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Design Static and Dynamic Analysis and Weight Optimization of Car Chassis by Using Fea Method

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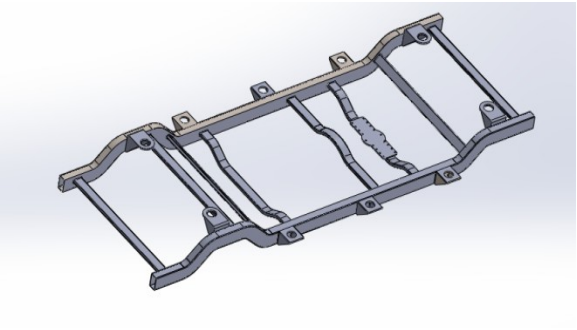
ABSTRACT

A chassis consists of an internal vehicle frame that supports a manmade object in its construction and use. An example of a chassis is the under part of a motor vehicle, consisting of the frame on which the body is mounted. If the running gear such as wheels and transmission, and sometimes even the driver's seat, are included, then the assembly is described as a rolling chassis.

Car chassis is a major component in a vehicle. In car chassis different type of failures are occur due to static loading condition. In this present work static load characteristics are analyzed using FE models from this work. It is found that identifying location of high stress area, displacement and strain. Modal updating of car chassis model will be done by adjusting the selective properties such as different materials. Thus modeling of a car chassis is done in solid works 2016 software and analysis is carried out in anasys workbench 14.5 software.



INTRODUCTION

Fundamentally chassis is mulled over as a structure to help the body, engine and diverse parts which make up the auto. Chassis lends the entire vehicle help and weight. Suspension by and large comprises of two or three longitudinally broadening channels and a few transverse move benefactors that converge the channels. The transverse patrons have a marked down cross stage which will take into consideration a longitudinally broadening garage space.The chassis needs to incorporate the different added substances required for the race car notwithstanding being essentially based around a driving force's cockpit. The security of the frame is a main factor in the design, and must be thought about by means of all stages. For the most part, the crucial case sorts comprise of spine, step, space outline and monolog. Particular styles of frame design result the particular general execution.

Wording the prescribe of car chassis is to keep up the state of the car and to help the assorted burdens connected to it. The structure typically represents a huge offer of the change and generation charge in new vehicle modified and numerous particular basic measures are accessible to the designer. It's miles fundamental that the top notch one is made sure suited auxiliary general execution inside various format limitations which incorporates expense, amount and approach of creation, item programming and

loads of something beyond.Trial of the execution of a vehicle shape are related with its strength and stiffness. An outline objective is to harvest adequate degrees of those with as meager mass as feasible.

Energy the energy necessity infers that no a piece of the shape will lose its component when it's miles subjected to road masses. Loss of capacity can come about because of momentary over-burdens because of exorbitant load occasions, or through fabric fatigue. Moment disappointment might come about because of both overemphasizing of segments past the flexible confinement, or by methods for locking of things in pressure or shear weight, or with the guide of disappointment of the joints. The life to start of fatigue cracks is colossally subject to outline component, and may easiest be evaluated when a point by point data of the issue is accessible. Thus assessment of weariness energy is regularly conceded until after the applied design level.The power might be rather depicted as the most power which the shape can stand up to. Outstanding load occasions restrictive neighborhood part masses, yet the structure need to have adequate power for all load cases firmness the solidness of the structure relates the avoidance delivered while stack is connected. It applies best to structures inside the flexible assortment and is the incline of the weight versus redirection diagram. The solidness of a vehicle shape has significant effect on its overseeing and vibrational conduct. It is pivotal to ensure that diversion due to serious hundreds isn't so huge to hinder the normal for the vehicle, for an occasion all together that the entryways won't close, or suspension geometry is changed. Low stiffness are prompt inadmissible vibrations, alongside 'abandon shake'.

Afresh selective load cases require diverse stiffness definitions, and some of those are frequently utilized as 'benchmarks' of vehicle auxiliary execution. The two most extreme generally utilized on along these lines are (jason, 2002): a) bending stiffness kb, which relates the symmetrical vertical avoidance of a factor close to the focal point of the wheelbase to products of the aggregate static hundreds on the car.A improved model of this to relate the redirection to a solitary, symmetrically executed load near the focal point of the wheelbase. Of the shape to torsion firmness kt, relates the torsion diversion actualized normal torque t roughly the longitudinal hub of the vehicle.The car is subjected to the 'characteristic torsion stack case'. Curve point of view is measured between the front and back suspension mountings. Twist are middle of the road factors along the wheelbase is once in a while moreover measured in order to spotlight districts of the structure wanting stiffening. The two cases apply completely unique neighborhood burdens to man or lady added substances inside the car. It is typically found that the torsion case is the most extreme intense to plan for, all together that the torsion stiffness is frequently utilized as a benchmark to connote the adequacy of the vehicle shape.Vibration conduct the overall vibration qualities of a vehicle are related with the two its stiffness and mass conveyance. The frequencies of the overall bending and tensional vibration modes are ordinarily utilized as benchmarks for car auxiliary execution. Those aren't examined in this book. In any case bending and tensional stiffness kb and kt affect the vibration conduct of the structure, particularly its first natural recurrence.

TYPE OF CHASSIS

Chassis is thought to be one of the critical structures of a vehicle. It's generally made of a steel outline, which holds the body and engine of a car vehicle. To be exact, car chassis or vehicle body is a skeletal edge which bolts different mechanical parts like engine, tires, brakes, steering and hub gatherings. Case normally made of light a metal or composite plastic which gives quality expected to

supporting vehicle segments and load into it. Here I recorded a few unique kinds of car chassis which incorporate step chassis, spine suspension, monolog body and tubular space outline frame

Ladder chassis is thought to be one of the most established types of car body or car case that is still been utilized by the majority of the suvs till today. It is additionally takes after a state of a ladder which having two longitudinal rails bury connected by a few horizontal and cross supports. The sidelong and cross individuals give unbending nature to the structure.

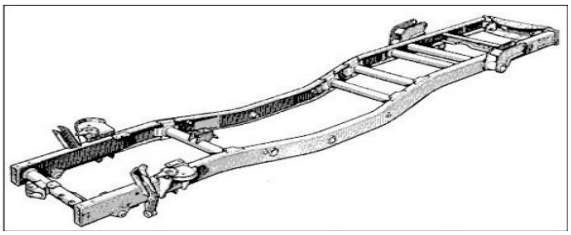


Fig1: ladder chassis

The elective kind of case is tubular body which has a rectangular tube like spine and simple in structure. It ordinarily made up of glass fiber this is utilized for joining the front and back pivot together and liable for most extreme of the mechanical vitality of the system. The space inside the shape is utilized for situating the power shaft on the off chance that a back wheel drive. Moreover, the power teach, engine and suspensions are altogether identified with each of the closures of the chassis. This sort of frame is sufficiently solid to offer help littler games vehicle other than it is easy to make and cost viable.

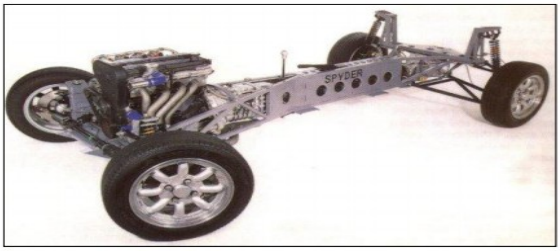


Fig2: Monologue Chassis

With respect to monolog chassis, most bleeding edge cars nowadays utilize this kind of suspension. A monolog case is an unmarried bit of structure that offers shape to the car. A one-piece chassis is built by method for welding various bits all things considered. It's far unique from the stepping stool and determination frame dislike them consolidated with the body in an unmarried piece, wherein as the previous least difficult guide the strain individuals. The awful of a monolog skeleton particularly duplicated on account that it's miles expense powerful and reasonable for robotized generation.

