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Design and Analysis of Car Crash Element

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Abstract: *Passenger safety is the primary concern of every car manufacturer today. New standards are set for occupant safety in various crash scenarios such as frontal head impact, angled impact, side impact, rear impact and rollover. In today's world, fuel consumption is also a serious issue to consider. Taking these limitations into account, a lighter and stronger composite material than steel is used in the car's front rail. Using this material would help reduce fuel consumption without sacrificing vehicle safety. In this project, the conventional material used for the front sub-frame rails in the car, steel, is replaced by the composite materials Carbon Epoxy and Glass Carbon. The 3D model of the subframe railis made In CATIA v5. Impact analysis is performed on Ansys workbench for all materials to compare displacements and stresses at different speeds of 80 km/h, 100 km/h. and 120 km/h.*

Keywords: Car Crash.

I. INTRODUCTION

Composites are familiar to the automotive industry for a long time. They offer great weight savings with respect to monolithic structural materials, but more importantly, if properly designed, they are an ideal engineering material for the wide range of tasks they can be adapted to. Composites are currently used at both ends of the automotive application spectrum: at the lower end of the scale are high-volume (200,000units per year) commercial vehicles that use randomly oriented glass fibers as molding compounds (SMCs) or are cast in quick-set polyester resins for processes RTM type. At the higher end, small-volumeFormula 1 or Indy championship racing vehicles (1-30 examples per year) that use fighter technologies such as vacuum bags, autoclaved high-modulus and high-strength carbon/epoxy prepregs. In between, find their placement, closer to the lower end, relatively large and relatively high-end sports vehicles (5,000-20,000 per year) that use fiberglass mats with selective unidirectional stiffeners in low-end thermoplastics or thermoset resins for semi-automated processes; and closer to high-end, low- and high- end (50-500 per year) sports-luxury vehicles, such as the Lamborghini Murcie`lago, which are currently turning to continuous fiber, high-quality epoxy composite materials derived from the aerospace industry for their high performance requirements. The Murcie`lago (Fig. 1) features a full carbon/epoxy body (bumpers, fenders, hood, etc.) except for the doors and roof structure. Using composites for this application allows for a weight savings of 75 lb or 34 kg.

- Rails in Car
- Motivation
- Crashworthiness
- Composite materials of crashworthiness

II. RAILS IN CAR

The use of composite materials in this application saves 75 lbs or 34 kg (about 40 percent) over its aluminum-bodied predecessor, the Diablo. Other solutions using carbon/epoxy composites include high- tensile systems such as transmission lines, floor plates and rocker plates (Figure 2). Manual laying, vacuum bagging, autoclave curing, etc. of pre-impregnated carbon/epoxy composites. are expensive operations. can be configured to send information. Special, high torsional and bending stiffness for handling and performance; body weight, which can be improved by design and analysis; efforts to improve safety and security; This information is easier to replenish and regulations are more stringent; theability to quickly prototype for rapid design and product modification; higher material and process costs are reduced due to lower equipment required for annual production; lack of machining, higher geometric tolerances and surface quality can be achieved. ; making the most of the joint, reducing the joints, therebyimproving the functional

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structure (weight, integrity, vibration, etc.)and limit the chances of failure; The improved performance of thermoset polymeric materials provides environmental protection and disinfection.

The purpose of this paper is to initiate an experimental study to examine the effect of fiber structure and bonding methods on the relative strength of polymer composites such as those used in Murcie`lago production epoxy system. The flexural strength of the material, determined according to ASTM standard D790, is an important parameter in the design of reinforced plastics. Interlayer shear (ILS) strength is a special property of layered materials such as polymer materials because they have a weak matrix- weighted character. ILS stress results from inconsistencies in the mechanical properties of individual laminates in a laminate and develops at free edges and affected areas such as nicks, ply losses, joined andbolted connections.

These stresses need to be evaluated before the model can be used, and service is considered by many authors to be an important issue in evaluating the durability and damage of laminated composite systems. The three-point bending test ASTM D2344, also known as the short beam shear test, is often used to measure the apparent ILS strength of composite laminates. Concerns have arisen about the three-point bending test due to damage to the strong region in the lower part of the children, so the four-point bendingtest, which is a modification of this test, is frequently used as in the current study. While materials with the highest mechanical properties are desired, these materials may not meet other engineering requirements such as reliable pseudo-isotropic behavior, ease of fabrication (drapability) and integration, protection against environmental degradation, and surface quality, so Designers have to. constant exchanges. Class A surface certification means that the surface must meet certain standards for inclusions,voids, roughness and tolerance.

These certifications are a set of procedures that affect not only the final product, but also the mathematical model, materials and equipment.

III. MOTIVATION

Design vehicle models to withstand the impact of a variety of collisions such as frontal vertical, corner, offset, bar and side impact. In addition, other non-accident performances such as vibration, durability and fatigue life are also important for vehicle design. However, due to increased safety concerns, new vehiclesmust be tested against new and more stringent requirements set by the NHTSA, such as a 30-degree car- to-car slope shift. This change could make the hull design with more strength, stiffness, and dimension.

At the same time, the environment and fuel economy should be expected to be lighter and more cardesign, making the area lower.

When the compression area is limited, the body structure is often specified to dissipate most of the impact energy, adding weight should have thicker sheets and/or higher alloys.

