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Crash Evaluation of a Composite Car Body using Ansys Workbench 16.2

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ABSTRACT

To minimise the damage during car accidents, the solidity of the car body structure must be a priority for the automotive industry. This work aims to analyse the possibility of replacing conventional material used in car bodies by establishing the best suitable composite material in order to provide strength, rigidity, crashworthiness, safety, lightweight, improve the fuel efficiency of cars. In this project, we will design a car body structure and solid concrete wall by using Solid works 2018 software and make suitable composite materials through Ansys ACP (Ansys composite pre-post). Then perform crash analysis on the car body in Ansys workbench software by explicit dynamic module by using different composite materials in car body at different speed of the car. The behaviour of automotive car structure is analysed by evaluating equivalent stress, strain, total deformation.

Keywords: - *Composite, FEM, ACP (Ansys composite Prepost), crashworthiness, Etc.*

INTRODUCTION

In recent decades the use of composite materials has increased significantly in the automotive industry. Most of the public and private sector companies are focussing on automobiles safety, crashworthiness and lightweight. So that they tend to move towards the application of composite materials by replacing conventional materials like steel and aluminium.

Now a day's many parts of vehicles are made of light weight composite materials, which offers great potential for increasing vehicle efficiency by a reduction in vehicle weight. Reduced vehicle weight, offer less fuel consumption results to increase the speed of vehicles.

In this project, it proposes to analyse and study of crash analysis of car body. So that a car body structure and a concrete wall is modelled by using 3D modelling software Solid works 2018. And then imported these two models to Ansys workbench software for crash analysis. By using ACP, light weight composite material has to be prepared. Here in this project, five different light weight high strength (carbon and glass reinforced) composite materials are selected as a material of a car body. Such as-

1. CFRP (Carbon fiber reinforced plastic)
2. GFRP (Glass fiber reinforced plastic)
3. Carbon fiber reinforced polypropylene
4. Glass fiber reinforced polypropylene
5. Glass fiber reinforced polyester

An explicit dynamic module is used from Ansys software for analysis to study a car crash at three different speeds of car at 60 km/hr, 90km/hr, and 120 km/hr, use of these materials alternatively. So, the crashing of the car is performed by the mechanical impact on the front surface area of the car body with a concrete wall. That is a way equivalent stress, equivalent strain, total deformation will analyse for the best suitable material that will provide high strength, weight ratio and can provide the maximum safety to passengers due to crash.

The finite element method is consisting of three steps

1. Pre-processing, in which the analyst develops a finite element mesh to divide the subject geometry into sub-domains for mathematical analysis, and applies materials properties and boundary conditions.

2. Solution, here we derive the governing matrix equations from the car body model and solve for primary quantities.

3. Post-processing, in which the analyst checks the validity of the solution, examines the values of primary quantities (such as displacement and stresses) and derives and examines the results.

The Ansys explicit dynamics suite enables us to capture the physics of short-duration events for products that undergo highly nonlinear, transient dynamics forces. With Ansys, you can gain insight into how a structure responds when subjected to severe loading.

ACP (Ansys composite Prepost)

Ansys composite Prepost (ACP) is an integrated tool in the Workbench platform dedicated to composite laminates modelling (pre) and advanced analysis results (post) using dedicated failure tools.

Characteristics of composite materials:

Composites are being considered to make lighter, safer, and more fuel-efficient vehicles. A composite is composed of a high-performance fiber (such as carbon or glass) in a matrix material (epoxy polymer) that when combined provides enhanced properties compared with the individual materials by themselves.

Light weight, high specific stiffness, and strength, easy mouldable to complex forms low electrical conductivity, and thermal expansion. Good fatigue strength is one of the characteristics advantages of composite materials over conventional materials.

