International Journal Of Multidisciplinary Research In Science, Engineering And Technology (IJMRSET)

Volume 1, Issue 4, July 2020

# Design and Analysis of 40 Tonne Semi Trailer Chassis

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**ABSTRACT:** The trailer is a main load carrying element of the full scale vehicle model. This trailer frame consists of two strong, long members of mostly I-section sections and connected by means of cross members of ISMC 200. Geometry and location of various parts has to be selected or modified carefully to avoid interference, depending up on the purpose or requirement of the trailer for which it is used.

In this study, the purpose of the vehicle is to carry the heavy rocket hardware, solid motors and boosters of about 40T safely. If any mistake happens the result will be very ferocious as the material is highly hazardous. This study mainly addresses the stability and improvement of the safety standards.

Detailed study of static and dynamic behavior of chassis frame is very important from structural point of view. Here the detailed static analysis is done in analytical and numerical methods and the results obtained are matching. Model analysis done by using ANSY 2019 and determined the natural frequencies and the mode shapes.

**KEYWORDS:** ISMC, Structural analysis, Dynamic analysis, Modal analysis, Mode shapes.

## I. INTRODUCTION

A **trailer** is an unpowered vehicle towed by a powered vehicle and is generally used for transportation of goods and materials from one place to another place on the ground. A motor vehicle is somewhat different from the trailer. Motor vehicle or vehicle means any mechanically propelled vehicle adopted for similar purpose upon the ground but in this case the load carrying unit is an integral part with the powered unit, in simple terms both the powered unit and the Trailer together form a Motor vehicle. The trailer is also differs from the railway bogie, as bogie is not moving on the ground. The trailers are further calcified in many ways, two important classification bases are one is based on the load and another one is based on the arrangement of the axles and the number of axles

## II. LITRATURE REVIEW

[1] Divyanshu Sharma and Y D Vora has studied the design of chassis, identified various chassis types &designed and analyzed a chassis for heavy duty trailer by using FEA software. Their study result shows that reduction in the trailer weight for the proposed cross sections with equal rigidity and stiffness with zero / negligible deformation at the chassis rear side.

[2] Gajanan S. Datar has analyzed the static and dynamic load behavior of a 40 tonne heavy duty trailer's frame. They concluded as the structure is safe with nearly least deflection.

[3] Heman t B.Patilhas identified various ways to reduce the magnitude of stress in the chassis frame by varying the thickness of side member, thickness of cross member and cross member position. The Numerical study results show's that changing the position of cross member may be a good alternative if the thickness change is not possible.

[4] Joel Galos is identified that for carrying weight over axle the double- deck trailer can be used as they were very useful in light weighting the trailer and they found that, due to the poor height clearance it cannot be used in the under bridges and tunnels. They suggested most successful composite solutions for making a balance between performance, cost, and weight reduction and they designed a new lightweight heavy duty goods vehicle trailer.

[5]Jeong Jae Kim a, Jeongju Kim:research paper aims to reduce the aerodynamic drag exerted on heavy vehicles. They identified various ways to reduce the drag including cab roof fairing, gap fairing, boat tail, and side skirt.

[6] M. Zehsaz has identified the stress distribution in the truck chassis under static and dynamic loads conditions. They identified the effect of various types of joints and their thickness on their strength.

[7] Mohammad Reza Forouzan has investigated the natural frequencies and mode shapes of the truck chassis. Along with that the relationship between engine operating speed and natural frequencies has been explained. Their study shows the main disturbance to the truck chassis is that the road excitation, because natural frequencies of chassis lie within the frequency range of road excitation.

[8] MohdAzizi Muhammad Nora has calculated the low loader structure's Safety factor by modeling, simulation and performing the stress analysis of an I-beams design for actual low loader structure.

[9] N.K.Ingole this research paper aims to modify the existing structure of chassis to reduce the weight within the safe stress values. FEA analysis has done on the chasis members to identify the stress distribution.

[10] Vijaykumar V. Pateland R. I. Patel has done static structural analysis in the truck chassis. The chassis of truck is modeled in cad software PRO-E. Finite element analysis is done by using the ANSYS Workbench FEA software.

