Impact Factor (SJIF): 3.632

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444

Volume 3, Issue 4, April -2016

Structural Analysis and Optimization of Truck chassis

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Abstract — *The chassis frame is an important part in a truck and it carries the whole load acting on the truck as well as different parts of the automobile. So it must be strong enough to resist the shock, twist, vibration and other stresses. Maximum stress and maximum deflection are important criteria for design of the chassis. The objective of present is to determine the maximum stress, maximum deflection and to recognize critical regions under static loading condition. Static structural analysis of the chassis frame is carried out by FEA Method.*

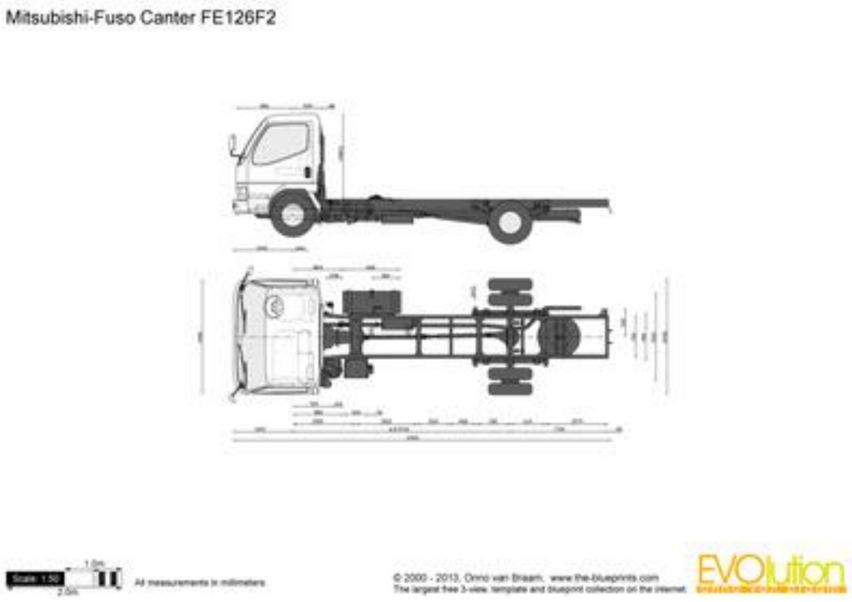
Keywords- Modeling, Ansys, chassis, frame work, Optimization

I.INTRODUCTION

Truck chassis is a major component in a vehicle system. This work involved static and dynamics analysis to determine key characteristics of a truck chassis. The Static characteristics include identifying location of High Stress Area and determining the Torsion Stiffness of the chassis. The Dynamic characteristics of truck chassis such as the Natural Frequency and Mode shape were determined by using Finite Element Method.

II. CHASSIS FRAME

Automotive chassis is a skeletal frame on which various mechanical parts like engine, tires, axle assemblies, brakes, steering etc. are bolted. The chassis is considered to be the most significant component of an automobile. 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. Tie bars, that are essential parts of automotive frames, are fasteners that bind different auto parts together. Automotive frames are basically manufactured from steel. Aluminium is another raw material that has increasingly become popular for manufacturing these auto frames. In an automobile, front frame is a set of metal parts that forms the framework which also supports the front wheels. It provides strength needed for supporting vehicular components and payload placed upon it. Automotive chassis is considered to be one of the significant structures of an automobile. It is usually made of a steel frame, which holds the body and motor of an automotive vehicle.



Chassis Frame

Since chassis frame forms the backbone of a heavy vehicle, its principal function is to safely carry the maximum load for all designed operating conditions. It must also absorb engine and driveline torque, endure shock loading and accommodate twisting on uneven road surfaces. To achieve a satisfactory performance, the construction of a heavy vehicle chassis is the result of careful design and rigorous testing.
Consequently, a modification to the chassis frame should only be attempted after consultation with the vehicle manufacturer or engineer experienced in commercial vehicle chassis modifications to ensure that the proposed modification will not be detrimental to the vehicle's safety or performance. Because various manufacturers have individual design concepts and different methods of achieving the desired performance standards for the complete chassis, not all chassis components are interchangeable between various makes and models of vehicles. Due to the complexity of the variation in chassis design and because the major application of this section is for medium to heavy goods vehicles, the information supplied is orientated to suit the type of chassis used on these vehicles. It should be noted that this 'ladder' type of frame construction is designed to offer good downward support for the body and payload and at the same time provide torsional flexibility, mainly in the region between the gearbox cross member and the cross member ahead of the rear suspension. This chassis flexing is necessary because a rigid frame is more likely to fail than a flexible one that can 'weave' when the vehicle is exposed to arduous conditions. A torsionally flexible frame also has the advantage of decreasing the suspension loading when the vehicle is on uneven surfaces.

