

# **CRASH ANALYSIS OF ROLL CAGE CHASSIS FOR SUV**

Submitted in partial fulfilment of the requirements for the award  
of Bachelor of Engineering degree in Auto mobile Engineering

BY

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# SATHYABAMA



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**BONAFIDE CERTIFICATE**

This is to certify that this Project Report is the bonafide work of **KASILINGAM.S(37860014). SHINO ASWIN.R(37860034).** Who carried out the project entitled **CRASH ANALYSIS OF ROLL CAGE CHASSIS FOR SUV** under my/our supervision from Dec 2020 to Mar 2021

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## DECLARATION

I **KASILINGAM.S(37860014). SHINO ASWIN.R(37860034)** hereby declare that the Project Report *entitled* **“CRASH ANALYSIS OF ROLL CAGE CHASSIS FOR SUV”** done by me under the guidance of **Mr. R. KUMARASUBRAMANIAN, M.E.,** at Satyabhama Institute of Science and Technology is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Automobile Engineering.

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I convey my thanks to **Dr. S. Prakash, M.E., Ph.D., Dean, School of Mechanical** and to **Dr. V.K. BUPESH RAJA. M.E., Ph.D., Heads of the Department, Department of Automobile Engineering** for providing the necessary support and details at the right time during the progressive reviews.

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## **ABSTRACT**

The roll cage is one of the most important part for the personal protection in every sport car and in rally vehicles. It is generally made of thin gauge pipes, joined together, to assemble a safety structure. This frame has to be designed in the way to absorb the kinetic energy during impacts reducing the risk of injuries for drivers and navigators. The design of an appropriate roll cage to be installed on a race vehicle and its validation by Finite Elements methods represent the main motivation for this investigation.

Role cage frame will be modelled in Solid works software a powerful solid modelling tool. Finite Element analysis will be carried out using finite element analysis software, ANSYS Workbench/ LS Dyna. Frontal, Side crash analysis will be carried out on the roll cage under different conditions and the effect on the structural members are studied and discussed. The results are very much helpful and assure that the car is in safe condition in case of a crash or accident.

Two different materials were considered for the analysis. The results of displacement of frame, nodal solution, element solution and bending moment are discussed.

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# CHAPTER-1

## 1.1 INTRODUCTION:

Roll cage is a mainly engineered and built body constructed in now and again around, wherein case it's miles referred to as an ex. cage the passenger compartment of a automobile to guard its occupant from being injured or killed in an coincidence, especially withinside the event of a roll over Roll bars also are used traditionally on row crop tractors, and roll cages are not unusual place as a part of the cab on cutting-edge tractors The roll cage acts as a aid for attaching all of the structures (braking, suspension etc) for the automobile so it must be strong. While designing the roll cage of a Sports Vehicle the different factors to be taken into consideration which incorporates compact layout, ergonomics, durability, ease whilst production and mild weight. Now earlier than beginning the layout it's miles critical to keep in mind the numerous feasible failures.

The want for layout and evaluation of the roll cage of a racing automobile utilized by college students in the course of competitions are to deal with due to the failure of structural contributors Which ends in injuries? The shape of a roll cage needs to be mild weight and inflexible. Also, it needs to act because the critical mounting bracket for all different structures and additives. The layout power of the shape cannot be located at once from any empirical formulation rather must be located out from the opinions of the drivers. Vehicle frame is split into components; roll cage and bodywork. The traditional Roll cage seems much like a truss and is welded at joints. This body protects its Occupants from an coincidence particularly in case of a roll over. A chassis which could soak up excessive strength affects even as controlling the fee of deceleration will growth the probability of drivers surviving a crash without injury.

The layout process starts off evolved with the studies on beyond designs and growing new Ideas. After the preliminary layout has been chosen, for similarly development, it's miles subjected to finite detail modelling and optimization. The subsequent step is the Engineering of the body to a usable position. The shape is then examined to attain a few beneficial records and then the clothier may also extrude the choices made in the course of the layout manner. The maximum critical factor to be taken into consideration whilst Designing the body is that it needs to be reliable, low-budget and noticeably adjustable. A 3-dimensional finite version become formulated with pipe16

factors and elastic helps to permit for simulation of numerous stages of load switch. The first step in designing a roll cage is the know-how of numerous masses appearing on it.

The major modes for a car roll cage are given in

- (i) Longitudinal torsion
- (ii) Vertical bending
- (iii) Lateral bending
- (iv) Horizontal loosening.

Torsion masses is brought on because of the motion of masses at the oppositely adverse corners of the automobile. The body may be taken into consideration to be as torsion spring connecting the 2 ends at which the suspension masses act. Tensional loading influences each the dealing with as well the overall performance of the automobile. Some experimental strategies have been supplied with an emphasis at the complete-automobile torsion process. A bendy chassis reduces the capacity of the race engineer to translate a extrude in the front to rear roll stiffness ratio right into antitrade in the front to rear load switch distribution. In truth the automobile will affect with deformable objects, which includes tyre, barriers, cones or different automobiles. Static evaluation finished in a have a look at confirmed that deflections decrease with growth in stiffness while the again of the chassis become loaded. Finite detail layout device has substantially progressed each the requirements of engineering designs and the method of the layout manner in lots of commercial applications.

The roll cage acts as a aid for attaching all of the structures (braking, suspension etc) for the automobile so it must be strong. While designing the roll cage of an atv the different factors to be taken into consideration which incorporates compact layout, ergonomics, durability, ease whilst production and mild weight. Now earlier than beginning the layout it's miles critical to keep in mind the numerous feasible failures. Aru et al., 2014[1],noorbhasha,n., 2010[2] and raina et al., 2015[3] have finished static evaluation for predicting the modes of failure of the roll cage. This paper consists of all of the feasible crash circumstance and those situations are analysed in static situations. For dynamic situations bharat et all.,2016[4] have finished evaluation of roll cage in dynamic situations.

In cutting-edge engineering evaluation it's miles uncommon to discover a undertaking that doesn't require numerous varieties of evaluation for the behaviour of the version below sure specific situations. The benefits of evaluation are severe and critical. The body includes the motive force, engine, brake system, gas system, and guidance mechanism, and need to be of ok power to guard the motive force withinside the occasion of a rollover or effect. This roll cage is completely designed and evolved below the all regulations and policies said withinside the SAE Mini-Baja rule book.

Roll cage of a automobile is generally designed with cause to keep the weight from the additives of automobile and mass from the motive force. Roll cage want to fulfil some of necessities whose objectives partially battle due to special working situations that are loaded and unloaded weight, acceleration and braking force, degree or choppy street and directly jogging or cornering. Nowadays, maximum of the additives of automobile are withinside the degree of changing with Steel and aluminium materials. This is because of the residences of fabric that may be designed freely to keep the *weight from any direction*. The roll cage's mild-weight assets makes it feasible to increase the overall performance of the automobile whilst retaining low weight.

The automobile is needed to have an aggregate body and roll cage together with metallic contributors. As weight is essential in a automobile powered through a small engine, a stability need to be located among the power and weight of the layout. To nice optimize this stability using stable modelling and finite detail evaluation (FEA) software program is extraordinarily beneficial similarly to standard evaluation. The software program version is ready in SolidWorks software program. Later the layout is examined towards the numerous varieties of failure through accomplishing numerous effect situations and pressure evaluation with the resource of Hyper Mesh Software. After efficiently designing the roll cage, it is prepared for fabricated.

The goal of the have a look at is to layout and increase the roll cage for All-Terrain Vehicle. The layout thing includes safe-ty, smooth production, durability & preservation of the body and a compact, lightweight & ergonomic layout. This paper attention on numerous loading checks like Front Impact, Rear Impact, Side Impact, Roll over to test whether or not the roll cage can undergo all varieties of affects. A software program version is ready in Solid work software program. Later the layout is analysed

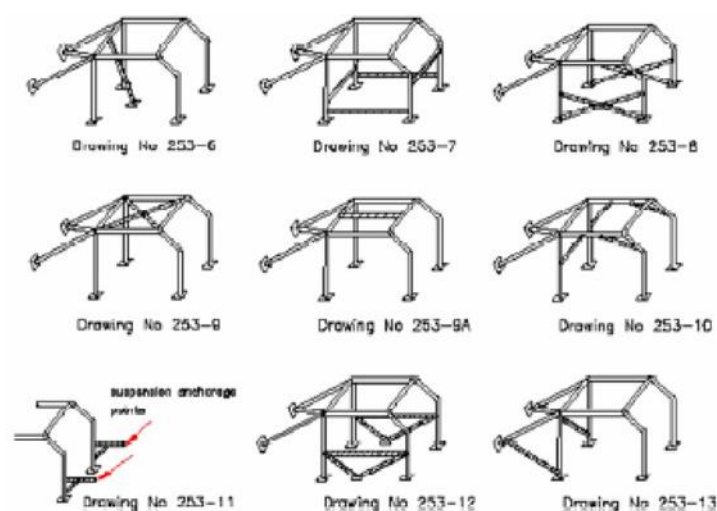
towards all modes of failure through accomplishing numerous simulations and pressure evaluation with the resource of Ansys Software. Based at the end result received from those checks the layout is changed accordingly. For a right running of a formulation pupil automobile it's miles critical that each one the additives paintings withinside the favoured manner. As roll cage/chassis being the critical system, which absorbs all of the static and dynamic masses, the shape needs to be such that it'll preserve the stresses generate without deformation.

There are numerous forces appearing at the automobile while the automobile is in static in addition to withinside the dynamic circumstance. These forces can reason deformation ensuing into pressure era in numerous components of the roll cage. These forces are usually going on in the course of braking, acceleration, cornering or aggregate of above. The stiffness of the roll cage needs to be such that it need to be capable of withstand those forces. An Ideal Roll cage is one that absorbs all of the masses from the suspension with none deformation. This is likewise one of the fundamental requirements of the roll cage. The 2d fundamental requirement is that it have to act as a aid or mounting for all of the different additives at the automobile. The 0.33 requirement is that it need to have excessive longitudinal in addition to excessive torsional stiffness to preserve the forces in the course of braking and cornering.

There are 2 varieties of loads withinside the automobile – Sprung and the Un-sprung mass. All the mass this is damped through the spring is known as because the sprung mass. Generally the sprung mass need to be extra than that of the un sprung mass. Roll cage comes below the class of the sprung mass of the automobile. Moreover, the roll cage is made through welding pipes together. First a right layout of the body or the roll cage is carried out. The pipes are reduced withinside the required lengths. If required, bending of the pipes also are finished. Then notching is finished of those pipes. These pipes are then joined or linked through welding them together.

The roll cage (or someday known as protection cage) is a protecting shape designed to guard the occupants of game cars from rollovers, frontal crashes or different cap potential injuries of any type and severity. When the automobile flips upside down, for example, the roll cage has to guard the roof of a automobile from crushing down, stopping the rider from getting caught interior overwhelmed metal. It additionally enables to stiffen the chassis, that's a proper bring about each racing application.

Since the '60, the roll cages had been in large part used on rally automobiles, racing automobiles in preferred and, even, convertibles. The performance of those protections need to be licensed through worldwide institutions and, handiest after strict controls they may be authorized and geared up on racing automobiles. The use on ordinary automobiles is against the law and cannot therefore, both mount or approve. There are many special roll cage designs, relying at the precise applications, subsequently various racing agencies have differing specs and policies. In particular, a World Rally Car is a racing car constructed according with the specs set through the International Automobile Federation (FIA), the worldwide motorsports governing frame and compete withinside the outright magnificence of the World Rally Championship (WRC). The WRC specs have been added through the FIA in 1997 and periodically evolved, particularly in phrases of automobile stiffness and passenger's protection. As a result of those changes, all the protecting devices, along with the roll cages, had been an increasing number of evolving in complexity. Several designs had been proposed (Fig. 1) whilst a layout validation is necessary. The roll cage is usually constructed becoming a member of very inflexible bars (additionally known as roll-bars), made through excessive power metallic and capable of aid even the burden of the complete automobile without breaking. These frames are frequently known as cells or survival cages for his or her wonderful resistance to all varieties of shocks: the front, facet or from tip-over. Essentially, there are varieties of cages, relying of the manner roll-bars are linked to every different among welded and bolted.



**fig 1.1 ROLL CAGE**

The bolted roll cage, this is certain to the gadget body with the bolts, is commonly favoured in which the usage of the automobile is much less burdensome and consequently the opportunity of effect is reduced. On the opposite the welded roll cages are followed in which the opportunity of injuries may be very excessive and their severity may be deadly for the occupants. Typical examples are the rally automobiles: in those styles of roll-bar metal tubes are welded immediately onto the chassis of the automobile and can not be eliminated after their attachment, however make certain a completely excessive protection degree. Notable stories of roll cage layout are suggested in along with the deployment of superior tactics for injuries modelling. According to a Total Quality method and a Design for Safety unique priority, at the one-of-a-kind levels of the car layout, it's far viable to satisfy complicated geometric adjustments withinside the roll cage shape. These versions may be associated with miscellaneous elements together with:

- optimisations in automobile layout;
- enhancements in protection;
- evolutions in race rules.

These layout adjustments may be correctly observed and checked with the aid of using the usage of Finite Elements. FEs permits, in fact, to speedy carry out a excessive quantity of comparative analyses, lowering value and time associated with the experimental tests. Tests are constrained to the very last model of protection cage.

This unique research has been applied with the aid of using the subsequent steps:

- Creating the 3-D version of the roll cage
- Define the Finite Elements (FE) for discretization
- Define the fabric version
- Realisation of nonlinear quasi static simulation
- Comparing numerical and experimental results.

Vehicle rollover injuries constitute one of the maximum risky sorts of crashes with recognize to fatalities and accidents in keeping with human beings involved. Rollovers are 2d handiest to frontal crashes of their degree of damage severity. In addition, the hazard of unmarried car injuries and of passengers being ejected from a car is lots better in case of rollover then in different sorts of crashes. Accident statistics research

suggest that almost all of rollovers have befallen in unmarried car injuries. Two simple sorts of rollover phenomena, tripped and untipped, often arise in unmarried car injuries. The tripped rollovers are greater not unusual place in comparison to untipped. A tripped car rollover can end result if the car moves a inflexible kerb or different *impediment on the car's tires or wheels which induces a rotational movement to the* car ensuing in rollover. Research has proven that car rollover is because of interplay of a huge variety of factors, together with car geometry, inertial and suspension traits, function and value of lateral effect forces, resultant lateral acceleration and mixed impact of lateral acceleration and braking. Geometric parameters of the car are with the aid of using some distance the maximum influential traits in a rollover situation. A roll cage is a protection characteristic mounted in a car utilized in environments in which there's a excessive risk of rolling, together with race automobile driving, ATVs in addition to army and police use. Some automobiles are mainly designed with roll cages mounted, even as others have had this tool mounted at some stage in a retrofit. Roll cages are available some of patterns designed for one-of-a-kind settings and car types.

