DESIGN ANALYSIS AND OPTIMIZATION OF TWO-WHEELER CHASSIS FOR WEIGHT REDUCTION

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Abstract - *The chassis frame forms the backbone of a vehicle; its principle function is to safely carry the maximum load for all designed operating conditions. Automotive chassis is the main carriage system of a vehicle. The chassis serves as a skeleton upon which parts like gearbox and engine are mounted. The two-wheeler chassis consists of a frame, suspension, wheels and brakes. The chassis is what truly sets the overall style of the two-wheeler. Commonly used material for two-wheeler chassis is steel which is heavy in weight or more accurately in density. There are various alternate materials like aluminium alloys, titanium, carbon fibre, magnesium, etc. which are lesser in weight and provide high strength and thus can be used for chassis. The frame consists mostly of hollow tubes and serves as a skeleton on which components like the fuel tank and engine are mounted.*
This project deals with design of two-wheeler chassis frame and its weight optimization. Various loading conditions like static loadings were carried out on the chassis and the structural stability of the chassis is analyzed by using alternate material as well as alternate geometry while maintaining the strength. Geometry modification in present chassis design by changing thickness of hollow tube . The various materials are studied and the best material will be selected as the solution. The weight optimization is achieved in this project. The 3d model of the chassis is created using appropriate modelling software. And its structural behaviour is analysed using Ansys Workbench R16.

***Key Words*: Weight Optimization., Chassis Frame, Structural Stability, 3D Modelling.**

1. INTRODUCTION

The chassis frame forms the backbone of a vehicle; its principle function is to safely carry the maximum load for all designed operating conditions. Automotive chassis is the main carriage system of a vehicle. The chassis serves as a skeleton upon which parts like gearbox and engine are mounted. The two-wheeler chassis consists of a frame, suspension, wheels and brakes. The chassis is what truly sets the overall style of the two-wheeler. Commonly used material for two-wheeler chassis is steel which is heavy in weight or more accurately in density. There are various alternate materials like aluminium alloys, titanium, carbon fibre, magnesium, etc. which are lesser in weight and provide high strength and thus can be used for chassis.

The frame consists mostly of hollow tubes and serves as a skeleton on which components like the gear box and engine are mounted. Suspension The frame also serves as a support for the suspension system, a collection of springs and shock absorbers that helps keep the wheels in contact with the road and cushions the rider from bumps and jolts. Wheels Motorcycle wheels are generally aluminium or steel rims with spokes, although some models introduced since the 1970s offer cast wheels. Cast wheels allow the bikes to use tubeless tires, which, unlike traditional pneumatic tires, don't have an inner tube to hold the compressed air .Brakes The front and rear wheels on a motorcycle each have a brake. The rider activates the front brake with a hand lever on the right grip, the rear brake with the right foot pedal.

A motorcycle frame is a motorcycle's core structure. It supports the engine, provides a location for the steering and rear suspension, and supports the rider and any passenger or luggage. Also attached to the frame are the fuel tank and battery. At the front of the frame is found the steering head tube that holds the pivoting front fork, while at the rear there is a pivot point for the swingarm suspension motion. Some motorcycles include the engine as a load-bearing stressed member; while some other bikes do not use a single frame, but instead have a front and a rear sub frame attached to the engine.

Optimization is a design tool that assists designers automatically to identify the optimal design from a number of possible options, or even from an infinite set of options. Optimization design is increasingly applied in industry since it provides engineers a cheap and flexible means to identify optimal designs before physical deployment. Optimization capabilities have also been increasingly integrated with CAD/CAM/CAE software such as Adams, Nastran,and OptiStruct. Even in our daily life, we are constantly optimizing our goals (objectives) within the limit of our resources. For example, we may minimize our expenditure or maximize our saving while maintaining a certain living level. When shopping for a car, we may try to meet our preference (performance of the car, safety, fuel economy,etc.) maximally on the condition that the price does not exceed what we can afford. It is the same case in engineering design where we optimize performances of the product while meet all the design requirements.