DESIGN AND CALCULATIONS OF EXISTING CHASSIS

A. Basic Calculation for Chassis

- Model No. = 2518tp Truck (AMW)
- Specification of chassis as per the IS 9435 for the wheel base 4565mm as mentioned as under
- Front track = 1933mm
- Rear track = 1856mm
- Overall length = 7085mm
- Front Overhang = 1350mm

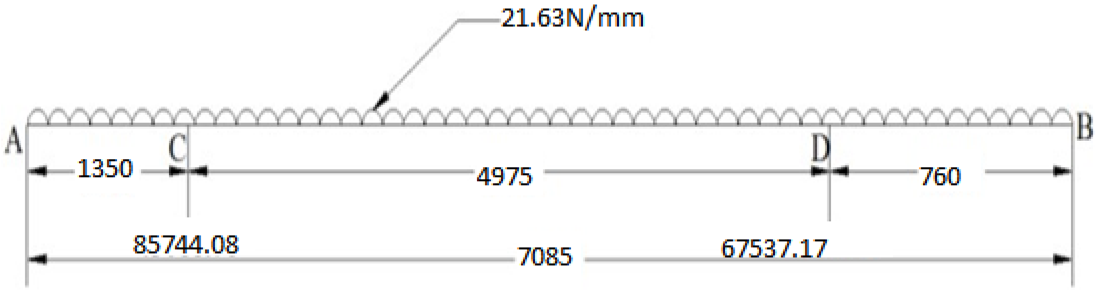
Weight of the chassis as per the IS 9211 for the wheel base 4565mm as mentioned as under: Tolerance of the chassis is maintained according to the INTEREUROPE StVZO.

- Complete chassis kerb weight = 4235 Kg.
- Bare chassis kerb weight with cowl = 4045 Kg.
- Max. Permissible gross vehicle weight = 16200 Kg.
- Weight of the Engine = 413 Kg.
- Total weight acted on the chassis = 25000 Kg.
- Capacity of Truck = 25 ton
  =25000 kg
  = 245250 N

Capacity of Truck with 1.25% = 245250 x 1.25 N = 306562.5 N
Total Load acting on the Chassis =306562.5 N
All parts of the chassis are made from "C" Channels with 256mm x 75mm. Each Truck chassis has two beam. So load acting on each beam is half of the Total load acting on the chassis. Load acting on the Chassis=Total load acting on the chassis /2 = 306562.5 / 2 = 153281.25 N / Beam

B. Calculation for Reaction:-

Beam is simply clamp with Shock Absorber and Leaf Spring. So Beam is a Simply Supported Beam with uniformly distributed load. Load acting on Entire span of the beam is 153281.25 N. Length of the Beam is 7085 mm. Uniformly Distributed Load is 153281.25 / 7085 = 21.63 N / mm Now taking the reaction around the support A. According to loading condition of the beam, beams has a support of three axle means by three wheel axles but among these three wheels one wheel / axle are working as a supporting only. Total load



For getting the load at reaction C and D, taking the moment about C and we get the reaction load generate at the support D. calculation of the moment are as under.

Momentum about C:-

$21.63\times 1350\times 1350/2 = (21.63\times4975\times4975)/2 - 4975\times D + 21.63\times760\times5355$

$19710337.5 = 267678009.4 - 4975\ D + 88029774$

$9036187.88 = 143726214.10 - 4726\ D + 131088343.8 \quad 4726\ D = 265778370$

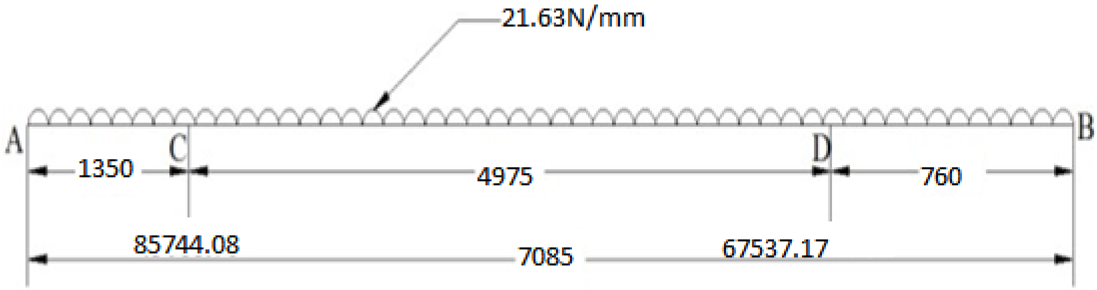
$D = 67537.17$ N

Total load acting on the beam is 99326.25 N. so load acting on the reaction is as under

