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Structural, Material and Modal Analysis of Ashok Leyland 2516 Model Truck Chassis using ANSYS 14.0

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***Abstract**: Chassis acts as a backbone or framework of automobiles which supports power trains, transmission system, braking system etc. It is of various types such as ladder, backbone and monocoque. Their strength varies as the design of chassis and material varies. Chassis strength, deformations, load-carrying capacity, stresses generated, vibrations, etc. are many fields that require regular research to keep vehicles safe, to improve vehicles fuel efficiency and also should be cost effective. In present work structural, material and modal analysis is being done to find the rate of deformation, strength, deformations occurring at different frequencies etc. in order to find the best material which can fulfil the requirements of truck chassis. Software such as SOLIDWORKS 2016 and ANSYS 14.0 is used for modelling and analysing Ashok Leyland 2516 model truck. On comparing all the stress, strain, deformations of respective materials we can conclude that among three materials i.e. Structural steel, AISI4340, Carbon fibre which material is well suited to design a chassis frame*

***Keywords**: ANSYS 14.0, Ashok Leyland 2516 model truck Chassis, Ladder frame, SOLIDWORKS 2016*

1. INTRODUCTION

Chassis is a French term which was used to connote the frame parts or the basic Structural of vehicle. The chassis is considered to be one of the most significant structure of an automobile. Chassis supports Power plant, Transmission System, Axles, Wheels and Tyres, Suspension, Controlling Systems like Braking, Steering etc., and also electrical system parts are mounted on the chassis frame. It not only provides safety to the vehicle but also reduce the noise level, vibration etc. There are many types of chassis such as Ladder chassis, Backbone chassis and monocoque chassis chassis. Further classification of chassis is based on location of engine, type of drive, type of Structural etc. Different type of chassis is used in different categories of vehicle. From past many years chassis strength and stability is a focused section for researchers. In the present work Chassis of Ashok Leyland 2516 model truck is taken for study. Structural Steel, AISI4340 and Carbon fiber is taken for modeling and analysis of chassis. From the results we can easily conclude that how different materials affects strength and life of chassis .Composite materials are modern materials less in weight and more in strength. This study will clearly shows comparison between the conventional materials and modern materials.

1.1 OBJECTIVE OF PROJECT

The main objective of the project is to:

1. Design a chassis of Ashok Leyland 2516 model Truck with the help of SOLIDWORKS Software.
2. Conduct Stress Analysis in different sections of the chassis to find the load conditions and deformations in the designed chassis
3. Conduct Material and Modal Analysis by using different materials in order to obtain a correct material for the chassis, capable of reducing the weight and increasing the fuel economy and able to bear the payloads up to certain imit.

2. SPECIFICATION OF CHASSIS

Table1-Design Parameters

S.No.	Parameters	Dimensions
1.	Model	ASHOK LEYLAND 2516
2.	Length of frame	7162 mm
3.	Width of frame	863.6 mm
4.	Ground Clearance	260 mm
5.	Gross Vehicle Weight	25 tons
6.	Kerb weight	6116 kg
7.	Payload	15800 kg
8.	C-Channel	228.60 x 88.90x 25.40 mm^3

3. MATERIAL AND METHODS

3.1 Material Properties

Table 2- Material Properties

Properties	Structural steel	AISI4340	Carbon fiber
Density (kg/m^3)	7850	7827	1500
Young's Modulus	2×10^{11}	1.995×10^{11}	1.5×10^{11}

(Pa)			
Poisons ratio	0.3	0.32	0.38
Tensile Ultimate Strength (Pa)	2.5×10^8	8.6184×10^8	6×10^8

3.2 Methodology

In present work chassis of Ashok Leyland truck is modeled and analyzed by using SOLIDWORKS 2016 and ANSYS 14.0 software respectively. Structural steel, AISI4340 and carbon Fiber are the materials which are taken into consideration for analysis. Steps follows in m