2. PROBLEM DEFINATION AND OBJECTIVES

2.1 Problem Definition

Vehicle chassis play important role in the performance of any vehicle. Continuous efforts are made to reduce weight and cost of vehicle by modifying chassis design. There is scope in modification of chassis design of present motorcycle. Weight reduction and smart chassis is required for two-wheeler is required for two-wheeler to improve its performance with reduced cost. While modifying the design weight is to be optimized keeping same strength and other properties.

2.2 Objectives

1. To study the current system in detail with its specification and all required considerations of a motorcycle.

2. To design, optimize, the existing material for existing chassis to minimize the overall weight of it, to save considerable amount of material.

3. The optimization of system will be according to one of the following cases: Changing dimensions of system and keeping material same as it is. Keeping same dimensions and changing material of components,

4.Changing both material as well as dimensions of component. The modeling of new design with help of CATIA software. To analysis of the redesigned new chassis to study the stress on the system.

3 CHECK DESIGN AND FINITE ELEMENT ANALYSIS OF EXISTING CHASSIS.

3.1 Check design of existing chassis.

The Yamaha FZ chassis have been used in this project.
Specification of Yamaha FZ :
Engine:

Table 1: Engine Specification

Displacement (CC)	149 cc
Max power	13.2 Ps @ 8000 rpm
Max torque	12.8 Ps @ 6000 rpm
Bore	57.3 mm
Stroke	57.9 mm
Valve per cylinder	2
Fuel delivery system	Fuel Injection
Fuel type	Petrol

Dimension and weight

Table 2: Dimension and weight Specification

Length *Height*Width	2073 x 700 x 1050
Wheel base	1330 mm
Ground clearance	160 mm
Fuel capacity	12 L
Kerb weight	150 Kg

3.2 CAD Model of existing chassis:

Modelling of the existing two wheeler chassis will be by using CATIA software and after proper modelling the analysis of system will be done using ANSYS software.

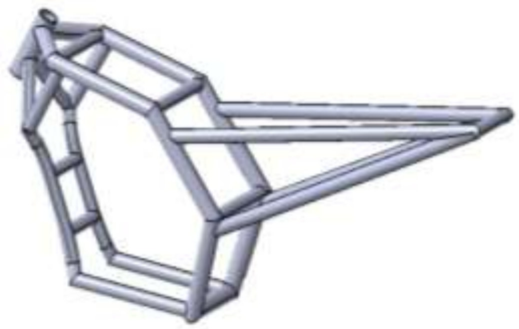

Figure 1. CAD Model of Chassis

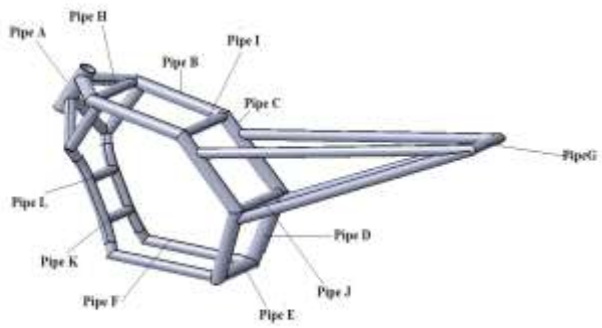

Figure 2. Detail nomenclature of existing chassis

Table 3: Dimensions of Chassis

Sr. No	Pipe	Dimension
1	A	O.D. = 48.30 mm , I.D. = 42.76 mm
2	B	O.D. = 42.2 mm , I.D. = 36.66 mm
3	C	O.D. = 42.2 mm , I.D. = 36.66 mm
4	D	O.D. = 42.2 mm , I.D. = 36.66 mm
5	E	O.D. = 42.2 mm , I.D. = 36.66 mm
6	F	O.D. = 33.4 mm , I.D. = 27.86 mm