CRASH WORTHINESS

The ability of the vehicle structure to absorb the force during an accident is defined as a collision. In this day and age, many people (about 30,000) die in car-to-car frontal collisions. The vehicle should be designed so that its occupants do not experience more than 20 g of net deceleration at higher speeds. The impact structure must be designed in such a way that it absorbs the force in a controlled manner, thus allowing the passenger compartment to rest without people in case of pressure drops that can cause severepain, especially brain damage.

The demands for more crashes and lighter models require the development of a better white body, chassis,suspension and drivetrain. The subframe and underbody cross members provide rigidity to the front end of the vehicle, allowing the longitudinal members to compress properly.

Impact toughness is the ratio of the average crush stress (S) to the composite density (D). ES = Average Crush Stress/Density of Composite Material = S/D

Vehicle design engineers should design keeping in mind that the vehicle structure must absorb the maximum force during an impact. In the force v/s deflection curve, the area under the curve represents theforce absorbed.

The structure should be designed in such a way that the area under the curve is maximum when the car hits, thus reducing patient injuries.

In today's world, accidents happen every hour, and most of them are very dangerous. A frontal collision isone of the most serious types of collisions. Figure 1 shows a comparison of different accident scenarios. Itis seen that the positive effect is higher than all other effects.

COMPOSITE MATERIALS OF CRASH WORTHINESS

Fibre-reinforced composites are widely used in many vehicle models due to their exceptional strength, high coefficients and high damping capacities. If composite material is used for cars, it can not only reduce the weight of the car, but also reduce noise and vibration. In addition, composite materials have ahigh resistance to fatigue and corrosion.

Polymer composites are increasingly replacing steel to reduce vehicle weight and improve fuel economy. Unlike steel, most composites during compression are generally characterized by a brittle rather than ductile response to load

IV. LITERATURE SURVEY

The concept of composite is not a new or new idea. The natural world is full of examples where the concept of composition is used. For example, a coconut tree leaf is nothing more than a console using theconcept of fiber. Wood is a composite fiber: cellulose fibers in a lignin matrix. Cellulose fibers have hightensile strength but are not flexible (eg. to. low strength), lignin atrium binds fibers together and gives skin. Bones are another example of a natural structure that supports the weight of the body. It consists of short, soft collagen fibers embeddedin a mineral matrix called apatite. In addition to these composite materials, there are many engineering materials that are composite in general and have been used for a long time.

Examples are carbon black in rubber, Portland cement or asphalt mixed with sand, and fiberglass in resins. So the idea that we're seeing the mix isn't a new idea. However, the foundations of the special discipline of composition can be safely laid in the early 1960s. It would not be an exaggeration to say thatjoint research and construction studies on composite materials started in 1965 in aviation, space, energy and civil engineering.

The demands on materials for excellent performance are so high that no single product can meet them. This has led to the revival of the age-old concept of combining different materials into composite products to meet customer needs. Such composite machines have features that cannot be achieved with individual products and have the advantage of simple design; that is, the data can follow a well-designedstructure. The main reason to replace glass with natural fibers is that they are cheaper to grow than glass.The cost of fiberglass is around Rs. 300,00/kg at a density of 2.5 g/cm3. On the other hand, natural fibers cost Rs. 15. 00 / 25.00 / kg, density 1.21.5 g / cubic centimeter. The tensile strength of natural fibers is lower than thatof 92 glass fibers, but the modulus is the same size.

However, when considering the specific modulus (modulus per unit specific gravity) of natural fibers, natural fibers are comparable to and even outperforming glass fibers. The material savings from the use ofnatural fibers and high-grade fiberfill, together with the advantage of not wearing out the mixing and production equipment, make natural fibers a great possibility. These results mean that natural fibers can be used in many applications, including construction, automobiles, appliances and other applications.

Attempts to incorporate them into polymers and the properties of these new composites have been reported, and the problems that arise when making composites even when exposed to the environment and an attempt to minimize them are announced. Some product development efforts and their performance measurements in real use are presented. Recommendations for future work are also made.

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This section provides an overview of some of the most recently published materials in the composites literature, with particular emphasis on the electrical properties of static polymer matrix composites. Dueto the increasing demand for green products and the desire to reduce the cost of traditional fiber

V. METHODOLOGY

Crash-testing requires the destruction of a number of test vehicles during the tests and is also time- consuming and uneconomical. One of the new trends of recent times that is gaining huge popularity is computer-simulated crash-testing. Here an FE (Finite Element) model of the vehicle is generated insteadof the actual vehicle and used to perform various tests that were performed before using the actual vehicles. There are several software packages that are equipped to handle vehicle crash tests, but one of the most popular is ANSYS. We use Ansys software for crash simulation. The software performs both static and dynamic analysis. The car body is designed and tested by simulation and the results are used tooptimize the vehicle in body design and safety. Vehicle analysis is calculated at 80 km/h, 100 km/h, 12 km/h. The actual speed of the vehicle may vary with the designed speed.

