ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Structural Analysis of Chassis Frame and Modification for Weight Reduction

S.Prabakaran[*1], K.Gunasekar[2]
[*1,2] Department of Mechanical Engineering, PSNA College of Engineering and Technology, Dindigul, India
prabakaron@gmail.com

Abstract

Chassis is an important part of automobile. The chassis serves as a frame for supporting the body and different parts of automobile. Also, it should be rigid enough to withstand the shock, twist, vibration and other stresses. Along with strength, an important consideration in chassis design is to have adequate bending stiffness for better handling characteristics. So, maximum stress, maximum equilateral stress and deflection are important criteria for the design of the chassis. This report is the work performed towards the optimization of the automotive chassis with constraints of maximum shear stress, equivalent stress and deflection of chassis under maximum load. Structural systems like the chassis can be easily analysed using the finite element techniques. A sensitivity analysis is carried out for weight reduction. So a proper finite element model of the chassis is to be developed. The chassis is modelled in SOLID WORKS. FEA is done on the modelled chassis using the ANSYS Workbench.

Keywords: Chassis Frame, Weight Reduction.

Introduction

Definition of a Chassis

The chassis is the framework that is everything attached to it in a vehicle. In a modern vehicle, it is expected to fulfil the following functions:

- Provide mounting points for the suspensions, the steering mechanism, the engine and gearbox, the final drive, the fuel tank and the seating for the occupants;
- Provide rigidity for accurate handling;
- Protect the occupants against external impact.

While fulfilling these functions, the chassis should be light enough to reduce inertia and offer satisfactory performance. It should also be tough enough to resist fatigue loads that are produced due to interaction between the driver, engine, power transmission and road conditions.

Ladder Chassis:

Ladder chassis is considered to be one of the oldest forms of automotive chassis or auto mobile chassis that is still used by most of the SUVs till today. As its name connotes, ladder chassis resembles a shape of a ladder having two longitudinal rails inter linked by several lateral and cross braces.

Literature Survey

There are two main objectives, which involves on the development of truck chassis. Firstly, the appropriate static and dynamic characteristics of the existing chassis have to be determined. Secondly, structural development process in order to achieve high quality of the product. There are many factors involve and must take into account, which can affect on the vehicle rolling, handling, ride stability and etc. Today, there are many researches and development program available in the market especially by the international truck manufacturers, which are very much related to this study. Therefore, there are several technical papers from the 'Engineering Society for Advancing Mobility Land Sea Air & Space' (SAE) and some other sources which are reviewed and discussed in this chapter.

Truck Chassis Research

Dave Anderson and Greg developed a Multi-Body Dynamic Model of the Tractor-Semitrailer for ride quality prediction. The studies involved representing the distributed mass and elasticity of the vehicle structures e.g. frame ladder, the non-linear behaviour of shock absorbers, reproduce the fundamental system dynamics that influence ride and provide output of the acceleration, velocity and displacement measures needed to

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

compute ride quality. There were three main factors contributed in this study. Firstly, the author had come out with the development of an ADAMS multi-body dynamics model for use as a predictive tool in evaluating ride quality design improvement. The model includes frame, cab and model generated from finite element component mode synthesis. Second, the construction and correlation of the model has been developed and followed a multi-step process in which each of the major sub-systems were developed and validated to test results prior to corporation in the full vehicle model. Finally, after a series of refinements to the model, the next steps were implemented to obtain an acceptable degree of correlation. The author had managed to evaluate the model's ability to predict ride quality by using accelerations measured in the component, which were then processed through an algorithm to compute an overall ride comfort rating.

In order to study the frame flexibility, the author had come out with the truck frame modelled using the Finite Element Method (FEM) and its modal properties have been calculated. Numerical results were presented for the truck, including power spectral densities and root mean square values of the vehicle dynamic response variables.

