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Design And Analysis Of Chassis By Using Fea

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Abstract : The automotive chassis serves as a frame work for supporting the body and different parts of the automobile. Also, it has to withstand the shock, twist, vibration and other stresses caused due to sudden breaking, acceleration, shocking road condition, centrifugal force while cornering and forces induced by its components. the chassis acts as the backbone of a heavy vehicle which carries the maximum load for all designed operating conditions. This paper describes design and analysis of heavy vehicle chassis as the prime objective of any automobile industries in today's fast changing world. in the present paper the pertinent information of an existing heavy vehicle chassis replacing materials of high specific weight with lower density materials without reducing rigidity and durability. Replacement of steel with aluminium, magnesium, composites are taken for modelling. Designing using computer aided design software catia and analysis by subjected to the identical load as that of a chassis. The numerical results are validated with analytical calculation considering the stress distribution and deformation using the ansys software.

Keywords: Automotive chassis design, Steel with aluminium, Magnesium, composites, catia, ansys.

1. INTRODUCTION

A **vehicle frame**, also known as its *chassis*, is the main supporting structure of a motor vehicle to which all other components are attached, comparable to the skeleton of an organism.

2. CHASSIS FRAME:

Frame is the basic frame work of the automobile. It supports all the parts of the automobile attached to it. It is made of drop forged steel. All the parts related to automobiles are attached to it only. All the systems related to automobile like power plant, transmission, steering, suspension, braking system etc are attached to and supported by it only.

The chassis provides the strength needed for supporting the different vehicular components as well as the payload and helps to keep the automobile rigid and stiff. Consequently, the

chassis is also an important component of the overall safety system. Furthermore, it ensures low levels of noise, vibrations and harshness throughout the automobile. Chassis should be rigid enough to withstand the shock, twist, vibration and other stresses. Along the strength, an important consideration is chassis design is to have adequate bending and torsional stiffness for better handling characteristics. So, strength and stiffness are two important criteria for the design of chassis. The load carrying structure is the chassis, so the chassis has to be so designed that it has to withstand the loads that are coming over it

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Layout of Chassis and its main components:

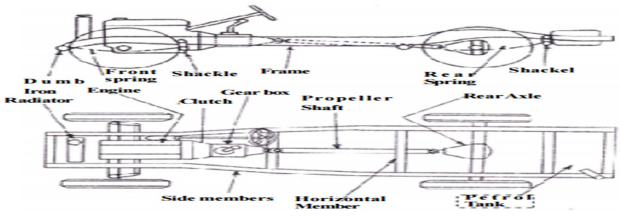


Fig 1.1 Chassis

3. MATERIALS USED FOR CHASSIS:

Different chassis materials can reduce the weight of the vehicle, improvingthe vehicle power to weight ratio. Material selection can also provide advantages byreducing member deflection, increasing chassis strength and can determine the amount of reinforcement required.

Aluminium Alloys, Magnesium Alloys, Steel, Carbon Epoxy

***Problem Of Statement*:**
Auto mobiles are constricted in first stage is started with chassis design so chassis is major component like basement and each component load is acting on chassis so this chassis is design and manufacturing materials are with stand in any load carrying conditions. So in this project we discuss the design and which materials are suitable for the chassis

Objective Of Work:
In this project explain the chassis design using ctia v5 and analysis of chassis is done using four deferent materials like steel and aluminum alloy, magnesium alloys, carbon epoxy materials ansys software. Finally conclude which one are better suitable materials for chassis

4. LITERATURE REVIEW

Many of the early research works in chassis design and analysis were limited to the computation of stress distributions and fatigue life in the chassis with many assumptions.

- Miner (1945) explained fatigue damage during the crack initiationphase. Damage during the initiation phase can be related to dislocations, slipbands, micro cracks, etc. Since these phenomena can only be measured in ahighly controlled laboratory environment, most damage summationapproaches for the initiation phase are empirical in nature. Thesemethodsrelate damage to the expended life for a small laboratory specimen. For thispurpose, life is defined as the separation of a specimen, which is equivalent tothe formation of a small crack in a large component or structure.

- Gurney (1976) studied about the analyses carried out in this workwere restricted to results which had been obtained for K butt joints underaxial loading and transverse non-load-carrying fillet welds under both axialand bending loads. However, by far the greatest amount of data examined wasthat relating to as-welded transverse fillet welds under axial loading. In allcases the thickness range considered did not extend beyond 10-26mm.

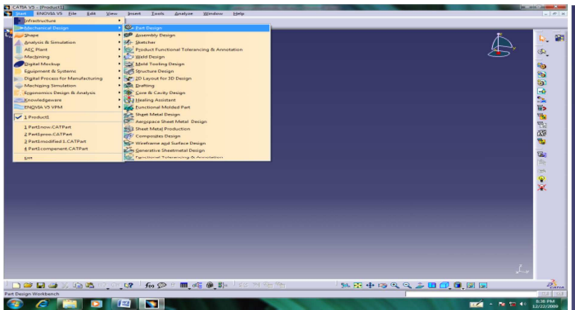
- Tanaka et al (1981) studied about the stress analysis of a truckchassis with riveted joints was performed by using FEM. The commercialfinite element package ANSYS version 5.3 was used for the solution of theproblem. Determination of the stresses of a truck chassis beforemanufacturing is important due to the design improvement. In order to reducethe magnitude of stress near the riveted joint of the chassis frame, sidemember thickness, connection plate thickness and connection plate lengthwere varied. Numerical results showed that stresses on the side member canbe reduced by increasing the side member thickness locally. If the thicknesschange is not possible, increasing the connection plate length could be a goodalternative.