VI. MATERIALS USED

6.1 Existing Material

PROPERTIES	**Structured Steel**
Density, Kg/m3	7.75 to 8.1 g/cm3
Young's Modulus, N/m2	2×10^{11}
Poisson's Ratio	0.27 to 0.3
Bulk Modulus	154 GPa
Shear Modulus	81000 MPa
Specific Heat, J/Kg-K	420

6.2 Proposed Material:

PROPERTIES	**Carbon Fibre Epoxy**	**TitaniumAlloy**
Density, Kg/m3	$1.6e^{-6}$	$4.512e^{-6}$
Young's Modulus	220 GPa	120 GPa
Poisson's Ratio	0.34	0.37
Bulk Modulus	228 GPa	153 Gpa
Shear Modulus	1.93 -5.60 GPa	45 GPa
Specific Heat, J/Kg-K	1130	570

VII. INTRODUCTION TO CATIA

CATIA (Computer Aided Three-dimensional Interactive Application) is a multi-platform commercial CAD/CAM/CAE software package developed by the French company Assault Systems. Written in the C++ programming language, CATIA is the cornerstone of Assault Systems' product lifecycle management software suite.

CATIA competes in the CAD/CAM/CAE market with Siemens NX, Pro/E, Autodesk Inventor and Solid Edge and many others.

1. SCOPE OF APPLICATION

Commonly referred to as a 3D Product Lifecycle Management software suite, CATIA supports multiple phases of product development (CAx), from conceptualization, design (CAD), manufacturing (CAM) andengineering (CAE).

CATIA enables collaborative engineering across disciplines, including surface and shape design, mechanical engineering, equipment and systems engineering. Design of surfaces and shapes.

CATIA provides a suite of surface treatment, reverse engineering and visualization solutions for creating,modifying and validating complex innovative shapes. From sectioning, styling and class A surfaces to mechanical functional surfaces. engineering:

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CATIA enables the creation of 3D parts, from 3D sketches, sheet metal, composites and pressed, forgedor tooled parts to the definition of mechanical assemblies. It provides tools for complete product definition, including functional tolerances, as well as kinematics definition. Equipment Design:

CATIA facilitates the design of electronic, electrical and distributed systems such as fluid and HVACsystems, all the way to production documentation. Systems Engineering:

CATIA offers solutions for modeling complex and intelligent products through a systems engineering approach. It includes requirements definition, system architecture, behavior modeling, and creation of avirtual product or embedded software

VIII. FINITE ELEMENT ANALYSIS

INTRODUCTION

Finite element analysis (FEA) is a computer numerical technique for calculating the strength and behaviorof engineering structures. It can be used to calculate deflection, stress, vibration, buckling behavior and many other phenomena. It can be used to analyze either small or large deflection under load or applied displacement. It can analyze elastic deformation or "permanently bent out of shape" plastic deformation. A computer is necessary because of the astronomical number of calculations required to analyze a large structure. The power and low cost of modern computers have made finite element analysis accessible to many industries and companies. In the finite element method, the structure is decomposed into many small simple blocks or elements.The behavior of an individual element can be described by a relatively simple set of equations. Just as a set of elements are combined to form an entire structure, the equations describing the behavior of the individual elements are combined into an extremely large set of equations that describe the behavior of the entire structure.

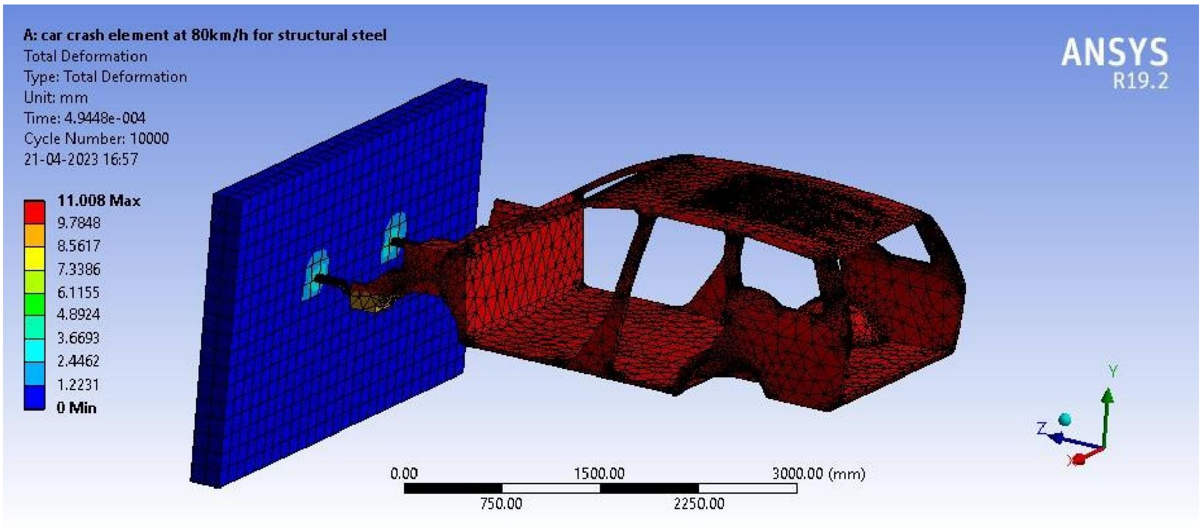
A computer can solve this large set of simultaneous equations. The computer extracts the behavior of individual elements from the solution. From this he can obtain the stress and deflection of all parts of the structure. The stresses will be compared to the allowable stress values for the materials to be used to determine if the structure is strong enough. The term "finite element" distinguishes the technique from theuse of infinitesimal "differential elements" used in calculus, differential equations, and partial differential equations.The method also differs from finite differential equations for which, although the steps into which the space is divided are of finite size, there is little freedom in the shapes that the discrete steps cantake.Finite element analysis is a way to deal with structures that are more complex than can be solved analytically using partial differential equations. FEA deals with complex boundaries better than finite difference equations and gives answers to "real world" structural problems. It has been significantly expanded over the roughly 40 years of its use.