Advantage

Higher load capacity and strength

Disadvantage

The body tends to vibrate easily and the overall vehicle handling and refinement is lower.
It is used in truck, bus and in suv cars and bigger vehicles.

Fig3: car chassis

Advantage

Less rattles and squeaks are developed.

Handling is better due to the higher body rigidity and weight.

Disadvantage

The load carrying capacity is lower.

It is not safe in accidental condition

Used mostly in hatchback and sedan cars.

The selection of materials for a vehicle is the first and most vital factor for car design. There is an assortment of materials that can be utilized as a part of the car body and body, however the reason for configuration is the primary

test here. The most vital criteria that a material should meet are lightweight, monetary adequacy, security, recyclability and life cycle contemplations. Some of these criteria are the consequence of enactment and direction and some are the prerequisites of the clients. Be that as it may, some of these criteria might conflicting and hence the optimization comes into business here.

To start with we begin with clarifying every foundation and afterward keep on introducing a few materials and where they can be utilized.

Requirements of the Materials in Automotive Design:

Lightweight

	Steel (kg)	Aluminium (kg)	Magnesium (kg)	%weight Reduction (part)	%weight reduction (vehicle)	% cost increase (part)
Body In white	285	218	N/a	23.5	3.90	250
	14.8	8.3	N/a	44	0.48	300
Bonnet	15.7	9.5	N/a	39	0.40	275
Door	11.4	N/a	6.3	45	0.33	350
Ip beam						

Table1: weight loss versus the price boom by way of changing steel by means of aluminum or magnesium for a number of the elements

The weight reduction versus the value blast by method for changing steel by methods for aluminum or magnesium for some of the components is accounted for in table.

MATERIALS

Steel

Aluminum

Composites

ADVANCED COMPOSITE MATERIALS

Fiber strengthened composites offer a wide variety of advantages to the car industry. It has the ability for saving weight presented by using their low density. Component designs can be such that the fibers lie in the direction of the important stresses, and quantity of fiber used is sufficient to face up to the strain, therefore optimizing materials usage.

Carbon-fiber epoxy composite

Most as of time, the large portion of the racing car organizations considerably more depend on composites shape whether it would be plastic composites, kevlar and in particular carbon-fiber epoxy structure. It is on the grounds that the composite structures are the high quality/low weight proportion. The most widely recognized materials utilized for racing car are carbon (graphite), kevlar and glass filaments. Epoxy composites have been the principal decision in recipe 1 car ventures and other race cars

Aluminum metal composites

Aluminum metal Composites are being used mostly for the sports vehicle which incorporates method 1 vehicles. It is lighter than metallic and aluminum, easy to be formed and rust-proof. And more important aspect is that it's far cheap to be produced in small amount.

DESIGN APPROACH

To acquire a excessive excellent layout the subsequent approach is used: − the design specs that observe from the trouble definition are said − the loads that act on the wheel centers of a components scholar vehicle had been analyzed previously by lamers [15] and are used to evaluate the quantity and excellent of the one-of-a-kind hundreds that act on the chassis − the structural opportunities and obstacles regarding the to be had substances are investigated − the auxiliary building components in regards to a light-weight however firm and powerful and simple to manufacture format are provided − ergonomic and assurance issues are assessed − a ton of these components are then consolidated in the last design that has been discovered iteratively the utilization of considerable fea procedures

Design specification the overall performance is off path the primary issue in designing a race automobile. Inside the formulation student opposition the most important gain

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over the opposition is attainable thru superior handling of the vehicle, or lateral grip. Except the mass of a vehicle there are a number of parameters that have an impact on the vehicle dealing with are discussed underneath. Inside the formula pupil competition overall performance isn't the most effective important design parameter however. The car must be constructed by means of untrained college students with a especially small budget. So the chassis must meet the layout specifications at all time while remaining easy and easy to built. What the group lacks in funding and massive enjoy in composites it makes up for in cheap and plentiful exertions and know-how.

SOLID WORKS

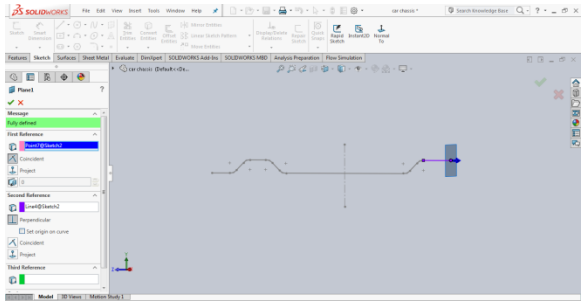
Solid Works is mechanical design automation software that takes advantage of the familiar Microsoft Windows graphical user interface.

It is a simple to-learn instrument which makes it feasible for mechanical designers to rapidly outline thoughts, try different things with features and measurements, and deliver models and point by point drawings.

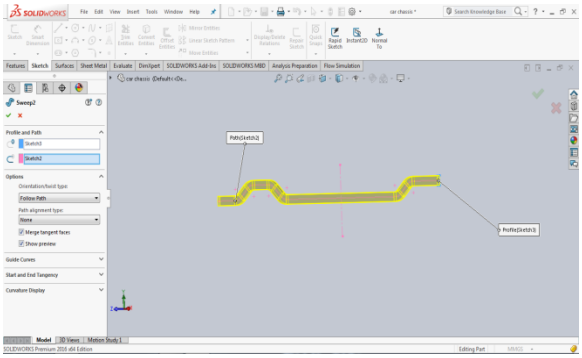
A Solid Works model consists of parts, assemblies, and drawings.

MODELING OF CAR CHASSIS:

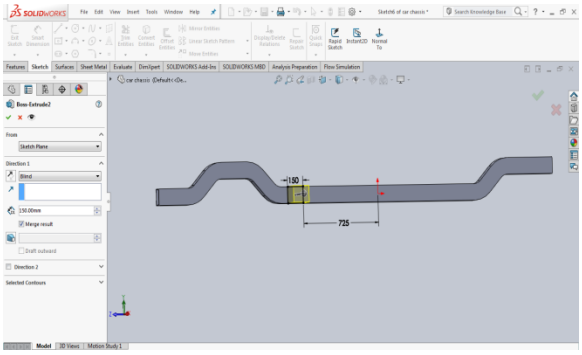
Draw a sketch as follows and create a plane in reference geometry at a point selected as shown in fig