$C = 153281.25 - D$

$= 153281.25 - 67537.17$

$= 85744.08$



Reaction generated on the beam

C. Calculation for Shear Force Diagram and Bending Moment Diagram Shear Force Diagram:-

$F_A = 0$ N

$F_C = -21.63\times1350 + 85744.08$

$= -29200.5 + 85744.08$

$= 56543.58$ N

$F_D = -21.63\times6325 + 85744.08 + 67537.17$

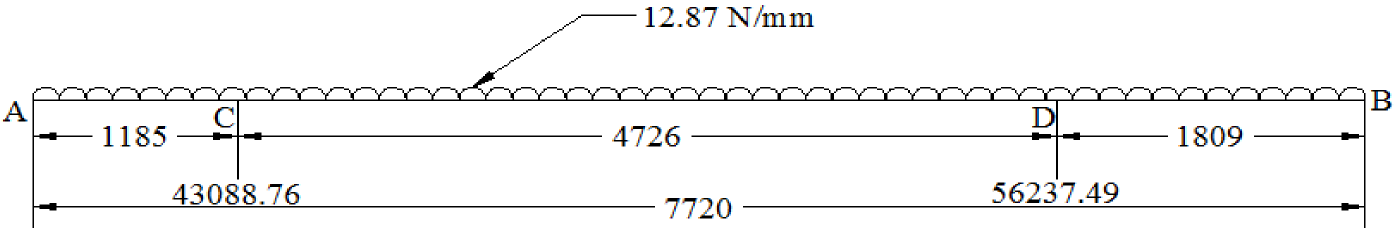
$= -136809.75 + 153281.25$

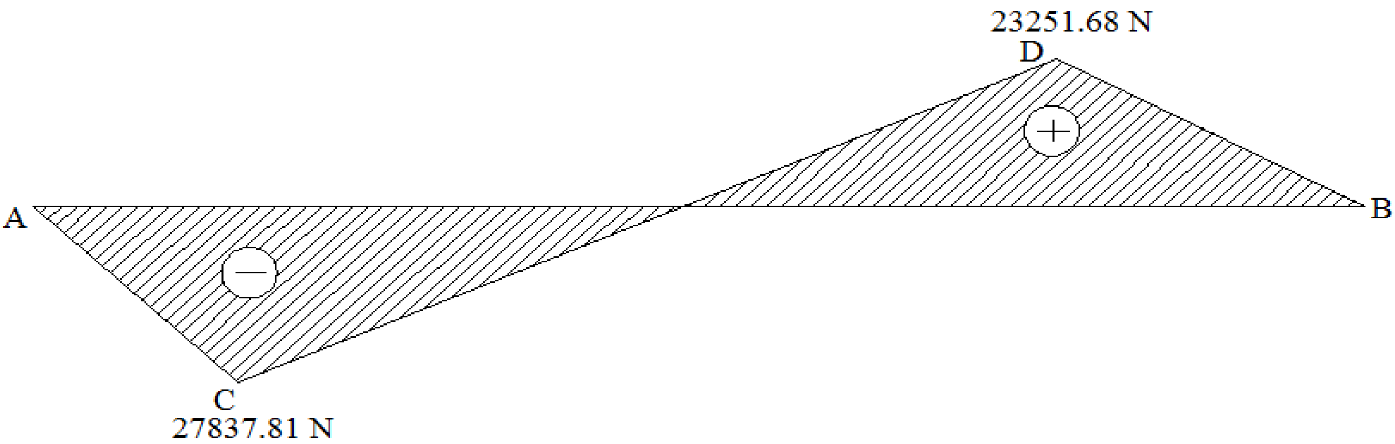
$= 16471.5$ N

$F_B = -21.63\times 7085 + 85744.08 + 67537.17$

$= -153281.25 + 153281.25$

$F_B = 0$ N





Shear Force Diagram

Bending Moment Diagram:-

$M_A = 0$

$M_C = -(21.63 \times 1350 \times 1350) / 2$

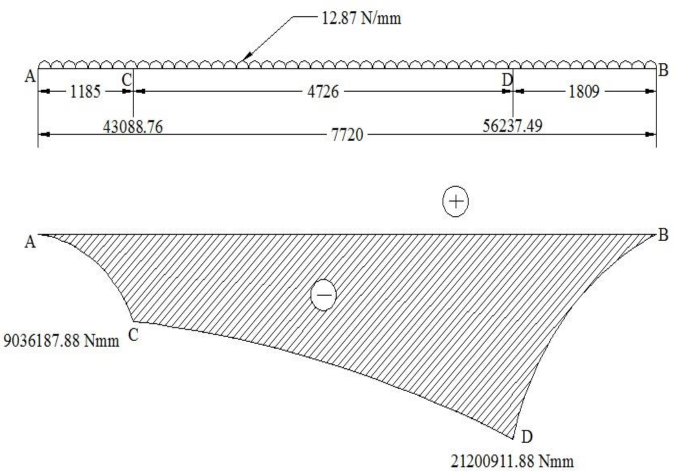
$= -19710337.5$ N mm

$M_D = -(21.63 \times 6325 \times 6352) /2 + 85744.08 \times 4975$

$= -432660834.4 + 426576798$

$= -6084036.4$

$M_B = 0$



Bending Moment Diagram

D. Calculation for the deflection:-

M_{max}= 21200911.88 Nmm

Material of the Chassis is as per IS: - 9345 standard is Structural Steel with St37.

Material Property of the St37:-

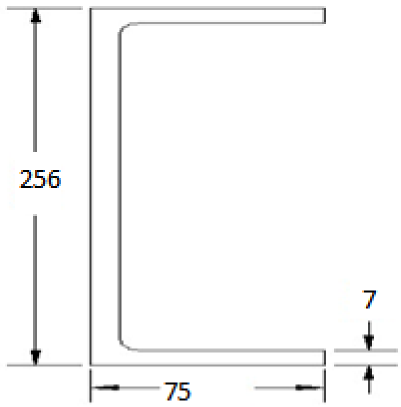
Ultimate Tensile Strength = 370 to 490 N/mm2

E = 2.10 x 105 N / mm2

Poisson Ratio = 0.29

