ISSN: 2277-9655
Impact Factor: 1.852

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY
TECHNOLOGY

Finite Element Analysis of Truck Chassis

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Abstract

Automotive chassis is an important part of an automobile. The chassis serves as a frame work for supporting the body and different parts of the 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 project 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. A sensitivity analysis is carried out for weight reduction. So a proper finite element model of the TATA 1612 chassis is to be developed by using actual parameter, the chassis is modeled in CATIA v5.

FEA is done on the modeled chassis using the ANSYS Workbench12,the FEA is carryout for static, dynamic and shape optimization.

Result obtained after the analytical approach for the chassis beam in terms of it stress development is approximately closer to the FEA values. By reducing the height of the cross-member of chassis is found to be reduced by 8.72%

Keywords: Data storage, solitude preservative.

Introduction

Chassis is one of the important parts that used in automotive industry This structure was the bigger component in the any automobile vehicle, the vehicle shape dependent to this chassis. Also known as the “backbone” of the vehicle, because all the major component of a vehicle are place on it. The main function of the chassis is not only support the components and payload mounted upon it including engine, body, passengers and luggage, but also to maintain the desired relationship between the suspension and steering mechanism mounting points. The greater the energy absorbed by the chassis on impact the lower the energy levels transmitted to a vehicles occupants and surroundings, lowering the chances of injury. the chassis is subjected to stress, bending moment and vibrations due to road roughness, weather and components that mounted on it, When the truck travels along the road, Stress that acting on chassis is varies with the displacement and each part on the car chassis. The major challenge in today’s ground vehicle industry is to overcome the increasing demands for higher performance, lower weight in order to satisfy fuel economy requirements, and longer life of components, all this at a reasonable cost and in a short period of time also give new safety requirements. for further modification analysis of this chassis is very necessary it may be Modal Analysis, Finite Element Torsion and Bending Analysis. Besides that, the correlation and modal updating technique also important in order to create a good model for further analysis. From the global torsion analysis, it has been found that the torsion load is more severe than bending load. In order to overcome this problem, a cross bar and material selection are very important to consider during design stage.

Truck Definition and Classification

Generally, truck is any of various heavy motor vehicles designed for carrying or pulling loads. Other definition of the truck is an automotive vehicle suitable for hauling. Some other definition are varied depending on the type of truck, such as Dump Truck is a truck whose contents can be emptied without handling; the front end of the platform can be pneumatically raised so that the load is discharged by gravity. There are two classifications most applicable to Recreational Vehicle tow trucks.

- Light Duty Truck
- Medium Duty Truck
- Heavy Duty Truck

Theory Of Load Cases

A chassis is subjected to three load cases: bending, torsion and dynamic loads.

Bending Load Case:

The bending (vertical symmetrical) load case occurs when both wheels on one axle of the vehicle encounter a symmetrical bump simultaneously. The suspension on this axle is displaced, and the compression of the springs causes an upward force on the suspension mounting points .This applies a bending moment to the chassis about a lateral axis.

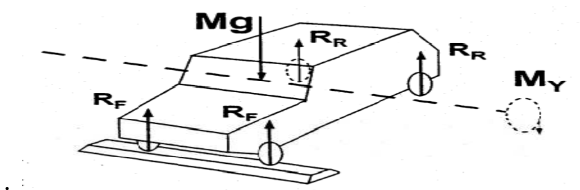


Figure: Bending Load Case.

In this type of bending load different cases is carried out to understand the behavior of the chassis under different frequency. Seven mode shapes are found out for each bending case of chassis. The long frame of chassis can be divided into three parts. Individual pressure is act along each part of the chassis. When a road wheel comes across a bump or pit on the road, it is subjected to vertical force, tensile or compressive, depending up on the nature of road irregularity. These are absorbed by the elastic, compression, shear, bending or twisting of the spring .The mode of a spring resistance depends upon the type of material of spring used. In this bending case both the wheel get simultaneously over a bump. The truck chassis was fixed at the rear end structure. The load was applied at the front end structure and the applied load was 9807N.

Torsion Load Case:

The torsion (vertical asymmetric) load case occurs when one wheel on an axle strikes a bump. This load is causing the chassis in torsion as well as bending. It has been found both in theory and in practice that torsion is a more severe load case than bending.

