Crash Analysis of Roll Cage Chassis for a Sport Utility Vehicle

Dillip Kumar Sahoo[1], Sathwik Kotha[2] Mohammed Musthakeem Basha[3]

[1]Associate Professor, School of Mechanical Engineering, Sathyabama Institute of Science and Technology, Chennai, TN, India,600119.
[2,3] UG students, School of Mechanical Engineering, Sathyabama Institute of Science and Technology, Chennai, TN, India,600119.
Email- dillipkumarsahoo@gmail.com[1], sathwikkotha24@gmail.com [2]
bashamusthakeem@gmail.com [3],

Abstract

The roll cage is one of the most important parts for personal protection in every sports car and rally vehicle. In this analytical study, an optimized roll cage has been designed, which has more tendency to observe Kinetic energy during a collision. The optimized roll cage is modeled using solid works software, and the cash analysis has been done using Ansys workbench. The role of the cage has undergone Both frontal and Side impact analysis Using different load conditions, and the response of the structural member is extensively discussed and analyzed. In this mechanical behavior, two different materials are considered for a structural member of the Roll cage; the development of equivalent stress, total deformation, and Internal Energy are analyzed.

Keywords: Structural steel, Carbon fiber, Total deformation, Equivalent Stress, Internal Energy

1 Introduction

The passenger compartment of an automobile guards its occupant against being injured or killed. The roll cage is an 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 considered incorporate compact layout, ergonomics, durability, ease during production, and mild weight. Y.Mahajan et al [1] developed a dynamic analysis of a roll cage for an off-road car. The dynamic evaluation includes a crash test effect, facet effect, and a head-on collision with a hyper mesh software system. Denish, et al [2] describe how the evaluation of strain effects while loading shows front, facet, and rear effects using an Ansys workbench. The want of the layout and evaluation of the roll cage of a racing automobile utilized by college students in the course of competitions is to deal with the failure of structural contributors, which ends in injuries. The shape of a roll cage needs to be mild in weight and inflexible. Also, it needs to act because of 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 driven.

Mahendra H M, et al [3] describe how a not-unusual place version of the roll cage has 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. And suggested using carbon steel over metallic bars. Bharat Kumar Sati et al. [4] states that static and dynamic evaluation of the roll cage of ATV. Static evaluation of the roll cage has executed the usage of

ANSYS Static Structural for exceptional collisions like the front, facet, rear, and rollover. Pruthviraj Vitthal et al [5] described the element description of ordinary layout considerations and static and dynamic evaluation of the FSAE roll cage. This paper offers the general layout technique of roll cage of the FSAE car from start to end, in addition to its Finite Elemental Analysis (static & dynamic). A 3-D CAD version of a roll cage is made using the Solidworks software program, and FEA evaluation has executed the usage of ANSYS 17.0.

The vehicle frame is split into components; roll cage and bodywork. The traditional Roll cage seems like a truss welded at joints. This body protects its Occupants from a coincidence, particularly in case of a rollover. A chassis that could soak up excessive strength affects even controlling the fee of deceleration will grow the probability of drivers surviving a crash without injury.

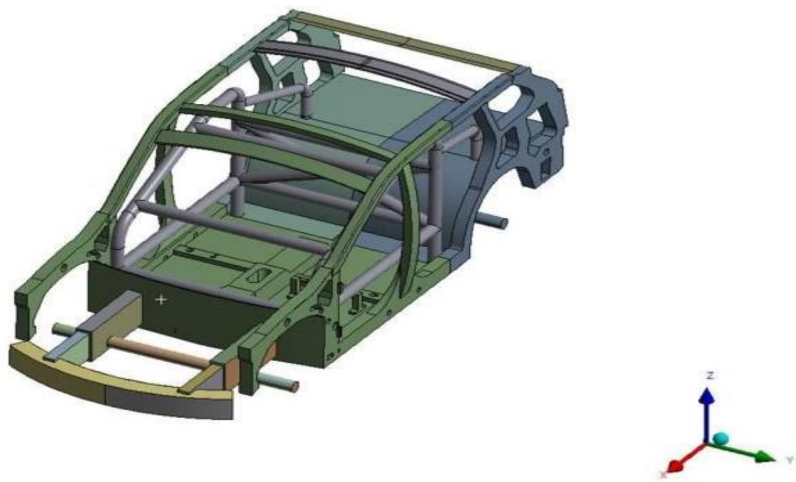


Figure 1: Frame Layout of a sports utility vehicle

Deepak Raina et al. [6] described the roll cage's layout goal as effectively and safely encapsulating all car additives, including a motive force. The roll cage's principal elements targeted during the layout and implementation blanketed motive force protection, suspension, drive-teach integration, structuralpressure, weight, and operator ergonomics.

2 Modeling and meshing

2.1 Modeling

The roll cage design into a layout with the Solid Works software program which is shown in figure 2.. It is designed so that during a collision, it tends to observe the kinetic energy during the collision and provides structural support to the chassis.

