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Shape Optimization of Automobile Chassis

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***Abstract*—This paperproposes an idea about the analysis and shape optimization of ladder chassis frame for TATA truck Model No. TATALPT 2518. Practically load distribution on the chassis is not uniform across its total area but for simplicity we are considering the load distribution is uniform on whole of the chassis. We will be Analyzing the effect of reduction in cross section area with constrains of bending stress and deflection, reduction in area will save amount of material required for ladder chassis.. Reduction of area for some specific span will distribute nearly uniform stresses across its whole area. The research work is carried out on transverse and longitudional members of ladder chassis**

Keywords*— Cross section area, Ladder chassis, Side member, Weight Reduction

INTRODUCTION

The chassis is considered to be skeleton of an automobile. It is the frame which holds both the car body and the power train parts such as engine, drive train, the axle assemblies including the wheels, the suspension parts, the brakes, the steering components, etc The chassis provides the strength needed for supporting the different vehicular components as well as the payload and helps to keep the automobile rigid and stiff. Also it ensures low levels of noise, vibrations and harshness throughout the automobile. Chassis should be rigid enough to withstand the shock, twist, vibration and other stresses. Along the strength, an important consideration is chassis design is to have adequate bending and torsional stiffness for better handling characteristics. So, strength and stiffness are two important criteria for the design of chassis. The load carrying structure is the chassis, so the chassis has to be so designed that it has to withstand the loads that are coming over it.

I. LITERATURE REVIEW

P.S Madhu., T.R.Venugopal RADIOSS has used as solver for the analysis. They found the position of von mises stress and they minimizedstresses by relocating the position of the cross members and deflection of the chassis side members can be reduced considerably.[1]

H.Patel, K.C.Panchal and C.S.Jadhav performed the optimization of the automotive chassis with constraints of maximum shear stress and deflection of chassis. For optimization of chassis different cross sections are selected.[2]

H.B.Patil, S.D.Kachave and E.R.Deore have selected different thicknesses for cross members and sidemembers of truck. They have suggested that to change the thickness of cross member at critical stress point than changing the thickness of side member and position of chassis for reduction in stress values and deflection of chassis. [3]

II. PROBLEM STATEMENT

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III. OBJECTIVE

The objective of research work is design theladder chassis according to the application of luniform load acting on it. The generation of stresses will be according to the applied load on the chassis i.e. in some area of chassis magnitude of stresses will be high and remaining portion of chassis will be under low stresses. Consider these conditions.

1. Design the chassis by considering its existence dimensions. It will give the magnitude of stresses and deflection which is generating in thechassis.
2. Reduce the area where intensity of stress is less.
3. Generated stresses after reducing area must be less than its allowable limit.
4. Calculate amount of weight reduction after reducing the area

IV. METHODOLOGY

The solution for the problem is performed in three stages - Theoretical Analysis, Finite Element Analysis.

A. Theoretical Analysis

Theoretical Analysis is performed by using the basic concepts of Strength of Materials. Total load acting on the Chassis is taken as a sum of capacity of the chassis and weight of the body and engine. This total load is considered as uniformly distributed load acting throughout the span of the beam . Reaction forces , Bending moment ,bending stresses and moment of ineriaare calculated based on the total load.

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B. Finite Element Analysis

In FEM it includes: define the geometric domain of the problem, the element type(s) to be used, the material properties of the elements, the element connectivity (mesh the model), the physical constraints (boundary conditions) and the loadings. In solution phase, the governing algebraic equations in matrix form are assembled and the unknown values of the primary field variable(s) are computed.After this we determined the values of bending stresses ,FOS and deflection usding ANSYS15.0

V. CASE STUDY

Truck Side bar of the chassis are made from "C" Channels

Material of the chassis is ASTM A710 Steel

Yield Strength = 450 N/mm2

Factor of Safety = 2.5

Allowable Bending Stress = 450/2.5 = 180 N/mm2

Front Overhang (a) = 776.24 mm

Rear Overhang (c) = 1263.76 mm

Wheel Base (b) = 5683 mm

Modulus of Elasticity, E = 2.10 x 105 N / mm2

Poisson Ratio = 0.28

Total Capacity of Truck = 25tons = 25000kg = 245000 N

Capacity of Truck with 1.24% = 305830.8N

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 = 30530.8/2 = 152915.4 N / Beam

Chassis (frame) has current weight of 443kg

Coming to shape optimization chassis has tranverse and longitudinal members. We will be doing shape optimization of transverse members.

A. Calculation for Reaction Beam is simply clamp with shock absorber and leaf spring. So, beam is considered as a simply supported beam supported at A,B, C and D with uniform distributed load.

