Vibrational analysis and optimization of composite tractor trolley chassis using finite element Analysis

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Abstract

Tractor trolley chassis is an important part in automobile sector. The main focus is to identify key performance indicators of tractor trolley chassis. This work involves static and vibration analysis to determine the key characteristics of a chassis. The static characteristics include identifying location of high stress area and determining the stiffness of the chassis. This is done in FEA software's (meshing in HYPERMESH, post processing in ANSYS-15). 3D model is to be done in CATIAV5. Based on results of stresses and deformation modification is to done i.e. Types Of Chassis Frame to be used for better strength and to reduce the weight of the chassis or design changes can be done to increase its strength. At last, the improvement of the advanced FE tractor chassis model was suggested to gain the strength and optimize the weight of the chassis. Further, the model will be fabricated and tested to validate with numerical results.

Keywords: *Analysis with Ansys-15, Tractor trolley, Principle stresses.*

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1. INTRODUCTION

Tractor trailers are extensively used for farming purpose, this vehicle used to deliver the many farming products from one place to another. A tractor is an engineering vehicle its designed to reach a high tractive effort (or torque) at slow speeds, for that need of hauling a trailer can be used in agriculture or construction works. The term is used to explore a farming vehicle that provides the power to perform the agricultural tasks, especially (and originally) in village, but now a great extensive of tasks. Agricultural implements may be towed behind or mounted on the tractor, and the tractor is the soul to provide a source of power if the implement is mechanized.

Fig-1: Tractor trolley

Trailers are intensively used for agriculture aspects, to transport construction material and many industry oriented equipment. The power require to pull the trailer is done by human, animals and machines. In trailer many variables are available and use of that particular trailer depends upon the need of application. The main aim of trailer manufacturing is high throughput, easy maintains, longer working and robust construction.

1.1 Problem Statement

In urban and rural areas trolleys are very impressive in terms of transport, cheaper. But these trolleys are manufactured in various small to large scale automotive industries; due to this the design of the chassis is not tested for load bearing capacities and proper vibration aspects. As design is not properly done according to the stress and vibrational aspects the chassis may fail or due to overdesign it may be heavy too. Therefore there is a scope for its optimization.

1.2 Objectives

The main objective in this project is to carry out FEA analysis on present trolley chassis and optimizing the same for weight reduction and cost by varying Types of Chassis frame and using composite material. To achieve this, following steps are needed to be taken:

a) To make a 3D Model of a chassis using CATIA CAD Software,

b) To conduct design analysis using Hypermesh and Ansys Simulation software
c) Optimization of structure
d) Interpreting the Ansys results
e) Fabrication, testing and validation

1.3 Methodology

1) Preparing the cad model in catia.2) Application of boundary conditions3) Structural analysis on chasis.3) Interpreting the results.4) Geometry change with iterations.5) Comparing the results with existing model.6) Fabrication and testing of chasis.7) Validating the results.

2. LITERATURE SURVEY

Various researchers have worked for the development of composite tractor trolley

Ms. Kshitija A. Bhat[1] The final conclusion by the study was as follows, the finite element analysis shows that the trolley chassis is showing the lot of failures. From the deep study of existing chassis, the main failure is due to the self weight of chassis .So from the analysis of various problems, a proper redesigning of chassis is needed according to the stress strain analysis is required by reducing self-weight of trailer.

J.M. Biradar, B.V [2] In this paper, they analyzed the failure of weight matrices, and those results are weight saving, that has been explained briefly. The method developed that has been applied to size of a typical chassis structure that can be used in various applications. Optimize of the structure has been carried out with modal frequencies and frame deformation under static payload, as the suitable metrics.

K.Venkatesh[3] In this paper they carried out how to optimize the centre thickness and the number of stiffener locations to maximize various frequency of truck chassis, keeping the strength , Torsion, Stiffness and Weight with moderate limit.

Shaik Neelophar[4] This work describes design and analysis of vehicle chassis. How to reduce weight that is question in various automobile sectors.

Mohsen Fereydooni[4] In this study, the main objective is to differentiate effect of change in engine rotation and type of ground on operator of tractors and implements how that can be utilized.

Dr.R.Rajappan[5] From this paper we looked into the various factors of the natural frequencies and different mode variety of the truck chassis, founding the mounting locations of components on the truck chassis and analyzing response of the truck chassis under fixed loading conditions parameters.

