© 2017 IJSRSET | Volume 3 | Issue 2 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Pro E-Model of Structural Analysis of Heavy Vehicle Chassis Using Composite Materials

Mohd Khalid Ahmed, Mohd Yousuf Ahmed, V. Sai Krishna, N. Ashwin Siddhartha

Mechanical Engineering Department, Lords Institute of College Engineering and Technology, Hyderabad, Andhra Pradesh, India

ABSTRACT

The chassis is considered to be the most significant component of an automobile. It is the most crucial that gives strength and stability to the vehicle under different condition. The chassis is a term used to denote the frame parts or basic structure of the vehicle. A vehicle without body is called chassis. Chassis is the structural backbone of any vehicle. Chassis frame has to withstand the stresses developed, as well as the deformation occurs in it. The commonly used materials for chassis are mild steel. The analysis is done for the chassis using the composite materials such as carbon epoxy, E glass epoxy, S2 glass epoxy, as materials. Composite materials are replacing traditional metals in many engineering applications due to its light weight and high strength, which has laid a way to the use of composite materials in structural engineering applications. Structural analysis deals with stresses, strains, and deformations in engineering structures subjected to mechanical and thermal load. Composites have high strength and ductility, as well as bending and membrane related mechanical properties, improved fracture toughness, longer fatigue life and excellent impact resistance compared to traditional composite materials. The analysis results can be used to select best materials for chassis. Fatigue analysis is needed on the chassis is subjected to dynamic loads and total life of the chassis.

Keywords: Finite Element Analysis, Pro e, Designing.

I. INTRODUCTION

The Chassis is a term used to denote the frame parts or basic structure of the vehicle, it is the backbone of the vehicle. A large number of designs on pressed –steel frame form a skeleton on which the engine, wheels, axle assemblies, transmission. steering mechanism, brakes, and suspension members are mounted. During the manufacturing process the body is flexibly bolted to the chassis

This combination of the body and frame performs a variety of functions. It absorbs the reactions from the movements of the engine and axle, receives the reaction forces of the wheels in acceleration and braking, aerodynamic wind forces and road shocks through thesuspension, and the major energy of impact in an accident.

There has been a gradual shift in modern designs. And also a trend toward combining the chassis frame and the body into a single structural element, to achieve better noise -isolation characteristics, separate frames are used for other vehicles. The presence of heavier -gauge steel components in modern separate frame designs also tends to limit intrusion in accidents.

II. PROCEDURE

A. Literature Review

There are two main objectives, which involves on the development of truck 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. There are many factors involve and must take into account, which can affect on the vehicle rolling, handling, ride stability and etc. Today, there are many researches and development program available in the market especially by the international truck manufacturers, which are very much related to this study

B. Types of Chassis

Automotive chassis is a skeletal frame on which various mechanical parts like engine, tires, axle assemblies, brakes, steering etc. are bolted. The chassis is considered to be the most significant component of an automobile. It is the most crucial element that gives strength and stability to the vehicle under different conditions. Automobile frames provide strength and flexibility to the automobile. The backbone of any automobile, it is the supporting frame to which the body of an engine, axle assemblies are affixed. Tie bars, that are essential parts of automotive frames, are fasteners that bind different auto parts together.

C. Ladder Chassis

As its name connotes, ladder chassis resembles a shape of a ladder having two longitudinal rails inter linked by several lateral and cross braces.

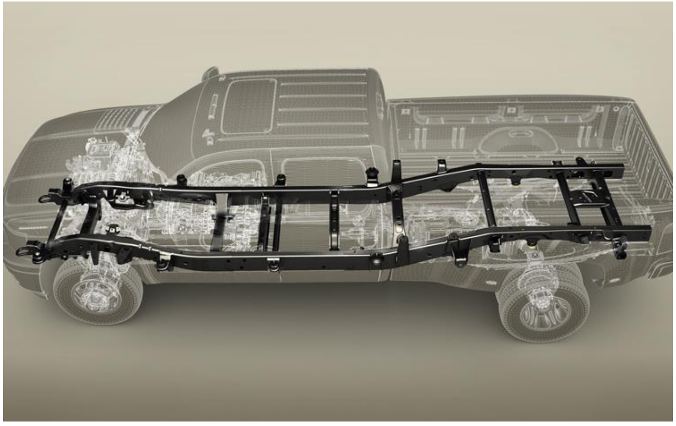

Figure 1: Ladder Chassis

D. Backbone Chassis

Backbone chassis has a rectangular tube like backbone, usually made up of glass fibre that is used for joining front and rear axle together. This type of automotive chassis or automobile chassis is strong and powerful enough to provide support smaller sports car. Backbone chassis is easy to make and cost effective.

E. Monocoque Chassis

Monocoque Chassis is a one-piece structure that prescribes the overall shape of a vehicle. This type of automotive chassis is manufactured by welding floor pan and other pieces together. Since monocoque chassis is cost effective and suitable for robotized production, most of the vehicles today make use of steel plated monocoque chassis.