STEPS IN FINITE ELEMENT ANALYSIS

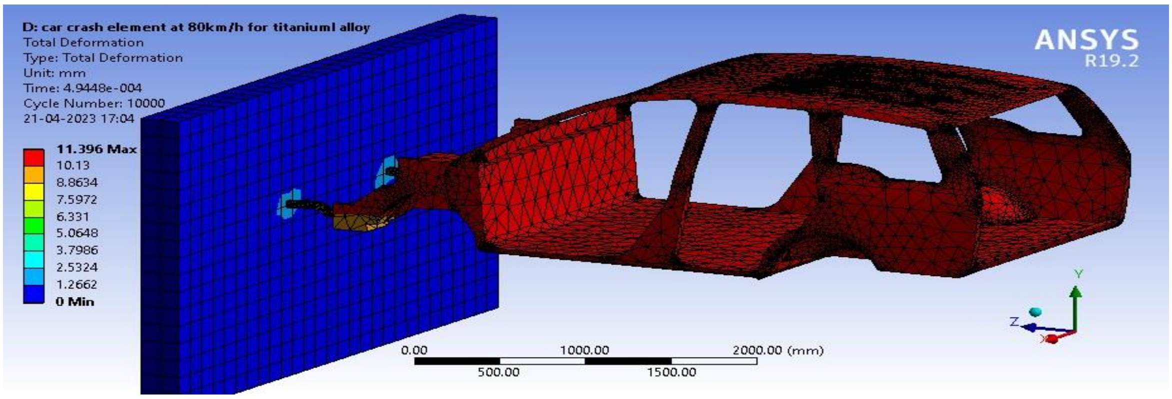
The steps in the finite element method when applied to structural mechanics are as follows.

1. Divide the continuum into a finite number of subregions (or elements) of simple geometry, such as line segments, triangles, quadrilaterals (Square and rectangular elements are a subset of quadrilaterals), tetrahedrons and hexahedra (cubes), etc
2. Select a key point on the elements that will serve as nodes where the equilibrium and compatibilityconditions are to be enforced.
3. Assume displacement functions within each element such that the displacement at each general pointdepends on the nodal values.
4. Satisfy the strain and stress-strain relationship within a typical element. Determine the stiffness andequivalent nodal loads for a typical element using work or energy principles.
5. Create the equilibrium equations for the discredited nodes.
6. Continuum in terms of element contributions.
7. Solve the equilibrium for the nodal displacement.