3. CAD MODEL GENERTION

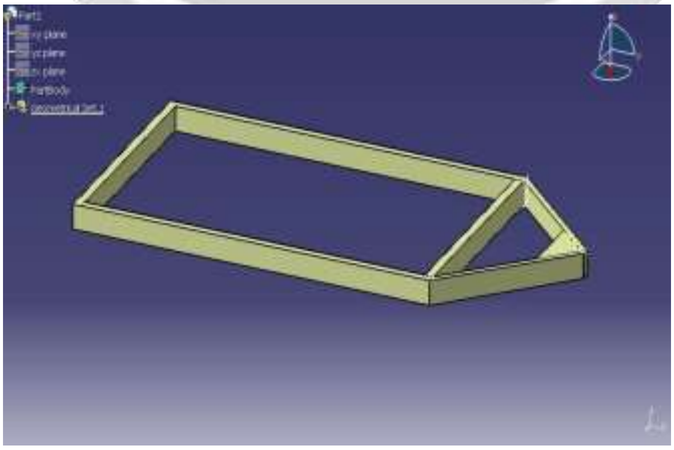

Fig-3: 3D model of tractor trolley in CATIAV5

4. FINITE ELEMENT ANALYSIS

4.1 Meshing

A structure or we can say component are consisting of number of various particles that can be In meshing we divide these components into finite numbers. Dividing helps us to carry out calculations on the meshed part. We divide the component by nodes and elements. Here, we are using tetra-hedral element for meshing

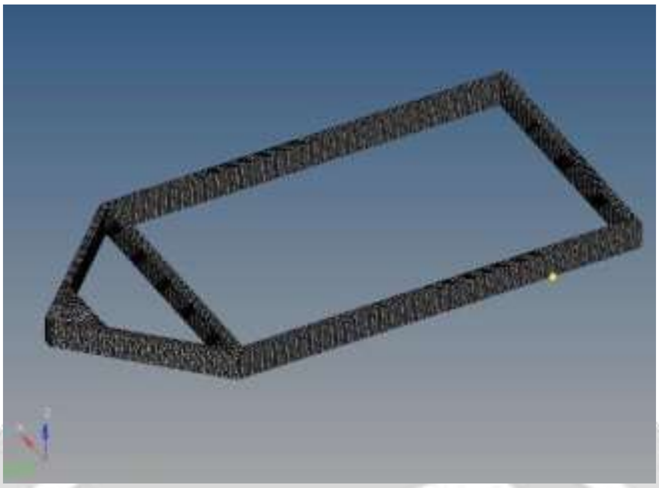

Fig-4.1: Meshed model of tractor trolley

4.2 Finite element analysis of exiting tractor trolley

After meshing is completed we apply boundary conditions. In short we here go for the preparation of deck. Here we apply define and apply various loads. Various load steps are introduced which are to be used during analysis. Surrounding condition taken in count while applying loads. Elements are defined based on their property metrics. Here proper arrangements are made so that we can run the analysis in solver software. After the completion of process model is exported to the solver.The total capacity of the trolley is 60KN but the self weight of trolley and the other accessories is 13 KN. So we consider the gross weight come over is 73 KN. Considering uniformly distributed load and fixed supports are applied at trolley hook and wheel axial on the chassis and constraints as shown in below fig analysis can be done.

