International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2020): 7.803

Design and Fatigue Analysis of Chassis with Different Cross - Sectional Members to Estimate its Life

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Abstract: ***Chassis is one of the major components of any automotive that carries engine, body and passengers. The chassis are having horizontal and side members. These members are of different cross sections like I - Sections, C - Sections and Box - Sections. Several loads will occurs on chassis like static loads, dynamic loads and impact loads, due to variations and over loads on chassis the chassis may fail and reduces its life. In the present study, it is clear that the chassis are made of C - Section or I - Section for both horizontals and side members. In this project, the chassis are designed with different combinations of cross sections for horizontal member and side member. The 3D CAD model has been generated in CATIA V5 R20 and Finite Element Analysis has been performed in ANSYS Workbench 2021. The static structural and fatigue analysis has been performed to find out static strength and the life of the chassis. In this project, the chassis designed with the combination of I - Section for Side member and Box section for horizontal member can be used for better performance with better design.***

Keywords: Chassis Analysis, C-section, I-section

1. Introduction

Functions of Chassis Frame:
1) To carry all the stationary loads attached to it and loads of passenger and cargo carried in it.
2) To withstand torsional vibration caused by the movement of the vehicle
3) To withstand the centrifugal force caused by cornering of the vehicle
4) To control the vibration caused by the running of the vehicle
5) To withstand bending stresses due to rise and fall of the front and rear axles.

There are different types of chassis frame sections:
1) Channel section
2) Box section
3) Tubular section

The loads acting on the chassis frame:
1) Stationary loads namely the loads of permanent attachment like all the parts of the chassis, body etc.
2) Short duration loads while turning, braking etc.
3) Momentary loads while quick acceleration, sudden braking etc.
4) Loads applied while crossing roads of irregular and uneven surfaces
5) Loads caused by sudden accidents, head on collusions etc.
6) Loads caused by irregular and overloading of vehicle.

Material used: Steel, Aluminium, Magnesium

Features: Lightweight, Economic, Safety, Recyclability

2. Objective and Methodology

Following are the Major Objectives:
- The primary objective of the current work is to optimize the design of chassis with different combinations of cross section members
- Conduction of linear static analysis is to optimize the structural design of chassis
- Determination of Maximum Stresses and Deformations in chassis with different cross section to find out the better design of the chassis
- Fatigue analysis will be performed to estimate the life of chassis with different cross section members
- Optimization of chassis with better strength and performance
- Presenting the final design of the Chassis.

Following are the Methodology of the project:
- Review the design of chassis with international journals.
- Generating the model of chassis in CATIA.
- Import the geometry into ANSYS Workbench.
- Mesh the model and preparation of boundary conditions.
- Estimate the Stresses, Deformations, Fatigue Life and Safety Factor of the Base line Design using FE approach.
- Compare the results with literature.
- Design modifications to increasing the efficiency.

Finite element analysis of Chassis

Calculation for Chassis Frame
Chassis Model: TATA 2518 TC
Cross Section of Frame: ‘C’ Section (285×65×7) mm
Overall Length: 9010mm
Width of Chassis: 2440mm
Wheel Base: 4880mm

Front Overhang: 1260mm
Rear Overhang: 2155mm
Capacity of Truck= 25 tons= 25000 kg = 245166 N
Load Acting on Chassis of Truck with 1.25% of Capacity of Truck = 248230 N

Boundary condition and material properties for Steel 37

Load = 248230 N
Load applied on each Member = 124130 N
Youngs Modulus = 210 GPa
Poissons Ratio = 0.29
Density = 7850 kg/m3
Yield stress = 260 MPa
Ultimate stress = 460 MPa

