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STRUCTURAL AND MODAL ANALYSIS OF A LADDER FRAME CHASSIS

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ABSTRACT

Automobile chassis is an important load bearing member which play an important role of seating an automobile body. Chassis is the most decisive element that gives strength and stability to the vehicle under different conditions. Also, it should be rigid enough to bear the shock, twist, vibration and other stresses to which it is exposed while vehicle is moving on road. Maximum stress, maximum equilateral stress and deflection are important criteria for the design of the chassis. This paper is the work done towards the study of deformation, natural frequency and stress induced in an automotive chassis of Ashok Leyland Vikings model under maximum load for different cross-section of cross members namely C, I, and Rectangular Box (Hollow) type cross sections. The chassis is modelled in SOLIDWORKS and FEA is done on the modelled chassis using the ANSYS Workbench.

Keywords: chassis, deformation, natural frequency, cross member, von-mises stress.

INTRODUCTION

The French term 'Chassis' was at first used to mean the fundamental structure of the vehicle. A ladder Chassis is the simplest and oldest frame used in modern vehicular construction. It was originally taken from "horse and buggy" style carriages as it provided sufficient strength for holding the weight of the components. So, automotive chassis is a skeletal frame which provides support to the various vehicle components. The components of the vehicle like transmission system, engine, axles, wheels, suspension, controlling systems and some electrical system are affixed on the chassis frame. Frame should withstand shock, twist, vibrations and other stresses to provide comfort and safety to the occupants of the vehicle. Automotive frames are usually made from steel alloys. Conferring to the structure of chassis, the body of a vehicle is flexibly moulded at the time of manufacturing. Automobile chassis confirms less noise, vibrations and harshness throughout the vehicle. Magnitude of stress can be used to predict the lifespan of the bus chassis. The accuracy of prediction of life of truck chassis is depending on the result of its stress analysis.
Chassis Specifications:

Wheel Base (b) = 5334 mm
Rear Overhang (c)= 3182 mm
Front Overhang (a)= 1584 mm
Length = 10100 mm
Width = 2440 mm

METHODOLOGY

For analysing the stress and deformation of the frame, the frame of the bus is modelled with the help of solid modelling software package SOLIDWORKS. This model is then imported into the ANSYS workbench. Load on each longitudinal member is taken as half the total weight acting on chassis. Eight fixed support are given at the point of suspension mounts. After that, for the three different cross-section - C, I, and rectangular box (Hollow type) of cross members, max deflection, von-mises stress and natural frequency with different mode shape are

determined keeping the longitudinal members same (C section). Also, the weight of cross members is kept constant.
Basic Design Calculations for Chassis Frame
Capacity of Bus = 60 persons
(Assume avg. weight as 65 kg)
Capacity of Bus = 60*65 kg = 3900 kg
Capacity of Bus with overload and luggage
 = 1.25*3900 kg
= 4875kg
Weight of Body and Engine = 2000 kg
Total Load acting on chassis = 6875*9.81 N
= 67443.75 N

Chassis has two longitudinal members. Load acting on each member will be half of the total load acting on chassis. Load acting on one longitudinal member= 67443.75/2 N
= 33722 N

For validation of FEM model consider an overhang C-section beam subjected to uniformly distributed load.
Deflection of the beam at mid-point:

$$y = \frac{Wx(l-x)}{24EIL} \left[x(l-x) + l^2 - 6c^2 \right]$$

Where,
y   = Deflection in the beam
W   = Gross vehicle Weight
l   = wheel base
E   = Young's modulus
I   = Area Moment of inertia
L   = Total length of chassis
c   = Overhang distance
x   = Point of max deflection
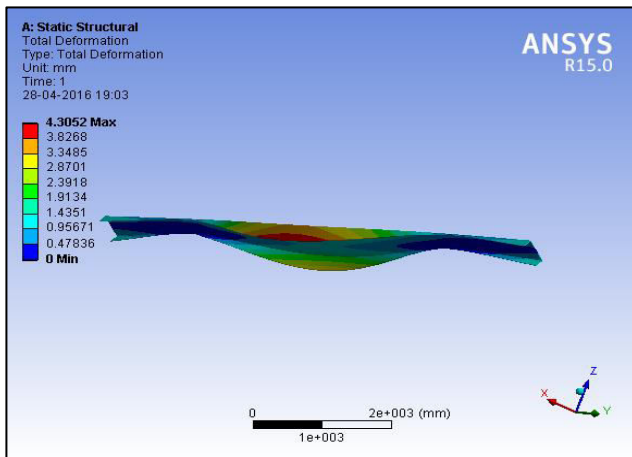
This gives, y = 4.1 mm

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Figure-1. Deformation of beam.

The above Fig. shows the deformed shape of the beam. The deflection obtained by FEM is4.3 mm

Deflection obtained by Analytical method =4.1mm

Error = [(4.3-4.1) / (4.1)] x 100 = 4.87%

As error is within acceptable limit, so we can conclude that mesh density and type of element selected are capable of giving correct results for whole chassis.

FEM ANALYSIS OF MODEL

Modeling

Chassis is modelled using SOLIDWORKS which is shown in the figure given below
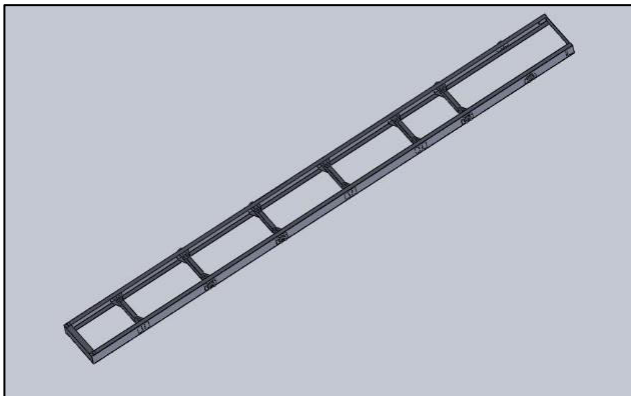
Figure-2. Chassis CAD model.

Different Cross-members are modelled keeping weight as a constant parameter in the solid works.
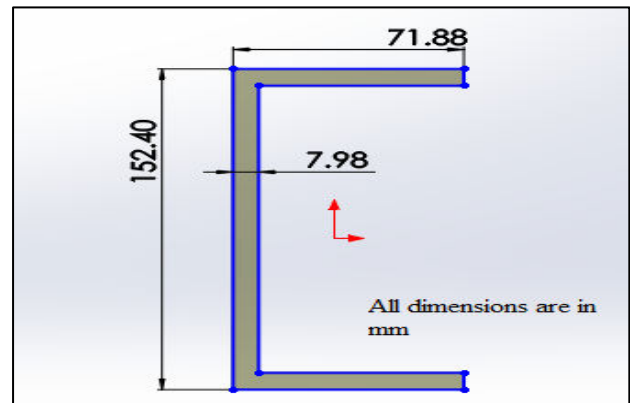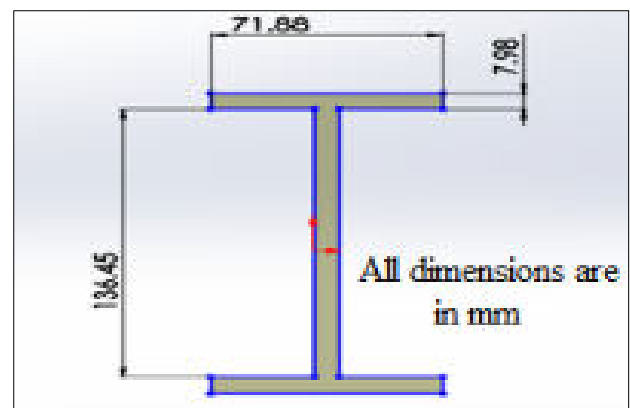