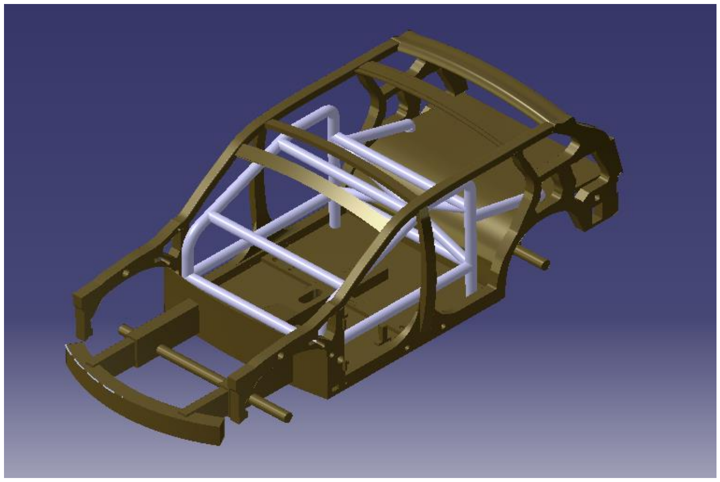
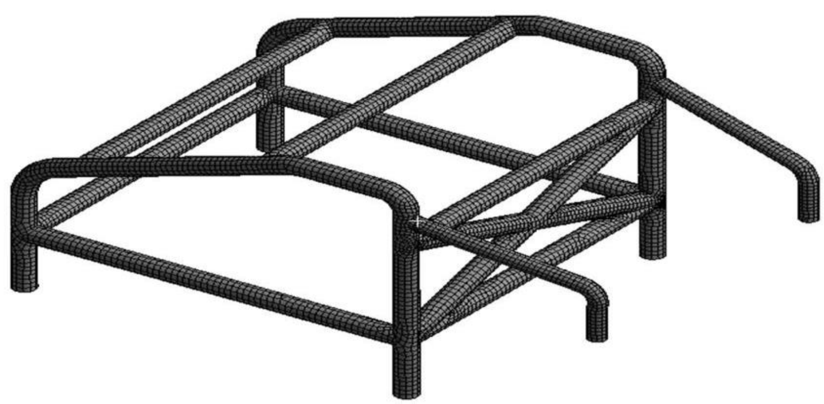


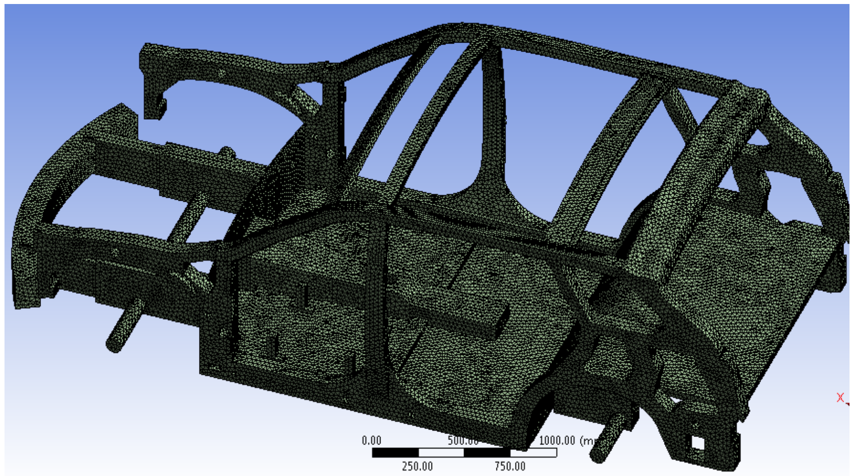
Figure 2: Model of a roll cage used for analysis

2.2 Mesh Generation

The geometry is discredited to shape a mesh of factors and nodes. This method divides the shape into small sub-areas on which the numerical analog of the governing equations may evolve. The meshed format relies upon one. The geometry of the shape, the kind of evaluation, i.e., static, dynamic, thermal, or non-linear, the boundary situations, the loading, and the required result. The BEAM189 detail is appropriate for studying narrow to reasonably stubby/thick beam systems. The detail is primarily based on the Timoshenko beam concept, which incorporates shear-deformation outcomes. The detail is a quadratic 3-node beam detail in 3-D. With default settings, six ranges of freedom occur at every node; those consist of translations inside the x, y, and z guidelines and rotations approximately the x, y, and z guidelines. Elasticity, plasticity, creep, and different non-linear fabric fashions are supported. A pass segment related to this detailed kind may be a built-up segment referencing a couple of fabrics. Added mass, hydrodynamic introduced mass and loading, and buoyant loading are to be had. The meshing structure of the roll cage and chassis is shown in figure 3.



(a)



(b)

Figure 3: meshing structure (a) roll cage (b) chassis

2.3 Crash Analysis

A crash simulation is a digital endeavor of a negative crash that takes a look at an automobile the Use 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 with inside the Computer-Aided Design (CAD) procedure of modeling new cars. During a crash simulation, the kinetic strength, the strength of the 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 top of the effect. Data from a crash simulation imply the functionality of the automobile frame shape to guard the occupants during a collision (and additionally pedestrians hit with the aid of using an automobile) in opposition to injury.

