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DESIGN & ANALYSIS OF TRUCK CHASSIS FRAME USING CAE TOOLS

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ABSTRACT

A vehicle frame, which is also historically known as chassis is the major member of the vehicle as it contains the highest load for the designed operating conditions. It is a supporting member of a vehicle because all the mechanical components get support only by the chassis. The chassis is used as a platform to connect the front suspension and rear suspensions without any destruction. Also, it is enough rigid to bear the shocks, deflections, twisting, vibrational and format of stresses caused by sudden braking, uneven roads, instant acceleration, etc. The current study has examined some literatures. After a careful study of various research studies taken place so far it has been found that there is a scope of optimization in different factors like weight, stress and strain, deformation etc. This could be done by changing cross-section and material of the chassis frame. In this paper we have taken the measurements of TATA 2518TC Truck chassis frame, for structural analysis of heavy vehicle chassis having cross-section of C-shape and from same dimensions we made a chassis having a cross-section of I and Unsymmetrical C- Section and then we calculate the distribution of stress and total deformation under highest load. The various materials which we have selected for this project are Structural steel, Grey cast iron, AISI4130 alloy steel and ASTM A710 steel grade A class (III) due to their availability and familiar properties. A 3-dimensional solid model is prepared in CAE software Solid-works and then by the help of ANSYS 14.5 software analysis work is done.

Keywords: Truck Chassis Frame, SOLIDWORKS, ANSYS 14.5, Stress Distribution, Total Deformation.

I. INTRODUCTION

In current scenario the major challenge regarding road vehicle industry is to conquer increasing demand of higher performance, light weight, and long-life components, all these facilities in a reasonable cost. The chassis of the truck is the pillar as it is the major member and it combine-together the required components such as axle, suspensions, transmission, power train, trailer and cab. From the center of the 20th century, the chassis come in existence. Since the chassis is a most important part of the vehicle so it is repeatedly point out for improvement.

The chassis frame comprises of side members which are attached with 6 to 7 cross members. Using Finite Element Method (FEM) the juncture which has the very best stress are often located. This juncture causes the fatigue failure. The magnitude of the strain won't to predict the lifetime of the truck chassis.

The function of chassis is to provides fixing points for the suspension, steering system, for engine, for gearbox, for ultimate drive, for fuel tank and also the seats for the tenant. To deal with static and dynamic loadings without any deflection or distortion. Saves the tenant from external collision.

Types of chassis frames are:

1. Ladder Frame Chassis.
2. Backbone Chassis.
3. Monocoque Chassis.
4. Tubular Chassis.

The Ladder Frame Chassis are mostly used in Heavy vehicles like Trucks, Busses, to carry maximum load without any distortion. The Backbone Chassis are used in cars like Skoda Rapid & DMC DeLorean. It has good torsional rigidity. Monocoque Chassis are famous because of their unibody structure. This chassis is mostly used in cars now a days. Tubular Chassis are mostly used in racing cars due to their unrivalled safety. This chassis is a upgraded form of ladder chassis.

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II. MATERIAL PROPERTIES

The material used in (TATA 2518TC) Truck Chassis is according to IS: - 9345 standard is steel St 37. Steel in common words having different chemical composition lead to changes in names. The standard chemical constitutions of the material are 0.56%C, 1.81% Si, 0.72%Mn, 0.04%P and 0.04%S. The other materials are:

1. Structural Steel- The composition of structural steel in terms of entire constituent elements are- C (0.12%), Mn (1.60%), Si (0.5%), P (0.025%). [3]

2. Gray Cast Iron- The composition of grey cast iron is: C (4.3%), S (5%), Mn (0.81%), S (.072%), P (0.3%), Mo (up to 0.8%), Cr (0.4%), V (0.2%).

3. AISI 4130 Alloy Steel – The chemical constitutions of the AISI 4130 steel alloy is given asC (0.28-0.34%), Cr (0.8-1.12%), Fe (97.3-98.3%), Mn (0.4-0.6%), Mo (0.15-0.3%), P (up to 0.04%), S (up to 0.04%), Si (0.15-0.4%). [3]

4. ASTM A710 Steel Grade A Class (III)- The chemical constitutions are given as follows- C (0.07), Mn (0.4-0.7), P (0.025), S (0.025), Si (0.035), Cr (0.60-0.90), Ni (0.7-1), Mo (0.15-0.25), Cu (1-1.3), Niobium (0.02). [3]

Table.1 Physical Properties of Selected Materials.

