# DESIGN AND ANALYSIS OF LIGHTWEIGHT CHASSIS USED IN ANTI-DROWNING VEHICLE

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## ABSTRACT

*The main goal of the paper is to analyze and find a light material suitable for a car chassis. The material should withstand all the load carried by the chassis. At present, materials with steel alloys are used in chassis, but they are heavy. As the weight of the chassis increases, the load on the engine increases and thus the performance of the vehicle decreases. Thus, it can be used to improve the efficiency of lightweight vehicle materials such as aluminum alloys. In this work, we considered a steel alloy ASTM A710 (currently used material), two aluminum alloys AA 6063, AA 7075. These material properties are applied to the ladder chassis and analyzed under maximum load conditions. The ladder chassis is designed with a C-section to minimize weight. The chassis is modeled in SolidWorks with the appropriate dimensions. Analysis for different materials is done in ANSYS based on model and theoretical calculations.*

**Keywords**: *Automotive chassis, SolidWorks*

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## 1. INTRODUCTION

The chassis is the main skeleton or frame on which all static and dynamic loads are applied. It also contributes to the main weight of the vehicle. We know that vehicle performance increases as unwanted weights and loads decrease, so lightweight chassis design plays a major role in terms of performance. Chassis weight can be minimized by using lightweight materials and a distinctive design.

### 1.1. Statement of the problem

To increase the performance of the vehicle, it is necessary to reduce the load on the engine. Therefore, light materials are used in the production of chassis. These materials must withstand the load acting on the chassis. Based on the properties of the materials and theoretical analyzes of the design.

### 1.2. Solution

The problem is solved in three steps

- Theoretical analysis
- Modeling in CAD software
- Structural analysis in FEA software

### 1.3. Theoretical analysis

In this, we performed calculations on the beam based on the loading conditions and found out the bending stress and deformations.

### 1.4. Modeling in CAD software

We designed a basic industrial truck ladder chassis. Modeling is done in solid works and is imported into ANSYS, workbench design modeler.

### 1.5. Structural analysis in FEA software

In the static analysis, we entered the boundary conditions of the model, a uniformly distributed load is applied to the rail girders and analyzed for three different materials, and the maximum bending stress, principal stress and strains are calculated.

**Table 1**

| Property | ASTM A710 Steel | AA 6063-T6 | AA 7075 |
|---|---|---|---|
| Density | 7.8 | 2.7 | 2.81 |
| Yield Strength | 585 | 214 | 503 |
| Ultimate Tensile Strength | 620 | 241 | 572 |
| Poisson Ratio | 0.29 | 0.33 | 0.33 |
| Shear Modulus | 80 | 25.8 | 26.9 |
| Young's Modulus | 205 | 68.9 | 71.7 |

## 2. MATERIAL SPECIFICATIONS

The mechanical properties of steel and aluminum alloy materials Steel ASTM A710, AA6063-T6 and AA 7075 are shown in Table 1. The general properties required for static static analysis are considered. These values are used in the analysis phase of our solution.

## 3. DESIGN CALCULATIONS

The chassis we are considering is made with a C-section beam. We designed cross beams in a straight rectangular section, six cross beams are used to join the side rails. All measurements needed for the model are given below.

**dimension**
Side (C-Channel) = 210 x 76 x 6 mm3 Front = 935 mm
Rear part = 1620 mm Wheel distance = 3800 mm Width = 2250 mm
Young's Modulus = 71.7 Gpa (Aluminum 7075) Poisson's Ratio = 0.33 (AA 7075)
Capacity = 8000 x 9.81 = 78480N Weight at 1.25% = 98100N Weight of body and motor = 19620N
Total load = 117720N
Acting load on a single chassis line = 58860N

**Reaction Forces**
We are assuming the side rail as a simply supported beam with uniformly distributed load acting on the beam = 58860N
Length of beam = 6355 mm

**Uniformly distributed load:**
The load acting on the beam is 58860 N, and the length of the beam is 6355 mm. Converting mm to

meters:
Uniformly distributed load (w) = Load / Length
w = 58860 N / 6.355 m ≈ 9256.57 N/m

**Shear forces:**
The shear force (V) at any section of the beam can be calculated by summing the loads on one side of the section. Since the beam is simply supported, the shear force at any section will be half of the total load (w) times the distance (x) from the support.
V = (w * x) / 2

**Bending moment:**
The bending moment (M) at any section of the beam can be calculated by integrating the area under the shear force curve. In this case, the bending moment at any section (x) from the support can be calculated as:
M = (w * x^2) / 2

**Bending stress:**
The bending stress (σ) can be calculated using the bending moment (M) and the section modulus (Z). The section modulus of a C-Channel can be determined using standard formulas for the cross-sectional shape. For a C-Channel, the section modulus is given by:
Z = (2 * b * h^2 - b1 * h1^2 - b2 * h2^2) / 6

where b1, h1, b2, and h2 are the dimensions of the smaller rectangle within the C-Channel, and b and h are the dimensions of the overall C-Channel.