Load acting on the entire span of the beam = 152915.4 N

Length of the beam = 7723 mm

Uniformly Distributed Load = 152915.4 / 7723= 19.8 N/mm

Fig1.TATA LPT 2518 truck

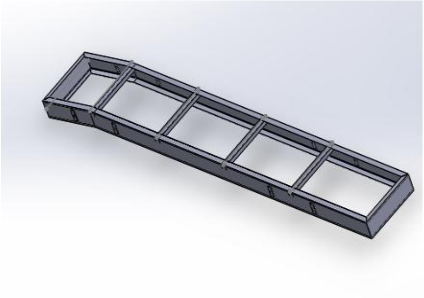
Fig2. TATA Truck Chassis

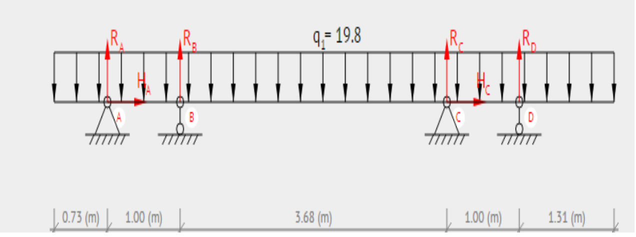

Fig3.UDL Drawing

Ra+Rb+Rc+Rd=152915.4

Calculation of Rxn's:

Ra=436902.8 KN
Rb=-174759 KN
Rc=-152918.3 KN
Rd=43689.7 KN

B. Calculation of bending moment:
Ma = -5338917.635 KNmm
Mb = 107280794.7 KNmm
Mc = 1393173685 KNmm
Md = 1104308851 KNmm

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C. Moment of inertia about x-x axis=424442.35mm4

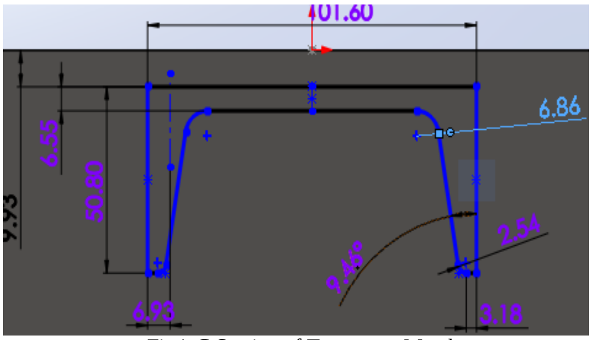

Fig4. C Section of Transverse Members

Basic bending equation is given by,

$$\frac{M}{I}=\frac{\sigma}{Y}=\frac{E}{R}$$

Mmax=1393173685 KNmm
Y=41.51mm
And Bending stress acting on the beam=136.250Mpa

Now Comes the Ansys report in which we observed its FOS just to see how much percentage of shape optimization could be done in such a chassis