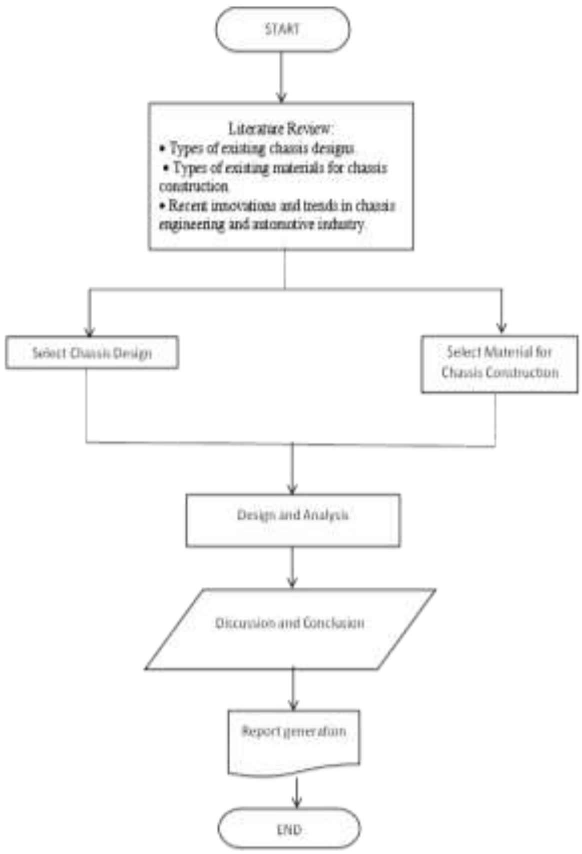


Figure 1: Flowchart of Methodology

3.3 Design of Chassis Frame

The designing process requires CAD software like SOLIDWORKS 2016 .The chassis of Ashok Leyland is designed with unique measurements and as per the requirements of the category of vehicles. We have therefore designed the Ashok Leyland 2516 model truck chassis with exact measurements such as overall length, wheel base, track width, and other vehicle measurements. Different views are mentioned in order to understand the design easily.

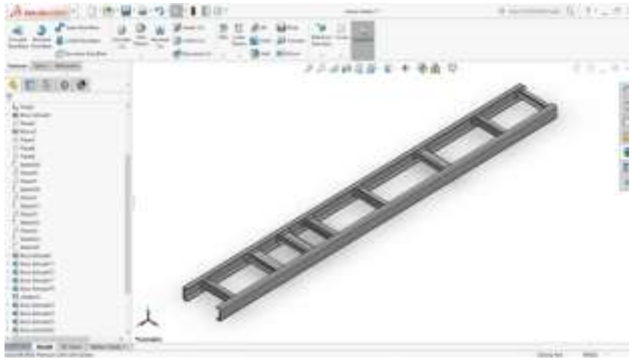


Figure 2: SOLIDWORKS MODEL

As per the above-mentioned design requirements, the truck chassis designed as follows:

Step 1- After collecting all the dimensions a Structural of chassis is being created with the help of SOLIDWORKS .While sketching the Structural first of all, the plane i.e front, top or right is chosen.

Step 2- Now Longitudinal member is drawn which is C channel whose dimension is 228.60 x 88.90x 25.40 mm^3.With the help of mirror, extrude etc. options , structure got its exact look.

Step 3-Next is to draw the cross members at the fixed distance as it is in actual structure. The cross member contain C Section, I section.

Step 4-Next is to provide supports to the cross members. The supports are C Section Structural and provide load bearing capacity to the Structural.

Step 5-After designing make sure the all the components should not merge in each other.

3.4 Analysis of Chassis

The step of analysis is as follows:

Step 1-Firstly, after opening the software we choose Static Structural option from the table listed at the left most part of the screen.

Step 2- Now as shown in the fig below a chart A appears .Starting from option number 2 Engineering data, here we choose material on which the analysis is performed

Step 3- After choosing the material now the CAD model of the Ashok Leyland 2516 model truck Chassis frame, is imported into this software from SOLIDWORKS 2016 where various inputs are provided to start the analysis process of this design.

Step 4-Ater importing contact between the all the members i.e. longitudinal member, cross members and supports is being provided. Here in the present analysis we have given bonded relationship between all the members.