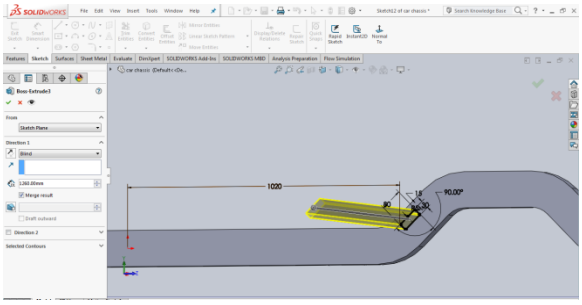
Now make a sweep from features



Draw a sketch as follows and extrude it

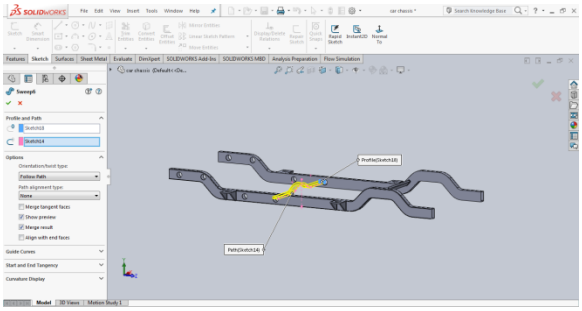


Draw another sketch and make extrude cut as follows



Make same options to get the shape as above on another side

Draw a sketch as follows to sweep



Isometric view of car chassis

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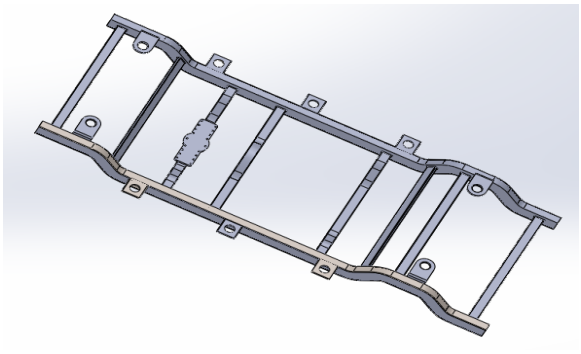
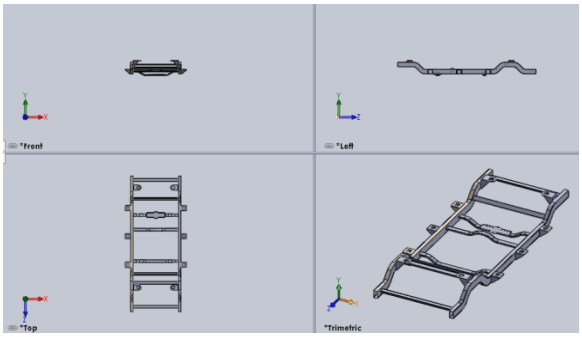




Four different views of car chassis

ANSYS

ANSYS delivers innovative, dramatic simulation technology advances in every major Physics discipline, along with improvements in computing speed and enhancements to enabling technologies such as geometry handling, meshing and post-processing. These advancements alone represent a major step ahead on the path forward in Simulation Driven product development

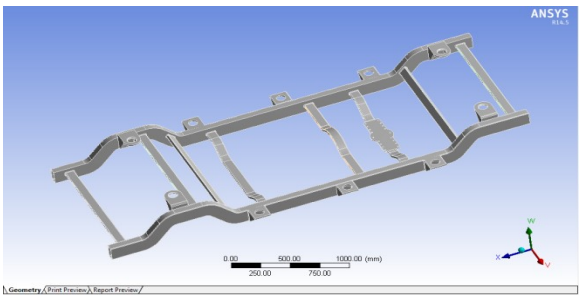
ANALYSIS OF CAR CHASSIS

The car chassis solid works model is converted to iges to import in the ansys software

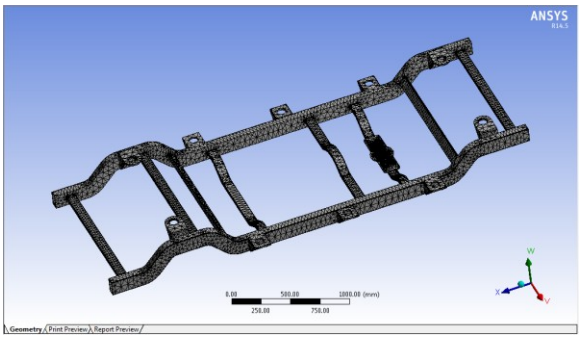
After importing the geometry four different materials are assigned one by one they are

Aluminum alloy, Magnesium alloy, 42CrMo4 (special steel alloy), Titanium alloy, S2 Glass Epoxy

