

Design and Development of Mini Tractor Trolley Chassis Using FEA Method

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ABSTRACT

The automobile is divided into two parts body and chassis. The chassis is basic structure of a vehicle. It contains all the engine parts and power systems but the frame is the main portion of chassis. Its principle function is to safely carry the maximum load for all designed operating conditions. This paper describes modeling and analysis of existing 'C' section Mini Tractor Trolley chassis. In the present work, the dimensions of an existing 'C' section Mini Tractor Trolley chassis is taken for modeling and analysis. Weight reduction is now the main issue in automobile industries.

This paper aims to redesign a modified chassis for tractor trolley. By keeping the material and dimension similar and using 'I' cross section area instead of 'C' resulted in more safer stresses than 'C' and 36% reduction in weight. As raw material required is less, cost of chassis ultimately reduces.

Key Words: Optimize, Mathematical Model, Design Chassis, FEA.

1. INTRODUCTION

In modern world ON-Road vehicles have changed drastically based on the design and other functional aspects. Market demands the faster and higher transportation in a short span. In order to meet this market demand, vehicle manufacturers are designing heavy load carrying vehicles. These heavy load carrying vehicles gives an advantage of faster, heavy transportation in a short span. On the other side the safety of the heavy load carrying vehicle has to be ensured. Based on the historical data Chassis/body is responsible for only 7% of the failure types. However, failures of chassis are catastrophic with serious consequences. In some cases, a consequence of these in-service failures results in the recall of all affected vehicles with heavy costs and bad publicity. Every vehicle has a body, which has to carry both the loads and its own weight.

Vehicle body consists of two parts; chassis and bodywork or superstructure. The conventional chassis frame, which is made of pressed steel members, can be considered structurally as grillages. The chassis frame includes cross- members located at critical stress points along the side members. To provide a rigid, box-like structure, the cross-members secure the two main rails in a parallel position. The cross-members are usually attached to the side members by connection plates. The joint is riveted or bolted in trucks and is welded in trailers. Chassis is the backbone of any vehicle. If any failure occurs in chassis it will leads to the collapse of a whole vehicle system. Also chassis is not a component that can be replaced easily. If any failure occurs at chassis, either have to replace the chassis totally or require the cost and effort similar to the new vehicle assembly.

2. LITERATUREREVIEW

CicekKaraoglu and N. Sefa Kuralay (2002) did the finite element analysis of a truck chassis. The analysis showed that increasing the side member thickness can reduce stresses on the joint areas, but it is important to realize that the overall weight of the chassis frame increases. Using local plates only in the joint area can also increase side member thickness. Therefore, excessive weight of the chassis frame is prevented.

Mohamad Tarmizi Bin (2008) Mechanical Engineering department University Malaysia Pahang he use 3D model for finite element analysis issues regarding the experimental analysis of car chassis is addressed. The modeling approach is investigated extensively using both of computational and compared it to experimental modal analysis. A comparison of the modal parameters from both experiment and simulation shows the validity of the proposed approach. Then perform the computational stress analysis with linear material type analysis to find the stress concentration point in theca chassis.

Manpreetsinghbajwaet.al. (2013) reported on the effect of static load and give an analysis (excluding damping and inertia effects) of the chassis of TATA super ace using ANSYS workbench and its verification using solid mechanics. The chassis of TATA super ace is of ladder frame type which has two side members or longitudinal members of C- cross section and five transverse members called as cross members of box cross section.

Karaoglu and Kuralay investigated stress analysis of a truck chassis with riveted joints using Fem.

Numerical results showed that stresses on the side member can be reduced by increasing the side member thickness locally.

Ferreira et al. investigated the fatigue life of Volvo S80 Bi-Fuel using MSC/Fatigue Conle and Chu did research about fatigue analysis and the local stress-strain approach in complex vehicular structures. Structural optimization of automotive components applied to durability problems has been investigated by Ferreira et al.

Swami K.I. et al. (2014) related his work to perform towards the static structural analysis of the truck chassis. Structural systems like the chassis can be easily analyzed using the finite element techniques. Thus proper finite element model of the chassis has been developed. The chassis is modeled in ANSYS. Analysis is done using the same software.