Beermann et al (1984) described vertical as well as horizontal andtorsion static and dynamic loads that act on chassis frames. The torsionbehavior of most commercial vehicle frames is dominated by warpingtorsions, because warping is inhibited in the joints where the cross-membersare attached to the side-members. This paper presents a hybrid method ofanalysis, which combines finite

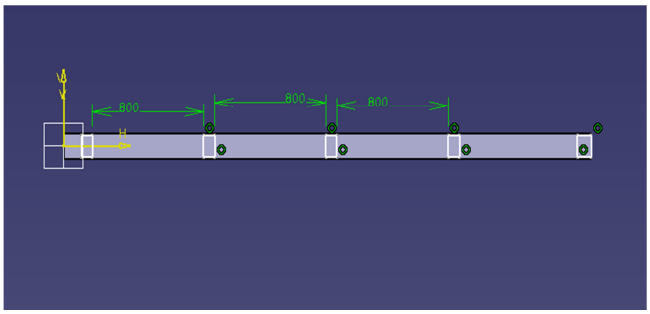
element idealization of the joint areas withanalytically derived beam elements for the cross-member and side-membersections. The beam element includes warping torsion force displacementrelationships. The flexibility of the joints is included together with thecompatibility of their displacements. The method gives close agreement with experimental results.

5. DESIGN OF CHASSIS:

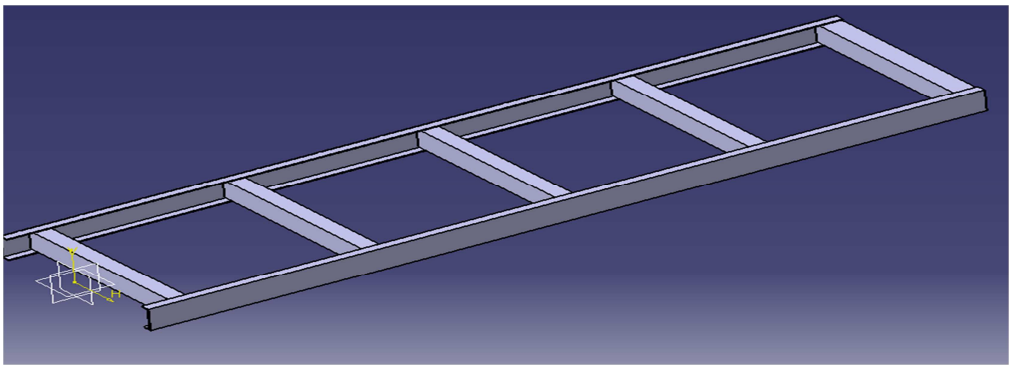
There are different modules in **CATIA** using which different tasks can be performed. The main window and modules of **CATIA** shown in figure:



INTRODUCTION OF CATIA PAGE



DIMENSIONS OF CHASIS GIVEN IN CATIA



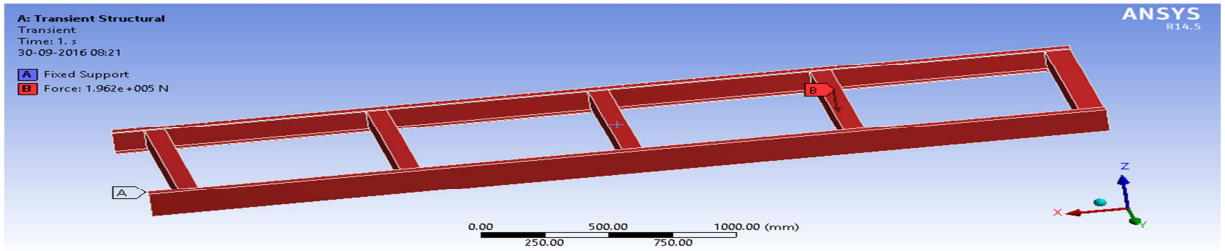
DESIGN OF CHASIS IN CATIA

6. INTRODUCTION TO FEA:

Finite Element Analysis (FEA) was first developed in 1943 by R. Courant, who utilized the Ritz method of numerical analysis and minimization of variational calculus to obtain approximate solutions to vibration systems

FEA consists of a computer model of a material or design that is stressed and analyzed for specific results. It is used in new product design, and existing product refinement. A company is able to verify a proposed design will be able to perform to the client's specifications prior to manufacturing or construction. Modifying an existing product or structure is utilized to qualify the product or structure for a new service condition. In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition. Analysis part is done by ANSYS software.

