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MODELING AND STATIC MODAL ANALYSIS OF HEAVY VEHICLE CHASSIS

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ABSTRACT

One of the most crucial components of an automobile is the chassis. The internal frame serves as the vehicle's support throughout operation, allowing it to withstand the specified circumstances. The core of any automobile is the supporting framework that houses the axle assembly and engine body. It is thus the most crucial part that gives the car strength and stability in a range of conditions. The majority of these chassis are steel frames that hold up a car's body and engines. The frame or fundamental structure of a car is referred to as the "chassis". Investigating the design and statistical structural analysis of a large vehicle chassis with different alloy materials at different ideal loads is the aim of this effort. The heavy vehicle chassis will be developed in CATIA V5, Fusion 360, and Ansys Workbench for structural analysis. The goal of the project is to construct a better chassis that, in the best of situations, lowers the overall weight of the vehicle while boosting its performance in large vehicles.

Key words: CATIA V5, Fusion 360, modelling, heavy vehicle chassis, static structural analysis.

I. INTRODUCTION

The chassis is considered to be the most important component of a car. It is also the essential part that provides the automobile with strength and stability under various driving circumstances. The chassis, sometimes known as the "Frame," serves as the main structural element of the vehicle. It

withstands any load placed on the car when it is driving and stopped. Every vehicle, whether it a car, truck, or two-wheeler, is made up of a chassis and frame. Its shape does, of course, vary according on the kind of vehicle. It supports the whole vehicle, including the engine, gearbox, chassis, propeller shaft, axles, and tiers in addition to the petrol tank. The cross members of a vehicle have varying cross sections depending on the kind. I-section, C-section, and Box-type cross sections are the most common cross sections seen in heavy vehicle chassis. A structural study using ANSYS Workbench may be used to determine the optimal cross section for a large vehicle.

1.1 Types of Chassis:

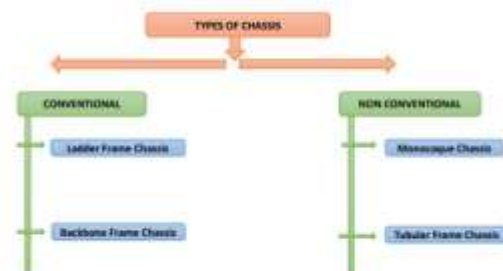


Fig -1: Chassis Types

1.2 Main Objectives:

- To analyze the different types of chassis and their selection of material
- To construct a new design from an existing one which minimizes the overall weight of the vehicle with excellent load bearing capacity
- To do static structural analysis using ANSYS workstation
- To observe the varied load circumstances.



II. METHODOLOGY AND MATERIAL SELECTION:

2.1 Methods used:

A static analysis: Static analysis is mostly used to conduct an analysis by considering the dynamic conditions and this method is used to determine various factors such as stress, deflection, strain, strain energy, volume, weight etc.

Modal Analysis: Modal analysis is the process of applying Different load conditions to the model by fixing at different locations (fixed joints were made at that place). Conditions such as front end impact, Rear impact and Central impact Front end and Rear end Twisting.

2.2 Selection of Material:

Aluminum-Alloy, Cast Iron, and Structural Steel are the materials under consideration for design and analysis. The design criteria were chosen and investigated with the goal of minimizing design outcomes in areas where aluminium is often used in the vehicle industry, such as chassis and body building. The using of aluminium is an advantage to reduce the overall weight vehicle.

Steel alloys are much harder and stronger than aluminium but steel alloys are heavier in weight compared to other alloys, It is a major disadvantage for steel alloys and steel alloys are not suitable for low light vehicles. 7075 aluminum alloy (AA7075) is an aluminum alloy using zinc as the main alloying element. It possesses exceptional mechanical properties, including high ductility, strength, toughness, and fatigue resistance.

III. DESIGN:

3.1 Specifications:

1. Chassis length : 6355mm
2. chassis width : 700mm
3. Front overhung : 935mm
4. Rear overhung : 1620mm
5. Cross section dimensions : 210×76×6

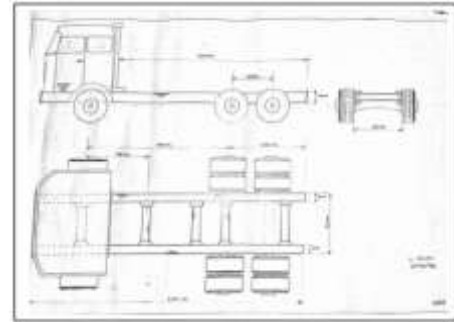


Fig -2: Isometric drawing of the Chassis

3.2 Design Calculations:

Material & Geometry of the Truck made with C – type Chassis with the following dimensions 210 mm x 76 mm x 6 mm

