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# DESIGN AND STRUCTURAL ANALYSIS OF A QUAD BIKE CHASSIS

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## ABSTRACT

*This paper introduces a new design for the quad bike chassis which is expected to show better performance with lesser deformations as compared to the conventional designs of quad bikes. Along with these factors driver comfort, improved aesthetics and affordable price are added advantages to the list. The chassis has been designed keeping in mind all the above mentioned parameters in CATIA V5 R19 software. The material selection has been done through extensive market research and the most appropriate material has been selected which its AISI 1018. Once the material is selected the design is tested for its strength in the form of front and rear impact tests in ANSYS 14.5 workbench. The results of the impact tests show that the deformations produced are within limits and the chassis is structurally stable.*

***Keywords: Chassis, FEA, Strength, Quad Bike***

## I. INTRODUCTION

A chassis is the actual frame or structure of an automobile. The chassis serves as a framework for supporting the body and different sub-systems of the automobile and is also responsible for its protection. It also provides better seating area and ergonomics to the driver **[1]**. A Quad bike is one which is supposed to function in any type of terrain and hence it is similar to any other All-Terrain Vehicle. It is mainly designed for off road usage which requires a strong chassis which should not deform under any circumstances. The chassis of conventional ATV's occupy more space leading increase in number of members resulting into higher values of weight and vehicle space. This increased weight lessens the overall performance of the ATV. Therefore it is imperative to design a chassis which has reduced weight and occupies less space. Considering these factors this paper presents a chassis with minimum possible weight and optimized space, leading to improved power to weight ratios. The proposed design is later analyzed for front and rear impact tests in ANSYS 14.5 workbench.

## II DESIGN METHODOLOGY

### 2.1 Frame Design

The designing of the frame started by obtaining the layout of ergonomic driver space and the optimum dimensions were achieved. After carrying out many iterations of the design using software tools, the optimum frame design was attained as shown in Fig. 1 & 2. The key points in the designed frame consist of sufficient members with sustainable strength due to inclusion of triangulations along with puzzle fit for sub-system mounting **[2]**. This enhances better force distributions through the members resulting into reduced deformation

and stress values. Also, the chassis is designed such that the roll center of the vehicle is kept at minimum possible distance from ground **[3].**