3 RESULTS AND DISCUSSION

3.1 Analysis of Frontal impact structure of roll cage chassis.

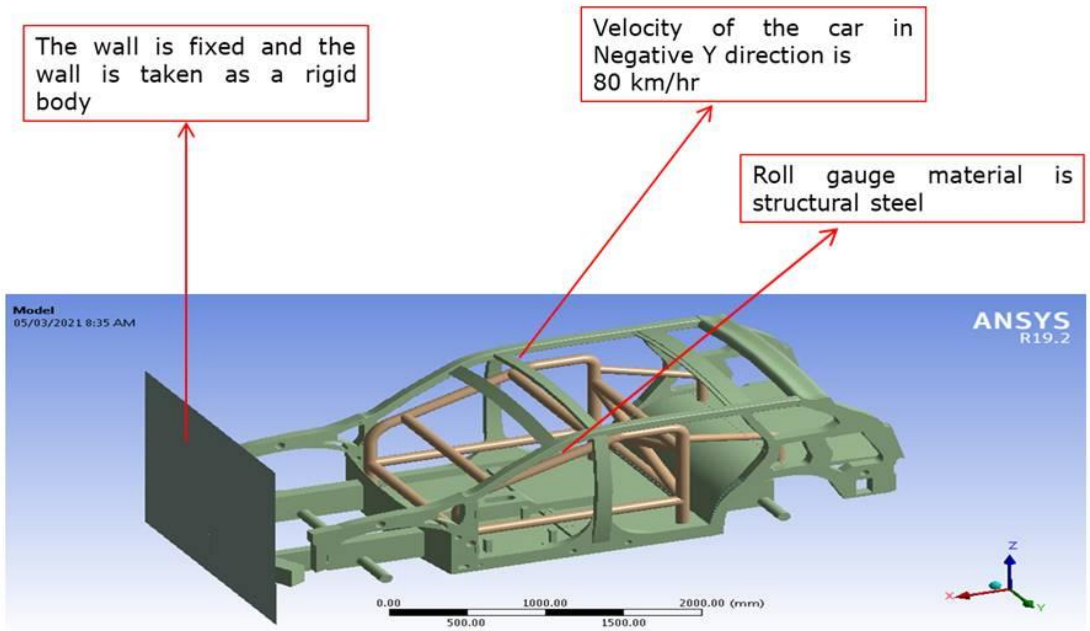
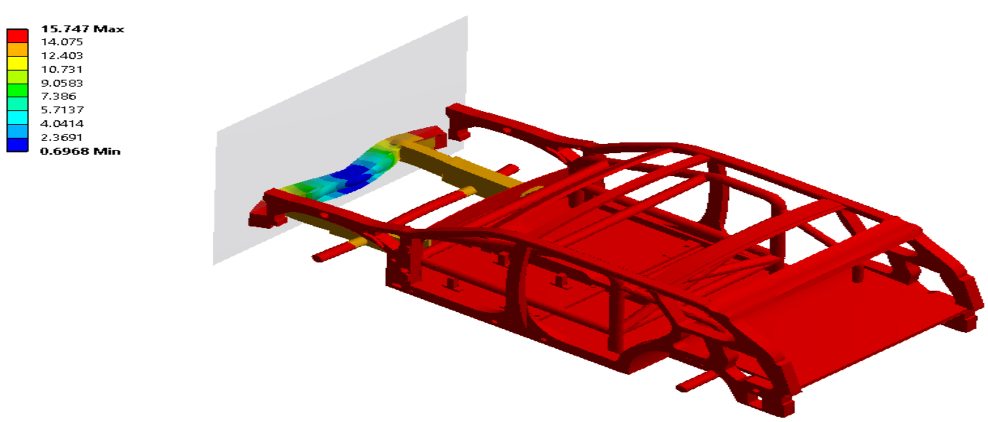


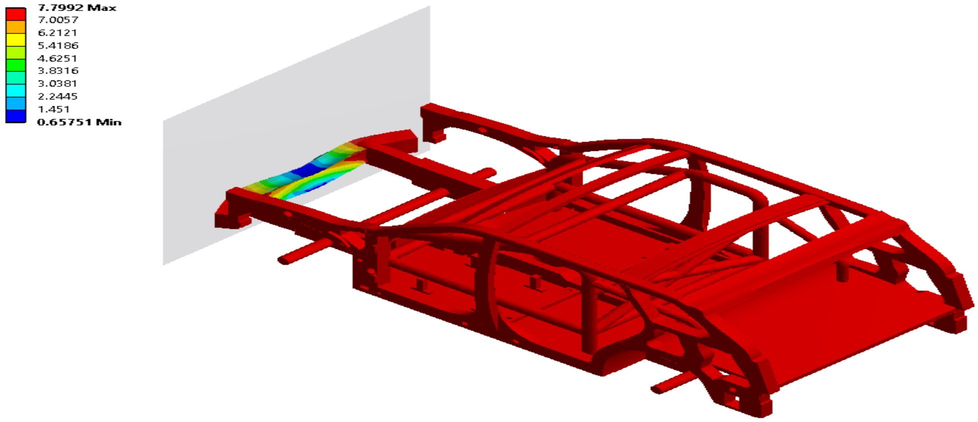
Figure 4: Frontal Crash Test

Figure 3 represents the boundary condition for the frontal crash test. Here, the wall is fixed as a rigid support, and the car's velocity in the negative direction is considered as 80 Km/hr. The total deformation, Equivalent Stress, and Internal Energy are compared and analyzed.