The concept at the back of a roll cage is if the car rolls, it's going to guard the occupants. While elements of the car can be broken or crushed, the roll cage prevents intrusion into the passenger compartment, developing a secure pocket. In severe injuries, the roll cage might not provide sufficient safety, however, and it's far nevertheless viable to be critically injured even though the roll cage capabilities precisely as intended. This protection characteristic is designed to paintings with different protection functions like collapse zones and seat belts to provide safety in an accident

## **CHAPTER- 2**

### **2.1 LITERATURE REVIEW**

**[1]Y. Mahajan,N. Pagare, R. Awate ,N. Phalke And Prof. V. Shinde Design and Dynamic Analysis of Roll Cage for The Off-Road Vehicle Published in International Journal for Science and Advance ResVolume three Issue 6 - JUNE 2017 , ISSN [ONLINE]: 2395-1052**

This paper offers with the Design, Development and Dynamic Analysis of Roll Cage for the off-Road car. The roll cage version is designed with the assist of Solid Works software program and Hyper Mesh is the software program used for the Dynamic evaluation. In the Dynamic evaluation the exceptional crash exams like the front effect, facet effect and head-on collision are completed with the assist of Hyper Mesh software program for figuring out the greatest Factor of Safety. This challenge simplest offers with facet effect and the front effect evaluation, does now no longer cope with any roll over evaluation

**[2.]Denish S. Mevawala, mahesh P. Sharma, devendra A. Patel and darshan A. Kapadia strain evaluation of roll cage for an all terrain car posted in IOSR magazine of mechanical and civil engineering (IOSR-JMCE) e-issn: 2278-1684, p-issn: 2320-334X PP 49-53**

this paper offers with layout of roll cage for an ATV and diverse loading exams like the front effect, facet effect and rear effect had been conducted. The modeling and strain evaluation is executed via way of means of ANSYS software program. We have targeted on each factor of roll cage to enhance the overall performance of car with out failure of roll cage. The roll cage analyzed appropriate for unmarried seater cars, it additionally fails to discover roll over evaluation.

**[3.] Mahendra H M, B S PraveenKumar,Puttaswamaiah.S. Design and crash evaluation of a roll cage for formulation SAE race automobile Published in IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308**

This paintings describes how a not unusual place version of the roll cage is developed the usage of Catia v5 and Hyper Mesh to permit each linear and non-linear Finite

Element Analysis to be performed via way of means of LS-DYNA software. This is in education for a destiny semi-monocoque layout. Improvements for the trying out techniques encompass a want for a lighter and extra correct automobile swing setup, alongside an extra inflexible torsional test. This paper suggests to comprise carbon fibre skins over slight metallic bars this ends in peeling of pores and skin because of put on and tear lack of integrity withinside the roll cage

**[4].Bharat Kumar Sati, Prashi Upreti, Anirudh Tripathi &ShankarBatra. Static and Dynamic Analysis of the Roll Cage for an All-Terrain Vehicle. Published in Imperial Journal of Interdisciplinary Research(IJIR) Vol-2, Issue-6, 2016,ISSN: 2454-1362.**

This paper outlines static and dynamic evaluation of the roll cage of ATV. Static evaluation of the roll cage is executed the usage of ANSYS Static Structural for exceptional collisions like the front, facet, rear and roll over. Dynamic evaluation of various crash situations like head-on, the front, facet, rear and roll over of the roll cage is executed the usage of ANSYS Explicit Dynamic. This challenge is simplest appropriate for compact unmarried seater all terrain car.

**5. Pruthviraj Vitthal Wable Design and Analysis of FSAE Roll cage Published in International Journal of Innovative Research in Science, Engineering and Technology Vol. 6, Issue 2, February 2017**

This paper entails in element description of ordinary layout considerations, static and dynamic evaluation of FSAE roll cage. Formula SAE (FSAE) competitions offers a challenging environment where an engineering scholar can exercise and increase diverse engineering skills. This paper offers with the general of layout technique of roll cage of FSAE car from start to end, in addition to Finite Elemental Analysis (static & dynamic) of it. 3-D CAD version of roll cage is made the usage of CREO 2.0 software program and FEA evaluation is executed the usage of ANSYS 17.0.

## CHAPTER-3

### 3.1 AIM :

•To simulate the effect among the roll cage and a inflexible wall whilst the car is journeying at eighty Kmph and look at the:

- *Internal Energy absorbed in the course of effect*
- *Stress distribution*
- *Deformation of the roll cage.*
- *Then, we are able to calculate the Factor of Safety for the layout and determine*

if the version is secure for business purposes

### 3.2 PROBLEM IDENTIFICATION:

| S.No | Reference                                                               | Work done                                            | Problem identified                                                                                                                                                                                                                                                                                |
|------|-------------------------------------------------------------------------|------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.   | Design and dynamic analysis of roll cage for the off-road vehicle       | Side and Front impact analysis                       | This work does not involve roll over analysis                                                                                                                                                                                                                                                     |
| 2.   | Stress Analysis of Roll Cage for an all-terrain vehicle Impact Analysis | side, front and rear impact analysis                 | This work does not involve roll over analysis. it is suitable for single seater cars                                                                                                                                                                                                              |
| 3.   | design and analysis of a roll cage for formula SAE race car             | crash side and front impact analysis<br><br>Analysis | This paper suggests to incorporate carbon fiber skins over mild steel bar this leads to the peeling of skin due to wear and tear causing loss of integrity in the roll cage. This work does not roll over analysis. Added weight of mild steel with carbon fiber skin makes the structure heavier |
| 4    | static and dynamic analysis of the roll cage for an all-terrain vehicle | side, front and roll over impact analysis            | it does not provide any safety rear mounted engines.                                                                                                                                                                                                                                              |

|   |                                       |                                                  |                                                                                           |
|---|---------------------------------------|--------------------------------------------------|-------------------------------------------------------------------------------------------|
| 5 | design and analysis of FSAE roll cage | side, front and torsion and rear impact analysis | it is suitable for single seater open wheel racing cars. roll over analysis not conducted |
|---|---------------------------------------|--------------------------------------------------|-------------------------------------------------------------------------------------------|

***Table 3.1 PROBLEM IDENTIFICATION***

## **CHAPTER 4**

### **4.1 DESIGN AND DEVELOPMENT**

The layout and improvement procedure of the roll cage consists of different factors that are fabric choice, pass segment determination, body layout and the finite detail evaluation. The properly layout selection of our body guarantees the protection and reliability of the motive force and higher overall performance in addition to performance of the car that's accomplished with the aid of using the selecting the best fabric for the body. To make sure that the most beneficial fabric is chosen, the good-sized studies changed into executed and it's far in comparison with the alternative substances from more than one classes. The key classes for contrast have been taken into consideration as electricity, weight, fee and the primary essential thing is the supply of that fabric in India.

### **4.2 MATERIAL CHOICE AND PASS SEGMENT DETERMINATION**

As the car might be going to compete in numerous Mini-Baja layout countrywide opposition executed for the undergraduate college students in India. So, the standards for fabric choice of the roll cage is precisely follows the all guidelines said in the guideline of thumb ee-e book that's given with the aid of using the SAE India Baja. The fabric might be going to apply for the assemble of roll cage have to be of metallic tubes with the minimal 0.18 Carbon with the minimal of 1.57mm wall thickness for the number one participant and have to be minimal of 25.4mm outer diameter with the wall thickness 0.89mm for secondary participants. After executed the good-sized studies at the different factors like fee, exceptional, availability and weight of fabric, protection of motive force and simplicity of production, AISI1018 and AISI4130 metallic tubes are taken into consideration for the body layout. The AISI 4130 metallic of plane grade is the fabric decided on for our roll cage. Since the AISI4130 consists of chromium and molybdenum as strengthening marketers with the carbon content material 0.28-0.33%. Also, the AISI4130 have properly weld capacity in addition to machinability, it additionally has the excessive closing tensile pressure and yield pressure.

### 4.3 INTRODUCTION TO MODELING

Throughout the records of our commercial society, many innovations had been patented and entire new technology have evolved. Perhaps the unmarried improvement that has impacted production extra fast and substantially than any preceding generation is the virtual laptop. Computers are getting used an increasing number of for each layout and detailing of engineering additives withinside the drawing office.

Computer-aided layout (CAD) is described because the software of computer systems and portraits software program to useful resource or beautify the product layout from conceptualization to documentation. CAD is maximum usually related to the usage of an interactive laptop portraits gadget, known as a CAD gadget. Computer-aided layout structures are effective gear and withinside the mechanical layout and geometric modelling of merchandise and additives.

There are numerous properly motives for the usage of a CAD gadget to aid the engineering layout function:

- *To boom the productivity*
  - *To enhance the exceptional of the layout*
  - *To uniform layout standards*
  - *To create a production statistics base*
  - *To remove inaccuracies due to hand-copying of drawings and inconsistency among drawings.*
- Computer-aided production (CAM) is described because the powerful use laptop generation in production making plans and manage.

CAM is maximum carefully related to capabilities in production engineering, inclusive of procedure and manufacturing making plans, machining, scheduling, Management, exceptional manage, and numerical manage (NC) component programming. Computer-aided layout and laptop-aided production are frequently mixed CAD/CAM structures.

This aggregate permits the switch of records from the layout into the level of making plans for the producing of a product, without the want to re input the statistics on component geometry manually. The database evolved in the course of CAD is stored; then it's far processed further, with the aid of using CAM, into the essential statistics

and commands for working and controlling manufacturing machinery, fabric coping with equipment, and automatic trying out and inspection for product exceptional.

#### **4.4 RATIONALE FOR CAD/CAM**

The intent for CAD/CAM is just like that used to justify any generation-primarily based totally development in production. It grows out of a want to constantly enhance productivity, exceptional and competitiveness. There also are different motives why a enterprise would possibly make a conversion from guide techniques to CAD/CAM:

- *Increased productivity*
- *Better exceptional*
- *Better conversation*
- *Common database with production*
- *Reduced prototype creation casts*
- *Faster reaction to customers*

#### **4.5 CAD/CAM HARDWARE**

The hardware a part of a CAD/CAM gadget includes the subsequent additives one or mare layout workstations, virtual laptop, plotters and different output gadgets, an garage gadgets.

The courting a few of the factor is illustrated. In addition, the CAD/CAM gadget might have a conversation interface to allow transmission of statistics to and from different laptop structures, as a consequence allowing a number of the advantages of laptop integration. The pc is the interface among laptop and consumer withinside the CAD gadget.

The layout of the CAD pc and *it's* to be had functions have an essential have an impact on at the convenience, productivity, and exceptional of the consumer's output. The pc has to consist of a virtual laptop with an excessive-pace manage processing unit (CPU). It consists of require a and logic/mathematics segment for the gadget.

The maximum broadly used secondary garage medium in CAD/CAM is the tough disk, floppy diskette, or a aggregate of each.

The ordinary I/O gadgets utilized in a CAD gadget. Input gadgets are usually used to switch records from a human or garage medium to a laptop where "CAD capabilities"

are executed. There are simple processes to enter an current drawing: version the item on a drawing or digitize the drawing. The widespread output tool for CAD/CAM is a CRT show.

There are primary of CRT presentations: random-experiment-line-drawing presentations and raster-experiment presentations. In addition to CRT, there also are plasma panel presentations and liquid-crystal presentations.

#### **4.6 APPLICATIONS OF CAD/CAM**

The emergence of CAD/CAM has had a prime effect on production, with the aid of using standardizing product improvement and with the aid of using decreasing layout effort, try-out, and prototype paintings; it has made viable substantially decreased prices and advanced productivity. Some ordinary programs of CAN/CAM are as follows:

- *Programming for NC, CNC, and commercial robots*
- *Design of dies and moulds for casting, in which, for example, shrinkage allowances are preprogramed*
- *Design of gear and furniture and EDM electrodes*

Quality manages and inspection for instance, coordinate-measuring machines programmed on a CAD/CAM pc; Process making plans and scheduling.

AutoCAD is a laptop-aided drafting and layout gadget applied on a non-public laptop. It helps a big range of gadgets. Device drivers include the gadget and consist of maximum of the digitizers, printer/plotters, video show boards, and plotters to be had at the market.

AutoCAD helps 2-D drafting and three-D wire-body fashions. The gadget is designed as an unmarried-consumer CAD package deal. The drawing factors are strains, poly strains of any width, arcs, circles, faces, and solids. There are many approaches to outline a drawing detail. For example, a circle may be described with the aid of using middle and its radius, 3 factors, and stop factors of its diameter. The gadget constantly activates the consumer for all alternatives. Of course, the set off may be became off with the aid of using superior customers.

Annotation and dimensioning also are supported. Text and size symbols may be positioned on everywhere at the drawing, at any angle, and at any size. A style of fonts and patterns also are to be had.

#### **4.7 INTRODUCTION TO ANSYS DESIGN MODELER**

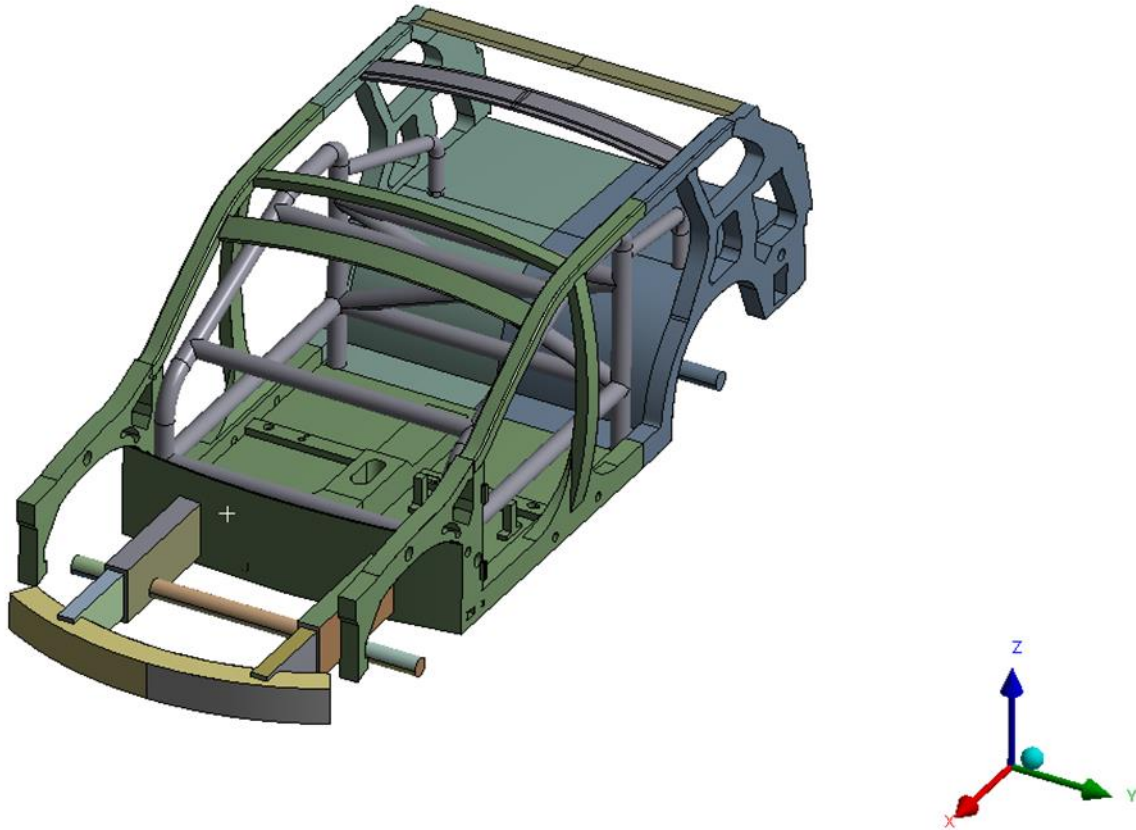
Ansys layout modeler is a three-D modelling device. Unlike different three-D modeling gear, Ansys layout modeler isn't completely 3 dimensional. Other packages permit the consumer to without difficulty attract 3-dimensional area. In Pro/Engineer, one attracts in a aircraft after which extrudes solids from the aircraft. Planes are used to reap role in 3-dimensional area. It is viable to attract in 3-dimensional area the usage of Pro/Engineer, however could be very difficult. Therefore, the first-class approach of making 3 dimensional gadgets is the usage of planes.