Material of chassis is ASTM A710 Steel

Front Overhang (a) = 930.0 mm

Rear Overhang (c) = 1620.0 mm

wheel base [b] = 3810 mm

Young's modulus, [E] = 2.15×10^5 N / mm²

Poisson's Ratio = 0.287

Capacity of vehicle = 8.2 tons = 8200kg = 79480 N

Capacity of vehicle with 1.25% = 98100.0 N

Weight of the vehicle = 2 ton = 2000 kg = 19620 N

Total load acting on chassis = Capacity of Chassis +

Weight of body and engine = 98100 + 19820 = 117740 N

a) Calculation of Reactions:

Load acting on the beam = 58660 N

Beam Length = 6345 mm

Uniformly distributed load = $58660 / 6345$ = 9.36N/mm

Considering the moment about C and the reaction load generated at the support D, we obtain the load at reaction C & D.

Moment about C:
 $9.26 \times 935 \times 935 / 2 = (9.24 \times 3800.0 \times 3800.0 / 2) - (R_d \times 3800.0) + (9.24 \times 1620.0 \times 4610.0)$
 $= 34757.650 \text{ N}$
 Total load acting on beam $= 9.26 \times 6355.0 = 58847.305 \text{ N}$
 $R_C + R_D = 58857.36$
 $R_C = 24119.645 \text{ N}$

b) Calculation of SF and BM:
 Shear force calculations:
 $F_A = 0 \text{ N}$
 $F_C = (-9.24 \times 936) + 24200.66 = 15462.66 \text{ N}$
 $F_D = (-9.26 \times 4735) + 34727.65 + 2411 = 115008.40 \text{ N}$
 $F_B = 0 \text{ N}$
 BM calculations:
 $M_A = 0 \text{ N mm}$
 $M_C = (-9.26 \times 5 \times 934.0) / 2 = -4047661.705 \text{ N mm}$
 $M_D = [(-9.26 \times 4735.0 \times 4735.0) / 2] + (24119.65 \times 3800.0) = -12150971.075 \text{ N mm}$
 $M_B = 0 \text{ N mm}$

c) Calculation of Shear Stress:
 M.I. about X-X axis $(I) = (BH^3 - bh^3) / 12 = 13372380 \text{ mm}^4$
 Bending stress from bending equation $M/I = f_s / y = E/R$
 $M_{max} = 12150971 \text{ N mm}$
 Bending Stress $f_s = 95 \text{ N/mm}^2$
 Shear stress from Torsion equation $T/I = \tau / r = G\theta / L$
 Shear stress $\tau = 482.7 \text{ N/mm}^2$
 Von Mises Stress $= \sqrt{(f_s^2 + 3\tau^2)} = 448.5 \text{ Mpa}$

IV. DESIGN AND MODELLING:

Fusion 360 software was used to design the chassis.

Fusion 360 is an interactive three-dimensional application. It's a solid modeling program that combines 3D parametric features with 2D tools, as well as addressing the whole design to production process. Fusion gives you the option to see your designs in 3D.

The following are the steps required in designing a chassis using Fusion360:

1. Using the draw command, draw the separate parts of the part in 2D.
2. Using the dimensions command to set the dimensions for each line.
3. Using the extrude command, convert the 2D drawing to 3D.
4. Using the material command, change the material to aluminum.
5. Assemble the component parts in the part drawing.

4.1 Design using Fusion360 (C-cross section):



Fig-3: Top View



Fig-4: 3-D View

4.2 Design using Fusion360 (I-section):



Fig-5: Top View



Fig-6: Sectional View



Fig-7: 3-D View

4.3 Design using Fusion360 (Rectangular Section):

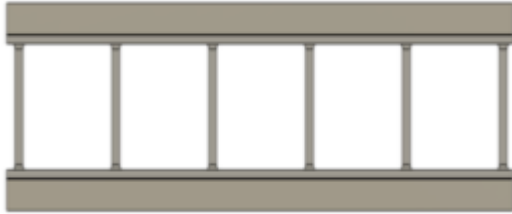


Fig-8: Top View



Fig-9: Sectional View



Fig-10: 3-D View

V. ANALYSIS USING ANSYS WORKBENCH:

Ansys 19.2 is a powerful simulation program that allows us to do a variety of analyses, including static, dynamic, fluid flow, and thermal analysis. The chassis design is saved as IGS/IGES format, which can be imported into the ANSYS software.