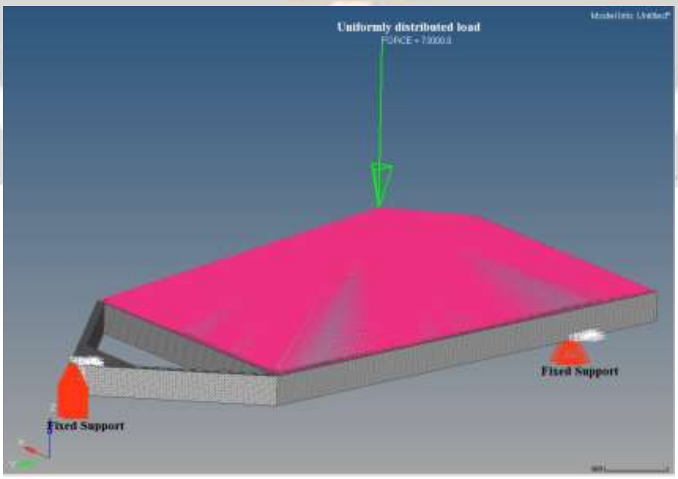

Fig-4.2: Constraints and forces applied on model in Hypermesh

4.3 Following are the results displayed for stress and deformation

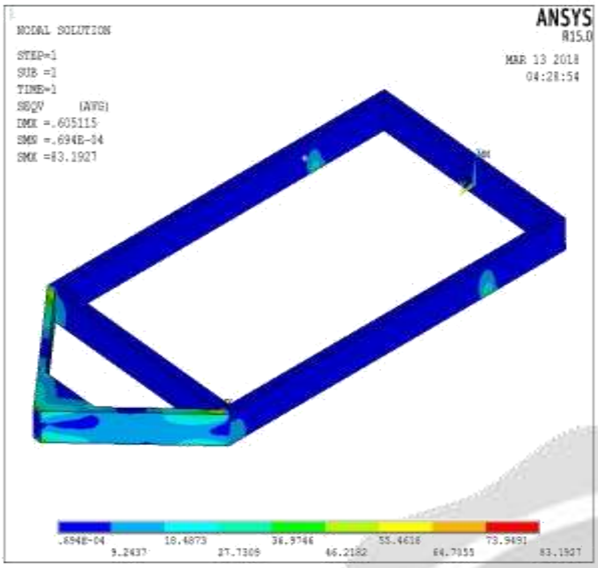

Fig-4.3.1: Von-mises stress for trolley

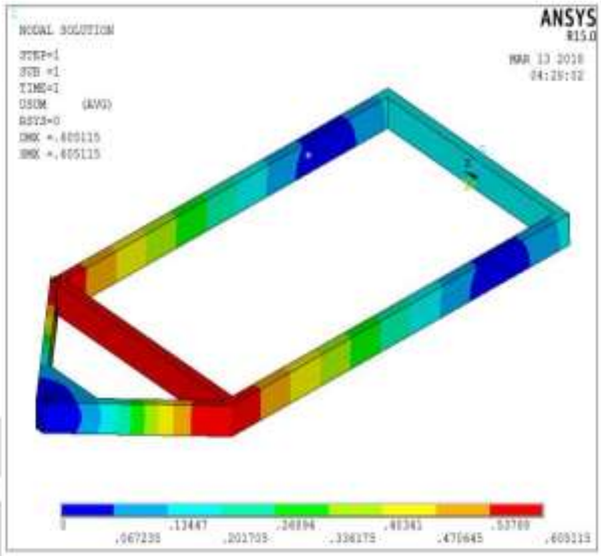

Fig-4.3.2: Displacement result for trolley

Stress value for trolley is 83.19 N/mm^2 which is well below the critical value. Hence, design is safe

From fig, deformation for trolley is 0.605 mm.

We can see, there's a scope for optimization. Material can be changed or removed from low stressed region and further be optimized.

4.4 Vibrational (Modal) Analysis of existing Tractor Trolley

Results for modal analysis:

Mode 1**:**

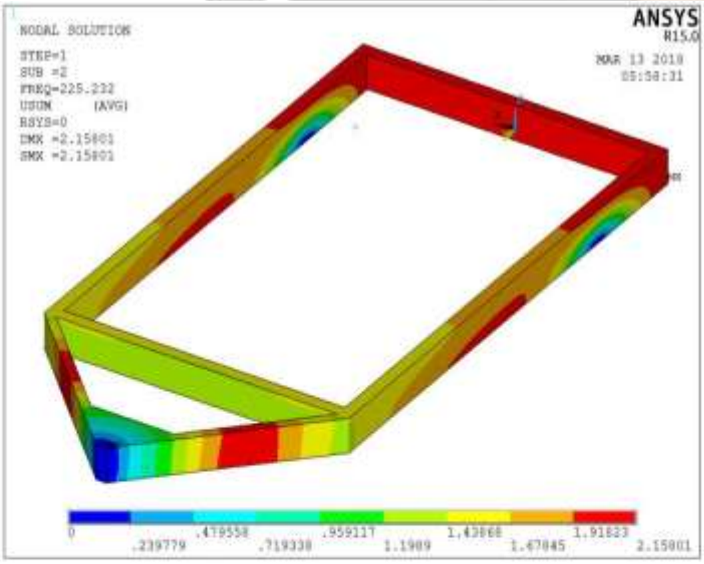

Fig-4.4.1: 1st mode shape of tractor trolley

The frequency of 1st mode is **95.41** Hz

Mode 2**:**

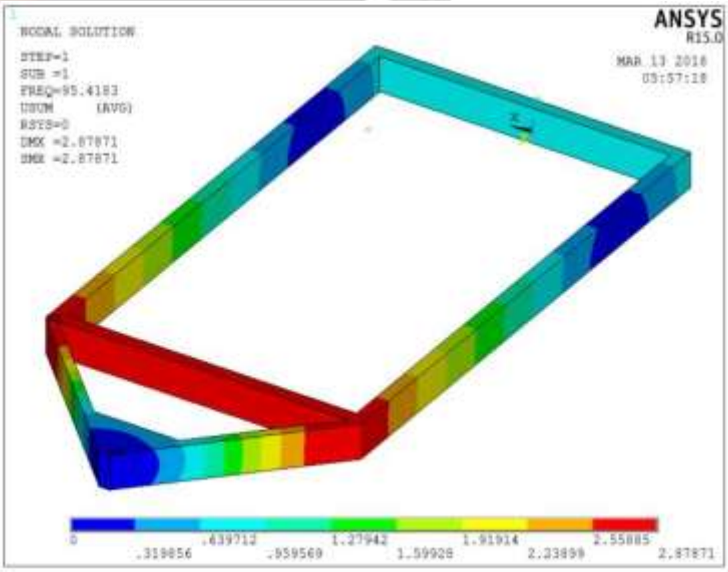

Fig-4.4.2: 2nd mode shape of tractor trolley

The frequency of 2nd mode is **225.23** Hz.

Mode 3**:**

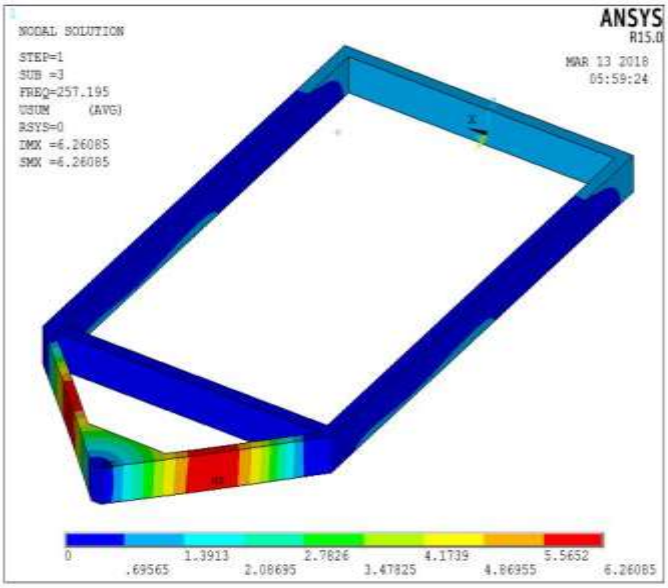

Fig-4.4.3: 3rd mode shape of tractor trolley

The frequency of 3rd mode is **257.19** Hz.

Mode 4**:**

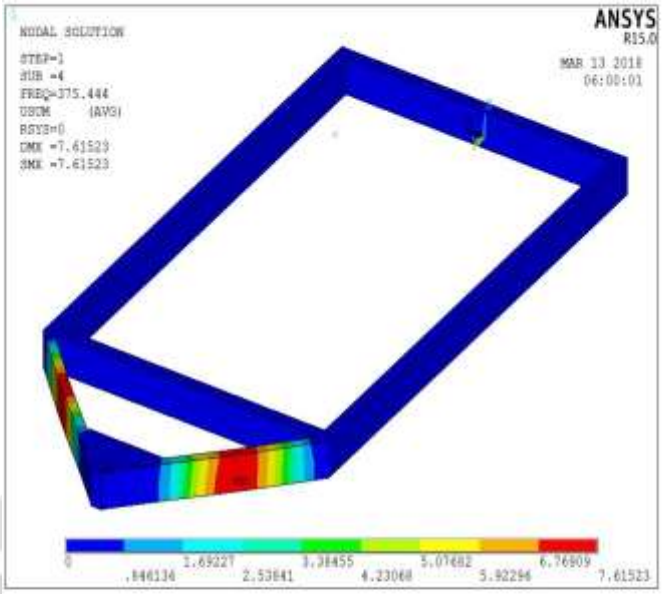

Fig-4.4.4: 4th mode shape of tractor trolley

The frequency of 4th mode is **375.44** Hz.