Figure-3. C-section.
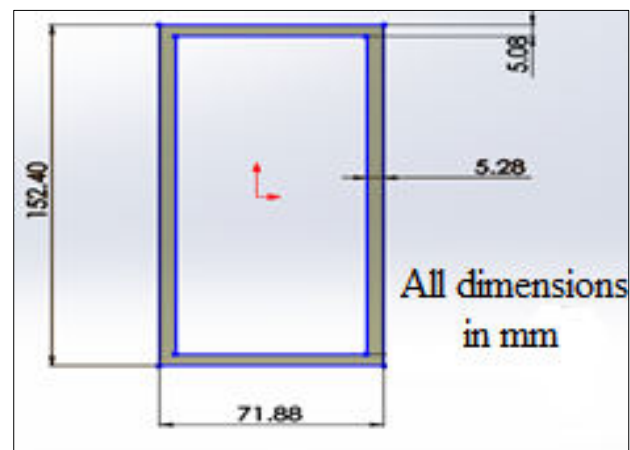

Figure-4. I-section.

Figure-5. Rectangular hollow-section.

Modal and Structural analysis is done using ANSYS Workbench by importing CAD model from the SOLID WORKS. Tetrahedral meshing is done on the geometry. Body Sizing is also given to refine the mesh. Named selection is given to the different chassis component. Then different boundary conditions are applied on the geometry in order to get deformation, equivalent stress, natural frequency and mode shapes.

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RESULTS

All the Cross-member are analysed using ANSYS Workbench for von-mises stress, maximum deformation, mode shapes and natural frequency. The results obtained are shown as below:

1. Von-Mises stress

Equivalent stress (Von-mises) obtained for all the three chassis with different cross-member by applying the loading conditions are given as
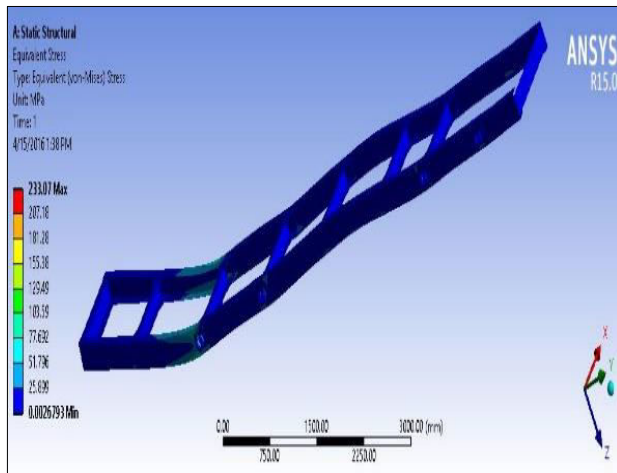

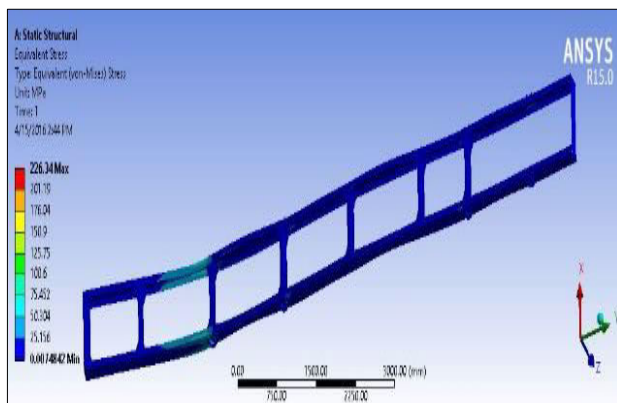**Figure-6.** C-Sec von-mises stress.
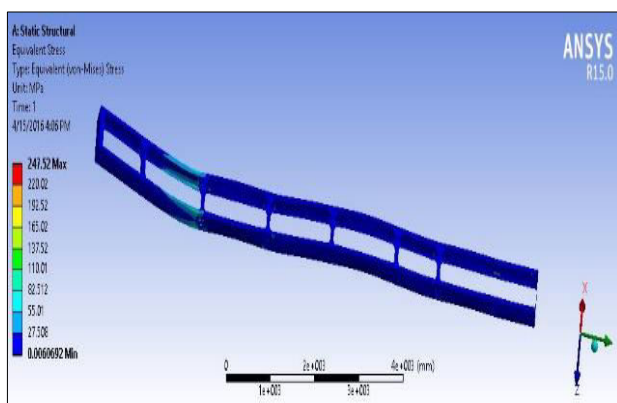

Figure-7. I-Sec von-mises stress.