Step 5- Now, the CAD model is meshed followed by the fixing of fixed supports. And then different loads are applied and the structural analysis is carried out to obtain the deformation distribution results. All the results of this analysis are listed in the ANSYS 14.0 structural analysis report in APENDIX.

Step 6- For showing the deformations due to various frequencies we opt modal option from the main ANSYS window and a chart B appears on the screen .Here we solve the modal and get various results.

Step 7- Now generate the report.

Step 8- Repeat this whole process for n number of materials on which analysis is to be performed and after generating the result compare all the result and choose the best material. Here in the present work I have used three materials – Structural Steel, AISI4340 and Carbon Fibre.

Figure 3: ANSYS Window

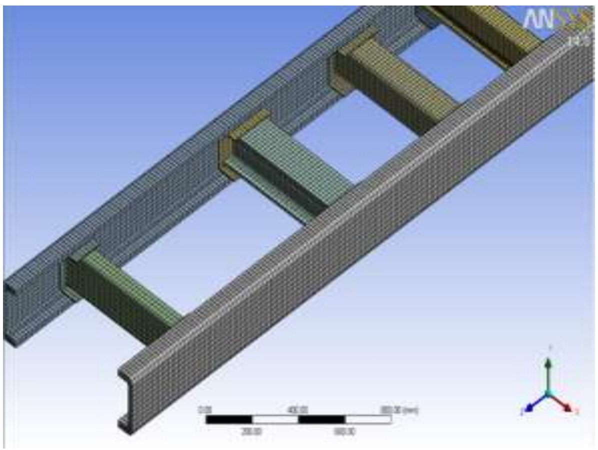


Figure 4: Meshed View

(Nodes-288611, Elements- 47199)