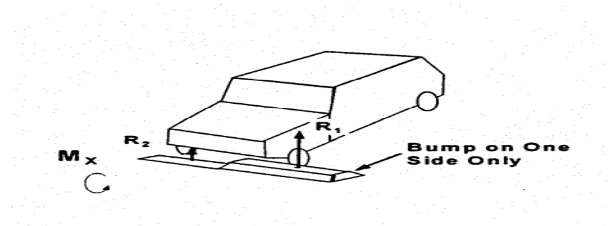


Figure : Torsion Load Case.

Technical Specifications

For the analysis of the chassis used truck model of TATA 1612 It gives the Constant research and development and unrelenting efforts to meet the customers need has created this marvel. More power, more torque, more reliability and of course more productivity. There is a choice of body size, type as well as wheel base for different application.

Data for the vehicle :

- Suspension type : Parabolic spring at front and semi elliptical leaf spring at rear. Option 2:semi elliptical spring at front and rear..
- Number of gears : 6 forward , 1 reverse gears
- Maximum engine output: 135 Kw181 Hp@2500 rpm.
- Maximum engine Torque: 685 Nm @ 1400 rpm

Performance Of Vehicle:

- Gross Vehicle Weight (GVW): 25000kg.
- Gross Combined Weight (GVW + Payload): 26200kg.
- Maximum Gear speed: 78 km/hr.
- Frame: Ladder type heavy duty frame,Depth-285mm,width-65mm,frame width-903mm.
- **Weights (kg):**

$$\text{Max. permissible GVW} = 25000$$

$$\text{Max. permissible FAW} = 6000$$

$$\text{Max. permissible RAW} = 19000$$

Loading And Boundary Conditions For Static And Dynamic Analysis:

For this model, the maximum loaded weight of truck plus cargo is **25,000 kg**. The load is assumed as a uniform pressure obtained from the maximum loaded weight divided by the total contact area between cargo and upper surface of chassis. In the analysis, the situation considered is the standstill condition of the vehicle on a level road loaded to the maximum payload. The other loads considered include weight of the engine, weight of

ISSN: 2277-9655
Impact Factor: 1.852

two persons in the cabin. Detail loading of model is shown in below Figure.

Total weight of chassis=25,000 kg.
Weight of Engine=600 kg.
Weight of Cabin=400 kg.
Weight of persons= 200 kg.
Total weight acting on frame= (25000+600+400+200) kg.
=26200 kg.
= 257022 N
Total weight acting on one side of chassis =257022/2
=128511 N

The magnitude of pressure on the upper side of chassis is determined by dividing it into **3** parts.

For **part 1**, the magnitude of pressure on the upper side of chassis, P1

$$P_1 = F/A = 128511/65*10^{-6}*6670$$
$$= \mathbf{290321.9248}\ N/m^2$$

Similarly,

For **part 2**, the magnitude of pressure on the upper side of chassis, P_2

$$P_2 = 1200*9.81/65*10^{-6}*1400$$
$$= \mathbf{129362.6374}\ N/m^2$$

For **part 3,** the magnitude of pressure on the upper side of chassis, P_3

$$P_3 = 1200*9.81/65*10^{-6}*740$$
$$= \mathbf{244740.1247}\ N/m^2.$$

Solid Modeling of Truck chassis :

For the solid modeling of truck chassis CATIA software are used

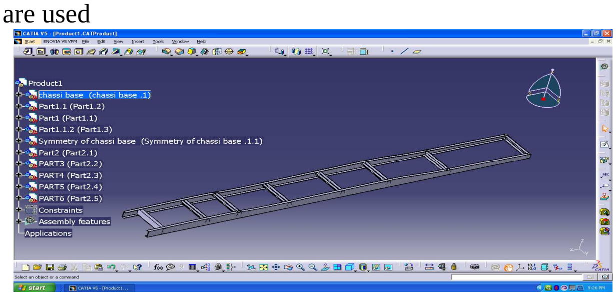


fig: Solid Modeling of Truck chassis

Analysis of Chassis

Material used

Before the Structural Analysis, it must have material assigned to it. Each material in ANSYS has mechanical properties for computing the analysis for different materials. These properties are Young's Modulus, Poisson Ratio, for the analysis of chassis used Mild steel. Mild steel, also called plain-carbon steel, is the most common form of steel because its price is relatively low while it provides material properties that are acceptable for many applications, more so than iron. Low-carbon steel contains approximately 0.05–0.3% carbon making it malleable and ductile. Mild steel has a relatively low tensile strength, but it is cheap and malleable; surface hardness can be increased through carburizing. It is often used when large quantities of steel are needed,