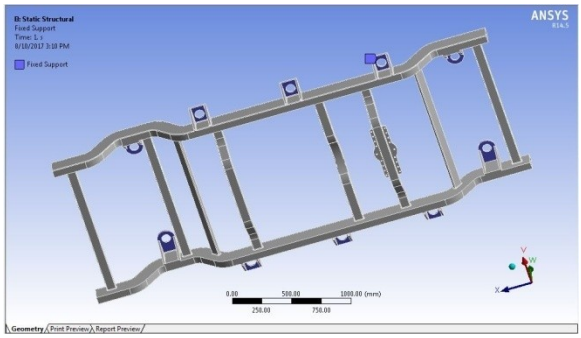
Model



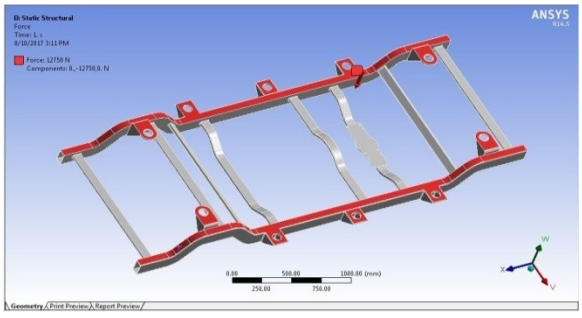
Mesh



Fixed support

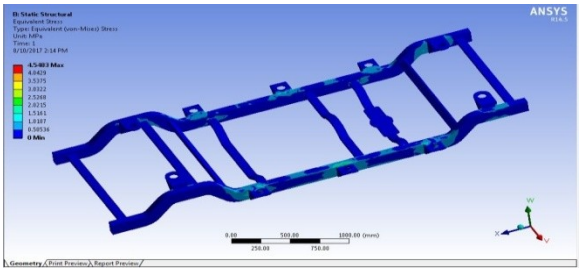


Load: Force= 12750 N

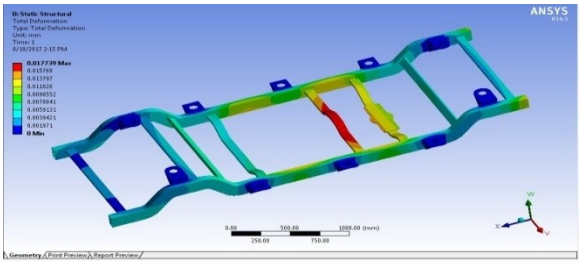


Material: Aluminum alloy

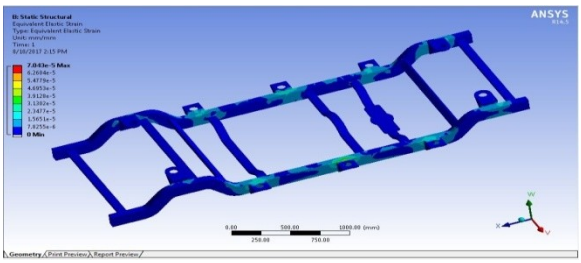
Maximum stress



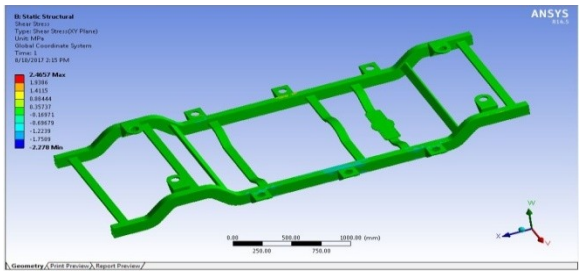
Total deformation



Maximum strain

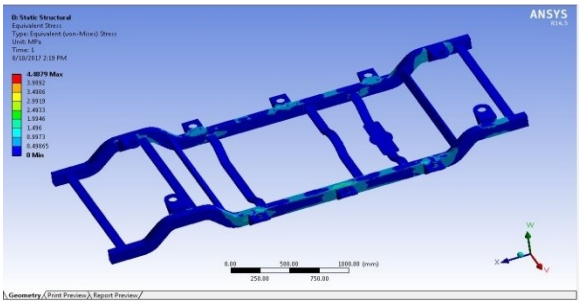


Max Shear Stress

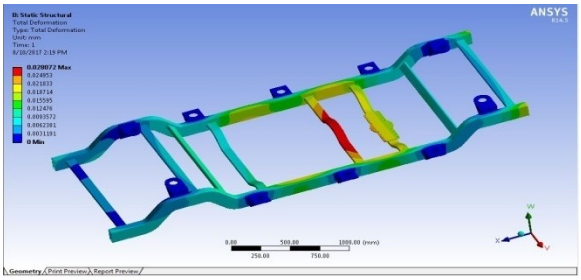


Materials: Magnesium alloy

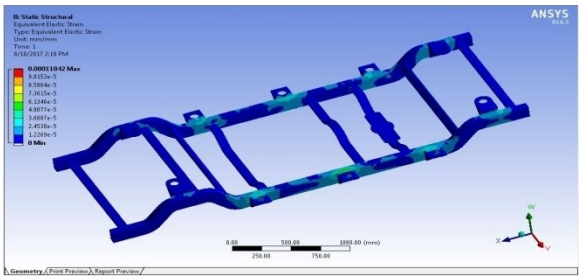
Maximum stress



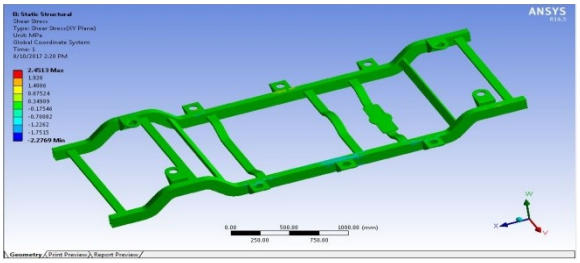
Total deformation



Maximum strain

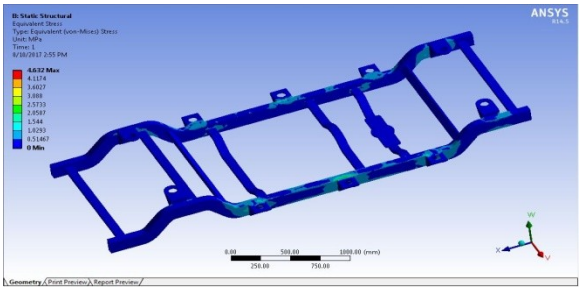


Max Shear Stress

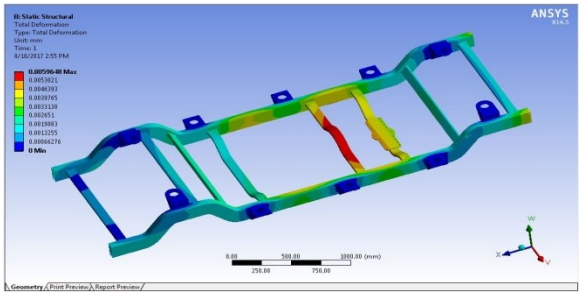


Materials: 42CrMo4 (special steel alloy**)**

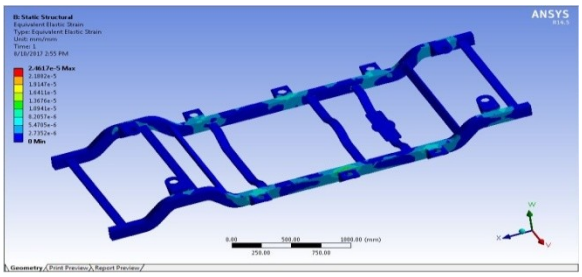
Maximum stress



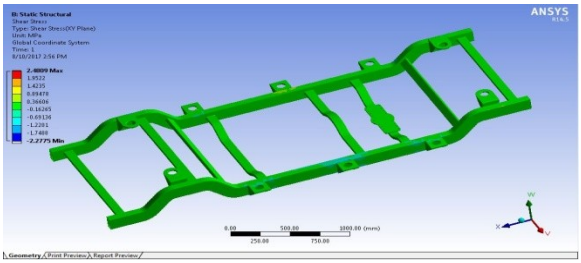
Total deformation



Maximum strain

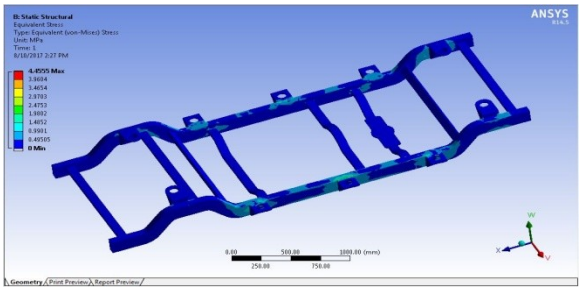


Max Shear Stress

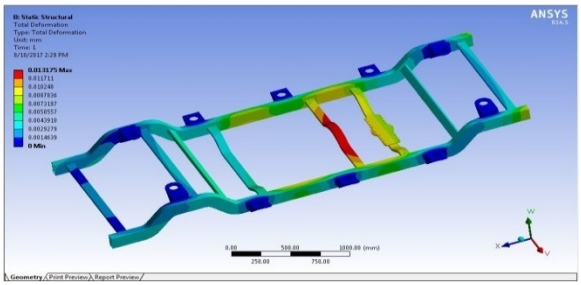


Material: Titanium Alloy

Maximum stress

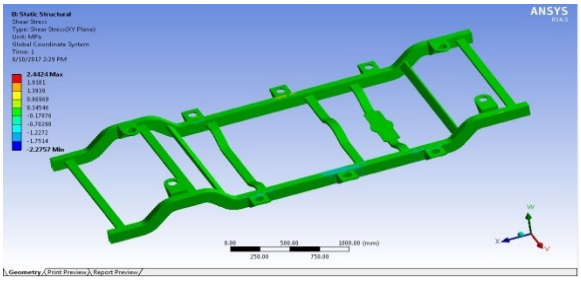


Total deformation



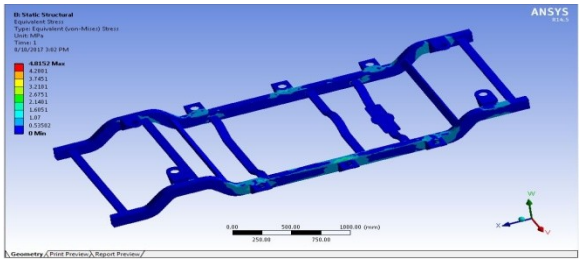
Maximum strain

Max Shear Stress

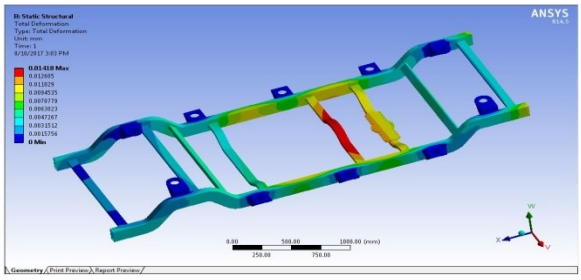


Material: S2 Glass Epoxy

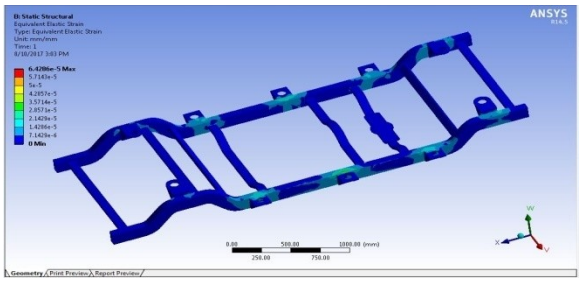
Maximum stress



Total deformation



Maximum strain



Max Shear Stress

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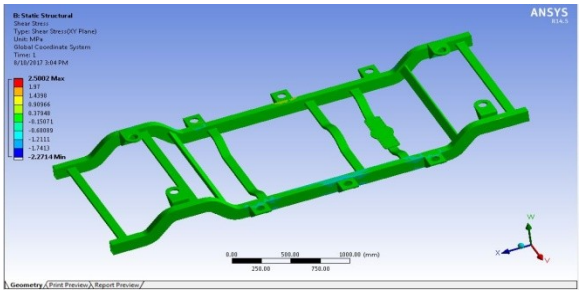