3.1.1 Analysis of Total Deformation



(a)

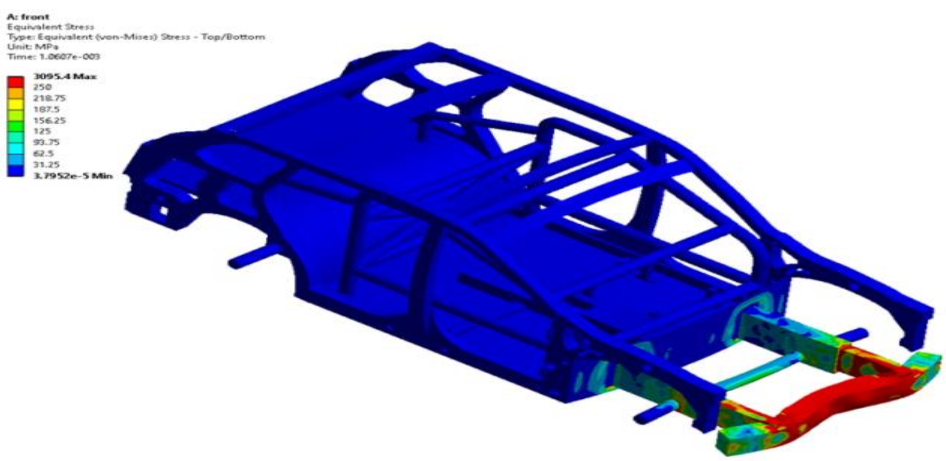


(b)

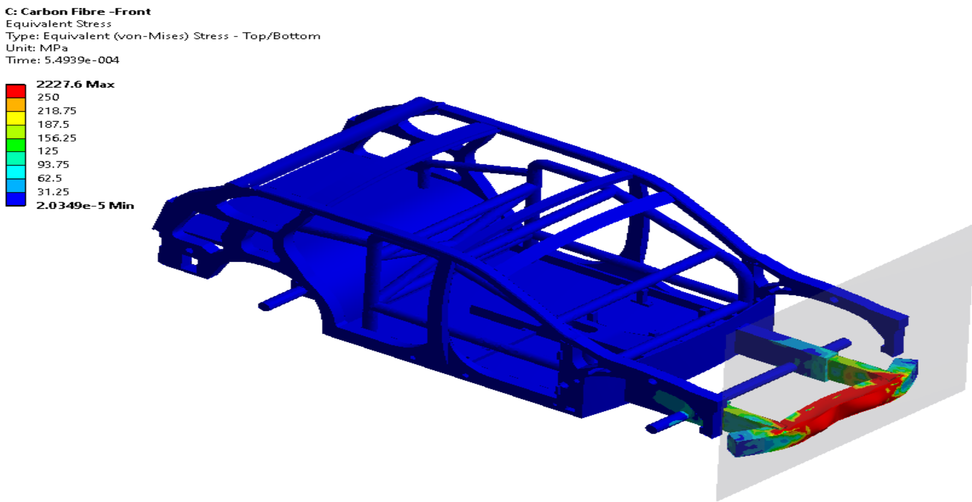
Figure 5: Total deformation of roll cage (a) structural steel and (b) carbon fiber materials

Figure 5 represents the total deformation of structural steel and carbon fiber. In structural steel 4a during the frontal crash test. The deformation is lower in the middle portion of the car. In carbon fiber 4b, we observe that the deformation is very low compared to structural steel. The maximum deformation is represented as 15.747 and 7.7992, respectively.

3.1.2 Analysis of Equivalent Stress



(a)

