ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF GRADUATE STUDIES

Design And Static structural Analysis of Chassis for Green and Light Vehicle Using Composite Material.

A Thesis Submitted to the Graduate School of Addis Ababa University

In Partial Fulfilment of the Requirements for the Degree of Masters of Science

In

Mechanical Engineering (Mechanical Design)

By: Henok Getaneh

Advisor: Dr. Daniel Tilahun

Co-Advisor: Hairedin Ismael

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Addis Ababa University

Addis Ababa Institute of Technology

School of Mechanical and Industrial Engineering

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Approved By Board of Directors

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DECLARATION

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This is to certify that the thesis prepared by Henok Getaneh, entitled: "**Design And Static structural Analysis of Chassis for Green and Light Vehicle using composite material.**", do here by declare this thesis is my original work and that it has not been submitted partially, or in full for a degree in any university/institution, which compiles with the regulations of the university and meets the accepted standards with respect to originality and quality.

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Abstract

Nowadays, transportation industry plays major role in the economy of modern developing and industrialized countries. Weight reduction is now the main issue in automobile industries. The chassis frame is an important part in automobiles. The main function of the automobile chassis is to carry the goods and payload placed upon it. So it must be strong enough to resist the shock, twist, vibration and other stresses. In the present work, the dimensions of an existing light vehicle chassis of a TOYOTA(LJ150-GKMEE) vehicle is taken for modelling and analysis of a vehicle chassis with composite materials namely S-GLASS epoxy and HSLA Steel, subjected to the same load as that of a steel chassis. Reduction of weight of various parts of a vehicle can improve the performance and efficiency of the automobile. The composite materials provide a good strength-to-weight ratio, which could be replaced for the conventional materials. This paper deals with the structural analysis of a frontend cross bar which is replaced with s-glass Fiber Reinforced Polymer composite material. Maximum stress and maximum deflection are important criteria for design of the chassis. The objective of present is to determine the maximum stress, maximum deflection. For validation the design is done by applying the vertical loads acting horizontally in the existing cross sections. To do this research I use The FE analysis for a light modeling by utilizing commercial finite element analysis software packages like CATIA and ANSYS. Then I contribute light and high strength chassis for light and green vehicle.

KEYWORDS: light vehicle, chassis, Static analysis, HSLA Steel, catia, ansys s-glass epoxy.

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NOMENCLATURE

V_M	Volume of Matrix (Cm3)
P_f	Density of Fiber (Gm/Cm3)
M_m	Matrix Mass Fraction
ρ_m	Density of Matrix (Gm/Cm3)
M_f	Fiber Mass Fraction
V_f	Fiber Volume Fraction
M_f	Mass of Fiber (Gm)
E_L	Longitudinal Young's Modulus
E_T	Transverse Young's Modulus
E_f	The Fiber Modulus,
V_f	The Fiber Volume Fraction,
E_M	The Matrix Modulus
N_{12}	Major Poisson's Ratio
G_{12}	In-Plane Shear Modulus

LIST OF ABBREVIATION AND ACRONYMS

ASTM	American Society of Testing Materials
FEA	Finite Element Analysis
FEM	Finite Element Method
(FRP)	Fiber-Reinforced Polymer
Mph	Miles per Hour
Min	Minute
Hr.	Hour
Cc	Cubic Centimeter
Eq.	Equation
M	Meter
Mm	Millimeter
HSLA	high strength low alloy steel
AAIT	Addis Ababa University Institute of Technology

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Transportation industry plays a major role in the economy of modern industrialized and developing countries. The purpose of this THESIS is to design and structural analysis of chassis for light and green vehicle using composite material. There are many types of pollution such as water pollution, noise pollution, thermal pollution and air pollution Air pollution can be considered as one of the main hazard to the health of human being. The air pollution is due to the increasing number of vehicle use by human. When the number of vehicle increase the usage of the petrol also increase. The lack of the source of the petrol makes the price increase by time to time specially for developing country like Ethiopia. The emission from the vehicle makes the environment faces the air pollution that in critical level.

Many steps need to reduce the number of the vehicle in other side to reduce the price of the petrol. Besides that it also uses to reduce the air pollution. The big number of vehicles in each country makes the prevention to reduce the number of vehicle difficult. So, the other prevention is increase the efficiency of the vehicle's engine. When the engine at the efficient level, the emission is at the low level and the most important is the usage of petrol is low. The prevention is reducing the weight of the body and chassis of each vehicle. [1]

This thesis focused to reduce the usage of petrol by design and analysis the chassis to reduce the weight of the chassis of vehicle

Light weight is a primary goal for all components in green automobile as a lower weight requires less force to accelerate by the same amount. Newton's 2nd law says;

$$Force = Mass \times Acceleration$$

So given the same force, a lighter automobile will accelerate quicker. This applies in all transient conditions including braking and cornering. If a car will be light, then it can be green. So wherever possible everything in green car should be as light as possible [2]

Green cars technology typically used in the light vehicle, alternative energy is a current issue in automotive industries. The design of a green vehicle is severely limited by the amount of energy input into the car. Because of the power using may be solar or electricity instead of fuel.

This thesis will be focused on the chassis and the design of the light vehicle that used alternative power source as it main energy. Chassis is one of the main components for the light vehicle. Chassis is a structural system that supports other components of a physical construction.

Design is one of the main processes in producing the light vehicle. This will help to make a light vehicle that follows the criteria needed by the designer and the customer. To design light weight vehicle currently the available material is composite material. Composite material is a material composed of two or more distinct phases (matrix phase and dispersed phase) and having bulk properties significantly different from those of any of the constituents. Different types of composite material are available and one of it is Polymer matrix composite. It is very popular due to their low cost and simple fabrication methods. It has the benefits of high tensile strength, high stiffness and good corrosion resistance etc. At present this polymer matrix composite materials are used in aerospace, automobile industries due to it high strength to low weight ratio. [3] Chassis of Automotive helps to keep an automobile rigid, stiff and unbending. Automobile chassis ensures less noise, vibrations and harshness throughout the automobile. Along with the strength, an important consideration in the chassis design is to increase the stiffness (bending and torsion) characteristics. In the conventional design procedure the design is based on the strength and emphasis is then given to increase the stiffness of the chassis, with very little consideration to the weight of the chassis. One such design procedure involves the adding of structural cross member to the existing chassis to increase its torsion stiffness. As a result weight of the chassis increases. This increase in weight reduces the fuel efficiency and increases the cost due to extra material. The design of the Chassis with adequate stiffness and strength is necessary. [4]

Many steps need to reduce the number of the vehicle in other side to reduce the price of the petrol and to reduce the air pollution. The big number of vehicles in each country makes the prevention to reduce the number of vehicle difficult. So, the other prevention is increase the efficiency of the vehicle‘s engine. When the engine at the efficient level, the emission is at the low level and the most important is the usage of petrol is eliminated. The prevention is reducing the weight of the body and chassis of each vehicle. This paper focused to reduce the usage of petrol by design and analysis the chassis to reduce the weight of the chassis of vehicle. At the same time, the global usage of the petrol also reduced. So that more fuel-efficient passenger vehicles can be prepared for the automobile competition market like Ethiopia. [5]

To design an alternative source vehicle, the chassis must be designed based on the requirements and the ability of the source to move it. [6]

Structural analysis of the chassis can be performed by finite element analysis method. Normally software packages used for the analysis are Hyper Works, ANSYS, NASTRAN, etc. [7]

Weight reduction is given a high priority across automotive industry today. It has become imperative for auto manufacturers to create designs that minimize weight of the vehicle. Modern methods of chassis design focus on weight reduction by removal of the additional weight or by changing the material by composite material. New and innovative ways are being studied and searched for reduction in weight of the existing vehicle design complying with industrial standards. Various types of finite element analysis like linear static analysis, non-linear analysis, dynamic analysis, fatigue analysis, optimization analysis, crash analysis, etc. can be performed to assess the stress values of the chassis. [7]

1.2 Chassis

Chassis is one of the main components for the vehicle. Chassis is a structural system that supports other components of a physical construction. Automotive chassis is a

French word that was initially used to represent the basic structure. An example of a chassis is the under part of a motor vehicle, consisting of the frame (on which the body is mounted). The components of the vehicle like Power plant, Transmission System consisting of clutch gearbox, propeller shaft and rear axle, Wheels and Tires, Suspension, Controlling Systems like Braking, Steering etc. and electrical system parts are also mounted on the Chassis frame. It is the main mounting for all the components including the body. So it is also called as Carrying Unit. If the running gear such as wheels and transmission, and sometimes even the driver's seat, are included, then the assembly is described as a rolling chassis. It gives strength and stability to the vehicle under different conditions. [8] The chassis provides the strength needed for supporting the different vehicular components as well as the payload and helps to keep the automobile rigid and stiff. Consequently, the chassis is also an important component of the overall safety system. Furthermore, it ensures low levels of noise, vibrations and harshness throughout the automobile. Chassis should be rigid enough to withstand the shock, twist, vibration and other stresses. Along the strength, an important consideration is chassis design is to have adequate bending and torsional stiffness for better handling characteristics. So, strength and stiffness are two important criteria for the design of chassis. The load carrying structure is the chassis, so the chassis has to be so designed that it has to withstand the loads that are coming over it. [9] The chassis receives the reaction forces of the wheels during acceleration and braking and also absorbs aerodynamic wind forces and road shocks through the suspension. So the chassis should be engineered and built to maximize payload capability and to provide versatility, durability as well as adequate performance. To achieve a satisfactory performance, the construction of a vehicle chassis is the result of careful design and rigorous testing. [10]

The main functions of the chassis are to support the chassis components and the body to withstand static and dynamic loads without excessive deflection or distortion. [11]

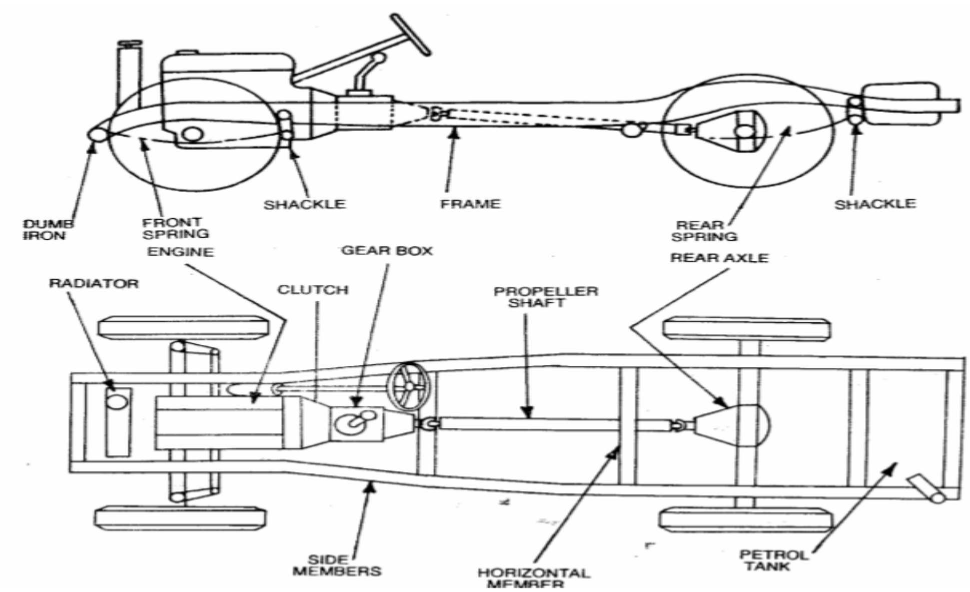


Figure 1: Skeletal view of Chassis

1.2.1: Main components of the Chassis are

1. Frame: it is made up of long two members called side members riveted together with the help of number of cross members.
2. Engine or Power plant: It provides the source of power
3. Clutch: It connects and disconnects the power from the engine fly wheel to the transmission system.
4. Gear Box
5. U Joint
6. Propeller Shaft
7. Differential

1.2.2: Functions of the chassis frame:

In a modern vehicle, chassis is expected to fulfill the following functions:

- Provide rigidity for accurate handling;
- Protect the occupants against external impact.
- To carry load of the passengers or goods carried in the body.
- To support the load of the body, engine, gear box etc.,
- To withstand the forces caused due to the sudden braking or acceleration

- To withstand the stresses caused due to the bad road condition.
- To withstand centrifugal force while cornering

While fulfilling these functions, the chassis should be light enough to reduce inertia and offer satisfactory performance. It should also be tough enough to resist fatigue loads that are produced due to interaction between the driver, engine, power transmission and road conditions. [12]

1.3: Types of chassis frames:

1.3.1: Ladder frame chassis

The history of the ladder frame chassis dates back to the times of the horse drawn carriage. It was used for the construction of „body on chassis" vehicles, which meant a separately constructed body was mounted on a rolling chassis. The chassis consisted of two parallel beams mounted down each side of the car where the front and rear axles were leaf sprung beam axles. The beams were mainly channeled sections with lateral cross members, hence the name. The main factor influencing the design was resistance to bending but there was no consideration of torsion stiffness. [13]

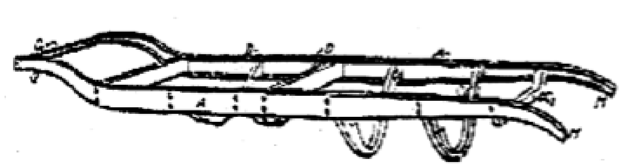


Figure 2: Ladder frame

A ladder frame acts as a grillage structure with the beams resisting the shear forces and bending loads. To increase the torsion stiffness of the ladder chassis cruciform bracing was added in the 1930"s. The torque in the chassis was retrained by placing the cruciform members in bending, although the connections between the beams and the cruciform must be rigid. Ladder frames were used in car construction until the 1950"s but in racing only until the mid-1930"s [13]

1.3.2: Twin tub

The ladder frame chassis became obsolete in the mid 1930‟s with the advent of all-round independent suspension, pioneered by Mercedes Benz and Auto Union. The suspension was unable to operate effectively due to the lack of torsion stiffness. The ladder frame was modified to overcome these failings by making the side rails deeper and boxing them. A closed section has approximately one thousand times the torsion stiffness of an open section. Mercedes initially chose rectangular section, later switching to oval section, which has high torsion stiffness and high bending stiffness due to increased section depth, while Auto Union used tubular section. The original Mercedes design was further improved by mounting the cross members through the side rails and welding on both sides. The efficiency of twin tube chassis‟ is usually low due to the weight of the large tubes. They were still in use into the 1950‟s, 1958 Lister-Jaguar being an example of this type. A typical twin-tube chassis is shown in Figure 3. [13]