In this case, b1 = 210 mm, h1 = 70 mm, b2 = 180 mm, h2 = 60 mm, b = 210 mm, and h = 76 mm. Substituting these values into the formula:

Z = (2 * 210 * 76^2 - 210 * 70^2 - 180 * 60^2) / 6

**Shear stress:**
The shear stress (τ) can be calculated using the shear force (V) and the section modulus (Z). The formula for shear stress is:
τ = (V * y) / Z

where y is the distance from the neutral axis to the extreme fiber of the beam. In this case, assuming the C-Channel is an I-beam with a rectangular shape, the distance y can be calculated as half of the height (h) minus half of the thickness (t):

y = (h / 2) - (t / 2)

**Von Mises stress:**
The Von Mises stress (σ_von Mises) is a measure of the combined stresses acting on the material and can be calculated using the bending stress (σ) and the shear stress (τ). The formula for Von Mises stress is:
σ_von Mises = sqrt(σ^2 + 3 * τ^2)

**Principal stress:**
The principal stresses (σ_1 and σ_2) represent the maximum and minimum normal stresses at a given point. They can be calculated using the bending stress (σ) and the shear stress (τ) as follows:
σ_1 = (σ + τ) / 2
σ_2 = (σ - τ) / 2

**Maximum shear stress:**

The maximum shear stress ($\tau_{max}$) can be calculated using the shear stress ($\tau$) and the principal stresses ($\sigma_1$ and $\sigma_2$). The formula for maximum shear stress is:

$\tau_{max} = \sqrt{(\sigma_1 - \sigma_2)^2 + \tau^2}$

**Total deflection:**

To calculate the total deflection accurately, we need additional information about the beam's moment of inertia (I) or its Young's modulus (E). Unfortunately, the provided information does not include the moment of inertia. Hence, we cannot calculate the total deflection accurately.

## 4. Modeling the chassis using SolidWorks

Chassis components are individually designed in SolidWorks. The rail members of the chassis are designed with a C cross-section and the cross members are designed with a rectangular cross-section. A chassis model designed in SolidWorks is shown in Fig