1. Structural Steel Analysis-Solution of analysis is mentioned below:

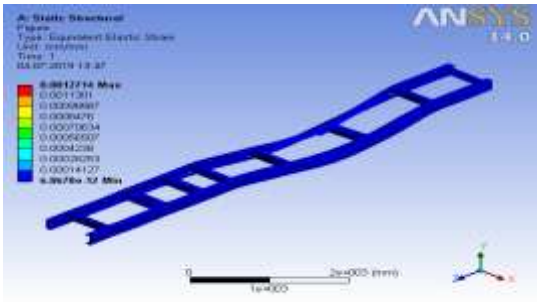


Fig 5: Equivalent Elastic strain

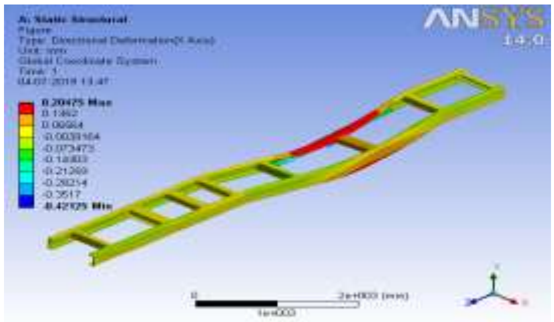


Fig 6: Directional Deformation

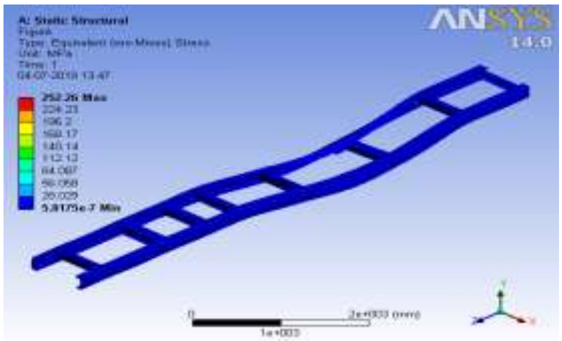


Fig 7: Equivalent Von –Mises Stress

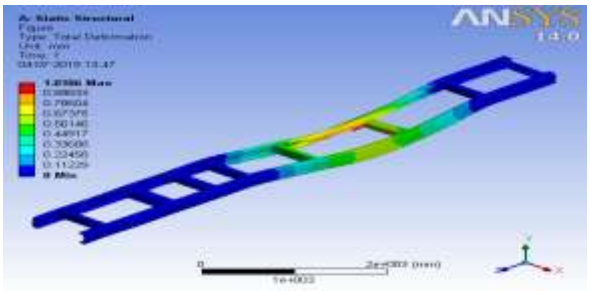


Fig 8: Total Deformation

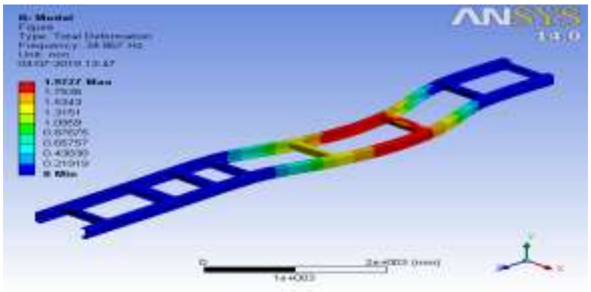


Fig 9: Total Deformation (34.867Hz)

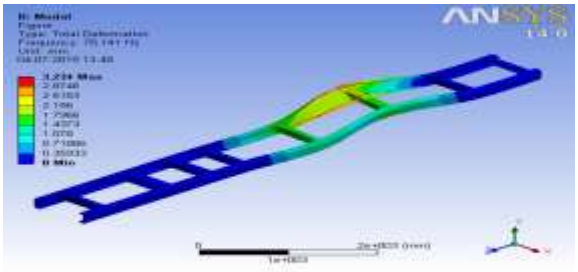


Fig 10: Total Deformation (78.141Hz)

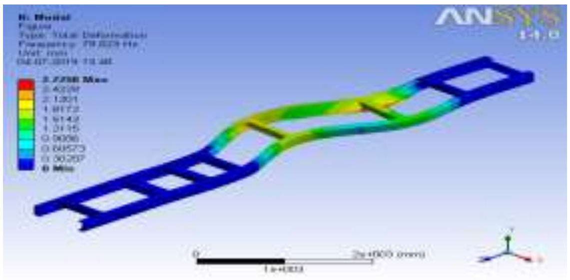


Fig 11: Total Deformation (79.823Hz)

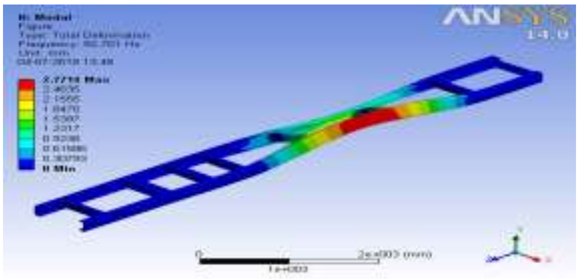


Fig 12: Total Deformation (92.701Hz)

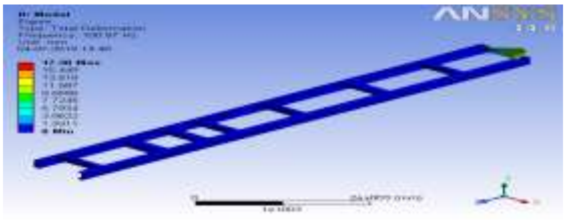


Fig 13: Total Deformation (100.57Hz)

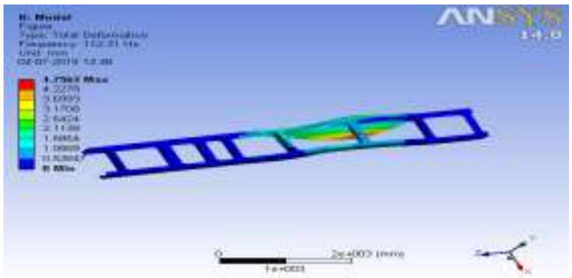


Fig 15: Total Deformation (112.21Hz)

2) **AISI4340**- Solution of analysis is mentioned below:

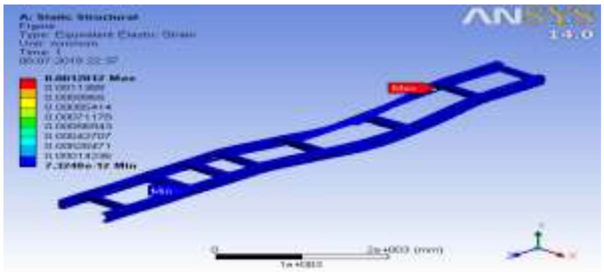


Fig 16: Equivalent Elastic strain

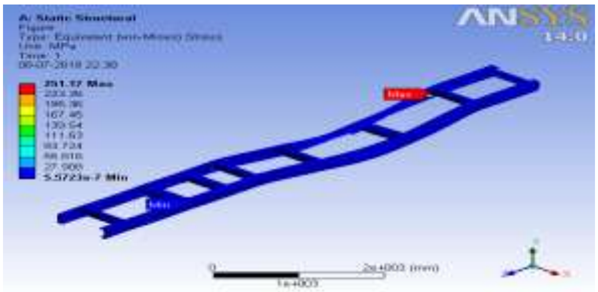


Fig 18: Equivalent Von –Mises Stress

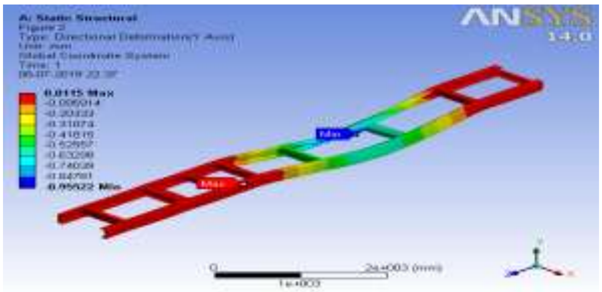


Fig 19: Directional Deformation

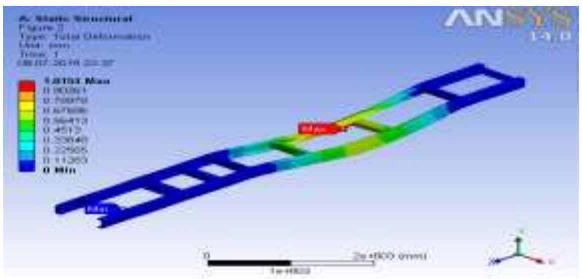


Fig 20: Total Deformation

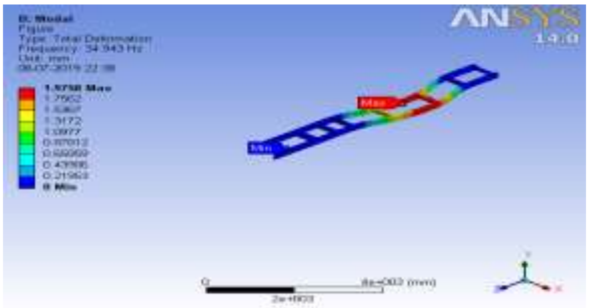


Fig 21: Total Deformation (39.943Hz)

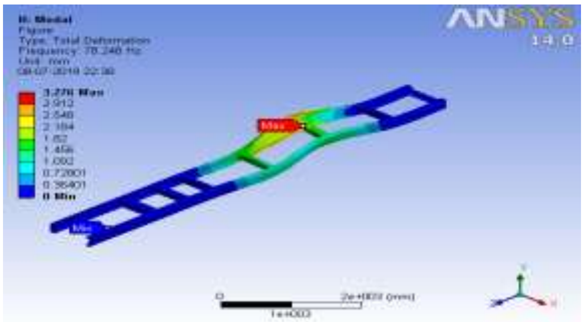


Fig 22: Total Deformation (78.248Hz)

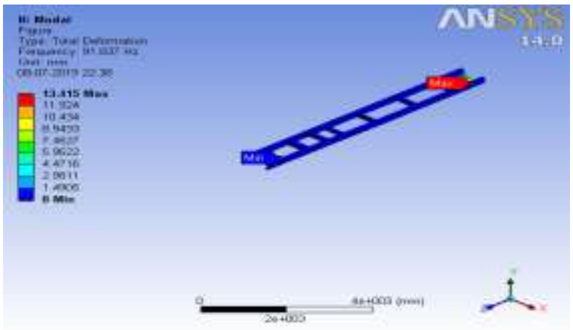


Fig 23: Total Deformation (91.837 Hz)