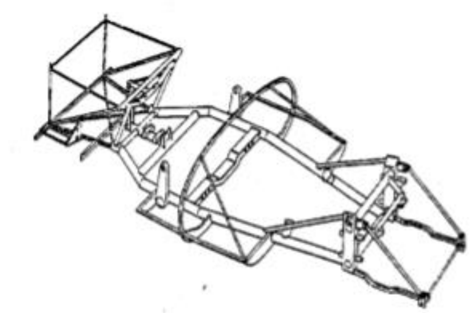


Figure 3: Twin-tube chassis

1.3.3: Space frame

Although the space frame fig 4 demonstrated a logical development of the four-tube chassis, the space frame differs in several key areas and offers enormous advantages over its predecessors. A space frame is one in which many straight tubes are arranged so that the loads experienced all act in either tension or compression. This is a major advantage, since none of the tubes are subject to a bending load. Since space frames are inherently stiff in torsion, very little material is needed so they can be lightweight. The growing realization of the need for increased chassis torsion stiffness in the years following World War II led to the space frame, or a variation of it, becoming universal among European road race cars following its appearance on both the Lotus Mk IV and the Mercedes 300 SL in 1952. While these cars were not strictly the first to use space frames, they were widely successful, and the attention they received popularized the idea. [13]

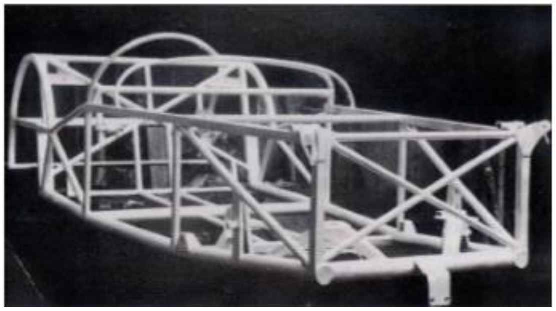


Figure 4: 1952 Lotus Mk.IV space frame

1.3.4: Various loads acting on the frame:

Various loads acting on the frame are

1. Momentary duration Load - While taking a curve.
2. Short duration Load - While crossing a broken patch
3. Impact Loads - Due to the collision of the vehicle.
4. Inertia Load - While applying brakes.
5. Static Loads - Loads due to chassis parts.
6. Over Loads - Beyond Design capacity. Short duration Load - While crossing a broken patch.

1.4 Problem Statement

Automobiles that uses gasoline or diesel fuels affect the environment and the country economy specially the developing country like Ethiopia. So it is necessary to build green and light vehicle. We can solve this problem by reducing the size and the weight of automobile by using light weight material such as aluminum, composite like metal metrics composite and polymer composites.

When the vehicle number increases, the usage of petrol (fuel) also increases. At the same time, the emission from the vehicles increases the air pollution. reducing the weight of the vehicle which can reduce the usage of petrol. If the chassis is designed in an optimal material usage then it will save the amount of material consumed for single time also the reduction in fuel cost will also be economical for customer.

1.5: Objective of the study

1.5.1: General objective

The general objective pf the thesis is to design and analysis of chassis at static condition for light weight vehicle

1.5.2: Specific objective

The specific objective of the study includes

I. To develop a new light weight chassis by reducing the existing weight and by selecting the composite material.

II. To determine the static structural analysis of vehicle chassis by modal analysis and finite element method.

1.6: Scope of the study

The scopes of the study are:

- To study about the design of the chassis of current vehicle.
- Literature study on the chassis structure of light vehicle.
- Analyze the material used for the vehicle based on types and the sizes.
- Develop designs for the chassis of the light vehicle.
- Analyze the performance (using ansys) of the new designs that follow the requirements of the vehicle.
- Propose the new design of the chassis based on the analyses that have been done.

1.7: Organization of the Thesis

This study is organized in five chapters.

Chapter one: it outlines the background, the general idea of the researches and statement of the problems, the scopes of the study, the objectives of the study as well.

Chapter two: deal with literature review from previous studies.

Chapter three: this chapter shows analytical methods and conditions about the chassis design. Here determination of load and boundary condition are discussed.

Chapter four: this chapter shows results from finite element methods and from analytical result.

Chapter five: conclusion, recommendation.

CHAPTER 2

LITERATURE REVIEW

2.1: Introduction

The function of this chapter is to survey different journals, scholarly articles, books and other sources related to my title. Light vehicle chassis is a major component in an on road vehicle system. This research work contains modeling, design and structural analysis of light vehicle chassis. The FE analysis have been done for a light vehicle chassis model by utilizing commercial finite element analysis software packages like CATIA and ANSYS. The automotive chassis is tasked with holding all the components together while driving, and transferring vertical and lateral loads, caused by accelerations, on the chassis through the suspension and to the wheels. The chassis of an automobile provide mounting points for the components like engine, driveline, suspension system and wheels. Main functions of the chassis are to support the chassis components and the body to withstand static and dynamic loads without excessive deflection or distortion. As a result the weight of the chassis increases. [11] This paper focused to eliminate the usage of petrol by design and analysis the chassis to reduce the weight of the chassis of vehicle. At the same time, the global usage of the petrol also reduced. The design of the Chassis with adequate stiffness and strength is necessary.

Weight reduction is now the main issue in automobile industries. Because of if the weight of the vehicle increases the fuel consumption increases. At the same time as the weight of the vehicle increases the cost also increases which becomes a major issue while purchasing an automobile. Steel structures exposed to air and water, such as bridges are susceptible to corrosion. In conditions of repeated stress and more temperatures it can suffer fatigue and cracks. These are the main problems of steel and these are compensated by inducing composite materials. [4] [8]

At the time of manufacturing, the body of a vehicle is flexibly molded according to the structure of chassis. Automobile chassis is usually made of light sheet metal or composite plastics. It provides strength needed for supporting vehicular components and payload placed upon it. Automotive chassis or automobile chassis helps keep an automobile rigid, stiff and unbending. It ensures low levels of noise, vibrations and harshness throughout the automobile. [8]

2.1.1: Previous work about chassis.

C.V. Babu et al. (2015) [20] have analyzed the Eicher 11.10 chassis frame. The conventional steel frame is entirely replaced with CFRP to obtain better strength-to-weight ratio. The stress and deflection results are better in composite frame than the conventional steel frame.

Ms. Kshitija et al. (2014) [14] have conducted a failure analysis on the Tractor Trolley chassis using the Finite Element Method. The results have shown that the stresses get accumulated at a region where heavy loads are applied, which is also indirectly related to the self-weight of the frame. Thus it is required to redesign the chassis with respect to the stress strain analysis and thereby reducing the self-weight of the trolley.

H.B. Patil et al. (2013) [15] have analyzed the stress of a ladder type low loader truck chassis structure. The objective of the work was to reduce the cost of the chassis frame by reducing the thickness of the side member and cross member and changing the position of the cross member. It was concluded that, changing the thickness of the cross member gave better reduction in stress and deflection values than changing the thickness of cross member and the position of cross member.

J.S. Nagaraju and U.H. Babu (2012), [16] in their paper have replaced the conventional materials of the chassis frame with Carbon Epoxy and E-Glass Epoxy composites. Structural and Modal Analyses are conducted by varying the layers and the reinforcement angles in the layers. Results have shown that the Carbon and E-Glass Epoxy have generated low stress values than the conventional steel material when subjected to vertical loads. The weight is reduced four times than the steel frame. It is also observed that using many layers of same thickness has given better strength than a single layer.

M.R. Chandra et al. (2012), [17] have described the design and analysis of a heavy vehicle chassis. The dimensions of a TATA 2515EX vehicle is taken for modeling and analysis with three different materials, Carbon/Epoxy, E-Glass/Epoxy and S-Glass/Epoxy, subjected to the same loading conditions as that of a Steel chassis. With similar design specifications, the composite frame has shown reduced stress and deflection values than the conventional steel, also reducing the weight of the chassis frame.

Vijayan, Sendhil kumar.(2015), [18] This paper describes design and analysis of heavy vehicle chassis by comparing steel with composite material s-glass epoxy using different cross section. The result shows the magnitude of stress and deformation of steel are greater when compared to other polymer composites. When compared with C and Box cross sections. the I cross section induces very low stress and deformation. S-Glass Epoxy material of C and BOX cross section as high stress and deformation when compare to I cross section. Fig 13 and 14 indicates the deformation and stress distribution curve for the analysis performed on various cross sections with different materials like steel and S-Glass Epoxy composite. From the above curve it is clear that S-Glass Epoxy polymeric composite induces high level of deformation and stress distribution when compared with steel. I-Cross section provides low deformation and stress distribution when compared to other cross sections like C and Box.

Purushotham (2013), [19] presented in his work a stress and deflection analysis of a three wheeler passenger and load carrier chassis and modifying into one chassis for both types. Main focus of his work was to reduce the tooling cost and increasing the rate of production. To achieve this author performed a finite element analysis of the existing chassis of passenger vehicle. Software package used for this analysis was ANSYS. In existing analysis of passenger vehicle chassis under the static loading, values of stress and deflection were checked. Author also performed analysis of existing load carrier chassis under GVW and 50% overload condition and assessed the values of stress and deflection. An attempt was made to modify the chassis to make only one chassis for both types with simple modifications to reduce the tooling cost. Comparison of the results showed lesser values of stress and deflection for modified chassis.

S. S. Sane, Ghanshyam Jadhav, Anandraj H (2012), [20] Performed stress analysis of a light commercial vehicle chassis by using finite element method. Initially analysis of the existing chassis of the vehicle was performed and values of the stress and deflection were obtained. A total of nine different load cases were considered for the analysis of the chassis. To reduce the stress values stiffeners of varying height were added at the critical locations. The chassis was analyzed by finite element method using Altair HyperWorks software package. Comparison of the results showed that stresses on the critical location were reduced up to 44% by addition of stiffener.

Mohd. Azizi Muhammad Nor, Helmi Rashid, Wan Mohd Faizul Wan Mahyuddin, Mohd Azuan Mohd Azlan, Jamaluddin Mahmud.(2012), [21]Using finite element modelling, simulation and analysis of low loader chassis is carried out and comparison of the results of the chassis was done with reinforcement and original chassis consisting of I-beams design application of 35 tons trailer. Finite element modeling (FEM), simulations and analysis was performed using a modeling software i.e. CATIA V5. Stress and displacement contour were later constructed and the maximum deflection and stress were determined by performing stress analysis. Computed results were then compared to analytical calculation, where it was found that the location of maximum deflection agrees well with theoretical approximation but varies on the magnitude aspect.

Tushar M. Patel, Dr. M. G. Bhatt, Harshad K. Patel,(2013), [22] did a study of the stress developed in chassis and deformation of chassis frame of Eicher 11.10 in Ansys and compared with mathematical calculations. The author did the study of the stresses developed in chassis and deformation of chassis frame of EICHER 11.10. The stress and deformation were calculated for the chassis frame and the finite element analysis was performed for the validation on the chassis frame model. The model of the chassis was developed in solid works 2009 and static structural analysis was done in ANSYS workbench. It was observed that the generated shear stresses were less than the permissible value so the design was considered safe.

Hemant B. Patil, Sharad D. Kachave, Eknath R. Deore,(2013), [23] performed stress analysis of ladder type low loader truck chassis with varying thickness of side member. Model used for the analysis was of Eicher 10.75. Basic calculations for the chassis frame were done by using simple bending theory and maximum values of stress and deflection were found out. In order to reduce the stress at critical points, a study was made in which five different cases were considered. Out of five cases in first three cases thickness of the side member were varied. In fourth case position of the cross member was changed and in the last case thickness of the cross member was changed. Static structural analysis was performed and results of all cases were compared with the analytical calculations. Value of maximum deflection agrees well with the theoretical value but varies on the magnitude aspect. Through the study the author concluded that changing the thickness of the cross member is better than changing the thickness of the side member.

Patel Vijaykumar V., Prof. R. I. Patel (2012), [24] focused their work towards weight reduction of chassis by performing structural analysis. Basic calculations for the chassis frame were done analytically based on the bending theory and values of stress and deflection were obtained. Finite element analysis for the existing chassis was performed for overload condition and stress and deflection values were obtained. For weight reduction design modifications were made by doing a sensitivity analysis. In sensitivity analysis section modulus and flange width were kept constant. Three cases were considered for weight reduction in which thickness and height of the flange were varied. Comparison of the results showed that out of three cases third case resulted in weight reduction of about 7% and stress and deflection values were reduced by about 12% and 11% respectively.

Sandip Godse, Prof. D. A. Patel.2013, [25]performed a static load analysis of TATA Ace Ex Chassis using ANSYS Workbench. In their work the authors performed static analysis of the existing chassis of the vehicle and found out the maximum value of stress and deflection. Author performed optimization exercise by the method of reinforcement techniques to reduce the value of stresses and increase the payload. After addition of reinforcements static analysis was performed and it was found that the stress values were reduced by about 38% thus increasing the payload of the chassis. Thus the author concludes that the modification made by optimization of the chassis through reinforcement techniques the chassis is capable of carrying loads beyond previous payload.

Dr. S. B. Rane, Harshal Shirodkar, P. Sridhar Reddy, (2013), [26]did their work in the use of optimization techniques for redesign of the forklift chassis by the use of finite element analysis. Author focused their work on the study of the optimum material distribution to get an idea of the load flow path based on which new design with higher strength to weight ratio as compared with original design could be obtained. Assembly fitment parameters/functional requirements were to be kept as it is. Methodology used by the author for structural optimization was in three phases. In first phase chassis was subjected to topology optimization to obtain optimum density plots to reduce its weight. In second phase after topology optimization, size optimization is performed to obtain the optimal thickness of all the structural members. Finally the output model is run for remaining load cases in the third phase. Author concludes how optimization techniques can be used as a tool in finite element analysis for achieving weight reduction. Through optimization techniques weight of the chassis was reduced by around 14.5 %.