Tensile Strength (Mpa)	Young's Modulus(Gpa)	Yield Strength (Mpa)	Poisson's Ratio	Density (Kg/m^3)
620	207x10^9	550	0.3	7800

Stress Analysis of chassis Using ANSYS Without Load

Loading And Boundary Conditions:

The truck chassis model is loaded by static forces from the truck body and cargo. The load is assumed as a uniform pressure obtained from the maximum loaded weight divided by the total contact area between cargo and upper surface of chassis. In this, rear and front end of the chassis are kept fixed. As chassis is divided into 3 parts, pressure is applied on all these parts at each side. The pressure applied on first part is 290321.9248 N/m^2 ,pressure applied on the second and the pressure applied part is 129362.6374 N/m^2 and the pressure applied on third part is 244740.1247 N/m^2 .Figure given below shows the magnitude of pressures applied on the frame at different positions.

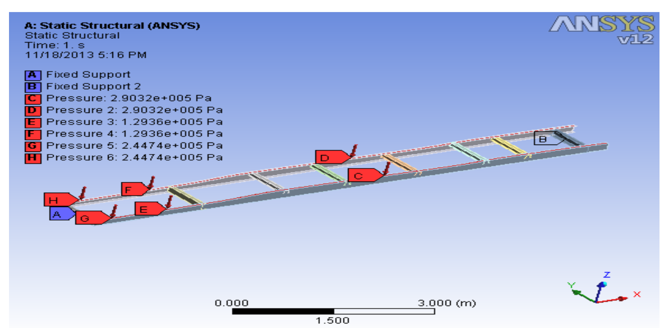


Figure : Loading and Boundary Condition of Static Analysis Truck Chassis.

Total Deformation:

Total deformation is nothing but the, "Total amount of change in length of chassis due to applied pressure." Figure given below shows the total deformation produced in the chassis. From figure it is seen that maximum total deformation will be at middle portion of the frame and its value will be 0.0.38208 m. Deformation will be minimum i.e. zero at the two fixed supports

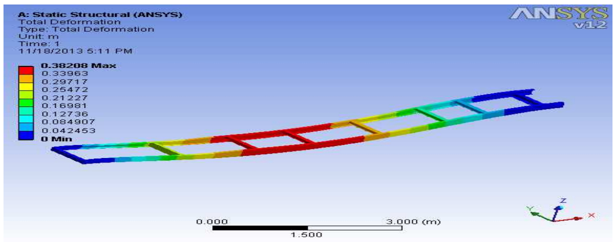


Figure : Total Deformation of Static Analysis Truck Chassis.

Directional Deformation:

Directional deformation is the deformation produced in a particular direction. Figure given below shows the directional deformation produced in the chassis. From figure it is seen that the maximum value of directional deformation is found to be 0.013308 m. And the minimum value is 0.012883 m.

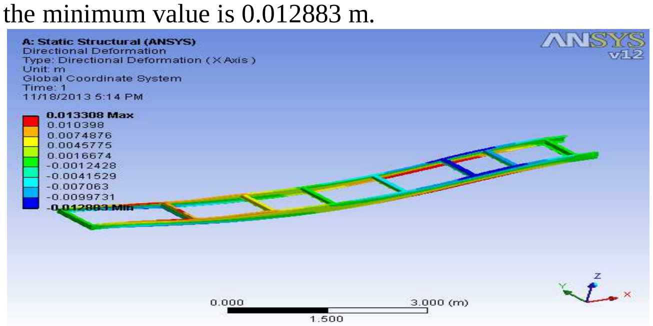


Figure : Directional Deformation of Static Analysis Truck Chassis.

Static Analysis with Load

Loading And Boundary Conditions

In static bending with chassis load both rear and front ends are kept fixed and different loading and boundary conditions are applied as shown in the figure given below. For bending it is assumed that the forces are acting at both side of the chassis in upward direction . It is also considered that the chassis load is also acting. In figure H and I denote the forces which are acting in upward direction whereas remaining are the chassis load acting in the downward direction. A and J denotes the fixed support.