The procedure technique for Robotic arm is begin shape geometric modeling, which has been performed the usage of stable modelling software program referred to as Pro/Engineer. Ansys layout modeler is a Parasolid-primarily based totally stable modeler, and makes use of a parametric feature-primarily based totally method to create fashions and assemblies. Parameters discuss with constraints whose values decide the form or geometry of the version or assembly.

Parameters may be both numeric parameters, inclusive of line lengths or circle diameters, or geometric parameters, inclusive of tangent, parallel, concentric, horizontal or vertical, etc. Numeric parameters may be related to every different thru the usage of a relation, which permits them to seize layout intent.

Shape-primarily based totally functions commonly start with a 2D or three-D comic strip of shapes inclusive of extrude bosses, holes, slots, etc. This form is then extruded or reduce to feature or do away with fabric from the component.

## FRAME LAYOUT



**Fig 4.1-FRAME LAYOUT**

The layout goal of the roll cage is to encapsulate all additives of the car, inclusive of a motive force effectively and safely. Principal elements of the roll cage targeted on in the course of the layout and implementation blanketed motive force protection, suspension and drive-teach integration, structural pressure, weight, and operator ergonomics. The supposed fabrication is essential because of the constraints of the talents and competencies of the construct group in addition to layout directives. The goal is to decrease the range of welded joints at the body in favour of bend participants. Bending is much less time ingesting and whilst nicely performed display a far decrease pressure concentration. The roll cage changed into layout withinside the SolidWorks software program with the aid of using the usage of weldments device. Then the uploading IGS document of the stable works version into the Hyper Mesh software program, the 2D meshed version is created. First of all, the surfaces are generated of the roll cage after which 2-D quad kind meshing is executed with a few exceptional index optimizations for the meshing.

#### **4.8 FINITE ELEMENT ANALYSIS**

After finalizing the body in conjunction with its fabric and pass segment, it's far very vital to check the pressure and electricity of the body beneath Neath numerous effect situations. The body have to be capable of preserve all of the impacts, torsion, roll over situations and offer complete protection to the motive force without present process excessive pressure and deformation. Finite detail evaluation is a automatic approach use with the aid of using FEA Software for predicting how a product reacts to actual global forces, vibration situations, and different bodily outcomes performing on it. Finite detail evaluation indicates whether or not a product will break, put on out, or paintings the manner because it changed into designed. Here we divide the roll cage into small sizes referred to as detail and collective factors at the version shape a mesh. The laptop analyses the factors and indicates us a collective end result. The fabric and shape of roll cage changed into finalized after which FEA changed into done on it. It is examined whether or not the roll cage might be capable of face up to the numerous situations like torsion, effect, bump and vibrations.

#### **4.9 STRUCTURAL ANALYSIS**

Structural evaluation might be the maximum not unusual place software of FEM. The time period structural implies now no longer handiest engineering systems inclusive of bridges and buildings, however additionally naval aeronautical and mechanical systems. Inclusive of ship, nulls, plane bodies, and gadget housings, in addition to mechanical additives inclusive of pistons, gadget elements and gear.

Seven forms of structural evaluation to be had withinside the ANSYS own circle of relatives of merchandise are proven beneath Neath.

- *Static Analysis*
- *Modal Analysis*
- *Harmonic Analysis*
- *Transient Dynamic evaluation*
- *Spectrum Analysis*
- *Buckling Analysis*
- *Explicit Dynamics Analysis*

#### **4.10 MESH GENERATION**

The geometry is discretized to shape a mesh of factors and nodes. This method that the shape is damaged down into small sub areas on which the numerical analogue of the governing equations may be evolved. The meshed format relies upon on following.

- *The geometry of the shape*
- *The kind of evaluation, i.e. static, dynamic, thermal or non linear*
- *The boundary situations*
- *The loading*
- *The required end results*

#### **4.11 TYPE OF MESH GENERATIONS**

- *Automatic mesh generations*
- *Parametric (guide) mesh generation*

##### **Automatic mesh generation**

Transition in regions of pressure gradient isn't viable with the aid of using car mesh. Tetrahedron detail utilized in car mesh is a regular stress detail, which for easy structures (or areas), it is simple to label the nodes to decrease the bandwidth.

But for big structures the methods grow to be almost impossible. Control of mesh produces the effects with 70% blunders and exceptional of car-meshed elements with geometric transition can't be controlled.

##### **PARAMETRIC (GUIDE) MESH GENERATION**

Structured (parametric) finite detail have to be used for the additives related to excessive cycle fatigue. Control of mesh transition in regions of pressure gradient is viable with higher convergence in effects the usage of dependent factors inclusive of brick with 8(or) 20 nodes.

Convergence of finite factors version the usage of brick factors is monatomic. Brick detail with the aid of using guide meshing exceptional of dependent meshed elements with geometric transition manage is viable.

## MESH THE MODEL

Meshing entails 3 fundamental steps:

- *Set the detail attributes and fabric properties*
- *Set mesh controls*
- *Generate the mesh*

## ELEMENTS ATTRIBUTES

Before meshing the version, factors attributes have to be precise primarily based totally at the fabric, evaluation and additionally on the specified effects. The factors used on this evaluation are defined withinside the following sub-topics.

Minimal assumptions are utilized in arriving on the slope of nonlinear force-displacement courting, i.e., detail goal stiffness hence; they're additionally referred to as steady formulations.

### 4.12 INTRODUCTION TO ANSYS

ANSYS is the handiest engineering simulation generation company with the intensity and breadth of gear to permit actual-*global Multiphysics*. *The ANSYS Workbench™* platform affords the muse for turning in incorporated Multiphysics simulation with a excessive diploma of automation and a consumer-pleasant interface all in a unified environment.

ANSYS Workbench permits customers to create parametric fashions throughout physics and geometry and to carry out sensitivity research and layout optimization with coupled-physics solutions. This, in turn, affords the best stage of constancy in digital modeling, whilst bodily trying out is both too costly, impractical or maybe impossible.

It is handiest whilst simulation entails more than one physics completely coupled, incorporated and unified that the advantages of digital prototyping and the Simulation Driven Product. Development procedure may be completely exploited withinside the quest for modern merchandise.

From the begin, ANSYS has designed its generation and gear with a bendy basis this is cautiously engineered for *scalability*. *As a consumer's dedication to simulation* evolves, ANSYS helps the strength of desire with the aid of using imparting

functionality degrees that meet the ones converting situations. The closing end result is an ROI course without a lifeless end.

The suite of software program gives scalable flexibility for any stage of know-how from the fashion dressmaker to the engineer to the analyst; scalable overall performance for any kind of use from the laptop to paintings stations to excessive-overall performance supercomputers; and scalable deployment to make bigger with maturing techniques for unmarried customers, paintings companies or the enterprise.

The purpose is to offer gear that match and may without difficulty be incorporated into the overall spectrum of consumer organizations, techniques and challenges, now no longer simply nowadays however with an eye fixed in the direction of the future.

#### **4.13 MESHING AND OPTIMIZATION METHODS**

The BEAM189 detail is appropriate for studying narrow to reasonably stubby/thick beam systems. The detail is primarily based totally on Timoshenko beam concept which incorporates shear-deformation outcomes.

The detail affords alternatives for unrestrained warping and constrained warping of pass-sections.

The detail is a quadratic 3-node beam detail in three-D. With default settings, six ranges of freedom occur at every node; those consist of translations withinside the x, y, and z guidelines and rotations approximately the x, y, and z guidelines.

An optionally available 7th diploma of freedom (warping magnitude) is to be had. The detail is well-proper for linear, big rotation, and/or big-stress nonlinear programs.

Elasticity, plasticity, creep and different nonlinear fabric fashions are supported. A pass-segment related to this detail kind may be a built-up segment referencing a couple of fabric. Added mass, hydrodynamic introduced mass and loading, and buoyant loading are to be had.

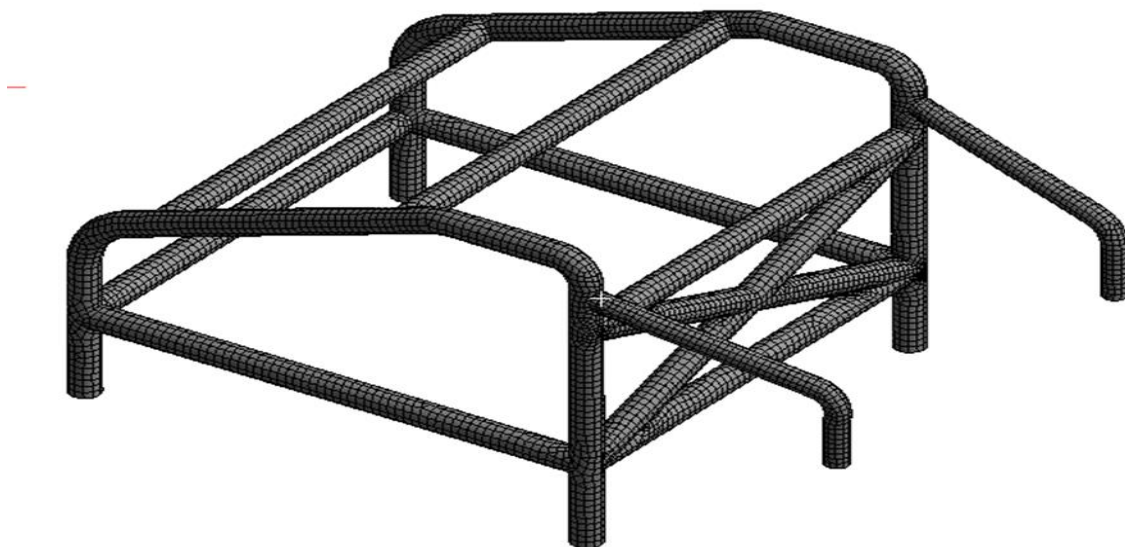
#### 4.14 MESHED MODEL-COMBINED



| Statistics                        |       |
|-----------------------------------|-------|
| <input type="checkbox"/> Nodes    | 68590 |
| <input type="checkbox"/> Elements | 94701 |

*Fig 4.2- MESHED MODEL-COMBINED*

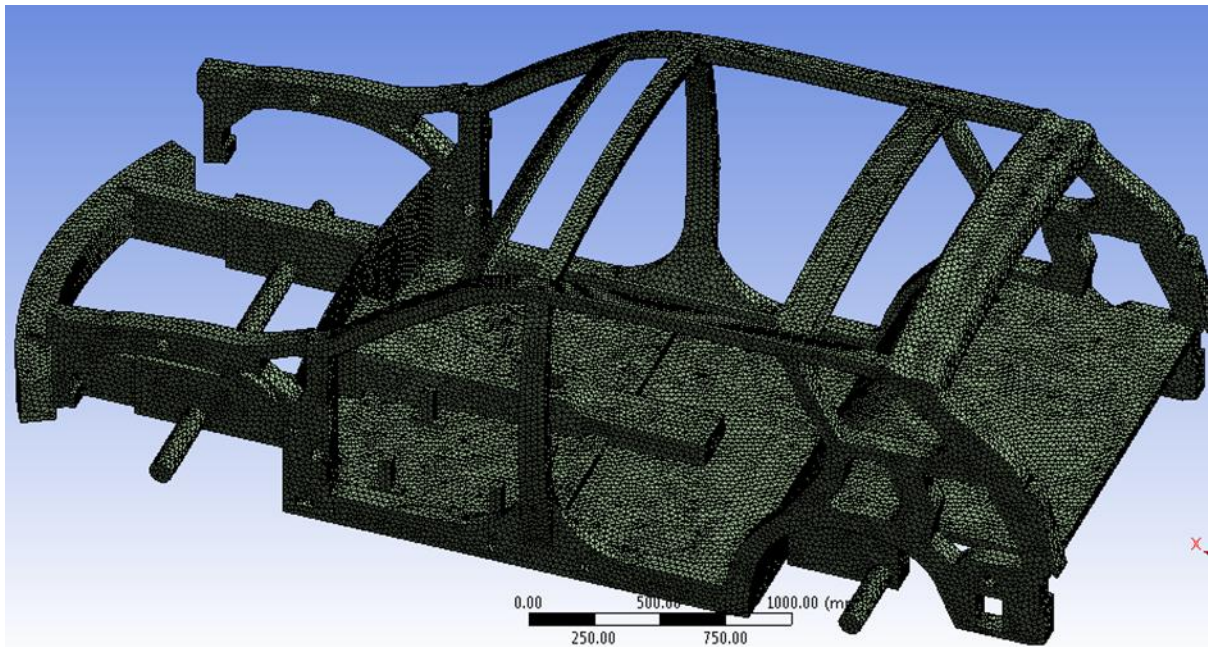
#### 4.15 MESHED MODEL – ROLL CAGE



| Statistics                        |        |
|-----------------------------------|--------|
| <input type="checkbox"/> Nodes    | 143344 |
| <input type="checkbox"/> Elements | 43313  |

*Fig 4.3- MESHED MODEL – ROLL CAGE*

#### 4.16 MESHED MODEL CHASSIS



**Fig 4.4- MESHED MODEL CHASSIS**

#### **MATERIAL PROPERTIES**

| Material         | Mass Density      | Poisson's Ratio | Yield Strength | Young's modulus     |
|------------------|-------------------|-----------------|----------------|---------------------|
|                  | Kg/m <sup>3</sup> | μ               | MPa            | MPa                 |
| Structural steel | 7580              | 0.3             | 250            | 2E <sup>05</sup>    |
| Carbon fibre     | 1810              | 0.3             | 4319           | 2.42E <sup>05</sup> |

**Table 4.1 MATERIAL PROPERTIES**

## **CHAPTER 5**

## 5.1 LS-DYNA INTRODUCTION

LS-DYNA is a sophisticated general-purpose Multiphysics simulation software program package that is actively evolved with the aid of using the Livermore Software Technology Corporation (LSTC). While the package deal maintains to include an increasing number of opportunities for the calculation of many complex, actual global problems, its origins and core-competency lie in fantastically nonlinear brief dynamic finite detail evaluation (FEA) the usage of explicit time integration.

LS-DYNA is being utilized by the automobile, aerospace, creation, military, production, and bioengineering industries.