Material	Modulus of Elasticity (GPa)	Density (kg/m^3)	Tensile Strength (MPa)	Yield Strength (MPa)
Structural Steel	210	7850	460	260
Gray Cast Iron	110	7200	240	_
AISI 4130 Steel Alloy	260	7798	1030	910
ASTM A710 Steel	205	7850	515	450

III. ANALYTICAL CALCULATIONS

Table.2 Details of Tata LPT 2518 TC Truck Chassis Frame are shown in this table.

S. No	Parameters	Value
1	Total length of the chassis	9010mm
2	Width of the chassis	2440mm
3	Wheel Base	4880mm
4	Front Overhang	1260mm
5	Rear Overhang	2155mm
6	Ground Clearance	250mm
7	Capacity (GVW)	25ton
8	Kerb Weight	5750Kgs
9	Payload	19250Kgs

Side members of the existing chassis frame are made in "C" Channels having Height = 285mm, Width = 65mm, Thickness = 7mm.

- **Basic calculation for chassis frame.**

Model No. = LPT 2518 TC (TATA)
Capacity of truck = 25tons (Kerb Weight + Payload)
= 25000kg = 245250N.

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Capacity of truck with 1.25% = 245250×1.25N = 306562N
Total load acting on the chassis = 306562N
All parts of chassis are made from "C" Channels with 285mm x 65mm x 7mm. All the truck chassis has two side members (beams), therefore, load working on single beam becomes half of the total weight applying on chassis.
Load acting on one frame = Total load acting on whole chassis frame ÷ 2
= 306562÷2 = 153281N Per Beam.

IV. OBJECTIVE

In this work, the dimensions of the TATA 2518TC truck is used for making three types of chassis which are C, I, and Unsymmetrical-C. These are the section of side members and the cross members are of C-Section only. Further these chassis are used for the structural analysis of the heavy vehicle chassis with four different materials subjected to same loading. The various materials chosen for chassis analysis are Structural Steel, Gray Cast Iron, AISI 4130 Alloy Steel, and ASTM A710 Steel Grade A Class (III) because their properties are known and can be easily available. A 3-D solid modelled in Solid-Works and analyzed in ANSYS 14.5. The upcoming results of all the chassis is then compared on the basis of stress distribution and total deformation.

V. METHEDOLOGY, MODELING AND ANALYSIS

1. METHEDOLOGY

The 3-dimensional solid prototype of the chassis is created in CAE software SOLID-WORKS and then the analysis takes place in ANSYS as shown in fig.7. The procedure for modelling and analysis mainly consists of following steps-

Step.1: Collection of dimensions from different sources for Truck chassis frame.
Step.2: Designing of all three different chassis frames using SOLID-WORKS i.e, C-section, I-section, and Unsymmetrical-C sections.
Step.3: Then each model imposed in ANSYS for Finite Element Analysis for different parameters like 'assembly weight', 'equivalent stress' and 'total deformation'.
Step.4: Checking of all the specifications whether they are in acceptable limit or not for selected materials.
Step.5: Comparison of results.
Step.6: Final result and conclusion.

2. MODELING

- **GEOMETRICAL MODELING: -** A 3-dimensional solid prototype of chassis frame is modeled in CAD software Solidworks. For the accuracy of the model, firstly the parts of the model are made and then they were assembled to make a complete model of chassis.
- **Creating Parts: -** Each part of the chassis, cross and side members are created separately in SOLIDWORKS. Creating a model in SOLIDWORK firstly starts with making a 2-D sketch and then it is converted in solid form by the help of extrude command. The sketch contains geometry like, lines, arcs, cones, splines, etc. Then measurements are given to define the sketch. The side members for the "C", "I", "Unsymmetrical-C" section with dimensions are shown in following figures, also the cross members and strip are same for all the three chassis.