7	G	O.D. = 33.4 mm , I.D. = 27.86 mm
8	H	O.D. = 33.4 mm , I.D. = 27.86 mm
9	I	O.D. = 33.4 mm , I.D. = 27.86 mm
10	J	O.D. = 33.4 mm , I.D. = 27.86 mm
11	K	O.D. = 33.4 mm , I.D. = 27.86 mm
12	L	O.D. = 33.4 mm , I.D. = 27.86 mm

3.3 Structural analysis of chassis

Structural analysis and design is a very old art and is known to human beings since early civilizations The main purpose of any structure is to support the loads coming on it by properly transferring them to the foundation.

i) Material: Steel

Table 4. Material Properties

Mechanical property	Value	Unit
Density	7850	Kg/m^3
Coefficient of Thermal Expansion	1.3e-005	1/c
Tensile Yield Strength	550	MPa
Young's Modulus	210	GPa
Poisson's Ratio	0.3	

ii) Meshing:

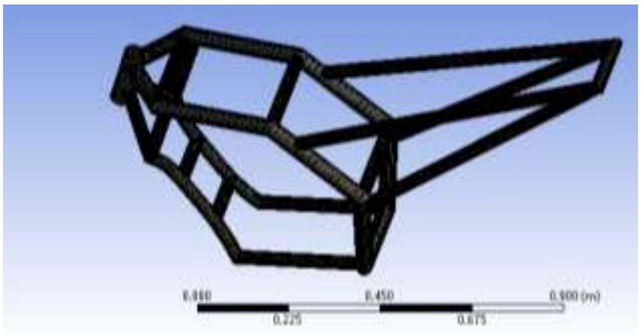

Figure 3: Meshing of Chassis

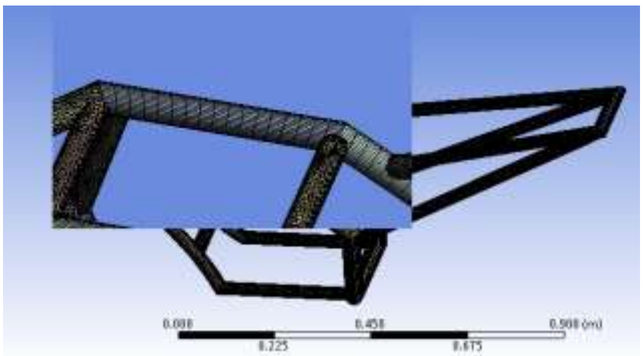

Figure 4. Meshing (Detail view)

Mesh quality check:

Table 5. Mesh quality parameter

Sr. no.	Mesh quality parameter	Required	Achieved
1	Skewness	<0.7	0.55
2	Jacobian	Ideal value 1	1
3	Warping	<30, Ideal value 0	9
4	Aspect ratio	<5	5
5	Orthogonal quality	> 1	0.6079

iii) Boundary conditions for structural analysis of chassis:

a) Fixed Support:

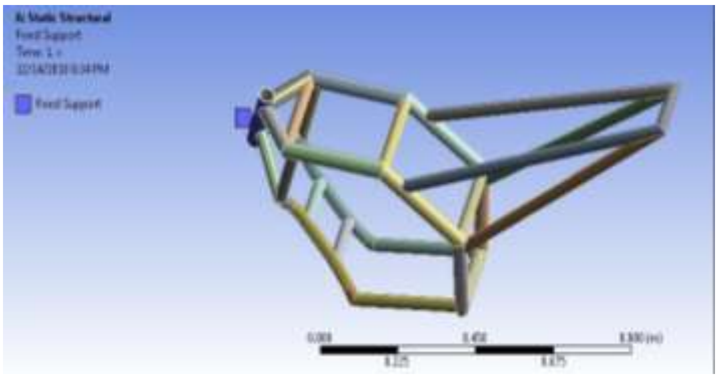

Figure 5. Boundary condition –Support

B) Fixed support:

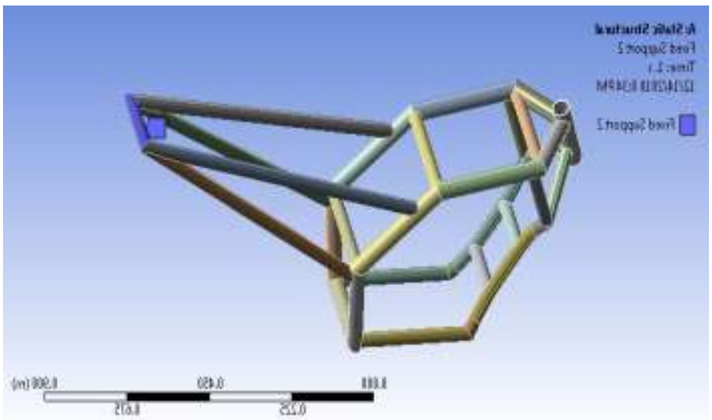

Figure 6. Boundary condition –Support

C) Force 1 :(Riders weight 2000N)

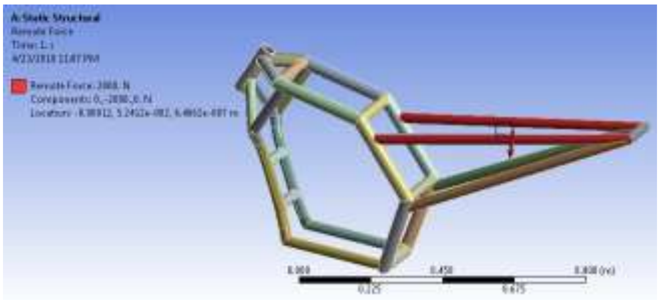

Figure 7. Boundary condition –Riders Weight

D) Force 2:(Engine load -500 N)

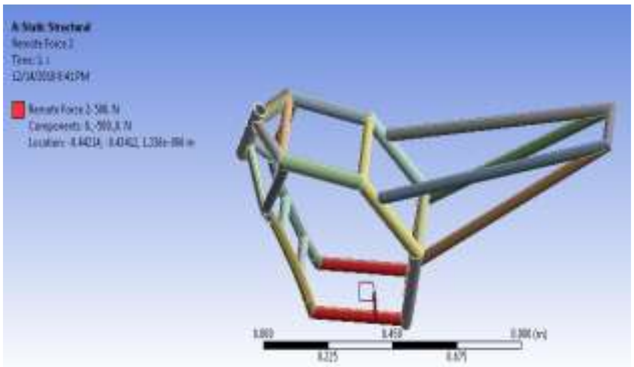

Figure 8. Boundary condition –Engine load

E) Force 3: (Fuel tank load -200 N)

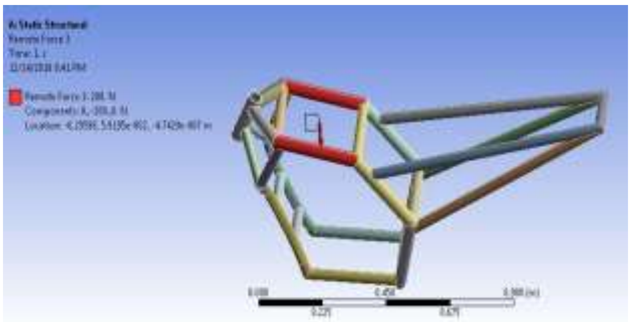

Figure 9. Boundary condition –Fuel tank load

4 DESIGN OF SYSTEM FOR OPTIMIZATION:

After study of existing system, 3D modelling of chassis is done in CAD software .Analytical design calculation of existing system is also carried out . Design of that system for optimization will be started. Different pipes will be studied and various parameters like geometry and materials will be studied. Optimization of system will be according to one of the following case: Changing dimensions of system and keeping material same as it is.