Hirak Patel, Khushbu C. Panchal, Chetan S. Jadhav, (2013), [27]carried out a sensitivity analysis for weight reduction of different cross-sections of truck chassis. The important criteria for the analysis of the chassis were maximum stress, maximum equilateral stress and deflection. The author performed his work towards the optimization of the automotive chassis for which a proper finite element model of the chassis was developed in PRO-E and finite element analysis was carried out using the ANSYS Workbench. The truck chassis analysis design was done analytically and the weight optimization was done by sensitivity analysis and a 17% weight reduction was achieved.

P. K. Sharma et al. (2014), [28] performed a stress analysis study of TATA Turbo Truck SE 1613. In the study finite element analysis was used in analyzing the chassis and author also explains its importance in minimizing the number of physical tests. For analysis model of Tata truck chassis is used. Analytical calculations were done for the overload condition of the chassis and the maximum values of the deflection and shear stress were obtained. Calculations were done for main section as well as its supporting section. Analytical stress and deflection values for the chassis were compared virtually by performing finite element analysis in ANSYS software package. Results showed that analytical values of stress and deflection agreed well with finite element analysis results.

S. Prabhakaran et al. (2014) [29] focused their work towards weight reduction of chassis by performing structural analysis. Basic calculations for the chassis frame were done analytically based on the bending theory and values of stress and deflection were obtained. Finite element analysis for the existing chassis was performed for overload condition and stress and deflection values were obtained. For weight reduction design modifications were made by doing a sensitivity analysis. In sensitivity analysis section modulus and flange width were kept constant. Three cases were considered for weight reduction in which thickness and height of the flange were varied. Comparison of the results showed that out of three cases third case resulted in about 6.7% of weight reduction.

Marco Cavazzuti et al. (2015), [30] focused their study on weight reduction of the automotive chassis by using structural optimization method linked with finite element analysis. Various optimization techniques were explained. The methods were briefly introduced, and some applications were presented and discussed with the aim of showing their potential. A particular focus was given to weight reduction in automotive chassis design applications. The author provided a quick overview on structural optimization methods. Author explained how topology and topometry optimizations were more suitable for an early development stage, whose outcome could be further refined through size and shape optimizations.

2.1.2: Research gap from previous studies

Most of the previous studies focus on heavy duty vehicle and the chassis having similar geometry throughout the beam. But my study investigate the TOYOTA model (LJ150-GKMEE) the deformation and the stress value of s-glass epoxy comparing to conventional HSLA steel material subjected the same loading condition. The model I analyzed has different thickness. And when I review the different journals I didn't show the orientation of the layers of composite material analyzing in ansys software. But my study fill this gap because I intestate the stress and the deformation by using the regular orientation using six number of layer.

2.3: Green vehicle

There are two main objectives, which involves on the development of automobile chassis. Firstly, the appropriate static and dynamic characteristics of the existing chassis have to be determined. Secondly, structural development process in order to achieve high quality of the product. [13] But today the research must be become to select a material used to manufacture light weight chassis for green and light vehicle. Green vehicle technologies are a promising technology for drastically reducing the environmental burden of road transport. More than a decade ago and also more recently, they were advocated by various actors as an important element in reducing CO2 emissions of particularly passenger cars and light commercial vehicles as well as emissions of pollutants and noise. [31] By green vehicle we can reduce also the foreign currency and maximize the country economic development because the usage of fuel is reduced and the vehicle uses alternative energy such as electrical, solar energy and other sources. This will happen by reducing the weight of chassis.

2.4: Reducing the existing chassis weight.

Weight reduction is now the main issue in automobile industries. [8] One of the easiest ways to reduce chassis weight is to look at alternatives to traditional steel. Materials such as Composites, Aluminum, Magnesium, Zinc and High Strength. Therefore it often takes many years to implement lightweight technology in mainstream production vehicles. Reduction in vehicle body chassis was considered to offer the greatest opportunity for achieving near-term, cost-effective reductions in fuel consumption. Reduction in vehicle weight and size could significantly reduce fuel consumption and greenhouse gas emissions. They estimated that direct weight reductions through the substitution of lighter materials as well as basic vehicle design changes which, for example, maximize the interior volume for a given vehicle length and width enable secondary weight reductions as other vehicle components are appropriately downsized. A shift in vehicle size distribution away from larger vehicles also reduces average weight and initially can be accomplished by changes in production volumes. [32].Modern methods of chassis design focus on weight reduction by removal of the additional weight. New and innovative ways are being studied and searched for reduction in weight of the existing vehicle design complying with industrial standards.

2.5: Materials used for chassis and their property.

This review presents the current and suitable material that can used for reducing the chassis weight, hence improve automobile energy conception. The review also would help identify specific engineering materials such as glass fiber composite, aluminum, high strength steel or magnesium which are most likely to demonstrate, by applying the design, analysis and manufacturing methods developed through the project, the feasibility of achieving drastic reductions of structural weight at affordable manufacturing costs and without compromising safety and durability

- **FERROUS ALLOYS**

Ferrous alloys—those of which iron is the prime constituent—are produced in larger quantities than any other metal type. They are especially important as engineering construction materials. Their widespread use is accounted for by three factors:

(1) iron-containing compounds exist in abundant quantities within the earth’s crust;

(2) Metallic iron and steel alloys may be produced using relatively economical extraction, refining, alloying, and fabrication techniques; and

(3) Ferrous alloys are extremely versatile, in that they may be tailored to have a wide range of mechanical and physical properties. The principal disadvantage of

many ferrous alloys is their susceptibility to corrosion. This section discusses compositions, microstructures, and properties of a number of different classes of steels and cast irons. A taxonomic classification scheme for the various ferrous alloys is presented in fig 5.

- **STEELS**

Steels are iron–carbon alloys that may contain appreciable concentrations of other alloying elements; there are thousands of alloys that have different compositions and/or heat treatments. The mechanical properties are sensitive to the content of carbon, which is normally less than 1.0 wt%. Some of the more common steels are classified according to carbon concentration—namely, into low-, medium-, and high carbon types. Subclasses also exist within each group according to the concentration of other alloying elements. Plain carbon steels contain only residual concentrations of impurities other than carbon and a little manganese. For alloy steels, more alloying elements are intentionally added in specific concentrations. [33]

Table 1: Compositions of Five Plain Low-Carbon Steels and Three High-Strength, Low-Alloy Steels

Designation[a]		*Composition (wt%)[b]*		
AISI/SAE or ASTM Number	*UNS Number*	*C*	*Mn*	*Other*
		Plain Low-Carbon Steels		
1010	G10100	0.10	0.45	
1020	G10200	0.20	0.45	
A36	K02600	0.29	1.00	0.20 Cu (min)
A516 Grade 70	K02700	0.31	1.00	0.25 Si
		High-Strength, Low-Alloy Steels		
A440	K12810	0.28	1.35	0.30 Si (max), 0.20 Cu (min)
A633 Grade E	K12002	0.22	1.35	0.30 Si, 0.08 V, 0.02 N, 0.03 Nb
A656 Grade 1	K11804	0.18	1.60	0.60 Si, 0.1 V, 0.20 Al, 0.015 N

Source: Adapted from Metals Handbook: Properties and Selection: Irons and Steels, Vol. 1, 9th edition, B. Bardes (Editor),American Society for Metals, 1978, pp. 185, 407.

As a consequence, these alloys are relatively soft and weak but have outstanding ductility and toughness; in addition, they are machinable, weldable, and, of all steels, are the least expensive to produce. Typical applications include automobile body components, structural shapes (I-beams, channel and angle iron), and sheets that are used in pipelines, buildings, bridges, and tin cans. Tables 1 present the compositions and mechanical properties of several plain low-carbon steels. They typically have a yield strength of 275 MPa (40,000 psi), tensile strengths between 415 and 550 MPa (60,000 and 80,000 psi), and a ductility of 25%EL. Another group of low-carbon alloys are the high-strength, low-alloy (HSLA) steels. They contain other alloying elements such as copper, vanadium, nickel, and molybdenum in combined concentrations as high as 10 wt%, and possess higher strengths than the plain low-carbon steels. Most may be strengthened by heat treatment, giving tensile strengths in excess of 480 MPa (70,000 psi); in addition, they are ductile, formable, and machinable. Several are listed in Table 1. [33]

Table 2: Mechanical Characteristics of Hot-Rolled Material and Typical Applications for Various Plain Low-Carbon and High-Strength, Low-Alloy Steels

AISI/SAE or ASTM Number	*Tensile Strength [MPa (ksi)]*	*Yield Strength [MPa (ksi)]*	*Ductility [%EL in 50 mm (2 in.)]*	*Typical Applications*
		Plain Low-Carbon Steels		
1010	325 (47)	180 (26)	28	Automobile panels, nails, and wire
1020	380 (55)	205 (30)	25	Pipe; structural and sheet steel
A36	400 (58)	220 (32)	23	Structural (bridges and buildings)
A516 Grade 70	485 (70)	260 (38)	21	Low-temperature pressure vessels
		High-Strength, Low-Alloy Steels		
A440	435 (63)	290 (42)	21	Structures that are bolted or riveted
A633 Grade E	520 (75)	380 (55)	23	Structures used at low ambient temperatures
A656 Grade 1	655 (95)	552 (80)	15	Truck frames and railway cars

2.5.1: High Strength Steel

Steel has been the base choice of material for automobile bodies due to its strength, ductility and low cost. This has led to the development of a vast knowledge of the material and processing properties as well as methods for efficient design of steel structures [32] automotive frames are basically manufactured from steel. It is usually made of a steel frame [18] Steels in the HSLA (High Strength Low Alloy) range are hardened by a combination of precipitation and grain size refining, resulting in high strength with low alloy content. This enhances weldability and choice of coatings, since these steels exhibit neither weld zone softening nor grain coarsening. These grades are particularly suitable for structural components such as suspension systems and chassis and reinforcement parts. For their respective yield strength levels, these steels all exhibit excellent cold forming and low-temperature brittle fracture strength (starting at grade 320).The entire range of HSLA steels offers good fatigue strength (suspension arm, shock tower) and impact strength (longitudinal beams, cross members, reinforcements, etc.).Because of their mechanical strength, the weight of reinforcement and structural components can be reduced. The HSLA range of products is available in hot and cold rolled grades. The various grades are identified by their yield strength.

2.5.2: Application of HSLA steel.

The steels in the HSLA range are suitable for structural parts such as suspension systems, reinforcements, cross members, longitudinal beams, chassis components, etc. The mechanical properties of hot rolled HSLA steels and their excellent cold forming performance and low-temperature brittle fracture resistance support cost-effective solutions for many parts and sub-assemblies for which weight, thickness and size reduction are sought, such as:

- Chassis components;
- Wheels;
- Slide rails;
- Cross members.

In normal atmospheres, the HSLA steels are more resistant to corrosion than the plain carbon steels, which they have replaced in many applications where structural strength is critical (e.g., bridges, towers, support columns in high-rise buildings, and pressure vessels).

2.6: Composite Matrix Materials

There are three main types of composite matrix materials:

2.6.1: Ceramic matrix

Ceramic matrix composites (CMCs) are a subgroup of composite materials. They consist of ceramic fibers embedded in a ceramic matrix, thus forming a ceramic fiber reinforced ceramic (CFRC) material. The matrix and fibers can consist of any ceramic material. CMC materials were designed to overcome the major disadvantages such as low fracture toughness, brittleness, and limited thermal shock resistance, faced by the traditional technical ceramics.

2.6.2: Metal matrix

Metal matrix composites (MMCs) are composite materials that contain at least two constituent parts – a metal and another material or a different metal. The metal matrix is reinforced with the other material to improve strength and wear. Where three or more constituent parts are present, it is called a hybrid composite. In structural applications, the matrix is usually composed of a lighter metal such as magnesium, titanium, or aluminum. In high temperature applications, cobalt and cobalt-nickel alloy matrices are common. Typical MMC's manufacturing is basically divided into three types: solid, liquid, and vapor. Continuous carbon, silicon carbide, or ceramic fibers are some of the materials that can be embedded in a metallic matrix material. MMCs are fire resistant, operate in a wide range of temperatures, do not absorb moisture, and possess better electrical and thermal conductivity. They have also found applications to be resistant to radiation damage, and to not suffer from outgassing. Most metals and alloys make good matrices for composite applications.

2.6.3: Polymer matrix

Polymer matrix composites (PMCs) can be divided into three sub-types, namely, thermoset, thermoplastic, and rubber. Polymer is a large molecule composed of repeating structural units connected by covalent chemical bonds. PMC's consist of a polymer matrix combined with a fibrous reinforcing dispersed phase. They are cheaper with easier fabrication methods. PMC's are less dense than metals or ceramics, can resist atmospheric and other forms of corrosion, and exhibit superior resistance to the conduction of electrical current.

A composite material is made by combining two or more materials – often ones that have very different properties. The two materials work together to give the composite unique properties. However, within the composite you can easily tell the different materials apart as they do not dissolve or blend into each other.

Natural composites exist in both animals and plants. Wood is a composite – it is made from long cellulose fibers (a polymer) held together by a much weaker substance called lignin. Cellulose is also found in cotton, but without the lignin to bind it together it is much weaker. The two weak substances – lignin and cellulose – together form a much stronger one.

Most composites are made of just two materials. One is the matrix or binder. It surrounds and binds together fibers or fragments of the other material, which is called the reinforcement.

The first modern composite material was fiberglass. It is still widely used today for boat hulls, sports equipment, building panels and many car bodies. The matrix is a plastic and the reinforcement is glass that has been made into fine threads and often woven into a sort of cloth. On its own the glass is very strong but brittle and it will break if bent sharply. The plastic matrix holds the glass fibers together and also protects them from damage by sharing out the forces acting on them.

Some advanced composites are now made using carbon fibers instead of glass. These materials are lighter and stronger than fiberglass but more expensive to produce. They are used in aircraft structures and expensive sports equipment such as golf clubs.

Carbon nanotubes have also been used successfully to make new composites. These are even lighter and stronger than composites made with ordinary carbon fibers but they are still extremely expensive. They do, however, offer possibilities for making lighter cars and aircraft (which will use less fuel than the heavier vehicles we have now).

