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Stress Analysis of Ladder Chassis with Various Cross Sections

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Abstract: *Automotive chassis is a skeletal frame on which various mechanical parts like engine, tires, axle assemblies, brakes, steering etc. are bolted. 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. The backbone of any automobile, it is the supporting frame to which the body of an engine, axle assemblies are affixed. Role of the chassis is to provide a structural platform that can connect the front and rear suspension without excessive deflection Moreover; it should be rigid enough to withstand the shock, twist, vibration and other stresses. So, strength and stiffness are two main criteria for the design of the chassis. The present study has analyzed the various literatures. After a careful analysis of various research studies conducted so for it has been found that sufficient studies have not been conducted on variable section chassis concept. This Paper describes Structural analysis & optimization of vehicle chassis with constraints of maximum shear stress and deflection of chassis under maximum load. The dimensions of an existing vehicle chassis of a TATA 912 Diesel bus is taken for analysis with materials namely Steel alloy (Austenitic) subjected to the same load. The three different vehicle chassis have been modeled by considering three different cross-sections. Namely C, I, and Rectangular Box (Hollow) type cross sections. Software used in this work Pro e 4.0 & Altair Hyperworks 11.0.0.39 (Hyper mesh).*
Keyword: *Static analysis, structural stiffness, FEM etc*.

I. Introduction

Chassis usually refers to the lower body of the vehicle including the tires, engine, frame, driveline and suspension. Out of these, the frame provides necessary support to the vehicle components placed on it. Also the frame should be strong enough to withstand shock, twist, vibrations and other stresses. The chassis frame consists of side members attached with a series of cross members Stress analysis using Finite Element Method (FEM) can be used to locate the critical point which has the highest stress. This critical point is one of the factors that may cause the fatigue failure. The magnitude of the stress can be used to predict the life span of the truck chassis. The ac curacy of prediction life of truck chassis is depending on the result of its stress analysis.

The different types of automobile chassis include:

Ladder Chassis: Ladder chassis is considered to be one of the oldest forms of automotive chassis or automobile 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.

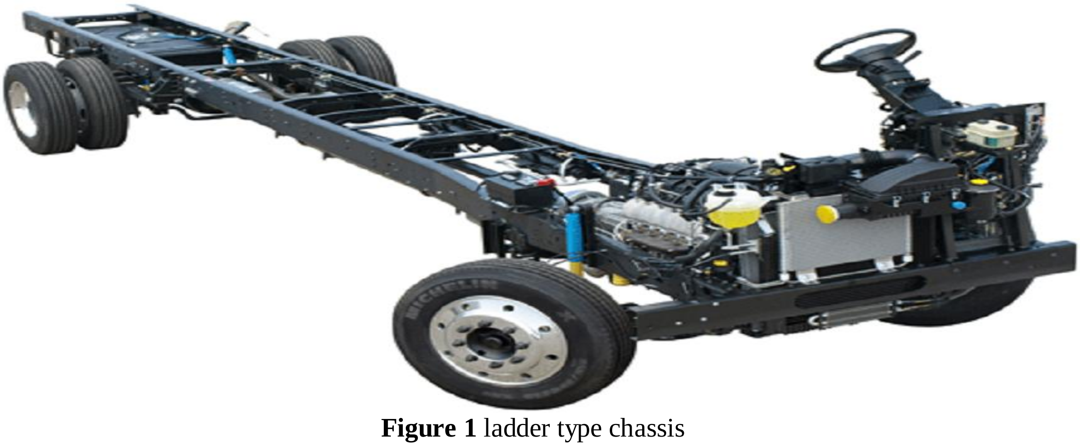

Figure 1 ladder type chassis

Monocoque Chassis: Monocoque Chassis is a one-piece structure that prescribes the overall shape of a vehicle. This type of automotive chassis is manufactured by welding floor pan and other pieces together. Since

Monocoque chassis is cost effective and suitable for robotized production, most of the vehicles today make use of steel plated Monocoque chassis.

Backbone Chassis: Backbone chassis has a rectangular tube like backbone, usually made up of glass fiber that is used for joining front and rear axle together. This type of automotive chassis or automobile chassis is strong and powerful enough to provide support smaller sports car. Backbone chassis is easy to make and cost effective.