Type: 1: Design and analysis of C - Section member

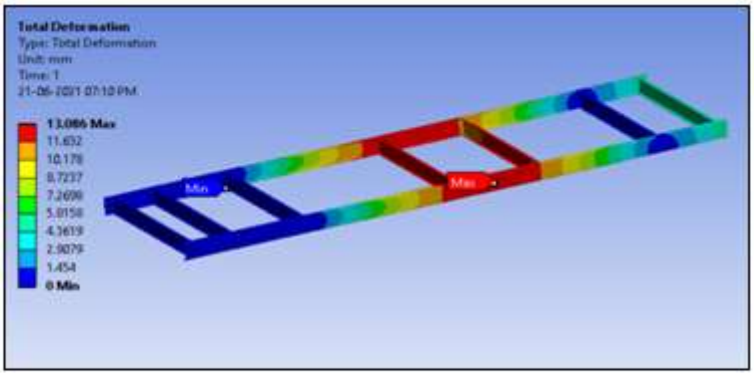

Figure 1.1: Deformation Plot

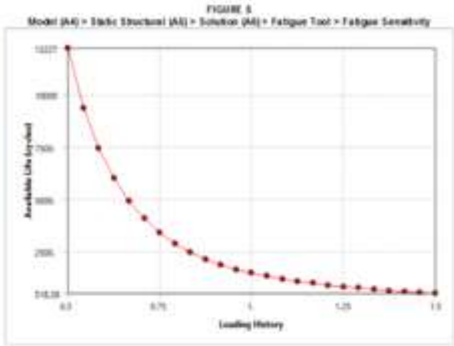

Figure 1.2: Fatigue Sensitivity Plot

Results

- The maximum stress developed in Von Mises stress plot is 494.12 MPa.
- The maximum deformation developed is of 13.08 mm as shown in fig1.1.
- The component can work with Minimum Life Cycle of 1e6 cycles from fatigue life cycle plot.
- From fig1.2, it can be observed that if the load is increased to 150% of actual load then the life of the component is reduced to 518.38 cycles.
- Factor of safety is 0.50

Type: 2: Design and analysis of I - Section member

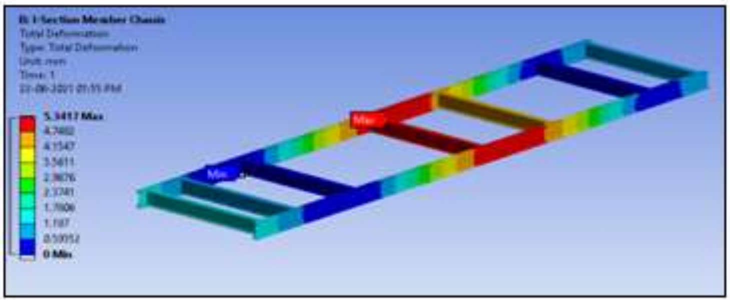

Figure 2.1: Deformation Plot

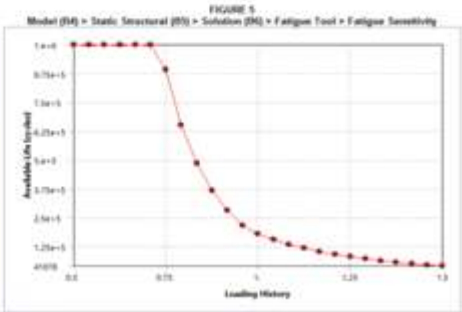

Figure 2.2: Fatigue Sensitivity Plot

Results:

- The maximum stress developed in Von Mises stress plot is 117.25 MPa.
- The maximum deformation developed is of 5.34 mm as shown in fig2.1.
- The component can work with Minimum Life Cycle of 1e6 cycles from fatigue life cycle plot.
- From fig2.2, it can be observed that if the load is increased to 150% of actual load then the life of the component is reduced to 41078 cycles.
- Factor of safety is 2.13

Paper ID: SR211001184504 DOI: 10.21275/SR211001184504

Type: 3: Design and analysis of I - C Section member

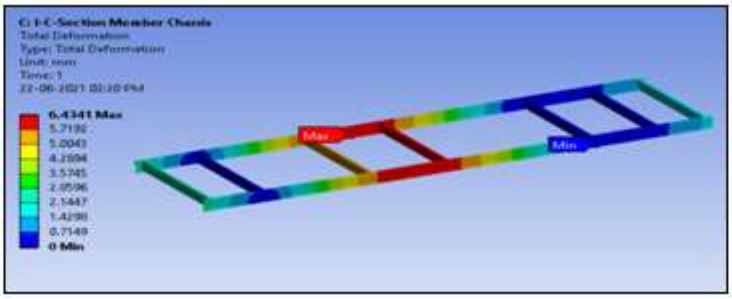

Figure 3.1: Deformation Plot

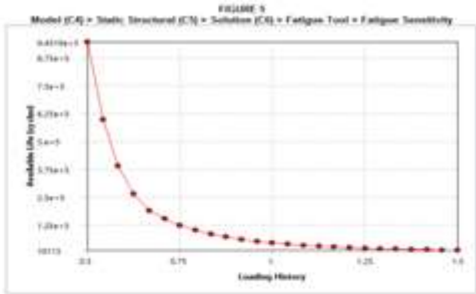

Figure 3.2: Fatigue Sensitivity Plot

Results:

- The maximum stress developed in Von Mises stress plot is 174.1MPa.
- The maximum deformation developed is of 6.43 mm as shown in fig3.1.
- The component can work with Minimum Life Cycle of 1e6 cycles from fatigue life cycle plot.
- From fig3.2, it can be observed that if the load is increased to 150% of actual load then the life of the component is reduced to 10113 cycles.
- Factor of safety is 1.43

Type 4: Design and analysis of C - I Section member

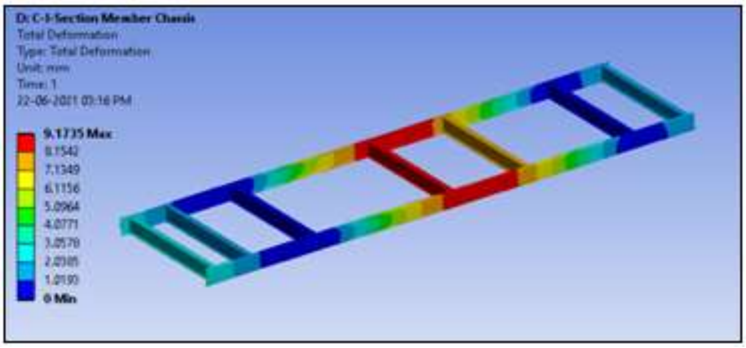

Figure 4.1: Deformation Plot

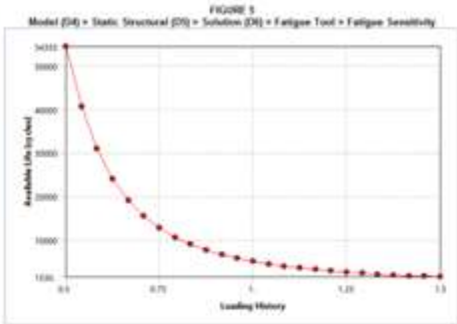

Figure 4.2: Fatigue Sensitivity Plot

Results:

- The maximum stress developed in Von Mises stress plot is 325.90MPa.
- The maximum deformation developed is of 9.17 mm as shown in fig4.1.
- The component can work with Minimum Life Cycle of 1e6 cycles from fatigue life cycle plot.
- From fig4.2, it can be observed that if the load is increased to 150% of actual load then the life of the component is reduced to 5093.8 cycles.
- Factor of safety is 0.76

Type: 5: Design and analysis of I - Box Section member

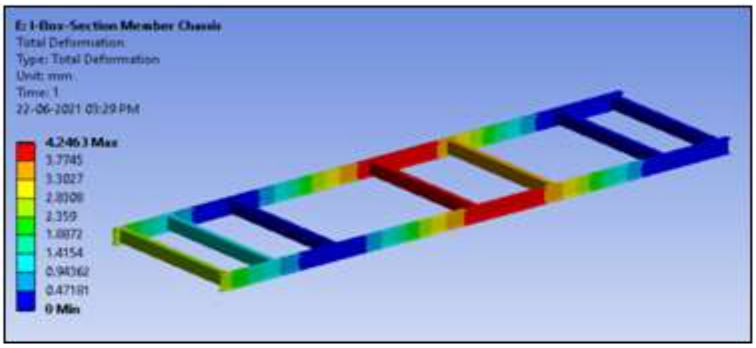

Figure 5.1: Deformation Plot

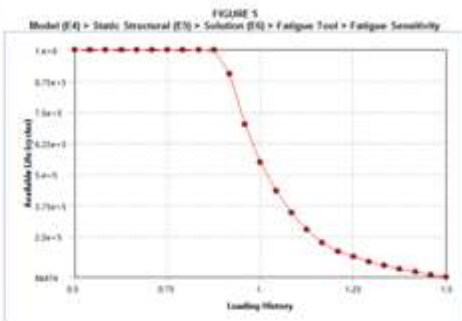

Figure 5.2: Fatigue Sensitivity Plot

Paper ID: SR211001184504 DOI: 10.21275/SR211001184504

Results:

- The maximum stress developed in Von Mises stress plot is 95.78MPa.
- The maximum deformation developed is of 4.24 mm as shown in fig5.1.
- The component can work with Minimum Life Cycle of 1e6 cycles from fatigue life cycle plot.
- From fig5.2, it can be observed that if the load is increased to 150% of actual load then the life of the component is reduced to 86474 cycles.
- Factor of safety is 2.61

Type: 6: Design and analysis of C - Box Section member

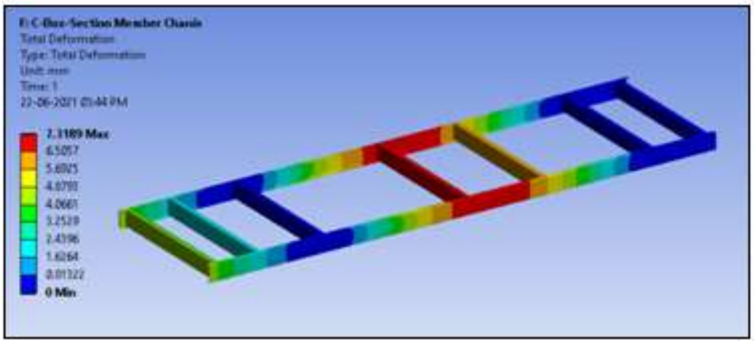

Figure 6.1: Deformation Plot

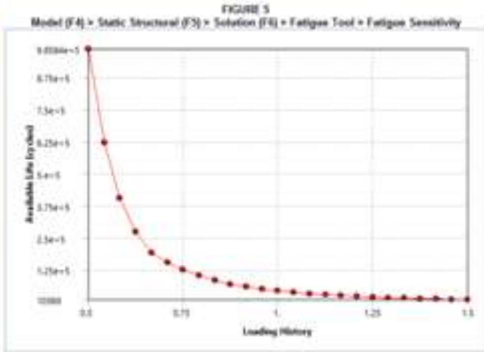

Figure 6.2: Fatigue Sensitivity Plot

Results:

- The maximum stress developed in Von Mises stress plot is 172.83 MPa.
- The maximum deformation developed is of 7.31 mm as shown in fig6.1.
- The component can work with Minimum Life Cycle of 1e6 cycles from fatigue life cycle plot.
- From fig6.2, it can be observed that if the load is increased to 150% of actual load then the life of the component is reduced to 10361 cycles.
- Factor of safety is 1.44

3. Results and Discussion

Below table shows the results comparison of linear static analysis of chassis with different cross section combinations.

Table: Comparison Results of Static and Fatigue Analysis

Cross Section Members	Von - Mises Stress (MPa)	Max.Deformation (mm)	Fatigue Life (No. Cycles)	Safety Factor	Fatigue Sensitivity For 150% of Load (No. Cycles)
C - Section Member	494.12	13.08	$1e^6$	0.50	518.38
I - Section Member	117.25	5.34	$1e^6$	2.13	41078
Side Member: I - Section **Horizontal Member:** C - Section	174.10	6.43	$1e^6$	1.43	10113
Side Member: C - Section **Horizontal Member:** I - Section	325.90	9.17	$1e^6$	0.76	5093.8
Side Member: I - Section **Horizontal Member:** Box – Section	95.78	4.24	$1e^6$	2.61	86474
Side Member: I - Section **Horizontal Member:** C - Section	172.83	7.31	$1e^6$	1.44	10361

4. Conclusion

From the above results of static structural analysis and fatigue analysis of chassis with different combinations of cross section members the following conclusions are made:

- The Static structural analysis is performed to estimate the maximum stresses and maximum deformations has been determined to identify the strength of chassis with combination of different cross section members
- From the results of static structural analysis it is observed that the chassis with the combination of I - Section for Side member and Box section for horizontal member is producing lesser stresses and deformation compared with different combination of cross sections
- The Fatigue Analysis is performed to estimate the life and safety factor of the chassis with different cross section members
- From the results of fatigue analysis it is observed that the chassis with the combination of I - Section for Side member and Box section for horizontal member can work for infinite number of cycles and more safety compared with different combination of cross sections
- Finally it can be concluded that the chassis with combination of I - Section for Side member and Box

section for horizontal member can be used for better performance with better design

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