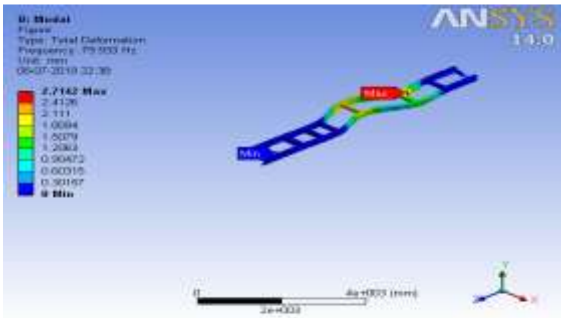


Fig 24: Total Deformation (79.933 Hz)

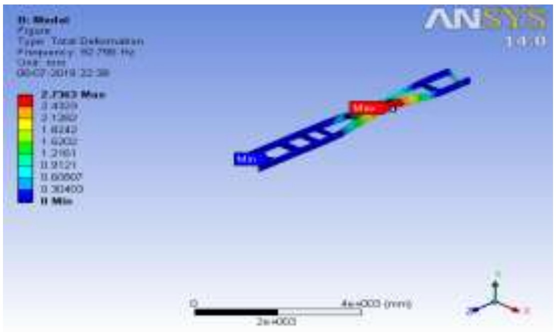


Fig 25: Total Deformation (92.76 Hz.)

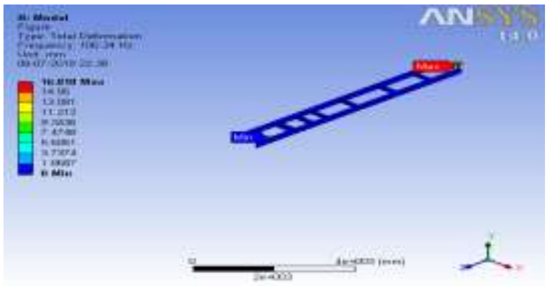


Fig 26: Total Deformation (106.34 Hz)

3) **Carbon Fiber-** Solution of analysis is mentioned below:

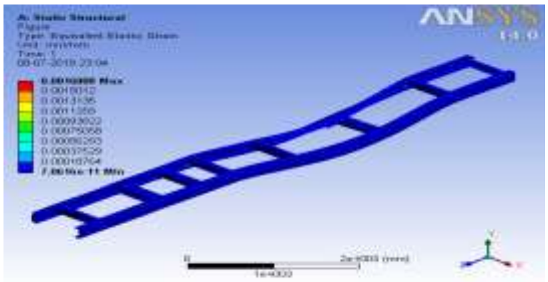


Fig 27: Equivalent Elastic strain

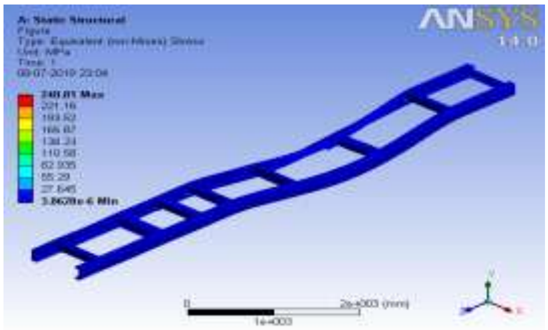


Fig 28: Equivalent Von –Mises Stress

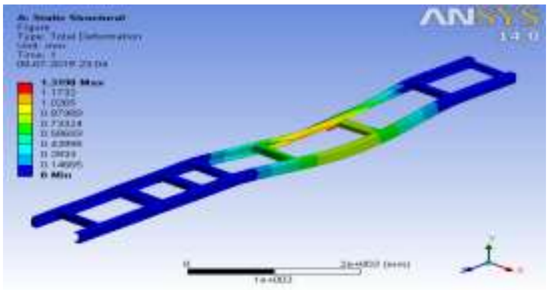


Fig 29: Total Deformation

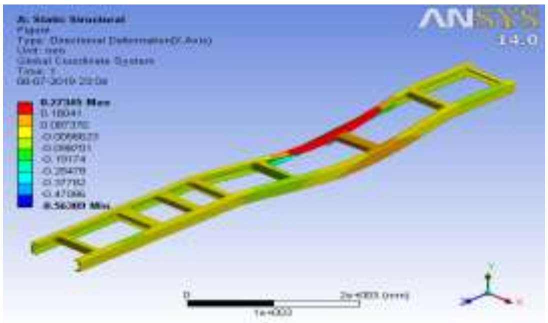


Fig 30: Directional Deformation

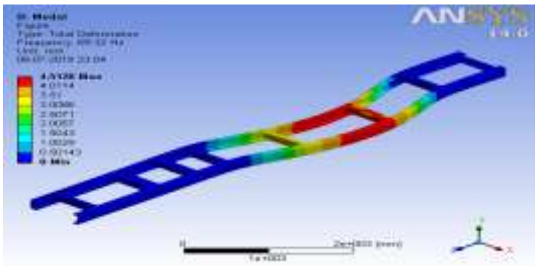


Fig 31: Total Deformation (69.32 Hz)

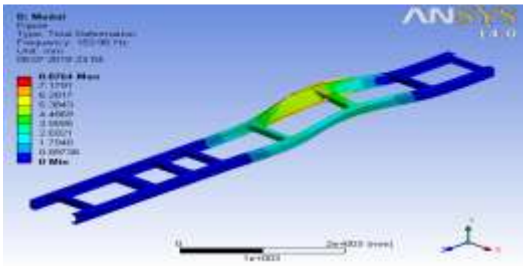


Fig 32: Total Deformation (153.96 Hz)

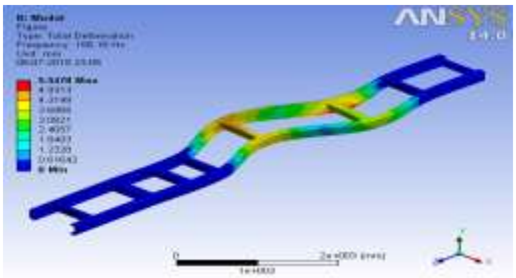


Fig 33: Total Deformation (158.18 Hz)

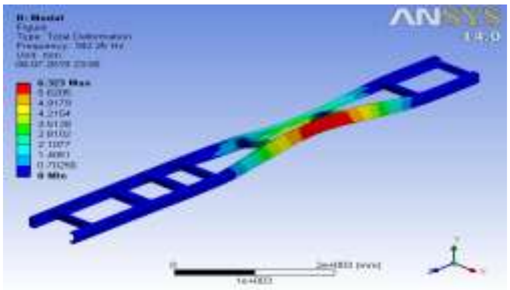


Fig 34: Total Deformation (182.25 Hz)

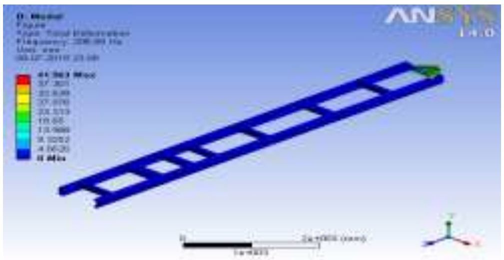


Fig 35: Total Deformation (208.55 Hz)

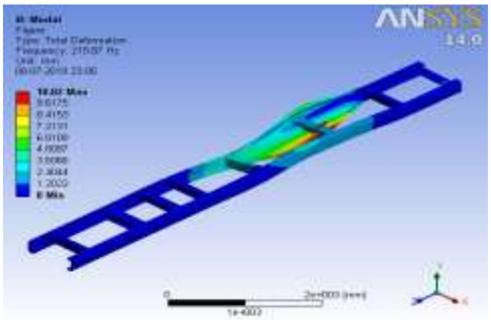


Fig 36: Total Deformation (219.84 Hz)