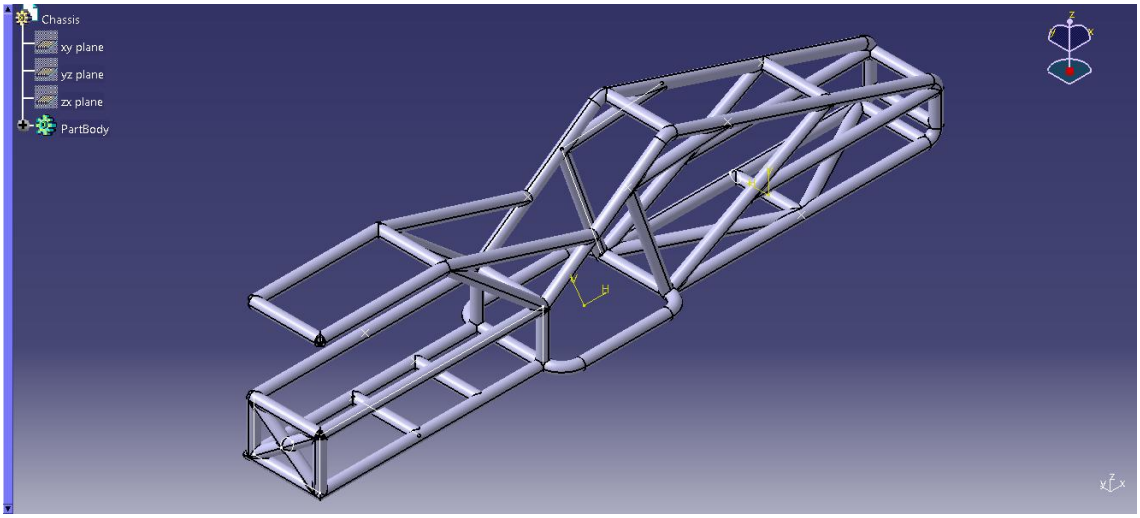


**Fig 1- Design of Quad Bike chassis prepared using CATIA V5 software**

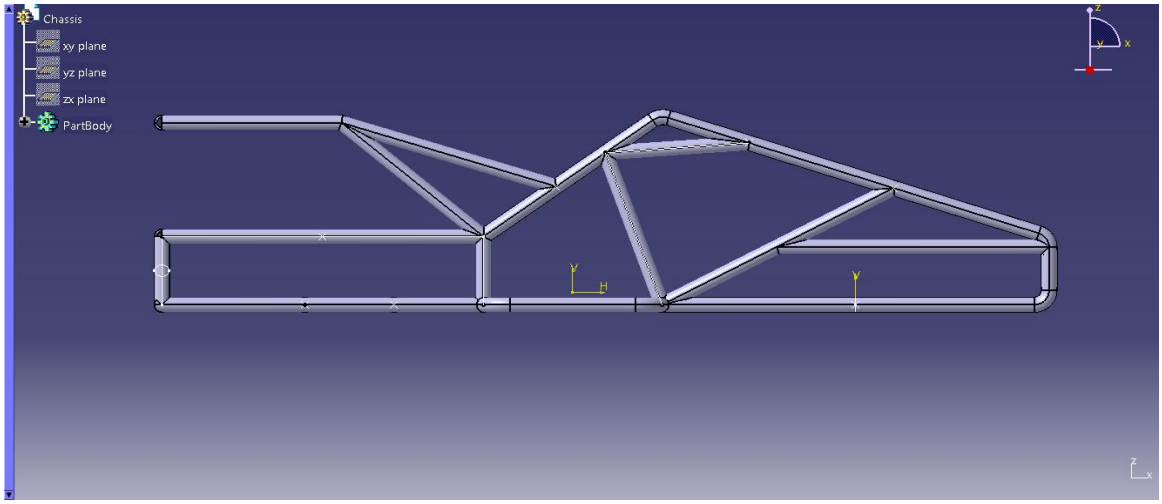


**Fig 2- Side view of quad bike chassis**

## 2.2 Material Selection

Selecting the chassis material is also an important phase of frame designing. The biggest challenge during material selection is reducing the cost without compromising with the strength requirements. Thus material selection was focused on parameters like lightweight, cost effectiveness, shock absorbing ability, weld ability, life of the material and lastly its recycling ability. The properties which must be concentrated on are density, Young's modulus, Poisson's ratio, tensile and yield strength of the material **[4]**. The market research showed three materials to be appropriate for the quad bike design. These materials along with their properties have been listed below in Table 1.

i) AISI 1018
ii) AISI 1010
iii) 4130 CHROMOLY

**Table 1 Probable Materials and Important Properties**

| Property / Material | Density (g/cc) | Yield Strength (MPa) | Carbon content | Cost (Rs./m) | Total points |
|---|---|---|---|---|---|
| AISI 1018 | 7.87 | 370 | 0.18 | 190 | 8.33 |
| AISI 1010 | 7.87 | 305 | 0.10 | 180 | 7.87 |
| 4130 Chromoly | 7.85 | 460 | 0.30 | 450 | 6.82 |

The strength and rigidity of the chassis hugely depends over the physical properties of the material along with its cross-section and dimensions **[4]**. The circular cross section is preferred over the square cross section since it provides better bending stress values along with reduced weight which an added advantage is contributing towards vehicle performance. After considering all the factors like cost, weight, availability etc. of the material the most appropriate material full filling the requirements of a quad bike is found to be AISI 1018 based on weighted-point method as shown in Table 1. The dimensions of the pipe are as follows:-

Outer diameter= 25 mm

Wall thickness= 4mm

Its physical properties are listed below in Table 2.

The material selected is the most suitable for the quad bike chassis with the following properties.