They were made of composite materials of different sizes, using several types of constituents to determine which material might be most suitable to replace metal in the manufacturing of the door and analysed behaviour of the automotive structure by using the finite element method for determining the stresses in the structure[1], and Praveen & Kumar also discussed and designed Hatchback body of a car and performed crashworthiness and reduce the damage of a car by using different composite materials and reported stress formed and deformation after analysis both were performed in Ansys software by explicit Dynamic module [2]. Murlidhar et. All studied about the fuel economy and performance of modern cars and the reduction of the weight of the car bodies by replacing conventional materials with composite materials [3]. Veeraraju Pendyala reported on the simulated crash test of an automobile. The objective of this work is to simulate a frontal impact crash of an automobile and validate the results [4]. Vivek Dayal et. Al studied on simulation of the frontal crash of a car at various speeds, and also reported on variation in total deformation, velocity, and equivalent stress included aluminium alloy and structural steel used for car body material [5]. Lin et al. had carried out the computer simulation of a car accident analysis. They analyzed two accident situations: a high-speed car crashed into a wall and a high-speed car crashed into a stationary car. The aim of the research was to know the sources that can harm the driver and passengers in car accidents and to create a model of the bumper to know its design to withstand impact loads [6]. Reddy et al. performed a crash analysis of the front bumper beam of a car using Hypermesh and RADIOSS software. A bumper is used to protect occupants from front and rear collisions. The design of a bumper is based on the degree of shock absorption. The analysis is carried out on the bumper beam model with different materials and different versions of the bumper. The scan was performed against a solid wall with different bumper materials. The behavior of the bumper in crash simulations is observed and changes to the design of the bumper are made [7].

METHODOLOGY

Modelling

- Create a surface car body model and solid wall in solid work 2018
- Open Ansys ACP (pre) in Ansys 16.2 workbench.

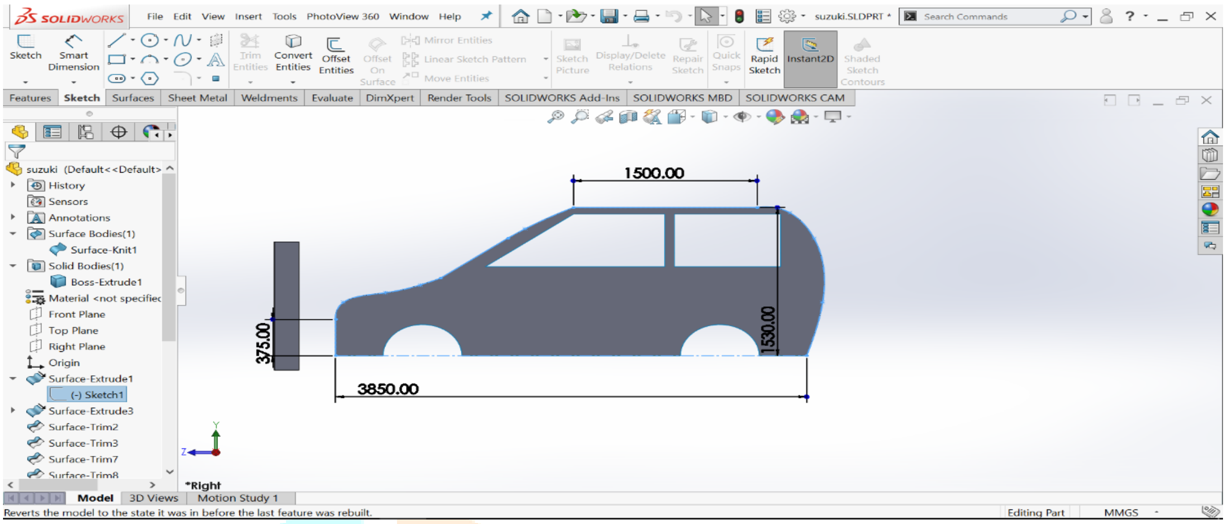


Fig.1: Modelling of car body with wall

Material used

Add desired materials for a model in engineering data from engineering data sources

Imported model in geometry in IGS format

Meshing The meshing of whole model is done by using Ansys mesh feature in Ansys workbench 16.2.