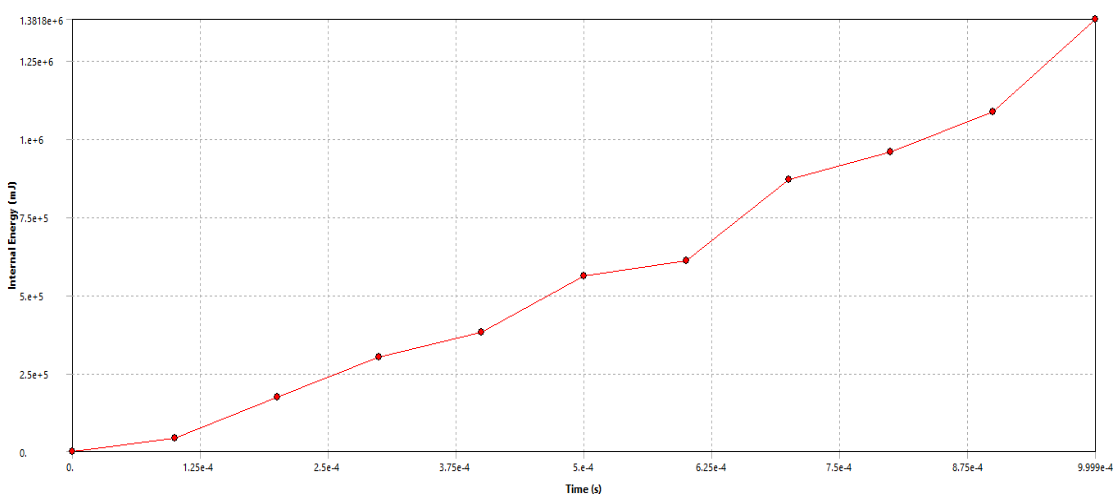


(b)

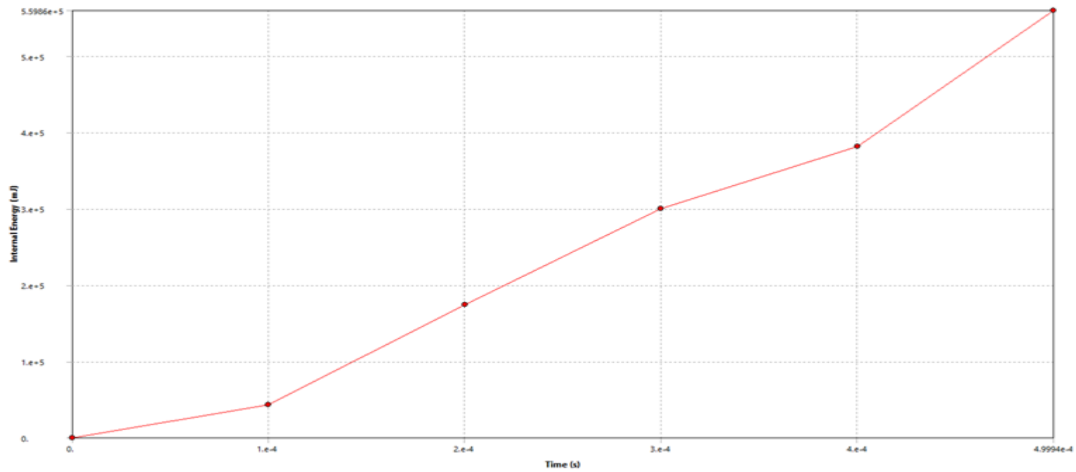
Figure 6: Equivalent Stress of Structural Steel (a) and Carbon Fiber (b)

Figure 6 measures the equivalent Stress of Structural Steel (a) And Carbon Fiber (b) that occurred during the side crash test. In structural steel 6(a), we found that stress is higher in the middle portion of the frame and gradually reduces and is represented as 3095.4 Mpa. In Carbon fiber 6(b), the stress is higher in the bottom end of the frame, and it is valued at 2227.6 Mpa, respectively.

3.1.3 Analysis of Internal Energy



(a)



(b)

Figure 7: Analysis of internal energy of roll cage using (a) Structural Steel and (b) Carbon Fiber

Figure 7 represents the Internal energy of Structural Steel and Carbon Fiber. The body's internal energy is the sum of the random distribution of kinetic and potential energy of all molecules in the body. Figure 7(a) represents internal energy vs. time taken during a frontal crash with structural steel. As there is an increase in time, internal energy increases rapidly for structural steel and carbon fiber 7(b). The maximum internal energy of structural steel and carbon fiber are represented as 1.3818e+6 and 5.5986e+5, respectively**.**

4. Analysis of the side impact of the roll cage chassis

The Side Impact Dynamic evaluation is performed if you want to discover the quantity of pressure generated and deformation inside the roll cage if the roll cage is receiving effect with the aid of using the face with the aid using any item. For the worst case situation in the 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 kinds of cars that's, to begin with at rest. This evaluation is executed with the aid of using the usage of a roll cage.