Figure-8. Rectangular-section von-mises stress.

2. Maximum deformation
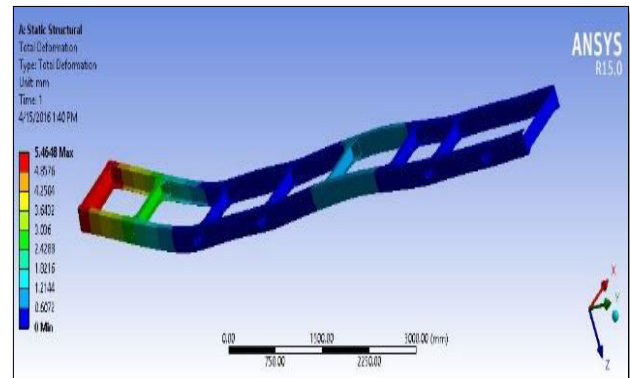

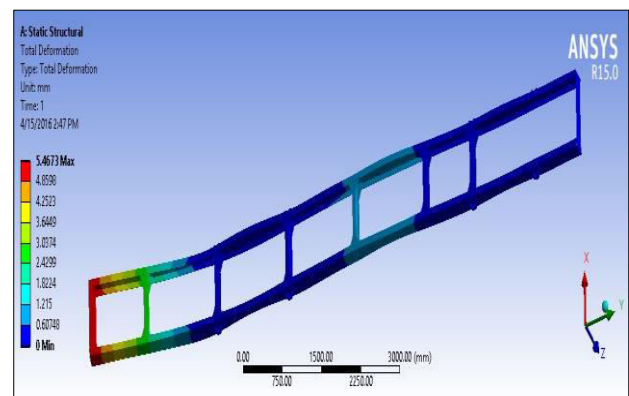**Figure-9.** C-Section deformation.

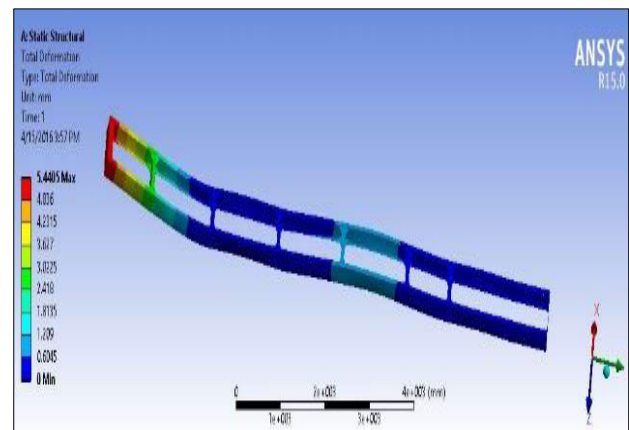**Figure-10.** I-Section deformation.

Figure-11. Rectangular - Section deformation.

Table-1. Deformation and von-mises stress.

S. No.	Cross-section	Deformation (mm)	Von-mises stress (MPa)
1	C-Type	5.465	233.07
2	I-Type	5.467	226.4
3	Rectangular Box(Hollow Type)	5.440	247.5

From above table it is clear that minimum stress is generated in case of I section and maximum in case of rectangular hollow section. This is because the thickness of rectangular section has been decreased to keep the weight constant. However, if thickness is kept constant and weight increased than rectangular section outperforms the other two types of cross sections.