**Table 2 Material Properties of AISI 1018**

| Property | Value |
|---|---|
| Density | 7.87gm/cc |
| Poisson's ratio | 0.29 |
| Specific Heat Capacity | 450J/kg-K |
| Strength to Weight Ratio | 55 to 60 kN-m/kg |
| Yield tensile strength | 370 MPa |
| Thermal expansion | 11.9 µm/m-K |
| Young's modulus | 205 GPa |
| Bending strength | 477.626 MPa |
| Bending stiffness | 4258.652 $N\text{-}m^2$ |

### 2.3 Structural Analysis

From the design considerations and required objectives, preliminary design of the frame structure was developed. In order to examine the strength and reliability of the design FEA is used to study tubular structure of the chassis under predetermined loading conditions based on estimated practical conditions. For efficient working in any terrain the main frame of the bike i.e. the chassis should be rigid enough to sustain the various

types of jerks and loads. The frame should be able to withstand the impact, torsion, roll over conditions and provide utmost safety to the driver without undergoing much deformation.

In order to check the stress, strain and displacement of the roll cage model prepared following tests will be performed on the chassis by using ANSYS software **[5] :**

1) Frontal impact test

2) Rear side impact test

**2.3.1 Methodology Adapted:**

- Creation of cad model of chassis
- Generation of mesh using 1-d and 2-d elements as shown in Fig 3.
- Modification of mesh quality considering "convergence of nodes"
- Application of load and constraints
- Solution of test
- Determination of stress and deformation values
- Modification of cad model based on stress value positions generated
- Repetition of FEA analysis till safe design is obtained

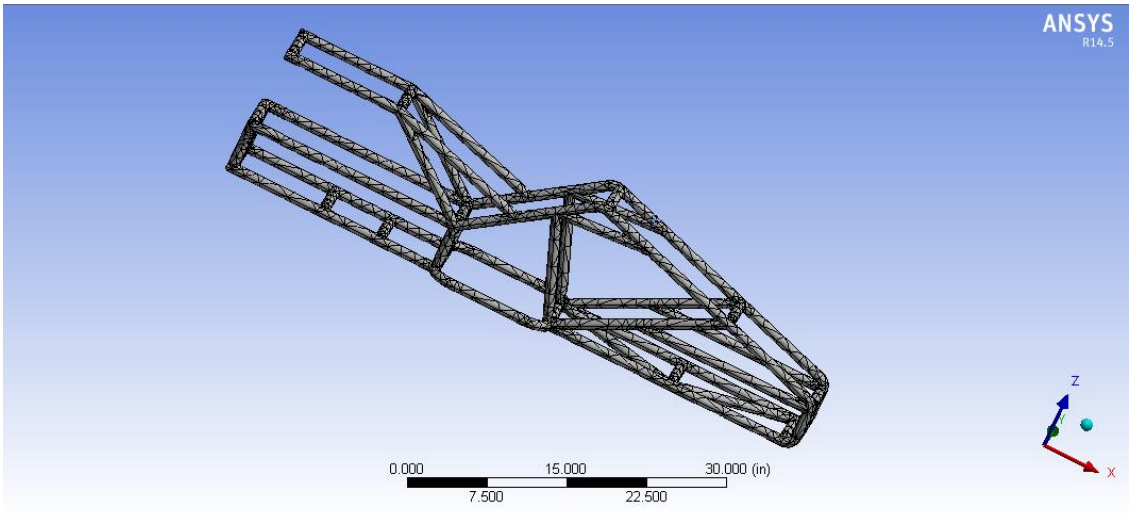


**Fig 3-Meshing in ANSYS**

## III. EXPERIMENTATION

### 3.1 Front Impact Test

#### 3.1.1 Load Calculations

The mass of the vehicle is 300kg. The vehicle frame subjected to impact analysis is assumed to be hitting a static wall with a velocity of 60 kmph. Thus considering the proposed weight of the vehicle and driver the impact load can be calculated based on G-force of magnitude 4 since the maximum amount of force which human body can bear without failure is 9G:

Initial velocity u=60 kmph=16.67m/s **[3]**

Final velocity v=0

F= m*a

F= 300*4*10

F = 12000N

Hence a gross load of 12kN **[1]** is applied at the front corners constraining the rear members as shown in the Fig.4.