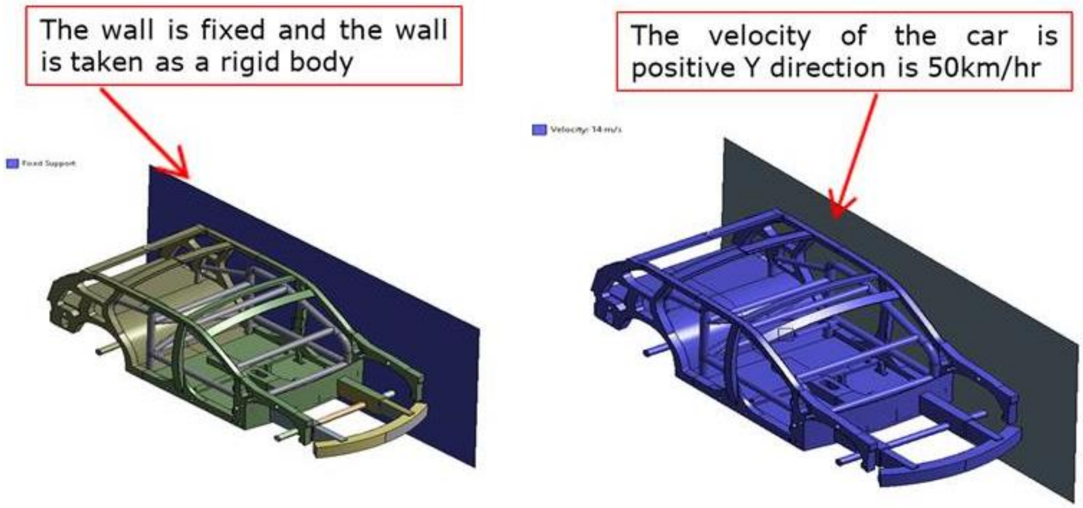
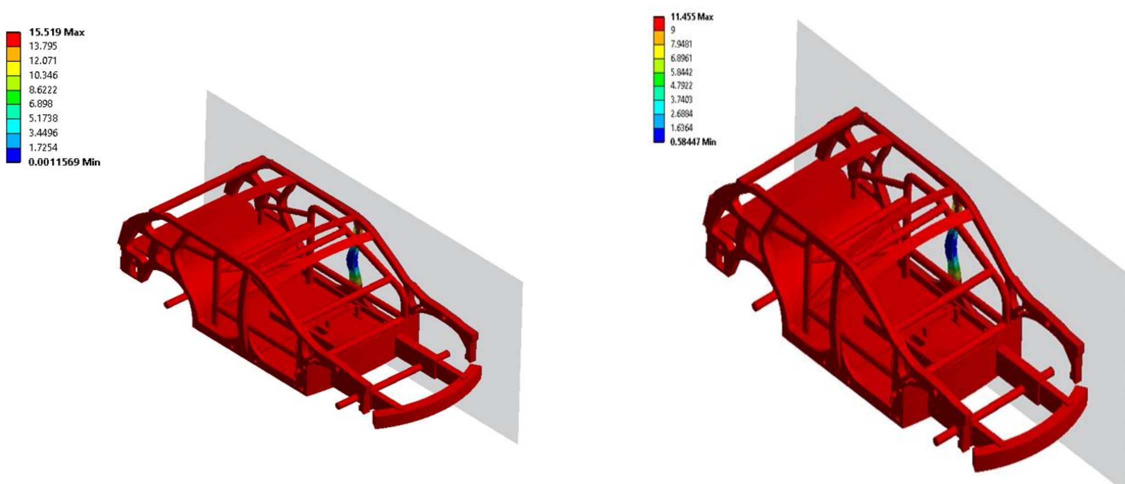


Figure 7: Side Crash Test

Figure 7 represents the Side crash test. Here, the wall is fixed as a rigid support, and the car's velocity in the positive Y direction is considered 50 Km/hr. Total deformation, Equivalent Stress, and Internal Energy are compared and analyzed on the left and right-hand sides.

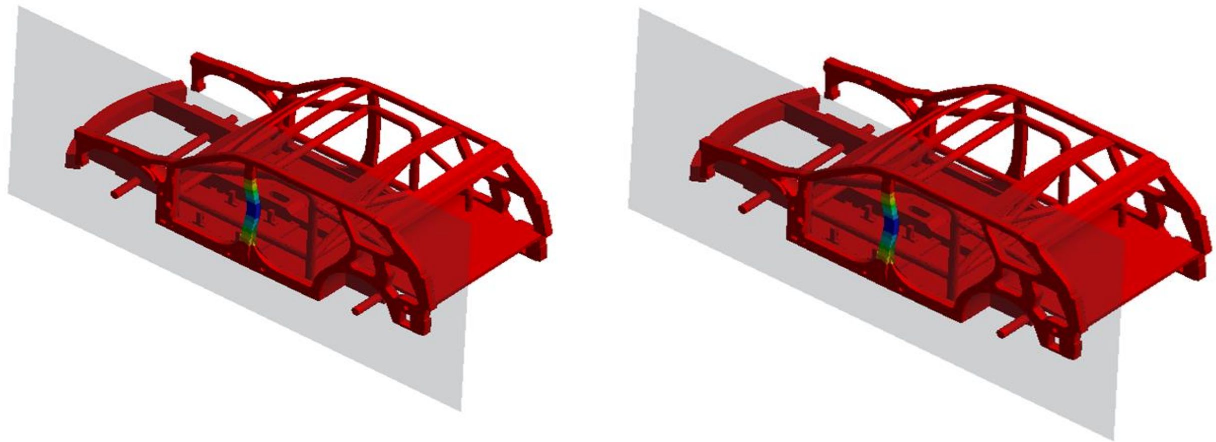
4.1.1 Analysis of total Deformation



a b

Figure 8: Left-hand side Total deformation of structural steel (a) and carbon fiber (b)

During The side crash analysis of the deformation of structural steel, it was observed that the total deformation of structural steel is higher than that of carbon fiber. The maximum deformation of structural and Carbon fiber is calculated at 15.519 mm and 11.45 mm, respectively.