Results

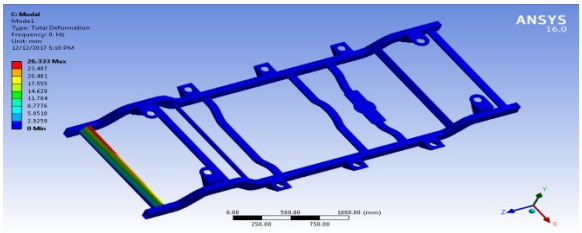
Material	Max stress (mpa)	Total deformation (mm)	Max strain	Max shear stress (mpa)	Mass (kg)
Aluminum alloy	4.5483	0.017739	7.043e-5	2.4657	169.92
Magnesium alloy	4.4879	0.028072	0.00011042	2.4513	110.42
42CrMo4	4.632	0.0059648	2.4617e-5	2.4809	480.32
Titanium Alloy	4.4555	0.013175	5.1599e-5	2.4424	283.41
S2-Glass	4.8152	0.01418	6.4286e-5	2.5002	150.91

Modal (dynamic) analysis:

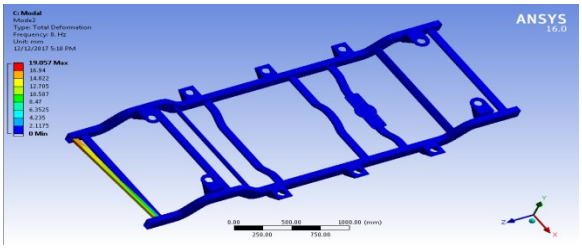
Data will be transfer from static structural to modal analysis module, to maintain the same boundary conditions and material.

Aluminum Alloy

Mode1



Mode2



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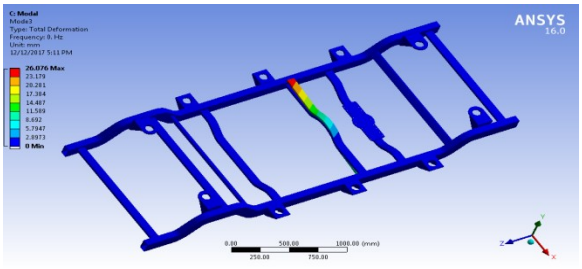

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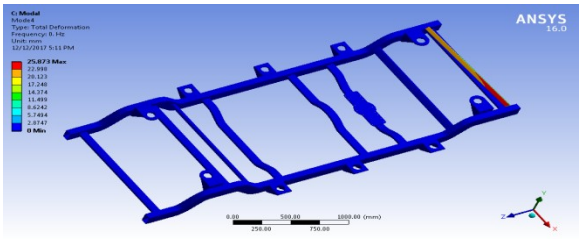

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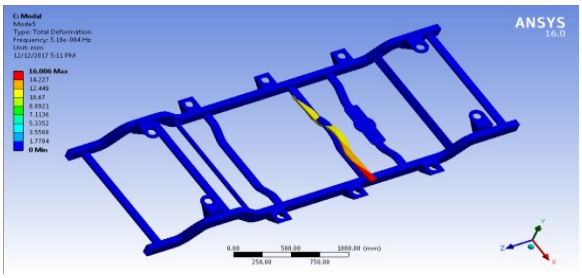

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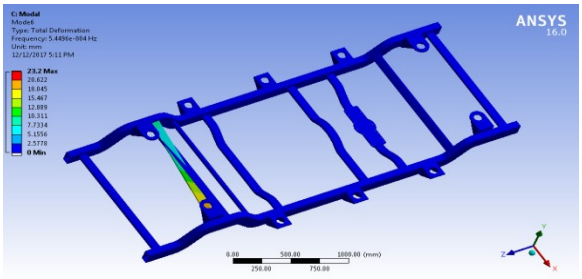

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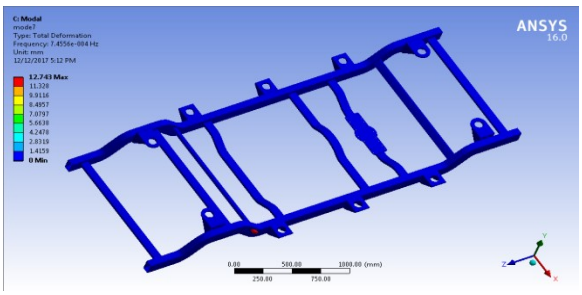

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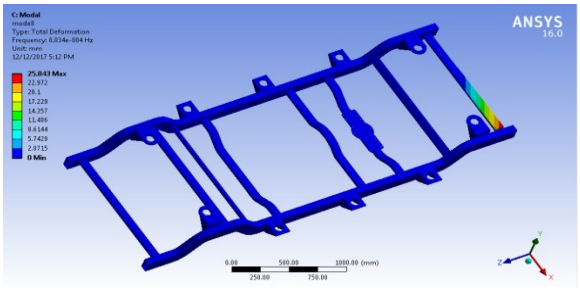

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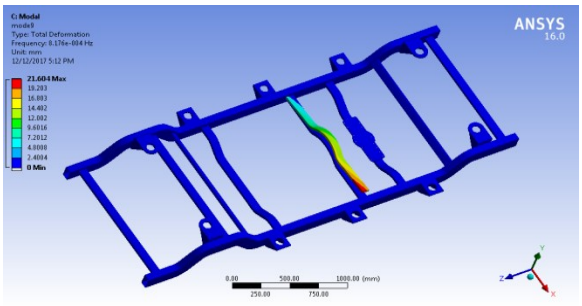
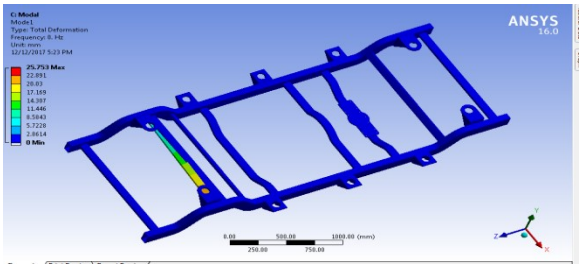


Magnesium Alloy

Mode1



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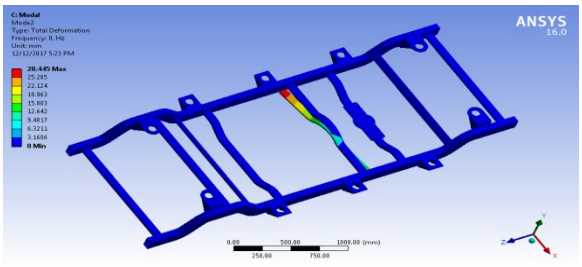

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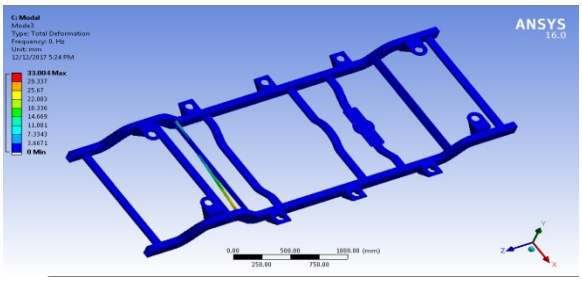