LS-DYNA is broadly utilized by the automobile enterprise to investigate car designs. LS-DYNA as it should be predicting a automobile's conduct in a collision and the outcomes of the collision upon the automobile's occupants. With LS-DYNA, automobile corporations and their providers can take a look at automobile designs while not having to device or experimentally take a look at a prototype, as a consequence saving time and expense.

### LS-DYNA'S SPECIALISED AUTOMOBILE FUNCTIONS

- *Seatbelts*
- *Slip rings*
- *Pre-tensioners*
- *Retractors*
- *Sensors*
- *Bumpers*
- *Accelerometers*
- *Airbags*
- *Hybrid III dummy fashions*
- *Inflator fashions*

## 5.2 CRASH ANALYSIS INTRODUCTION

A crash simulation is a digital endeavour of a negative crash take a look at of a automobile the usage of a laptop simulation if you want to look at the extent of protection of the automobile and its occupants.

Crash simulations are utilized by automakers in the course of Computer-Aided Engineering (CAE) evaluation for crashworthiness withinside the Computer-Aided Design (CAD) procedure of modeling new cars.

During a crash simulation, the kinetic strength, strength of movement, that a car has earlier than the effect is converted into deformation strength, broadly speaking with the aid of using plastic deformation (plasticity) of the automobile frame fabric (Body in White), on the stop of the effect.

Data acquired from a crash simulation imply the functionality of the automobile frame shape to guard the occupants in the course of a collision (and additionally pedestrians hit with the aid of using a auto mobile) in opposition to injury.

Important effects are the deformations (for example, guidance wheel intrusions) of the occupant area (motive force, passengers) and the decelerations (for example, head acceleration) felt with the aid of using them, which have to fall beneath Neath threshold values constant in criminal automobile protection regulations.

To version actual crash tests, modern crash simulations consist of digital fashions of crash take a look at dummies and of passive protection gadgets (seat belts, airbags, surprise soaking up sprint boards, etc.).

## **FRONT IMPACT ANALYSIS**

For worst situation in the front effect of car, it's far assumed to hit a wall at pace of 60 km/h. Hitting a wall will deliver most viable pressure as wall is non-deformable frame and effect time will smaller Impact evaluation is used to confirm the protection of the motive force.

In this evaluation situation, it's far assumed to be the car hits the wall at the rate of 60km/h. The fabric kind is chosen for the evaluation is the elastoplastic.

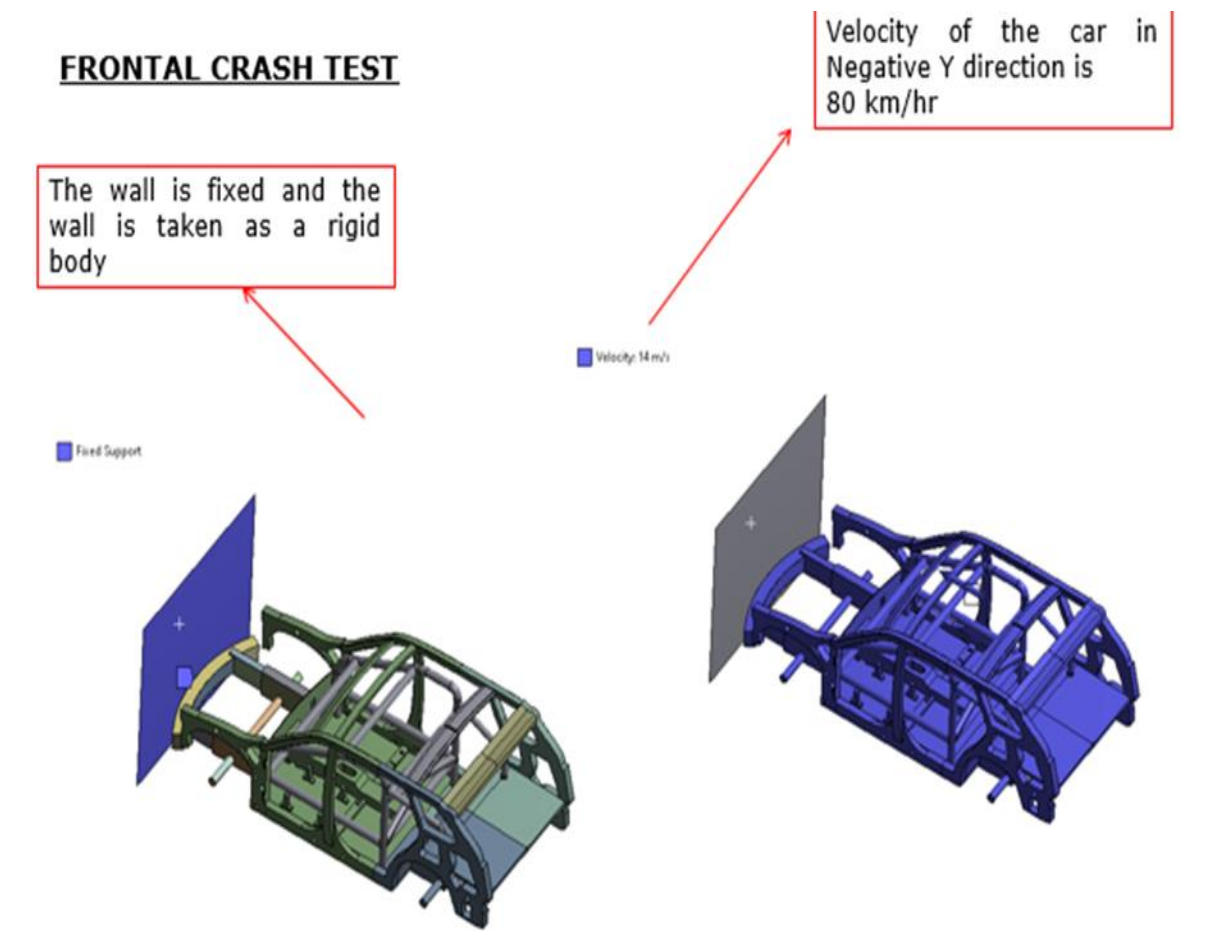
## **5.3 BOUNDARY CONDITIONS**

These specify the present-day nation of a few nodes withinside the finite detail mesh. This is a manner to specify how a number of the nodes withinside the version is

constrained. In order to remedy for effects, it's far essential to specify sufficient boundary situations or constraints.

Each of the nodes withinside the structural gadget has six ranges of freedom, the translational alongside the 3 square coordinate axes and 3 rotary axes approximately every of the square axes.

#### 5.4 FRONTAL CRASH ANALYSIS

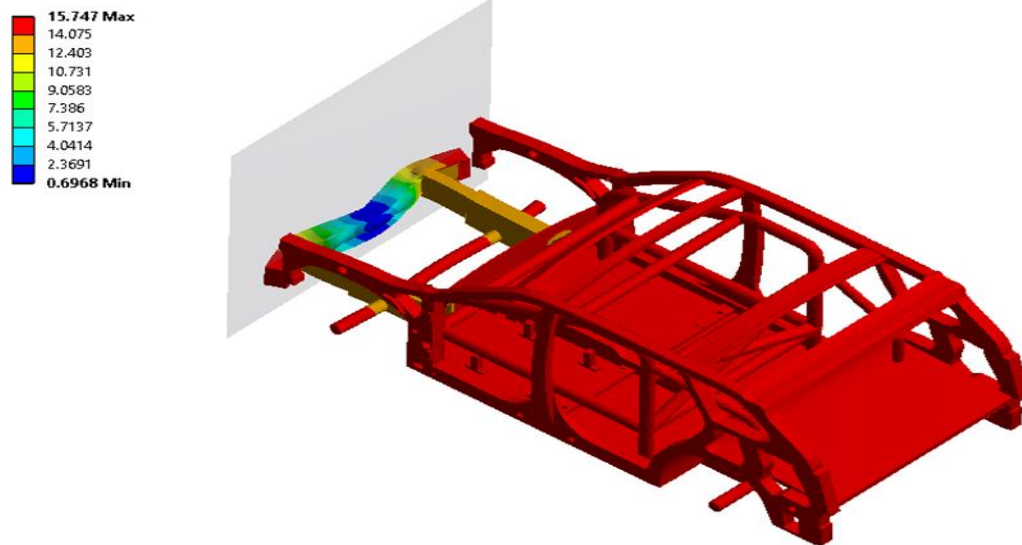


**Fig 5.1- FRONTAL CRASH TEST**

*The Above Figure represents boundary condition for frontal crash test. Here, the wall is fixed as rigid support and the velocity of the car in negative direction is considered as 80 Km/hr.*

## STRUCTURAL STEEL GAUGE RESULTS

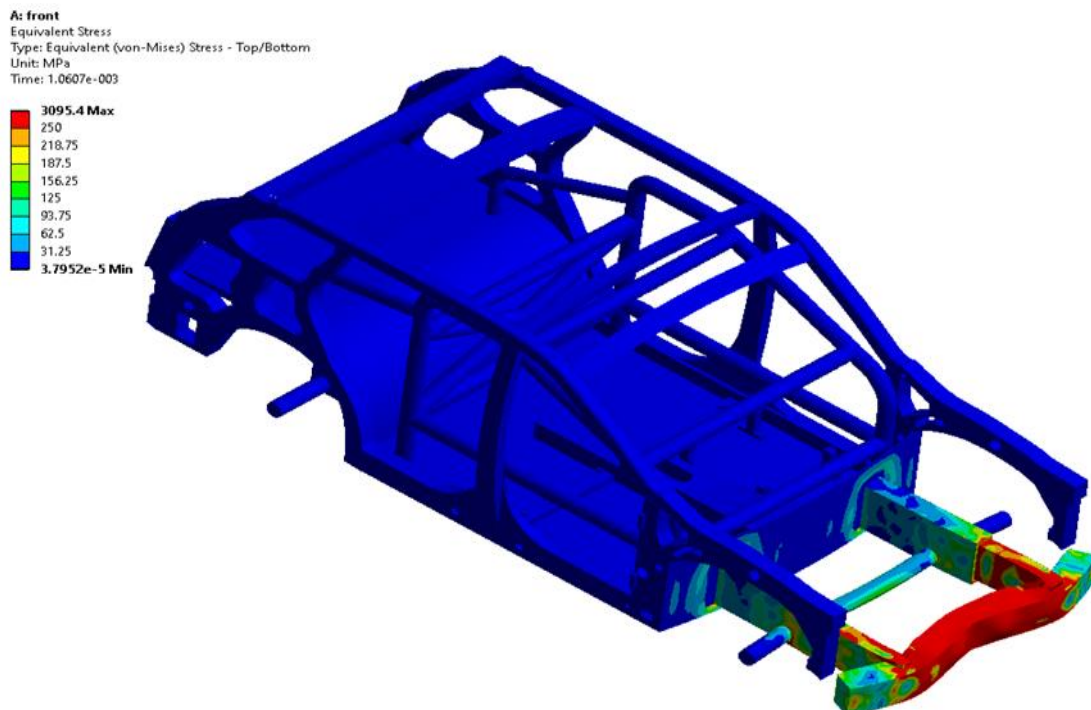
### 5.4.1 TOTAL DEFORMATION (MM)



**Fig 5.2-STRUCTURAL STEEL TOTAL DEFORMATION**

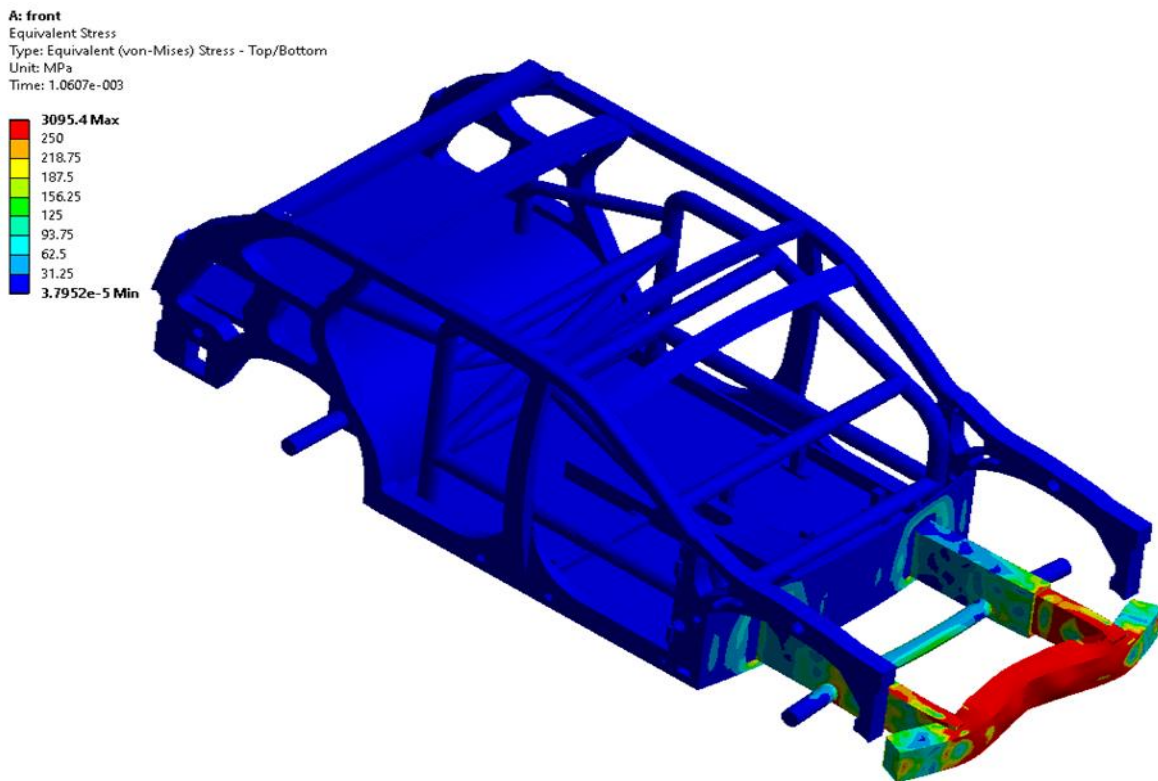
The Above Figure represents Total Deformation occurred during frontal crash test. By observing, it is found that deformation is lower in middle portion of car than other areas for Structural Steel Material.