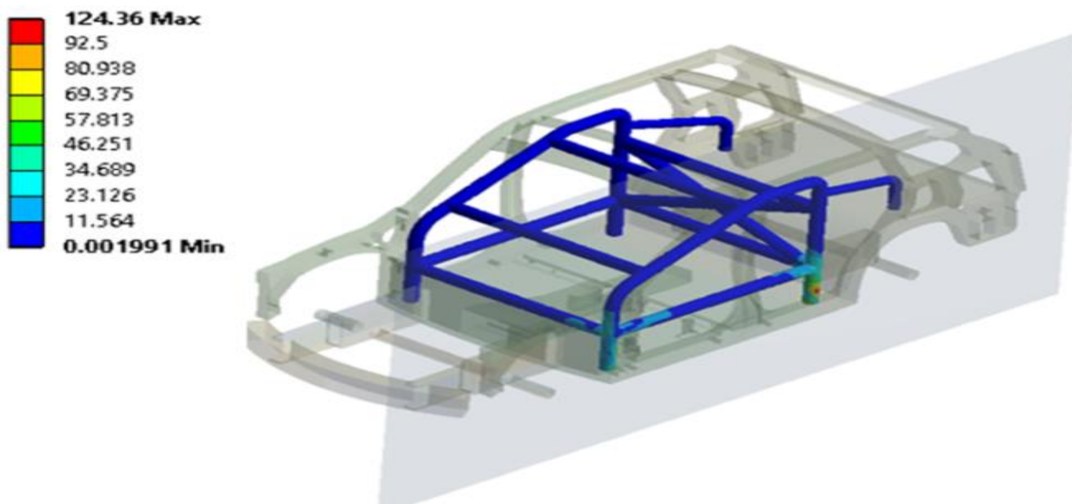


a b

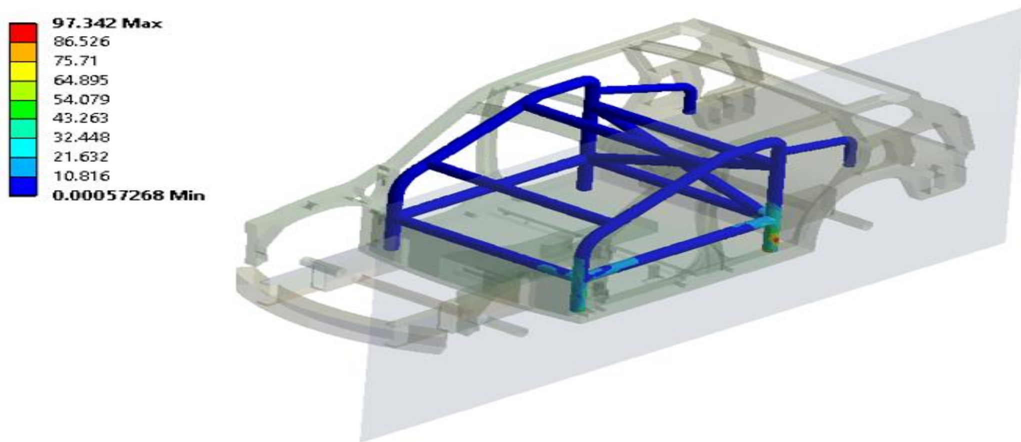
Figure 9: Right-hand side Total deformation of structural steel (a) and carbon fiber (b)

Figure 9 describes the right-hand Total Deformation in structural steel and carbon fiber. In structural steel 9(a) during the Side crash test. We calculated that deformation is lower in the middle portion of the car than in another side area. The deformation in the middle portion of carbon fiber 9(b) is minimum.

4.1.2 Analysis of Equivalent Stress



(a)