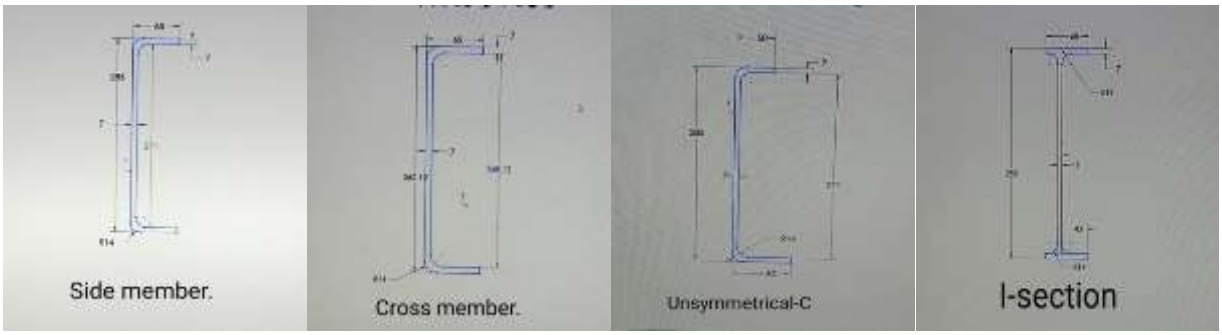

Fig.1 Different Cross-sections of Chassis Frame

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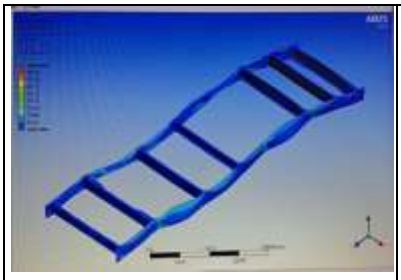
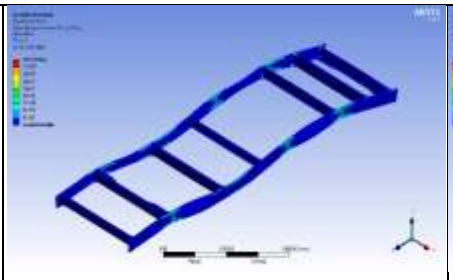
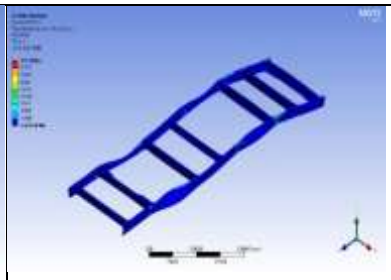
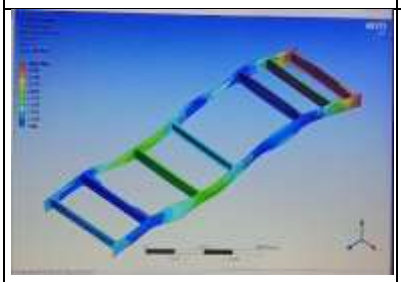
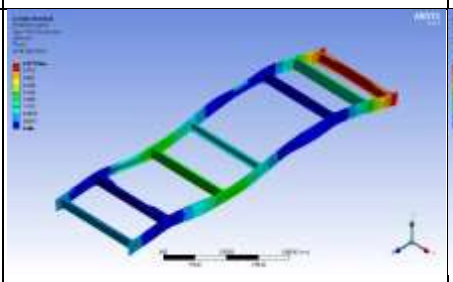
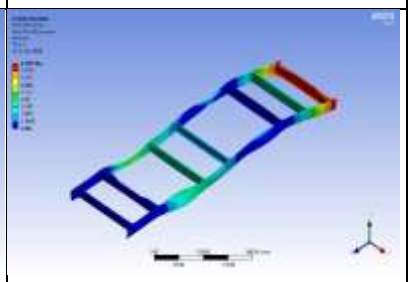
- **ASSEMBLY: -** As each item is finished, they are assembled in the assembly window, as seen in fig.12. Assembly mates describe analogous relations with regard to individual parts or components, enabling for the straightforward creation of assemblies, just as sketch relations define requirements like tangency, parallelism, and concentricity with reference to sketch geometry.