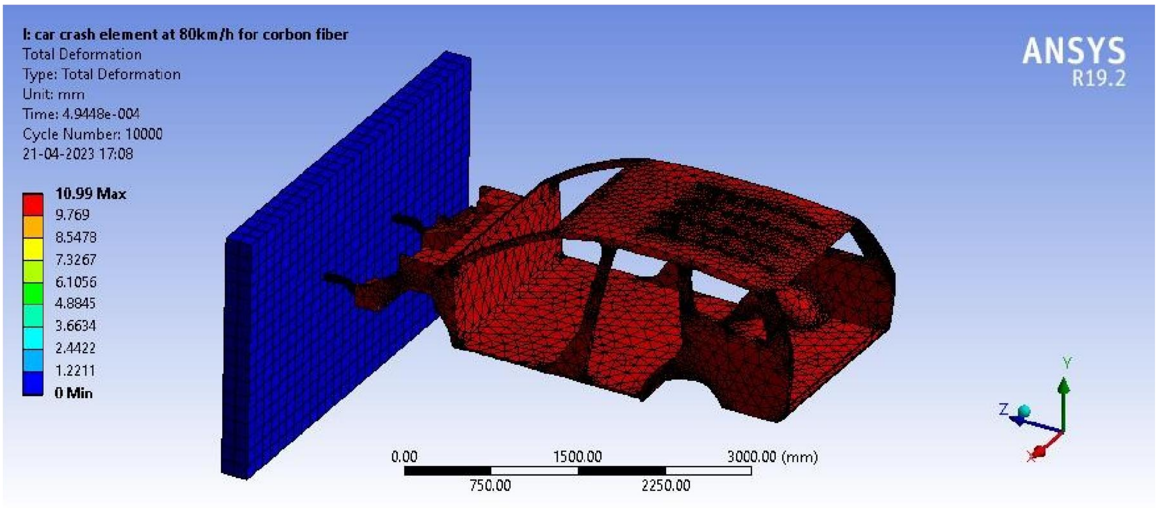
EXPLICIT DYNAMIC ANALYSIS



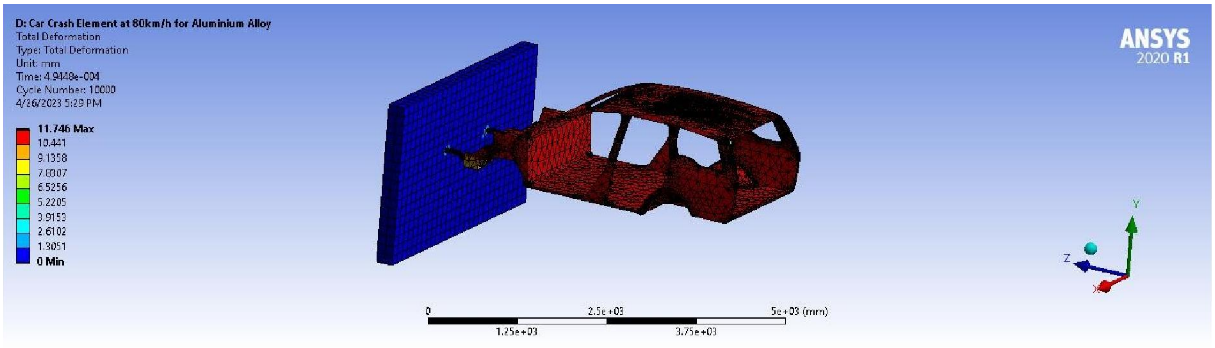
Structured Steel at 80 km/h



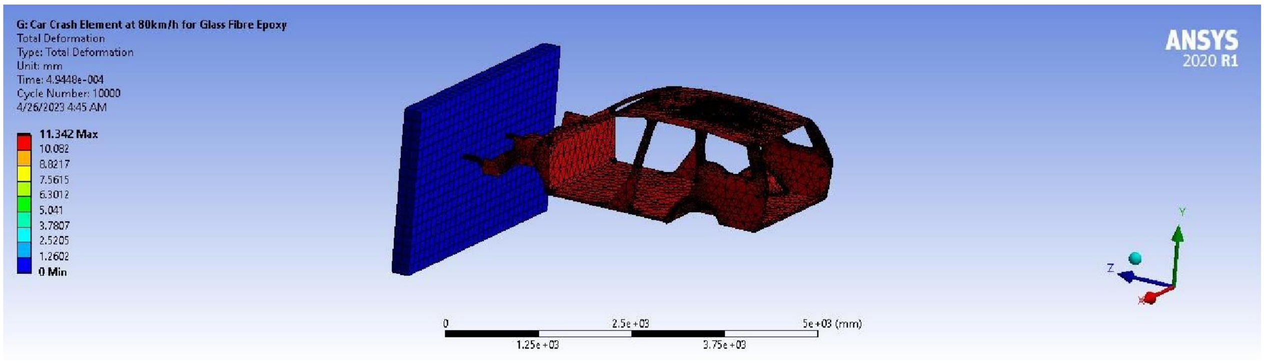
Titanium alloy at 80 km/h



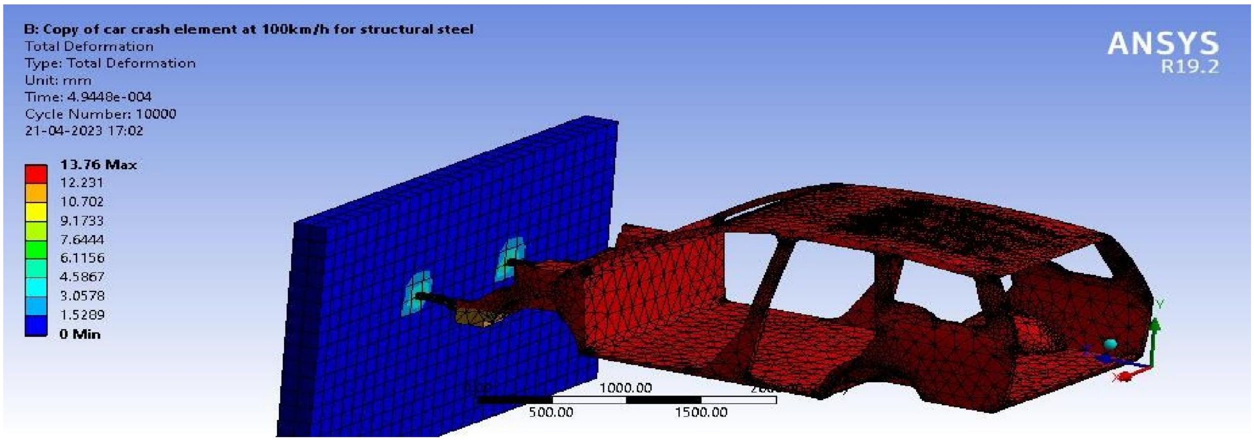
Carbon Fibre Epoxy at 80 km/h



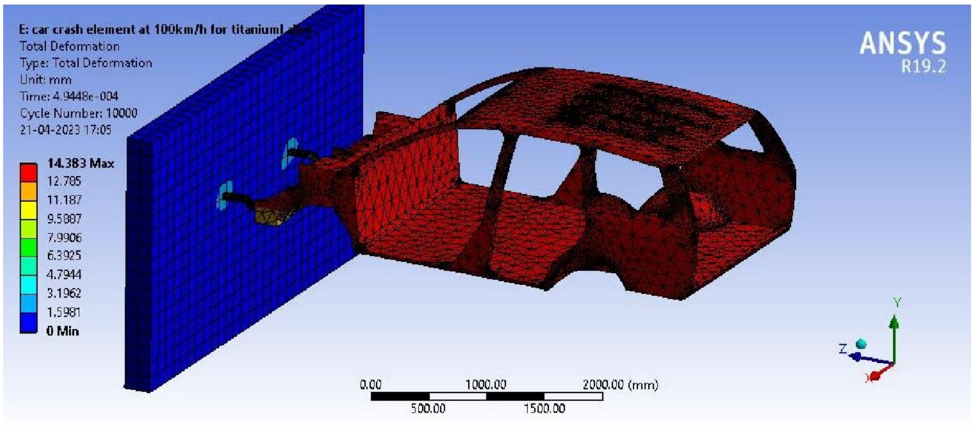