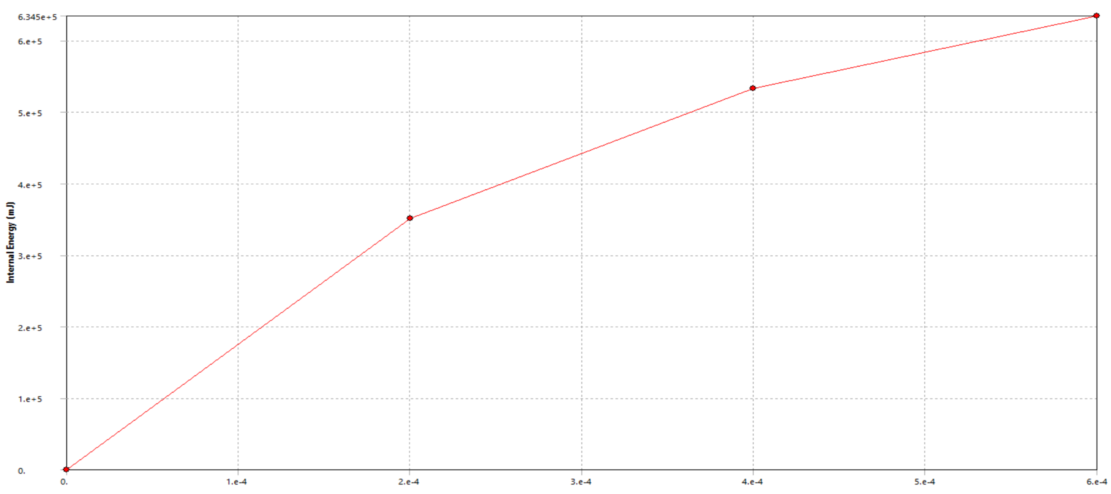


(b)

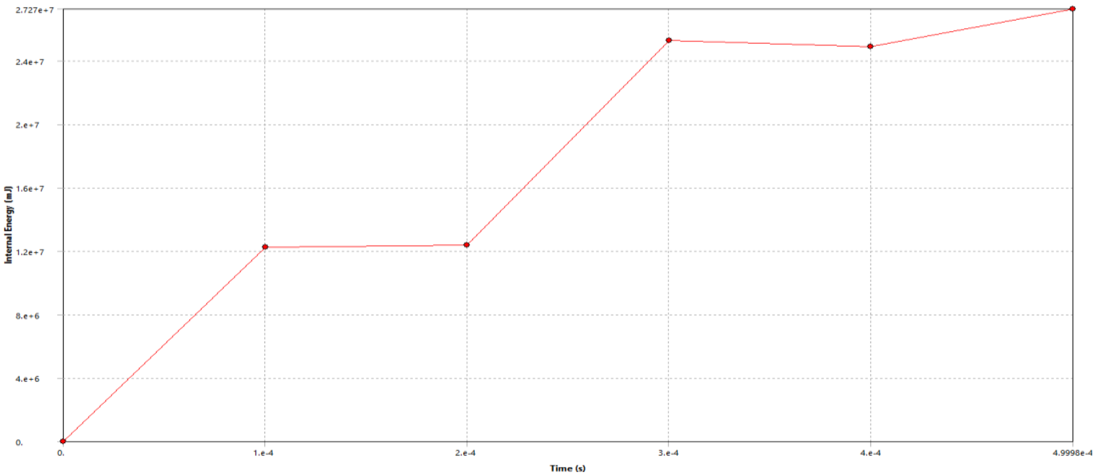
Figure 10: Equivalent Stress of Structural Steel (a) and Carbon Fiber (b)

Figure 10 measures the equivalent Stress of Structural Steel (a) And Carbon Fiber (b) during the side crash test. In structural steel 10(a), we found that stress is higher in the bottom end of the frame and gradually reduces towards the end. In the case of carbon fiber 10(b), the stress is normal in the middle portion and constant throughout its length.

4.1.3 Internal Energy Analysis



(a)



(b)

Figure 11: Analysis of internal energy of roll cage using (a) structural steel and (b) carbon fiber materials.

Figure 11 represents internal energy vs time taken during a side crash with Structural Steel material and carbon fiber. In structural steel 11, (a) material, the internal energy vs. time during a side crash rapidly increases, and it's represented as 6.345e+5. In carbon fiber material 11(b), the internal energy vs. time is low and measured as 2.727e+7.

5 Conclusion

The frontal and side crash analysis has done on roll cage of a SUV successfully. The facet crash pressure stage shows that the only facet of the automobile is completely crashed, and the passenger region additionally gets crashed within the side. The effect Internal strength figure indicates that when the crash, the inner strength of the automobile is extended in all the 3 crash tests. The strength of the automobile at the precise pace is switched to the wooden wall during the collision. At the time of effect, the internal energy from the automobile's precise pace is transferred to the wall,which may be diagnosed from the internal energy figures..

Types of Analysis	Deformation (mm)		Equivalent Stress(	
	Steel	Carbon Fiber	Steel	Carbon Fiber
Front Crash	15.747	7.992	3095.4	2227.6
Side Crash	11.455	15.519	1163.9	1113.8

References

[1] Y.Mahajan, N.Pagare, R.Awate, N.Phalke, Prof.V.Shinde Department of Mechanical Engineering DY Patil COE, Ambi, Talegaon-Dabhade, Pune-410506IJSARTVolume3Issue6–

JUNE2017

[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

[3] Mahendra H M, B S Praveen Kumar,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

[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.

[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

[6] Design and Development for Roll Cage of All-Terrain Vehicle-Deepak Raina*, Rahul Dev Gupta, Rakesh Kumar Phanden Department of Mechanical Engineering, M.M.University, Mullana(Ambala), INDIAVolume2,Issue7, March-2015ISSN:2347- 4718