The new Airbus A380, the world's largest passenger airliner, makes use of modern composites in its design. More than 20 % of the A380 is made of composite materials, mainly plastic reinforced with carbon fibers. The design is the first large-scale use of glass-fiber-reinforced aluminum, a new composite that is 25 % stronger than conventional airframe aluminum but 20 % lighter. The biggest advantage of modern composite materials is that they are light as well as strong. By choosing an appropriate combination of matrix and reinforcement material, a new material can be made that exactly meets the requirements of a particular application. Composites also provide design flexibility because many of them can be molded into complex shapes. The downside is often the cost. Although the resulting product is more efficient, the raw materials are often expensive. [34]

2.6.4: Fiber reinforced polymer (frp)

Continuous fiber-reinforced materials with polymeric matrix (FRP) can be considered as composite, heterogeneous, and anisotropic materials with a prevalent linear elastic behavior up to failure. Fiber reinforced polymer (FRP) is a composite material made by combining two or more materials to give a new combination of properties. However, FRP is different from other composites in that its constituent materials are different at the molecular level and are mechanically separable. The mechanical and physical properties of FRP are controlled by its constituent properties and by structural configurations at micro level. Therefore, the design and analysis of any FRP structural member requires a good knowledge of the material properties, which are dependent on the manufacturing process and the properties of constituent materials. [35] Automotive frames are basically manufactured from steel.

It is usually made of a steel frame, which holds the body and engine of an automotive vehicle. It provides needed for supporting vehicular components and payload placed upon it. At the time of manufacturing, the body of a vehicle is flexibly molded according to the structure of chassis. It provides strength needed for supporting vehicular components and payload placed upon it. Automobile chassis is usually made of light sheet metal or composite plastics this paper describes the design and analysis of heavy vehicle chassis considering weight reduction as the prime objective of any automobile industries in today's fast changing world. [18]

Figure 5: Formation of Fiber Reinforced Polymer Composite

Fiber: A fiber is a material made into a long filament with a diameter generally in the order of 10 tm. The aspect ratio of length and diameter can be ranging from thousand to infinity in continuous fibers. The main functions of the fibers are to carry the load and provide stiffness, strength, thermal stability, and other structural properties in the FRP. [35]

To perform these desirable functions, the fibers in FRP composite must have:

I. high modulus of elasticity for use as reinforcement;
II. high ultimate strength
III. low variation of strength among fibers;
IV. high stability of their strength during handling; and
V. High uniformity of diameter and surface dimension among fibers.

Types of fibers used in fiber reinforced polymer composites:

1) Glass fibers
2) Carbon fibers
3) Aramid fibers

2.6.5: Glass fibers:

These are fibers commonly used in the automobile, naval and industrial fields to produce composites of medium-high performance. Their peculiar characteristic is their high strength. Glass is mainly made of silicon (SiO_2) with a tetrahedral structure (SiO_4). Some aluminum oxides and other metallic ions are then added in various proportions to either ease the working operations or modify some properties (e.g., S-glass fibers exhibit a higher tensile strength than E-glass).The production technology of fiberglass is essentially based on spinning a batch made of sand, alumina, and limestone. The constituents are dry mixed and brought to melting (about 1260 °C) in a tank. The melted glass is carried directly on platinum bushings and, by gravity, passes through ad hoc holes located on the bottom. The filaments are then grouped to form a strand typically made of 204 filaments. The single filament has an average diameter of 10 µm and is typically covered with a sizing. The yarns are then bundled, in most cases without twisting, in a roving. [35] An individual structural glass fiber is both stiff and strong in tension and compression that is, along its axis. Although it might be assumed that the fiber is weak in compression, it is actually only the long aspect ratio of the fiber which makes it seem so i.e., because a typical fiber is long and narrow, it buckles easily. On the other hand, the glass fiber is weak in shear that is, across its axis. Therefore if a collection of fibers can be arranged permanently in a preferred direction within a material, and if the fibers can be prevented from buckling in compression, then that material will become preferentially strong in that direction. [8]

Table 3: Typical composition of fiberglass (% in weight)

	E-glass	S-glass
Silicon oxide	54.3	64.20
Aluminium oxide	15.2	24.80
Iron oxide	-	0.21
Calcium oxide	17.2	0.01
Magnesium oxide	4.7	10.27
Sodium oxide	0.6	0.27
Boron oxide	8.0	0.01
Barium oxide	-	0.20
Various	-	0.03

Table 4: properties of different fibers

Material	Density (g/cm^3)	Tensile Modulus (E) (GPa)	Tensile Strength (σ) (GPa)	Specific Modulus (E/σ)	Specific Strength	Relative Cost
E-glass	2.54	70	3.45	27	1.35	Low
S-glass	2.50	86	4.50	34.5	1.8	Moderate
Graphite, high modulus	1.9	400	1.8	200	0.9	High
Graphite, high strength	1.7	240	2.6	140	1.5	High
Boron	2.6	400	3.5	155	1.3	High
Kevlar 29	1.45	80	2.8	55.5	1.9	Moderate
Kevlar 49	1.45	130	2.8	89.5	1.9	Moderate

Glass fibers typically have a Young modulus of elasticity (70 GPA for E-glass) lower than carbon or aramid fibers and their abrasion resistance is relatively poor; therefore, caution in their manipulation is required. In addition, they are prone to creep and have low fatigue strength. To enhance the bond between fibers and matrix, as well as to protect the fibers itself against alkaline agents and moisture, fibers undergo sizing treatments acting as coupling agents. Such treatments are useful to enhance durability and fatigue performance (static and dynamic) of the composite material. FRP composites based on fiberglass are usually denoted as GFRP. [35]


Discontinuous fibers.


Discontinuous fibers *mat*.

Figure 6: Discontinuous Glass Fibers

The manufacturing process for glass fibers suitable for reinforcement uses large furnaces to gradually melt the silica sand, limestone, kaolin clay, fluorspar, colemanite, dolomite and other minerals to liquid form. Then it is extruded through bushings, which are bundles of very small orifices (typically 5–25 micrometers in diameter for E-Glass, 9 micrometers for S-Glass). These filaments are then sized (coated) with a chemical solution. Common uses of S-glass include high performance aircraft (gliders), boats, automobiles, baths, hot tubs, septic tanks, water tanks, roofing, pipes, cladding, casts, surfboards and external door skins. [8]

2.6.6: Carbon/ Epoxy

Carbon-Fiber-Reinforced Polymer, Carbon-Fiber-Reinforced Plastic or Carbon-Fiber- Reinforced Thermo Plastic (CFRP, CRP, CFRTP or often simply carbon fiber, or even carbon) is an extremely strong and light Fiber-Reinforced Polymer which contains carbon fibers. The binding polymer is often a thermo set resin such as epoxy, but other thermoset or thermoplastic polymers, such as polyester, vinyl ester or nylon, are sometimes used. The composite may contain other fibers, such as aramid e.g. Kevlar, Twaron, Aluminum or Glass fibers as well as Carbon fiber. The properties of the final CFRP product can also be affected by the type of additives introduced to the binding matrix (the resin). The most frequent additive is silica, but other additives such as rubber and carbon nanotubes can be used. CFRPs are commonly used in the transportation industry; normally in cars, boats and trains, and in sporting goods industry for manufacture of bicycles, bicycle components, golfing equipment and fishing rods. Although carbon fiber can be relatively expensive, it has many applications in aerospace and automotive fields, such as Formula One racing and wherever high strength-to-weight ratio and rigidity are required such as sailing boats and rowing shell hulls, top-end bicycles and motorcycles, As manufacturing techniques improve and costs reduce it is becoming increasingly common in small consumer goods that require strength, lightness and stiffness such as laptop bodies, tripod legs, tent poles, fishing rods, hockey sticks, bows and arrows, racquet frames, stringed instrument bodies, drum shells, golf clubs, crash helmets and billiards cues. [8] They have lower thermal expansion coefficients than both the glass and aramid fibers. The carbon fiber is an anisotropic material, and its transverse modulus is an order of magnitude less than its longitudinal modulus. The material has a very high fatigue and creep resistance. Since its tensile strength decreases with increasing modulus, its strain at rupture will also are much lower. Because of the material brittleness at higher modulus, it becomes critical in joint and connection details, which can have high stress concentrations. As a result of this phenomenon, carbon composite laminates are more effective with adhesive bonding that eliminates mechanical fastened. [35]

Table 5: Typical properties of carbon fibers

Typical Properties	Density (g/cm^3)	Young's Modulus (GPa)	Tensile Strength (GPa)	Tensile Elongation (%)
High Strength	1.8	230	2.48	1.1
High Modulus	1.9	370	1.79	0.5
Ultra-High Modulus	2.0 - 2.1	520 – 620	1.03 - 1.31	0.2

2.6.7: Kevlar fibers

Kevlar (poly-paraphenylene terephthalamide) is the DuPont Company's brand name for a synthetic material constructed of para-aramid fibers that the company claims is five times stronger than the same weight of steel, while being lightweight, flexible and comfortable. It is also very heat resistant and decomposes above 400 °C without melting. It was invented by Stephanie Kwolek of DuPont from research into high performance polymers, and patented by her in 1966 and first marketed in 1971. Kevlar is a registered trademark of E.I. du Pont de Nemours and Company. Kevlar fibers can be bonded to one another or to other materials to form a composite. Kevlar's main weaknesses are that it decomposes under alkaline conditions or when exposed to chlorine. While it can have a great tensile strength, sometimes in excess of 4.0 GPA, like all fibers it tends to buckle in compression. [35]

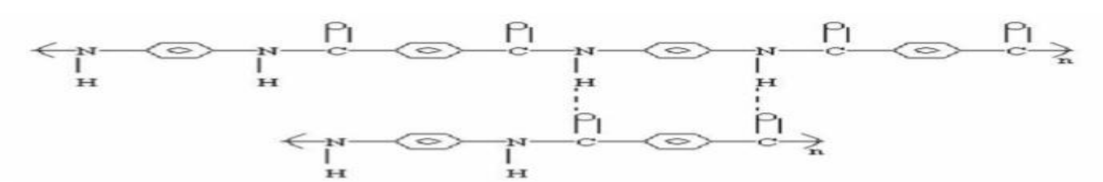


Figure 7: Structure of aramid fiber

2.7: Stresses developed in chassis Frame

It is a physical quantity that expresses the internal forces that neighboring particles of a continuous material exert on each other. For example, when a solid vertical bar is supporting a weight, each particle in the bar pulls on the particles immediately above and below it. These macroscopic forces are actually the average of a very large number of intermolecular forces and collisions between the particles in those molecules. There are many types of stresses developed in a component. The frame is analyzed by considering Equivalent stress and normal stress. [8]

2.7.1: Normal stress

The component of stress which is perpendicular to the plane on which the force is applied is called Normal stress. This stress is also called as principle stress. Its value should not exceed the yield strength of the material. In some of the situations design is considered to be safe if its value is less than the yield strength of the material. [8]

2.7.2: Equivalent stress

When an elastic body is subjected to loads in its three dimensions, the stresses will get developed along the principle axis of the body stresses. These stresses should not exceed the yield stress of the material. Von Mises postulated that, even though none of the principal stresses exceeds the yield stress of the material, it is possible for yielding of the same from the combination of stresses. So that all these stresses in three dimensions are together called as Equivalent stress. Von Mises stress is considered to be a safe haven for design engineers. Using this information an engineer can say his design will fail, if the maximum value of Von Mises stress induced in the material is more than strength of the material. It works well for most of the cases, especially when the material is ductile in nature. [8]

2.7.3: Deformation

When an object is subjected to loading its shape may be changed temporarily or permanently due to applied force. This change in shape is called deformation. If the object deforms permanently it is called plastic deformation or failure. If it deforms temporarily it is called elastic deformation. While analyzing a frame the frame should deform elastically within the maximum loading limit so that the design is safe. [8]

CHAPTER THREE

ANALYTICAL METHOD AND CONDITION

3.1: The design process

Design may be done in two ways one way is the component design which is done by improving the existing ones. The other is conceptual design where there is no reference and creation of new machines. A new or better machine is one which is more economical in the overall cost of production and operation. The process of design is a long and time consuming one. From the study of existing ideas, a new idea has to be conceived. The idea is then studied keeping in mind its commercial success and given shape and form in the form of drawings. In the preparation of these drawings, care must be taken about the availability of resources like money, man power and materials required for the successful completion of the new idea into an actual reality. In designing a machine component, it is necessary to have a good knowledge of many subjects such as Mathematics, Engineering Mechanics, Strength of Materials, Theory of Machines, Workshop Processes and Engineering Drawing. Generally the design of a component involves various steps in it. Initially, the drawings must be drawn in user friendly software and they must be converted into a 3D model. This 3D model must be imported into an analyzing medium where it is structurally or thermally analyzed to sustain the need.

Different steps involved in designing a component are

1. Part drawing

2. Modeling

3. Structural analysis

Structurally analyzed by using software and its procedure is explained as below.

The engineering design process is the steps of chassis design construction process. This process applied the basic science, mathematics and fundamental of engineering required in the thesis. The design process begins when all the analysis related to the thesis is done. This chapter explains how chassis were designed and how the simulations of the chassis were performed.

The solution for the problem is performed in three stages - Theoretical Analysis, Creating a Solid Model, Finite Element Analysis.

3.1.1: Theoretical Analysis

Theoretical Analysis is performed by using the basic concepts of Strength of Materials. The Chassis Ladder of this problem is considered as an overhanging beam with roller supports corresponding to front and rear wheels. Total load acting on the Chassis is taken as a sum of capacity of the chassis and weight of the body and engine. This total load is considered as uniformly distributed load acting throughout the span of the beam. Reaction forces, Shear forces and bending moment are calculated based on the total load.

Table 6: Specification of the existing chassis material

Property	**HSLA steel**
Mass density(kg/m3)	7850
Yield strength(MPa)	552
Ultimate tensile strength(MPa)	630
Poisons ratio	0.3
Shear Modulus(GPa)	76.9
Young's Modulus(GPa)	200

3.2: Design calculation and Static Analysis of Chassis Frame

Here in static analysis a typical ladder frame chassis is considered. The different load considerations are taken for analysis. The chassis is designed analytically by varying materials in rectangular cross section of beam.