Chassis Material Description

"C" Channel And Its Dimensions

TYPE: DIN 17100 ST 52-3 N
HIGH TENSILE PLATE

Nearest Euipvalent: *BS4360 Gr50 ASTM A572-50 JIS G3106 SM50*

Characteristic

Steel grade ST 52-3 N is a low carbon, high strength structural steel which can be readily welded to other weldable steel. With its low carbon equivalent, it possesses good cold-forming properties. The plate is supplied in normalized or control-rolled condition.

Application

Machinery parts, mobile equipment, crane, boom, chassis, buildings, bridges and most structural activities.

Chassis frame:

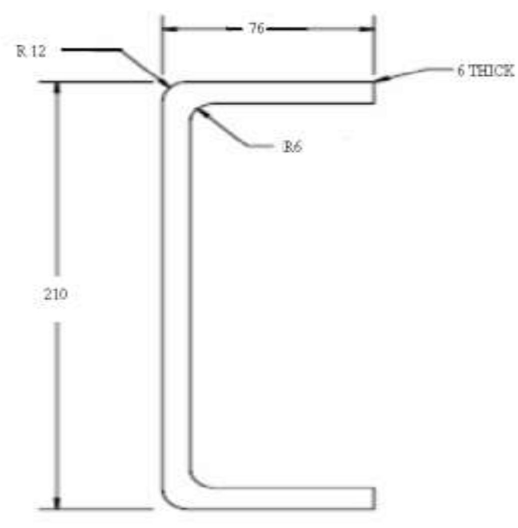
Our basic model: Eicher
Model no. = 11.10 ("C" channels)

Modelling of Chassis

FE analysis of Existing Chassis Frame

For carrying out the FE Analysis of chassis as per standard procedure first it requires to create merge part for assembly to achieve the connectivity and loading and constraining is required to be applied also idealization of parts is done on structure this will lead to faster analysis since the connected structure will not be physical but it will be a sketch with mechanical properties of mechanical structure. Procedure is followed in this section.

A. Cross Section of Main Frame
h = 210 mm, b = 76 mm, t = 6 mm



EXISTING SECTION

Basic Calculation For Chassis Frame
Model No. = 11.10 (Eicher E2)

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

Side bar of the chassis are made from "C" Channels with 210mm x 76 mm x 6mm

1. Front Overhang (a) = 935 mm
2. Rear Overhang (c) = 1620 mm
3. Wheel Base (b) = 3800 mm

Material of the chassis is St 52
E = 2.10 x 105 N / mm2
Poisson Ratio = 0.31
Radius of Gyration R=105 mm
Capacity of Truck = 8 ton
= 8000 kg
= 78480 N
Capacity of Truck with 1.25% = 98100 N
Weight of the body and engine = 2 ton
= 2000 kg
= 19620 N

Total load acting on chassis
= Capacity of the Chassis + Weight of body and engine
= 98100 + 19620
= 117720 N

Chassis has two beams. So load acting on each beam is half of the Total load acting on the chassis.

Load acting on the single frame= 117720/2
=58860N/Beam

Now we can calculate the maximum shear stress and maximum deflection using the equation given below.

$$\frac{M_e}{I} = \frac{\sigma}{y} = \frac{E}{R}$$

a. Deflection of chassis

$$Y = \frac{wx\ b-x}{24EI}\left[x\ b-x+b^2-2(c^2+a^2)-\frac{2}{b}\ \ c^2x+a^2(b-x)\right]$$

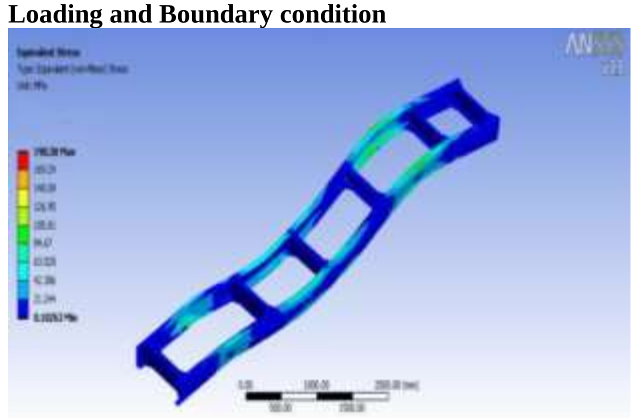
= 2.85 mm
That is within safe limit according deflect ion span ratio

