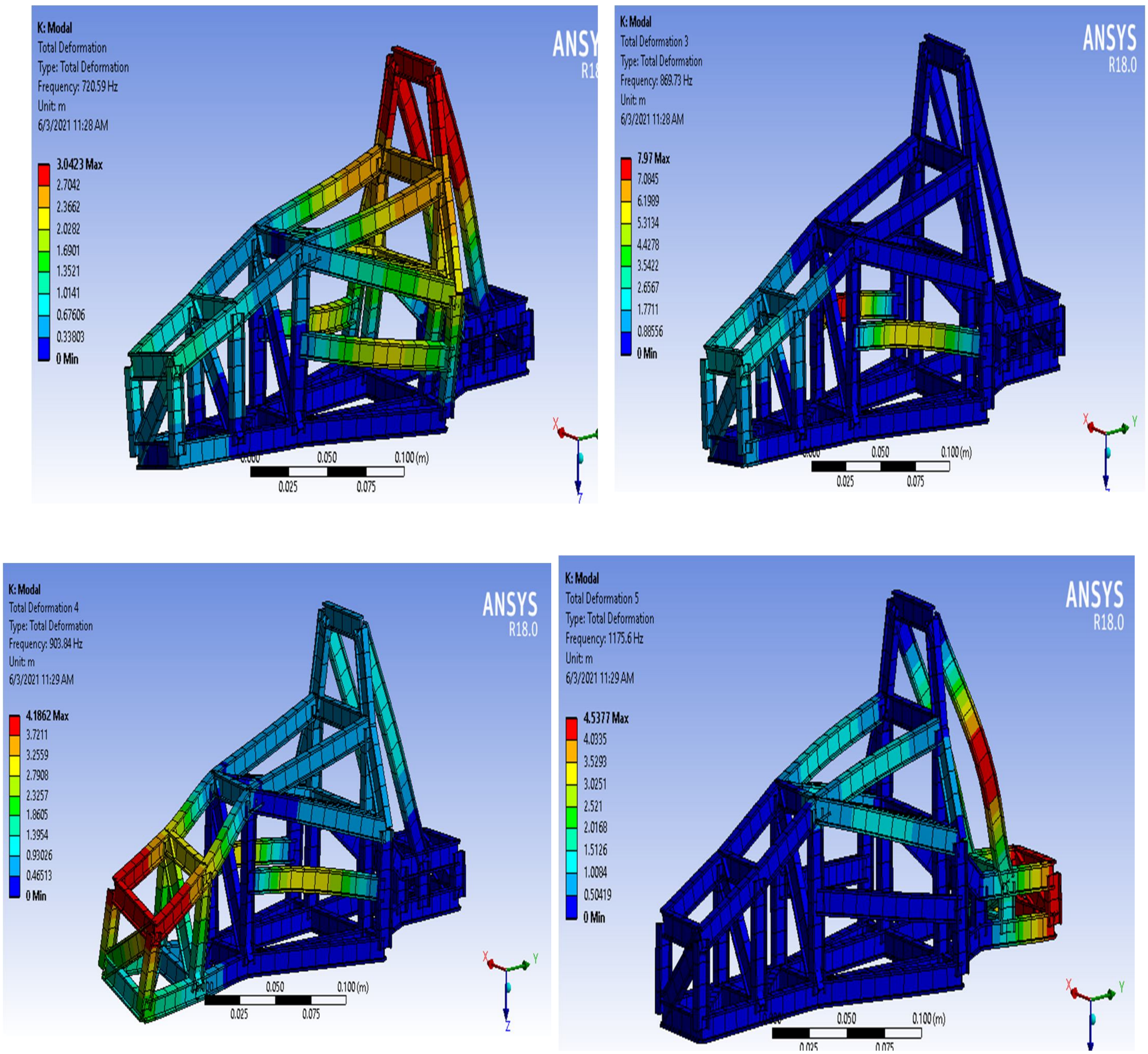
B. Modal Analysis

By taking the results from the static analysis, by observing them double frame-I cross section-titanium material gives good results; we are applying model analysis on that chassis. Modal analysis is a process of extracting modal parameters (natural frequencies, damping loss_factors and modal constants) from measured vibration data. Since the measured data can be in the form of either frequency response functions or of impulse responses, there are frequency domain modal analysis and time domain modal analysis. The fundamental of modal analysis using measured frequency response function data is about curving fitting the data using a predefined mathematical model of the measured structure. This model assumes the number of DoFs of the structure, its damping type and possibly the number of vibration modes within the measured frequency range. These assumptions should dictate the mathematical expression of each FRF curve from measurement. As a result, the subsequent work will be a curve-fitting process trying to derive all modal parameters in a mathematical formula of an FRF using measurement data.