Aluminium Alloy at 100 km/h



Glass Fibre Epoxy at 100 km/h



Structured Steel at 100 km/h



Titanium Alloy at 100 km/h

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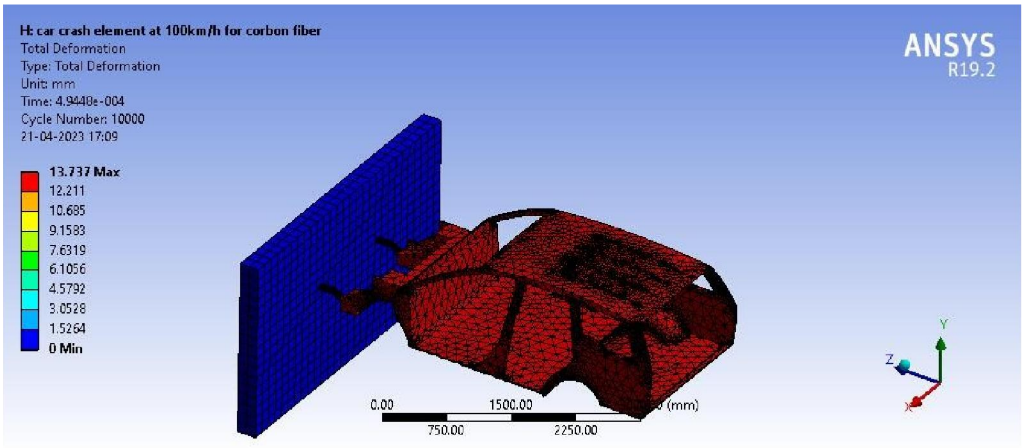
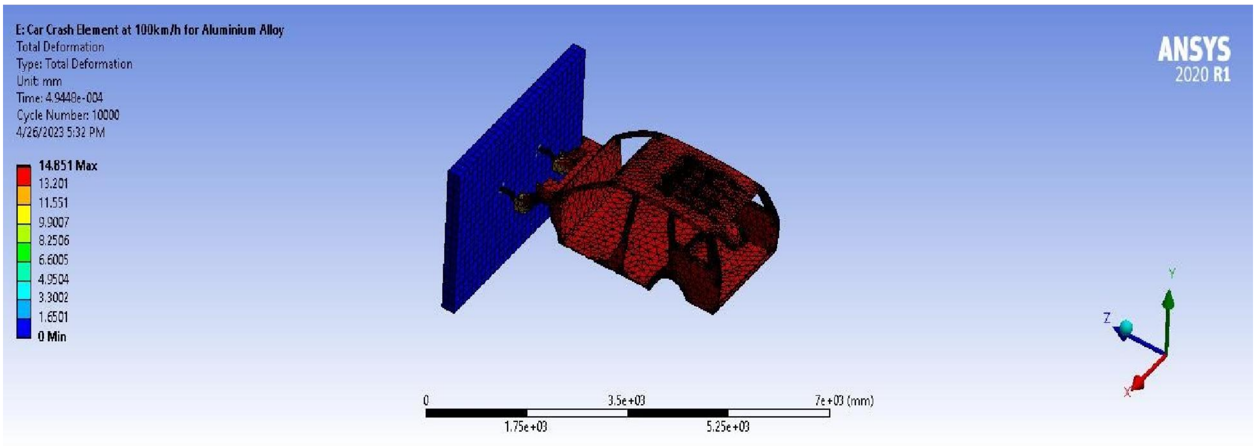
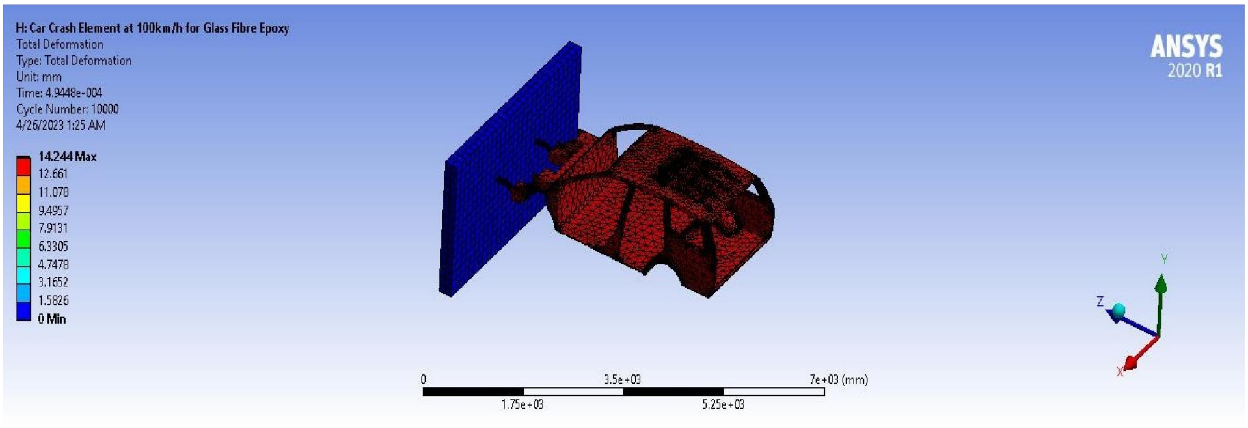