Finite Element Approach

CAD Model of Existing Chassis Frame

FE analysis of modified cross section
Case 1 (227.5 mm x 76 mm x 5.5 mm)

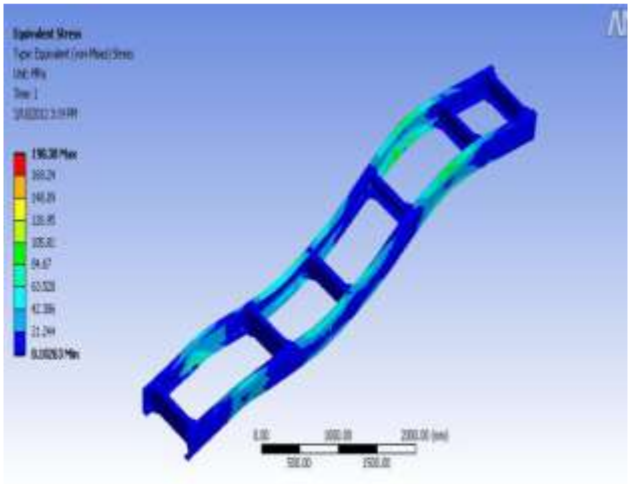
Loading and Boundary condition



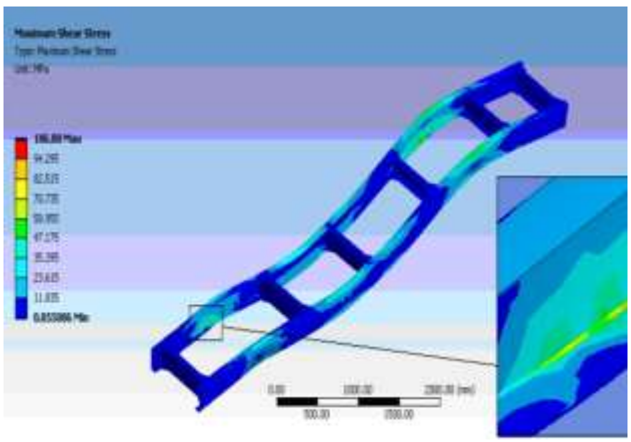
Results

The Von Misses stress magnitude of critical point is 190.38 MPa and the maximum shear stress magnitude is 106.08 MPa.

