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Stress Optimization of Frame with Reinforcement Technique by FEA

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***Abstract*— Frame is the backbone of heavy vehicle, its function is to carry the maximum load safely under all operating conditions. This paper deals with the design and analysis of heavy vehicle frame. A model of existing heavy vehicle frame of Ashok Leyland has been generated in CATIA V5 and then imported in ANSYS workbench for analysis. This paper presents static structural and modal analysis of heavy vehicle frame of Ashok Leyland using reinforcement technique. Results obtained from analysis is compared with the original .This is required to enhance the load carrying capacity of vehicle.**

Keywords- ***FEA, Ladder frame, structural analysis, CATIA V5R19, ANSYS Workbench software***

I. INTRODUCTION

The frames used for automobiles have changed remarkably in terms of construction, weight and material used. It is the main backbone of the vehicle, which works just like the skeleton of bones inside the human body. A well-structured and properly built frame improves crash worthiness, passenger safety and weight efficiency. The frame of an automobile is the necessary element in the designing of a car, as it is the supporting base which bears the loads laid by the engine, suspension system, tires, wheels, drive train, and steering system. It is the most crucial element that gives strength and stability to the vehicle under different conditions. Automobile frames provide strength and flexibility to the automobile. Automotive frames are manufactured from steel. Aluminium is another material that has increasingly become popular for manufacturing these auto frames.

The different types of automobile frames includes-
1. Conventional frame
2. Integral frame
3. Semi-integral frame

1. **Conventional frame:** It has two long side members and 5 to 6 cross members joined together, with the help of rivets and bolts. The frame sections are used generally.

   a. Channel Section - Good resistance to bending
   b. Tabular Section - Good resistance to Torsion
   c. Box Section - Good resistance to both bending and Torsion

2. **Integral Frame:** This frame is used now a days in most of the cars. There is no frame and all the assembly units are attached to the body. All the functions of the frame carried out by the body itself. Due to elimination of long frame it is cheaper and due to less weight most economical also. Only disadvantage is repairing is difficult.

3. **Semi - Integral Frame**: In some vehicles half frame is fixed in the front end on which engine, gear box and front suspension is mounted. It has the advantage when the vehicle is met with accident the front frame can be taken easily to replace the damaged chassis frame. This type of frame is used in FIAT cars and some of the European and American cars.

Functions of the frame:

- To support the chassis components and the body
- To withstand static and dynamic loading without undue deflection or distortion

Loads acting on frame are-

- Weight of carriage unit.
- Torque reaction from both drive line and brakes.
- Driving thrust, Lateral forces, Brake force, and drag.

II. OBJECTIVE

The main objective of this paper is to carry out static and modal analysis of original frame and reinforced frame.

- To find out the support
- Selecting proper material.
- Importing and meshing of 3D model.
- Fixing the support and applying load
- Structural and Modal analysis of original and reinforced frame.

III. SPECIFICATIONS

The truck model is Ashok Leyland. It consists of C channel on side rails and have 8 cross members along the 2 side rails as shown in Figure 1 and 2 resp. Arrangement of Chassis: 2 side rails and 8 cross rails. These are located exactly at the location where the rear suspension is mounted at the side rails. It is to strengthen the chassis frame as the suspension mounting point is a highly stressed area. Fig 1 shows cross-section of main frame. Fig 2 shows cross section of main frame with reinforcement.

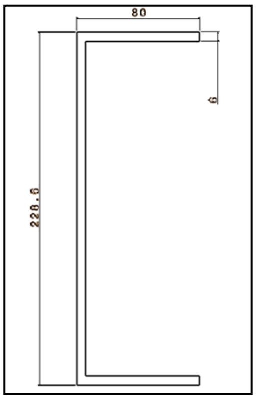

Fig 1 main frame

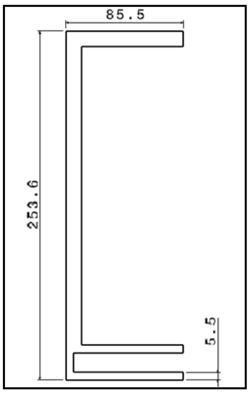

Fig 2 main frame with reinforcement

A. The material of the truck chassis is AISI 4130 alloy with quenched and tempered treatment.
B. Chemical Composition by weight, % = 0.30 C, 1.0 Cr, 0.90 Mn, 0.20 Mo
C. Modulus of Elasticity, E = 207 GPa
D. Mass Density = 7798 kg/m3
E. Yield Strength = 910 MPa
F. Tensile Strength = 1030 Mpa
G. The truck chassis used for the study has a payload of 16 ton.
H. The above load is applied in the form of pressure. The total area of application of load for original frame is 2122573.5mm^2.Total load applied is 16000×9.81=156960N. Total pressure applied is 156960/2122573.5=73947.69 Pa.
I. Total area of application of load for frame with reinforcement is 2195021.5 mm^2
J. The total Pressure applied =71477.96 Pa.