Mode 5**:**

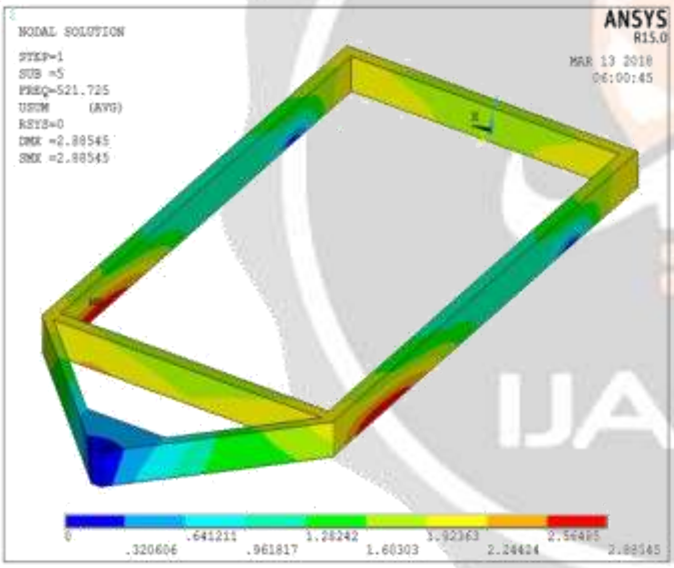

Fig-4.4.5: 5th mode shape of tractor trolley

The frequency of 5th mode is **521.72** Hz**.**

Mode 6**:**

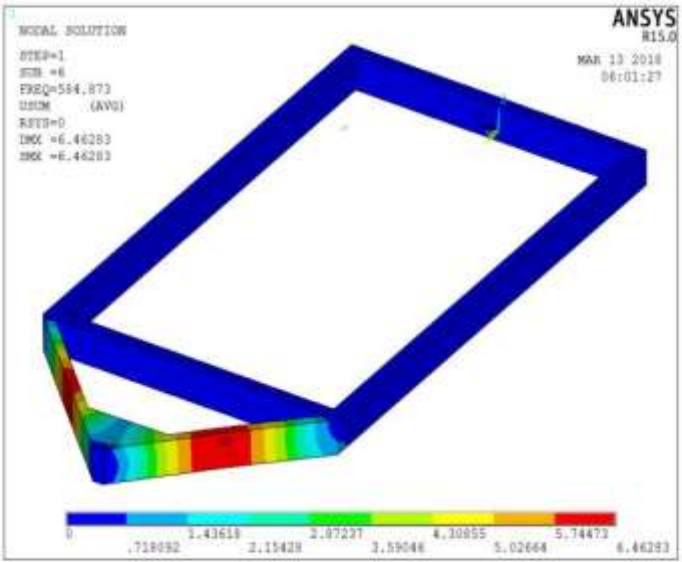

Fig-4.4.6: 6th mode shape of tractor trolley

The frequency of 6th mode is **584.87** Hz

Closure

Specifications of the tractor trolley were studied thoroughly. 3D model was drawn in CATIAV5 software and further analyzed taking force and boundary condition into consideration. It was observed that from von-mises stress plot, stresses are well below the critical value and there's a scope for changing material and removal of material from less stress concentrated regions. Future work will involve optimization of trolley by changing material composite (Glass fiber without compromising on strength and reducing weight will increase the efficiency of the vehicle.

4.5 Material optimization using composite material

Composite materials we can say hybrid materials which be aggregate as final material by using optimization technique. The composite material means the properties of two material is combined.

The word composite which signifies that two or more composite materials are combined to make third material. The main aspect is the macroscopic examination of a material carried out and components can be identified by the naked eye. Various materials can be added on a microscopic scale,
such as in alloying of metals, but the final material is, for all practical purposes, macroscopically homogeneous, for example the components cannot be differentiated by the naked eye.

Material Properties: Glass Fiber

Table-4.5: Mechanical properties for glass fiber

Property	Value
Young's modulus in x-direction, Ex	40300 MPa
Young's modulus in y-direction, Ey	6210 MPa
Young's modulus in z-direction, Ez	40300 MPa
Poisson's Ratio ,ν	0.2
Density, ρ	1.9x 10^{-9}tonne/mm3
Shear modulus in XY plane, Gxy	3070 MPa
Shear Modulus in YZ plane, Gyz	2390 MPa
Shear modulus in ZX plane ,Gzx	1550 MPa