Radius of Gyration R = (256 / 2)

=128m



Main "c" section

Moment of Inertia around the X – X axis:-

I_{XX}= bh^3-[b_1 h_1^3] /12

= $\underline{75 \times 256^3 - [68\times 242^3]}$

12

=124546834.67mm^3

Section of Modules around the X – X axis:-

Z_{XX}= bh^3-[b_1 h_1^3] /6h

=75 ×256^3- [68× 242^3] /6×256

=367553.39 mm^3

Basic Bending equations are as follow:-

(M/I)=(σ/y)=(E/R)

Maximum Bending Moment acting on the Beam:

I = 17279023.84 mm4

Y = 114.30 mm

M = 21200911.88 Nmm

Stress produced on the Beam is as under:-

σ=(M/Z)

(21200911.88

151172.56

=151172.56

Slope produced on the Beam:-

$i = (5\times w\times L^3) / (24\times E\times I)$

$= (5\times 21.63\times 4975^3) / (24\times 2.10\times 10^5\times 24546834.67)$

= 13316980966406.25/123716046736800

= 0.107641 rad

= 6.1673° slope of the deflection

Maximum Deflection produced on the Beam:-

$Y = (W\times X_2/ 24\times E\times I)\times L^3-2LX_1^3+X_2^3$

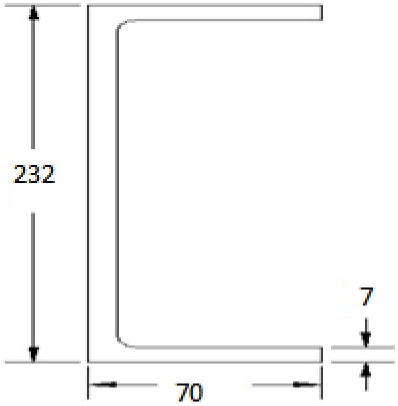
$= 21.63\times760/24\times2.1\times10^5\times17279023.84\times7085^3-2\times7085\times1350^3+760^3$

$= 4.86$mm

But allowable deflection for simply supported beam is 25.73 mm according to deflection span ratio.