F. Truck Chassis Research

Dave Anderson and Greg Shade [1] developed a Multi -Body Dynamic Model of the Tractor -Semitrailer for ride quality prediction. The studies involved representing the distributed mass and elasticity of the vehicle structures e.g. frame ladder, the non-linear behaviour of shock absorbers, reproduce the fundamental system dynamics that influence ride and provide output of the acceleration, velocity and displacement measures needed to compute ride quality. There were three main factors contributed in this study. Firstly the author had come out with the development of an ADAMS multi -body dynamics model for use as a predictive tool in evaluating ride quality design improvement. The model includes frame, cab and model generated from finite element component mode synthesis. Second, the construction and correlation of the model has been developed and followed a multi -step process in which each of the major sub -systems were developed and validated to test results prior to corporation in the full vehicle model. Finally, after a series of refinements to the model, the next steps were implemented to obtain an acceptable degree of correlation. The author had managed to evaluate the model's ability to predict ride quality by using accelerations measured in the component, which were then processed through an algorithm to compute an overall ride comfort rating.

III. DESIGN OF COMMERCIAL VEHICLE CHASSIS

Transportation industry plays a major role in the economy of modern industrialized and developing countries. The following facts are of special importance for the manufacturers of commercial vehicles

The total and relative volume of goods carried on trucks is high and still dramatically increasing. This results in acceptance and environmental problems. The transportation task itself becomes more and more specialized. Therefore, a large variety of different vehicles are required with the transportation increase in trucks & passenger vehicles on road.

A**. Chassis and Body Structure**

The vehicle design starts up with conceptual studies to define size, number and location of undriven and drive axles, type of suspension, engine power, transmission, tire size and axle reduction ratio, cab size and auxiliary equipment. The selected configuration has to be considered suitable for the transportation tasks and should match the existing production line. Either new vehicle type is generated or a certain improvement over existing types has to be achieved. Because of the fierce competition, and advanced technology in engineering, manufacturing and service and strenuous work is required to be successful.

The most important function of the "chassis" is supporting and distributing the loads originating from Payload including its vessels, weight of Axles with their fixtures, weight of coupling device, Driven train, Inertia forces generated from acceleration or declaration of the vehicles, forced deformation due to road conditions.

B. Frame Construction

A simplified diagram representing frame shows the longitudinal members A and the cross members B. The frame is up wept at the rear and front to accommodate the movement of the axles due to springing. It also keeps the chassis height low. The frame is narrowed down at the front either as shown in fig. to have a better steering locks. Which gives a smaller turning circle C are the brackets supporting the body.

EI are the dumb irons to act as bearings for spring shackles .they also take the bumper brackets. Brackets l arrangement for mounting the springs. The extension of the chassis frame ahead of the front axle is calling front overhang. Where as its extension beyond the rear axle is called rear overhang.

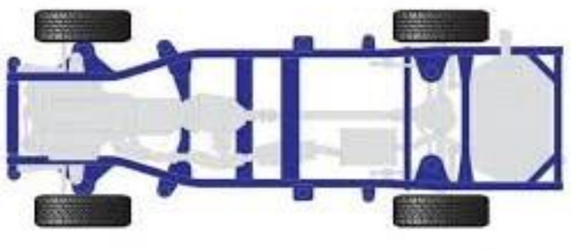

Figure 2 : Frame shape

Since the commercial vehicles have to carry large loads, framed construction is invariably used for these. Because in these vehicles, ground clearance is larger and sufficient space is otherwise available for steering the vehicles, the frames for these have only straight members without taper towards the front or upsweep at the front or rear

C**. Sub Frames**

Normally the various components are bolted directly to the main frame. But these components are mounted on a separate frame called sub frame. This is further supported by the main frame at three points. In this way the components are isolated from the effect of twisting and flexing of the main frame. The advantages of sub frame are mass of the sub frame alone helps to damp vibrations, the provisions of sub frames simplifies production on the assembly line and facilitates subsequent overhaul or repair.

D. Chassis Materials

Traditionally, the most common material for manufacturing vehicle chassis has been steel, in various forms. Over time; other materials have come into use.

E. Steel

The main aim of designing a chassis is to build a stiff structure to ensure other components can work as they're designed to, and steel really scores in this respect, as it's a pretty stiff material. In addition, steel rates well in terms of both yield strength and ultimate strength, particularly it's carefully alloyed and processed. Steel also resists fatigue failure even if the chassis flexes under load, such flexing need not lead to a critical failure.

F. Aluminium

Aluminium is extensively used for automotive chassis and engine applications. Properties like useful strength, low density, high thermal conductivity, excellent machining behaviour and good corrosion resistance are the main reasons for using Aluminium. Future Hybrid and Electro automobiles need lightweight designing materials like Aluminium because Batteries are heavy.