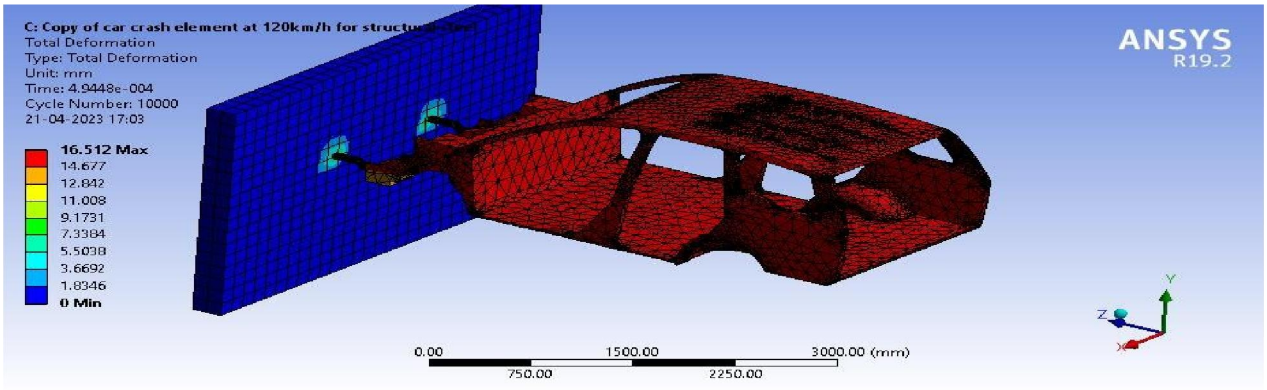
Carbon Fibre Epoxy at 100 km/h



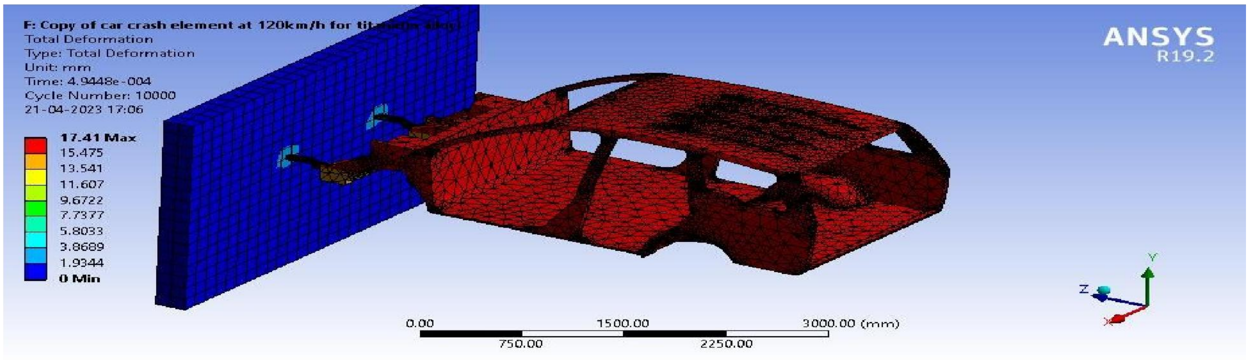
Aluminum Alloy at 100 km/h



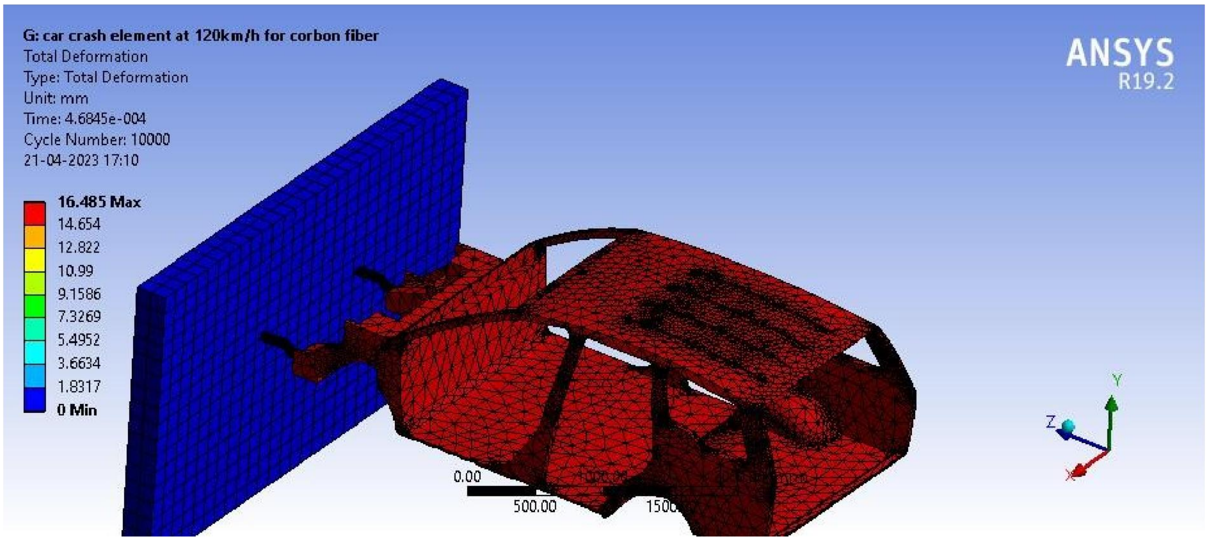
Glass Fibre Epoxy at 100 km/h



Structured Steel at 120 km/h



Titanium Alloy at 120 km/h



Carbon Fibre Epoxy at 120 km/

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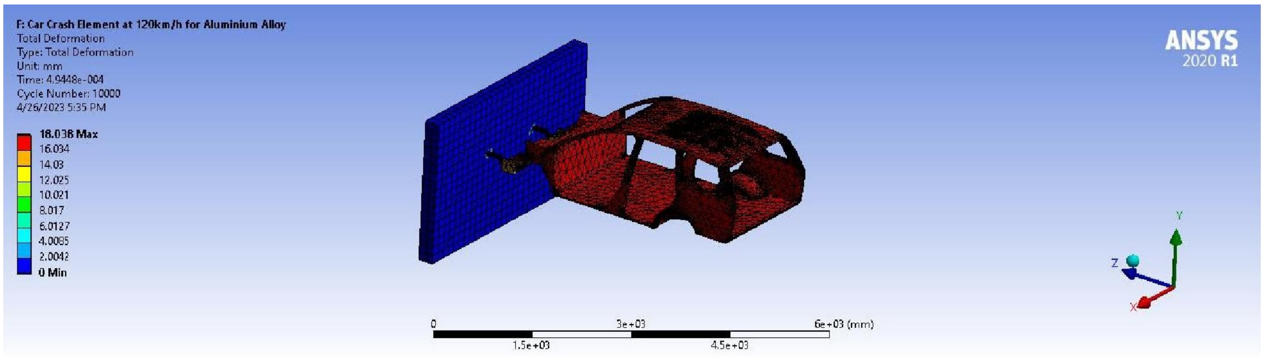
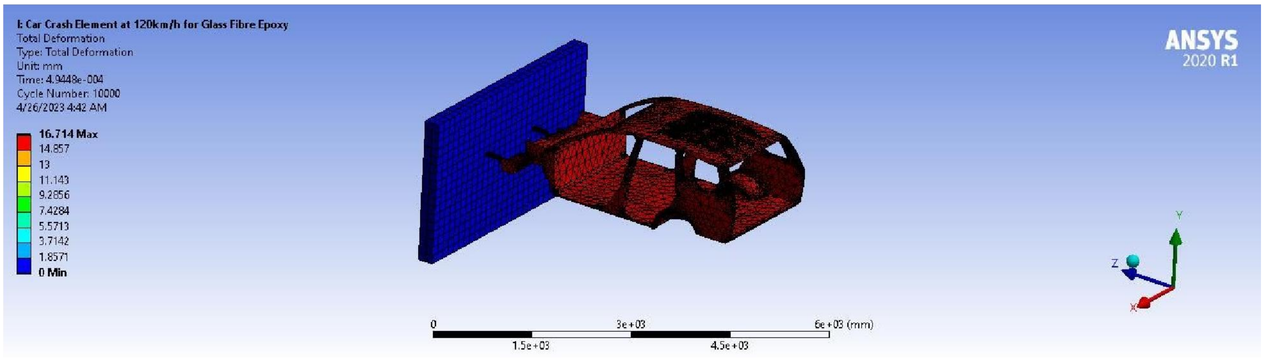


Aluminum Alloy at 120 km/h



Glass Fibre Epoxy at 120 km/h

IX. RESULT

TABULATION:

PARAMETER	Structured Steel	Titanium Alloy	Carbon FibreEpoxy
Total Deformation at 80km/h	11.008 mm	11.396 mm	10.99 mm
Total Deformation at100 km/h	13.76 mm	14.383 mm	13.737 mm
Total Deformation at120 km/h	16.512 mm	17.41 mm	16.485 mm

PARAMETER	Aluminium Alloy	Glass Fibre Epoxy
Total Deformation at 80km/h	11.746 mm	11.342 mm
Total Deformation at100 km/h	14.851 mm	14.244 mm
Total Deformation at120 km/h	18.038 mm	16.714 mm

The results for the Explicit Dynamic Analysis for five different materials at three different speeds are tabulated as shown in the figure above. The five materials are structural steel, titanium alloy, aluminum alloy, fiberglass epoxy, and carbon fiber epoxy. The obtained results show that carbon fiber epoxy produced less deformation compared to the other four materials.

X. CONCLUSION

In this project, the conventional material used for the front subframe rails in the car, steel, is replaced by a composite material of Glass Fiber Epoxy, Carbon Fiber Epoxy and Titanium alloys. The 3D model of the subframe rail is made in CATIA V5. The total deformation created after Explicit Dynamic Analysis is less for carbon fiber epoxy compared to other materials. Therefore, it can be concluded that the use of carbon fiber epoxy is better because its strength is greater than that of structural steel, aluminum alloy, glass fiber epoxy, and titanium alloy.

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