Now Check the Deflection and Slope of the Beam with all assembly of Chassis:-

Maximum bending moment is = 21200911.88 N mm



$I_{b1}= \quad bh^3-[b_1\, h_1^3]\ /12$

$= 232^3 \times70- [218\times 63^3]/12$

$=68299292.83\ mm^4$

Total cross member = 68299292.83 x 7

$= 478095049.83\ mm^4$

Average mass moment of inertia is

=24546834.67 + 478095049.83

$= 502641884.50\ mm^4$

Deflection of chassis

$Y = (2\times W\times X_2/ 384\times E\times I)\times[L^3-2LX_1^3+X_2^3]$

$= (2\times21.63\times760/384\times2.1\times10^5\times502641884.5)\times[7085^3-2\times7085\times1350^3+760^3]$

$= 5.98$mm

According deflection span ratio is allowable for simply supported beam is 1 / 300 According to 1 / 300 for 7720 length 5

= 7720 / 300 = 25.73 mm

So 21.40 mm is safe.

Maximum slope produced as chassis assembly

$i= (5\times w\times L^3) / (24\times E\times I)$

$= (5\times21.63\times 4975^3) / (24\times2.10\times10^5\times502641884.5)$

= 13316980966406.25/2533315097880000

= 0.005256 rad

$= 0.301^{\circ}$ slope of the deflection

E. Calculation for Shear stress generated in Chassis

Reaction generated on Beam at the center of wheel alignment

= 21.63 x 4975

= 107609.25 N

With the consideration of at the rate of angle of twist = 1°

$\theta=(1^{\circ}\times\pi)/180$

= 0.01752

By considering the whole system as a one rotational body as per following data when in twist from its support.

Width of the chassis = 864mm

Length of chassis = 7085mm
Distance between two reaction = 4975mm

Modulus of rigidity for structural steel= 80000 N/mm^2
Now basic rule for Twisting Moment is :-
$(T/J)=(\tau/r)=(G\times\theta)/L$
Now equating
$(T/J)=(G\times\theta)/L$
For the rotational shaft J is 2 times higher the Mass Moment of inertia:-
Mass moment of Inertia for Chassis body =502641884.5 mm4
So, Polar Moment of Inertia J= 2 x I
J= 2 x 502641884.50
J= 1005283769
$T=G\times\theta\times J/L$
$=80000\times0.01752\times1005283769/7085 = 198871662.75$ Nmm

Shear stress generated in Chassis body

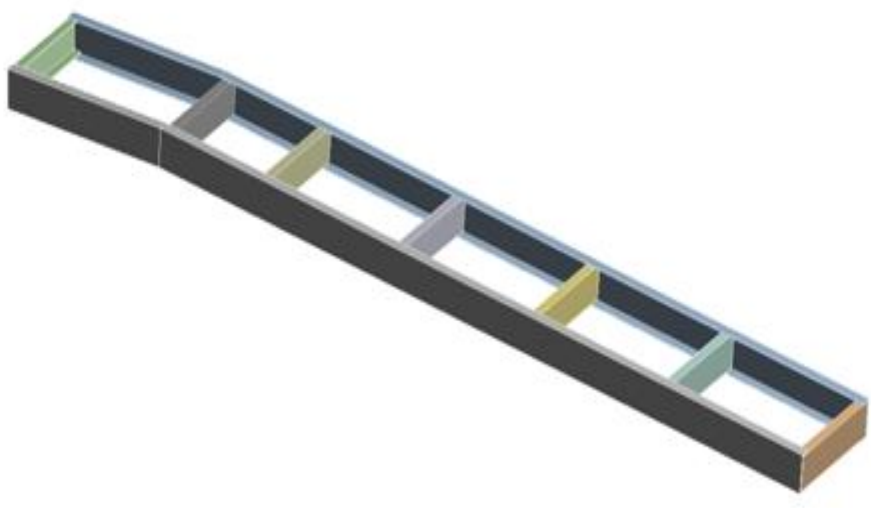
$(T/J)=(\tau/r)$
$\tau=(T\times r)/J$
$=198871662.75\times864/1005283769$
$=170.92$ N/mm2