4.6 Finite Element Analysis of Composite Tractor Trolley

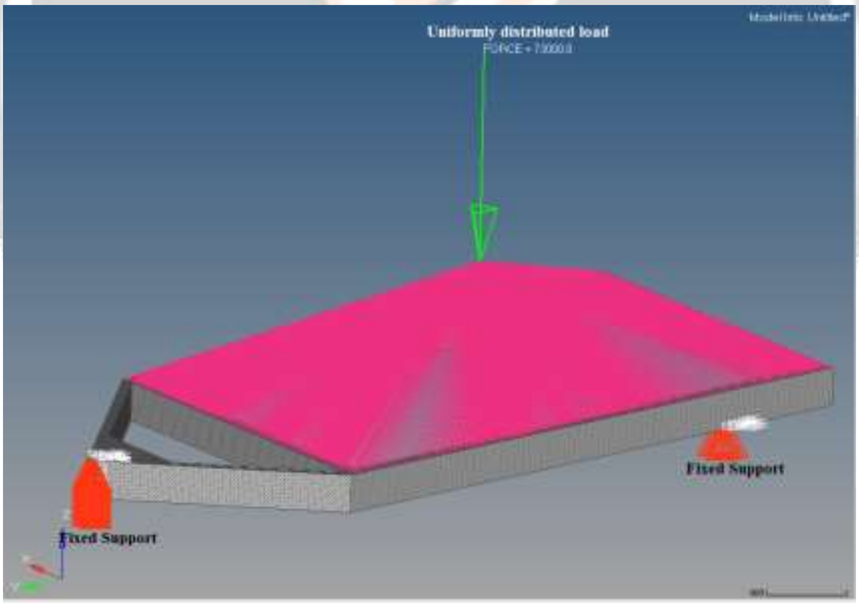

Fig-4.6: Meshed model for glass fiber tractor trolley and applied boundary conditions

4.7 Following are the results displayed for composite tractor trolley:

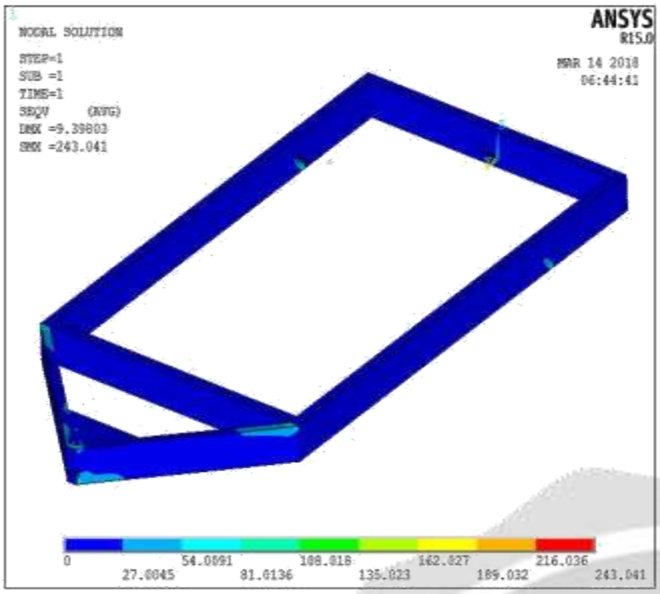

Fig-4.7.1: Von-mises stress for composite tractor trolley

Stress value for tractor trolley is 243.04 N/mm^{2}.

Stress value for trolley is 243.04 N/mm^{2} which is well below the critical value of glass fiber. Hence, design is safe.

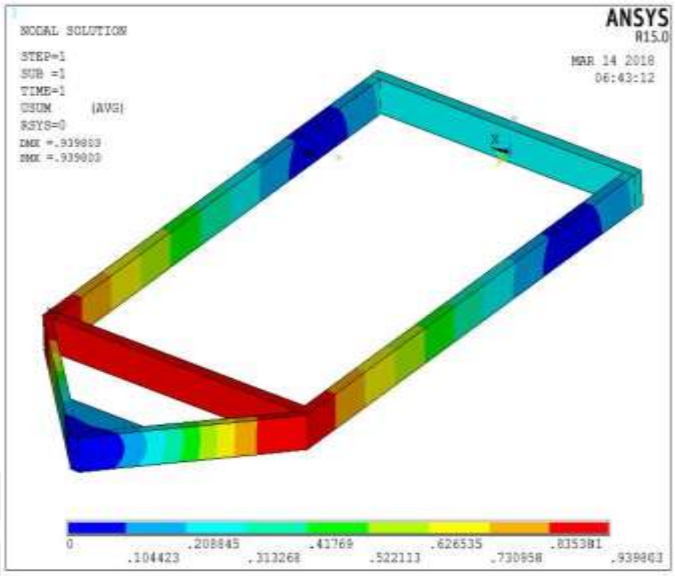

Fig-4.7.2: Displacement result for composite tractor trolley

From fig, deformation for composite tractor trolley is 0.939mm

4.8 Results for modal analysis of composite tractor trolley

Mode 1:

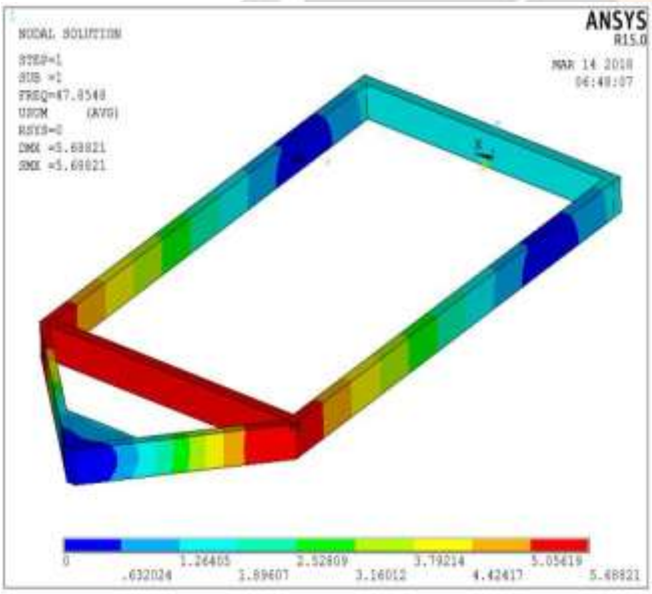

Fig.4.8.1:1st mode shape of composite tractor trolley

The frequency of 1st mode is **47.85** Hz.

Mode 2:

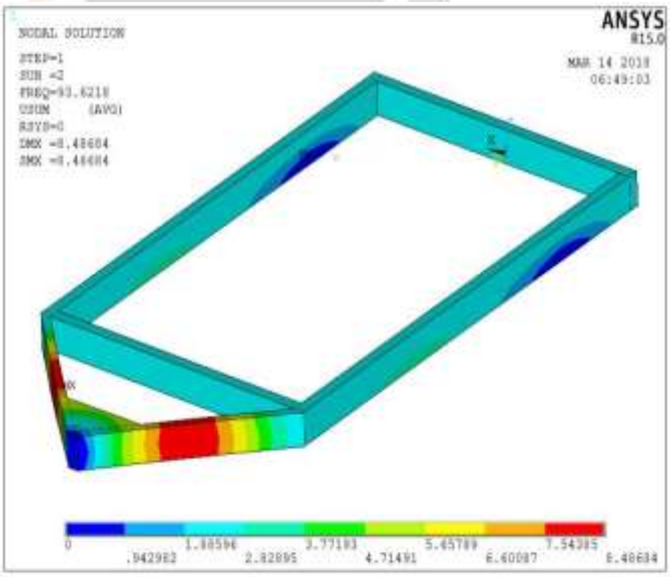

Fig.4.8.2: 2ndmode shape of composite tractor trolley

The frequency of 2nd mode is **93.62** Hz.

Mode 3:

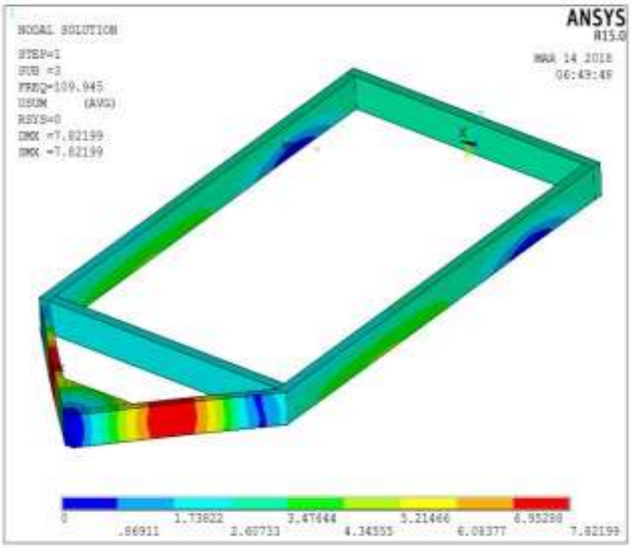

Fig.4.8.3: 3rdmode shape of composite tractor trolley

The frequency of 3^{rd} mode is **109.94** Hz.

Mode 4:

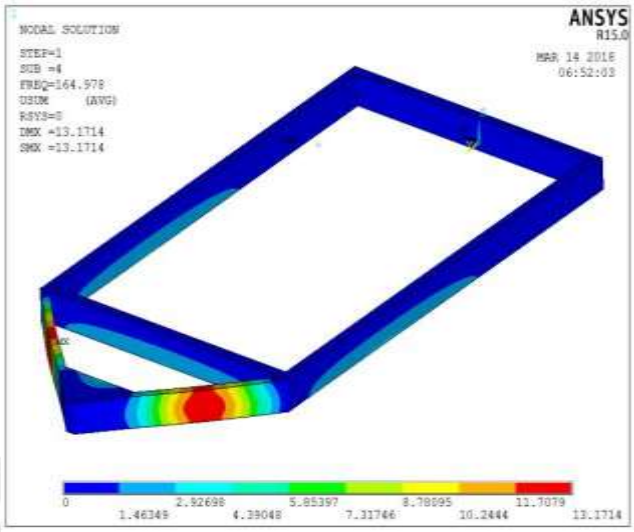

Fig.4.8.4:4th mode shape of composite tractor trolley

The frequency of 4^{th} mode is 164.97 Hz.