7. ANALYSIS OF CHASSIS BY ANSYS



Steel Material Analysis

Units

Unit System	Metric (mm, kg, N, s, mV, mA) Degrees rad/s Celsius
Angle	Degrees
Rotational Velocity	rad/s
Temperature	Celsius

Model (A4)

Geometry

TABLE4.1.1
Model (A4) > Geometry

Object Name	*Geometry*
State	Fully Defined
Definition	
Source	G:\catia designs\cadcam\chasis.igs
Type	Iges
Length Unit	Meters
Element Control	Program Controlled
Display Style	Body Color
Bounding Box	
Length X	3800. mm
Length Y	1000. mm
Length Z	160. mm
Properties	
Volume	6.7747e+007 mm^3
Mass	514.88 kg
Scale Factor Value	1.
Statistics	
Bodies	1
Active Bodies	1
Nodes	25601
Elements	12252
Mesh Metric	None

Basic Geometry Options	
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	No
Parameters	Yes
Parameter Key	DS
Attributes	No
Named Selections	No
Material Properties	No
Advanced Geometry Options	
Use Associativity	Yes
Coordinate Systems	No
Reader Mode Saves Updated File	No
Use Instances	Yes
Smart CAD Update	No
Attach File Via Temp File	Yes
Temporary Directory	C:\Users\Bhanuteja\AppData\Local\Temp
Analysis Type	3-D
Mixed Import Resolution	None
Decompose Disjoint Geometry	Yes
Enclosure and Symmetry Processing	Yes

Model (A4) > Geometry > Parts

Object Name	*Part 1*
State	Meshed
Graphics Properties	
Visible	Yes
Transparency	1
Definition	
Suppressed	No
Stiffness Behavior	Flexible
Coordinate System	Default Coordinate System
Reference Temperature	By Environment
Material	
Assignment	Steel
Nonlinear Effects	Yes
Thermal Strain Effects	Yes
Bounding Box	
Length X	3800. mm
Length Y	1000. mm
Length Z	160. mm
Properties	
Volume	6.7747e+007 mm^3
Mass	514.88 kg
Centroid X	-2012.2 mm
Centroid Y	2.7313e-013 mm
Centroid Z	-2.7867 mm
Moment of Inertia Ip1	5.5905e+007 $kg \cdot mm^2$
Moment of Inertia Ip2	8.1931e+008 $kg \cdot mm^2$
Moment of Inertia Ip3	8.7333e+008 $kg \cdot mm^2$

Statistics	
Nodes	25601
Elements	12252
Mesh Metric	None

Coordinate Systems

TABLE
Model (A4) > Coordinate Systems > Coordinate System

Object Name	*Global Coordinate System*
State	Fully Defined
Definition	
Type	Cartesian
Coordinate System ID	0.
Origin	
Origin X	0. mm
Origin Y	0. mm
Origin Z	0. mm
Directional Vectors	
X Axis Data	[1. 0. 0.]
Y Axis Data	[0. 1. 0.]
Z Axis Data	[0. 0. 1.]

Mesh

TABLE Model (A4) > Mesh

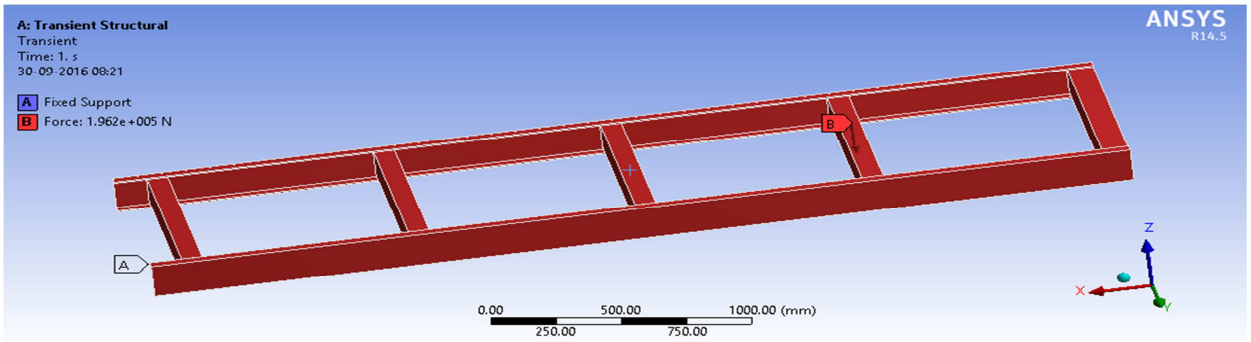
Object Name	*Mesh*
State	Solved
Defaults	
Physics Preference	Mechanical
Solver Preference	Mechanical APDL
Relevance	0
Sizing	
Use Advanced Size Function	Off
Relevance Center	Fine
Element Size	Default
Initial Size Seed	Active Assembly
Smoothing	Medium
Transition	Fast
Span Angle Center	Coarse
Minimum Edge Length	6.0 mm
Inflation	
Use Automatic Inflation	None
Inflation Option	Smooth Transition
Transition Ratio	0.272
Maximum Layers	5
Growth Rate	1.2
Inflation Algorithm	Pre
View Advanced Options	No
Patch Conforming Options	

Triangle Surface Mesher	Program Controlled
Advanced	
Shape Checking	Standard Mechanical
Element Midside Nodes	Program Controlled
Straight Sided Elements	No
Number of Retries	Default (4)
Extra Retries For Assembly	Yes
Rigid Body Behavior	Dimensionally Reduced
Mesh Morphing	Disabled
Defeaturing	
Pinch Tolerance	Please Define
Generate Pinch on Refresh	No
Automatic Mesh Based Defeaturing	On
Defeaturing Tolerance	Default
Statistics	
Nodes	25601
Elements	12252
Mesh Metric	None

Model (A4) > Mesh > Mesh Controls

Object Name	*Body Sizing*
State	Fully Defined
Scope	
Scoping Method	Geometry Selection
Geometry	1 Body
Definition	
Suppressed	No
Type	Element Size
Element Size	Default
Behavior	Soft

Transient (A5)