IV MODELLING OF FRAME

CAD model of frame is prepared in CATIA V5R19 and then structural analysis is done in ANSYS Workbench. Fig 3 shows original frame.Fig.4 shows a frame with reinforcement. Reinforcement is the technique of adding a cover plates on external side members at the highly stressed regions

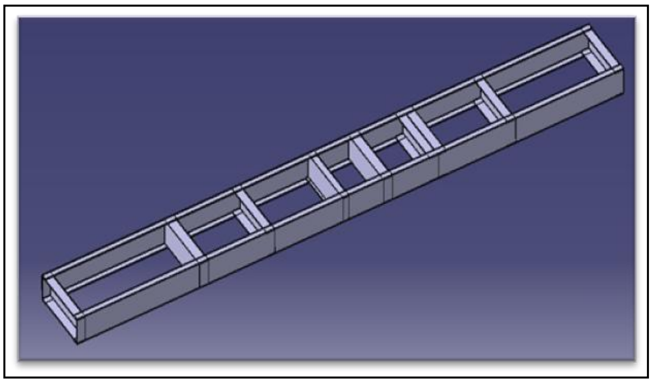

Fig.3.CAD model of original frame

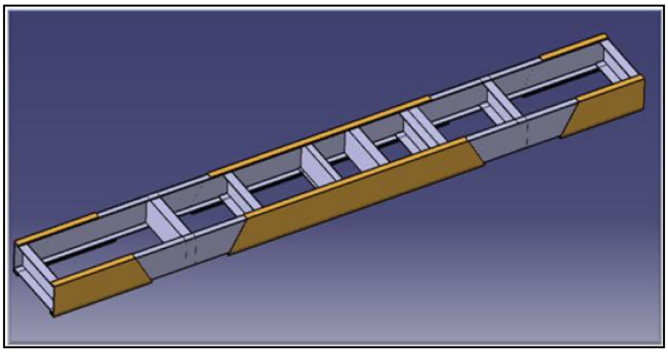

Fig.4.CAD model of reinforced frame

A. Static analysis of frame

In this part, the CAD model of chassis is discretized in ANSYS workbench software. The meshed model of main frame consist of 1, 43,231 elements and reinforced frame consist of 2, 21,625 elements. The meshed element type is tetrahedral.

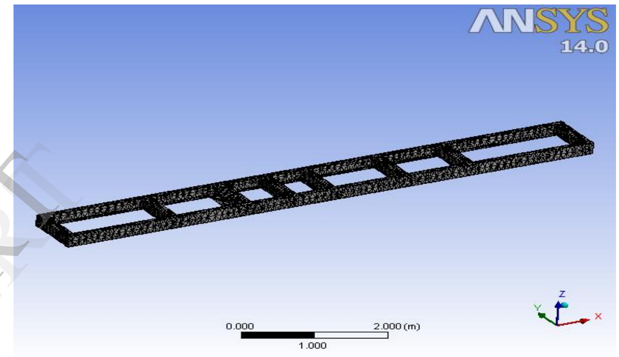

Fig. 5. Meshing of main frame

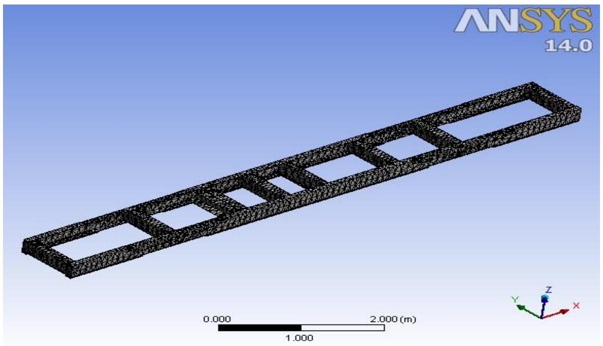

Fig.6. Meshing of reinforced frame

The meshed model of main frame and reinforced frame is shown in fig. 5 and fig 6. The meshed model has applied boundary conditions and load is applied on side rails. The load is applied on complete span of the side rail as uniformly distributed load. The cross rail are used to resist the horizontal lozenging of frame, hence load is not applied on the cross rails.