## III. RESEARCH GAP

From the Research Survey, it is seen that many researchers have worked on Design of heavy vehicle trailers.

- In almost all the papers the loading is UDL and is throughout the length of the chassis frame, so the intensity of loading is very less (not more than 4t/m length of chassis), but here the intensity of loading is very high and is more than 13t/m.
- The stability of the chassis is highly dependent on the height of Centre of Gravity (CG) of the loading, In this case Rocket boosters are placed and transported vertically, which raises the center of gravity (3.5m to 7m aprox.,) which reduces the stability and further increases the cornering forces. It was not considered in any paper.
- In many papers weight reduction of the chassis is the main theme, to achieve this cross sectional area is reducing and doing a single analysis either static or dynamic and comparing with previous results in other papers, if we do some other analysis i.e. in dynamic or fatigue analysis, the results are very poor.

## IV. OBJECTIVES

- To Design a 40 Ton semi trailer as per AISC guide lines by using structural steel -52
- To do Static analysis of chassis frame by using ANSYS. To find the maximum stress and strains in the chassis.
- To do Dynamic (Vibration) analysis of the chassis for predicting the failure modes of the chassis.

### LINEAR STATIC ANALYSIS

The linear static analysis is done for the chassis frame in its horizontal condition by specifying the pay load and self weight in Newton as UDL. These analytical calculations are done by using beam guru software. In the software beam is created, loads and reactions applied and solved.

Case-I:

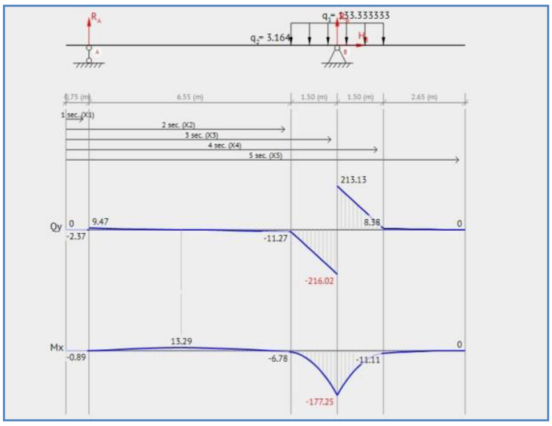
The trailer is resting on the tyres at the rear end and on the fifth wheel coupling at the front end.

International Journal Of Multidisciplinary Research In Science, Engineering And Technology (IJMRSET)

Volume 1, Issue 4, July 2020

Image 1 Shear force and bending moment diagram

(CASE-I)



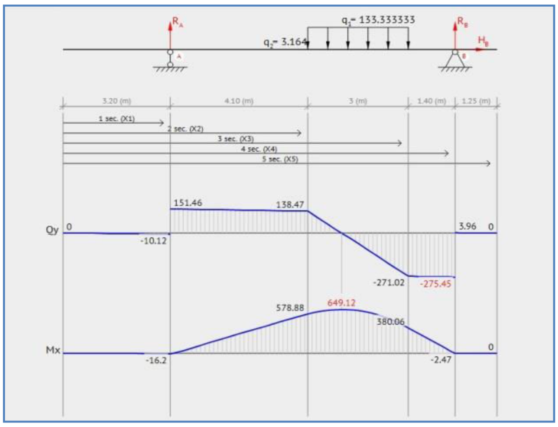

*Shear force in kN, **Bending moment in kN-m

Case-II:

Trailer is resting on the on the two speed landing leg at the front and rear.

Image 2 Shear force and bending moment diagram

(CASE-II)



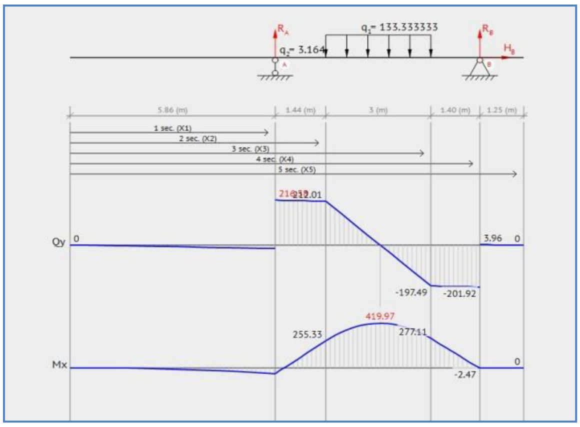

*Shear force in kN, **Bending moment in kN-m

Case-III:

When trailer is resting on the on the two speed landing leg in the middle and rear.