The permissible deflection span ratio is 1/300. For the chassis taken for analysis, with total span 10100mm, maximum deflection can be 33.67mm. Thus, the deflection is within the permissible limits and almost same for all the three cross sections considered for analysis.

3. RESULTS FOR MODEL ANALYSIS

All the three chassis with different cross members are analysed for free vibration case to determine the natural frequency, deformation and mode shape. Some results obtained are shown below:
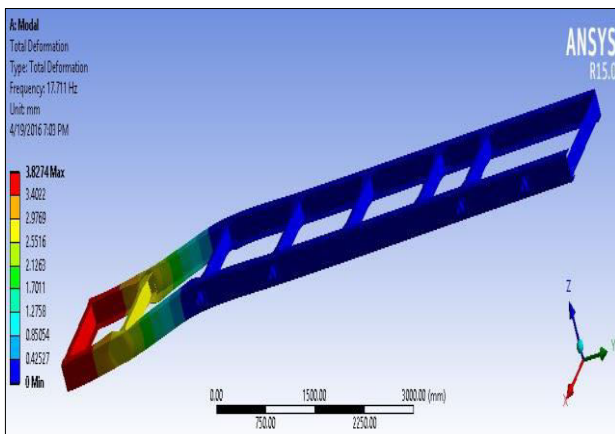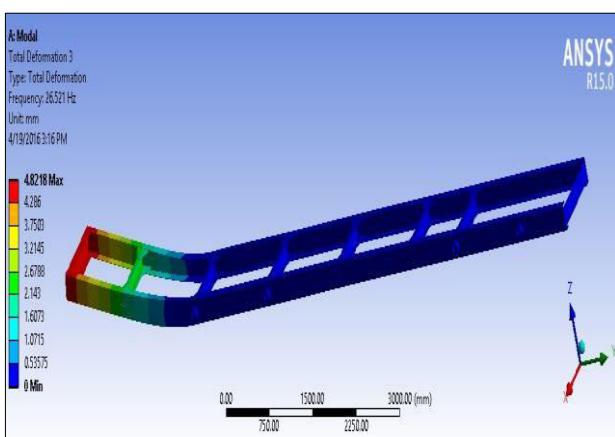

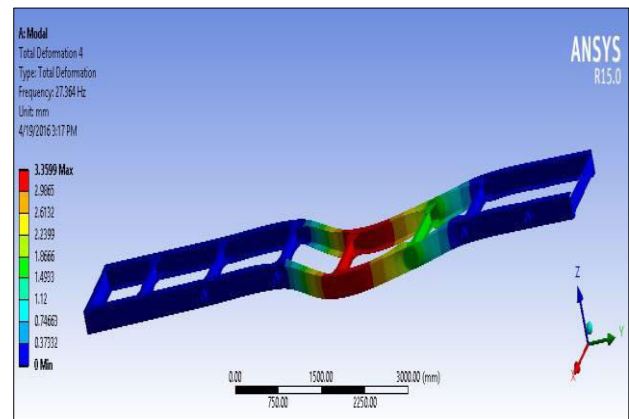**Figure-12.** I-section 1st mode shape.

Figure-13. I-section 2st mode shape.

Figure-14. I-section 3rd mode shape.