CHASIS IN ANSYS

TABLE
Model (A4) > Analysis

Object Name	*Transient (A5)*
State	Solved
Definition	
Physics Type	Structural
Analysis Type	Transient
Solver Target	Mechanical APDL
Options	
Environment Temperature	22. °C
Generate Input Only	No

Model (A4) > Transient (A5) > Initial Conditions

Object Name	*Initial Conditions*
State	Fully Defined

Model (A4) > Transient (A5) > Initial Conditions > Initial Condition

Object Name	*Modal (None)*
State	Fully Defined
Definition	
Pre-Stress Environment	None

Model (A4) > Transient (A5) > Analysis Settings

Object Name	*Analysis Settings*
State	Fully Defined
Step Controls	
Number Of Steps	1.
Current Step Number	1.
Step End Time	1. s
Auto Time Stepping	On
Define By	Time
Initial Time Step	1. s
Minimum Time Step	1. s
Maximum Time Step	1. s
Time Integration	On
Solver Controls	
Solver Type	Program Controlled
Weak Springs	Program Controlled
Large Deflection	On
Restart Controls	
Generate Restart Points	Program Controlled
Retain Files After Full Solve	No
Nonlinear Controls	
Force Convergence	Program Controlled
Moment Convergence	Program Controlled
Displacement Convergence	Program Controlled
Rotation Convergence	Program Controlled

Line Search	Program Controlled
Stabilization	Off
Output Controls	
Stress	Yes
Strain	Yes
Nodal Forces	No
Contact Miscellaneous	No
General Miscellaneous	No
Store Results At	All Time Points
Max Number of Result Sets	Program Controlled
Damping Controls	
Stiffness Coefficient Define By	Direct Input
Stiffness Coefficient	0.
Mass Coefficient	0.
Numerical Damping	Program Controlled
Numerical Damping Value	0.1
Analysis Data Management	
Solver Files Directory	
Future Analysis	None
Scratch Solver Files Directory	
Save MAPDL db	No
Delete Unneeded Files	Yes
Nonlinear Solution	Yes
Solver Units	Active System
Solver Unit System	Nmm

Model (A4) > Transient (A5) > Loads

Object Name	*Fixed Support*	*Force*
State	Fully Defined	
Scope		
Scoping Method	Geometry Selection	
Geometry	4 Faces	40 Faces
Definition		
Type	Fixed Support	Force
Suppressed	No	
Define By		Vector
Magnitude		1.962e+005 N (step applied)
Direction		Defined

Model (A4) > Transient (A5) > Force

Solution (A6)

TABLE
Model (A4) > Transient (A5) > Solution

Object Name	*Solution (A6)*
State	Solved

Adaptive Mesh Refinement	
Max Refinement Loops	1.
Refinement Depth	2.
Information	
Status	Done

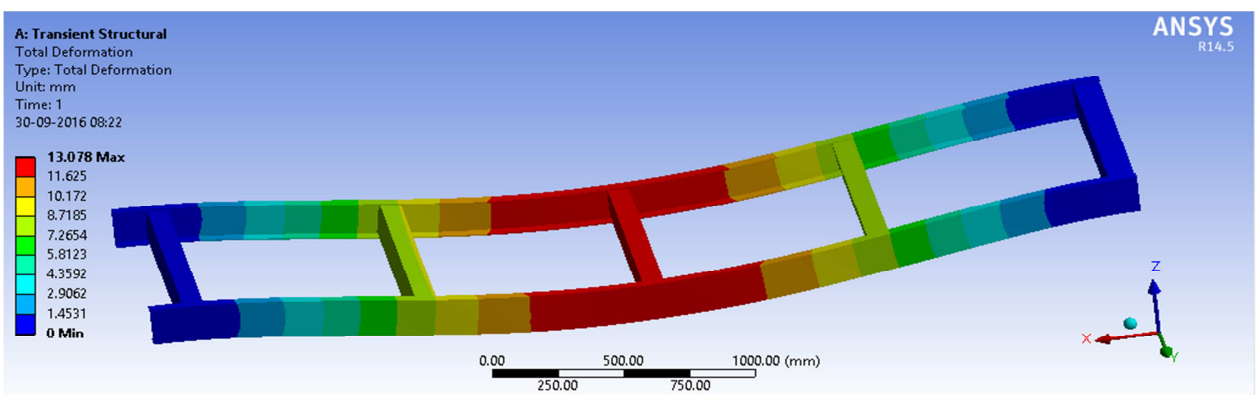
Model (A4) > Transient (A5) > Solution (A6) > Solution Information

Object Name	*Solution Information*
State	Solved
Solution Information	
Solution Output	Solver Output
Newton-Raphson Residuals	0
Update Interval	2.5 s
Display Points	All
FE Connection Visibility	
Activate Visibility	Yes
Display	All FE Connectors
Draw Connections Attached To	All Nodes
Line Color	Connection Type
Visible on Results	No
Line Thickness	Single
Display Type	Lines

Followed similar boundary conditions are applied for different materials like steel, magnesium, aluminium, carbon epoxy