Even used since more than 100 Years Aluminium has a high potential. With new production processes Aluminium alloys can pass a strength level of more than 1.000 MPa. A direct substitution of Steels seems to be achievable. New Aluminium -Composites with some unique features will introduce into the domain of Steel.

Aluminium finds extensive use for automotive chassis applications including sheets, structural and axle components, and others. Despite the higher cost of Aluminium alloys the usage has increased in the past Years for lightweight components. Even the new high strength Steel sheets have not significantly changed this. New Aluminium alloys could easily compete with these new Steels with similar strengths.

B. Fiber Glass Reinforced Composite

Adding glass fibres to reinforce plastic and strength its sturdiness and rigidity has been a common practice for many years. But technological limitations have only allowed an average addition of about 5-30% of glass fibres. If the proportion of glass fibres has to be increased and at the same time good fluidity of the mixed materials has to be maintained, crystalline plastic materials have to be used. Since traditional reinforced plastic chassis makers are not very familiar with the process of handling crystalline materials, they have to achieve desirable hardness for reinforced plastic chassis by making them thicker.

Therefore, to produce reinforced plastic chassis with sturdiness similar to metal ones while still meeting ultra-books' slimness requirements, makers can add high portions of glass fibre during the chassis production process. Mitac Precision's glass fibre reinforced plastic chassis materials for ultra-books have a proportion of 50% glass fibre to strengthen the chassis' sturdiness and provide better protection than ordinary reinforced plastic ones.

In addition to the requirements of lightness and slimness, the appearance is also one of the crucial factors for consumer electronics products. Currently, conventional reinforced plastic chassis makers employ an injection moulding technology where melted plastic materials are injected into a mould that has been heated up to 40 to 50 degrees and then are removed after cooling off and taking shape. Such a production method will often create floating fibres and welding lines on the surface, resulting in undesirable appearance that needs to be go through post -moulding processes such as surface polishing and gloss -finish coating to improve the looks. The Rapid Heat Cycle Moulding (RHCM) process adopted by Mitac Precision is a production process technology that enables moulding through quick changes in temperatures. When the mould's has been heated to the high temperatures necessary for the materials, plastic material with a high portion of glass fibre will then be injected into the mould. After it takes shape, the mould's temperature will quickly reduce to around room temperature and the product will then be removed from the mould. Compared to the conventional plastic production process, products manufactured on the RHCM process technology not only have excellent dimension uniformity, but also glossy surfaces without floating fibre or visible welding lines. The production cycle is also greatly reduced compared to the conventional method.

C. Carbon fiber Reinforced Composite

Carbon -fibre -reinforced polymers are composite materials. In this case the composite consists of two parts of a matrix and reinforcement. In CFRP the reinforcement is carbon fiber, which provides the strength. The matrix is usually a polymer resin, such as epoxy, to bind the reinforcements together. Because CFRP consists of two distinct elements, the material properties depend on these two elements. The maximum possible stiffness and strength combined with minimum weight, carbon fibre is possibly the best material, which the chassis is used in F I cars are all of Carbon fibre. For road vehicles, through the cost is too frightening.

The reinforcement will give the CFRP its strength and rigidity measured by Stress (mechanics)and Elastic modulus respectively. The isotropic materials like steel and aluminium, CFRP has directional strength properties. The properties of CFRP depend on the layouts of the carbon fibre and the proportion of the carbon fibres relative to the polymer. 121 Despite its high initial strength -to -weight ratio, a design limitation of CFRP is its lack of a definable fatigue endurance limit. This means, theoretically that stress cycle failure cannot be ruled out. While steel and many other structural metals and alloys do have estimable fatigue endurance limits, -the complex failure modes of composites means that the fatigue failure properties of CFRP are difficult to predict and design for. Consequently, when using CFRP for critical cyclic -loading applications, engineers may need to design in considerable strength safety margins to provide suitable component reliability over its service life.

D. Vehicle Chassis Design

The automotive chassis provides the strength necessary to support the vehicle components and the payload placed upon it. The steering mechanism is an integral portion of the chassis, as it provides the operator with a means of controlling the direction of travel. The tyres grip the road surface to provide good traction that enables the vehicle to accelerate, brake, and make turns without skidding. Working in conjunction with the suspension, the tyres absorb most of the shocks caused by road irregularities. The body of the vehicle encloses the mechanical components and passenger compartment. It is made of relatively light sheet metal or composite plastics. The components which make up the chassis are held together in proper relation to each other by the frame.

J. Frame

The separate frame and body type of vehicle construction is the most common technique used when producing most full-size and cargo vehicles. In this type of construction, the frame and the vehicle body are made separately, and complete by itself. The frame is designed to support the weight of the body and absorb all of the loads imposed by the terrain, suspension system. engine, drive train, and steering system, The body generally is bolted to the frame at a few points to allow for flexing of the frame and to distribute the loads to the intended load -carrying members. The components of this type of frame are as follows

The side members or rails are the heaviest part of the frame. The side members are shaped to accommodate the body and support the weight. They are narrow toward the front of the vehicle to permit a shorter turning radius of the wheels and then widen under the main part of the body where the body is secured to the frame. Trucks and trailers commonly have frames with straight side members to accommodate several designs of bodies and to give the vehicle added strength to withstand heavier loads.