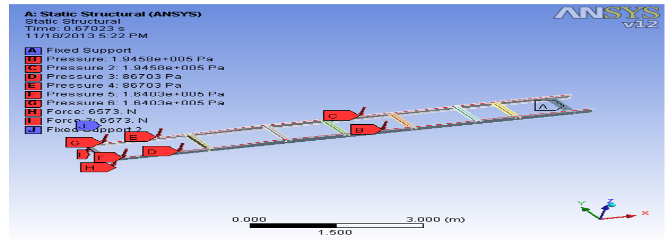


Figure: Loading and Boundary Condition of Static Analysis Truck Chassis.

Total Deformation:

Total deformation is nothing but the, "Total amount of change in length of chassis due to applied pressure." Figure given below shows the total deformation produced in the chassis. From figure it is seen that maximum total deformation will be at middle portion of the frame and its value will be 0.39193 m. Deformation will be minimum i.e. zero at the two fixed supports.

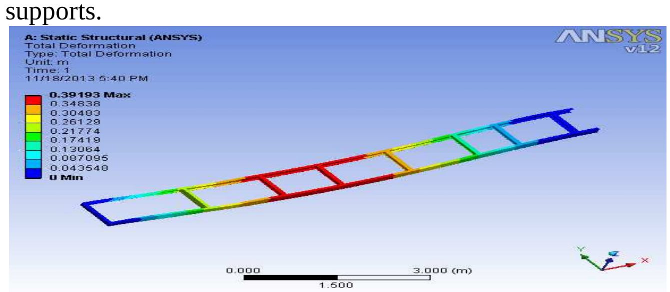


Figure : Total Deformation of Static Analysis Truck Chassis.

Modal Analysis Of Static Bending With Chassis Load

Loading And Boundary Condition

In static bending with chassis load both rear and front ends are kept fixed and different loading and boundary conditions are applied as shown in the figure given below. For bending it is assumed that the forces are acting at both side of the chassis in upward direction . It is also considered that the chassis load is also acting. In figure H and I denote the forces which are acting in upward direction whereas remaining are the chassis load acting in the downward direction. A and J denotes the fixed support. Then the analysis is made to find out different mode shapes and natural frequencies.

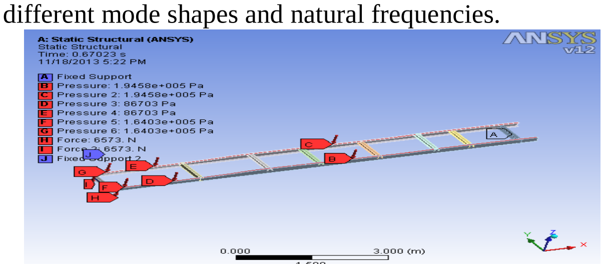


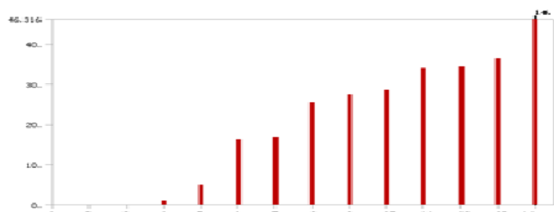
Fig: Loading & Boundary Condition

Eight natural frequencies were calculated for the mode analysis and are tabulated in Table no. below. It is observed that frequencies were varying from 20 Hz to 50 Hz.

Table: Mode shapes, Frequencies and displacement for Static Bending with Chassis Load Truck Chassis

Sr No.	Mode no.	Frequency	Displacement
1	1	16.894	Twisting about X-axis
2	2	25.537	Bending about Y-axis
3	3	27.427	Deformation about X-axis and Bending about Y-axis
4	4	28.746	Twisting about X-axis &Bending about Y-axis
5	5	33.971	Twisting about X-axis
6	6	34.316	Deformation about X-axis and Bending about Y-axis
7	7	36.564	Deformation about X-axis and Y-axis
8	8	46.316	Deformation about X-axis

Different mode shapes and their displacement natures are find out at these frequencies.



Graph:Frequencies at different modes for Static Bending With Chassis Load Truck Chassis

Mode Shapes Of Static Bending With Chassis Load:

Figure shows the **first mode shape** of the truck chassis at **16.894 Hz**. The chassis experienced first twisting mode about x-axis (longitudinal) and fall under global vibration as the whole chassis follow to vibrate. The **maximum** value of **deformation** at this frequency is found to be **0.13468m** while **minimum** deformation is **0.0012326m**. The maximum chances of failure of the chassis are at the top portion of the front end as it is subjected to maximum deformation. While minimum deformation is nearly at the central position of the chassis.