There is different kind of cross section in automobile chassis. There are:-

- Rectangular Section
- Square Section
- Tube Section

According to my literature rectangular cross section is essential for light automobile comparing to others type because of its strength and stiffness.

During static condition the chassis frame is only subjected to bending loads due to the weight of the members over here. By considering the equation of bending the cross sections are decided. Then the same cross sections are analyzed by using FEM

Let us consider the condition for designing the chassis

Material and geometry of TOYOTA model code (LJ15OR-GKMEE) automobile

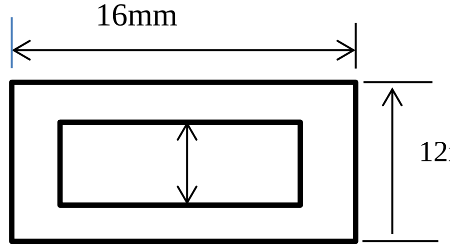


Figure 8: Side bar of the chassis are made from rectangular cross section.

Front over hang (a)……………………………………………………..…...660mm

Rear overhang(c)………………………………………………………….1000mm

Wheel base (b)…………………………………………………………….3000mm

Modulus of elasticity………………………………………………………$200GPA$

Poisons ratio ……………………………………………………………….0.3

Capacity of truck……………………………………………………..…350kg=3433.5N

Capacity of truck with 1.25%...437.5kg=4292N

Weight of the body and the engine………………………………..…2700kg=26487N

Total load acting on chassis

= Capacity of truck+ Weight of the body and the engine

= 4292N+26487N

=30779N

Chassis has two beams. So load acting on each beam is half of the Total load acting on the chassis. Load acting on the single frame.

=30779N/2

=15389.5NThe

The term beam has a very specific meaning in engineering mechanics: it is a component that is designed to support transverse loads, that is, loads that act perpendicular to the longitudinal axis of the beam, figure below. The beam supports the load by bending only. Other mechanisms, for example twisting of the beam, are not allowed for in this theory.

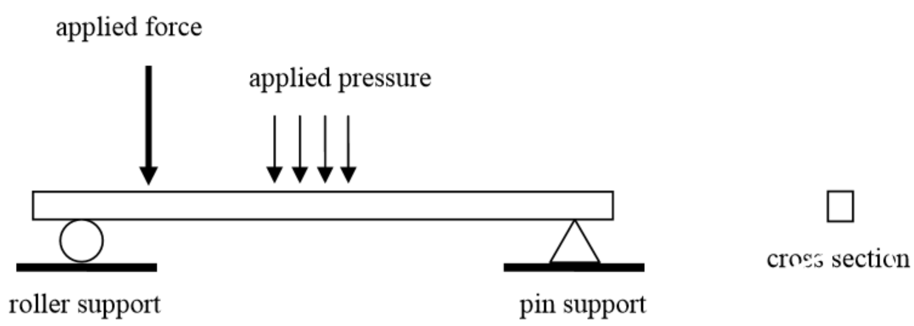
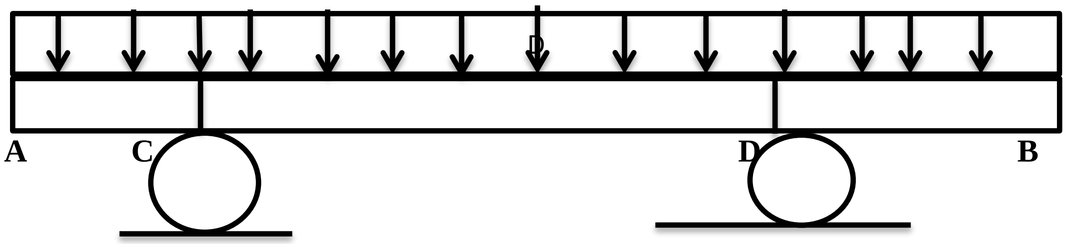


Figure 9: A supported beam loaded by a force and a distribution of pressure

Figure 10: The existing chassis model of TOYOTA (LJ150R-GKMEE)

3.2.1: Calculation for Reaction

Chassis is like beam. Beam is simply clamp with shock absorber and leaf spring. So, beam considered as a simply supported beam supported at C and D with uniform distribute load.



Load acting on the entire span of the beam……………………………= 15389.5N

Length of the beam ……………………………………………....= 4660mm

Uniformly Distributed Load……………………………………..=15389.5/4460 $=3.45\frac{N}{mm}$

For getting the load at reaction C and D, taking the moment about C and we get the reaction load generate at the support D. Calculation of the moment are as under.

Moment about C

$(3.45 \times 3000 \times 3000/2)$ =$(3.45 \times 3000 \times \frac{3000}{2})$-$(R_D \times 3000) + (3.45 \times 1000 \times 3500)$

$$R_D = 8949.53N$$

Total load acting on the beam $=3.45 \times 4660$

$$R_C + R_D = 15389.5\text{N}$$

$$R_C = 6439.97N$$

3.2.2: Calculation of shear force and bending moment:

Shear force calculation $F_A = 0N$

$$F_C = (-3.45 \times 660) + R_C$$

$$= 4162.7N$$

$$F_D = (-3.45 \times 3330) + R_D + R_C$$

$$= 3901N$$

$$F_B = 0N$$

Bending moment calculations:

$$M_A = 0Nmm$$

$$M_C = \left(-3.45 \times 660 \times \frac{660}{2}\right)$$

$$= -751410mm$$

$$M_D = \left[-3.45 \times 3660 \times \frac{3660}{2}\right] + (6439.97 \times$$

$$3000)$$

$$= -3787500Nmm$$

$$M_B = 0Nmm$$

Bending Stress Calculations

Moment of inertia about x-x axis: $I = \frac{bh^3}{12} - \frac{b_1 h_1^3}{12}$

$$= \frac{160 \times 120^3}{12} - \frac{100 \times 60^3}{12}$$

$$= 21240000mm^4$$

Basic bending equation is given by; $\frac{M}{I} = \frac{\sigma}{Y} = \frac{E}{R}$

Maximum bending moment acting on the beam=

$$M_{max} = 3787500Nmm$$

Bending stress acting on the beam $\sigma = \frac{MY}{I}$

$$10.67Mpa$$

Shear Stress Calculation **Assume angle of twist=1^0**

$$=\mathbf{1^0} \times \frac{\boldsymbol{\pi}}{\mathbf{180}}$$

=0.017452 rad

By considering the whole system as a one rotational body and as per following data when in twist from its support.

Width of the chassis =1200mm

Length of chassis =4660mm

Distance between two reactions=3000mm

Modulus of rigidity for HSLA steel. =76.9Gpa

Now basic rule for Twisting Moment is:=

$$=\frac{T}{J}=\frac{\tau}{r}=\frac{G\theta}{L}$$

Shear stress $\tau = 17.27Mpa$

According to Von Mises Stress Theory, ***Von Mises Stress*** $=\sqrt{\sigma^2 + 3\tau^3}$

=310.75Mpa

Principal Stresses:-$\sigma_{1\prime 2} = \frac{1}{2}[(\sigma_x + \sigma_y) \pm \sqrt{(\sigma_x + \sigma_y)^2 + 4\tau_{xy}{}^2}]$

Where σ 1 and σ 2 are the major & minor Principle Stresses respectively

Maximum Shear Stress $\tau_{max}= \frac{\sigma_1 - \sigma_2}{2}$

=155Mpa

Deflection of Chassis =

$$= \frac{W\times(b-x)}{24EI}[x(b-x) + b^2 - 2(c^2 + a^2) - \frac{2}{b}[xc^2 + a^2(b-x)]]$$

≈6.52mm

Where W= Weight of Chassis

= 30779N

a, b and c are the front overhang, wheel base and rear overhang respectively.

x = Total length/2

3.3: Creating a Solid Model

It is the process of developing a mathematical representation of any three-dimensional surface of object via specialized software. The product is called a 3D model

A Three Dimensional solid Toyota model of Ladder chassis is created on the computer using CATIA. This 3D Model is exported to Ansys for performing Finite Element Analysis.

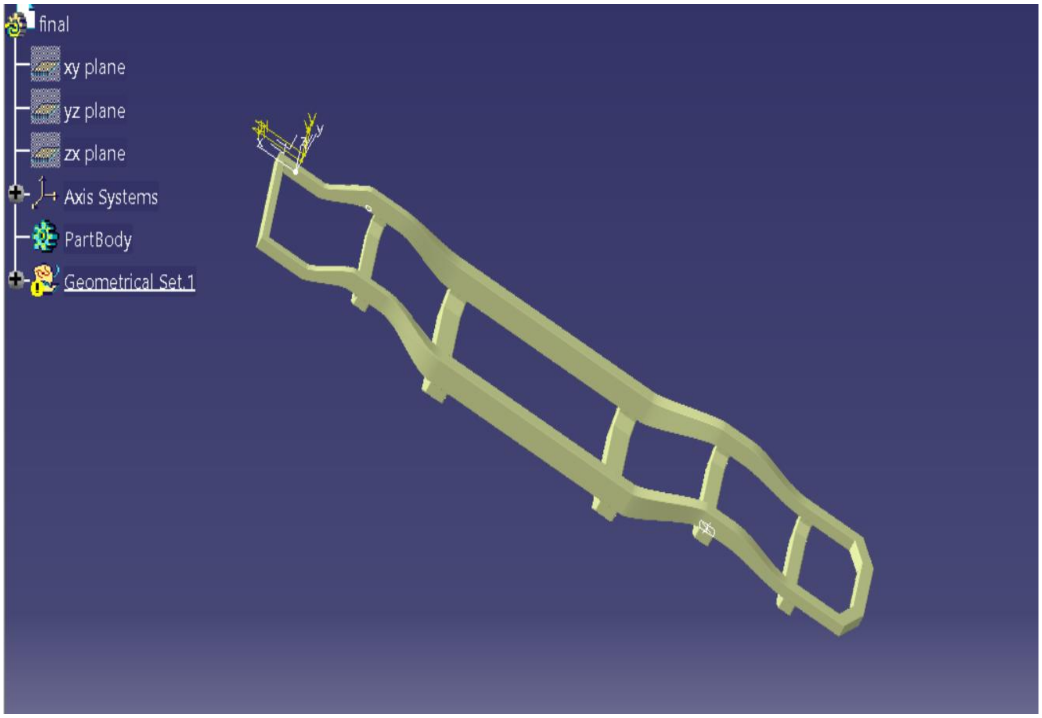


Figure 11: Design of chassis frame using catia

3.4: Structural Analysis

It is the methodology of determining the effects of loads on physical structures and their components. Structures subject to this type of analysis include buildings, bridges, vehicles, machinery, furniture, attire, soil strata, prostheses and biological tissue. Structural analysis incorporates the fields of applied mechanics, materials science and applied mathematics to compute a structure's deformations, internal forces, stresses, support reactions, accelerations, and stability. The results of the analysis are used to verify a structure's fitness for use, often saving physical tests. Structural Analysis is thus a key part of the engineering design of structures. The present frame model is converted into IGES format and it is then imported to ANSYS Workbench 18.2.

There are various steps that are to be followed in analyzing a component structurally. They are:-

1. Mesh generation
2. Fixed supports
3. Application of loads
4. Evaluating result

3.4.1: Finite Element Analysis

In this step there are three main steps, namely: pre-processing, solution and post processing. In pre-processing (model definition) includes: define the geometric domain of the problem, the element type(s) to be used, the material properties of the elements, the geometric properties of the elements (length, area, and the like), the element connectivity (mesh the model), the physical constraints (boundary conditions) and the loadings.

In solution phase, the governing algebraic equations in matrix form are assembled and the unknown values of the primary field variable(s) are computed. The computed results are then used by back substitution to determine additional, derived variables, such as reaction forces, element stresses and heat flow. Actually, the features in this step such as matrix manipulation, numerical integration and equation solving are carried out automatically by commercial software. In post processing, the analysis and evaluation of the result is conducted in this step.

3.4.2: Finite element analysis of chassis using ansys workbench

The model of chassis is saved in IGES format which can be directly imported into ANSYS workbench. The model imported to Ansys workbench is shown below.

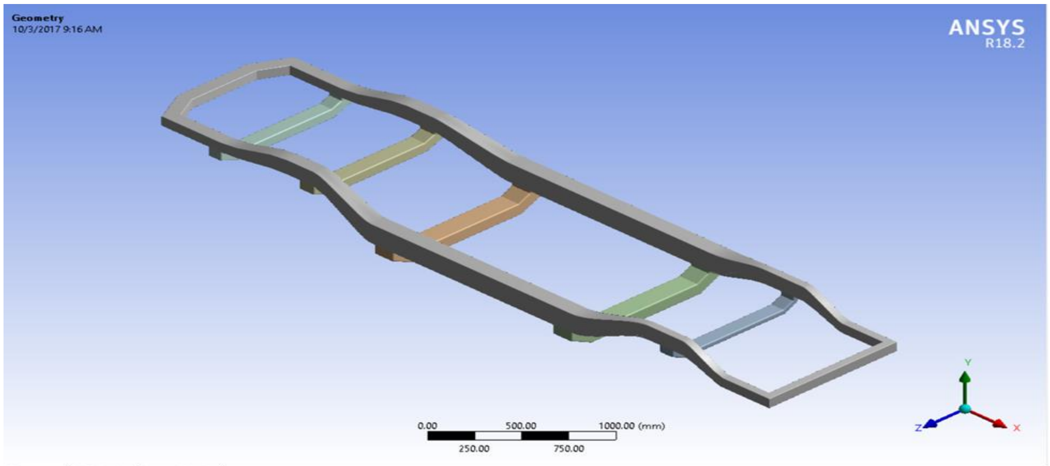


Figure 12: Imported Model in Ansys Workbench

3.4.3: Meshing and Boundary Conditions

The meshing is done on the model with 291662 number of nodes and 298211 numbers of elements. The Toyota chassis model is loaded by static forces from the truck body and load. For this model, the maximum loaded weight is 2700 kg. The load is assumed as a uniform distributed obtained from the maximum loaded weight divided by the total length of chassis frame. The finite element model of the chassis, applied with boundary conditions is shown in figure below. ANSYS Meshing provides a scalable solution. Quick automatic hex or hex-dominant mesh can be generated for optimal solution efficiency and accuracy.