To study the effect of cross section on structural stiffness the following three cases are consider

- Analysis of Model as per design (case I), in which cross section is 'C type' and dimensions are respectively.
- Analysis of Model as per design (case II), in which cross section is 'I type' and dimensions are respectively.
- Analysis of Model as per design (case III), in which cross section is 'Box type' (hollow) and dimensions are respectively.

II. Literature Review

Hemant B.Patil, Sharad D.Kachave, Eknath R.Deore (2013) This paper presents, stress analysis of a ladder type low loader truck chassis structure consisting of C-beams design for application of 7.5 tone was performed by using FEM. The commercial finite element package CATIA version 5 was used for the solution of the problem. To reduce the expenses of the chassis of the trucks, the chassis structure design should be changed or the thickness should be decreased. Also determination of the stresses of a truck chassis before manufacturing is important due to the design improvement. In order to achieve a reduction in the magnitude of stress at critical point of the chassis frame, side member thickness, cross member thickness and position of cross member from rear end were varied.

K. Rajasekar, Dr.R.Saravanan (2014) in this paper study has analyzed the various literatures. After a careful analysis of various research studies conducted so for it has been found that sufficient studies have not been conducted on variable section chassis concept. Hence in order to fill the gap future research studies may be conducted on variable section chassis concept in automobiles.

M. Ravichandra, S. Srinivasalu, Syed altaf Hussain (2012) studied the alternate material for chassis. They studied and analyzed Carbon/Epoxy, E-glass/ Epoxy and S-glass/Epoxy as chassis material in various cross sections like C, I and Box Section. TATA 2515 EX chassis was taken for study. Pro-E and Ansys software were used for this work. Study reveals that the Carbon/Epoxy I section chassis has superior strength, stiffness and lesser weight compared to other materials and cross section

Vijaykumar V. Patel, R. I. Patel (2012) have studied the Ladder chassis frame of Eicher E2 by static structural analysis. For this study chassis was assumed as simply supported beam with overhang. Pro-E and Ansys software were used for this work. The study also involved the analytical calculation of chassis. Both software analysis and analytical calculation results were compared and found that the stress value obtained from software analysis is 10% more and also displacement was 5.92% more.

III. Structural Analysis of Existing Chassis

Chassis Specifications:

Wheel Base (WB) = 4920 mm
Rear Overhang (ROH) = 2700 mm
Front Overhang (FOH) = 1275/1430 mm
Gross Vehicle Weight (GVW) = 9000 kg = 9 ton
Length = 8895 mm
Width = 2200 mm

Specification of Material (Steel alloy -Austenitic):

Mass density = 7.86 g/cm^3
Yield strength = 207 MPa
Ultimate Tensile Strength = 345 MPa
Young's Modulus = 220 GPa
Poisson's ratio = 0.275
Shear Modulus = 86.2745 GPa
Existing Cross-Section of the Chassis Frame
Height (H) = 225 mm, Thickness (t) = 6 mm, Width (B) = 80mm

Basic Calculations for chassis:

Weight of passengers = Weight per passenger × No. of passengers
= 75kg × 51= 3825 kg = 3.825 ton
Total load acting on chassis = Gross vehicle weight + Weight of passengers

= 9000 kg + 3825 kg = 12825 kg
= 9 ton + 3.825 ton = 12.825 ton

Chassis has two longitudinal members so load will be acted upon these two longitudinal members. Therefore, load acting on each member will be half of the total load acting on chassis. Load acting on one longitudinal member

= 12.825ton ÷ 2

= 6.288 ton = 61685.28N

Uniformly Distributed Load is 61685.28 /8895 = 6.934 N/mm.

The bending stress, shear stress and deflection of the frame are calculated using the formula Bending Stress is calculated from Flexure Formula