Image 3 Shear force and bending moment diagram

(CASE-III)

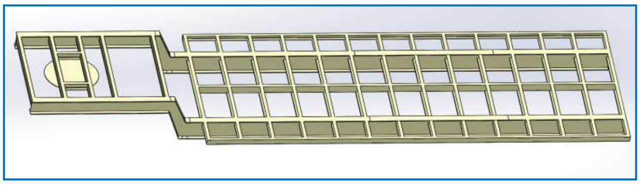



*Shear force in kN, **Bending moment in kN-m

THREE DIMENSIONAL MODEL OF THE CHASSIS FRAME.

Modeling of the chassis frame is done in solid works 2018. The main beams or the main longitudinal members are made of “I-section” of 550 X 170 X 20 X 10 tk. The cross members are made of folded channel sections of ISMC 200 in the middle and ismc150 in the outer sides of the structure.

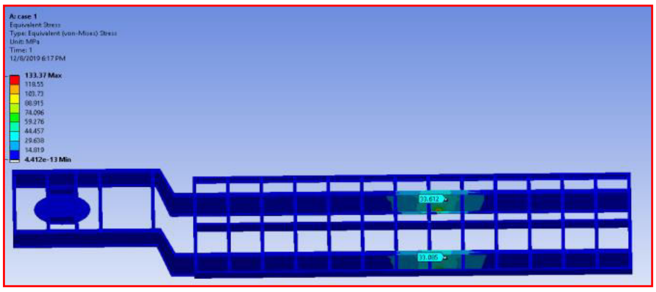
Image 4 Solid model of the chassis frame.



FINITE ELEMENT ANALASYS OF THE CHASSIS FRAME

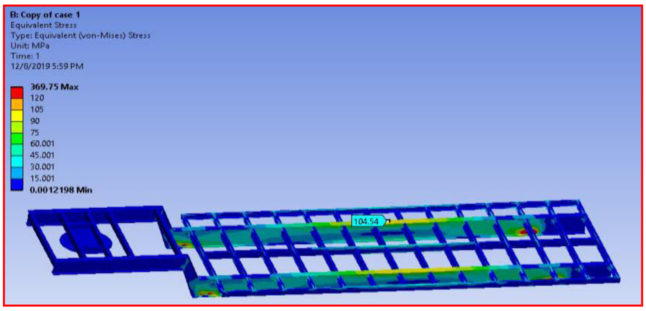
Case I: The trailer is resting on the tyres at the rear end and on the fifth wheel coupling at the front end.

Image 5 Bending stress in the chassis frame (Case-I)



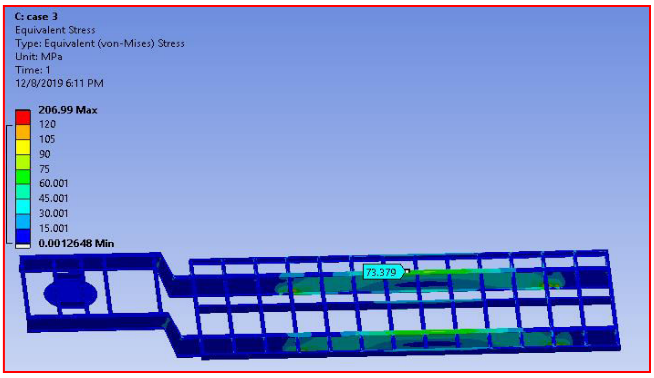
Case II: Trailer is resting on the on the two speed landing leg at the front and rear.

Image 6 Bending stress in the chassis frame (Case-II)




Case III: When trailer is resting on the on the two speed landing leg in the middle and rear.