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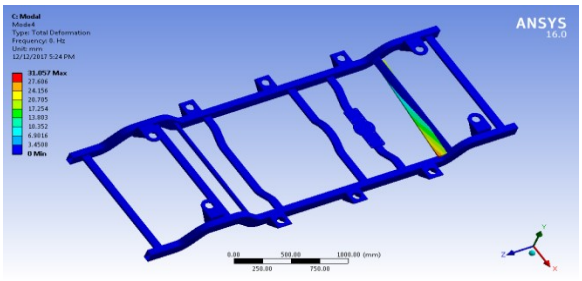

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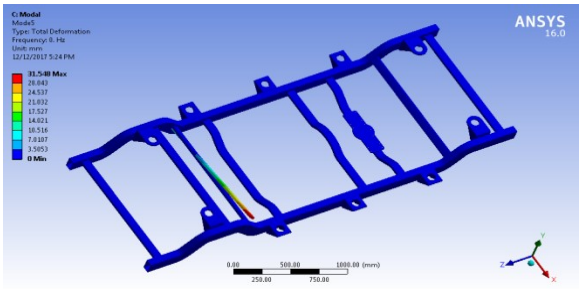

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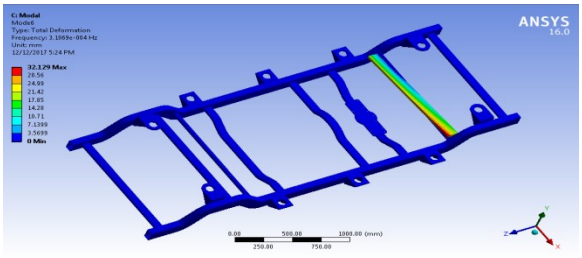

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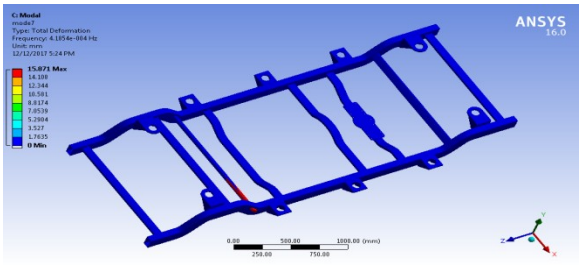

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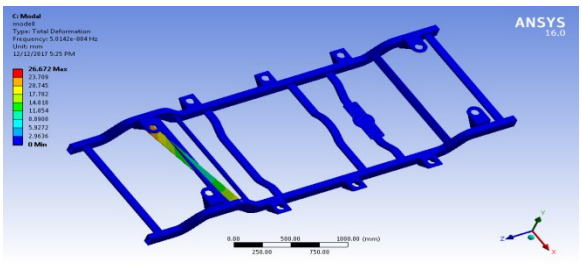

Mode9

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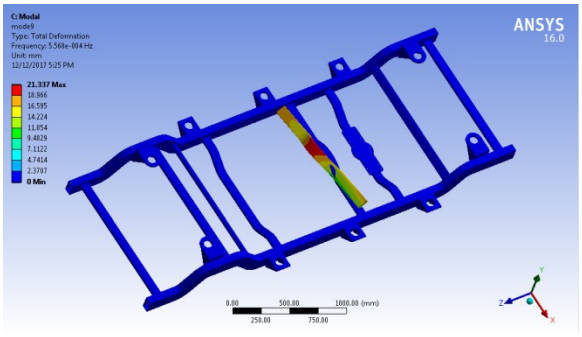
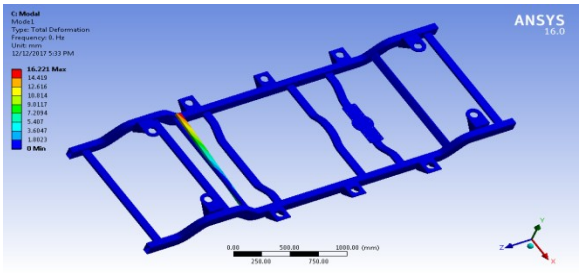


42CrMo4

Mode1



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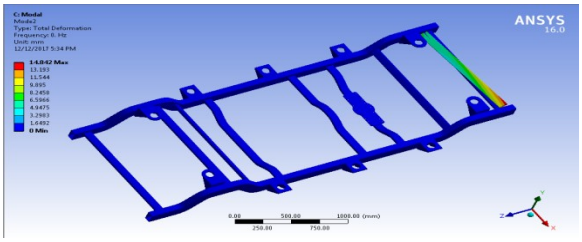

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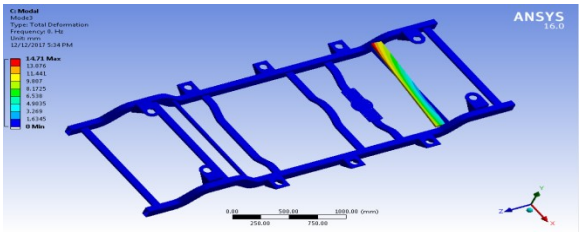

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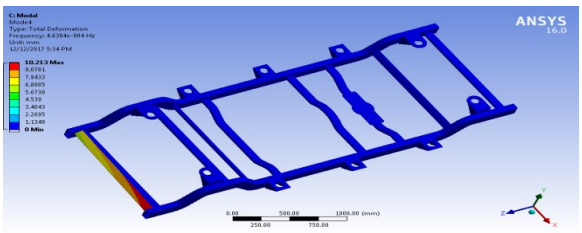

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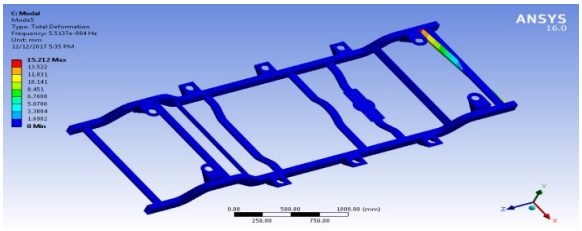

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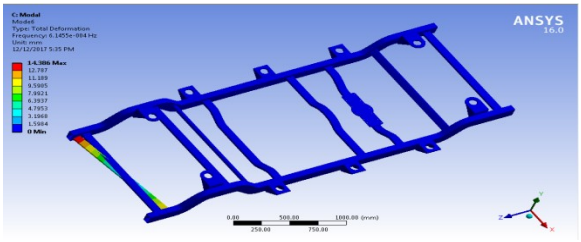

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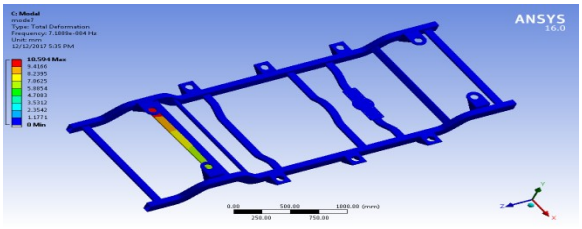

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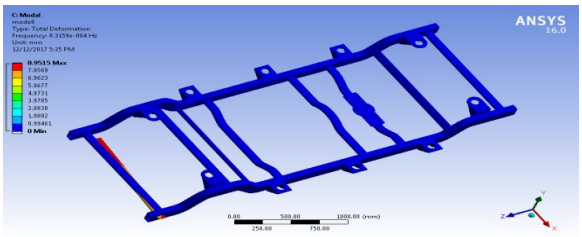

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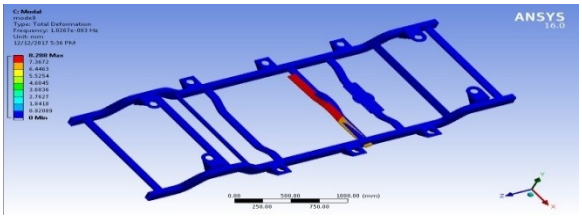