II.ANSYS

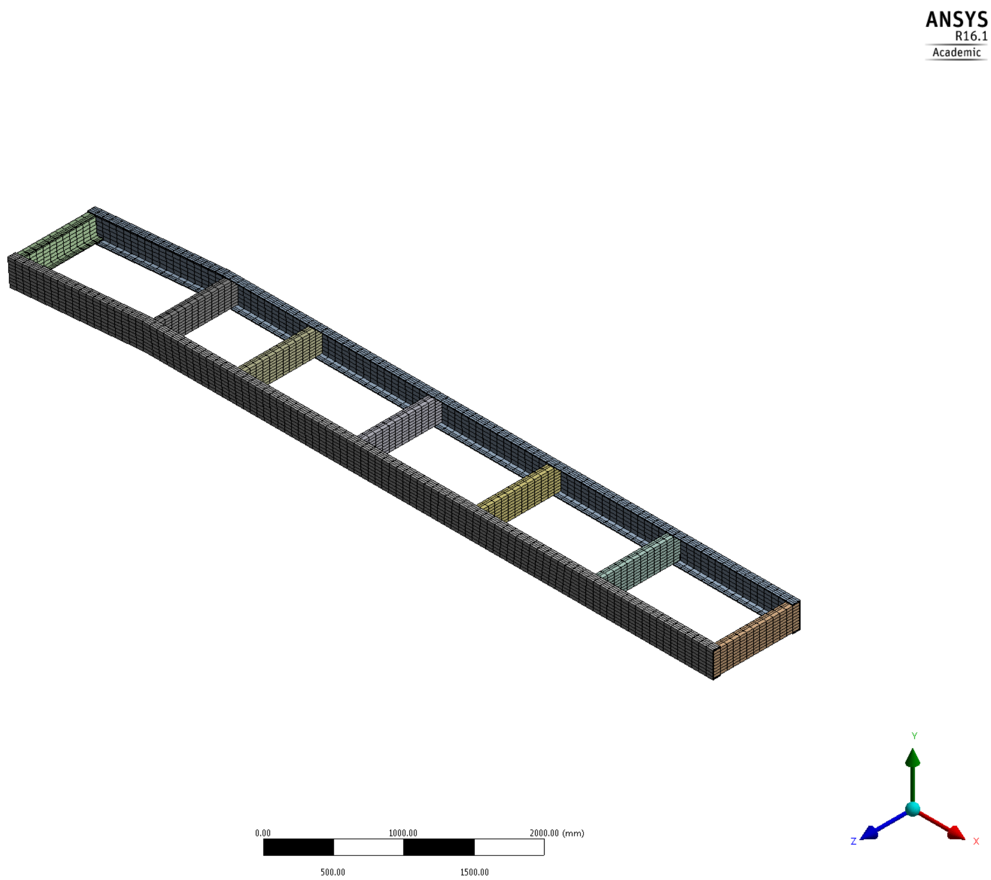
ANSYS is a general purpose software, used to simulate interactions of all disciplines of physics, structural, vibration, fluid dynamics, heat transfer and electromagnetic for engineers. ANSYS is a finite-element analysis package used widely in industry to simulate the response of a physical system to structural loading, and thermal and electromagnetic effects. ANSYS uses the finite-element method to solve the underlying governing equations and the associated problem-specific boundary conditions.

III.MODELING AND MESHING

As discussed in CFD,which deals with 4 basic steps modelling, meshing, solver and post processing. This present section deals with modelling & meshing of the domain which includes ducts and extract grills.
The detailed plan view of auto-cad model is as shown in the figure below.