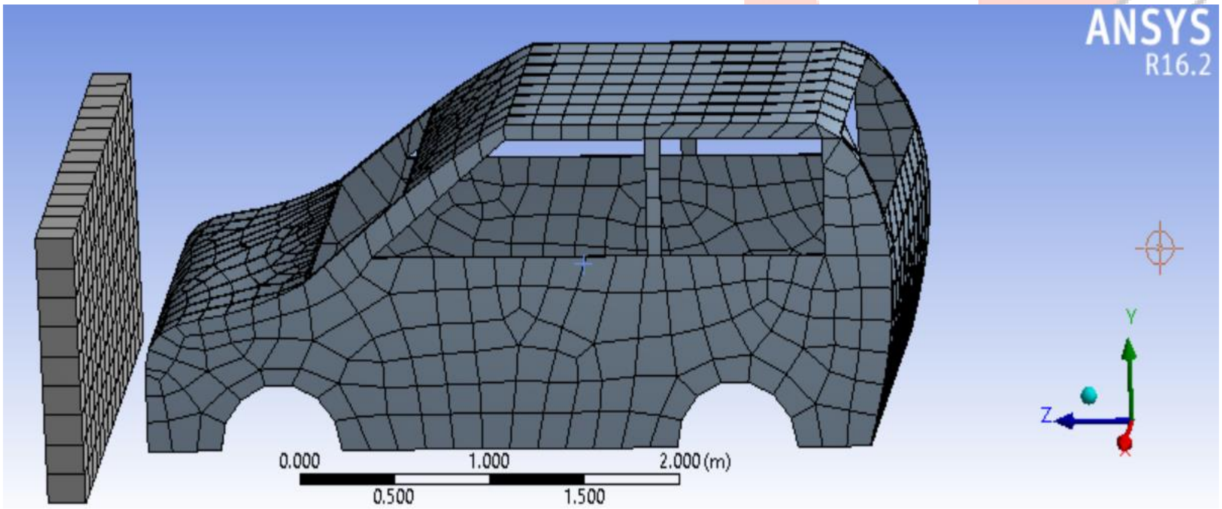


Fig.2: Meshing of geometry

Number of nodes - 1204
Number of elements - 918
Relevance centre - coarse
Minimum edge length – 2.6477e-002m

In Ansys ACP

- Created fabrics of chosen materials
- Create Rosettes
- Create oriented selection sets
- Create ply layers in modelling groups
- Convert into solid model