The cross members are fixed to the side members to prevent weaving and twisting of the frame. The number, size and arrangement of the cross members depend on the type of vehicle for which the frame was designed. Usually, a front cross member supports the radiator and the front of the engine. The rear cross members furnish support for the fuel tanks and rear trunk on passenger cars and the tow bar connections for trucks. Additional cross members are added to the frame to support the rear of the engine or power train components.

The gusset plates are angular pieces of metal used for additional reinforcement on heavy-duty truck frames. With this type of frame construction, the body structure only needs to be strong and rigid enough to contain the weight of the cargo and resist any dynamic loads associated with cargo handling and cargo movement during vehicle operation and to absorb shocks and vibrations transferred from the frame. In some cases, particularly under severe operating conditions, the body structure may be subjected to some torsional loads that are not absorbed completely by the frame. This basically applies to heavy trucks and not passenger vehicles. In a typical passenger vehicle, the frame supplies approximately 37 percent of the torsional rigidity and approximately 37 percent of the bending rigidity the balance is supplied by the body structure. The most important advantages of the separate body and frame construction are as follows:

Ease of mounting and dismounting the body structure, Strong, rugged designs are achieved easily however, vehicle weight is increased, Isolation of noise generated by the drive train components from the passenger compartment through the use of rubber mounts between the frame and the body, Simplistic design that yields a relatively inexpensive and easy manufacturing process. Frame members serve as supports to which springs, independent suspensions. radiators, or transmissions may be attached. Additional brackets, outriggers and engine supports are added for the mounting of running boards, longitudinal springs, bumpers, engines, towing blocks, shock absorbers, fuel tanks, and spare tyres.

IV. RESULT

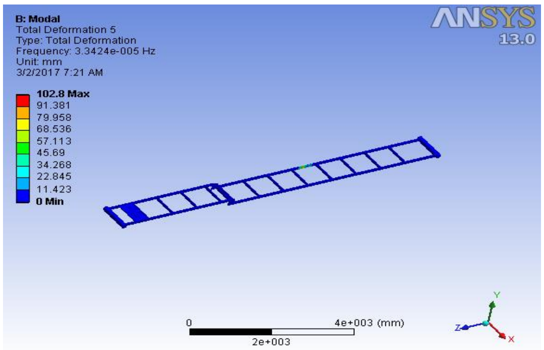

Figure 3 : Carbon-epoxy-Displacement-1-Frequency analysis

Load applied=1.963e+005N
The minimum. Displacement for carbon epoxy=0
Maximum. displacement for carbon epoxy=102.8

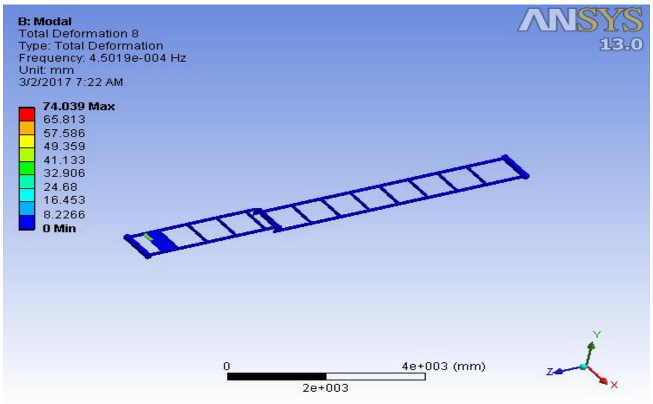

Figure 4 : Carbon-Epoxy Displacement 2 Frequency analysis

Load applied = 1.9613e+005N
The minimum Displacement for carbon epoxy=0
The maximum Displacement for carbon epoxy=74.039

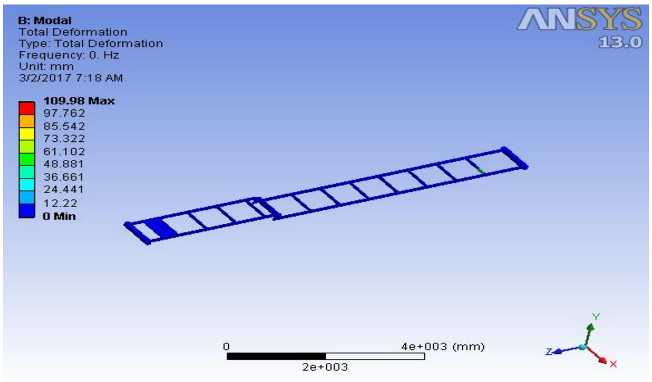

Figure 5: Eglass-Displacement-1-Frequency analysis

Load applied=1.963e+005N
The minimum displacement for E-glass epoxy=0
Maximum Displacement for E-glass epoxy=109.98