**Figure 1** SolidWorks model of C – c/s ladder chassis

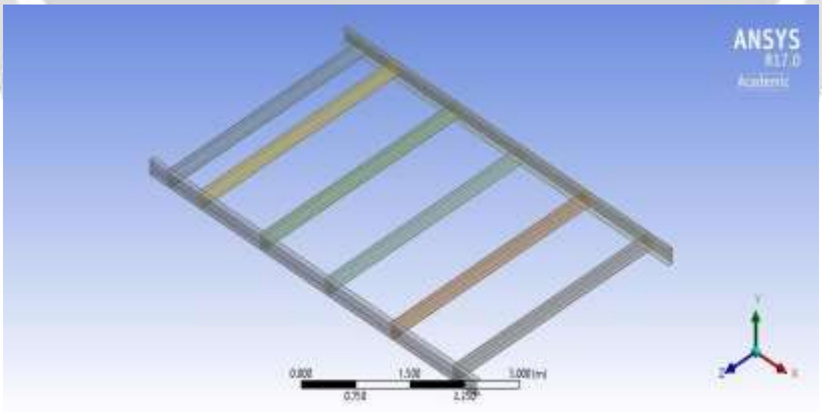


**Figure 3** Imported model in ANSYS Design Modeler

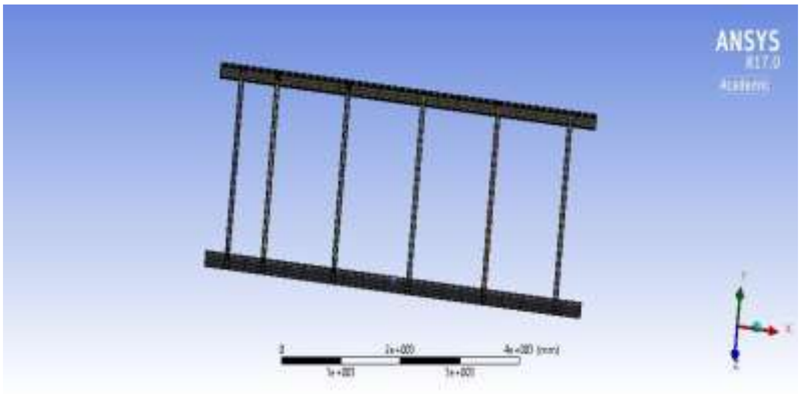


**Figure 4** Meshed Model

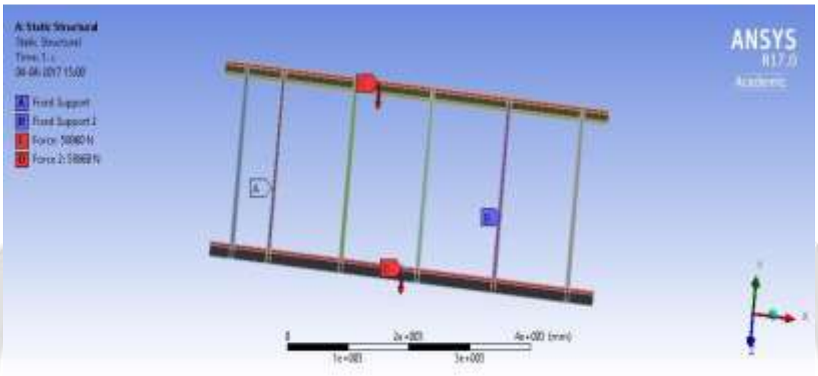


**Figure 5** Boundary conditions applied

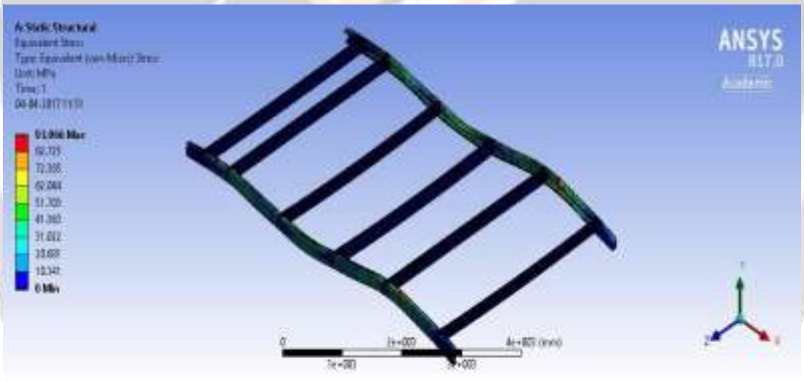


**Figure 6** Vonmisses stress AA 7075

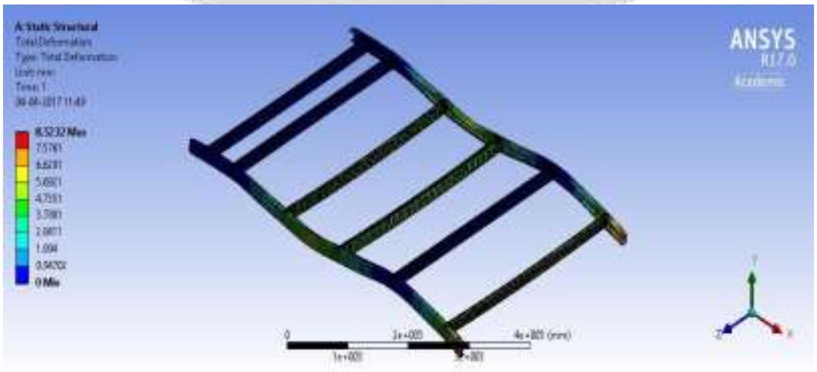


**Figure 7** Total deformation AA 7075

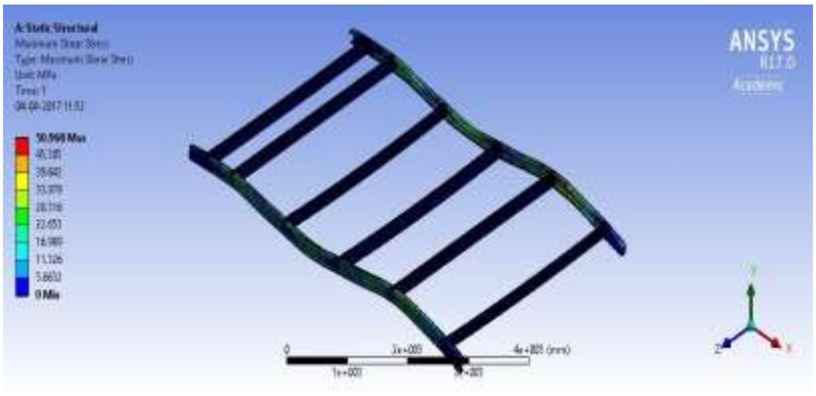


**Figure 8** Max Shear stress AA7075

Static structural analysis is performed on the model against three materials (ASTM A710, AA6063, and AA7075). The analysis result for material AA7075 is to be considered, it is displayed in the figure above(2-8).

4.RESULTS
Based on the analysis performed on ANSYS software and based on theoretical calculations, the stress and deformation of the model are calculated and tabulated. 2 The yield stress, maximum shear stress and deformation of the material are obtained from the analysis.

6. Conclusion
In this, analysis is performed on a C cross-sectional ladder chassis using three different materials (i.e. steel ASTM A710, aluminum 6063 and aluminum 7075). Through this analysis, we can confirm that all three materials have the same von Mises stress, max shear stress and aluminum 7075 shows less deformation compared to aluminum 6063 and more compared to ASTM A710. Although steel alloys show less deformation than aluminum alloys, the difference is acceptable and safe. Thus, our lightweight material of choice is aluminum 7075.

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