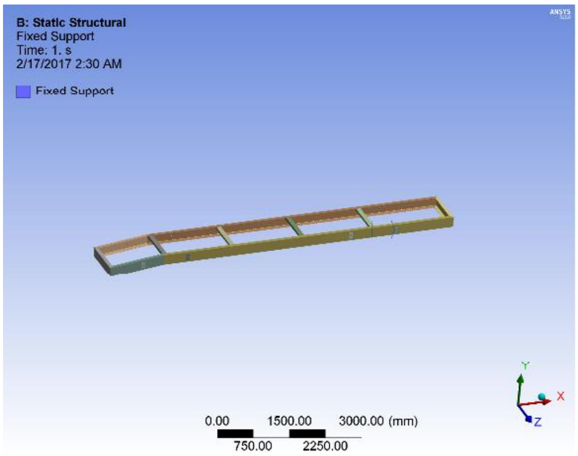

Fig5. Fixed support for chassis

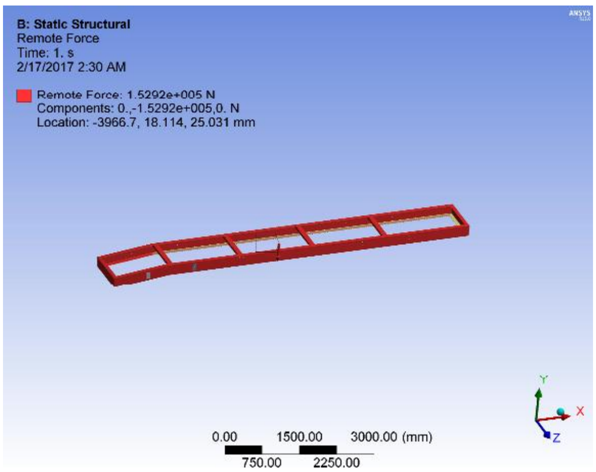

Fig6. Remote force on chassis

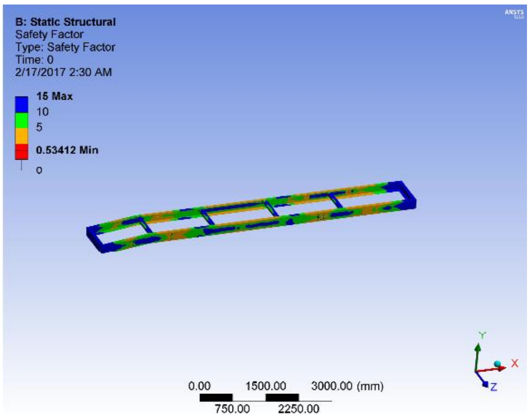

Fig7.Safety factor of chassis

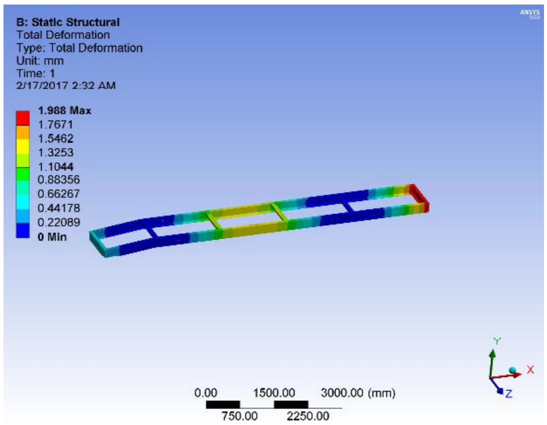

Fig8.Deformation of chassis

Coming to the shape optimization technique .it will be done only of the transverse members.

There are basically 2 techniques of shape optimization

1. Punching holes in the area where fos is more
2. Reducing the moment of inertia so that its premessible stress reaches the value of allowable bending stress.

I. Punching the holes

We did punched near about 20 holes in whole of the chassis .we punched holes at those places where the Fos is more than expected or where the chassis was over constrained by observing the ansys report very carefully. Due to this result we are able to reduce the weight of chassis by 26Kg and the original waight of the chassis was 443kg

And now the weight is reduced to 417kg

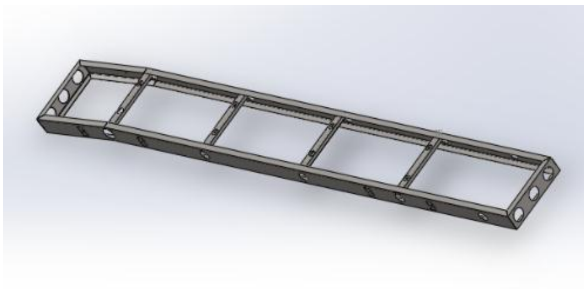

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Fig9. Hoes punched on the chassis

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II. Reducing the moment of Inertia of Transverse members. There are total 4 transverse members in current chassis. Next comes the fig which depicts the reduced moment of inertia

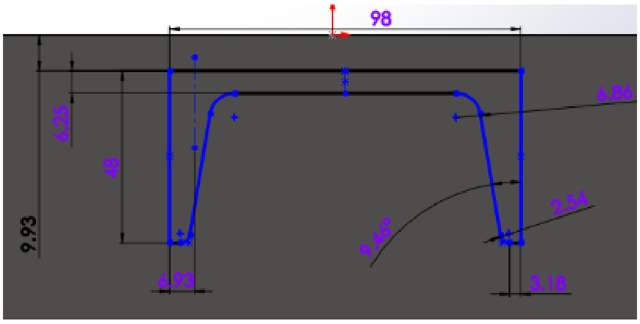

Fig10. Reduced moment of inertia

Now the Ixx=324762.12mm4

Also in the calculation of moment of inertia we have included moment of inertia due to punching of holes but due to constaint of space I am not showing calculation stuff. I am just posting the results which I have obtained or calculated.

Y=40.73mm

$$\frac{M}{I} = \frac{\sigma}{Y} = \frac{E}{R}$$

Mmax = 1393173685 KN mm

And Bending stress acting on the beam=174724.7 Mpa

Permissible Bending stress is less than the allowable Bending stress which concludes that our design is still safe after reducing the considerable amount of weight.

NOW the Ansys report of Optimized frame.