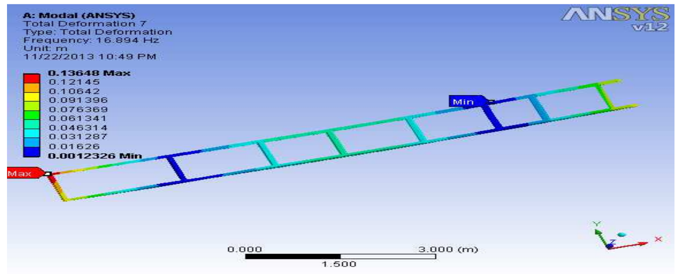
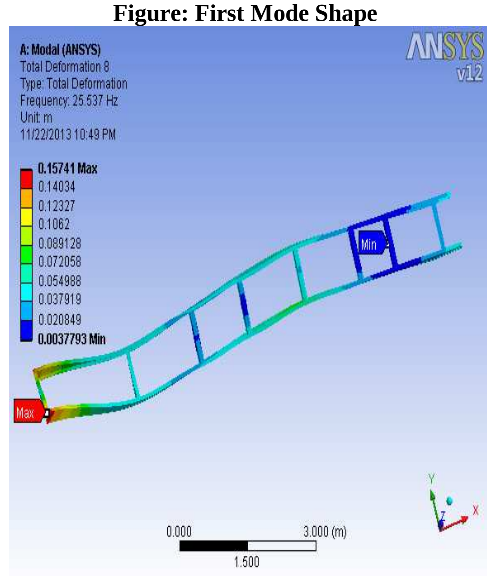


Figure: First Mode Shape



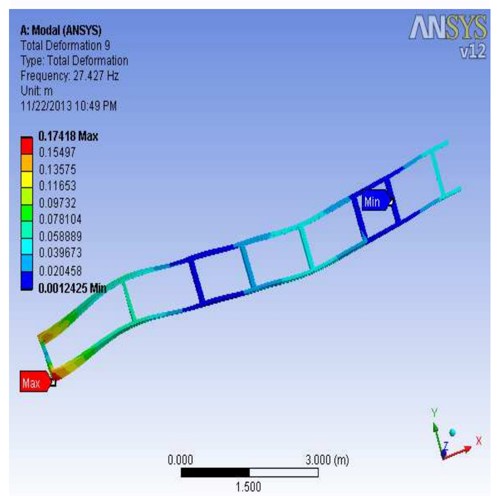


Figure: Second Mode shape
Figure: Third Mode Shape

ISSN: 2277-9655
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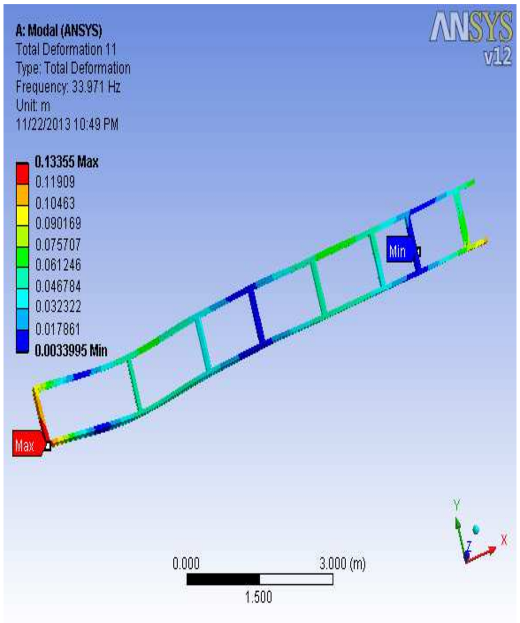