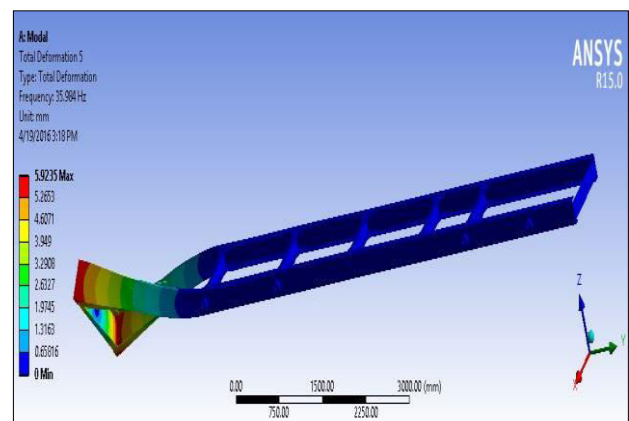
Figure-15. I-section 4th mode shape.
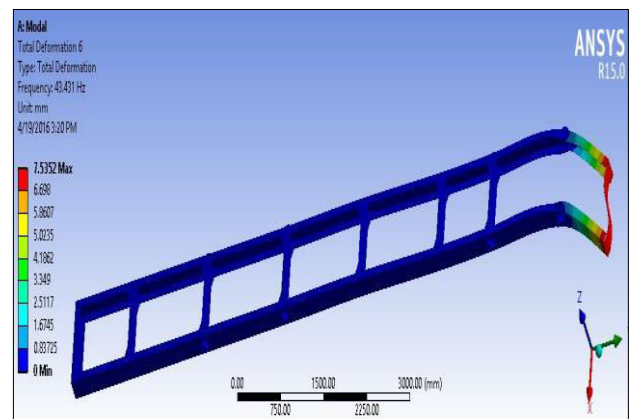
Figure-16. I-section 5th mode shape.

Table-2. Natural frequencies.

S. No.	Cross-section	Natural frequencies (Hz)			
		1	**2**	**3**	**4**
1	C - Type	17.51	26.52	27.3	35.5
2	I - Type	17.08	26.3	26	35.2
3	Rect. Box (HollowType)	17.71	26.6	27.6	38.96

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Table-3. Deformation for natural frequency.

S. No.	Cross-section	Deformation for natural Frequency(mm)			
		1	2	3	4
1	C - Type	3.83	4.82	3.35	5.95
2	I - Type	3.80	4.81	3.35	5.91
3	Rectangular Box(Hollow Type)	3.82	4.8	3.36	5.82

CONCLUSIONS

From the static structural and modal analysis done on the Ashok Leyland Viking ladder chassis it can be concluded that for constant weight, chassis with I section has highest strength as minimum stress is generated in it and rectangular section is better for torsional stiffness as deflection is minimum for it. The fundamental natural frequency of the original chassis is 17.51Hz. Also, fundamental natural frequency and mode shapes of chassis with different cross members are almost same, which means changing the cross section of cross members doesn't have any significant effect on natural frequencies and mode shapes. Thus, the strength can be improved by using I section instead of C section for cross members of the chassis used for analysis.

REFERENCES

Kurisetty, Sukumar and Gupta. Parametric Study of Ladder Frame Chassis Stiffness. SAE Technical Paper 2016-01-1328.

Chuaymung, Benyajati, Olarnrithinun S. 2015. Structural Strength Simulations of Ladder Frame Chassis for Light Agriculture Truck. SAE Technical Paper 2015-01-0090.

N.Sivanagaraju, M.V.H Sathish Kumar, U.koteswarao. ModelingAnd Analysis of an Innova Car Chassis Frame by Varying CrossSection. IJERT 2278-0181.

Abhishek Singh, Vishal Soni, Aditya Singh. Structural Analysis of Ladder Chassis for Higher Strength. IJERT e-ISSN 2250-2459.

Kamlesh Y. Patil, Eknath R. Deore. Stress Analysis of Ladder Chassis with Various Cross Sections. IOSR-JMCE e-ISSN 2278-1684.

Hemant B. Patil, Sharad D. Kachave, Eknath R. Deore. Stress Analysis of Automotive Chassis with Various Thicknesses. (IOSR-JMCE) e-ISSN 2278-1684.

K.Rajasekar, Dr.R.Saravanan. Literature Review on Chassis Design of On-Road Heavy Vehicles. IJISET e-ISSN 2348-79.

Vijaykumar V Patel and R.I Patel. 2012. Structural analysis of a ladder chassis frame. World Journal of Science and Technology. ISSN:2231-2587.

Monika S. Agrawal, Md. Razik. Finite Element Analysis of Truck Chassis. IJESRT ISSN:2277-9655.