Titanium Alloy

Mode1

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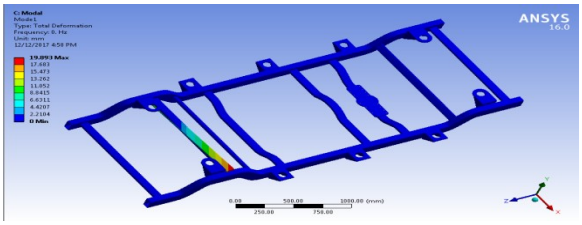

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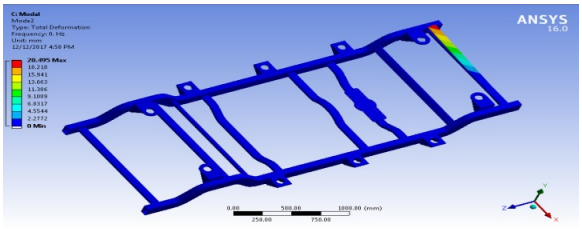

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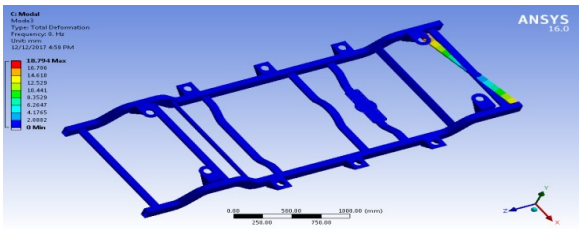

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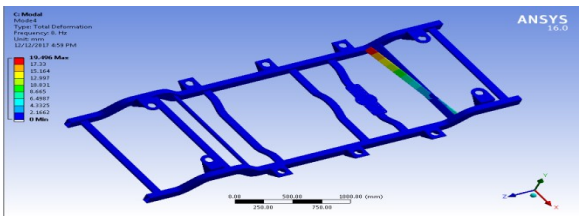

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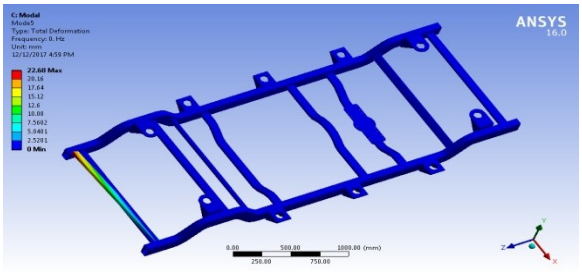

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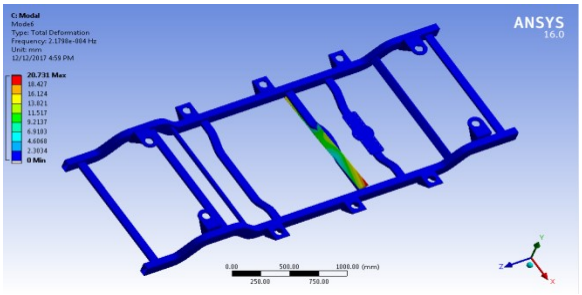

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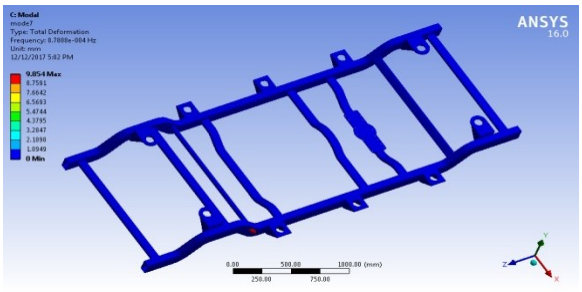

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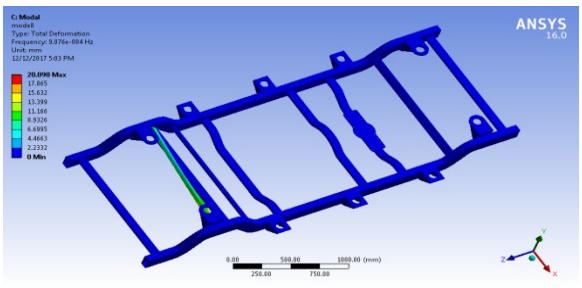

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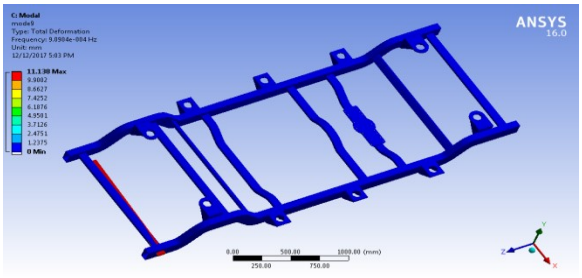
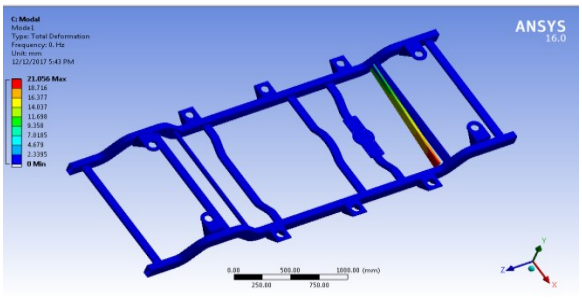


S2 Glass

Mode1



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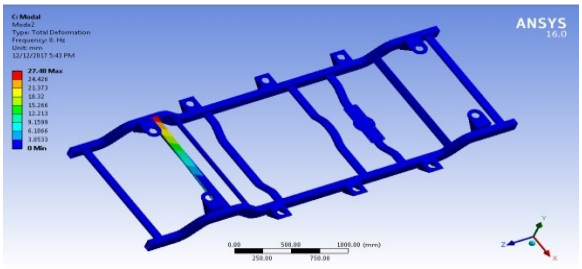

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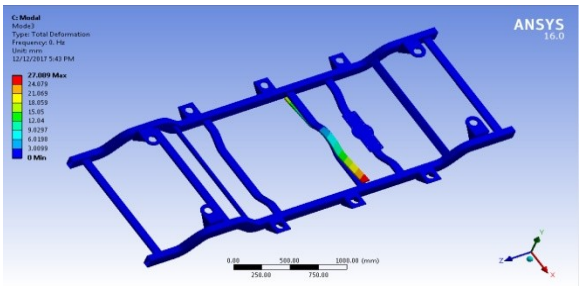

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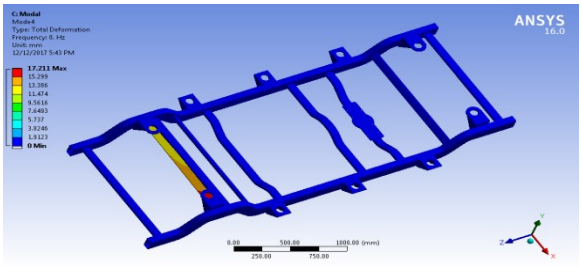

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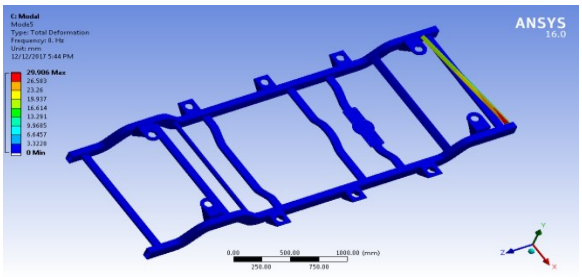

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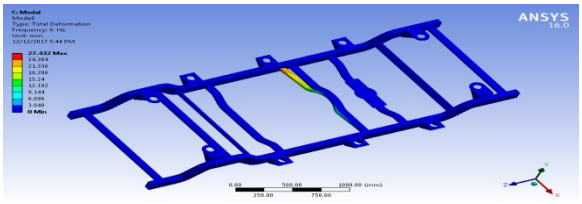