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852



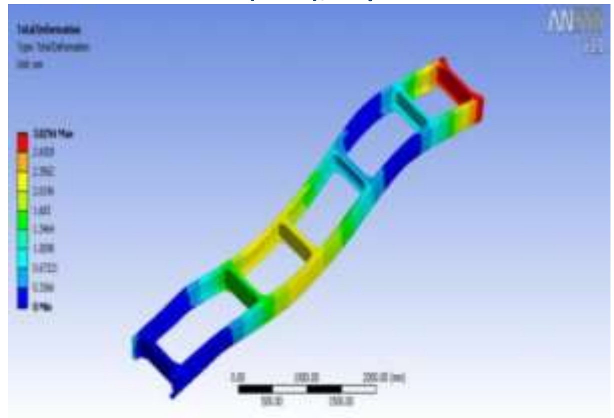
Equivalent stress in chassis frame



Maximum shear stress in chassis frame

Displacement

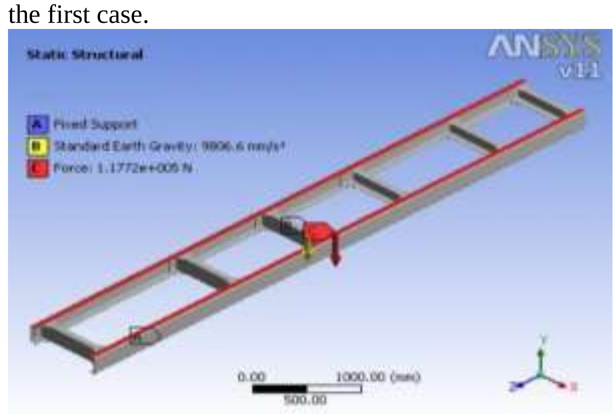
The displacement of chassis and location of maximum displacement is shown in Figure. The magnitude of maximum displacement is 3.0294 mm.



Displacement in chassis frame

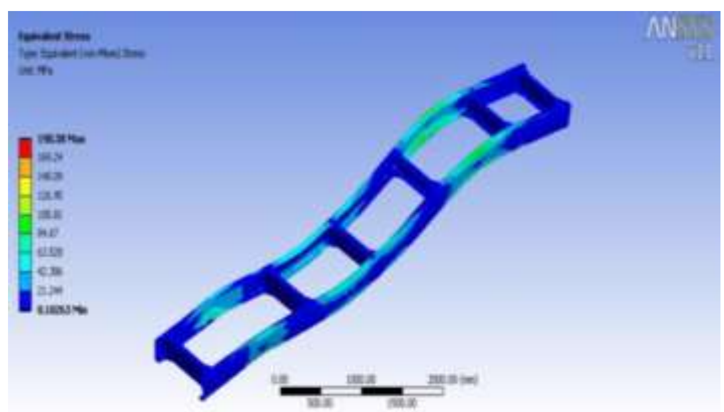
Case 2. (236.25 mm x 76 mm x 5.25 mm)

Loading and Boundary condition are same as the first case.



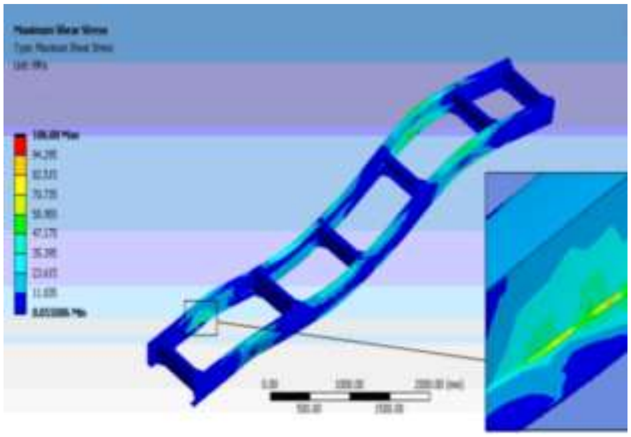
Results

The Von Misses stress magnitude of critical point is 190.38 MPa and the maximum shear stress magnitude is 106.08 MPa.



Equivalent stress in chassis frame

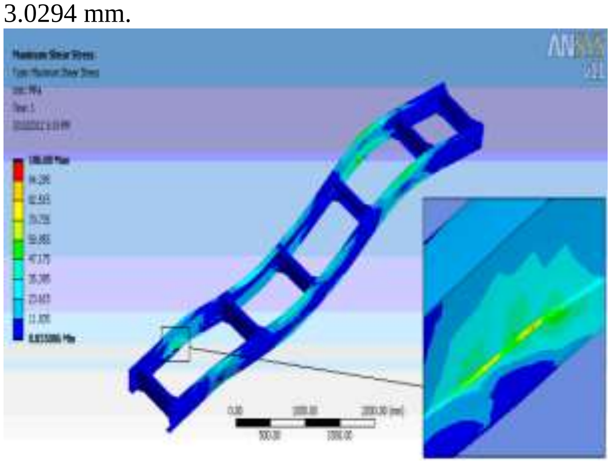
ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852



