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# Stress Analysis of Automotive Chassis with Various Thicknesses

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***Abstract :*** *This paper presents, stress analysis of a ladder type low loader truck chassis structure consisting of C-beams design for application of 7.5 tonne 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. Numerical results showed that if the thickness change is not possible, changing the position of cross member may be a good alternative. Computed results are then compared to analytical calculation, where it is found that the maximum deflection agrees well with theoretical approximation but varies on the magnitude aspect.*
***Keywords -*** *Stress analysis, fatigue life prediction and finite element method etc.*

## I. INTRODUCTION

The chassis of trucks is the backbone of vehicles and integrates the main component systems such as the axles, suspension, power train, cab and trailer, and is usually subjected to the weight of cabin, its content, and inertia forces arising due to roughness of road surfaces etc. (i.e. static, dynamic and cyclic loading). The stress analysis is important in fatigue study and life prediction of components to determine the highest stress point commonly known as critical point which initiates to probable failure, 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 chassis. The location of critical stress point is thus important so that the mounting of the components like engine, suspension, transmission and more can be determined and optimized, Finite Element Method (FEM) is one of the method to locate the critical point [1,2]. Safety factor is used to provide a design margin over the theoretical design capacity. This allows consolidation of uncertainties in the design process [3].Jadav Chetan S. et al reviews various factors affecting the fatigue life of an structure like cyclic stress state, geometry, surface quality, material type, residual stresses, size and distribution of internal defects, direction of loading & grain size [4].

In this study, chassis structures are comparing by the thicknesses of the profiles. For determining the strength of the frame, structural analyses were performed for these frames of thicknesses of 4, 5, 6 mm and also changing the position of cross member and change the thickness of cross member near high stress zone. The truck chassis was modeled and the finite element analyses were solved in CATIA V5R10.

During this five different cases consider to study the effect of thickness on chassis stresses

- Case 1 Thickness of Side member is 4 mm.
- Case 2 Thickness of Side member is 5 mm.
- Case 3 Thickness of Side member is 6 mm.
- Case 4 Change position of 4$^{th}$ Cross member at 2520 from rear end.
- Case 5 Thickness of 5$^{th}$ Cross member is 5 mm.

## II. LITERATURE REVIEW

Roslan Abd Rahman et al [1] does stress analysis of heavy duty truck chassis by utilizing a commercial finite element package ABAQUS. To determine critical point so that by design modifications the stresses can be reduces to improve the fatigue life of components. During this he uses ASTM low alloy steel a 710 C (Class 3) with 552 MPa of yield strength and 620 MPa of tensile strength for chassis founds the maximum stress 386.9 MPa at critical point occurred at opening of chassis This critical point is located at element 86104 and node 16045, which is in contacted with the bolt from this he concludes that this critical point is an initial to probable failure.

Cicek Karaoglu et al [2] does stress analysis of heavy duty truck chassis with riveted joints by utilizing a commercial finite element package ANSYS version 5.3.during this study, he examine the effect of the side member thickness and connection plate thickness with length change, the side member thickness is varied from 8 to 12 mm, and the thickness of the connection plate is also varied from 8 to 12 mm by local plate, the connection plate thickness is varied from 7 to 10 mm, and the length of the connection plate (L) is varied from 390 to 430 mm. from this he concluded that if the change of the side member thickness using local plates is not possible, due to increase weight of chassis then choosing an optimum connection plate length (L) seems to be best practical solutions for decreasing the stress values.

Mohd Azizi Muhammad Nor et al [3] performs the stress analysis of an actual low loader structure consisting of I-beams design application of 35 tonne trailer. He uses modeling software CATIA V5R18. The results of analysis revealed that the location maximum deflection and maximum stress agrees well with theoretical maximum location of simple beam under uniform loading distribution. This study found out that there is discrepancy between the theoretical (2-D) and numerical (3-D FEA) results. It is observed that the maximum deflection is pointed in situated in between BC1 and BC2 with magnitude of 7.79mm. The results of the numerical analysis revealed that the location maximum deflection and maximum stress agrees well with theoretical maximum location of simple beam loaded by uniform force.

Jadav Chetan S et al [4] review the investigations that have been made on the different fatigue analysis techniques of automobile frames.

N.K.Ingole et al [5] does the modifications in existing model of tractor trailer chassis by 1) Variation in Cross sectional areas of cross members, 2) Variation in cross sectional areas of cross and longitudinal members, 3) Variation in cross sectional areas of cross and longitudinal members and 4) Changing the position of cross members of main frames of chassis, Considering variable cross sectional areas of cross and longitudinal members. It has been found that, maximum stress present in existing chassis is 75 MPa and weight of chassis is 751.82 kg. Case 4 leads to maximum weight reduction of approx 112 kg as compared to case 1, 2 and 3. So modifications as per case 4 are also recommended, case 3 the weight reduction is 88 kg with maximum stress level in range of 25MPa to 66 MPa.