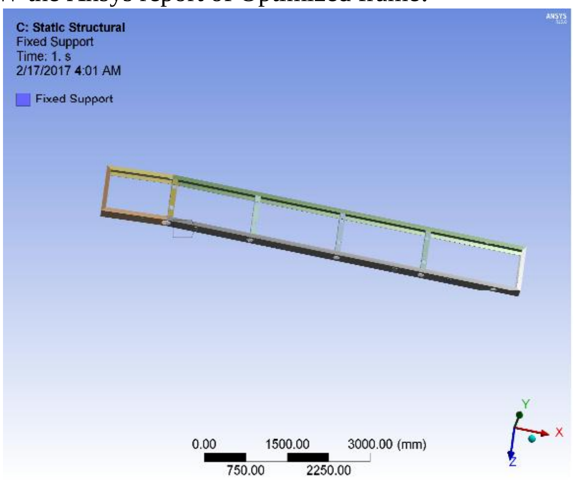

Fig11. Fixed support of optimized chassis

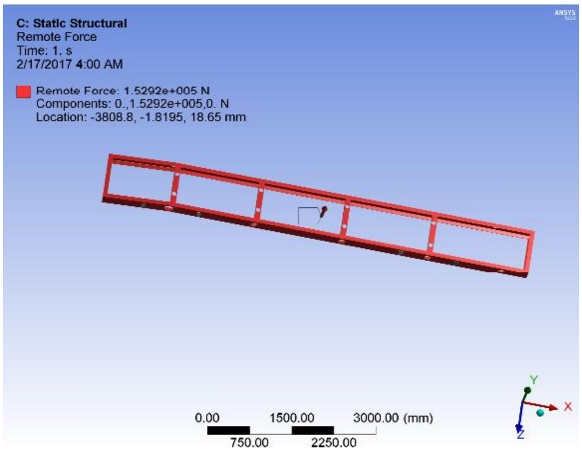

Fig12. Remote force on optimized chassis

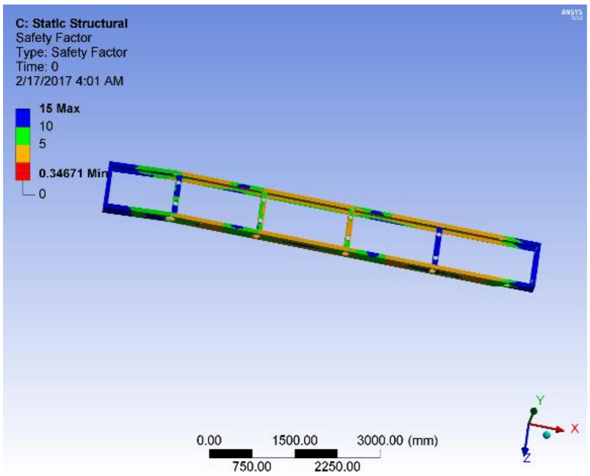

Fig13.Safety Factor of optimized chassis

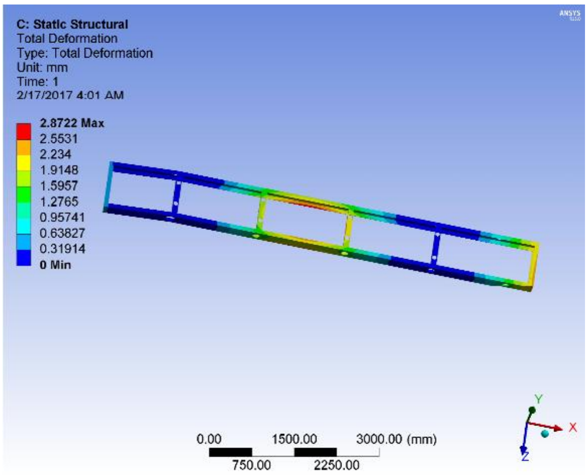

Fig14.Deformation of optimized chassis

As now we can see in Ansys report frame is safe. Though fos varies a lot at the front and at the rear still after punching holes at the front and the rear.

And the weight reduced by by decreasing the moment of inertia is 12Kg

And total weight reduction is Almost 38Kg.

And total weight reduction is Almost 38Kg.

VI. WEIGHT REDUCTION

Weight of changed section in percentage
= 405 / 443
= 91.4.18%
Percentage saving in weight = (100-92.18) = 8.61%

VII. RESUTS & CONCLUSION

a) The results revel that as area is decreasing due to the generated stresses in side member of ladder chassis are increasing but it is within allowable limit of stresses.

b) The Bending stress, FOS values calculated are within limit.

d) It helps to reduce the area for the transverse members and finally material saving is possible up to 8.61%

VIII. ACKNOWLEDGEMENT

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