### 5.4.2 EQUIVALENT STRESS



**Fig 5.3 STRUCTURAL STEEL EQUIVALENT STRESS**

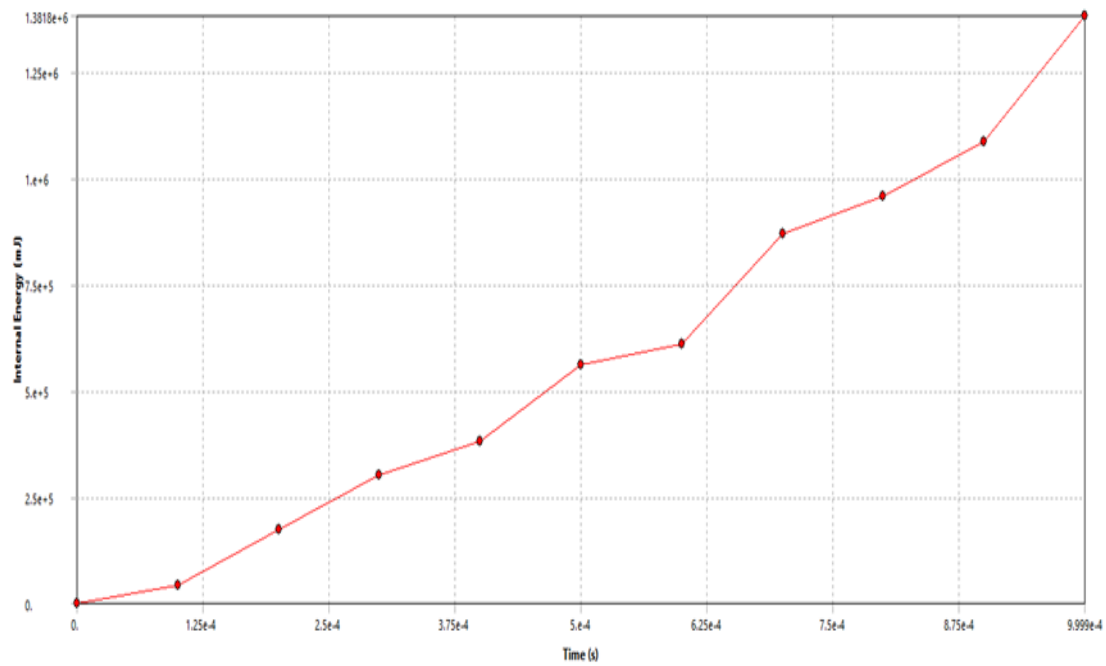
### 5.4.3 EQUIVALENT STRESS (MPa)



**Fig 5.4 STRUCTURAL STEEL EQUIVALENT STRESS**

The Above Figure represents Stress occurred during frontal crash test. By observing, it is found that stress is higher in middle portion of car than other areas.

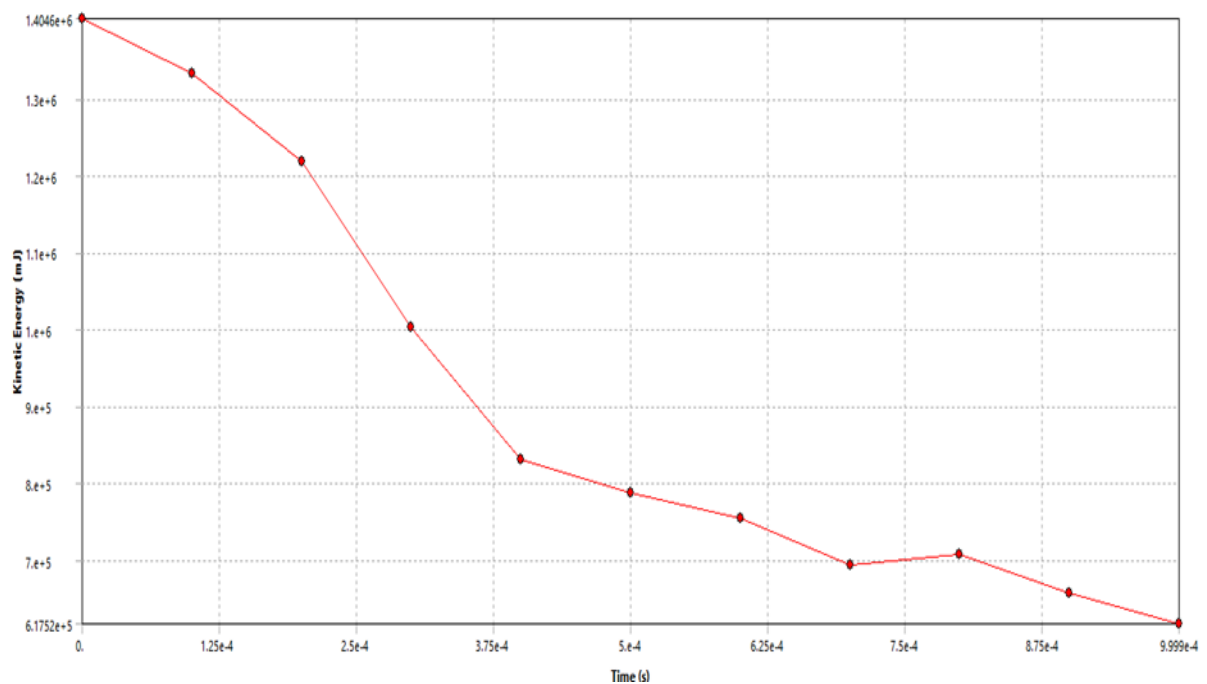
#### 5.4.4 INTERNAL ENERGY(MJ)



**Graph 5.1 STRUCTURAL STEEL INTERNAL ENERGY**

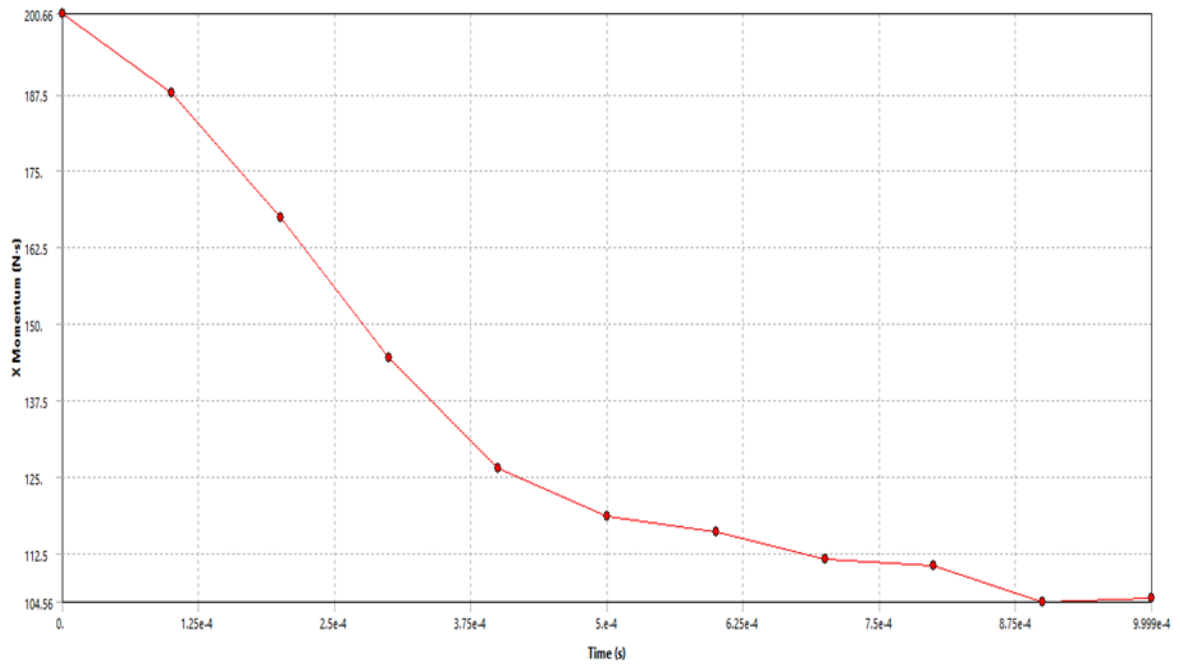
Internal energy of the body is the sum of the random distribution of kinetic and potential energy of all molecules in the body. Here the above Graph represents internal energy vs time taken during frontal crash with structural steel.

#### 5.4.5 KINETIC ENERGY(MJ)



## Graph 5.2 STRUCTRAL STEEL KINETIC ENERGY

### 5.4.6 MOMENTUM TRANSFER (N.s)



Graph 5.3 STRUCTRAL STEEL MOMENTUM TRANSFER

## 5.5 CARBON FIBRE GAUGE RESULTS

### 5.5.1 TOTAL DEFORMATION (MM)

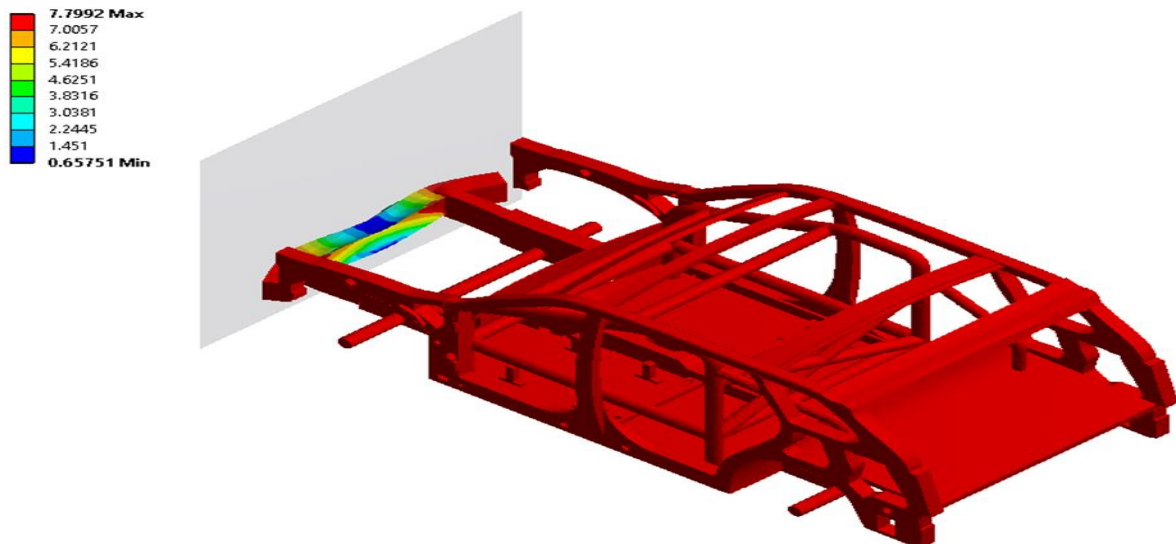
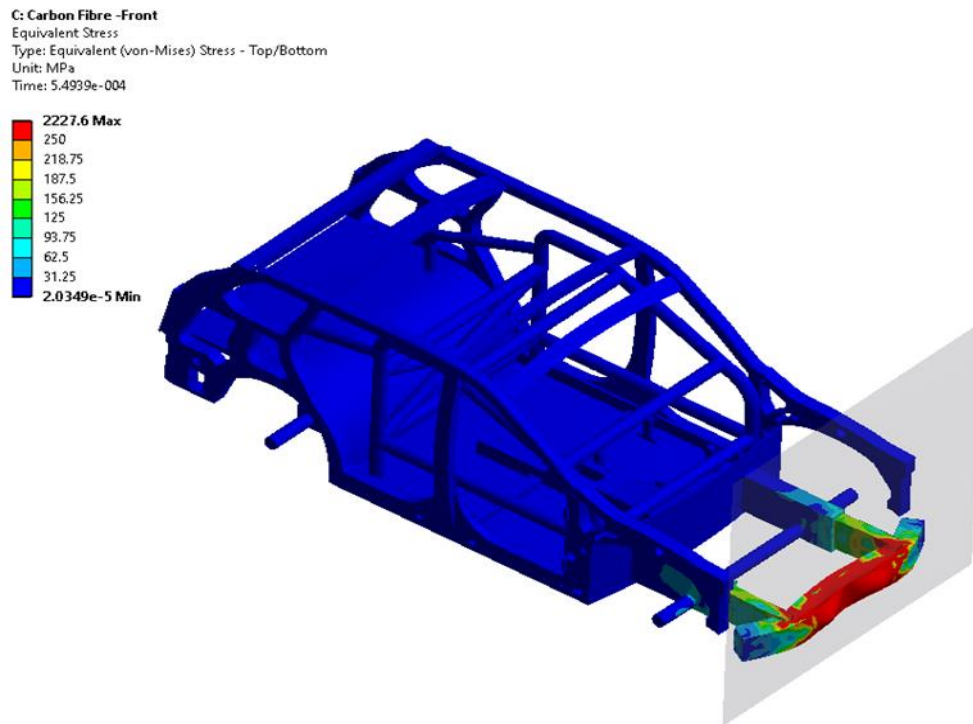


Fig 5.5 CARBON FIBER TOTAL DEFORMATION

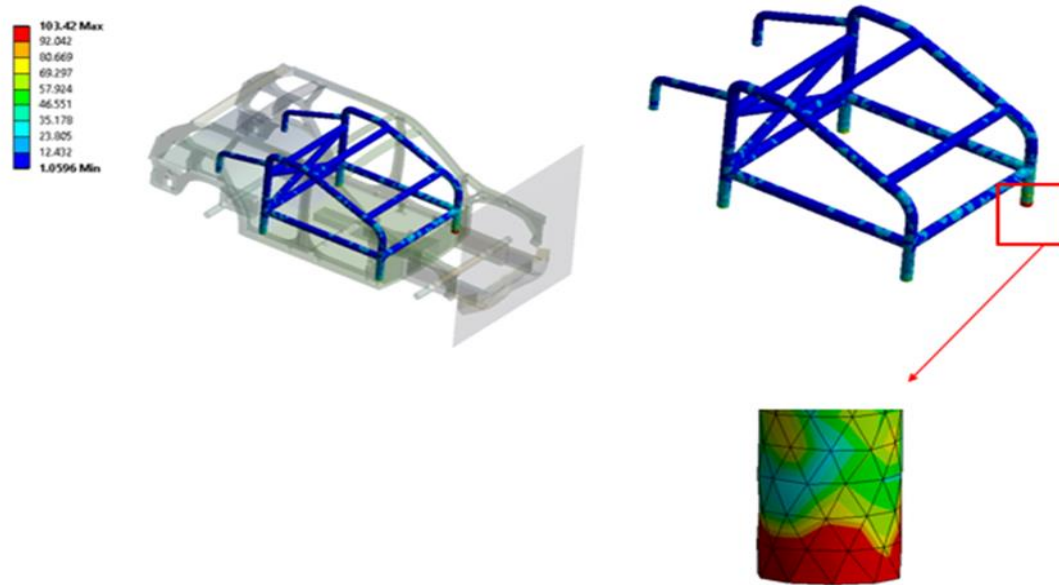
The Above Figure represents Total Deformation occurred during frontal crash test. By observing, it is found that deformation is lower in middle portion of car than other areas for carbon fibre Material.