3. ANALYSIS

- **STRUCTURAL ANALYSIS: -** Structural analysis is now carried on Ansys, for this the model which we created in Solidworks is imposed in Ansys. Ansys uses finite element solver for performing analysis as it is a general-purpose finite element analysis (FEA) software package.
- **MESHING:** - It is the most important part in analysis because without meshing, analysis cannot be done. Basically, meshing is use to break the whole model into small finite piece to acquire the accurate result for that analysis. The elements used for the meshing are 2-D Higher order triangle & quadrilateral elements. Given figure shows the mesh model of the chassis.
- **ANALYSIS: -** After applying calculated load i.e. 306562N, we get the desired result. This load is applied on all three chassis and the all chassis are compared on the basis of Stress distribution and Total deformation.

❖ **ANALYSIS OF ALL-SECTIONS FOR STRUCTURAL STEEL.**

		
Stress Distribution	Stress Distribution	Stress Distribution
		
Total Deformation	Total Deformation	Total Deformation
Fig.2 C-Section	**Fig.3** I-Section	**Fig.4** Unsymmetrical C-Section

VI. RESULT

❖ **Results in Graphical Form.**

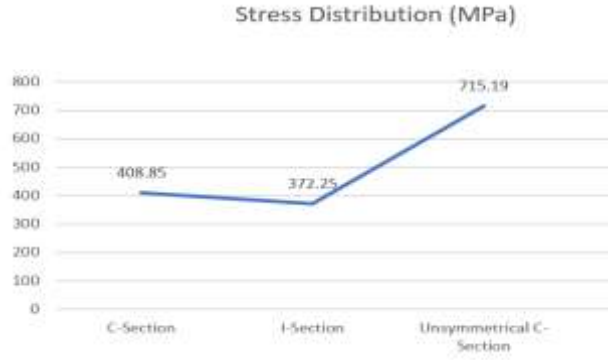


Fig.5 For Structural Steel

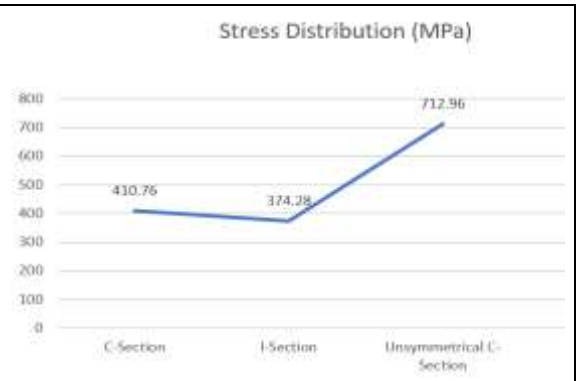


Fig.6 For Grey Cast Iron

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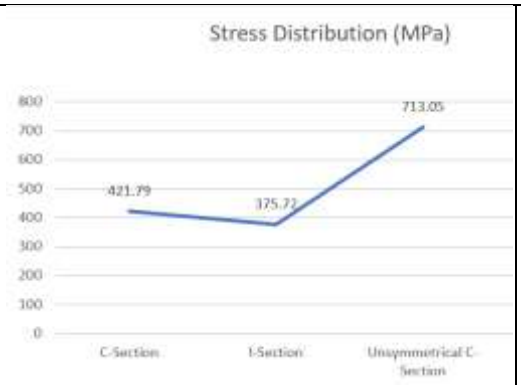

Fig.7 For AISI 4130 alloy steel

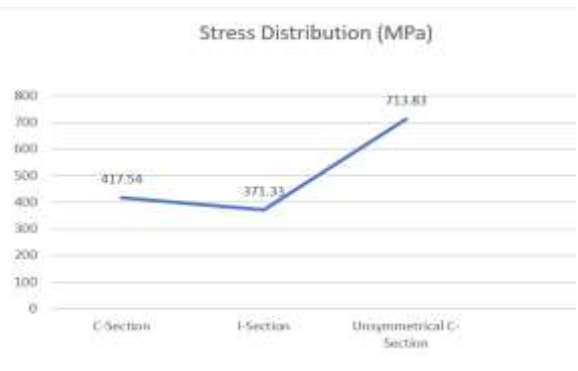

Fig.8 For ASTM A710 steel grade A class (III)