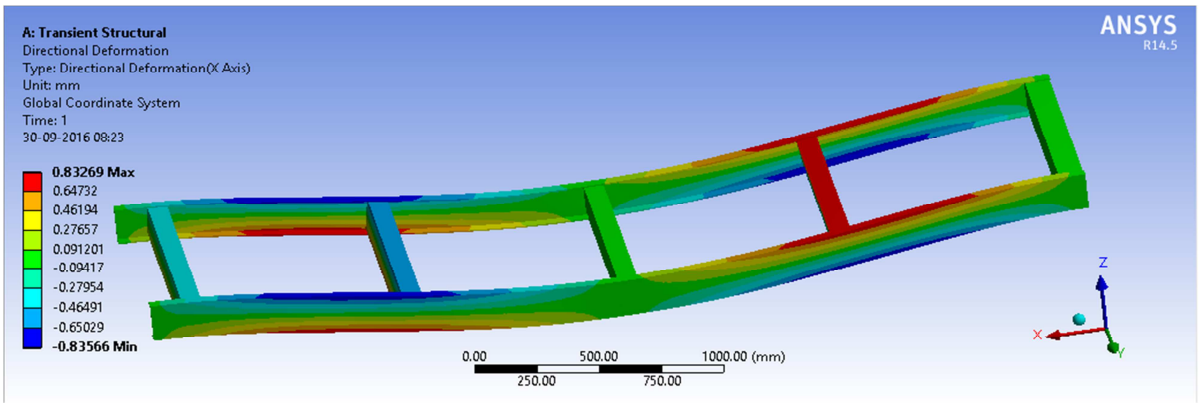
8. RESULTS AND DESCUSION

***Steel Result*:**



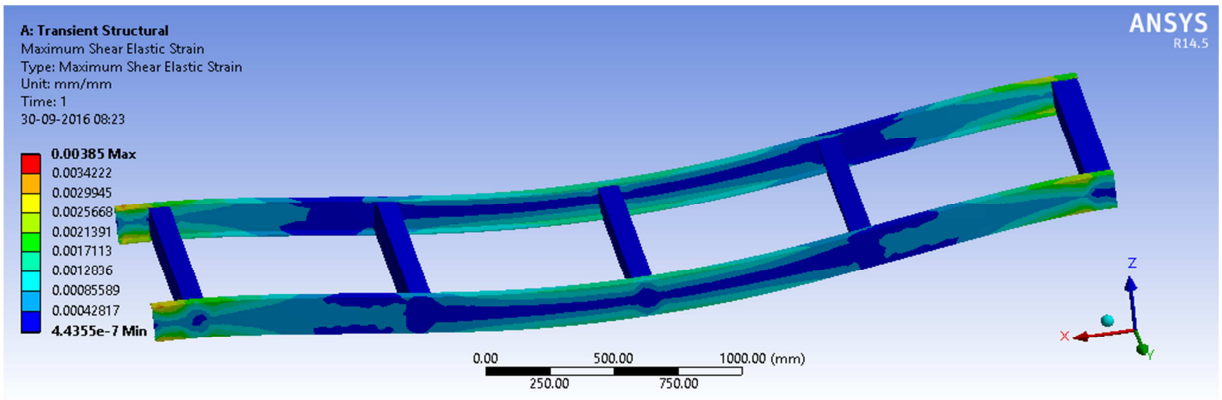
Total deformation

Figure shows that the maximum total deformation of the material will be 13.078 and minimum deformation will be zero.



Directional deformation

Figure shows that the maximum total deformation of the material will be 0.83269 and minimum deformation will be -0.83566.



Shear elastic strain

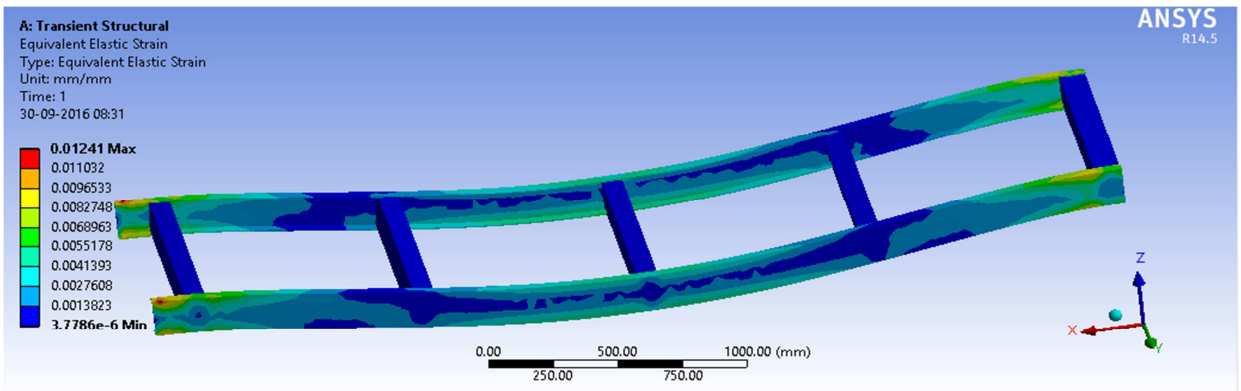
Figure shows that the maximum total deformation of the material will be 0.00385 and minimum deformation will be $4.4355e^{-7}$.