3. DEVELOPMENT OF MATHEMATICAL MODEL

Chassis design for heavy vehicle applications starts based on the loads primarily acting on it. In heavy transportation vehicles the vertical load due to payload is a primary. In order to overcome this vertical load the chassis has to resist the bending moment acting on it. As per the basic equations of pure bending, Bending Stress calculation:



Figure: 1 'I' Section channel

By flexural formula,

$$\sigma_b = \frac{My_{max}}{I_{min}}$$

Where,

σ_b = bending Stress

y_{max} = Distance from neutral axis

I_{min} = Min moment of inertia

@Momen to finertia X-axis, $= \frac{bd^3}{12} - \frac{bd^3}{12}$

@Moment of inertia Y-axis, $= \frac{12}{bd^3} - \frac{12}{bd^3}$

By using Parallel axis theorem, $I_{yy3} I_{yy} = I_{yy1} + I_{yy2} +$

Deflection of Chassis: $\delta = \frac{5}{384} \frac{\omega L^4}{EI} = X$

4. SPECIFICATION OF EXISTING MINI TRACTOR TROLLEY CHASSIS

The total capacity of the trolley is 50 KN but the self weight of trolley and the other accessories is 37 KN. So here the gross weight come over is 87KN is considered the existing chassis on its of "C" section having cross section area 150mm x 75mm x 5.8mm and the material used for manufacturing is structural steel. The specifications of tractor trolley are shown in table 1 which is collected from industry itself.

Table: 1 Specification of Tractor Trolley.

General	Overall Length	Box 3900mm Chassis :- 1800mm
Overall	Width	1370 mm
Load	Payload Capacity	5000 kg
	Unloaded Weight including weight of chassis	2220 kg
	Gross Weight considering factor of safety 1.2	8664kg

Table 2: Material Properties of Structural Steel used for chassis

Young's Modulus	200 x E9 pa
Poisson's Ratio	0.3
Density	7.85e-006 kg/mm ³
Tensile Yield Strength	250. Mpa

5. STRUCTURAL ANALYSIS OF CHASSIS

In the present study, market available tractor trolley Chassis is selected and its dimension is noted. The Possible loads acting and the place of loads are noted. According to the dimensions, tractor trolley Chassis is modeled using CATIA software. It is then imported to design modeler software ANSYS.

5.1 Mathematical calculations of existing trolley chassis

Channel Specification=150X75X5.7mm
 Weight of Channel/feet=5.12 kg (std. data)
 ∴ Total length of channel used for manufacturing of chassis is
 ∴ 1800X4=7200mm (Length)
 ∴ 1370X4=5480mm (Width)
 ∴ Total Length=12680mm
 ≅ 42 feet
 ∴ Raw material Weight for chassis=
 42X5.121=218.4 kg ≅ 220kg
 Net weight of chassis = 220kg
 Trolley box weight= 2000kg
 (Data from Manufacturer)
 ∴ Total Net Weight=2220kg
 Load Carrying Capacity=5000kg

Gross weight of tractor trolley & chassis = 7220kg
 Considering factor of safety=1.2
 ∴ Total gross weight=8664kg
 ∴ The Total weight acts on 2 beam so,
 Net load on, 1 beam = 8664/2 kg
 Net UDL on beam i.e. $\frac{\text{Total Load}}{\text{Length of Beam}} = \frac{8664 \times 9.81}{42 / 3.289} = 6656$
 N/m
 σ_b Bending Stress: $\sigma_b = \frac{1021.4 \times 10^3 \times 75}{0.896 \times 10^6} = \frac{1021.4 \times 75}{89.6}$
 85.49 N/mm²
 Deflection of Chassis: $\delta = \frac{5}{384} \times \frac{wL^4}{EI}$
 $\frac{6660 \times (1.3)^4 \times 10^{12}}{200 \times 10^3 \times 0.0896 \times 10^6} = X = 1.38$ mm

5.2 Mathematical calculations of trolley chassis using I section of 150x75x5.8

∴ Net mass/feet=4.5kg
 ∴ Total weight=31.28x4.5=140.76kg
 ∴ The net weight acting on chassis=Design load +
 Trolley box Weight + self-Weight
 =5000+2000+140.76
 =7140.76 Kg
 ≅ 7140 kg
 Considering FOS=1.2
 Hence Design Load=8568 kg
 UDL acting on Beam
 Total weight/Total length=8568/9.51

=9009.00 N/m
 As per design uniformly distributed load acting on
 beam=9009.6/2=4504.5 N/m
 Calculation of bending stress $\sigma_b = \frac{M \cdot y}{I}$
 $\frac{695.88 \times 150 \times 10^3}{2.1 \times 10^6 \times 2} = \sigma_b = 24.85 \text{ N/mm}^2 \frac{WL^4}{EI}$
 Deflection of Beam = $\frac{5}{384} \times \frac{5}{384} \times \frac{4.504 \times 1300^4}{200 \times 10^3 \times 2.565 \times 10^6}$
 $\delta = 0.322$ mm