B. Modal analysis of frame

Boundary conditions for modal analysis were applied on meshed model original and reinforced frame. .Modal analyses of both were carried out in ANSYS WORKBENCH.

V RESULTS AND DISCUSSION

The stress and displacement behavior of frames has been studied.

A. Static analysis orignal frame

Analysis of original frame gives maximum deformation of magnitude 5.0671 mm (fig 8) at the front side cross-bar, which is less than thickness of the bar. The Von Misses stress magnitude of critical point is 295.21 MPa (fig 7) and the maximum shear stress magnitude is 132.79 MPa (fig 9) in a close proximity of front axle at the joint of side member and cross member. The values of stresses are well below the yield strength; hence we can say that our frame is safe for static condition.

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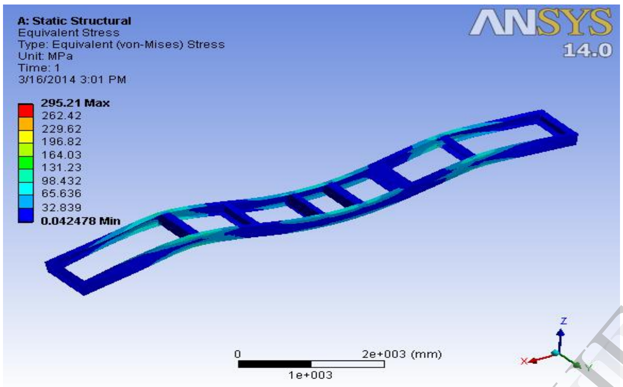


Fig. 7. Von Mises Stress Distribution in orignal frame

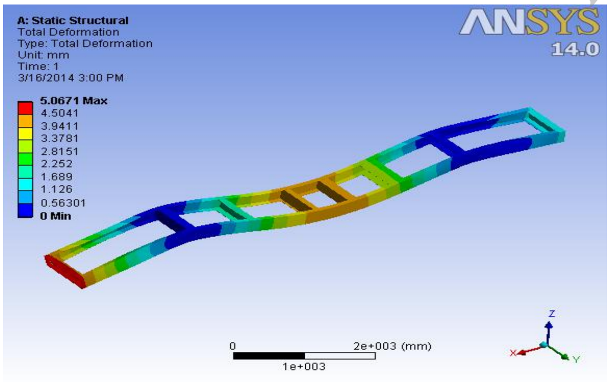


Fig. 8. Total Deformation of Orignal Frame

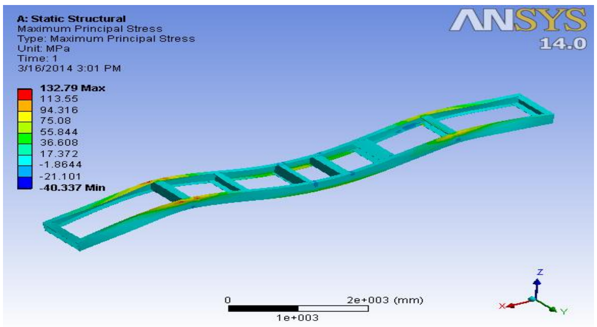


Fig. 9. Maximum Principal Stress in orignal frame

B. Static analysis Reinforced frame

Analysis of original frame gives maximum deformation of magnitude 4.8307 mm (fig 11) at the front side cross-bar, which is far less than thickness of plate. The Von Misses stress magnitude of critical point is 200.45 MPa(fig 10) and the maximum shear stress magnitude is 128.89 MPa(fig 12) in a close proximity of front axle at the joint of side member and cross member, which also less than yield strength of material. Hence, we can say that our material safer than original frame.