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

=473 N/mm^2

Deflection of chassis

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

=9.267 mm

IV. Fe Analysis of Chassis

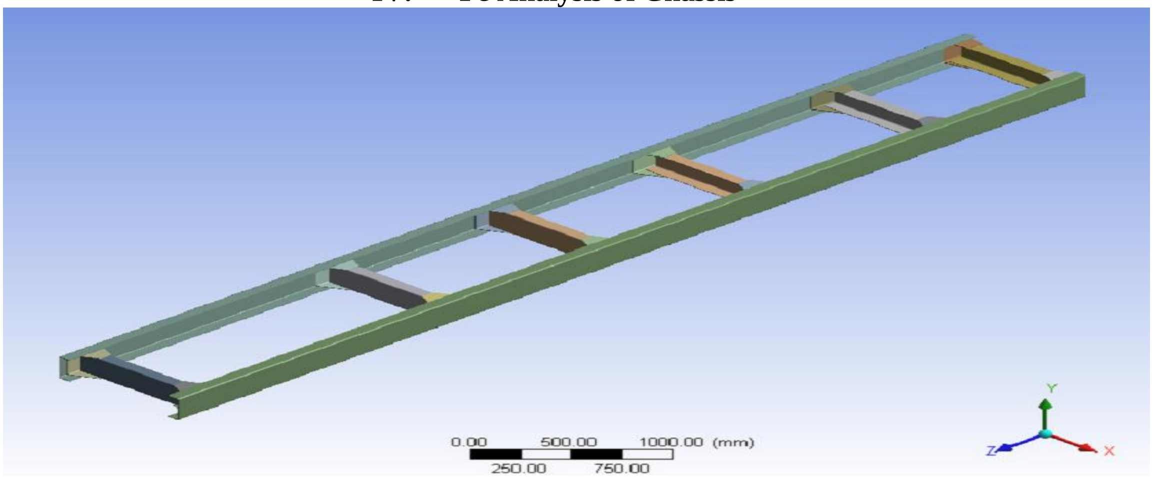

Figure 2 CAD model of chassis frame

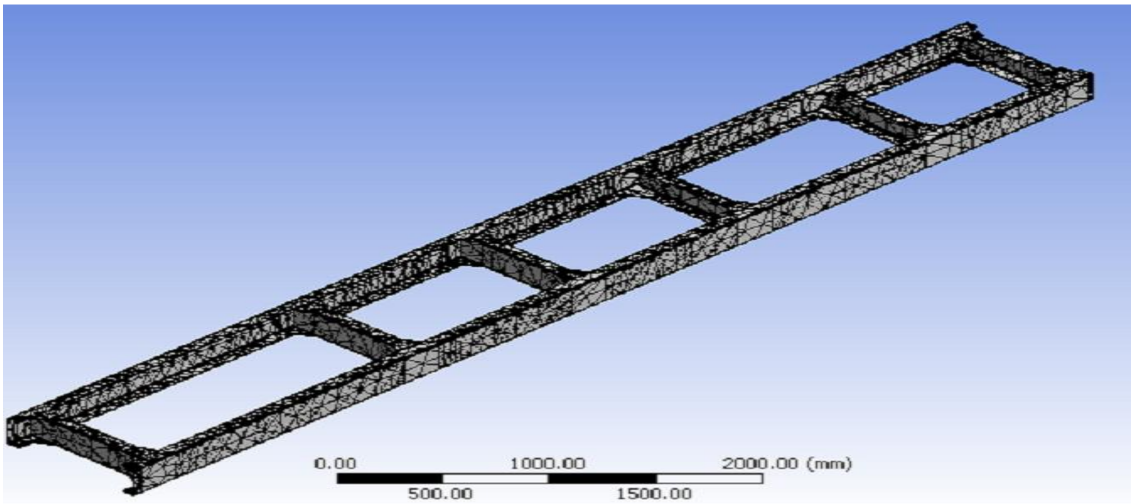

Figure 3 Meshing of chassis frame

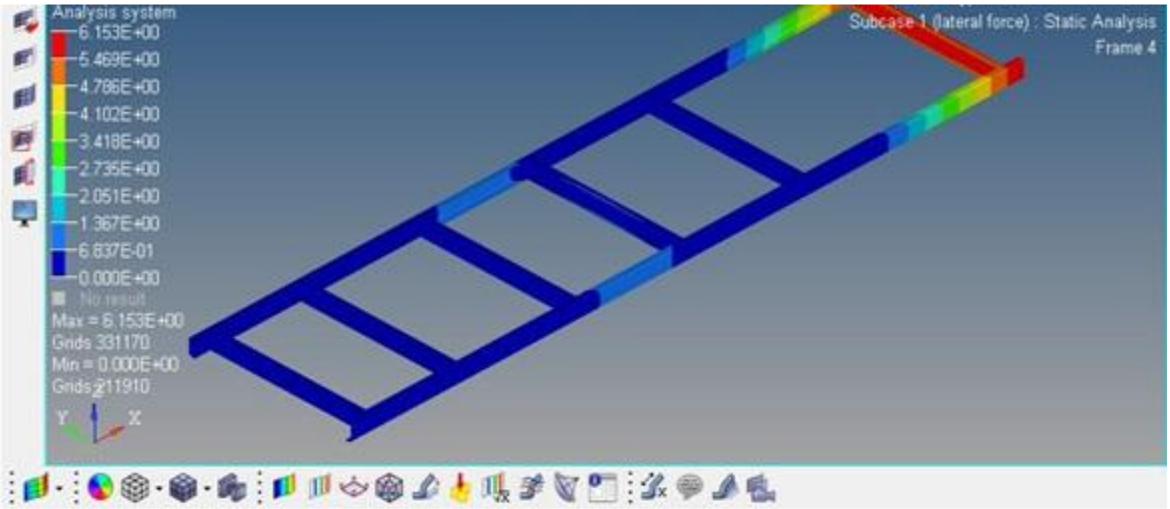

Figure 4: Displacements of C Type Cross Section Chassis

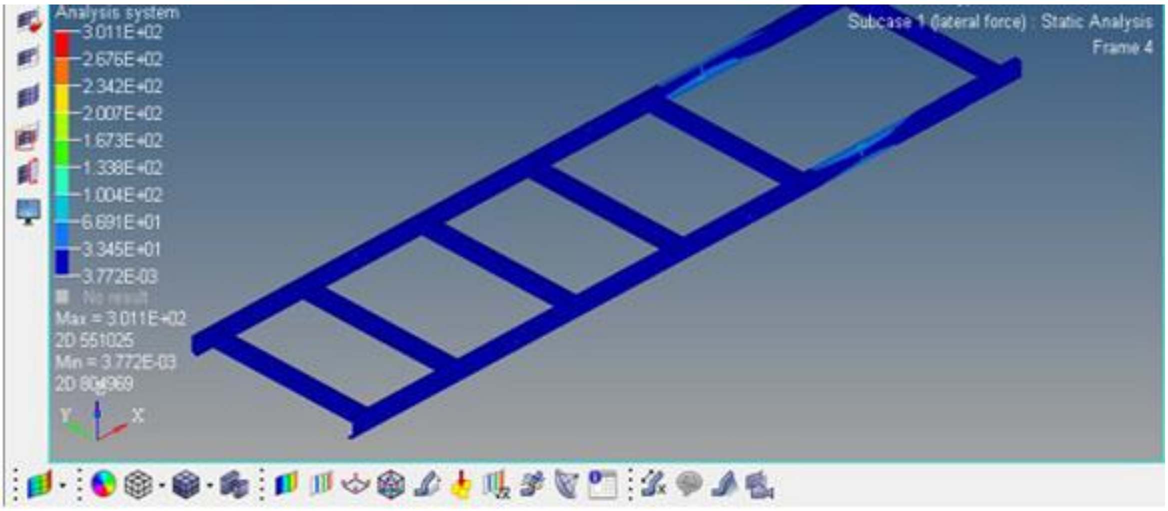

Figure 5 Von Mises Stress of C Type Cross Section Chassis