Changing dimensions of system and keeping material same as it is. In this approach weight reduction is achieved by minimizing thickness of hollow chassis tube. By increasing inner diameter of hollow chassis tubes as shown in figure.

Table 6. New dimensions of chassis

Sr.No.	Pipe	Present Design	Modified design 1	Modified design 2
1	A	O.D. = 48.30 mm , I.D. = 42.76 mm	O.D. = 48.30 mm , I.D. = 44 mm	O.D. = 48.30 mm , I.D. = 45 mm
2	B	O.D. = 42.2 mm , I.D. = 36.66 mm	O.D. = 42.2 mm , I.D. = 37.5 mm	O.D. = 42.2 mm , I.D. = 38.5 mm
3	C	O.D. = 42.2 mm , I.D. = 36.66 mm	O.D. = 42.2 mm , I.D. = 37.5 mm	O.D. = 42.2 mm , I.D. = 38.5 mm
4	D	O.D. = 42.2 mm , I.D. = 36.66 mm	O.D. = 42.2 mm , I.D. = 37.5 mm	O.D. = 42.2 mm , I.D. = 38.5 mm
5	E	O.D. = 42.2 mm , I.D. = 36.66 mm	O.D. = 42.2 mm , I.D. = 37.5 mm	O.D. = 42.2 mm , I.D. = 38.5 mm
6	F	O.D. = 33.4 mm , I.D. = 27.86 mm	O.D. = 33.4 mm , I.D. = 29 mm	O.D. = 33.4 mm , I.D. = 30.4 mm
7	G	O.D. = 33.4 mm , I.D. = 27.86 mm	O.D. = 33.4 mm , I.D. = 29mm	O.D. = 33.4 mm , I.D. = 30.4 mm
8	H	O.D. = 33.4 mm , I.D. = 27.86 mm	O.D. = 33.4 mm , I.D. = 29mm	O.D. = 33.4 mm , I.D. = 30.4 mm
9	I	O.D. = 33.4 mm , I.D. = 27.86 mm	O.D. = 33.4 mm , I.D. = 29mm	O.D. = 33.4 mm , I.D. = 30.4 mm
10	J	O.D. = 33.4 mm , I.D. = 27.86 mm	O.D. = 33.4 mm , I.D. = 29mm	O.D. = 33.4 mm , I.D. = 30.4 mm
11	K	O.D. = 33.4 mm , I.D. = 27.86 mm	O.D. = 33.4 mm , I.D. = 29mm	O.D. = 33.4 mm , I.D. = 30.4 mm
12	L	O.D. = 33.4 mm , I.D. = 27.86 mm	O.D. = 33.4 mm , I.D. = 29mm	O.D. = 33.4 mm , I.D. = 30.4 mm

5 RESULTS AND DISCUSSION

After the processing solutions, the contours of Von-Mises Stresses, Total Deformation, and Equivalent Elastic Strain in Static structural analysis are plotted.

5.1 Result of present design of chassis

A) Total deformation:

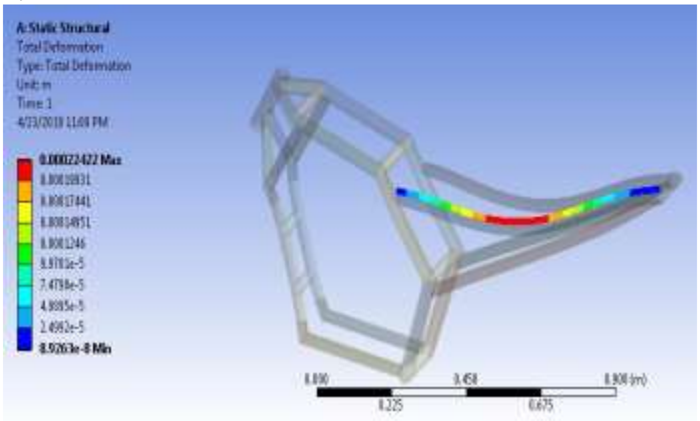

Figure 10. Total deformation

B) Von mises stress:

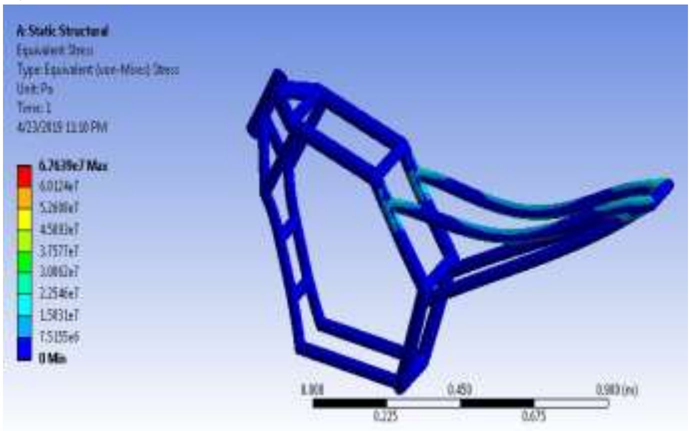

Figure 11. Von mises stress

5.2 Result of modified design 1 of chassis:

A) Total deformation:

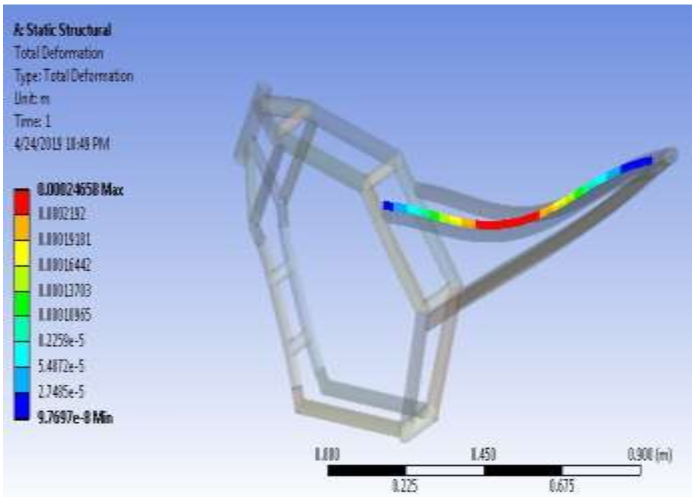

Figure 12. Total deformation

B) Von mises stress:

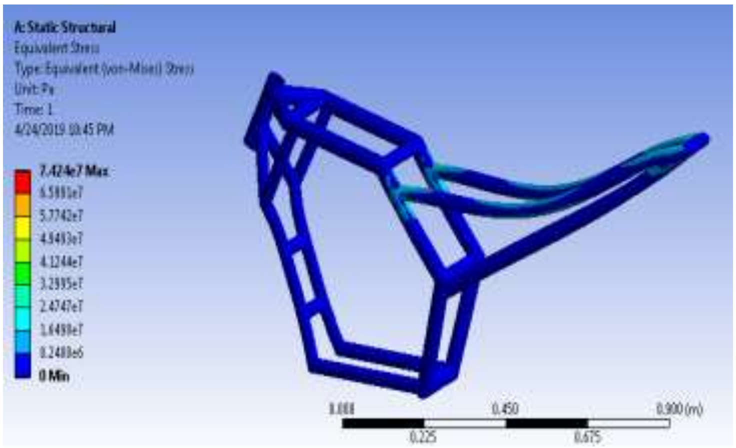

Figure 13. Von mises stress

5.2 Results of modified design 2 of chassis:

A) Total deformation:

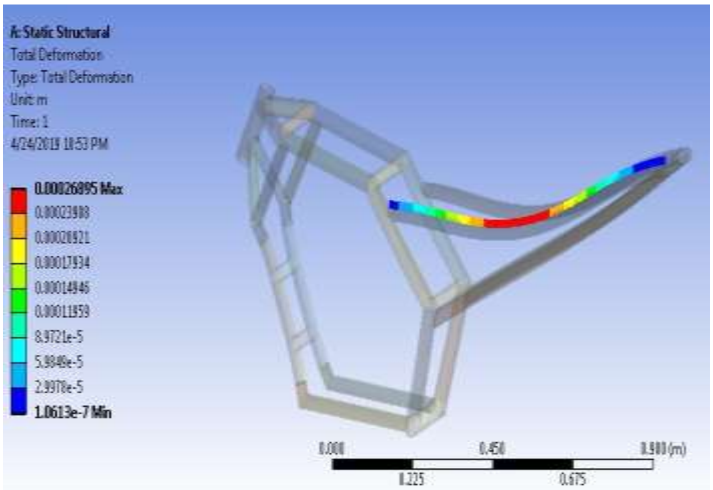

Figure 14. Total deformation

B) Von mises stress:

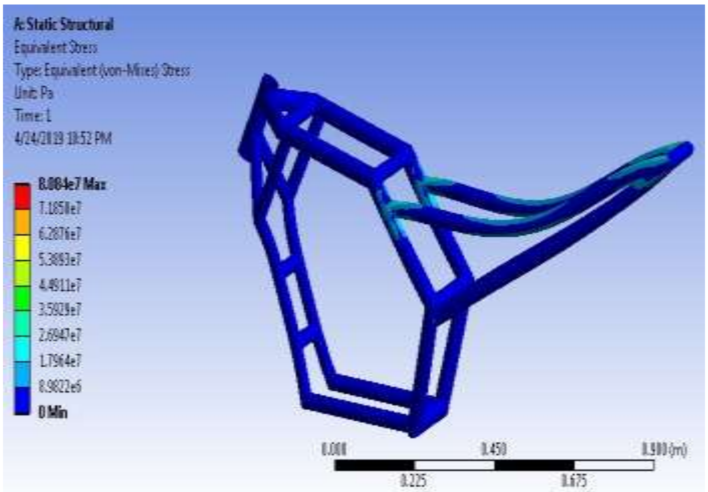

Figure 15. Von mises stress

Table 7. Result table 1

Design	Von mises stress (MPa)	Total deformation (m)	Maximum permissible stress (MPa)	F.O.S.
Existing Design	67.639	0.000224	270	3.99
Modified design 1	74.24	0.00024658	270	3.6368
Modified design 2	80.84	0.0002689	270	3.3399

Von mises stress for existing chassis design is 67.639 MPa which is below the maximum permissible stress. Hence design is safe. For weight reduction purpose we have modified the existing design. For modified design 1 and modified design 2 stress are 74.24 MPa and 80.84 MPa, but these stress values is below maximum permissible stress for steel.

Table 8. Result table 2

Design	Weight	Weight reduction
Modified design 1	18.45 Kg	16.05%
Modified design 2	16.23 Kg	26.15 %

6 CONCLUSIONS

Von mises stress for existing chassis design is 67.639 MPa which is below the maximum permissible stress. Hence design is safe. For weight reduction purpose we have modified the existing design. For modified design 1 and modified design 2 stress are 74.24 MPa and 80.84 MPa , but these stress value is below maximum permissible stress for steel. Weight reduction 16.05 % and 26.15 % is achieved for modified design 1 and design 2 .

If we compare stress value of steel with other material then we will get that stress value for steel and aluminum is almost same and stress value is lower for titanium and carbon fiber. Titanium and carbon fiber are costly material so we have eliminated these material on cost basis. In future we can develop chassis using various grade of aluminum

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