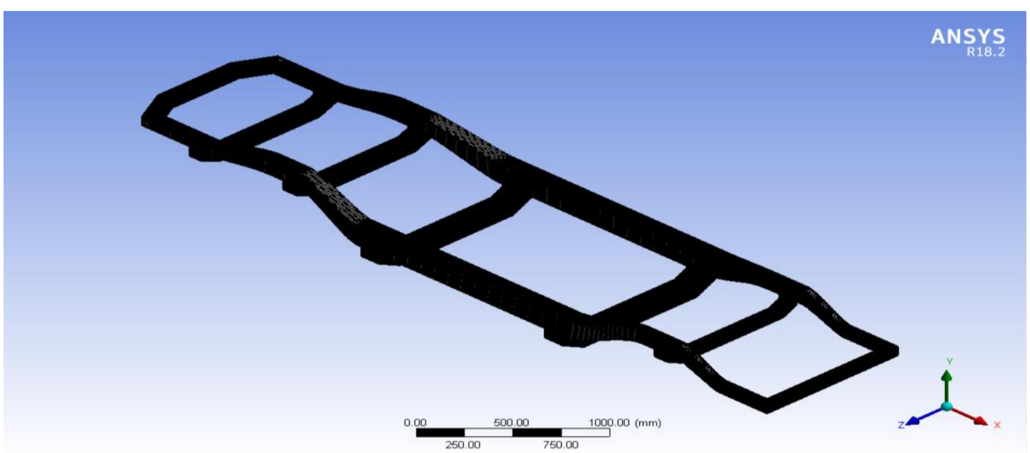


Figure 13: Isometric View of CHASIS after Meshing

3.4.5: Fixed Supports

The fixed supports for the frame are placed at the wheel positions. The total number of supports is four. The first support is placed at 1000 mm from the front end the second support is placed at 660 mm from the rear side. The other two supports are placed at same positions on the other side.

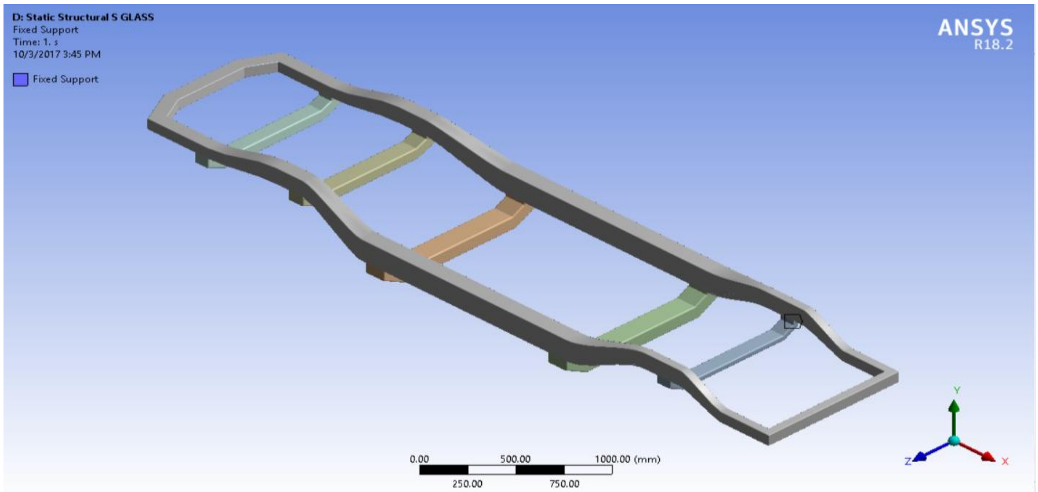


Figure 14: Fixed supports at Front and Rear wheel positions

3.4.6: Application of Loads

The load application is the major part in the analysis of a component. There may be different types of loads like Uniformly Distributed Load, Uniformly Varying Load and Point Load. The present frame carries the UDL throughout its length. From the vehicle specifications

Total pressure applied=30779N

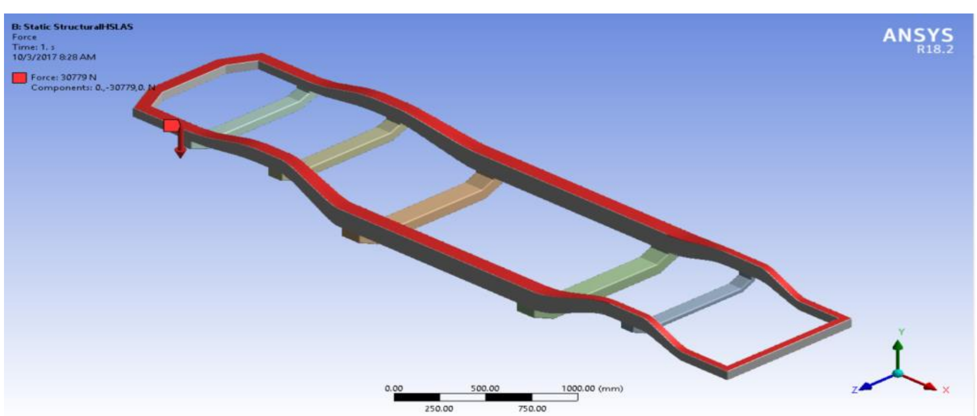


Figure 15: Area on which Pressure is applied on chassis

3.4.7: Mass of Frame

The mass of an object is a fundamental property of the object, a numerical measure of its inertia, a fundamental measure of the amount of matter in the object.

Mathematical equation for mass is

$$\text{Mass} = \text{Volume} \times \text{Density}$$

$$= 0.0194 \times 7800 \frac{kg}{m^3}$$

$$= 153.66 \text{ kg}$$

3.5: Finite element result of HSLA steel

3.5.1: Deformation of HSLA steel.

The values of deformation obtained in ANSYS 18.2 for structural steel are as shown in fig below is:-

Maximum deformation =3.05mm

Minimum deformation =0.29mm

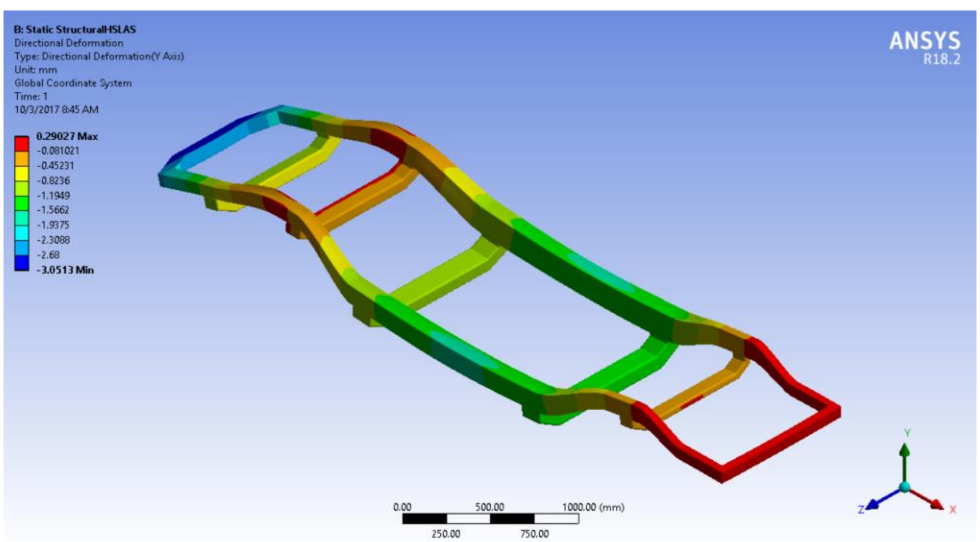


Figure 16: Total deformations of HSLA steel chassis

3.5.2: Equivalent stress

The Equivalent stress distribution in the frame for structural steel is as shown in Fig. 3.11. From Fig. 3.11 it can be inferred that

Maximum Equivalent stress = 260MPa (Approx.)

Minimum Equivalent stress = 0 MPa

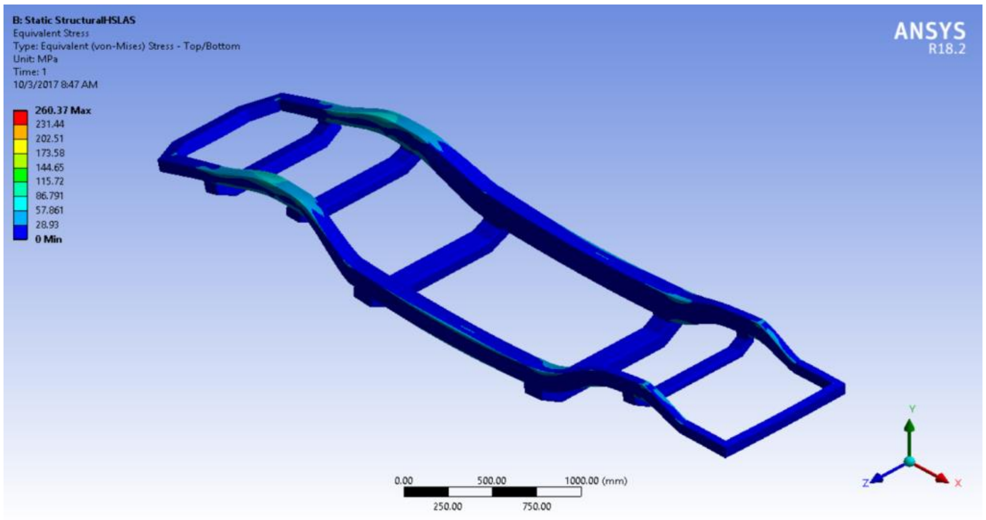


Figure 17: Von Mises Stress Distribution or equivalent stress of HSLA steel

3.5.3 Normal stress of HSLA steel.

The normal stress distribution in the frame for structural steel is as shown in Fig... From the Fig.18 it can be inferred that

Maximum normal stress = 277.93 Mpa

Minimum normal stress = - 20.866Mpa

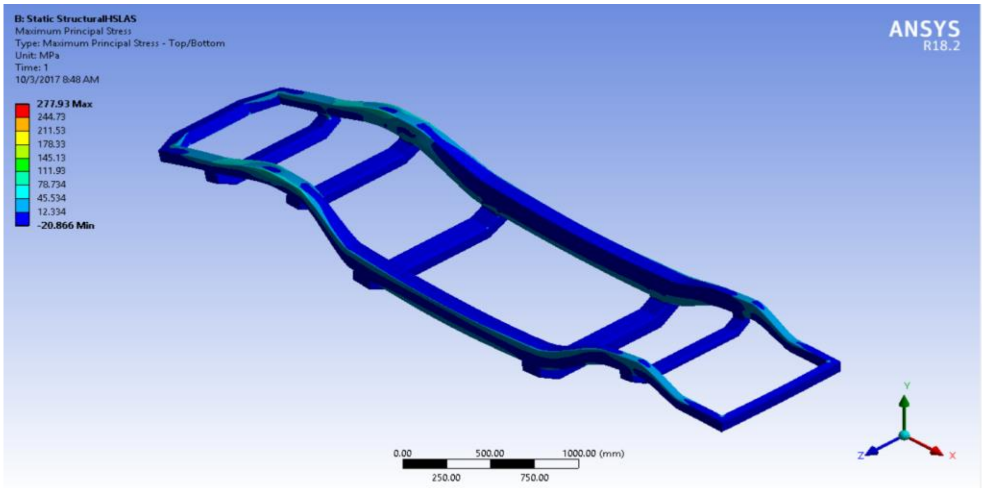


Figure 18: Maximum principal stress of HSLA steel.

3.5.4: Maximum Shear stress of HSLA steel

Maximum shear stress =141.3Mpa

Minimum shear stress =0Mpa

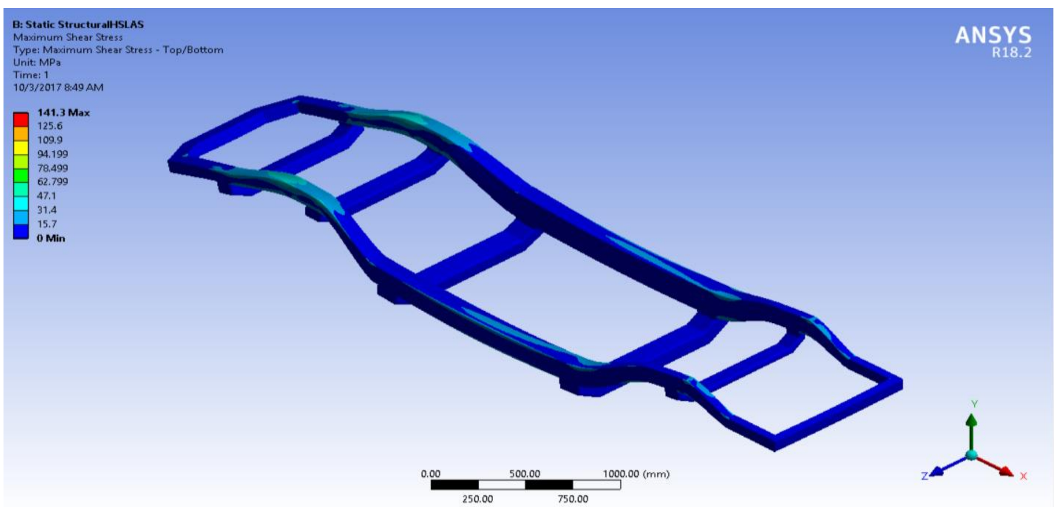


Figure 19: Maximum shear stress of HSLA steel.