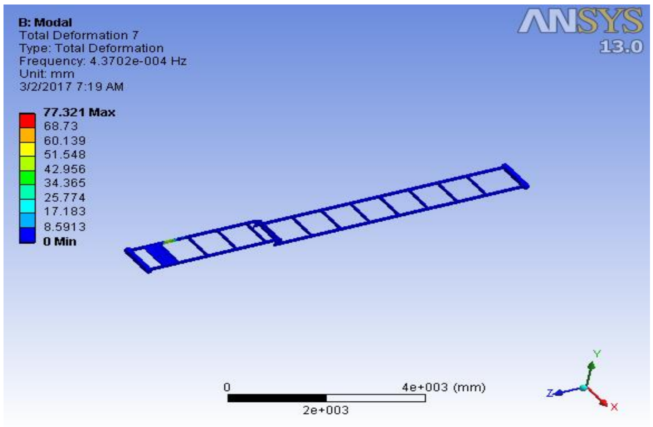

Figure 6: E-glass Displacement 2 Frequency analysis

Load applied=1.9613e+005N
The minimum. Displacement for E-glass=0
The maximum. Displacement for e-glass=77.321

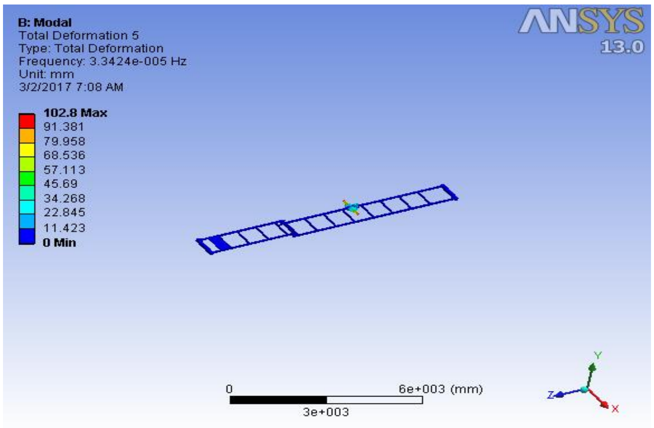

Figure 7: Frequency analysis (1)

Load applied=1.9613e+005N
The minimum. Frequency analysis=0
Maximum. Frequency analysis=102.8

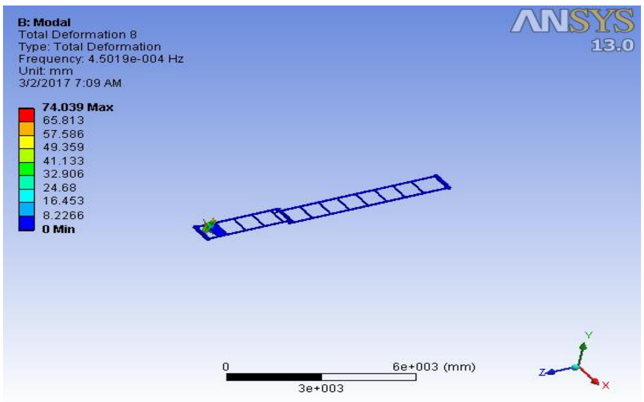

Figure 8: Frequency analysis (2)

Load applied=1.9613e+005N
The minimum Frequency analysis=0
Maximum Frequency analysis=74.039

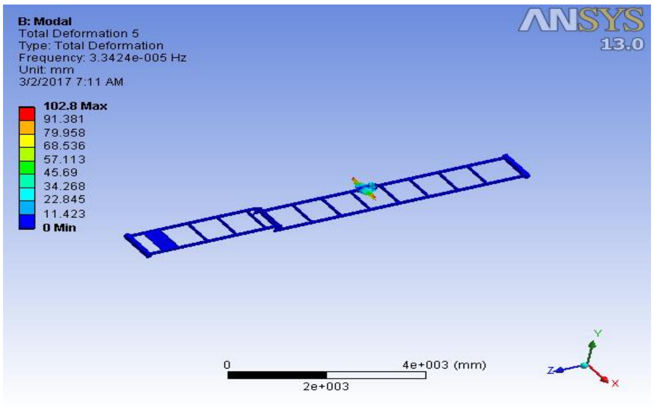

Figure 9: MS-Displacement-1-Frequency analysis

Load applied=109613e+005N
The minimum. Displacement for mild steel=0
Maximum. Displacement for mild steel=102.8