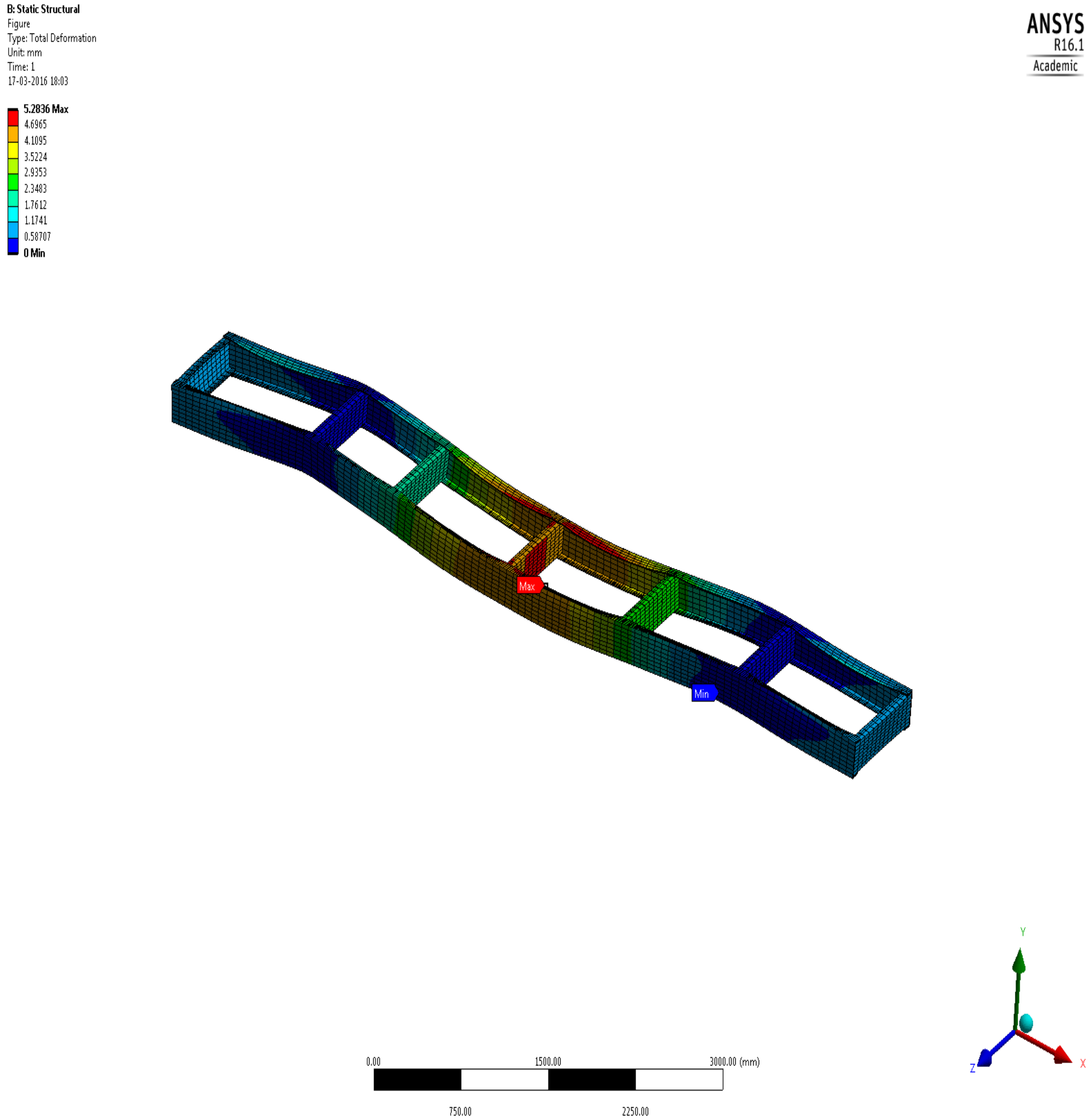


3d view of the Chassis

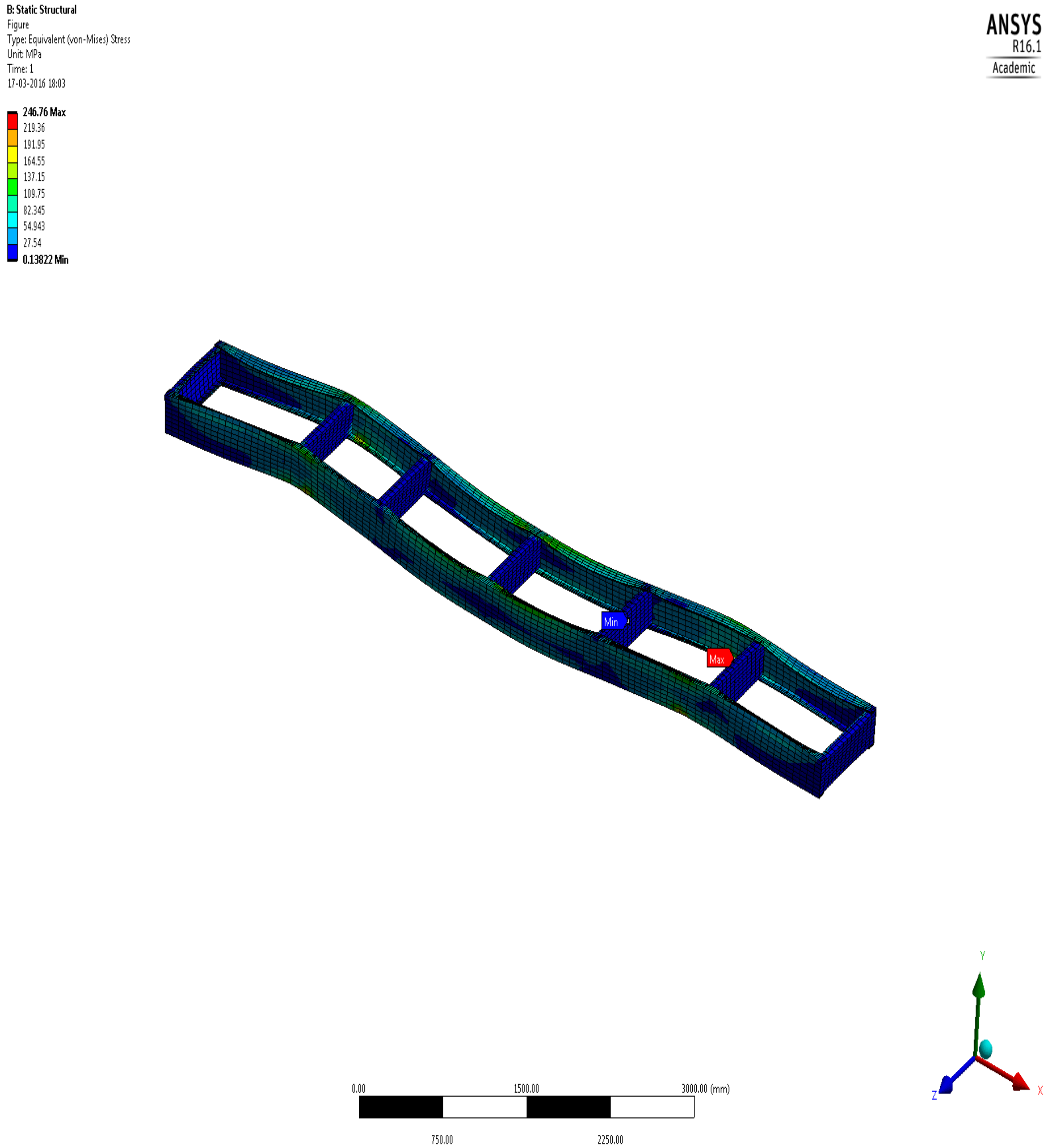


Mesh view for the Chassis

IV. RESULT AND ANALYSIS



Model (B4) - Static Structural (B5) -Solution (B6) - Total Deformation



Model (B4) - Static Structural (B5) - Solution (B6) - Equivalent Stress

CONCLUSION

In this work chassis model is checked for loading condition of 306562.5 N. To carry out these loading conditions the model is prepared in Cre-O and analysis in Ansys software. After the analysis the stress values are von misses stress 246.76 MPa, maximum shear stress 134.1 MPa, Maximum shear strain 0.001758 mm/mm, Equivalent stress 246.76 MPa. The distributions of the stress that acting on the chassis. Critical parts that will lead to failure are also observed.

Comparison is also mentioned in below table

Comparision of analysis and calculated results		
	Analysis Result	Calculated Result
Maximum stress	246.76 MPa	102.77MPa
Maximum shear stress	134.1 MPa	170.92 N/mm^2
Deformation	5.2836 mm	5.98mm

REFERENCES

1. Madhu Ps and Venugopal T R, Static Analysis, Design Modification and Modal Analysis of Structural Chassis Frame, International Journal of Engineering Research and Applications 4 (5) (2014) 6-10.