5.1 Steps involved in Static Analysis:

- Engineering data
- Geometry Setting
- Model importing
- Meshing part
- Analysis part
- Results obtained

5.2 Meshing and Load setup:

The meshing is done on a 3516 node model with 180282 cubical and tetrahedral components. The static forces from the truck

body and the load on the truck chassis model. For this kind, the max loaded weight of the vehicle+ body is 12,000 kg. The load is expected to be distributed evenly, with the max loaded weight divided by the whole length of the chassis frame. A finite element model with boundary conditions represents the chassis.

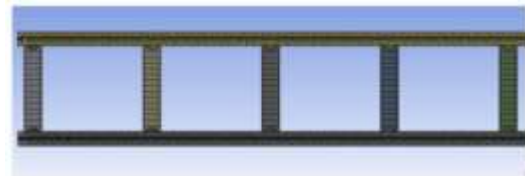


Fig-11: Meshing

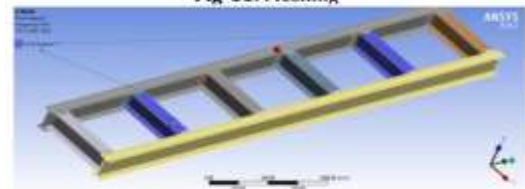


Fig-12: Boundary Conditions

5.3 Static Analysis of Chassis using ANSYS:

Initially the engineering data is set as per the requirement of material, units, other properties. Then the geometry is imported into the ansys workbench, click on edit model a new tab will be opened. The more intricate a mesh, the more realistic the 3D CAD model, enabling for high quality simulations. Meshing, also known as mesh production, is the process of creating a two-dimensional and three-dimensional grid.

VI. RESULTS:

6.1 Results for I-Section Chassis

material	Von - mises stress (Mpa.)	Maximum Shear stress (Mpa.)	Deformation mm
ASTM A710 steel	430	242	2.36
ASTM A302 alloy steel	326	185	2.6
aluminium alloy 6063-T6	166	90	7.2

6.2 Results for rectangular section Chassis



Material	Von-mises stress (Mpa)	Maximum Shear stress (MPa)	Deformation (mm)
ASTM A710 steel	440	252.3	2.84
ASTM A302 alloy steel	335	190.75	2.57
aluminium alloy 6063-T6	168	92.75	7.9

6.3 Results for C-Section Chassis

Material	Von Mises Stress (Mpa)	Max. Shear Stress (Mpa)	Deformation (mm)
ASTM A710 steel	434	250	2.064
ASTM A302 alloy steel	328	188.5	2.015
Aluminum alloy 6063-T6	158	84	6.35

6.4 ANSYS Results for I-Section Chassis

material	Von Mises Stress (Mpa)	Max. Shear Stress (Mpa)	Deformation (mm)
ASTM A710 steel	160	88	7.4
ASTM A302 alloy Steel	154	81	10.2
Aluminum alloy 6063 - T6	141	76	14.6

6.5 ANSYS Results for Rectangular Section Chassis

material	Von-mises stress (Mpa)	Maximum Shear stress (MPa)	Deformation mm
Astm A710 steel	70	15	2.1
Astm A302 alloy steel	59.6	11	3.5
Aluminium alloy 6064 - T6	56	6.1	7.2

6.6 ANSYS Results for C-Section Chassis

Material	Von-mises stress (Mpa.)	Maximum Shear stress (Mpa.)	Deformation mm
ASTM a710 steel	150	78	6.8
ASTM a302 alloy steel	140	71	9.3
Aluminium alloy 6063-T6	112	63	14.6

VII. CONCLUSIONS

In this paper, a ladder-style vehicle chassis architecture was evaluated using the ANSYS 20.1 program.

The study indicates that the Ladder Chassis C-section is more robust than the Rectangular and I Cross-section types. The C- Crosssection Ladder Chassis for Aluminium Alloy 6063-T6 has the lowest Von Mises stress and Maximum Shear stress, at 54.31 MPa and 5.98 MPa, respectively, and the least deflection, 2.96

mm. One effective method for handling the idea and formulation phases of design is finite element analysis. The analytical findings of the current investigation allow for the following conclusions to be made.

- The part is secure under the specified loading circumstances.
- To improve performance, the shape has been modified to enable stress levels to be lowered marginally below the yield limit.
- The design is safe for all three materials since the Von Mises Stress and Maximum Shear Stress generated are less than the allowed value.
- At specified boundary conditions, shear stresses were found to be highest in ASTM A710 steel and lowest in aluminium alloy 6063-T6.
- Under certain boundary circumstances, von Mises stresses were found to be highest in ASTM A710 steel and lowest in aluminium alloy 6063-T6.
- Of the three different cross section types of ladder chassis, the rectangle cross section type has the greatest shear stress, Von Mises stress, and lowest deflection for aluminium alloy 6063-T6 in all three materials.

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