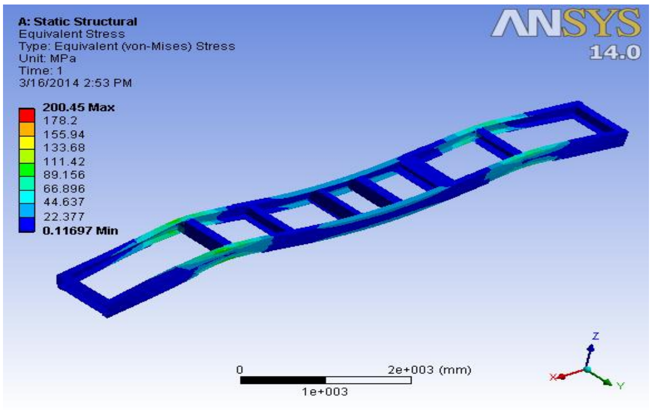


Fig. 10. Von Mises Stress Distribution in Reinforced frame

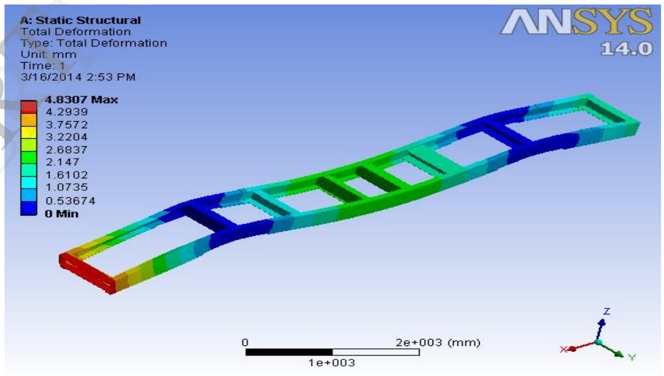


Fig. 11. Total Deformation of Reinforced Frame

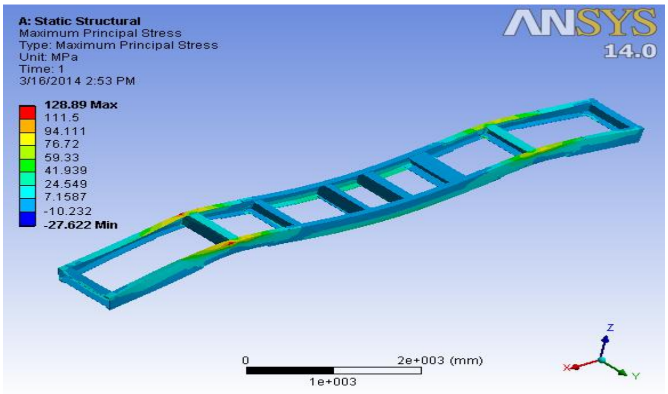


Fig. 12. Maximum Principal Stress in Reinforced frame

TABLE 1. STRUCTURAL ANALYSIS

Type	Main Frame	Reinforced Frame
Pressure(MPa)	0.07395	0.07148
Total Deformation (mm)	5.0671	4.8307
Von- Misses Stress(MPa)	295.21	200.45
Max Principal Stress	132.79	128.89

C Modal analysis of orignal frame

Frame forms the structural backbone of a commercial vehicle, when the truck travels along the road, the truck chassis is excited by dynamic forces caused by the road roughness, engine, transmission and more. Modal analysis using Finite Element Method (FEM) can be used to determine natural frequencies and mode shapes. After constructing finite element model of chassis and appropriate meshing with shell elements, model has been analyzed and first 6 frequencies that play important role in dynamic behavior of chassis, have been expanded. It is clearly depicts that number of modes increases with natural frequency. Also modes (or resonance) are purely depends on properties of material. Resonance determined from stiffness, mass, damping ratio and boundary condition.