- Update and exit

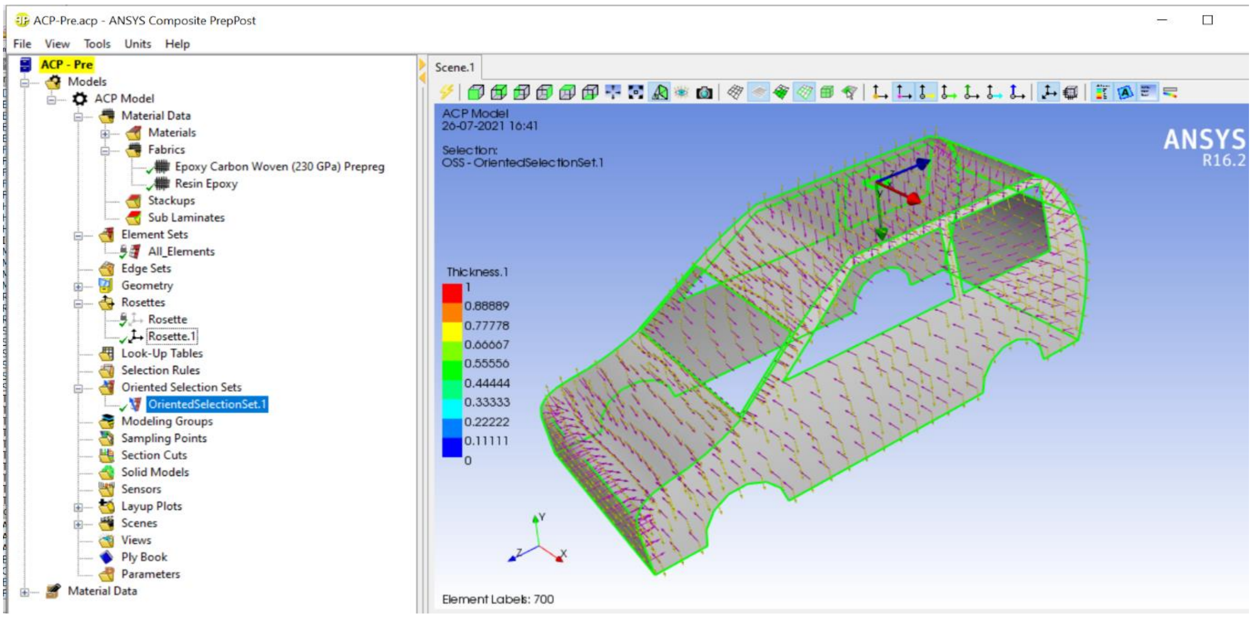


Fig.3: Orientation of layers(composite)

In explicit dynamics module

- The setup of Ansys ACP is imported to model of explicit dynamics module
- In connection apply manual contact region

Boundary condition

- The stiffness behaviour of a car body is set as FLEXIBLE
- Bottom and side face of the concrete wall is fixed
- Initial velocity is given 60 km/hr, 90 km/hr and 120 km /hr in positive Z direction alternately.

Analysis settings

- Specify end time - 0.02 second
- Number of cycles – 100

Solutions

In solution, we insert total deformation, equivalent stress and equivalent strain to check the stress-strain variation in all five types of selected materials composite car body.

PROBLEMS STATEMENT

Design the model of the car body and rectangular wall, and use composite materials for the car body and concrete for the wall. Crash analysis performed by the frontal sudden impact of the car body on concrete wall with a certain velocity, and to find the appropriate results such as total deformation, equivalent stress as well as equivalent strain, we have a focus on minimizing the damage, reduced weight and keep level of safety of a car.

ASSUMPTIONS

- Neglecting the air drag on the car body.
- The wall is assumed to be fixed from the side and bottom faces.
- The car body is subjected to initial velocity and constant acceleration.
- No friction at the base of the car body.

RESULTS

Table 1. Verification of results for aluminium alloy

	Velocity (m/s)	Total deformation (mm)	Equivalent stress (Mpa)
REF. [5]	30.55	304.21	1726.2
Obtained	30.55	275.17	1735.3

Table 2. Result for CFRP

Velocity (km/hr)	Total deformation (mm)	Equivalent stress (Mpa)	Equivalent strain
60	334.58	511.84	0.0099
90	407.69	610.71	0.0618
120	416.42	715.39	0.1469

Table 3. Result for GFRP

Velocity (km/hr)	Total deformation (mm)	Equivalent stress (Mpa)	Equivalent strain
60	333.39	260.35	0.0714
90	495.85	277.55	0.11425
120	698.95	675.52	0.13371

Table 4. Result for carbon fiber reinforced polypropylene

Velocity (km/hr)	Total deformation (mm)	Equivalent stress (Mpa)	Equivalent strain
60	334.54	599.03	0.0119
90	382.65	725.44	0.055
120	393.21	1132.8	0.1125

Table 5. Result for glass fiber reinforced polypropylene

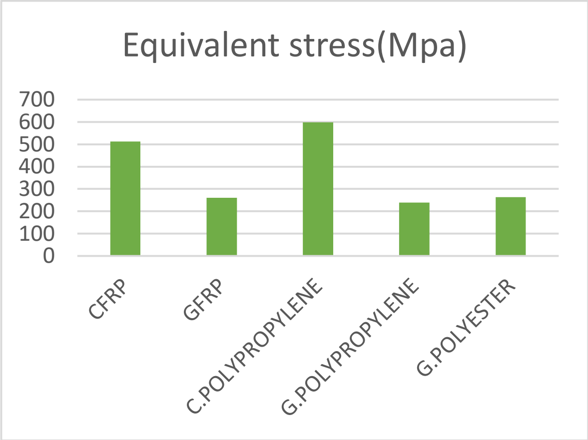
Velocity (km/hr)	Total deformation (mm)	Equivalent stress (Mpa)	Equivalent strain
60	333.33	238.56	0.07135
90	498.6	574.12	0.08635
120	661.76	891.96	0.1456

Table 6. Results for glass fiber reinforced polyester

Velocity (km/hr)	Total deformation (mm)	Equivalent stress (Mpa)	Equivalent strain
60	333.35	263.37	0.07037
90	496.14	471.93	0.1518
120	660.85	498.51	0.1707

Graph: Comparison graph of equivalent stress.