## III. BASIC CALCULATION FOR CHASSIS FRAME

For Case 1

Model No. = 10.75 (Eicher)

Side bar of the chassis are made from “C” Channels with 200mm x 55 mm x 5 mm

Front Overhang (a) = 1005 mm.

Rear Overhang (c) = 1305 mm.

Wheel Base (b) = 3515 mm. Material of the chassis is Steel

Table 1Material properties of the Truck Chassis Steel

| | |
|---|---|
| Young’s Modulus | 200 GPa. |
| Poisson’s Ratio | 0.266. |
| Density | 7860 $Kg/m^3$. |
| Yield Strength | 250 MPa. |
| Symmetry | Linear Isotropic. |

Capacity of Truck = 7.5 ton = 7500 kg = 73575 N.

Capacity of Truck with 1.25% = 9375 N = 91968.75 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
= 91968.75 + 19620
= 111588.75 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 =111588.75/2 = 55794.375 N / Beam.

Uniformly Distributed Load is 55794.375 / 5825 =9.578 N/mm.

Figure 1Typical Chassis

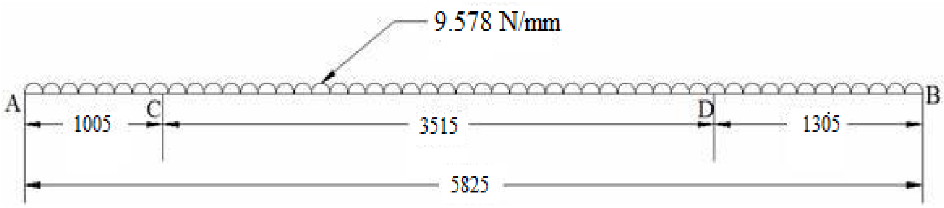


Figure 2Chassis as a simply supported beam with overhang.

Stress produced on the beam is as under

$$\sigma = \frac{Mmax}{Z}$$

=123.83 MPa.

Deflection of chassis

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

=1.08456 mm.

## IV. FE ANALYSIS OF CHASSIS

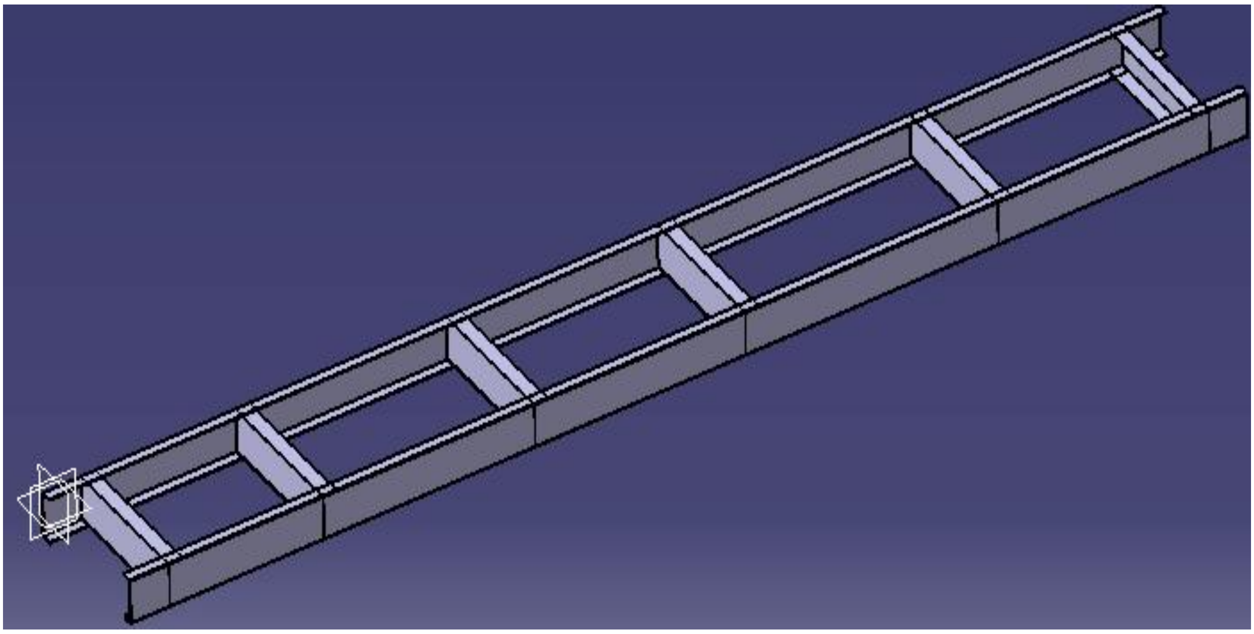

Figure 3Model of Chassis Case 1.