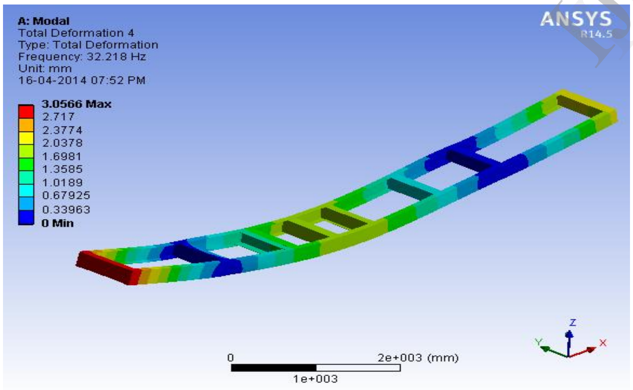


Fig. 13 First mode of frequency

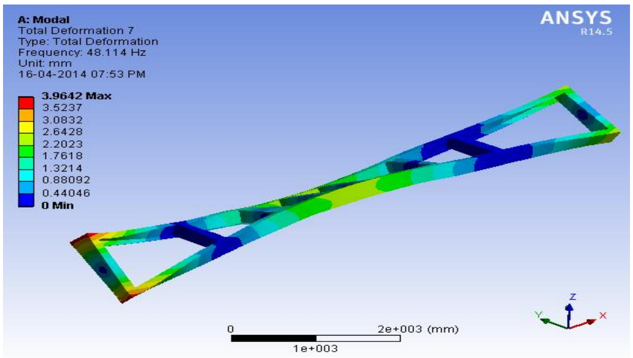


Fig 14 Sixth mode of frequency

D Modal analysis of Reinforced frame

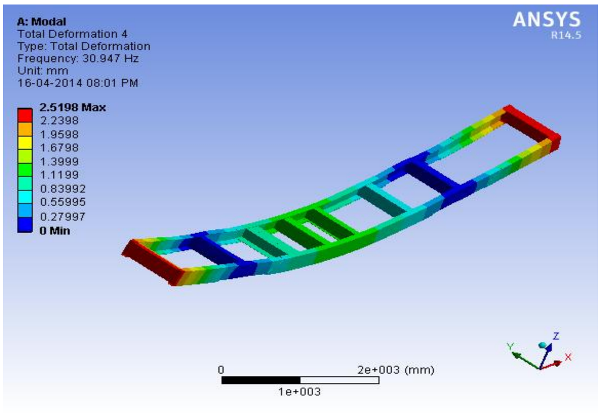
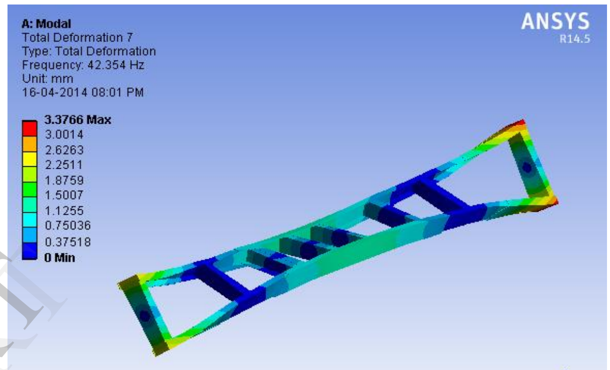


Fig. 15 First mode of frequency



The minimum frequency was found in first mode shape i.e.22.066 Hz and minimum deformation occurs in fourth mode shape at a frequency of 31 Hz. Frequency goes on increasing from first mode shape to last mode shape. The sixth mode is the torsion mode at 42.354 Hz with maximum translation at both ends of the chassis.

TABLE 2. MODAL ANALYSIS

Mode number	Natural frequency (Hz)	
	Main Frame	With reinforcement
1	23.824	22.066
2	29.360	27.53
3	32.218	30.947
4	32.817	31.000
5	38.779	34.222
6	48.114	42.354

VI CONCLUSION

In this project, modeling is done in CATIA V5R17. Importing and meshing of CAD model has been done in ANSYS WORKBENCH. Static and modal analysis of original and reinforced frame has been done in ANSYS WORKBENCH. Based on results obtained from analysis, it is concluded that

- Maximum stress and maximum displacement in reinforced frame is lower than original frame
- Reinforced technique decreases the deformation of frame by 4.7% and stress by 31.42 %.
- In order to obtain same deformation or stress level, we can apply additional load of 600 kg on the frame. So reinforced frame increases the load carrying capacity with same factor of safety as of original frame.
- Modes are inherent properties of material and can be changed by varying the properties of material.
- For reinforced frame basic natural frequency is lower than original frame, it can be overcome by selecting the appropriate material as per need.
- The factor of safety obtained for reinforced frame is far below the critical factor of safety, still there is scope to optimize the dimension of frame and reinforcement in order to reduce the cost.

REFERENCES

[1] Static Load Analysis Of Tata Ace Ex Chassis And Stress Optimisation Using Reinforcement

[2] Static and Modal Analysis of Chassis by Using Fea, Dr.R.Rajappan, M.Vivekanandhan.

[3] Vijaykumar V Patel1and ,R. I. Patel, "Structural analysis of a ladder chassis frame" World Journal of Science and Technology 2012, 2(4):05-08ISSN:2231–2587

[4] Monika S. Agrawal, Md. Razik "Finite Element Analysis Of Truck Chassis" International Journal Of Engineering Sciences & Research Technology December, 2013] Issn:2277-9655p.G.No.76-85

[5] M. Ravi Chandra1, S. Sreenivasulu, Syed Altaf Hussain "Modeling and Structural analysis of heavy vehicle chassis made of polymeric composite material by three different cross sections" International Journal of Modern Engineering Research (IJMER) Vol.2, Issue.4, July-Aug. 2012 pp-2594-2600