Image 7 Bending stress in the chassis frame (Case-III)



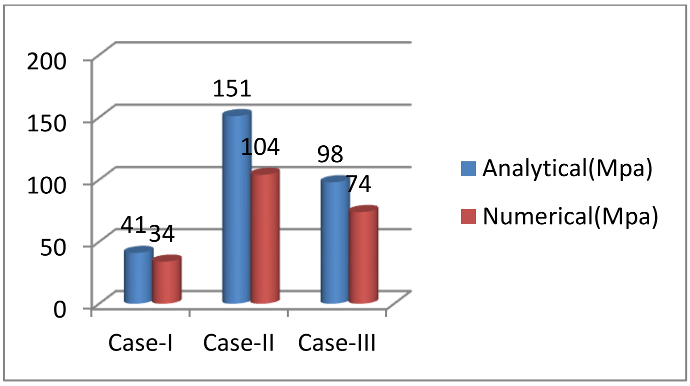

## V. COMPARISON OF STRESSES IN ANALYTICAL AND FINITE ELEMENT ANALYSIS METHODS.

Table 1 Comparison of stresses in analytical and finite element analysis methods

| S.NO. | | Analytical (Mpa) | NUMERICAL (Mpa) |
|---|---|---|---|
| 1 | Loading condition-I | 41 | 34 |
| 2 | Loading condition-II | 151 | 104 |
| 3 | Loading condition-III | 98 | 74 |

International Journal Of Multidisciplinary Research In Science, Engineering And Technology (IJMRSET)
Volume 1, Issue 4, July 2020

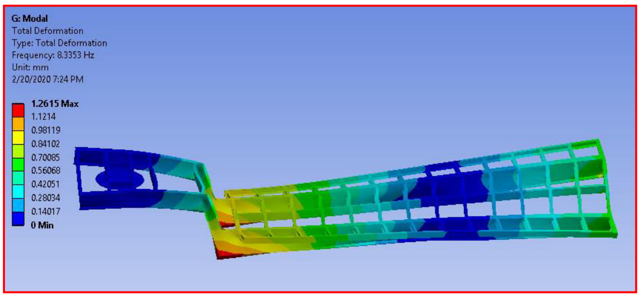
Graph 1 Comparison of stresses in analytical and finite element analysis methods



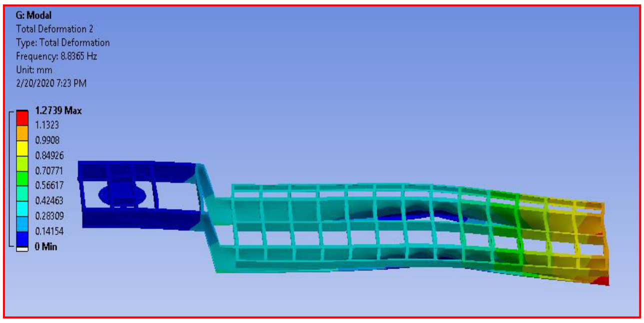

Dynamic analysis of the chassis

In Vibration Analysis, the loads applied on chassis are not considered as we want its natural frequency so that we can understand how many vibrations it can sustain and at what frequency level chassis may bend. Applied loads do not affect the results. Therefore the solution is obtained for six different sets of frequency. Each set will give its own chassis displacement value with area of displacement. Complete result obtained using FEA package is discussed bellow.

Deflection in Mode I




Deflection in Mode II



International Journal Of Multidisciplinary Research In Science, Engineering And Technology (IJMRSET)