Impulse time= weight of vehicle*(velocity/impact load)

= 300*(16.67/12000)

= 0.40 seconds

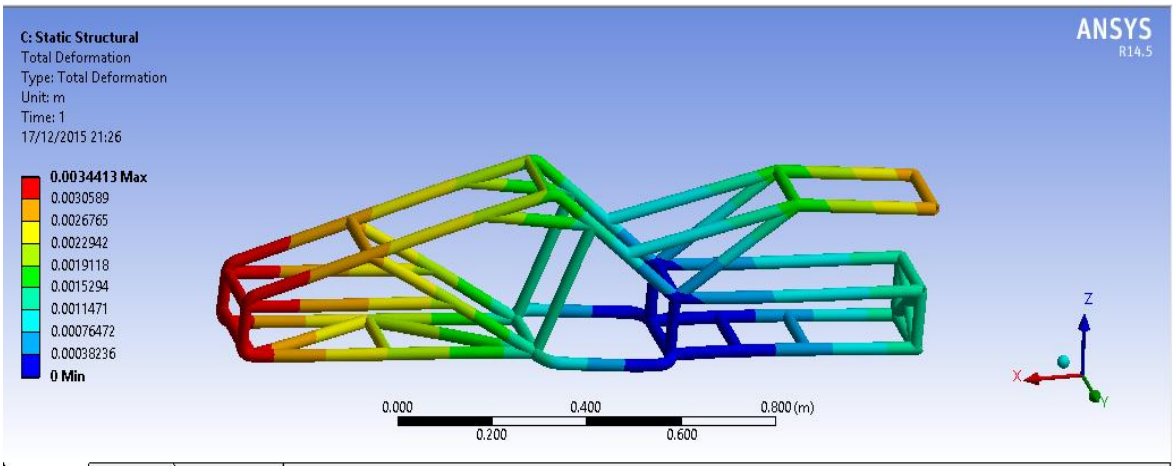


**Fig 4-Total Deformation for Front Impact Test**

### 3.2 Rear Impact Test

This test is basically done to check the strength of the designed chassis for an impact from the rear side. This test is useful in determining the deformations in the rear side. This helps us in providing extra safety on the rear if required as the complete transmission system of the vehicle is positioned on the rear part. The following figure shows total deformation of the design on the rear side for a force of 4G from the rear side.

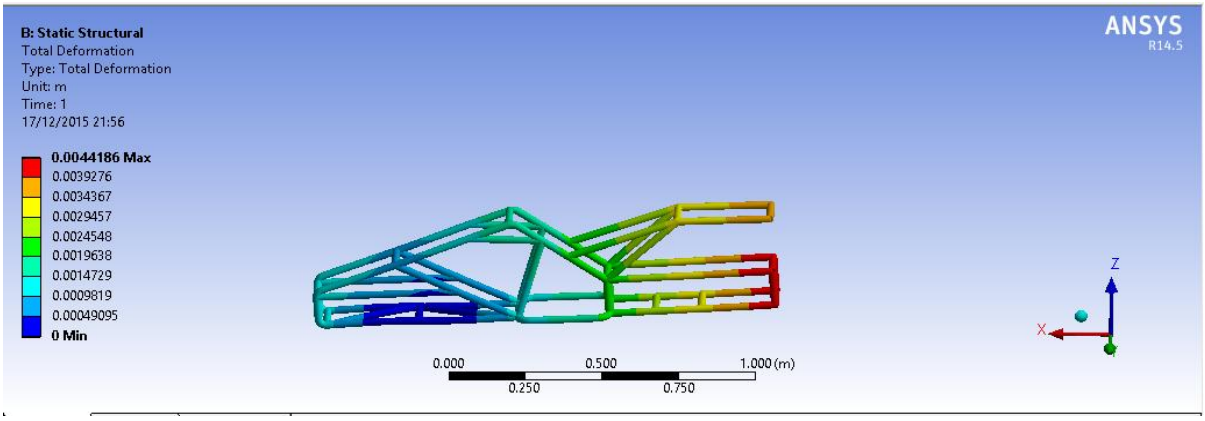


**Fig 5-Total Deformation for Rear Impact Test**

## IV. RESULTS

From the results obtained during front and rear impact analysis the maximum deformations are 3.4413 mm and 4.4186 mm respectively as shown in Fig. 4 & 5. These results are found to be within permissible limits and the design is safe for the driver.

## V. CONCLUSION

The paper introduces new design for quad bike chassis which is expected to show better performance and aesthetics when compared to conventional designs. The design is further tested for loading conditions like front impact and rear impact tests using ANSYS software tools. The results show that the proposed design has reduced values of stress and deformation which assure the safety of the chassis.

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