Object Name	*Total Deformation*	*Directional Deformation*	*Equivalent Elastic Strain*	*Maximum Shear Elastic Strain*	*Maximum Shear Stress*
State	Solved				
Scope					
Scoping Method	Geometry Selection				
Geometry	All Bodies				
Definition					
Type	Total Deformation	Directional Deformation	Equivalent Elastic Strain	Maximum Shear Elastic Strain	Maximum Shear Stress
By	Time				
Display Time	Last				
Calculate Time History	Yes				
Identifier					
Suppressed	No				

Orientation		X Axis			
Coordinate System		Global Coordinate System			
Results					
Minimum	0. mm	-0.83566 mm	3.1847e-007 mm/mm	4.4355e-007 mm/mm	3.5313e-002 MPa
Maximum	13.078 mm	0.83269 mm	2.9953e-003 mm/mm	3.85e-003 mm/mm	306.52 MPa
Information					
Time	1. s				
Load Step	1				
Substep	1				
Iteration Number	3				
Integration Point Results					
Display Option			Averaged		

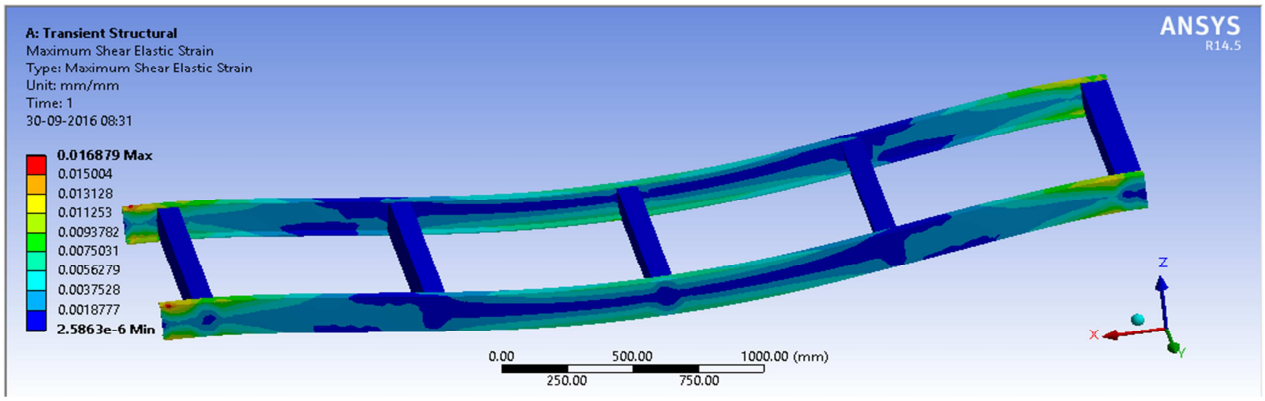
Magnesium Alloy Result:

Model (A4) > Transient (A5) > Solution (A6) > Results



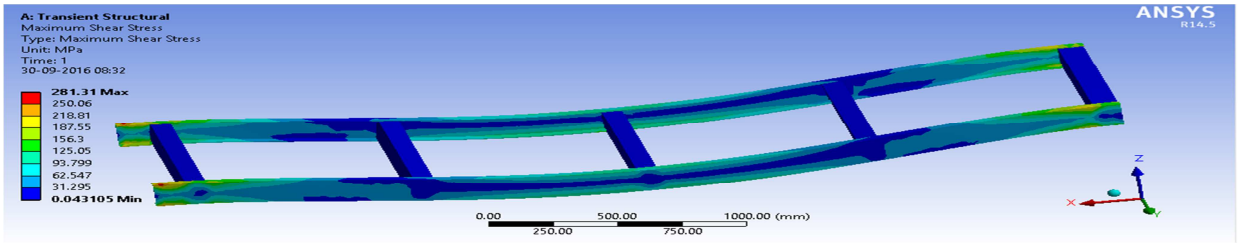
Electric strain

Figure shows that the maximum total deformation of the material will be 0.01241 and minimum deformation will be $3.7e^{-6}$



Shear elastic strain

Figure shows that the maximum total deformation of the material will be 0.016879and minimum deformation will be $2.586e^{-6}$.

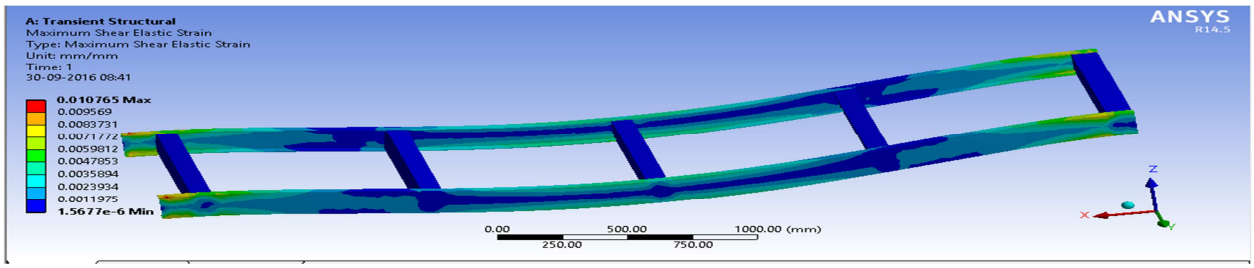


Shear stress

Figure shows that the maximum total deformation of the material will be 281.31 and minimum deformation will be 0.43105.