Model analysis for double frame-I cross section-Titanium material

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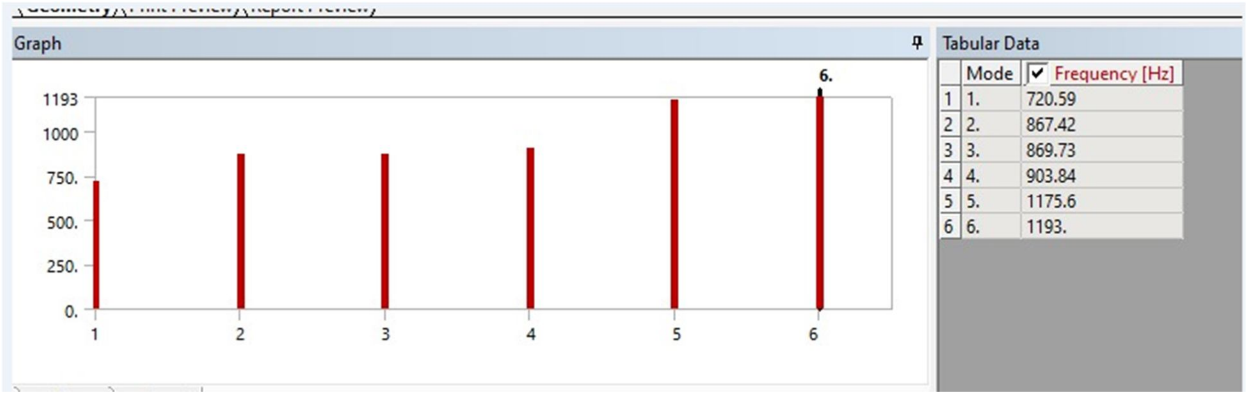
1) Result Analysis



From the results obtained in the model analysis are 720.59Hz, 867.42Hz, 869.73Hz, 903.84Hz, 1175.6Hz, 1193Hz. Before 720.59Hz there is no deflection in the chassis, after that the chassis may deform the following ranges. The maximum acceptable frequency is 1193Hz.

VI. CONCLUSION

The results state that, by comparing all the designs, single framed circular-cross section steel material is high deflection, then it is not recommended for making chassis & double framed I-cross section titanium material is best for making chassis. It can support all the loading conditions and therefore comply with the rules and regulations. At static analysis, max stress reached at 18.8Mpa & deflection at 0.2940mm, and the maximum of 1193Hz & minimum of 720.59 is obtained as the natural frequency of the chassis from Modal analysis, before 720.59Hz there is no change in the chassis. From above statements, the design is considered to be safe.

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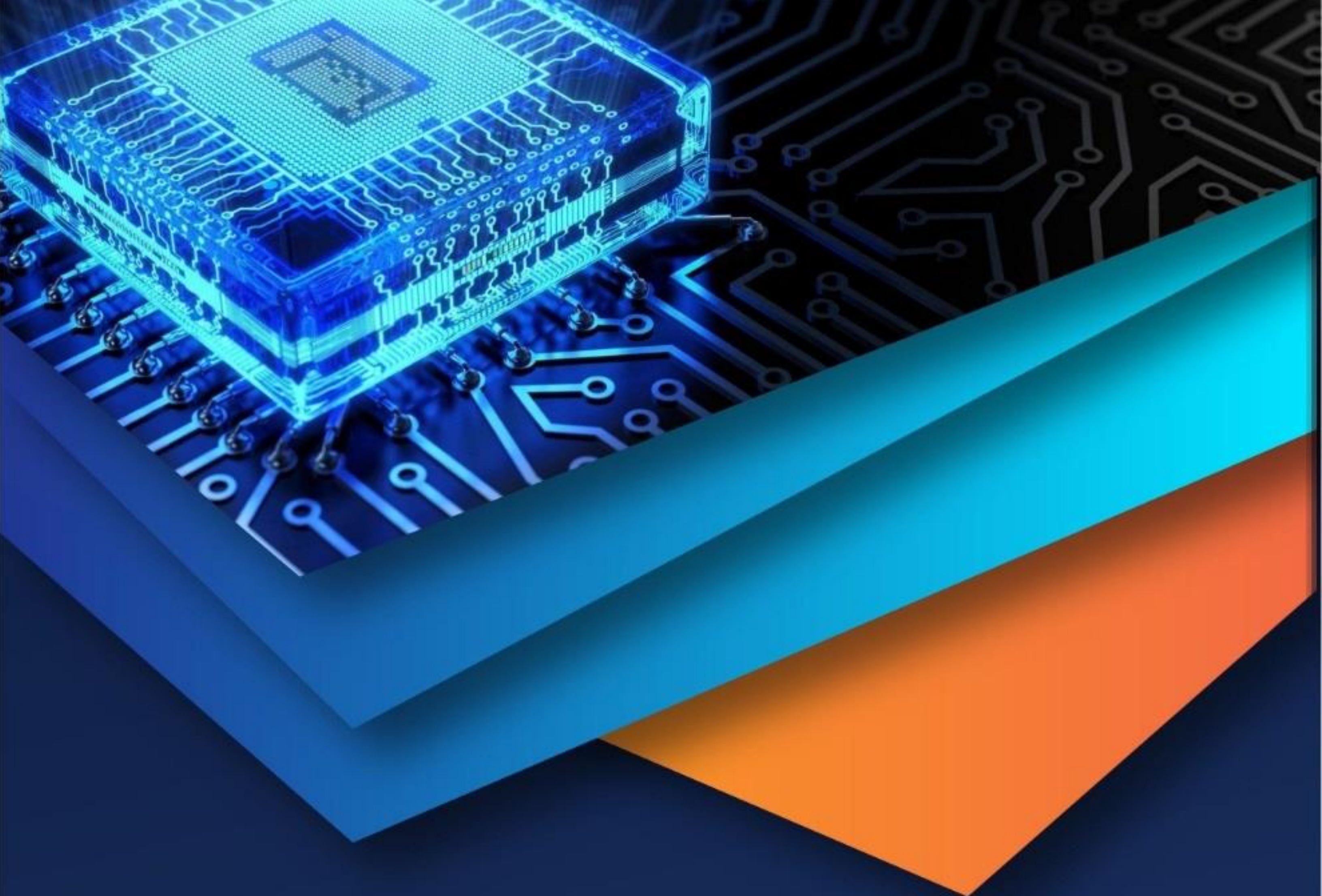

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