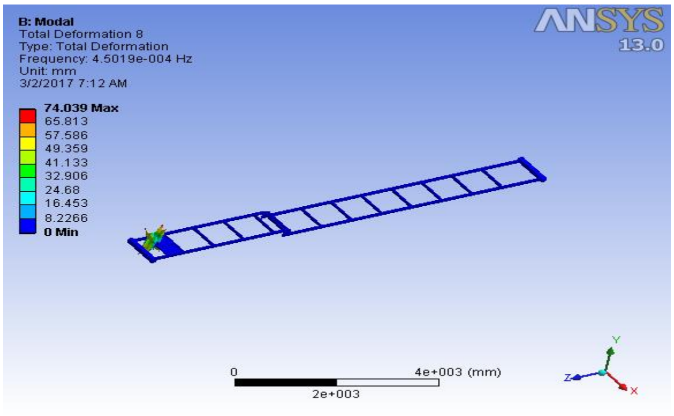

Figure 10: MS-Displacement-2-Frequency analysis

Load applies=109613e+005N
The minimum Displacement for mild steel=0
Maximum Displacement for mild steel=74.039

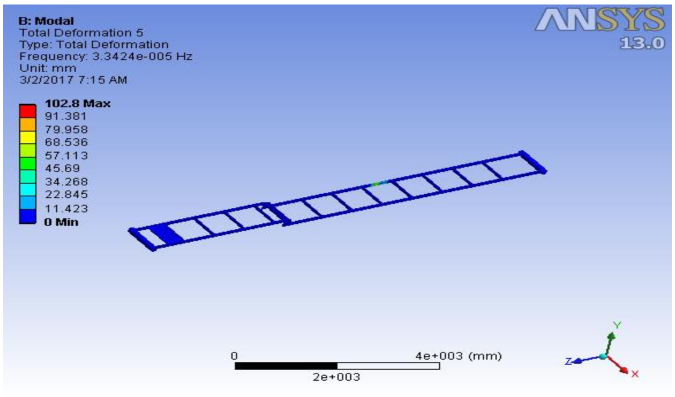

Figure11: S2-Displacement-1-Frequency analysis

Load applied=1.9613e+005N
The minimum S2glass epoxy displacement=0
Maximum Displacement for S2 glass epoxy =102.8

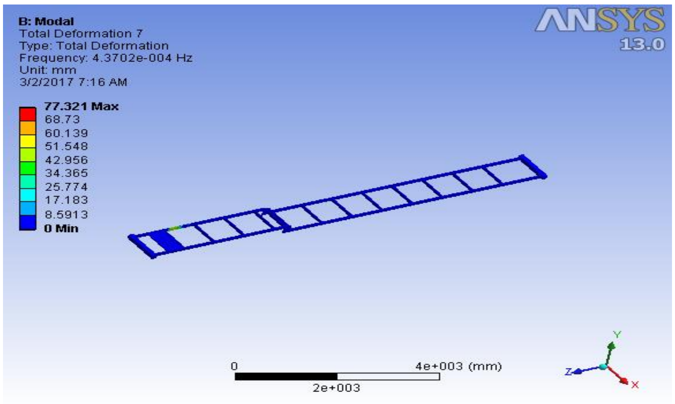

Figure 12: S2-Displacement-2-Frequency analysis

Load applied=1.9613e+005N
The minimum S2glass epoxy displacement=0
Maximum Displacement for S2 glass epoxy =77.321

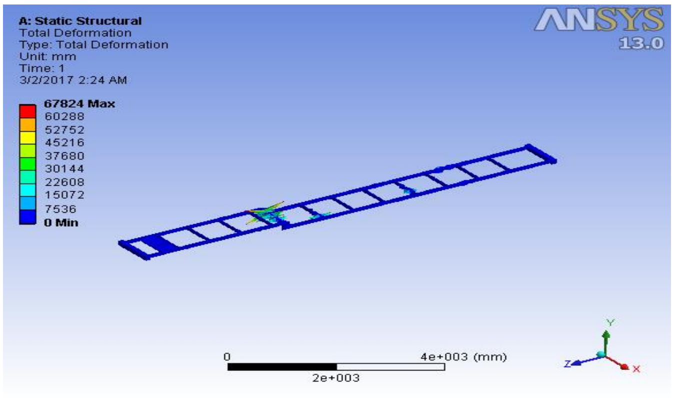

Figure 13: Mild Steel-Deformation

Load applied=19613.e+005N
The minimum deformation for mild steel=0
Maximum deformation for mild steel=67824

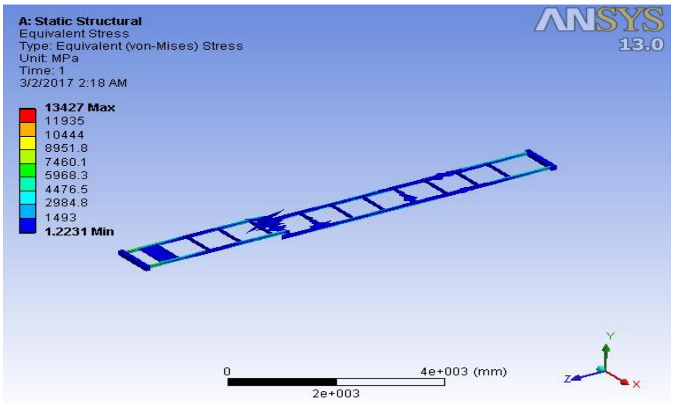

Figure 14: Mild Steel-VON Moises

Load applied=1.961.3e+005N
The minimum mild steel for VON moises=1.2231
Maximum Mild steel for VON moises=13427