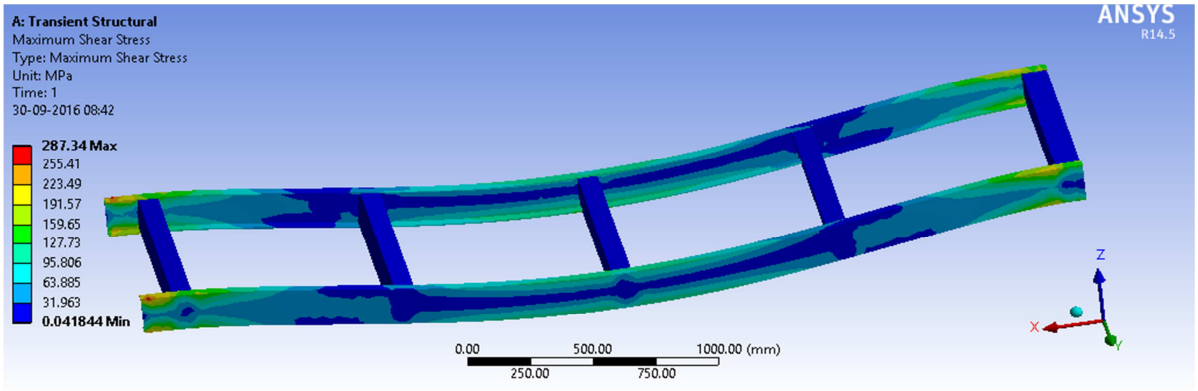
Aluminium Alloy Results:

Model (A4) > Transient (A5) > Solution (A6) > Results



Shear elastic strain

Figure shows that the maximum total deformation of the material will be 0.010765 and minimum deformation will be 1,5677e^{-6}.



Shear stress

Figure shows that the maximum total deformation of the material will be 287.34 and minimum deformation will be 0.041844.

.

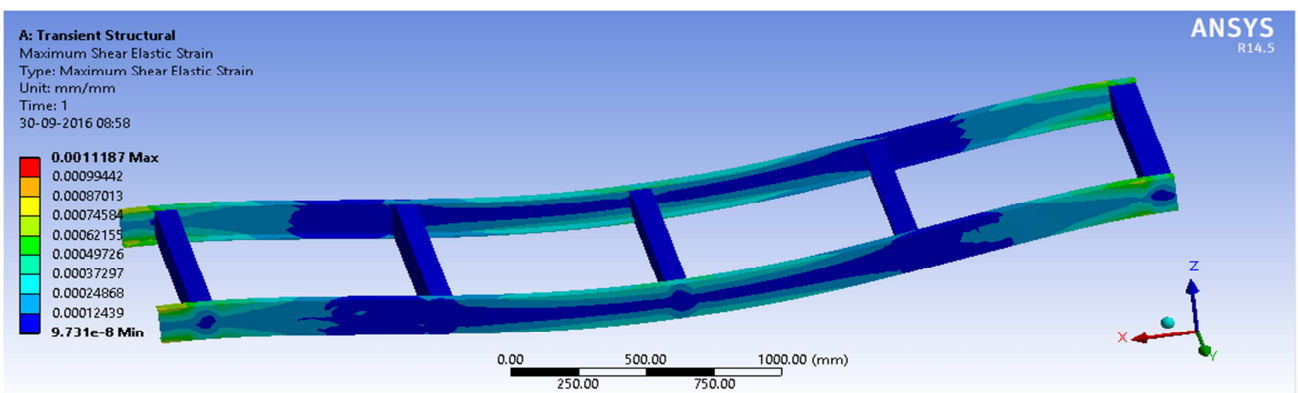
Object Name	*Total Deformation*	*Directional Deformation*	*Equivalent Elastic Strain*	*Maximum Shear Elastic Strain*	*Maximum Shear Stress*

State	Solved				
Scope					
Scoping Method	Geometry Selection				
Geometry	All Bodies				
Definition					
Type	Total Deformation	Directional Deformation	Equivalent Elastic Strain	Maximum Shear Elastic Strain	Maximum Shear Stress
By	Time				
Display Time	Last				
Calculate Time History	Yes				
Identifier					
Suppressed	No				
Orientation		X Axis			
Coordinate System		Global Coordinate System			

Results					
Minimum	0. mm	-2.4095 mm	1.6807e-006 mm/mm	1.5677e-006 mm/mm	4.1844e-002 MPa
Maximum	37.35 mm	2.4006 mm	8.0971e-003 mm/mm	1.0765e-002 mm/mm	287.34 MPa
Information					
Time	1. s				
Load Step	1				
Substep	1				
Iteration Number	4				
Integration Point Results					
Display Option			Averaged		

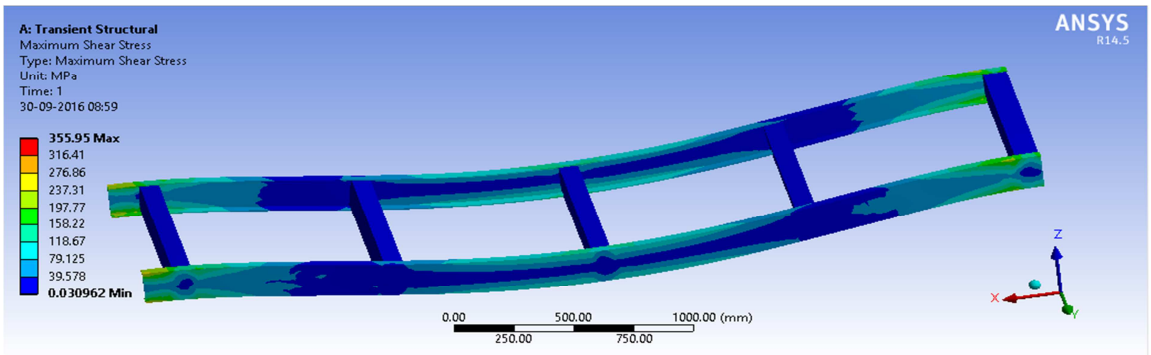
Table shows results of aluminium alloy results

Carbon Epoxy Composite Material Results:



Shear elastic strain

Figure shows that the maximum total deformation of the material will be 0.00118187and minimum deformation will be $9.73e^{-8}$.