Maximum shear stress in chassis frame

Displacement

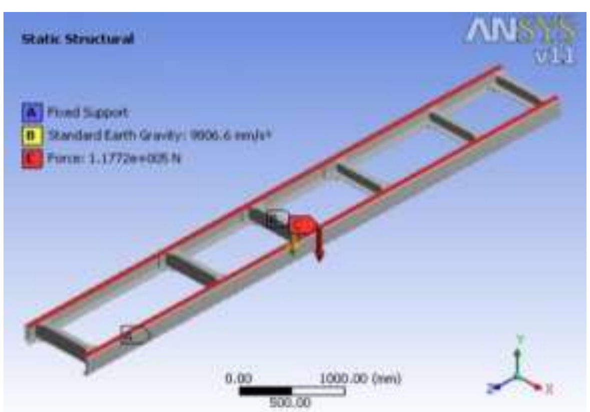
The magnitude of maximum displacement is 3.0294 mm.



Maximum shear stress in chassis frame

Case 3. (236.25 mm x 76 mm x 5.25 mm)

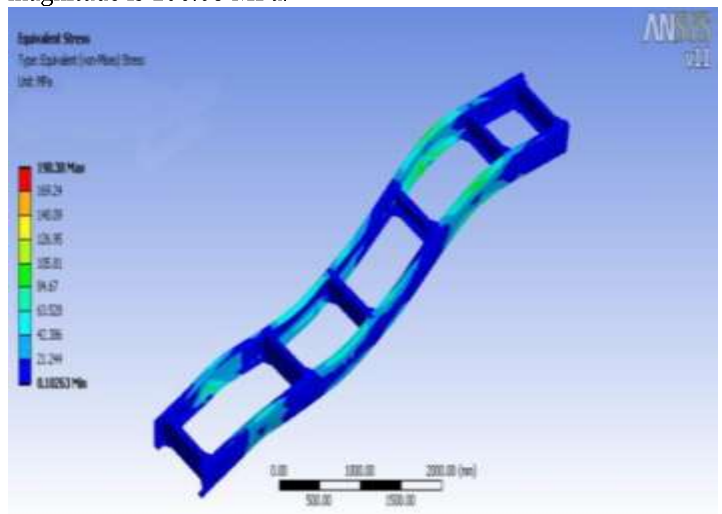
Loading and Boundary condition are same as the first case.



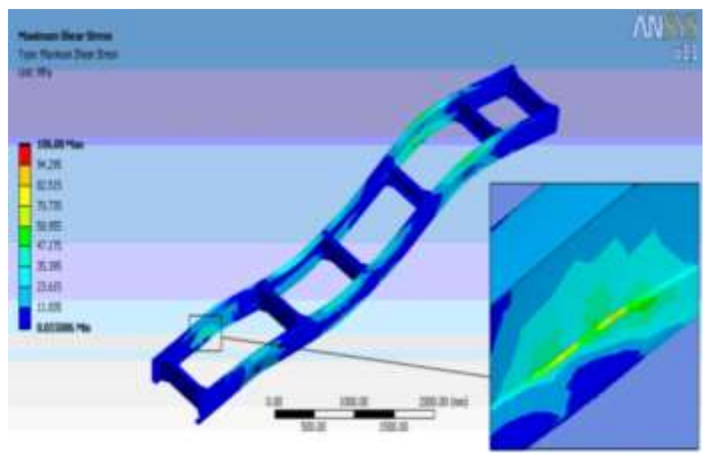
Structural load and boundary condition for chassis

Results

The Von Misses stress magnitude of critical point is 190.38 MPa and the maximum shear stress magnitude is 106.08 MPa.