5.3 Analysis of Existing 'C' Cross Section Chassis Using Ansys Tool

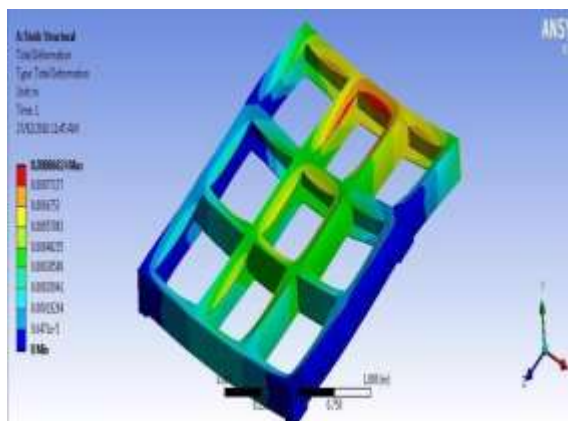


Figure: 2 Total Deformation

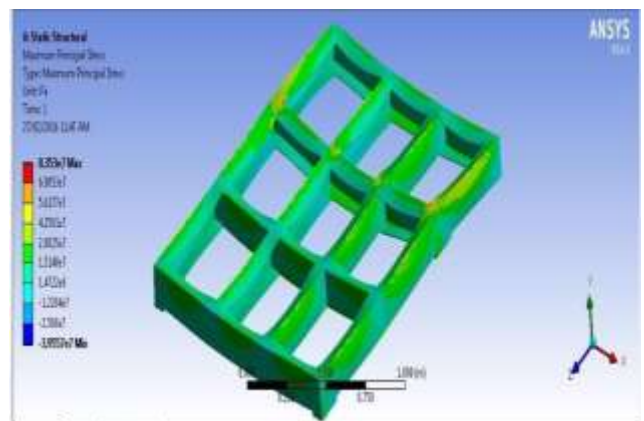


Figure: 3 Von-mises stress

5.4 Analysis of Modified 'I' Cross Section Chassis Using Ansys Tool

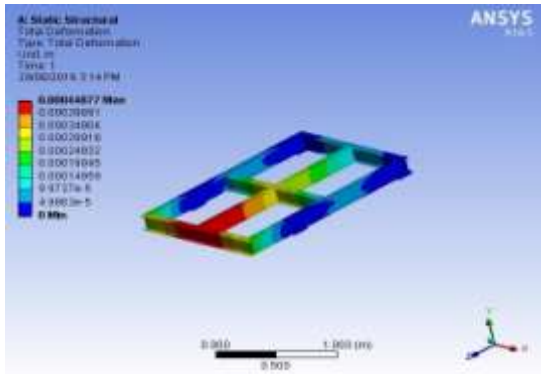


Figure:4 total deformation

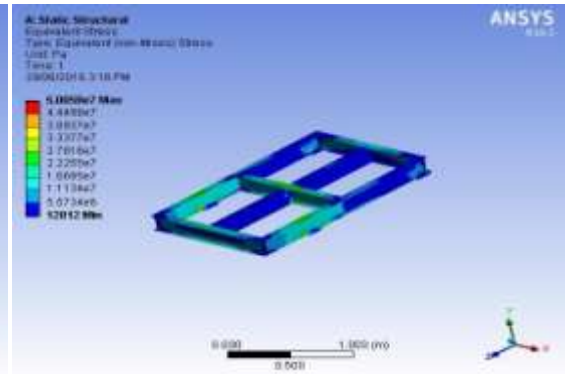


figure:5 von-mises stress concluding remarks

- The color contour shows the variation in stress and deformation. Red color shows maximum values 50 N/mm² and 0.4487 mm for stress (σ) and deformation (δ) respectively, accordingly the value decreases with change in color up to minimum value showed by color blue.
- The static structural analysis is done and by the observing the results there is less stress induced in some areas of Chassis.
- The maximum stress induces 50 N/mm² is less than that of yield stress (S_y) 250 N/mm² so a chance for modification is there in a chassis.
- So, the deflection induced in this channel is less than existing channel and stresses induced is within limit so this can be taken as optimize section.

Table:3 Comparison of Existing 'C' Section and Modified 'I' Section Mini Tractor trolley chassis.

Sr. No.	Factors	Existing 'C' Section	Suggested 'I' Section (150x75x5.8)
1	Equivalent (Von-Mises) Stress	83.5 N/mm ²	50 N/mm ²
2	Total Deformation	0.868 mm	0.4487 mm
3	Factor Of Safety	1.2	1.2
4	Mass	220 kg	140 kg
5	Weight Reduction		36%

6. CONCLUSION

- The newly designed "I" section Chassis reduces 36% of weight reduction as compared to the existing "C" section Chassis. Safer stresses are obtained in new suggested design.
- Increase in Factor of Safety obtained in new suggested design.
- Reduction in weight shows that raw material required for manufacturing of the Chassis is reduced.
- As raw material required is reduced, reduction in cost is achieved.

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