At 60 km/hr –



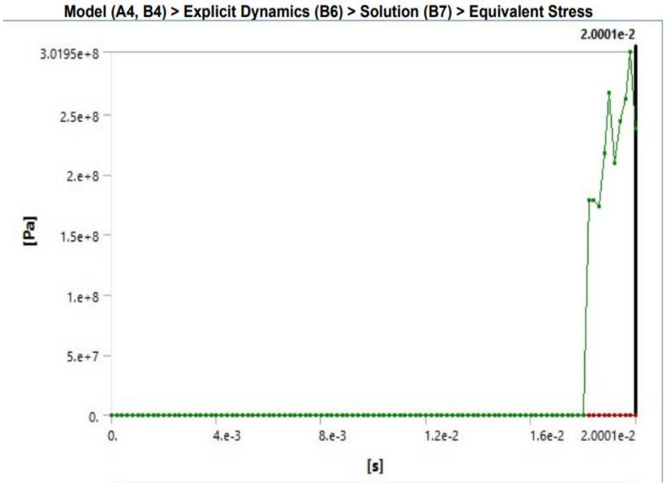
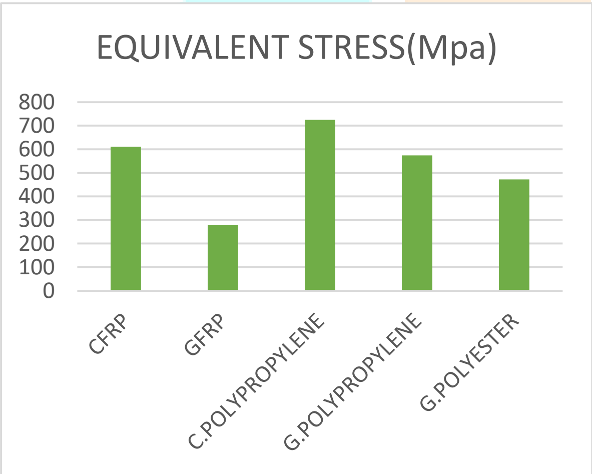


Fig.4: Graph of equivalent stress at 60 km/hr. **Fig.5:** Stress diagram of glass fiber polypropylene

It is observed that 60 km/hr. Glass fiber reinforced polypropylene is less equivalent stress as we see in above diagram.

At 90 km/hr.



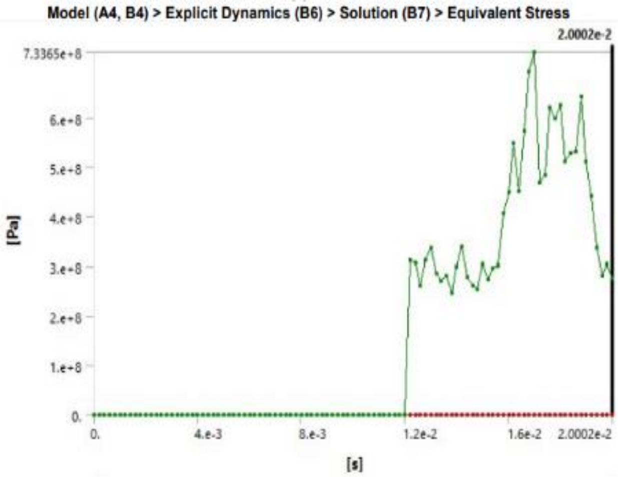
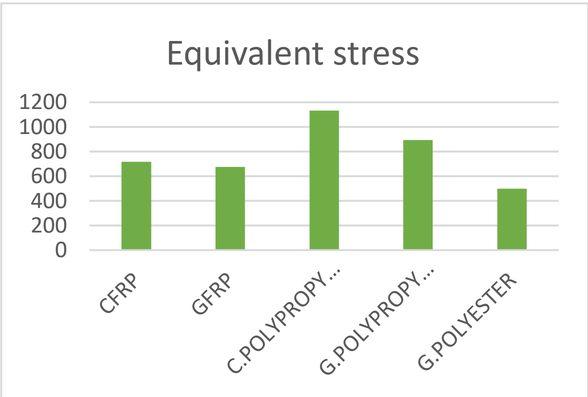