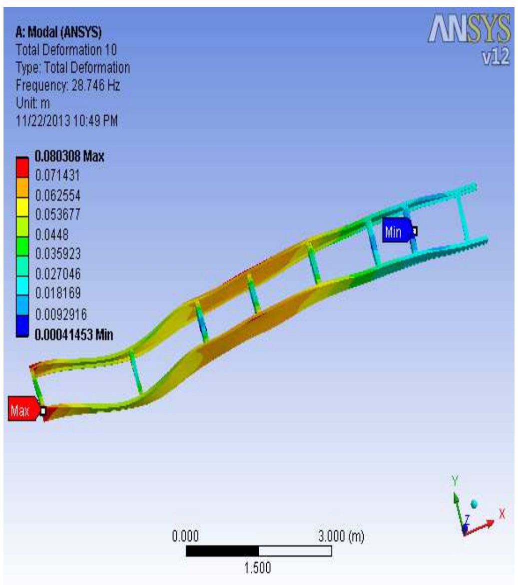

Figure: Fourth Mode shape
Figure: Fifth Mode Shape

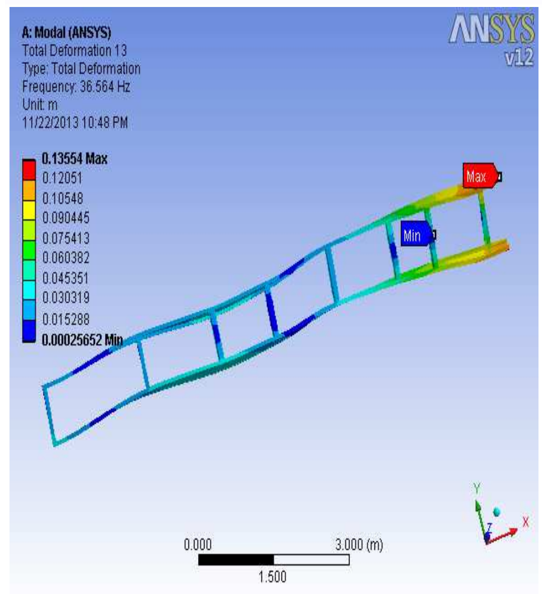

Figure: Sixth Mode shape
Figure: Seventh Mode Shape

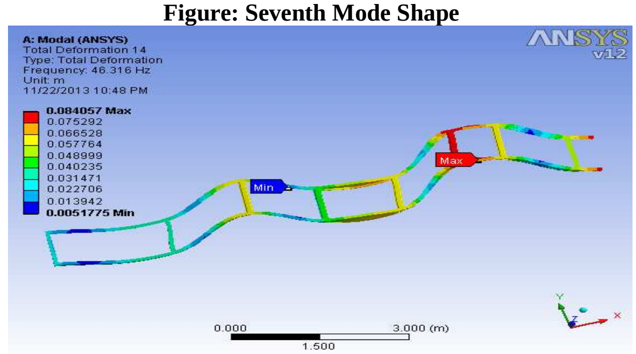

Figure: Eighth Mode shape

Shape Optimisation Of Chassis

Optimization of design has been achieved There has been considerable decrease in weight of chassis Optimization has been achieved by reducing the thickness of chassis C-section wherever less load is acting and where there are less deformations. following table shows the change in the mass of the chassis model and it is reduced from 401.55 kg to 366.76 kg.

Table: results after optimization.

Results	
Original Mass	**401.55 kg**
Marginal Mass	**1.3766 kg**
Optimized Mass	**366.76 kg**

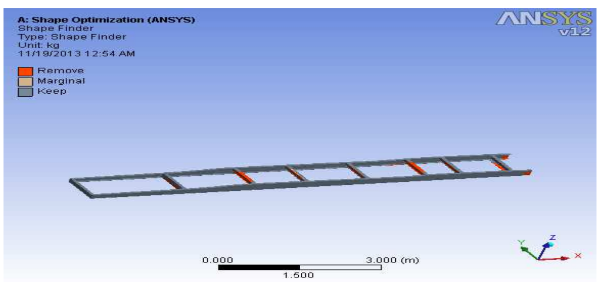

Fig: shape optimization.

Conclusion

The maximum shear stress, maximum equivalent stress and displacement are reduced and yield strength of chassis material is so large and if we consider results and yield strength , It is clear that design is safe. From the above result it is clear that the weight is also reduced by 8.49 % of the chassis frame. The paper has looked into the determination of the dynamic characteristic the natural frequencies and the mode shapes of the truck chassis, The eight natural frequencies of the truck chassis are below 100 Hz and vary from 13 to 50 Hz. Generally most truck chassis frequencies are below 50 Hz so 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 analyze modified chassis frame before manufacturing

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