3.6 Finite element result of s-glass epoxy composite material

3.6.1 Engineering constants of s-glass unidirectional composite lamina

Unlike isotropic materials that have similar properties in all directions, a uniax- ial lamina is orthotropic, with distinct properties along the fiber, transverse, and through-the-thickness directions, as seen in Figure 20. Isotropic materials have only two independent engineering constants, which are Young's modulus of elastic- ity (E) and Poisson's ratio (ν). Conversely, orthotropic laminas have nine distinct engineering parameters, including three Young's moduli along the three principal materials directions (E 1 , E 2 , E 3), three independent Poisson's ratios (ν 12 , ν 13 , ν 23), and three shear moduli (G 12 , G 13 , G 23). The generalized 3-D compliance relationship of an orthotropic sheet is [36]

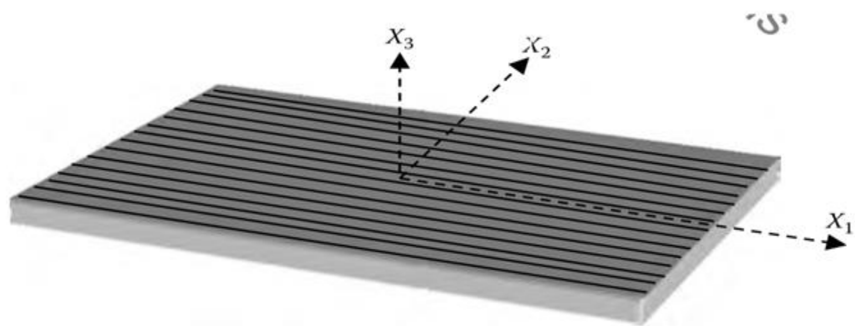


Figure 20: FRP lamina with the principal material directions

$$\begin{Bmatrix} \varepsilon_{11} \\ \varepsilon_{22} \\ \varepsilon_{33} \\ \circ_{12} \\ \circ_{13} \\ \circ_{23} \end{Bmatrix} = \begin{bmatrix} \frac{1}{E1} & -\frac{v21}{E2} & -\frac{v31}{E3} & 0 & 0 & 0 \\ -\frac{v21}{E1} & \frac{1}{E2} & -\frac{v32}{E3} & 0 & 0 & 0 \\ \frac{-v13}{E1} & \frac{-v23}{E2} & \frac{1}{E3} & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{1}{G12} & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{1}{G13} & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{1}{G23} \end{bmatrix} \begin{Bmatrix} \sigma_{11} \\ \sigma_{22} \\ \sigma_{33} \\ 12 \\ 13 \\ 23 \end{Bmatrix}$$

Where $\frac{v_{ij}}{E_i} = \frac{v_{ji}}{E_J}$ The stiffness matrix is obtained by inverting the compliance matrix in (eq.3.1) (Rasheed 1996)

$$\begin{Bmatrix}\sigma_{11}\\ \sigma_{22}\\ \sigma_{33}\\ \circ_{12}\\ \circ_{13}\\ \circ_{23}\end{Bmatrix} = \begin{bmatrix} \frac{1-v23v32}{\Delta}E1 & \frac{v21+v31v23}{\Delta}E1 & \frac{v31+v21v3}{\Delta}E1 & 0 & 0 & 0\\ \frac{v21+v31v23}{\Delta}E1 & \frac{1-v13v31}{\Delta}E2 & \frac{v32+v12v31E2}{\Delta} & 0 & 0 & 0\\ \frac{v31+v21v32}{\Delta}E1 & \frac{v32+v12v31}{\Delta}E2 & \frac{1-v21v12}{\Delta}E3 & 0 & 0 & 0\\ 0 & 0 & 0 & G12 & 0 & 0\\ 0 & 0 & 0 & 0 & G13 & 0\\ 0 & 0 & 0 & 0 & 0 & G23 \end{bmatrix} \begin{Bmatrix} 11\\ 22\\ 33\\ \gamma_{12}\\ \gamma_{13}\\ \gamma_{23}\end{Bmatrix} \quad \textbf{Eq. 3.1.}$$

where $\Delta = 1 - \nu_{12}\nu_{21} - \nu_{23}\nu_{32} - \nu_{13}\nu_{31} - 2\nu_{21}\nu_{32}\nu_{13}$.

Eq .3.2.

If the compliance matrix in Equation (3.1) is reduced to 2-D behavior (sheet analysis), the stress components σ33 = τ13 = τ23 = 0. The third, fifth, and sixth rows and columns are removed, yielding. [36]

$$\begin{Bmatrix}\varepsilon_{11}\\ \varepsilon_{22}\\ \circ_{12}\end{Bmatrix} = \begin{bmatrix} \frac{1}{E_1} & -\frac{\nu_{21}}{E_2} & 0\\ -\frac{\nu_{12}}{E_1} & \frac{1}{E_2} & 0\\ 0 & 0 & \frac{1}{G_{12}} \end{bmatrix} \begin{Bmatrix}\sigma_{11}\\ \sigma_{22}\\ 12\end{Bmatrix}$$

Eq .3.3

The 2-D compliance matrix in Equation (3.3) may be inverted to yield the 2-D stiffness matrix (Jones 1975),

$$\begin{Bmatrix}\sigma_{11}\\ \sigma_{22}\\ \circ_{12}\end{Bmatrix} = \begin{bmatrix} \frac{E1}{1-v12v21} & \frac{v12E2}{1-v12v21} & 0\\ \frac{v21E1}{1-v12v21} & \frac{E2}{1-v12v21} & 0\\ 0 & 0 & G12 \end{bmatrix} \begin{Bmatrix}\epsilon_{11}\\ \epsilon_{22}\\ 12\end{Bmatrix} \qquad \text{Eq. 3.4.}$$

3.6.2 S-glass epoxy composite sheet engineering constants from constituent properties

Using the mechanics-of-materials approach requires certain simplifying assumptions in order to derive the mechanical properties of a unidirectional composite sheet. The accuracy of the estimated property depends on the accuracy of the assumption made.

- Determination of $\boldsymbol{E_1}$

The first modulus along the fiber direction may be determined by the rule of mix tures that results from the assumption of having the fiber and the matrix deform in equal amounts along the fiber direction (Jones 1975). This assumption is known to be very accurate, leading to an accurate estimation of the apparent Young's modulus,

$$E_1 = E_f V_f + E_m V_m$$

Where E_f is the fiber modulus, V_f is the fiber volume fraction, E_m is the matrix modulus, and $V_m = 1 - V_f$ [36]

- Determination of E_2

The second modulus along the transverse direction is not as straightforward to derive. One simplifying assumption can be made considering the same transverse stress σ_2 in the fiber and the matrix, leading to the following mechanics-of-materials expression, which is known to yield a lower bound value of the apparent Young's modulus E_2. [36]

$$E_2 = \frac{E_f E_m}{V_m E_f + V_f E_m} \text{ Or } \frac{1}{E_2} = \frac{V_m}{E_m} + \frac{V_f}{E_f}$$

- Determination of $\boldsymbol{V_{12}}$

The major Poisson's ratio V_{12} may be determined by the rule of mixtures resulting from the previous two assumptions of having the fiber and the matrix deform in equal amounts along the fiber direction and having the transverse stress σ_2 = 0 (Jones 1975). These assumptions are known to be accurate, leading to an accurate estimation of the major Poisson's ratio V_{12}: [36]

$$V_{12} = v_f V_f + v_m V_m$$

- Determination of G_{12}

The sheet in-plane shear modulus G_{12} is determined in the mechanics-of-materials approach using the assumption that the shearing stress of the fiber and the matrix are identical. The well-known nonlinear shear stress–strain is linearized using this assumption. Accordingly, the resulting equation yields a lower bound solution to the in-plane shear modulus:G_{12} [36]

$$G_{12} = \frac{G_f G_m}{v_m G_f + v_f G_m} \quad \text{or} \quad \frac{1}{G_{12}} = \frac{V_m}{G_m} + \frac{V_f}{G_f}$$

- ❖ Determination of V_{21}

Once the first three parameters are estimated, the minor Poisson's ratio V_{21} is directly calculated, as discussed:

$$\frac{V_{12}}{E_1} = \frac{V_{21}}{E_2} \quad \text{OR} \quad V_{21} = \frac{V_{12}}{E_1} E_2$$

Since the ratio of $\frac{V_{12}}{E_1}$ is accurately estimated, the minor Poisson's ratio v_{21} will yield a lower bound solution if the mechanics-of-materials approach is followed.

Table 6: Typical mechanical properties for s-glass/epoxy unidirectional composites with V_f= 0.6

Typical mechanical properties for s-glass/epoxy unidirectional composites with V_f= 0.6	
Elastic constants	**Gpa**
Longitudinal modulus, E_L	55
Transverse modulus,E_T	16
Axial shear modulus,G_{LT}	76
Poisson's ratio, dimensionless,V_{LT}	0.28
Strength Properties	**Mpa**
Longitudinal tension,F_L^{tu}	1620
Longitudinal compression, F_L^{cu}	690
Transverse tension,F_T^{tu}	40
Transverse compression,	140
In-plane shear	80
Interlinear shear	80
Density, kg/m 3	2×10^3

Source: Courtesy of Zweben (1989).

3.6.3: Mass of s-glass epoxy chassis

Mass = Volume × Density

$$= 0.0194 \times 2000 \frac{kg}{m^3}$$

= 38.8kg

3.6.4 Directional deformation of s-glass epoxy**.**

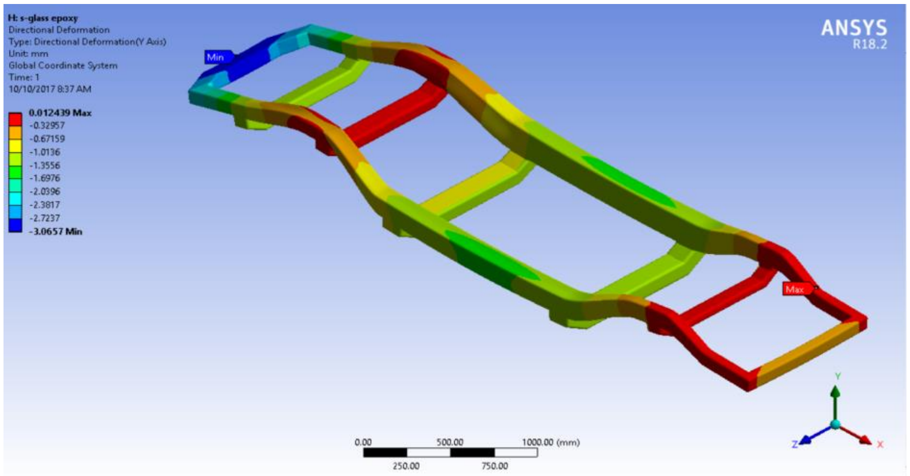


Figure 21: Total deformation of s-glass epoxy

Maximum deformation =3.06mm

Minimum deformation =0.012mm

3.6.5: Equivalent stress of s-glass epoxy

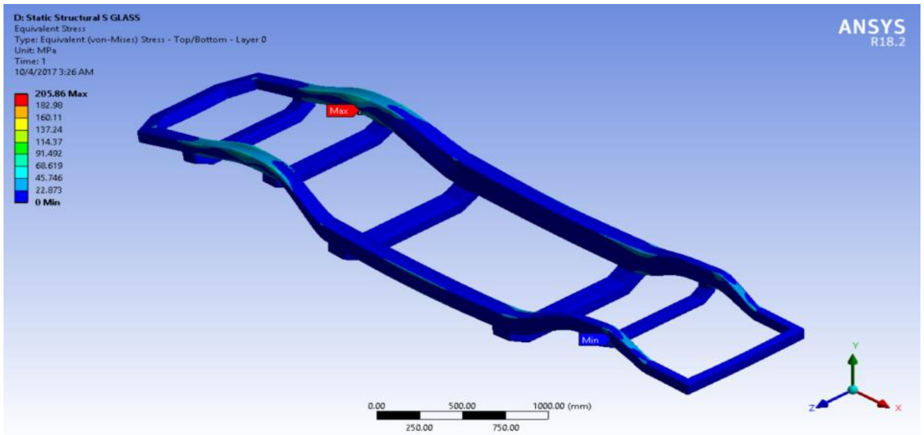


Figure 22: Equivalent stress of s-glass epoxy

Maximum equivalent stress =205.86 Mpa

Minimum equivalent stress =0Mpa

3.6.6: Normal (principal stress) of s-glass epoxy

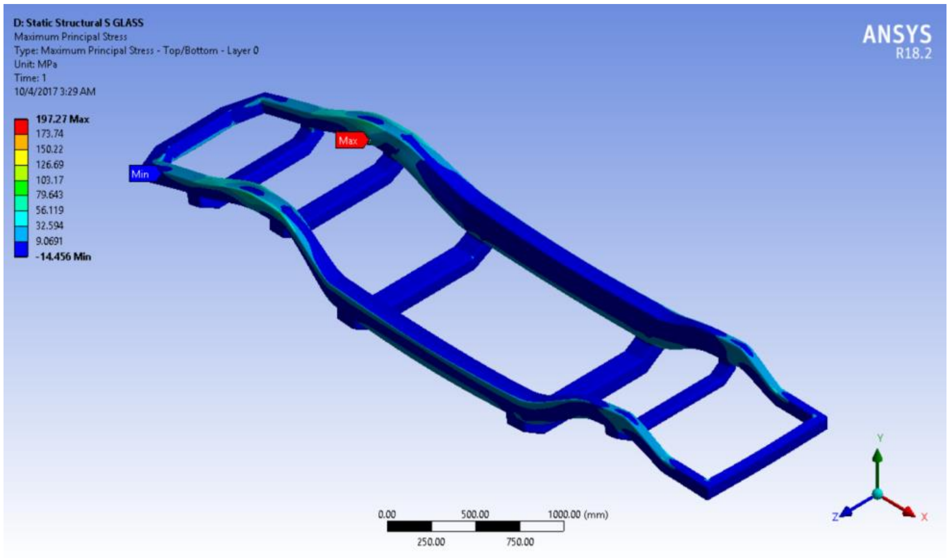


Figure 23: Normal (principal stress) of s-glass epoxy

Maximum principal stress =197.27Mpa

Minimum principal stress =-14.456Mpa

3.6.7: Shear stress of s-glass epoxy material.