Fig.6: Equivalent stress at 90km/hr. Fig.7 Stress variation in GFRP at 90km/hr.

It is observed that at 90 km/hr. GFRP has less equivalent stress.

At 120 km/hr.



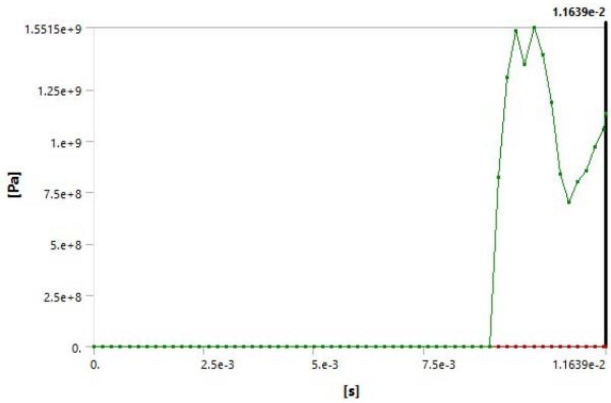


Fig.8: Equivalent stress at 120km/hr. **Fig.9:** Stress variation in carbon fiber polypropylene

It is observed that at 120 km/hr. carbon fiber reinforced polypropylene has highest stress.

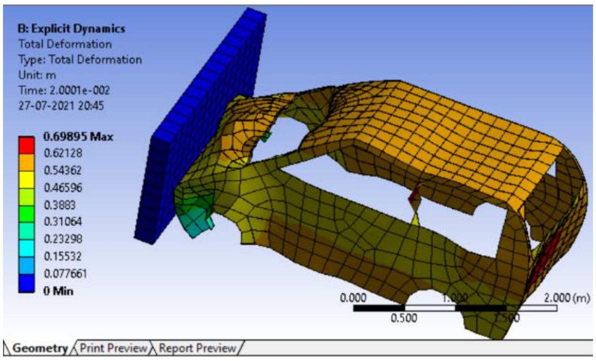


Fig.10: Total deformation in GFRP at 120km/hr.

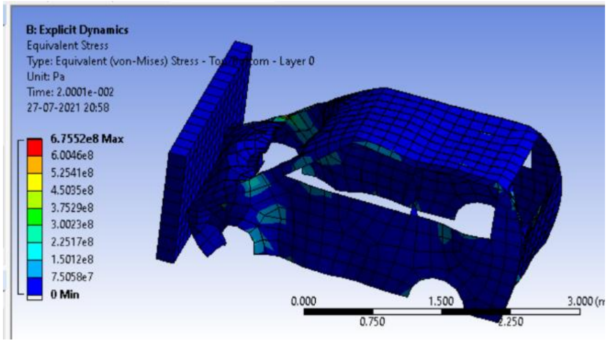
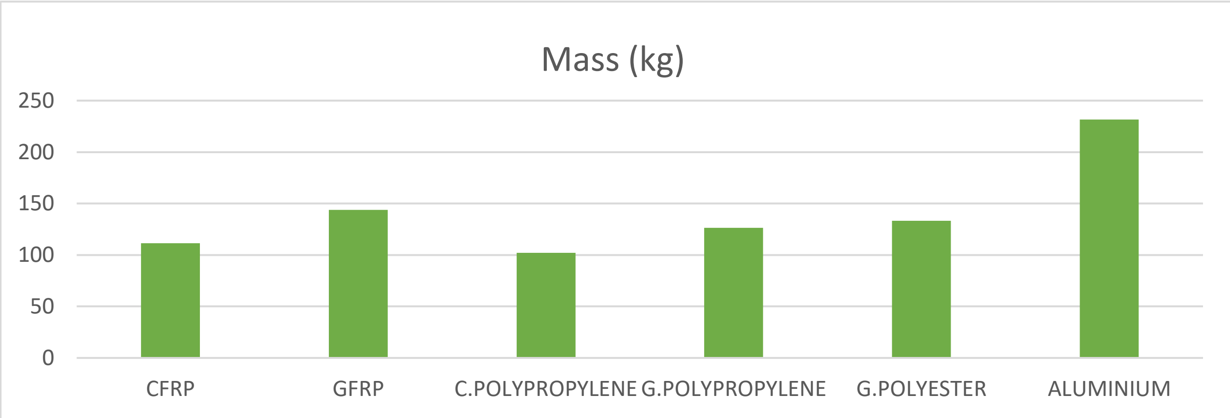