2. Hailemariam Fisseha Nega and Yang Hui, Study of Fatigue Analysis of Vehicle Truck Chassis, International Journal of Science and Research (IJSR) (2014)
3. Hirak Patel, Khushbu C. Panchal, and Chetan S. Jadav, Structural Analysis of Truck Chassis Frame and Design Optimization for Weight Reduction, International Journal of Engineering and Advanced Technology (IJEAT) 2 (4) (2013)
4. Ahmad O. Moaaz**1** and Nouby M. Ghazaly, A Review of the Fatigue Analysis of Heavy Duty Truck Frames, American Journal of Engineering Research 3 (10) (2014) 1-6
5. Hemant B.Patil and Sharad D.Kachave,EFFECTS OF WEB AND FLANGE THICKNESS ON BENDING STIFFNESS OF CHASSIS**,** International Journal Of Advance Research In Science And Engineering 2 (7) (2013)
6. Chen Yanhong, Zhu Feng,The Finite Element Analysis and The Optimization Design of The Yj3128-type Dump Truck's Sub-Frames Based on ANSYS,Elsevier
7. Patel Vijaykumar V #1, Prof. R. I. Patel*2 ,Structural Analysis of Automotive Chassis Frame and Design Modification for Weight Reduction, International Journal of Engineering Research & Technology (IJERT) 1 (3) (2012)
8. A.Hari kumar, V.Deepanjali, Design & Analysis of Automobile CHASSIS, International Journal of Engineering Science and Innovative Technology (IJESIT) 5, (1), (2016)