Shear stress

Figure shows that the maximum total deformation of the material will be 355.95 and minimum deformation will be 0.030962.

Object Name	*Total Deformation*	*Directional Deformation*	*Equivalent Elastic Strain*	*Maximum Shear Elastic Strain*	*Maximum Shear Stress*
State	Solved				
Scope					
Scoping Method	Geometry Selection				
Geometry	All Bodies				
Definition					
Type	Total Deformation	Directional Deformation	Equivalent Elastic Strain	Maximum Shear Elastic Strain	Maximum Shear Stress
By	Time				
Display Time	Last				
Calculate Time History	Yes				
Identifier					
Suppressed	No				
Orientation		X Axis			
Coordinate System		Global Coordinate System			
Results					
Minimum	0. mm	-0.24744 mm	8.2395e-008 mm/mm	9.731e-008 mm/mm	3.0962e-002 MPa
Maximum	3.8604 mm	0.24672 mm	1.0901e-003 mm/mm	1.1187e-003 mm/mm	355.95 MPa
Information					
Time	1. s				
Load Step	1				
Substep	1				
Iteration Number	2				
Integration Point Results					
Display Option			Averaged		

Table shows results of carbon epoxy composite material results.

Steel Result

Magnesium Alloy Result

	Total Deformation	Directional Deformation	Equivalent Elastic Strain	Maximum Shear Elastic Strain	Maximum Shear Stress
Minimum	0. mm	-3.7232 mm	3.7786e-006 mm/mm	2.5863e-006 mm/mm	4.3105e-002 MPa
Maximum	57.149 mm	3.7057 mm	1.241e-002 mm/mm	1.6879e-002 mm/mm	281.31 MPa

Aluminium Alloy

	Total Deformation	Directional Deformation	Equivalent Elastic Strain	Maximum Shear Elastic Strain	Maximum Shear Stress
Minimum	0. mm	-0.83566 mm	3.1847e-007 mm/mm	4.4355e-007 mm/mm	3.5313e-002 MPa
Maximum	13.078 mm	0.83269 mm	2.9953e-003 mm/mm	3.85e-003 mm/mm	306.52 MPa

	Total Deformation	Directional Deformation	Equivalent Elastic Strain	Maximum Shear Elastic Strain	Maximum Shear Stress
Minimum	0. mm	-2.4095 mm	1.6807e-006 mm/mm	1.5677e-006 mm/mm	4.1844e-002 MPa
Maximum	37.35 mm	2.4006 mm	8.0971e-003 mm/mm	1.0765e-002 mm/mm	287.34 MPa

Carbon Epoxy Composite Marerial

	Total Deformation	Directional Deformation	Equivalent Elastic Strain	Maximum Shear Elastic Strain	Maximum Shear Stress
Minimum	0. mm	-0.24744 mm	8.2395e-008 mm/mm	9.731e-008 mm/mm	3.0962e-002 MPa
Maximum	3.8604 mm	0.24672 mm	1.0901e-003 mm/mm	1.1187e-003 mm/mm	355.95 MPa

9. CONCLUSION:

In the present work, ladder type chassis frame for automotive Truck was analyzed using ANSYS 14.5 software. From the results, it is observed that the Rectangular Box section is having more strength than C and I Cross-section type of Ladder Chassis. The Rectangular Box Cross-section Ladder Chassis is having least deformation i.e., 3.8604 mm and least Von Mises stress and Maximum Shear stress i.e., 1.0901e-003 mm/mmrespectively for carbon epoxy in all the three types of chassis of different cross section. Finite element analysis is effectively utilized for addressing the conceptualization and formulation for the design stages. Based on the analysis results of the present work, the following conclusions can be drawn.

- Part is safe under the given loading condition.
- To improve performance, geometry has been modified which enables to reduce stress levels marginally well below yield limit.
- The generated Von Mises Stress & Maximum Shear Stress is less than the permissible value so the design is safe for all three materials.
- The Rectangular Box Cross-section Type of Ladder Chassis is having least deflection, Von Mises stress and Maximum Shear stress for carbon epoxy in all the three types of materials of three different cross section type of Ladder Chassis.Comparing the deformation results carbon fiber epoxy material maximum is 3.8604 mm and better deformation value comparing other 3 three materials.

- Carbone fiber epoxy Weight is low and high strength value comparing with other materials

FUTURE SCOPE:

Different other composite materials can be used for analysis i.e. for Symmetric condition the chassis can be analysed for further investigation. For further investigation, the chassis can be analysed with structural analysis. It is possible to do the regression analysis for same work. For the same geometry structural analysis to find the loads varying results and effecting results of chassis is possible.

There is a high scope for further research in chassis simulation to solve vibration, frequency response and mode shape analysis related problems. Useful future work would be to determine torsion stiffness of the chassis including the suspension, modeling infinite springs and loading differentially through the wheel hubs instead of at the chassis spring mounts. Other useful measures are to be determining camber and toe response to a lateral force at the ground contact point. This chassis structure should be further analyzed and improved on the overall performance especially on structural dynamic behavior and quality auditing for better refinement. Based on these factors, the overall recommendation is to study the structural analysis and should be covered on the overall truck system and after that focus on the specific area such as chassis. This analysis will help to make full body refinement and improvement because it can be related to actual running condition.

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