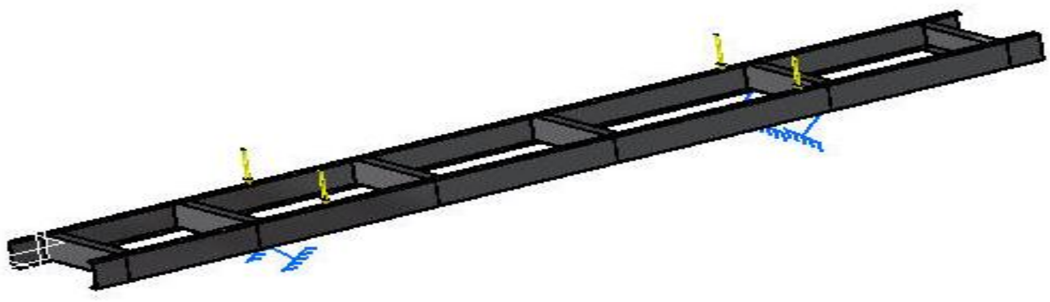

Figure 4Boundary Conditions Case 1.

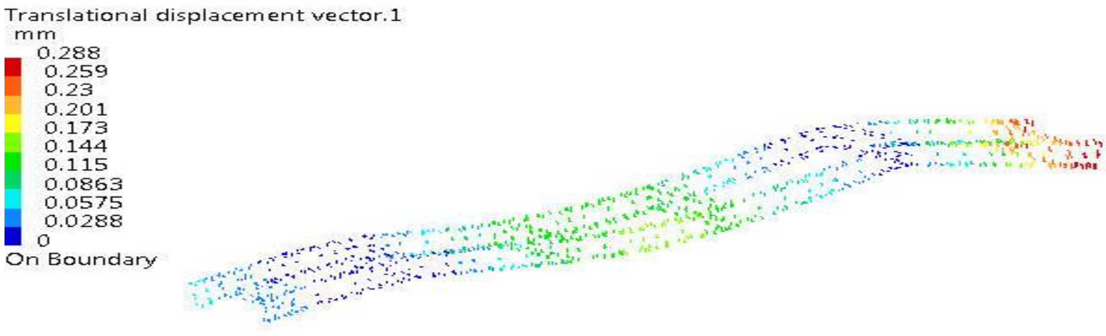


Figure 5 Displacements of Case 1.

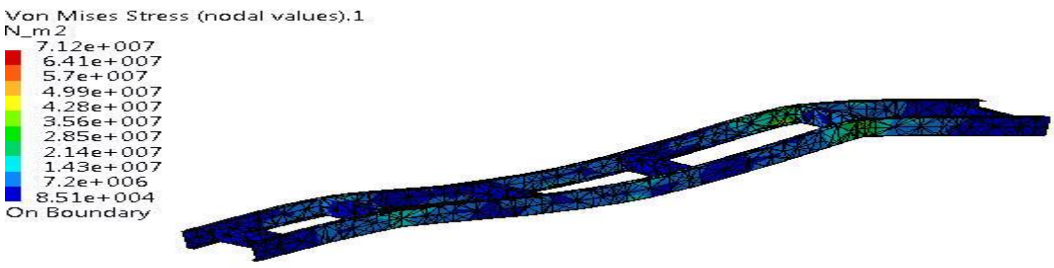


Figure 6 Von Mises Stress of Chassis for Case 1.