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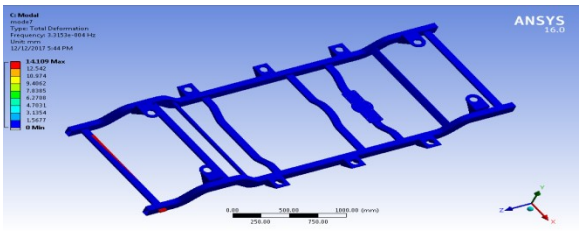

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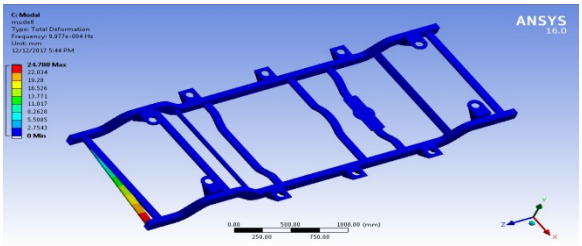

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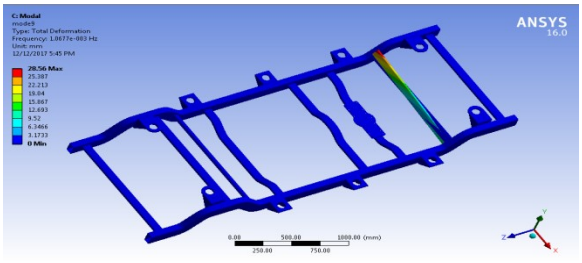

Modal Analysis Table:

Material	Mode 1		Mode 2		Mode 3	
	Frequency (Hz)	Deformation (mm)	Frequency (Hz)	Deformation (mm)	Frequency (Hz)	Deformation (mm)
Al Alloy	0	26.333	0	19.057	0	26.076
Mg Alloy	0	25.75	0	28.445	0	33.004
42CrMo4	0	16.22	0	14.842	0	14.71
Ti Alloy	0	19.893	0	20.495	0	18.79
S2 Glass	0	21.056	0	27.48	0	27.089

Material	Mode 4		Mode 5		Mode 6	
	Frequency (Hz)	Deformation (mm)	Frequency (Hz)	Deformation (mm)	Frequency (Hz)	Deformation (mm)
Al Alloy	0	25.873	5.19e-04	16.006	5.4496e-04	23.2
Mg Alloy	0	31.05	0	31.548	3.1069 e-04	32.129
42CrMo4	4.638 e-04	10.213	5.5137 e-04	15.212	6.1455 e-04	14.386
Ti Alloy	0	19.496	0	22.68	2.1798 e-04	20.731
S2 Glass	0	17.211	0	29.906	0	27.432

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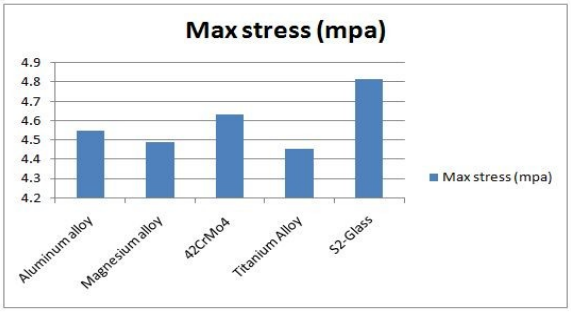
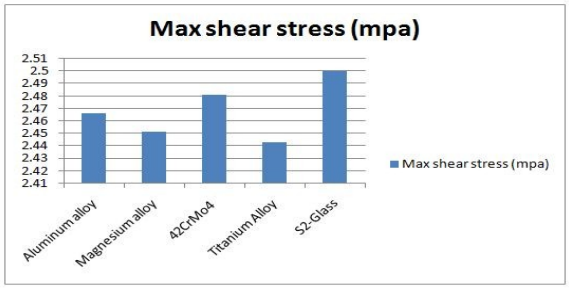
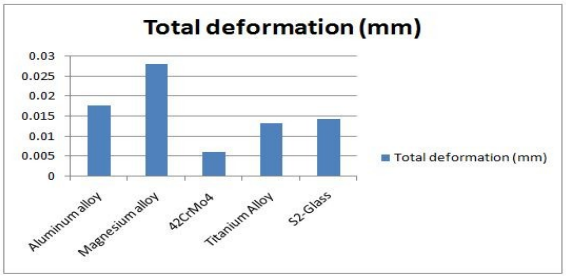
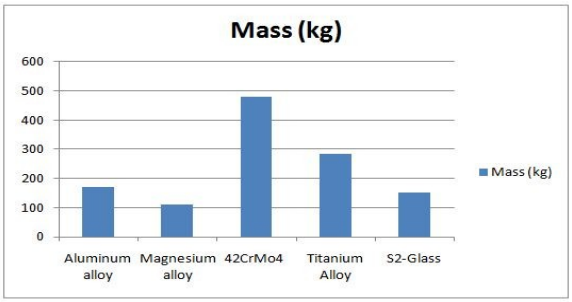
Material	Mode 7		Mode 8		Mode 9	
	Frequency (Hz)	Deformation (mm)	Frequency (Hz)	Deformation (mm)	Frequency (Hz)	Deformation (mm)
Al Alloy	7.4556 e-04	12.743	8.034 e-04	25.843	8.176 e-04	21.604
Mg Alloy	4.1854 e-04	15.871	5.0142 e-04	26.672	5.568 e-04	21.337
42CrMo4	7.1889 e-04	10.594	8.3159 e-04	8.9515	1.0267 e-03	8.288
Ti Alloy	8.7808 e-04	9.852	9.076 e-04	20.098	9.0904 e-04	11.138
S2 Glass	3.3153 e-04	14.109	9.977 e-04	24.788	1.0677 e-03	28.56

Graphs









Conclusion:

- Brief study about chassis and different type of chassis and applications are studied in this project.
- Modeling of car chassis is done in solid works 2016 software by using different commands and tools.
- And analysis is carried out in Ansys work bench software by converting solid works chassis model file into IGES file and transferring to Ansys software.
- Static structural analysis is done on working load of chassis.
- Different types of materials such as general alloy materials and fiber material are selected for analysis.
- General alloy materials such as aluminum alloy, magnesium alloy, 42CrMo4 (special alloy steel) Titanium alloy, and composite glass material such as S2-Glass are applied for analysis of the car chassis.
- Chassis is fixed on hinges and load applied on top face of chassis.
- Maximum Stress, maximum strain, total deformation & max shear stress of each individual material on given load condition is studied noted and tabulated.
- From the result table we can conclude that Titanium alloy is showing least stress value against given load condition compare to other four materials followed by Magnesium alloy.
- But the according to deformation concern 42CrMo4 (special steel alloy) is showing least deformation on body compare to other materials but it has heights weight value.
- While magnesium alloy has least weight ratio i.e. 110.42kg, less dense compare to other materials.
- As the magnesium alloy has nearly same stress value compare to titanium alloy, and its weight i.e. 110.42 kg is less than titanium alloy which has weight of 283.41 kg, and even magnesium alloy which is economically cheaper than titanium alloy because of all these factors we can suggest magnesium alloy is the best preferable material for car chassis.

- Thus magnesium alloy material because of good strength against load, stresses, economically, and less weight are preferable material compare to other materials.
- Modal (dynamic) analysis also performed on car chassis with same boundary conditions and materials, to study its behavior on dynamic condition.
- The values of deformation based upon natural frequency on 9 different mode shapes are noted and tabulated.
- Study of dynamic behavior of car chassis is done.

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[1] 2008 Formula SAE Rules. 2007.

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