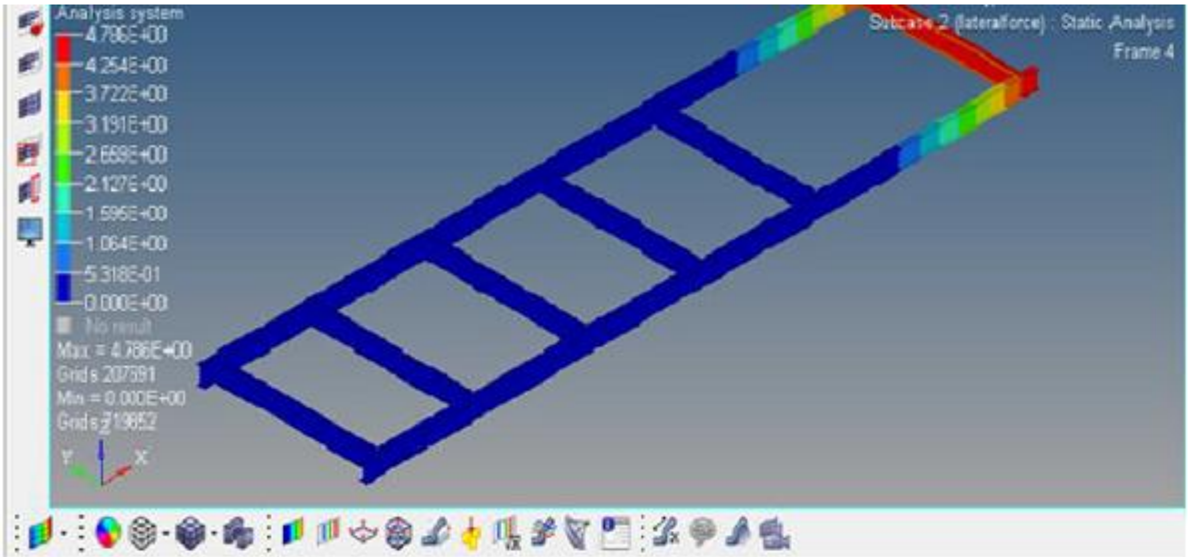

Figure 6 Displacements of I Type Cross Section Chassis

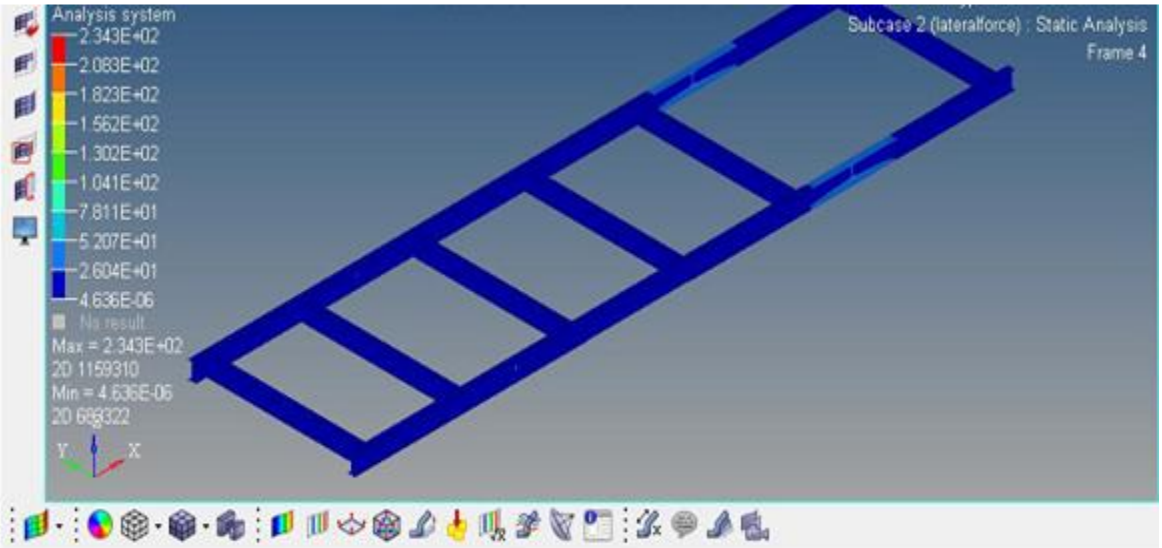

Figure 7 Von Mises Stress of I Type Cross Section Chassis

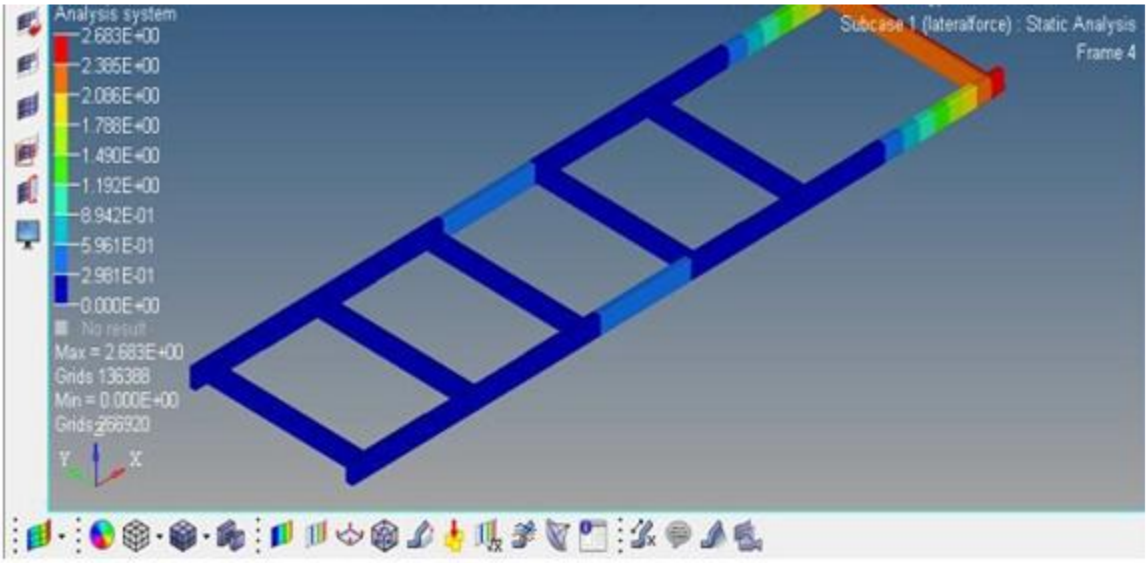

Figure 8 Displacements of Rectangular Box Type Cross Section Chassis

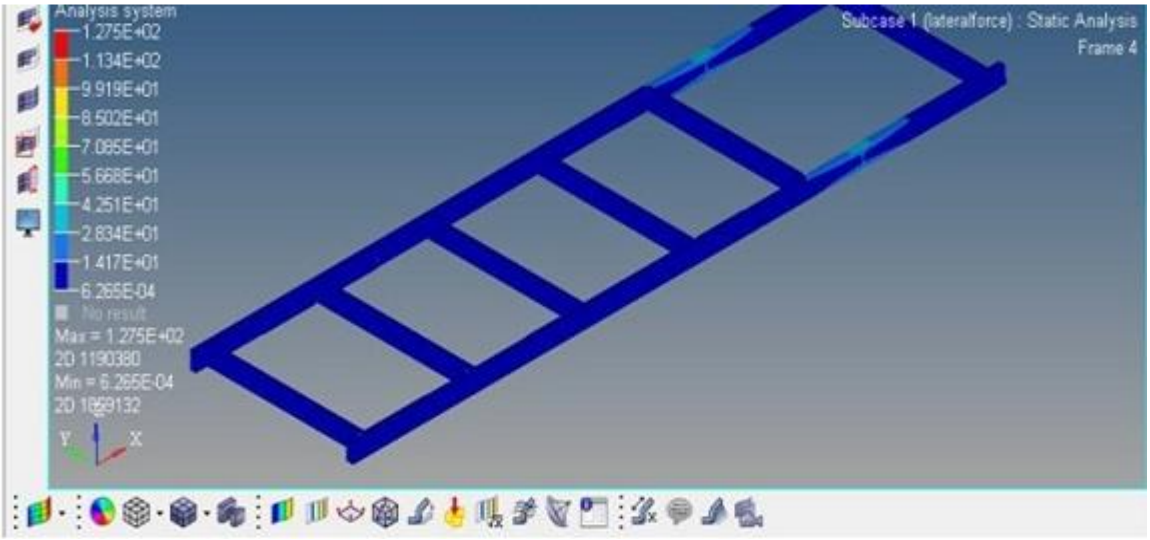

Figure 9 Von Mises Stress of Rectangular Box Type Cross Section Chassis

V. Result And Discussion

Table 1 Comparison of results

Cross sections	Weight (Kg)	Analytical Method		FE Analysis	
		Displacement (mm)	Stresses (N/mm^2)	Displacement (mm)	Stresses (N/mm^2)
C-Type	476	9.267	473	6.153	301
I-Type	462	6.842	319	4.786	234
Rectangular Box (Hollow) Type	631	4.017	187	2.683	127

VI. Conclusion

From the results, it is observed that the Rectangular Box (Hollow) section is more strength full than the conventional steel alloy chassis with C and I design specifications. The Rectangular Box (Hollow) section is having least deflection i.e., 2.683 mm and stress is 127 N/mm^2 in all the three type of chassis of different cross section. Finite element analysis is effectively utilized for addressing the conceptualization and formulation for the design stages. The results obtained are quite favorable which was expected. The iterations are carried out in the analysis phase which yields the suitable values for design parameter. The difference is caused by simplification of model and uncertainties of numerical calculation and improper meshing.

Acknowledgment

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