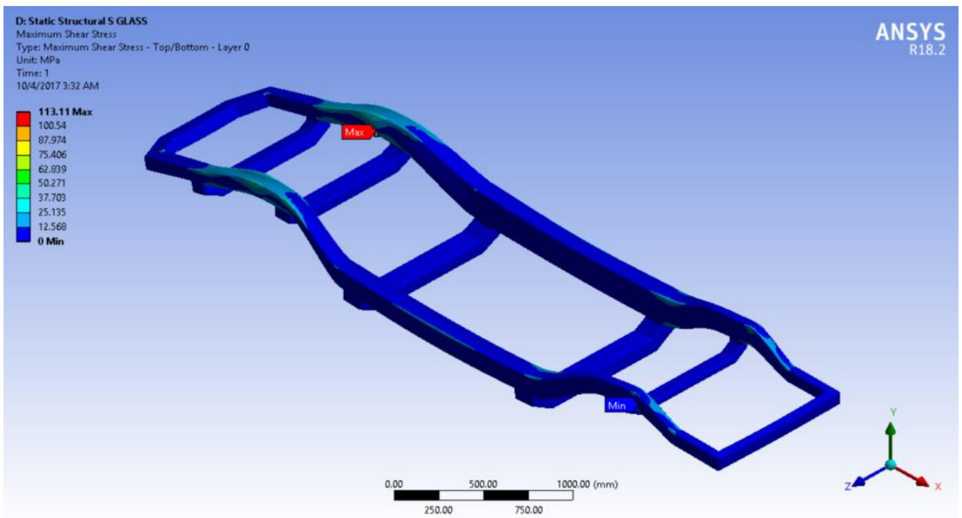


Figure 24: Shear stress of s-glass epoxy material.

Maximum shear stress =113.11Mpa

Minimum shear stress =0Mpa

CHAPTER FOUR

RESULT AND DISCUSSION

4.1: Result

From the above analysis using different materials, the results obtained for stresses and deformations are tabulated below.

Table 7: Comparison of the result

materials	Directional deformation (mm)	Max. Equivalent stress (Mpa)	Max. principal stress(Mpa)	Max. shear stress (Mpa)	Mass (Kg)
HSLA steel	3.05	260	277.93	143.3	153.7
s-glass epoxy	3.06	205.86	197.57	113.11	38.8

Table 8: Analytical values of existing material.

Analytical value of deflection and stresses in the existing material.	
Deflection(mm)	6.52
Maximum Equivalent stress (Mpa)	310.75
Maximum principal stress (Mpa)	290.85
Maximum shear stress	155

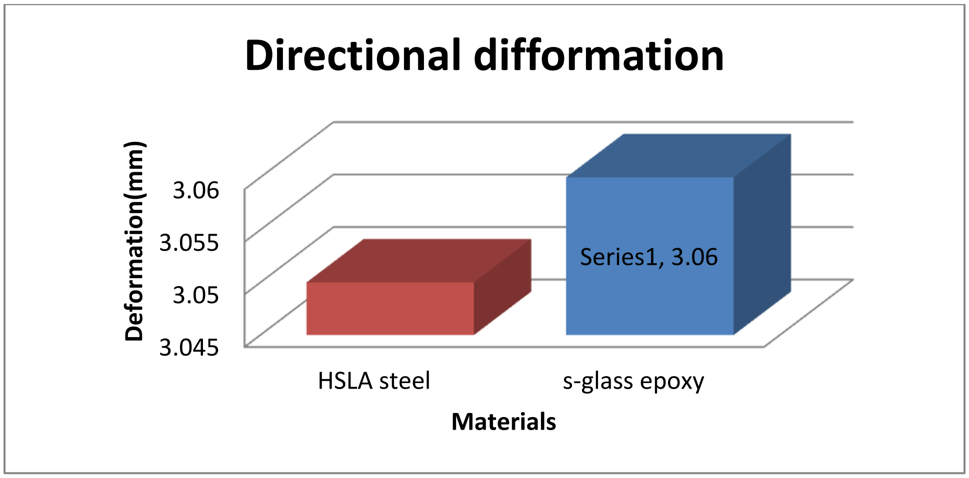


Figure 25: Graph showing Directional deformation of the chassis.

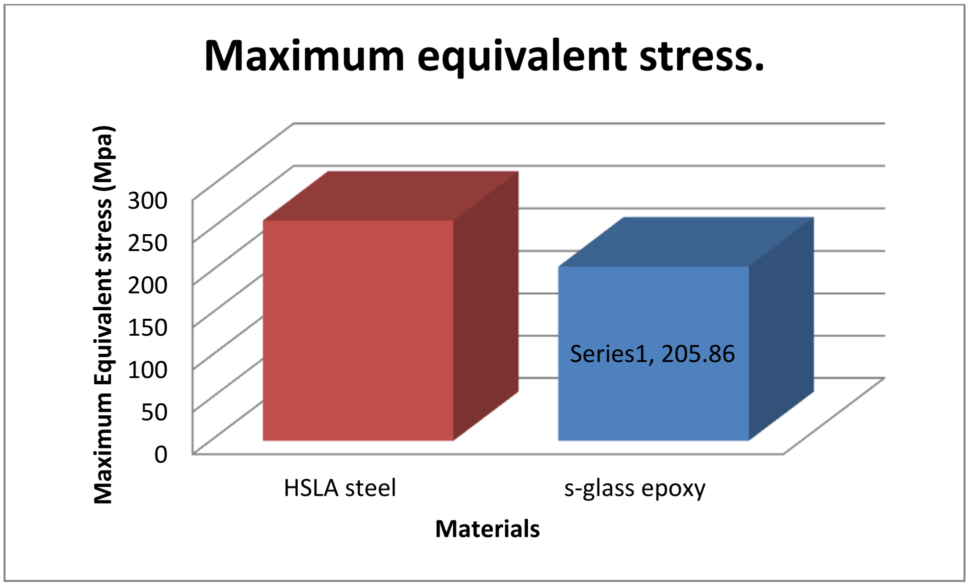


Figure 26: Graph showing Maximum Equivalent stress of the chassis.

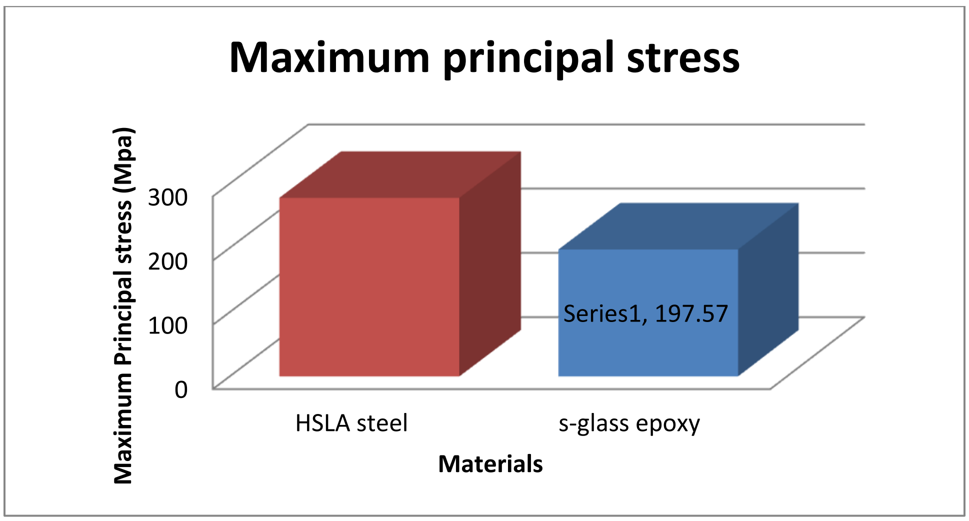


Figure 27: Graph showing Maximum principal stress.

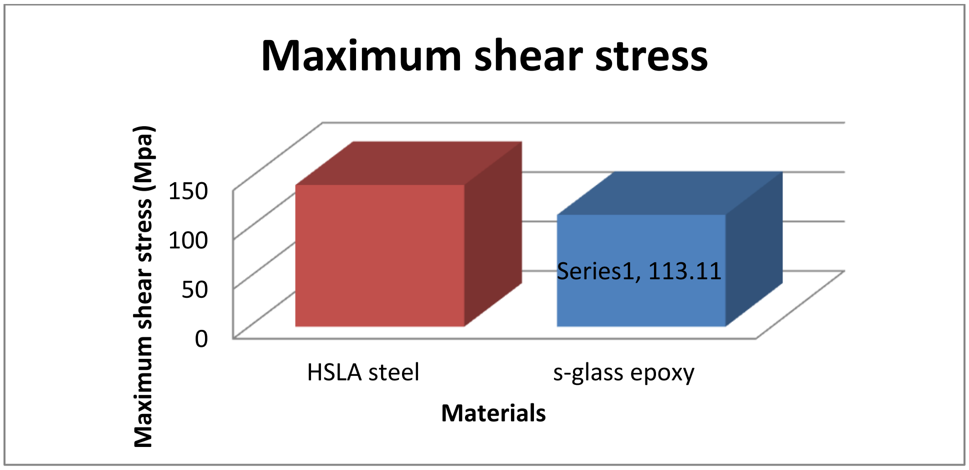


Figure 28: Graph showing Maximum shear stress.

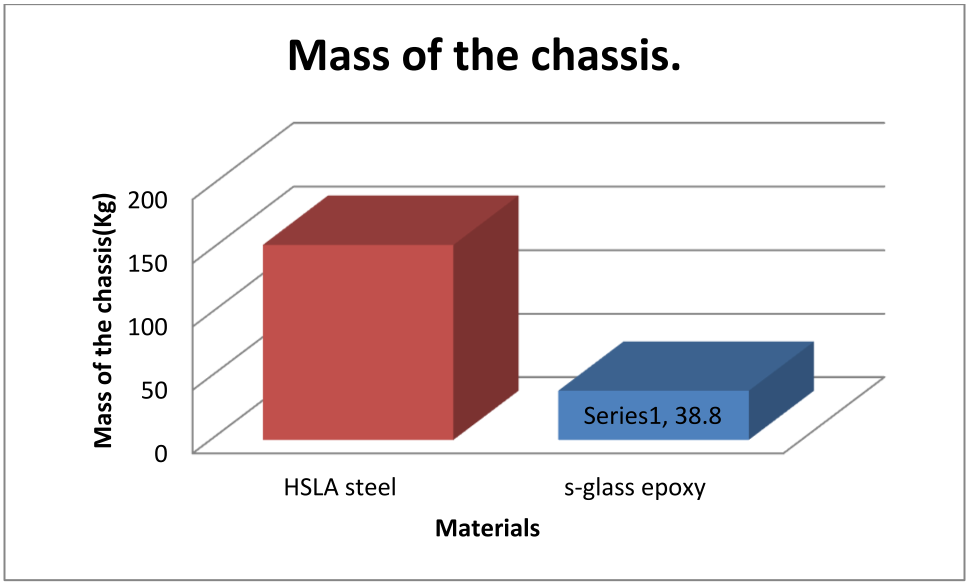


Figure 29: Graph showing mass of the chassis in the two materials

4.2: Discusion.

In this work modeled chassis used in a light vihcle using catia.static structural analyisis was done on the chassis using ansys 18.2. analysis is done using two materials those are the existing material HSLA steel and s-glass Epoxy composite material using 60% of fiber and 40% matrix composition and the orientation is regular or unidirectional with six number of layers using 0.5mm thickness and the ply angle is zero degree.we have done stress analysis and deformation analytically and using finite element method.

Fig.18 to 19 illustrates the deformation and stress distribution pattern for the rectangular holl cross section of the HSLA steel.similarly from fig 19 to 22 it represents the stresses distribution and total deformation for s-glass epoxy in the same cross section and the same applied lood.

The analytical results of stress distribution and deformation using strength of material concept tabulated in table 9.table 8 and 9 shows the stress distribution and and deformation value of the two distinct material both analiticaly and using Finite Element method.the deformation and the four stresses distribution of both convensional HSLA steel and s-glass epoxy polymer is determined from analysis.the deformation of the frame is transfered from the front most end through out the frame.the stresses distributed evenly on both the longtiudinal cross bars. In this thesis we can minimize weight according to my objective. From the above table it can be inferred that s-glass / Epoxy is having the least values when compared to HSLA steel materials. For less mass the s-glass / Epoxy gives more strength. From the result above it is clear that s-glass epoxy composite material is better prefereble than HSLA steel. it is clear that S-glass epoxy has nearly the same deformation and low stress distribution when compared to HSLA steel.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1: Conclusion.

The analyses are processed in the static and structural conditions. The existing light vehicle chassis of TOYOTA (LJ150-GKMEE) is taken for design and analysis with rectangular box cross sections for different materials like HSLA steel and S-glass /Epoxy composites is performed. The model of the chassis was created in catia and analyzed with ANSYS for same load conditions. After analysis comparison is made between existing conventional steel chassis and composite materials in terms of deflections and stresses, in order to select the property that fits for light weight vehicle in their mechanical property. The results of the HSLA steel and polymeric composites material with rectangular Box are performed. It is inferred that by employing s-glass/epoxy composites light vehicle chassis for same load carrying capacity, there is a reduction in weight when compared to HSLA steel. S-glass/epoxy induces nearly the same deformation and stress distribution when compared to HSLA steel. So using composites for chassis is safe. By using composites instead of HSLA steel, the weight of the chassis reduces 4 times than by using HSLA steel because density of steel is more than the composites.

From the above results of HSLA steel and S-glass/epoxy the maximum shear stress and equivalent stress principal stress generated in s-glass/epoxy is under acceptable limit and the total deformation is also within the limit. So we conclude that for the same load carrying capacity we can use s-glass epoxy polymer instead of HSLA steel for the manufacturing of chassis frame and thereby (mass of steel frame 153.7 Kg and S-Glass Epoxy = 38.8 Kg) this shows that chassis made of s-glass epoxy is 74.75% more lighter than conventional chassis. So we conclude that it is better to use a chassis s-glass epoxy made of as a material for frames of vehicle chassis. So we can eliminate fuel consumption for the vehicles. Finite element analysis is effectively utilized for addressing the conceptualization and formulation for the design stages. S-glass epoxy also having high strength and lesser weight also it is non corroded material, so that chemically it is suitable for chassis application. Light weight is a primary goal for all components in green automobile as a lower weight requires less force to accelerate by the same amount.

5.2: Recommendation

The following recommendations for future work can be noted:

- ✓ I highly recommend that to do on other types of analysis like dynamic, non-liner fatigue and optimization analysis and crash analysis must be studied for making the chassis safer in strength.
- ✓ It is better to check the stiffness of the automobile chassis by changing the geometrical dimension, cross section of the chassis member and structural properties.
- ✓ Based on these factors, the overall recommendation is to study the structural analysis and should be covered on the overall truck system and after that focus on the specific area such as chassis. This analysis will help to make full body refinement and improvement because it can be related to actual running condition.

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