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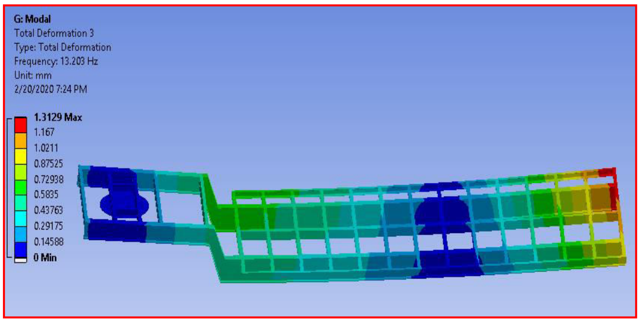
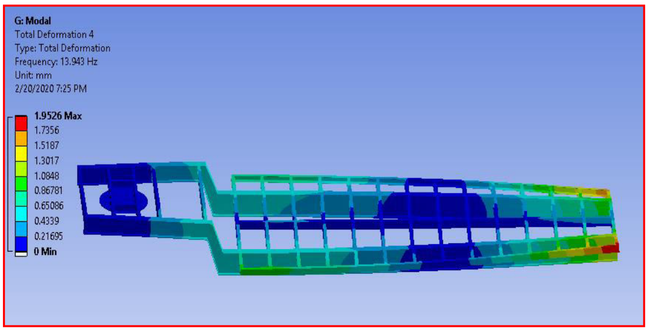
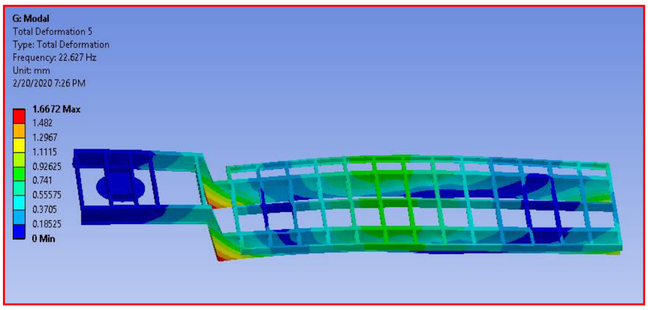
Deflection in Mode III



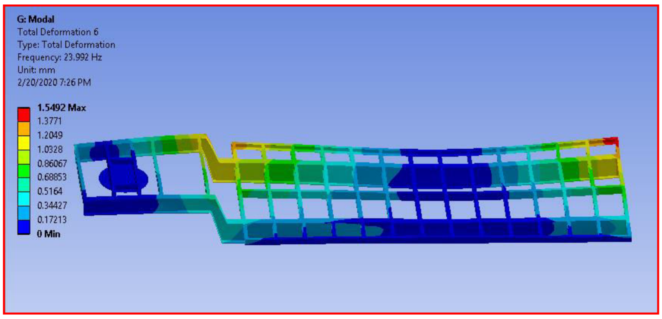

Deflection in Mode IV




Deflection in Mode V




Deflection in Mode VI



**Natural frequency and deflection in first six modes**

| *S.No* | *Mode No* | *Natural frequency(Hz)* | *Deflection(mm)* |
|---|---|---|---|
| **1** | Mode-1 | 8.33 | 1.26 |
| **2** | Mode-2 | 8.83 | 1.27 |
| **3** | Mode-3 | 13.20 | 1.31 |
| **4** | Mode-4 | 13.94 | 1.95 |
| **5** | Mode-5 | 22.62 | 1.66 |
| **6** | Mode-6 | 23.99 | 1.54 |

## VI. RESULTS AND DISCUSSION

The Finite element method is successfully utilized to determine the stress and deformation and also identified maximum stress value and also its approximate locations. The results of the numerical analysis revealed that the location of the maximum stress in the chassis frame is same as calculated theoretically and the stress values also proportionate in all the cases and the variation is due that the cross members are not considered in the analytical analysis.

Model analysis is the optimized way to find out effect of vibration on the chassis. As chassis always undergoes to continuous loading, there is always need to have better chassis which must satisfy all requirements of truck chassis. Also it must have high natural frequency so that while working in vibrations it should no bend or deform permanently.

By above analysis results, it can be concluded that Vibrations in chassis can cause deformation in chassis. Maximum frequency obtained by performing Vibration analysis is 23.99 Hz. Natural frequency of chassis needs to improve as more the frequency safer the object. Vibrations in chassis can be sustained by optimizing chassis design by means of Natural frequency.

## FUTURE WORKS

**Fatigue analysis of the chassis**: It is very essential to do the static fatigue analysis of the chassis frame, based on this only the fatigue life of the chassis frame can be estimated.

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