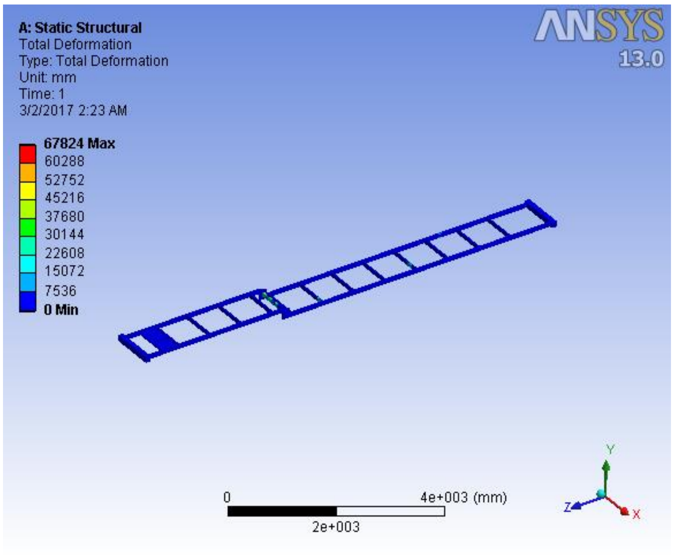

Figure 15: S2 epoxy Deformation

Load applied=1.9613e+005N
The minimum Deformation for S2 epoxy =0
Maximum Deformation for S2 epoxy=67824

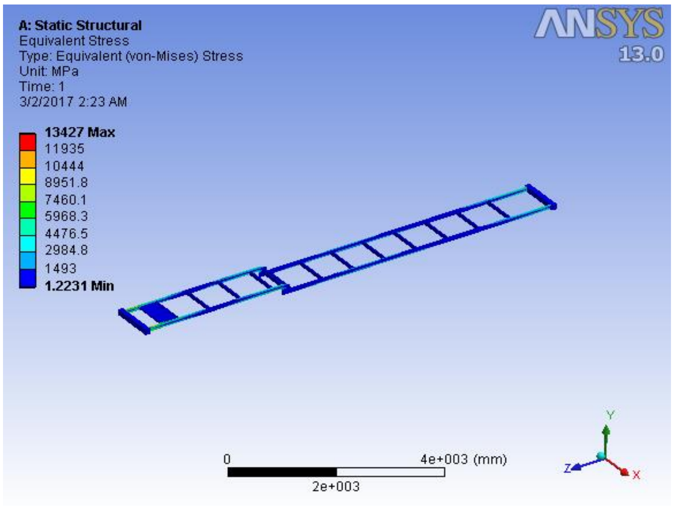

Figure 16: S2epoxy Von Moises

Load applied=1.9613e+005N
The minimum S2 glass epoxy for VON moises=1.2231
Maximum S2 glass epoxy for VON moises=1342