Equivalent stress in chassis frame

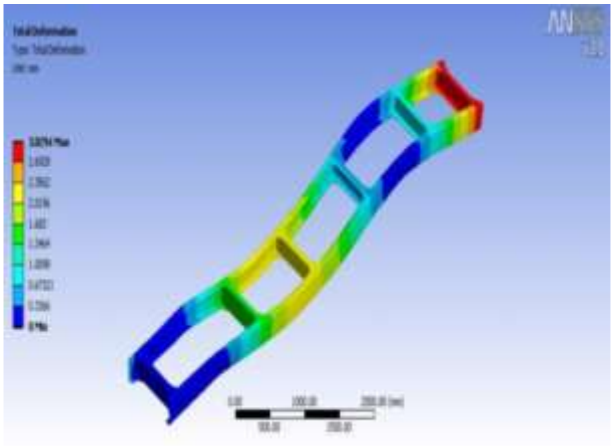


Maximum shear stress in chassis frame

Displacement

The magnitude of maximum displacement is 3.0294 mm.

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852



Displacement in chassis frame

Conclusion

Comparison of the result is shown in the table.

Sr. No	Section	Chassis Weight (Kg.)	Shear Stress (MPa)	Max. Displacement (mm)	Max Equivalent Stress (MPa)
1	Existing Section	326.36	106.08	3.0294	190.38
2	Case 1	318	113.71	2.6962	195.5
3	Case 2	311.45	111.89	2.7457	204.97
4	Case 3	**304.57**	**93.203**	**2.6901**	**174.11**

- From the above result it is clear that the weight is reduced by 6.68 % of the chassis frame.
- The maximum shear stress, maximum equivalent stress and displacement are also reduced respectively 12.14 %, 8.55 % and 11.20 %.
- It is clear that design is safe.
- So it is concluded that by using FEM software we can optimize the weight of the chassis frame and it is possible to analyse modified chassis frame before manufacturing.

References

[1] Stress analysis of a truck chassis with riveted joints by CicekKaraogluN. SefaKuralay, 2002.Departmentof Mechanical Engineering, DEU Faculty of Engineering, 35100 Bornova Izmir, Turkey ,Finite Elements in Analysis and Design 381115–1130

[2] The effect of connection plat thickness on stress of truck chassis with riveted and welded joint under dynamic loads is carried out by M. zehsaz, VakiliTahami and Esmaeili. Asian Journal of applied Science 2(1): 22-35, ISSN 1996-3343.

[3] Dynamic Analysis of a Modified Truck Chassis by Mohammad Reza Forouzan., Majlesi Journal of Mechanical Engineering, Vol. 3/ No. 4/ Summer

[4] Analysis of Torsional Stiffness and design improvement study of a Kit Car Chassis Prototype, by Wesley Linton, M.Sc. thesis, Cranfield University, School Of Industrial And Manufacturing Science Motor sport Engineering And Management

[5] PSG Design Data Book for Standard Data-M/s Kalaikathir Achchagam, Coimbatore2004

[6] Beam formula with shear and moment diagram, American forestand paper association, Inc.

[7] Shi C Q, Ding H M, Yang S M. Finite element analysis of truck frame and effects of cargo body on frame performance. Automobile Technology

[8] Autar K. Kaw, "Mechanics of Composite Materials", CRC press, 1997.

[9] Ahid D. Nashif, David I. G. Jones and John P. Henderson, "Vibration Damping", John Wiley& Sons Publication, 1985, Newyork.

[10]C. T. Sun and Y. P. Lu, "Vibration Damping of Structural Elements", Prentince Hall PTR, NewJeresy, 1995.

[11]T. E. Alberts and Houchun Xia, "Design and Analysis of Fiber Enhanced Viscoelastic Damping Polymers", Journal of Vibration and Acoustics, Vol. 117, October 1995, pp. 398-404.

[12]K. J. Buhariwala and J. S. Hansen, "Dynamics of Viscoelastic Structures", AIAA Journal