Fig.11: Stress in GFRP body at 120km/hr.

Mass of car body on different materials



The crash test is performed with CFRP, GFRP, carbon fiber reinforced polypropylene, Glass fiber reinforced polypropylene and glass fiber reinforced polyester respectively at different speeds. All materials have different capabilities as above the comparison graph of equivalent stress are shown at different speeds. We see that although GFRP has less value of stress GFRP shows very large deformation when speed is increased and also according to weight point of view GFRP is heavier than the CFRP in much amount. If we consider strength to weight ratio carbon fiber reinforced plastic (CFRP) has a high strength to weight ratio among all five materials so CFRP is the best replacement for conventional materials like aluminium alloy or structural steel. The results of the impact of the crash are based on the mechanical properties for all five different materials as mention above.

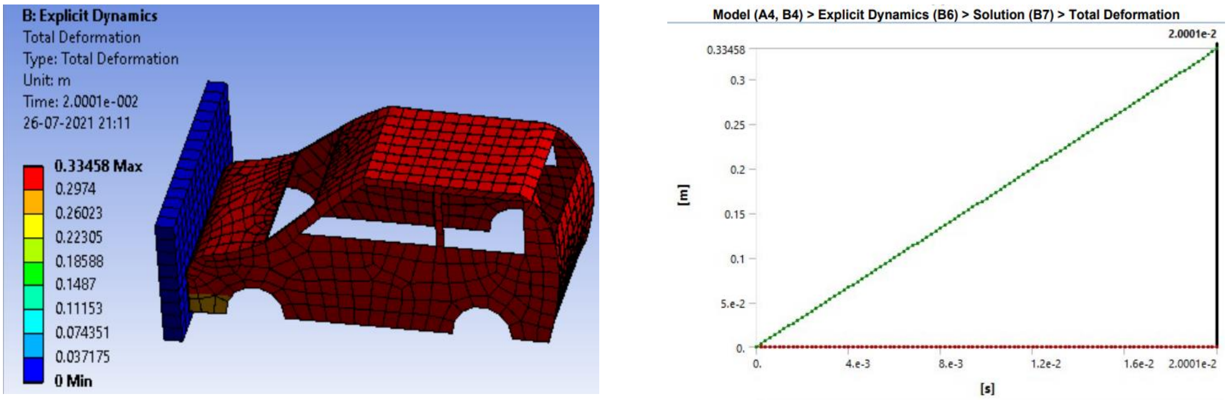


Fig.13: Total deformation for cabon fiber reinforced plastic(CFRP) with graph

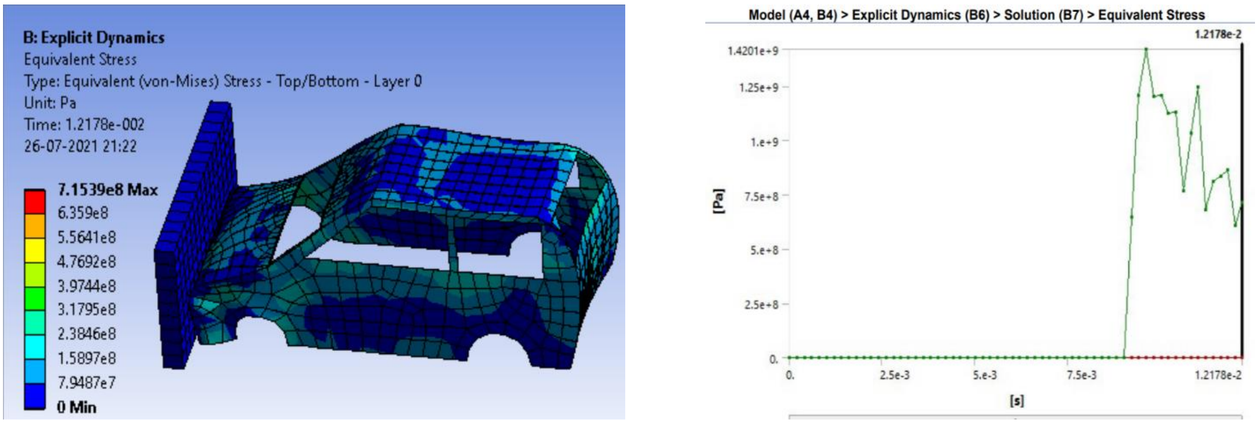


Fig.14: Equivalent stress variation in carbon fiber reinforced plastic (CFRP)

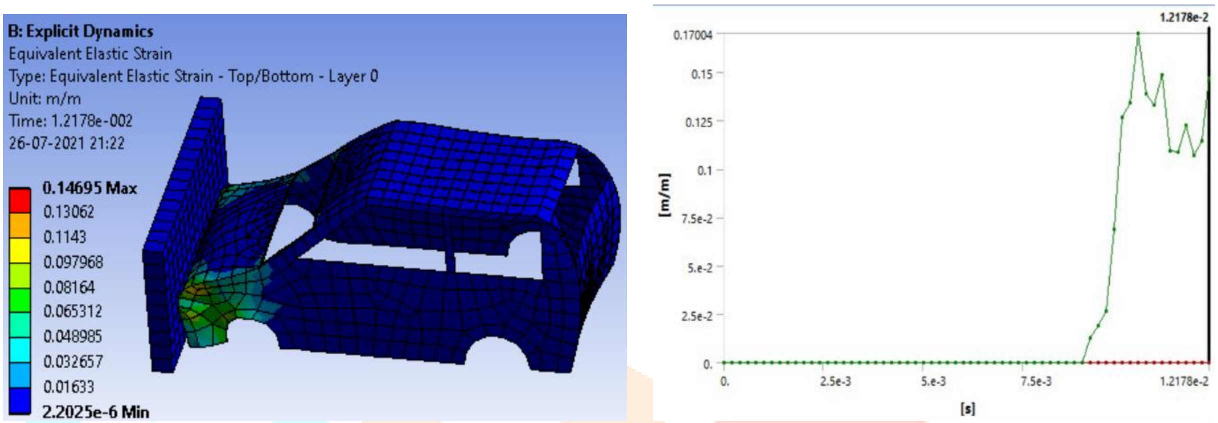


Fig.15: Equivalent strain for carbon fiber reinforced plastic (CFRP) with graph

CONCLUSION

The results of the crash analysis with different speeds of all materials are shown in the above tables at 60 km/hr. Carbon fiber reinforced polypropylene has the highest value of equivalent stress and GFRP has the least value of stress. At this speed, deformation is nearly equal for all materials and CFRP has the least value of strain among all materials. At 90km/hr. GFRP, glass fiber reinforced polypropylene and glass fiber reinforced polyester show deformation nearly equal and more than the other two materials. At 120km/hr. carbon fiber reinforced polypropylene has a very large amount of stress, CFRP has very little deformation than other materials and also do not have too much stress therefore if the crash occurs at high speed the CFRP will provide more safety than other materials. CFRP is also light in weight that's why it reduced fuel consumption too. CFRP also shows high strength at least weight.

Hence, we can conclude that CFRP is the best material among all five materials and also it is the best replacement for conventional material for a car body.

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