3D MODELING OF CHASSIS

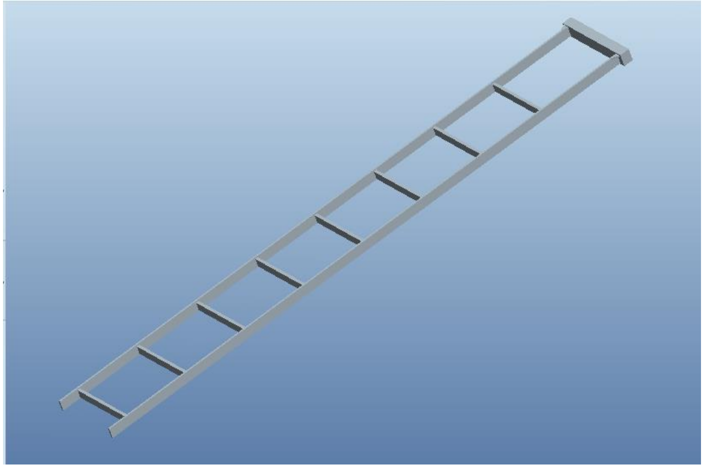

Figure 17: Modelling

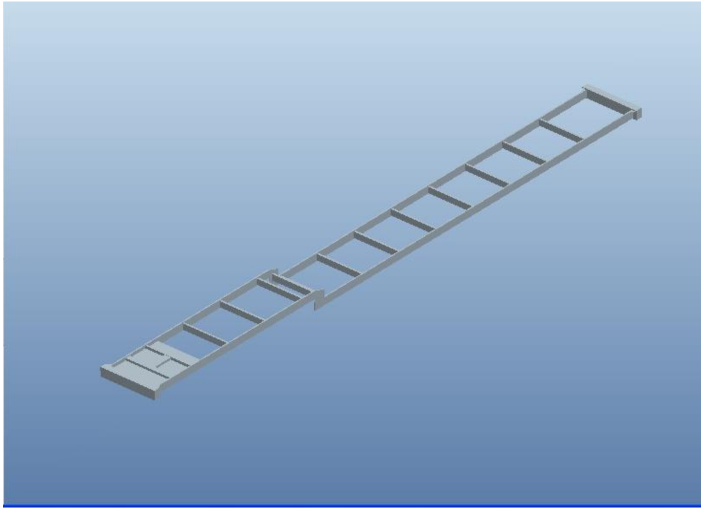

Figure 18: Modelling

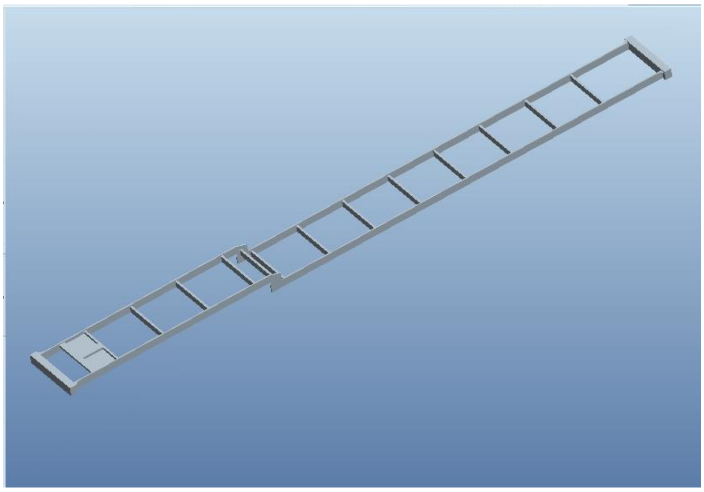

Figure 19: Modelling

V.CONCLUSION

The application of dynamic correlation technique together with finite element tools had been utilized in order to verify the simulation and experimental analysis of the chassis.

Experimental results were used in conjunction with the finite element to predict the dynamic characteristic of truck chassis such as the natural frequency and corresponding mode shape. The natural frequencies and mode shapes are importance parameters in chassis design.

Damage can occur if the truck chassis is excited at resonance during Operation. Therefore, based on the result gained from the finite element analysis. Further enhancement of the current chassis had been done through the chassis in order to improve its stiffness as well as reduce the vibration level.

Composite material with heavy vehicle chassis for the same load carrying capacity, there is a reduction in weight of 73%-40%. Natural frequencies of polymeric composite heavy vehicle chassis are 32% - 54% higher than steel chassis and 66 -78% stiffer than the steel chassis.

In structural analysis the Stress, Displacement, Strain of the modified model has been improved. The fatigue results shows that the modified model has less damage percentage when compared to the existing model.

VI. REFERENCES

[1] M. Ravi Chandra, S. Sreenivasulu, Syed Altaf Hussain, 'Modeling and Structural analysis of heavy vehicle chassis made of polymeric composite material by three different cross sections' International Journal of Modern Engineering Research (IJMER), Vol.2, Issue.4, July-Aug. 2012 pp-2594-2600 ISSN: 2249-6645

[2] Shaik Neelophar Begum, S.P.Bhanu Murthy, 'MODELLING AND STRUCTURAL ANALYSIS OF VEHICLE CHASSIS FRAME MADE OF POLYMERIC COMPOSITE MATERIAL' International Research Journal of Engineering and Technology (IRJET), Volume: 03 Issue: 08 | Aug-2016, p-ISSN: 2395-0072

[3] Archit Tomar & Dheer Singh, 'Modelling and Analysis of a Chassis Frame by Using Carbon Fiber and E-Glass Epoxy as Composite Material: A Comparative Study', International Research Journal of Engineering and Technology (IRJET), Volume: 03 Issue: 04 | April-2016, p-ISSN: 2395-0072

[4] K.W. Poh, P.H. Dayawansa, A.W. Dickerson, I.R. Thomas, Steel membrane floors for bodies of large rear-dump mining trucks, Finite Elements in Analysis and Design 32, (1999), 141-161

[5] I.M. Ibrahim, D.A.Crolla and D.C. Barton, "Effect of Frame Flexibility on the Ride Vibration of Trucks", Department of Mechanical Engineering, University of Leeds LS2 9JT, U.K. August 1994.

[6] Yogendra S. Rajput1, Vikas Sharma1, Shivam Sharma1, Gaurav Saxena, "A Vibration Analysis of Vehicle Frame", IJERA, Vol. 3, Issue 2, April 2013, pp.348-350.