### 5.5.2 EQUIVALENT STRESS (MPa)



**Fig 5.6 CARBON FIBER EQUIVALENT STRESS**

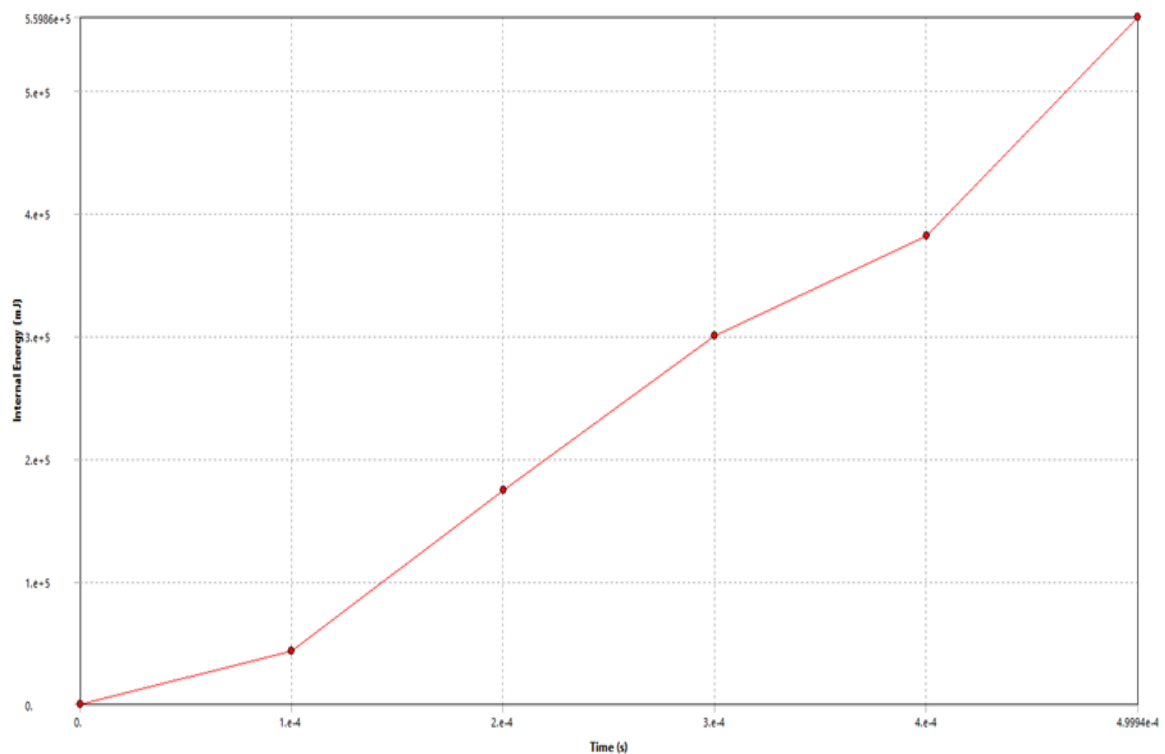
### 5.5.3 EQUIVALENT STRESS (MPa)



**Fig 5.7 CARBON FIBER EQUIVALENT STRESS**

The Above Figure represents Stress occurred during frontal crash test. By observing, it is found that stress is higher in bottom end of the frame and gradually reduces.

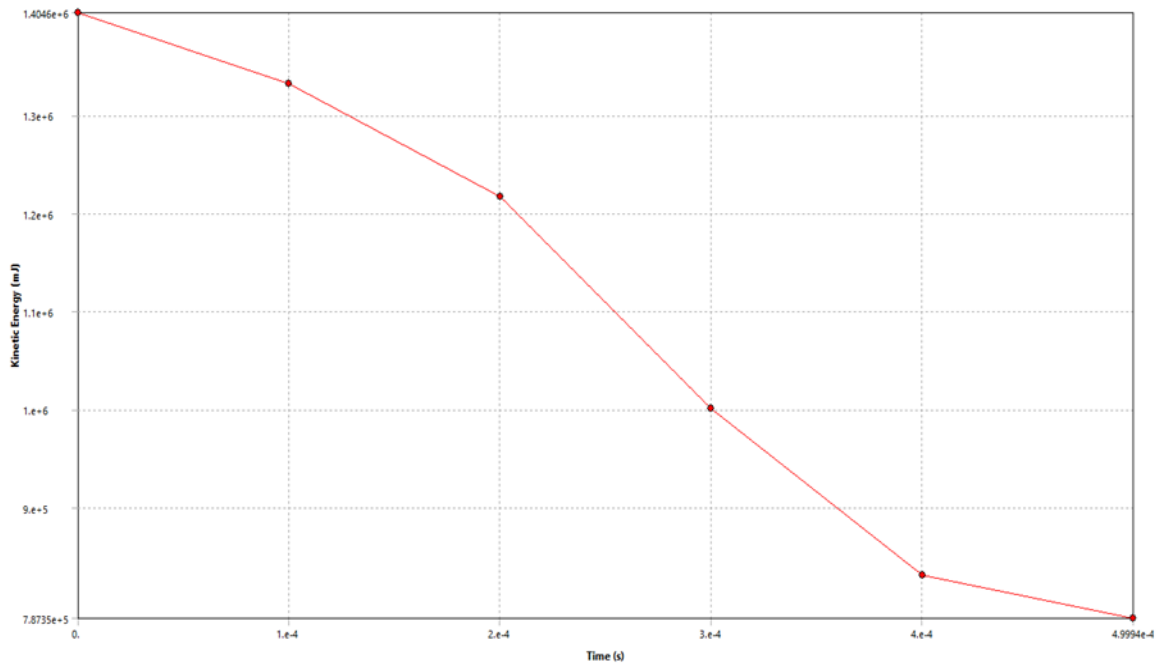
### 5.5.4 INTERNAL ENERGY (MJ)



**Graph 5.4 CARBON FIBER INTERNAL ENERGY**

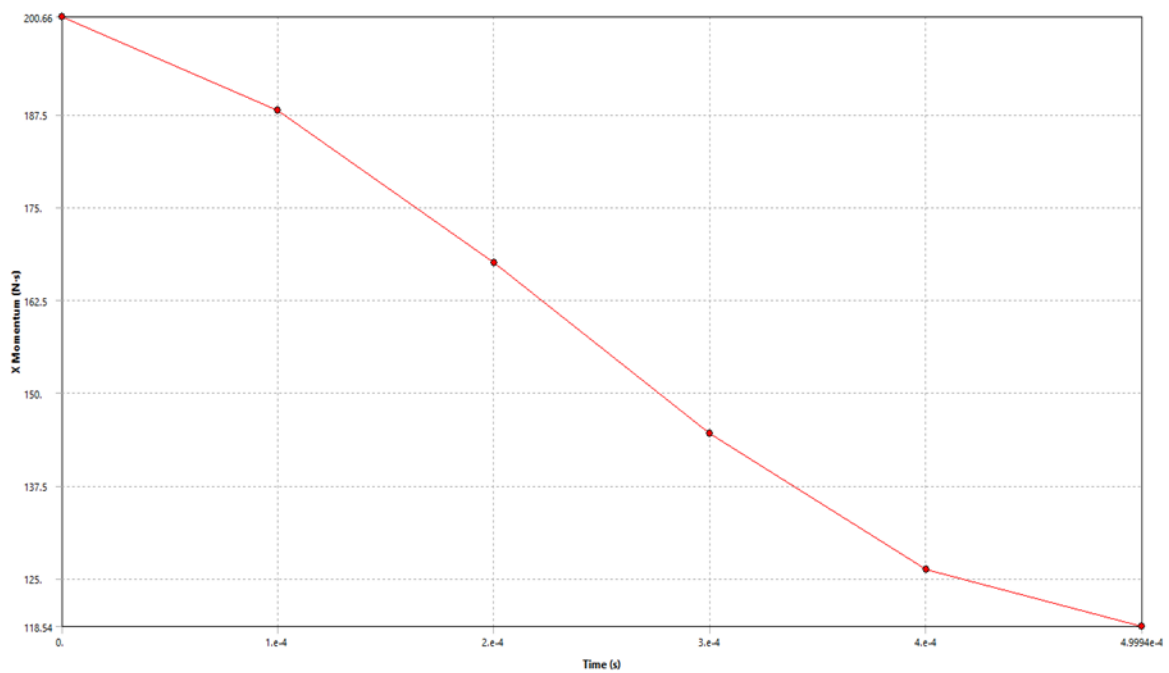
Internal energy of the body is the sum of the random distribution of kinetic and potential energy of all molecules in the body. Here the above Graph represents internal energy vs time taken during frontal crash with Carbon fibre.

### 5.5.5 KINETIC ENERGY(MJ)



**Graph 5.5 CARBON FIBER KINETIC ENERGY**

### 5.5.6 MOMENTUM TRANSFER (N.S)



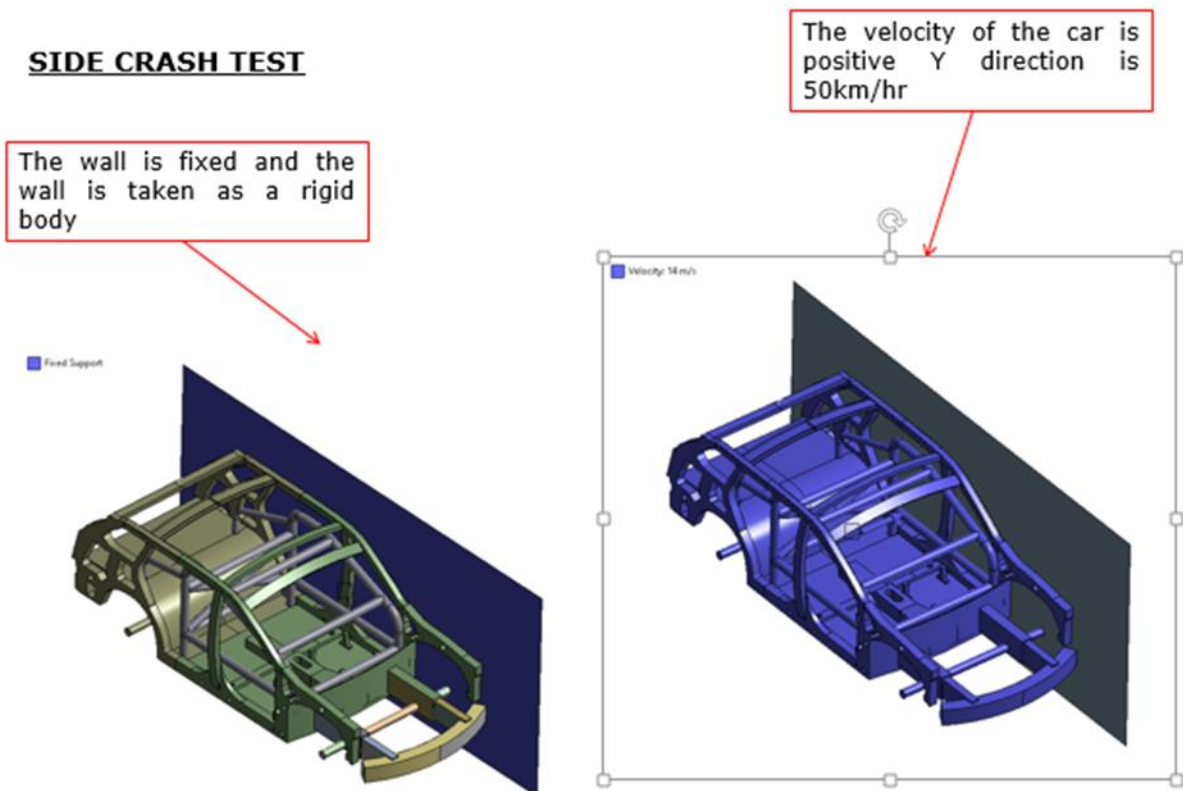
**Graph 5.6 CARBON FIBER MOMENTUM TRANSFER**

## 5.6 SIDE IMPACT ANALYSIS

The Side Impact Dynamic evaluation is performed if you want to discover the quantity of pressure generated and deformation withinside the roll cage if the roll cage is receiving effect with the aid of using the facet with the aid of using any item.

For worst case situation in case of facet effect, it's far assumed that, one car is in movement with the rate of 60km/h and it's far going to be hitting on the facet of different comparable kind of car that's to begin with at rest.

This evaluation is executed with the aid of using the usage of roll cage.

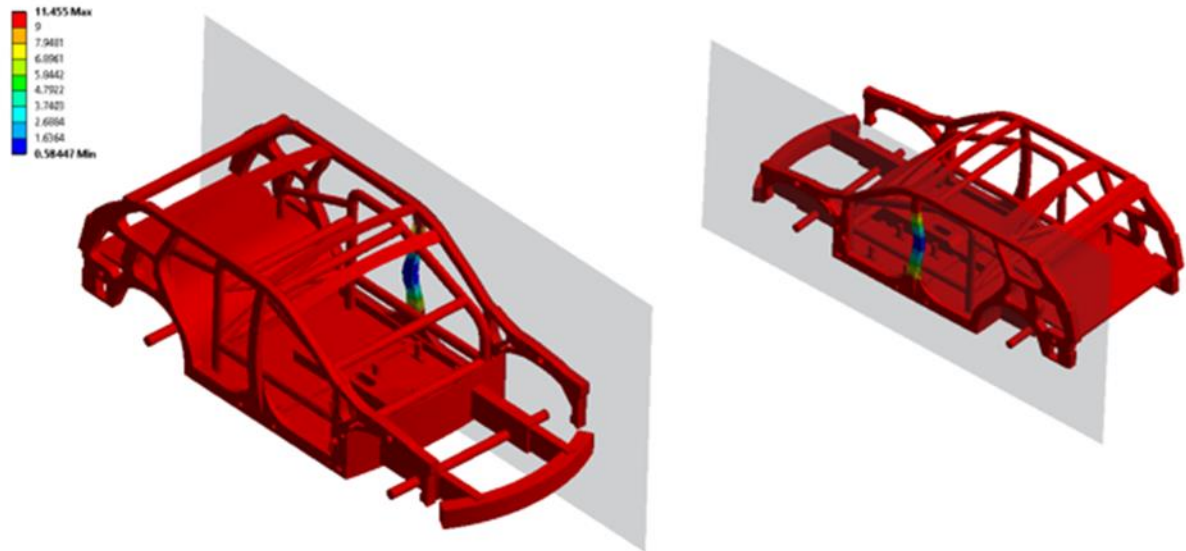


**Fig 5.8 SIDE CRASH TEST**

The Above Figure represents boundary condition for Side crash test. Here, the wall is fixed as rigid support and the velocity of the car in positive Y direction is considered as 50 Km/hr.

## 5.7 STRUCTURAL STEEL GAUGE RESULTS

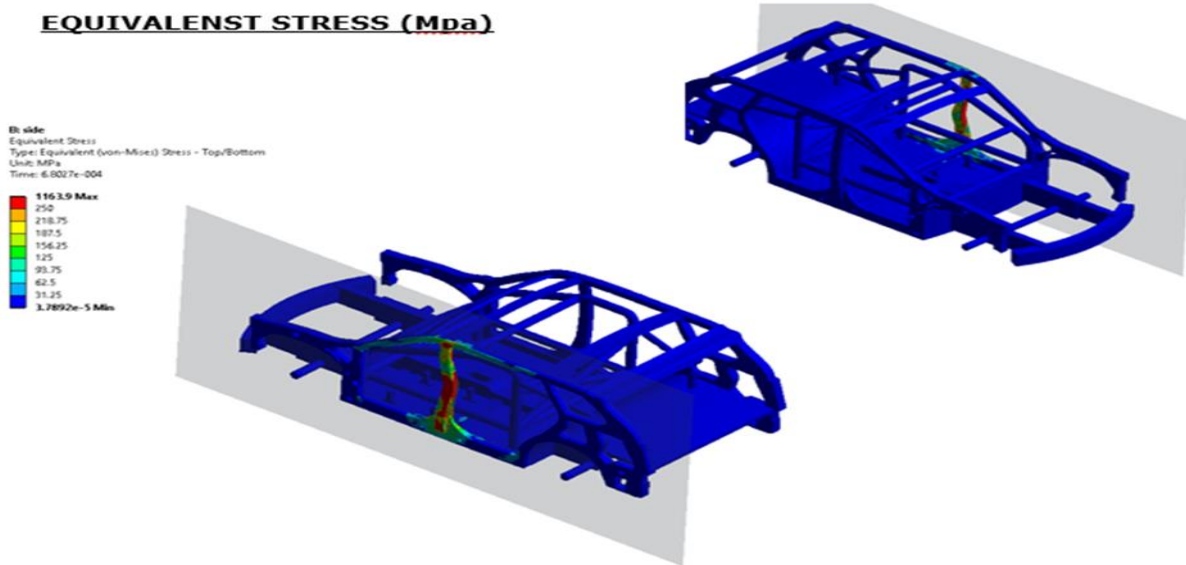
### 5.7.1 TOTAL DEFORMATION (MM)



***Fig 5.9 STRUCTURAL STEEL TOTAL DEFORMATION***

The Above Figure represents Total Deformation occurred during Side crash test. By observing, it is found that deformation is lower in middle portion of car than other areas for Structural Steel Material on side area.