4. Result & Discussion

A- Comparison Chart between materials

Table 3: Comparison Chart between Materials

Parameters /Materials	Structural steel		AISI 4340		Carbon Fiber	
	Min.	Max.	Min.	Max.	Min.	Max.
Equivalent Stress (MPa)	-5.8175e-7	252.26	5.5723e-7	251.17	3.8628e-6	240.81
Equivalent Strain	6.8678e-12	0.0012714	7.3248e-12	0.0012812	7.0616e-11	0.0016888
Total Deformation (mm)	0	1.0106	0	1.0154	0	1.3198
Directional Deformation (mm)	-0.42125	0.20475	-0.95522	0.0115	-0.56389	0.27345

B-Modal Analysis Comparison Charts

A-Structural Steel

Table 4: Structural Steel Modal Analysis

S.No.	Frequency(Hz)	Deformation (mm)
1)	34.867	1.9727
2)	78.14	3.234
3)	79.823	2.7258
4)	92.701	2.774
5)	100.57	17.38
6)	112.21	4.7563

B-AISI4340

Table 5: AISI4340 Modal Analysis

S.No.	Frequency(Hz)	Deformation (mm)
1)	34.943	1.9758
2)	78.248	3.276
3)	79.233	2.7142
4)	91.837	13.415
5)	92.76	2.7363
6)	106.34	16.818

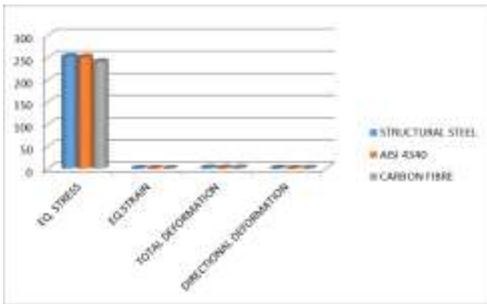
C-Carbon Fiber

Table 6: Carbon Fiber Modal Analysis

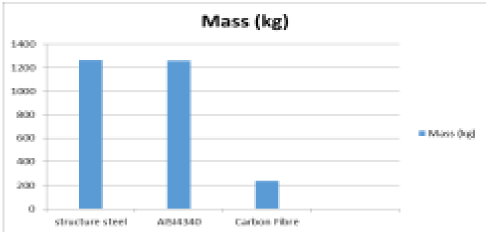
S.No.	Frequency(Hz)	Deformation (mm)
1)	69.32	4.5128
2)	153.96	8.8764
3)	158.18	5.5478
4)	182.25	6.323
5)	208.55	41.963
6)	219.84	10.82

Table 7: % Reduction in Mass of Chassis

S.No.	Material	Mass (kg)	% Difference
1	Structural steel	1263.2	
2	AISI4340	1259.5	0.3%
3	Carbon Fiber	241.37	80.8%



Graph 1: Bar Chart of static Analysis



Graph 2: Bar chart of material mass reduction potential

From the above mentioned tables the result is clearly visible that maximum equivalent von-mises stress generated in Structural steel is more than AISI 4340 and Carbon Fibre. But if we see the total deformation result, then the value of carbon Fiber is more than the other two materials, but if we increase the thickness of the c-channel then the deformation will be become less .In case of directional deformation the maximum value occurs in AISI4340. From the modal analysis results indicate that different deformation values appears in chart above. On comparing all the value study shows that at maximum frequency i.e. 219.84 Hz of carbon Fibre very less deformation occurs in the chassis. This shows that Carbon Fibre is safe for manufacturing truck chassis and its weight is approximately 80.8 % less than that of steel. This weight reduction also enhances fuel economy and reduces pollution.

5. CONCLUSION

Chassis strength and deformation under safe limits is very crucial parameter while designing and analysing chassis Structural. In this work, three materials i.e. Structural steel, AISI4340 and Carbon Fiber is selected for modelling and analysis and among them carbon Fibre gives best results. Composite material is very costly as compare to other metal used in auto vehicle chassis frame which incur some extra cost on the consumer .If cost is not considered then best alternative for the automobile and chassis frame is composite materials. The results of the modal analysis give a clear indication that the maximum stress induced is in steel and minimum stress induced is in composite material. It reduces weight of the chassis upto great extent which ensures fuel economy of the vehicle.

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