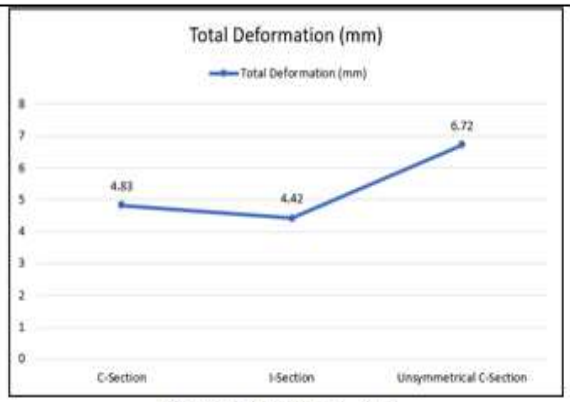

Fig.9 For Structural steel

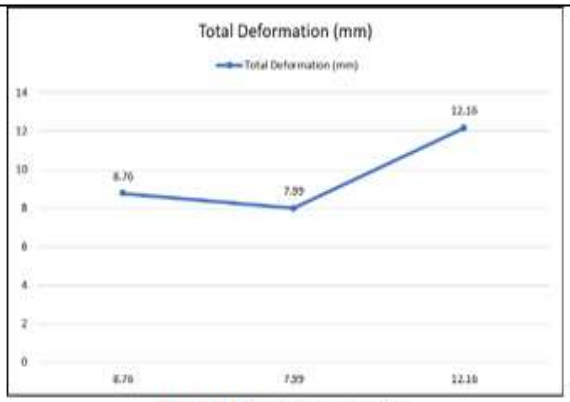

Fig.10 For Gray cast iron

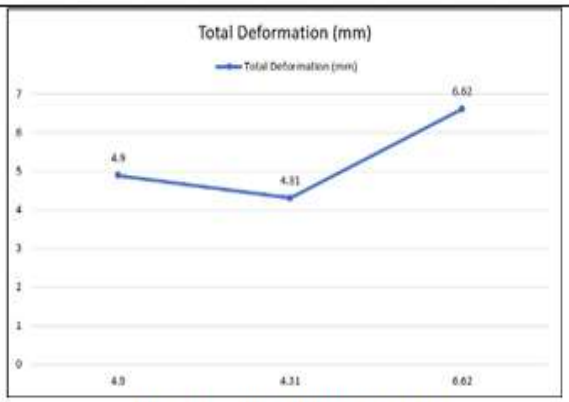

Fig.11 For AISI 4130 alloy steel

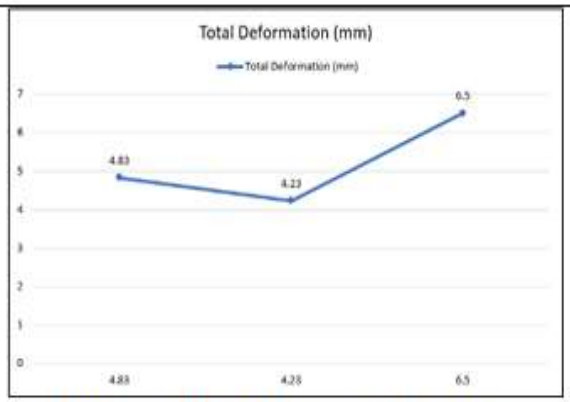

Fig.12 For ASTM A710 steel grade A class (III)

VII. CONCLUSION

The Truck Chassis taken for design analysis for different sections and for different materials. The chassis is modeled in Solidworks and then analyzed in Ansys for same loading conditions. After analysis a comparison is made between C, I, and Unsymmetrical-C on the bases of materials also in terms of stress and deformation to find out the better chassis.

The result shows that C-section chassis have same deformation for Structural steel and ASTM A710 Steel Grade A Class (III) and the deformation show by both the materials is less compared to other materials. But the I-section chassis with ASTM A710 Steel Grade A Class (III) has the least deformation as compared to C and Unsymmetrical-C on the basis of cross-section and materials.

So, for considering better alloy for chassis, ASTM A710 Steel Grade a category (III) is best than others and it's suitable for the heavy chassis.

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Finally, the analysis is successfully accomplished. The work not only provide analysis of the chassis but also shows the scope for the modification in actual.

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