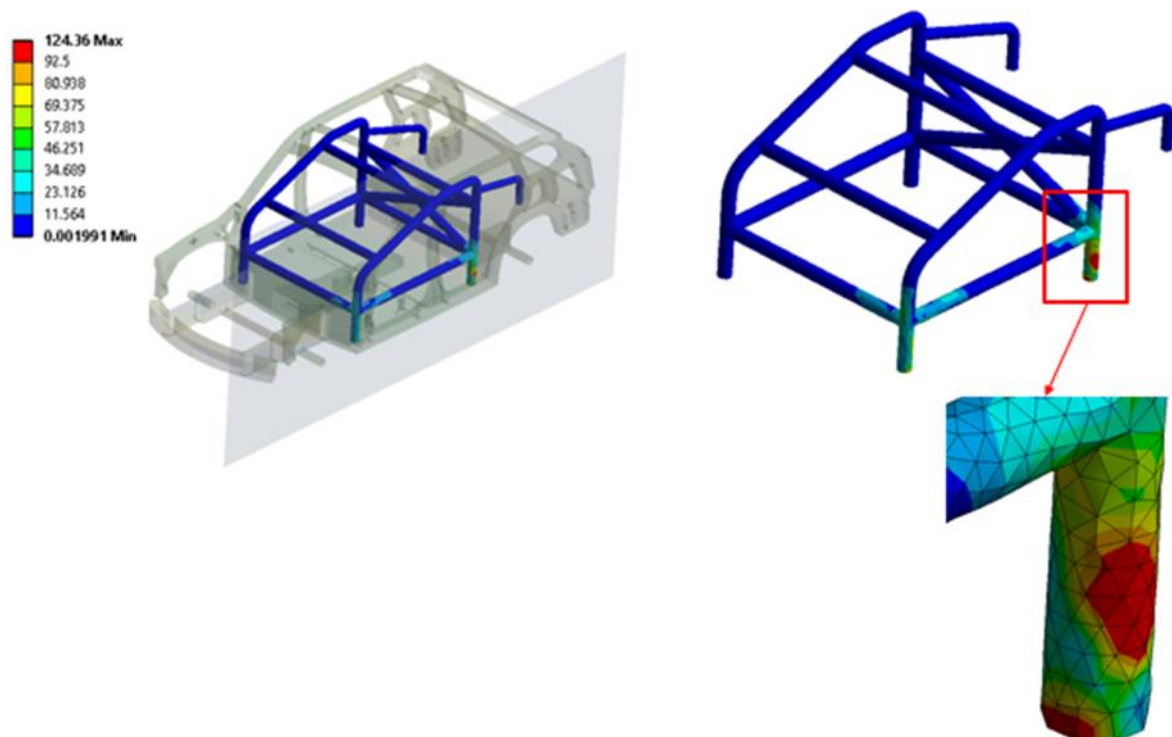
### 5.7.2 EQUIVALENT STRESS (MPa)



**Fig 5.9 STRUCTURAL STEEL EQUIVALENST STRESS**

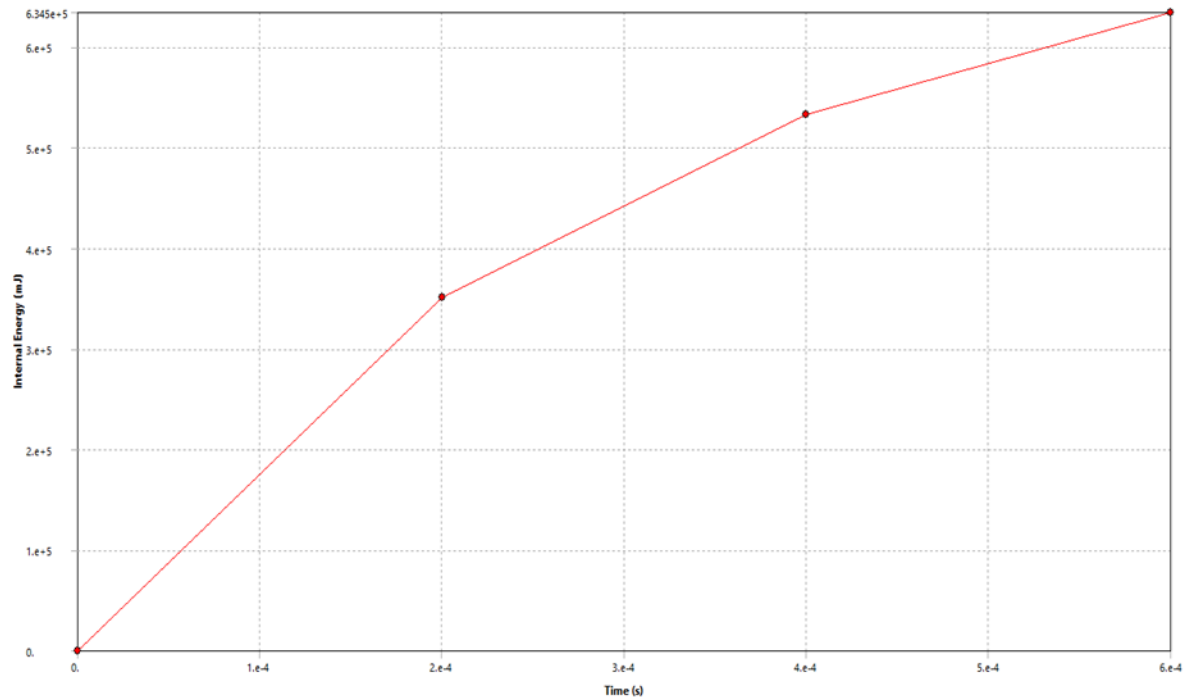
The Above Figure represents Stress occurred during side crash test. By observing, it is found that stress is higher in bottom end of the frame and gradually reduces.

### 5.7.3 EQUIVALENT STRESS (MPa)



**Fig 5.10 STRUCTURAL STEEL EQUIVALENT STRESS**

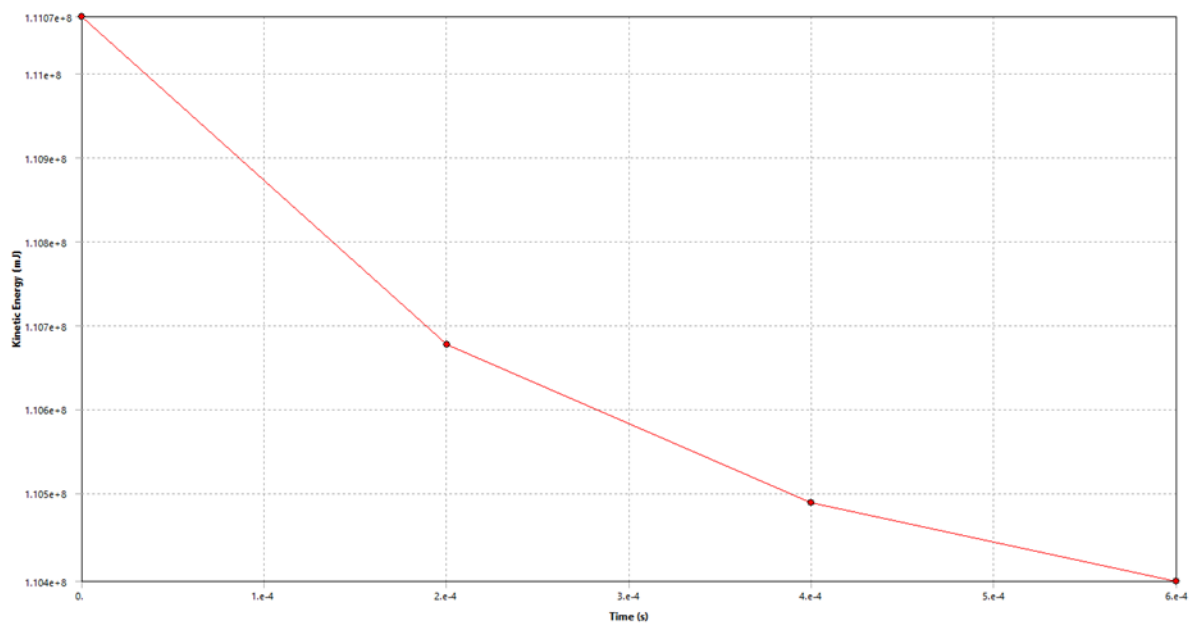
#### 5.7.4 INTERNAL ENERGY(MJ)



**Graph 5.7 STRUTRAL STEEL INTERNAL ENERGY**

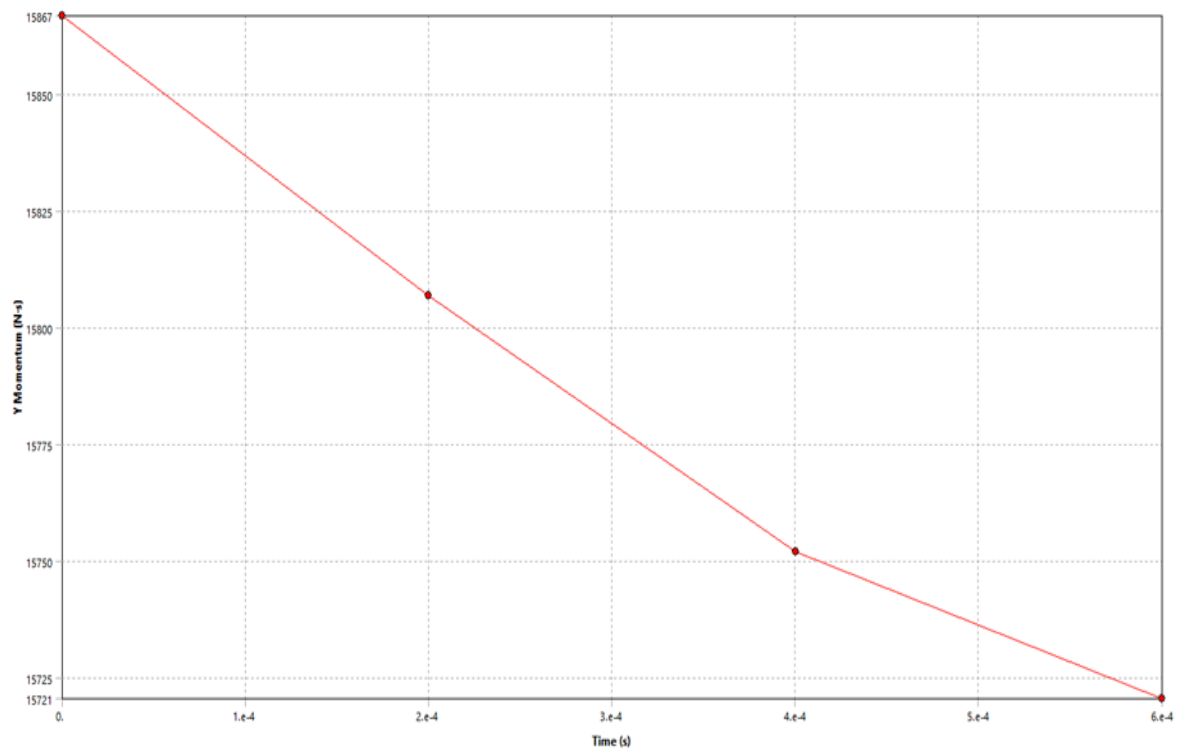
Internal energy of the body is the sum of the random distribution of kinetic and potential energy of all molecules in the body. Here the above Graph represents internal energy vs time taken during side crash with Structural Steel material.

#### 5.7.5 KINETIC ENERGY(MJ)



**Graph 5.8 STRUTRAL STEEL KINETIC ENERGY**

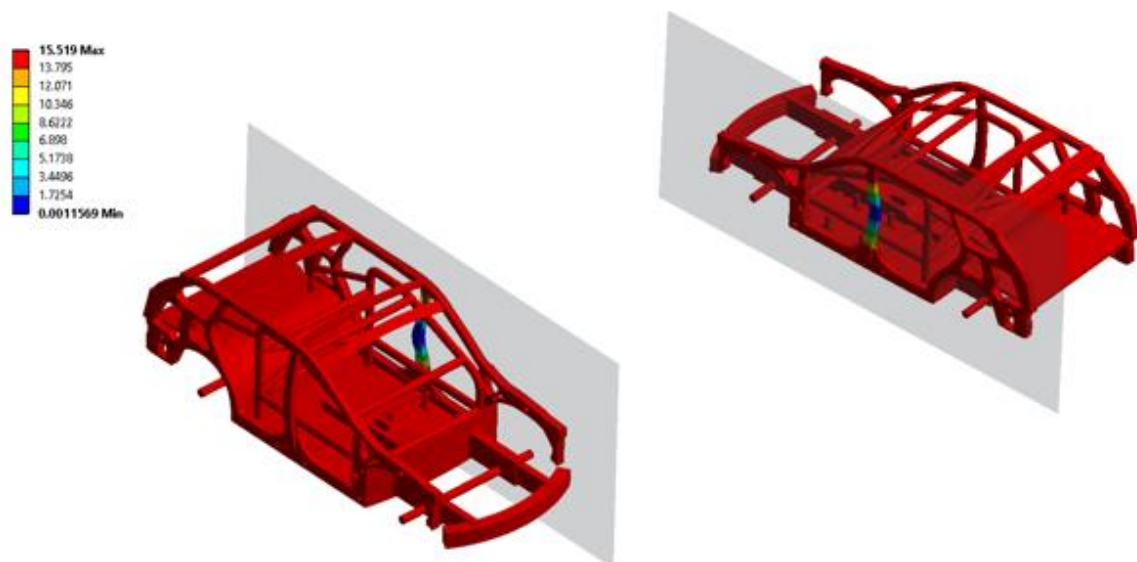
### 5.7.6 MOMENTUM TRANSFER (N.S)