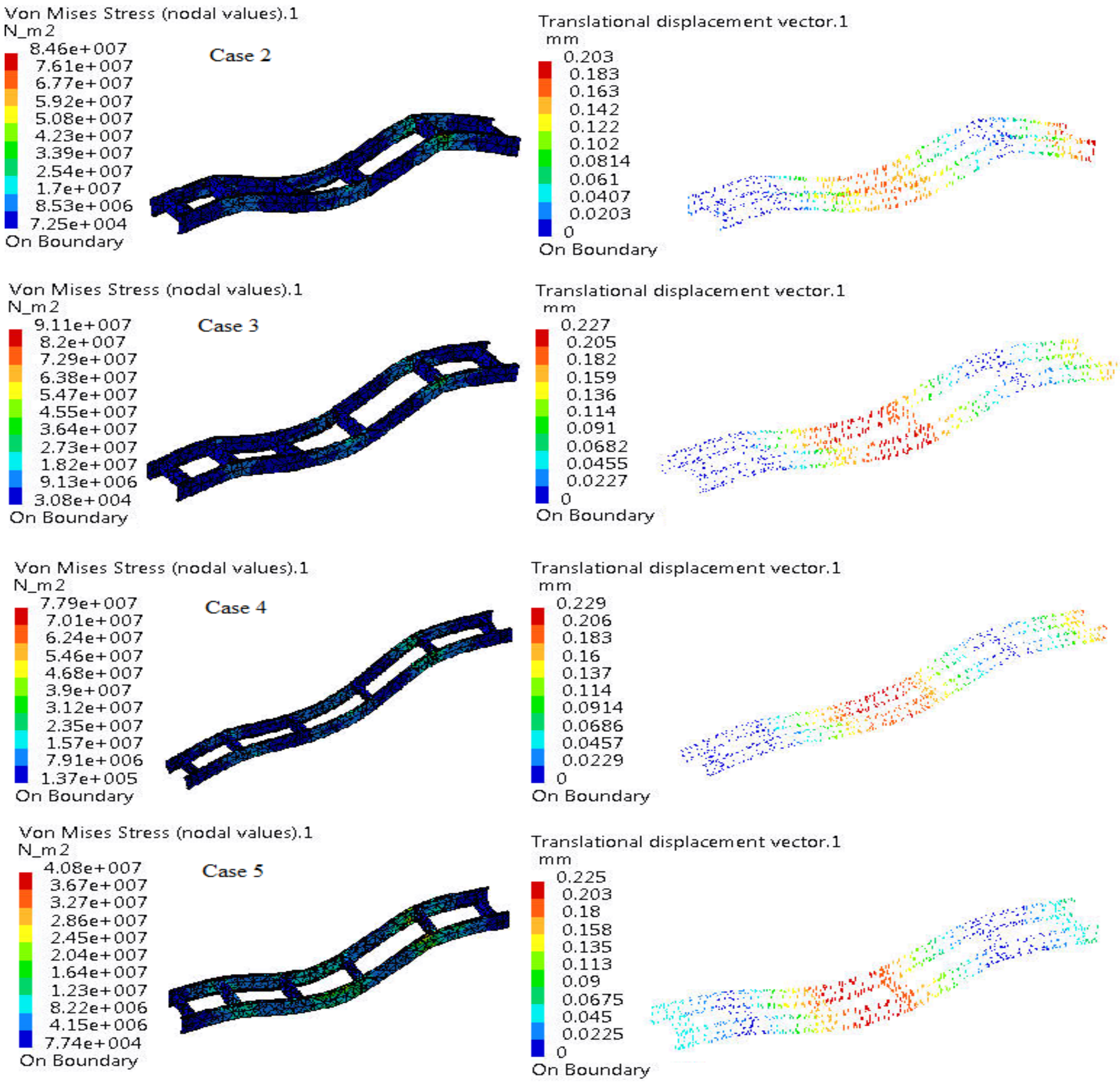


Figure 7 Von Mises Stresses and Displacements of Cases 2, 3, 4 and 5.

## V. RESULT AND DISCUSSION

Table 2 Comparison of results

| Sr No. | Analytical Method | | FE Analysis | | |
|---|---|---|---|---|---|
| | Displacement (mm) | Stresses ($N/mm^2$) | Displacement (mm) | Stresses ($N/mm^2$) | Weight (Kg) |
| **Case 1** | 1.0845 | 123.83 | 0.288 | 71.2 | 141.48 |
| **Case 2** | 1.0271 | 100.83 | 0.203 | 84.6 | 165.06 |
| **Case 3** | 0.9780 | 085.57 | 0.227 | 91.1 | 188.64 |
| **Case 4** | 1.0271 | 100.83 | 0.229 | 77.9 | 165.06 |
| **Case 5** | 0.9300 | 100.83 | 0.225 | 40.8 | 167.98 |

## VI. Conclusion

- The analyses are processed in the static and structural conditions. From comparison for 4mm thickness the highest stress occurred is 123.83 MPa by FE analysis and the calculated maximum shear stress is 123.83 Mpa. The maximum displacement of numerical simulation result is 0.288 mm. The difference is caused by simplification of model and uncertainties of numerical calculation and improper meshing.

- Comparing case 5 with case 2 only by increasing thickness of cross member weight is increases by 2.92 Kg stresses are decreased by 43.8 N/mm$^2$, and displacement is increased by 0.022mm.
- Comparing case 4 with case 2 only by changing the position of cross member weight is not affecting stresses are deceases by 06.7 N/mm$^2$, and displacement is increased by 0.026 mm.
- Comparing case 3 with case 2 only by increasing 23.58 Kg stresses are increased by 06.5 N/mm$^2$, and displacement is increased by 0.024mm.

Hence it is better 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.

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