Mode 5:

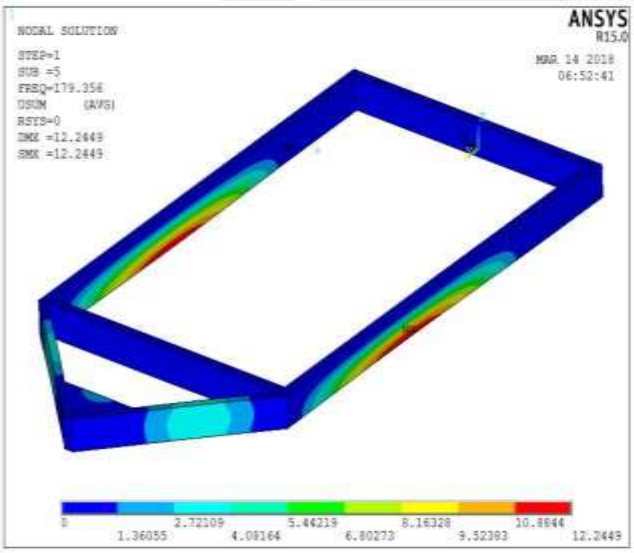

Fig.4.8.5: 5th mode shape of composite tractor trolley

The frequency of 5^{th} mode is 179.35 Hz.

Mode 6:

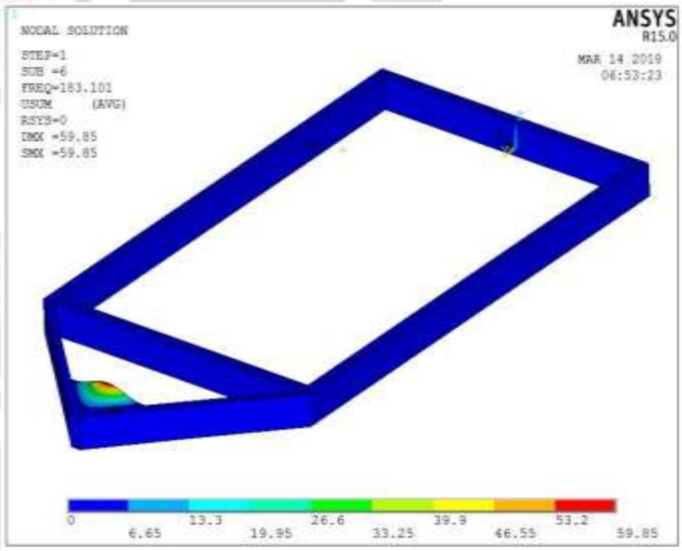

Fig.4.8.6: 6th mode shape of composite tractor trolley

The frequency of 6^{th} mode is 183.10 Hz.

5. RESULTS AND DISCUSSIONS

5.1 For Stress and Deflection

Cases	Total Deformation	Maximum Stress
Existing Steel Model	0.605 mm	83.19Mpa
Optimized model (Glass Fiber)	0.939mm	243.04 Mpa

Even though stress and deformation values are little high compared to existing steel but the values are well below the critical value. Hence, design is safe.

5.2 Comparison of Modal Analysis Results

Sr. No.	Mode	Frequency (Hz)	
		Steel	Glass Fiber
1	1	95.415	47.85
2	2	225.23	93.62
3	3	257.19	109.94
4	4	375.44	164.97
5	5	521.72	179.35
6	6	584.87	183.10

6. CONCLUSION

- The comparison, between modal analysis results of tractor trolley with Steel and Glass fiber, has been performed and it is summarized in table shown above.
- The comparison shows that the frequencies of vibration of Glass Fiber tractor trolley in six different modes are lower than that tractor trolley with Steel.
- This is due to the implementation of the Glass Fiber as the material. Glass Fiber is proven to be better in damping behavior. Hence the comparison shows that the main objective of this project work has been satisfied.
- Now these modal results will be validated experimentally by performing vibration testing of Glass Fiber tractor trolley prototypeon the FFT Analyzer.

7. REFERENCES

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Acknowledgements

Tools and Software Used: (As per requirement)

CAD: Catia v5

CAE: Hypermesh -14

Ansys -15