**Graph 5.9 STRUCTRAL STEEL MOMENTUM TRANSFE**

### 5.8 CARBON FIBER GAUGE RESULTS

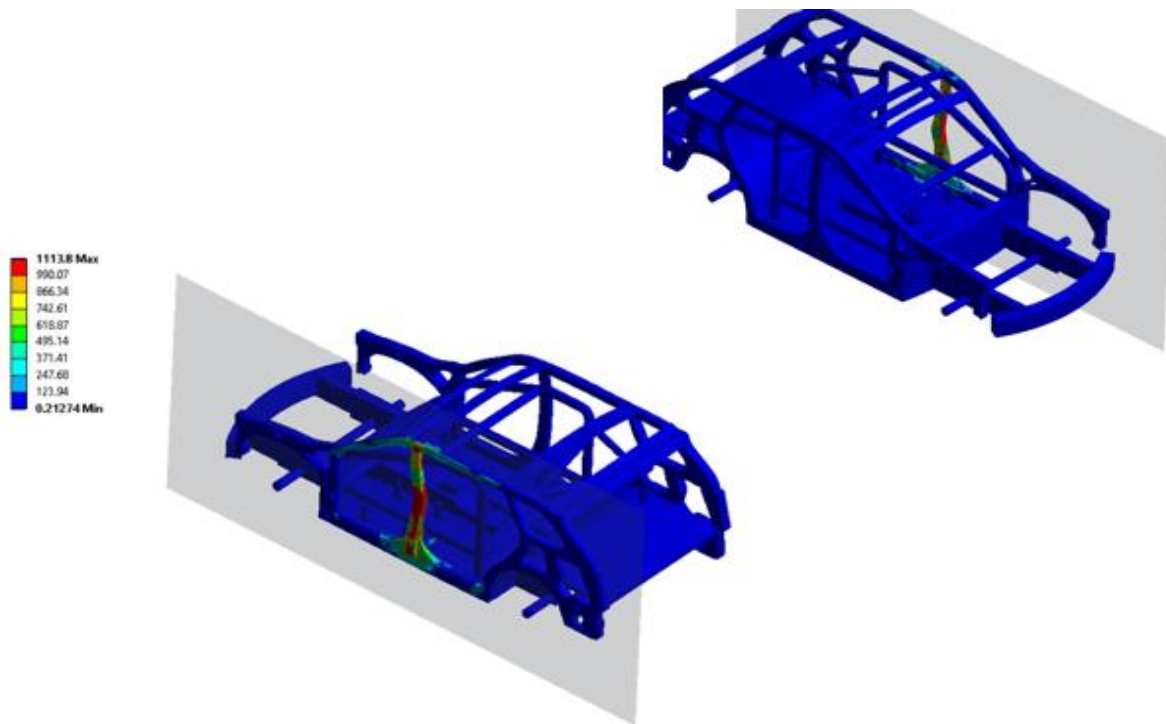
#### 5.8.1 TOTAL DEFORMATION (MM)



**Fig 5.11 CARBON FIBRE TOTAL DEFORMATION**

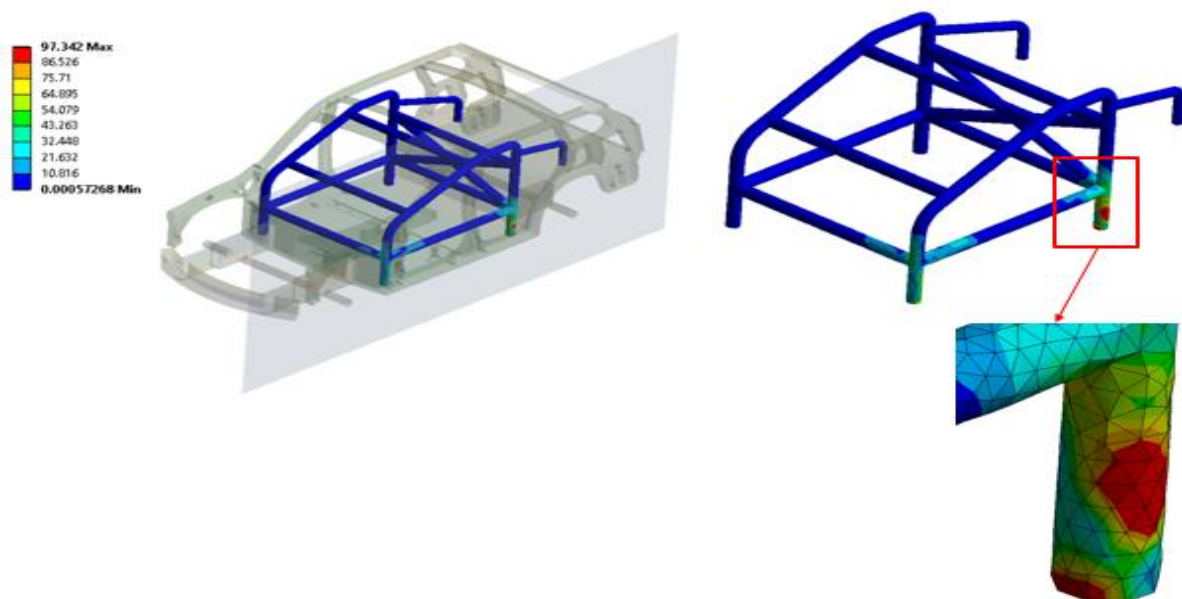
The Above Figure represents Total Deformation occurred during Side crash test. By observing, it is found that deformation is lower in middle portion of car than other areas for Carbon Fibre Material on side area.

### **5.8.2 EQUIVALENT STRESS (MPA)**



***Fig 5.12 CARBON FIBRE EQUIVALENT STRESS***

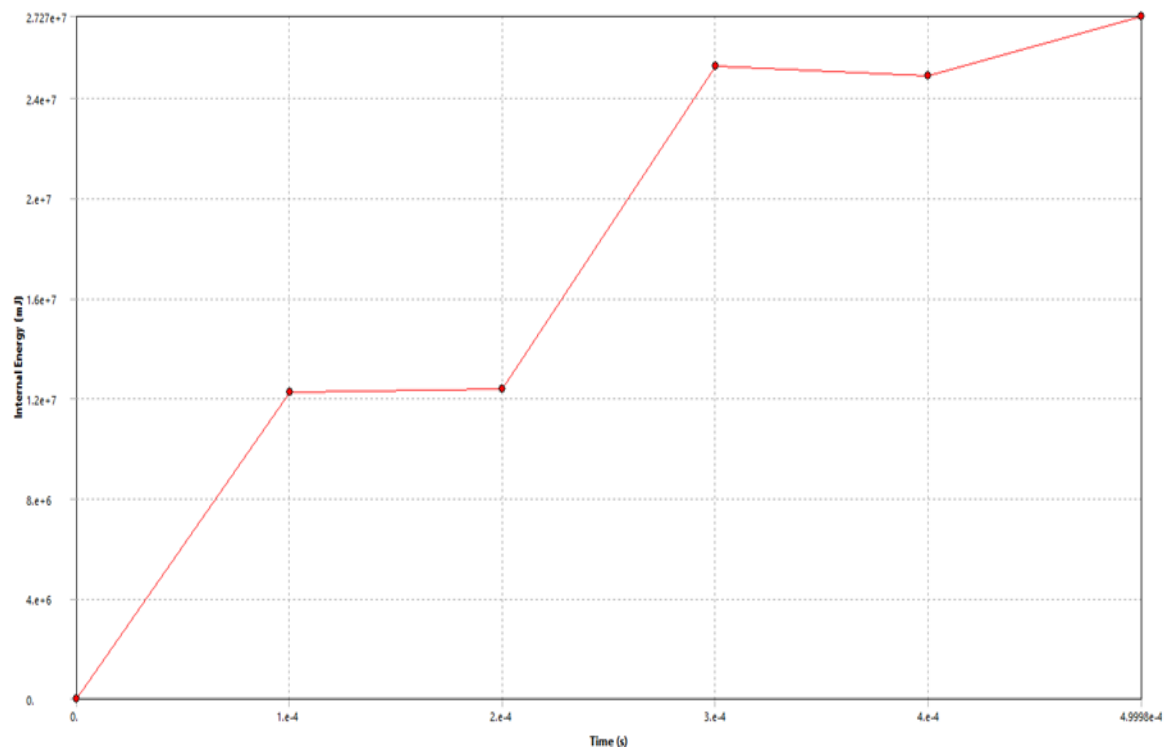
### 5.8.3 EQUIVALENT STRESS (MPa)



**Fig 5.13 CARBON FIBRE EQUIVALENT STRESS**

The Above Figure represents Stress occurred during side crash test. By observing, it is found that stress is higher in bottom end of the frame and gradually reduces.

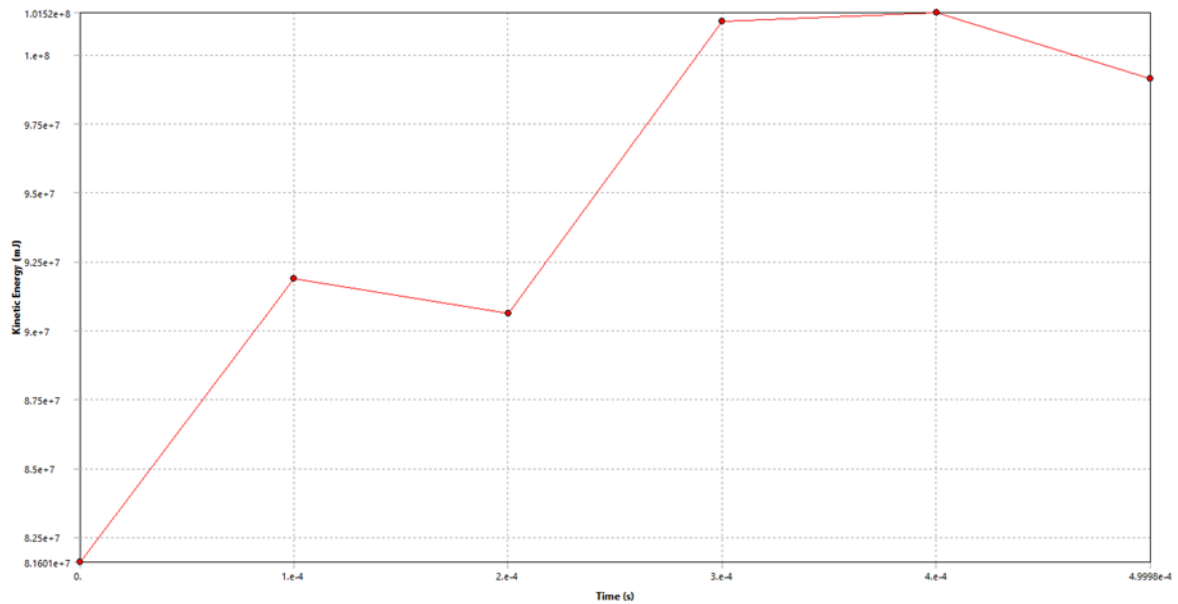
### 5.8.4 INTERNAL ENERGY(MJ)



**Graph 5.10 CARBON FIBER INTERNAL ENERGY**

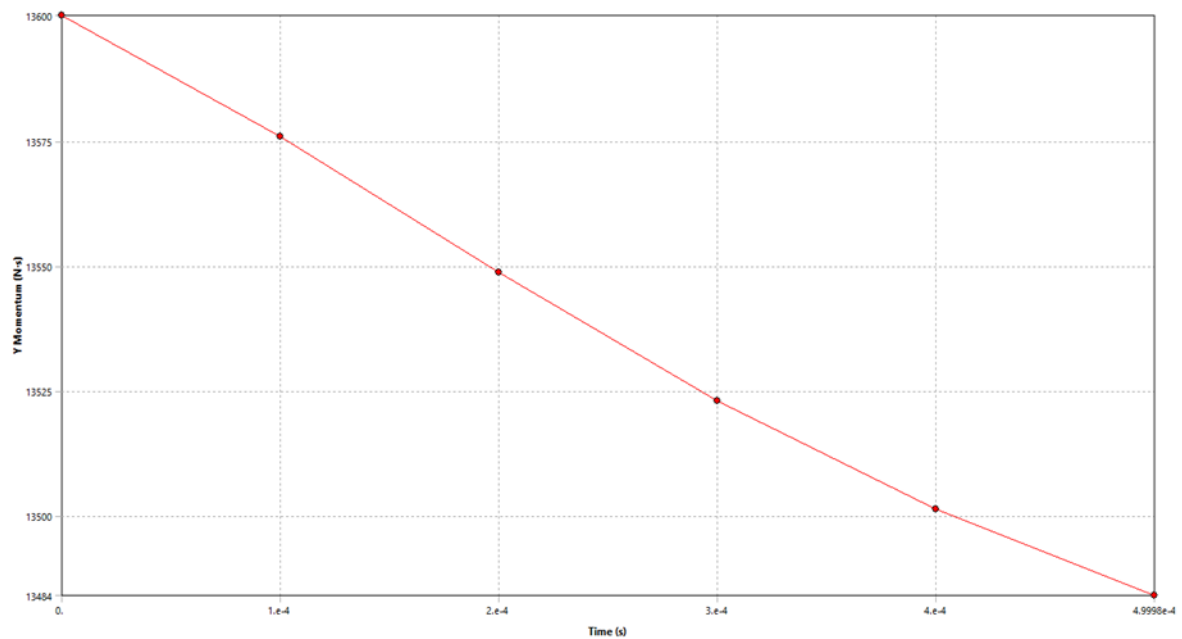
Internal energy of the body is the sum of the random distribution of kinetic and potential energy of all molecules in the body. Here the above Graph represents internal energy vs time taken during side crash with Structural Steel material.

### 5.8.5 KINETIC ENERGY(MJ)



**Graph 5.11 CARBON FIBER KINETIC ENERGY**

### 5.8.6 MOMENTUM TRANSFER (N.S)



**Graph 5.12 CARBON FIBER MOMENTUM TRANSFER**

## CHAPTER 6

### CONCLUSION

- Thus, we will from the frontal crash the front engine facet structural component handiest collides tons better than that of the passenger region.
- From the facet crash the pressure stage shows that the only facet of the automobile is completely crashed and the passenger region additionally get crashed withinside the effect.
- Internal strength graphs indicates that when the crash the inner strength of the automobile is extended in al the 3 crash tests.
- Kinetic strength of the automobile on the precise pace is switch to the inflexible wall in the course of the collision.
- At the time of effect, the Momentum from the automobile at precise pace is transferred to the wall which may be diagnosed from the momentum switch graphs.
- In this observe the traditional roll gauge fabric (metallic) changed into changed with the carbon fibre which offers a few upgrades in phrases of structural electricity and discount in weight

| TYPES OF ANALYSIS | DEFORMATION (MM) |              | EQUIVALENT STRESS (MPa) |              |
|-------------------|------------------|--------------|-------------------------|--------------|
|                   | STEEL            | CARBON FIBRE | STEEL                   | CARBON FIBRE |
| FRONT CRASH       | 5.747            | 7.992        | 3095.4                  | 2227.6       |
| SIDE CRASH        | 11.455           | 15.519       | 1163.9                  | 1113.8       |

**Table 6.1 RESULT**

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