Journal Homepage: www.ijrpr.com ISSN: 3049-0103 (Online)

International Journal of Advance Research Publication and Reviews

Vol 03, Issue 11, pp 90-96, November, 2026

Impact Collision Analysis for frontal impact of vehicle using Finite Element Analysis simulation

Vikas S. Avhad[1], Dr.T.Y.Badgujar[2], Prof. R.R. Chaudhari

[1] P.G. Research Scholar, [2]Head of Department, [3]Ast. Professor
Mechanical Engineering Department, Late G.N. Sapkal College of Engineering, Nashik, Maharashtra, India

ABSTRACT –

Automobile sector is growing rapidly due to new technological inventions. Apart from this, there has been a significant increase in accidents and road accidents. The main goal is to design and create an energy-absorbing crash box that is affordable, easy to manufacture, ecologically friendly, and suitable for installation in car bumpers to improve safety. The main goal of the work was to create bumpers that could absorb impact energy in the case of a collision. The use of bio-composites made from natural plant fibers is increasing day by day. Various sizes of absorbers can be manufactured and installed in the bumper. Materials used here for energy absorption are jute fiber and bamboo fiber.

Key Words: Energy Absorber, Jute, Bamboo, Impact Collision

Introduction :

1.1 Collision in Vehicle:

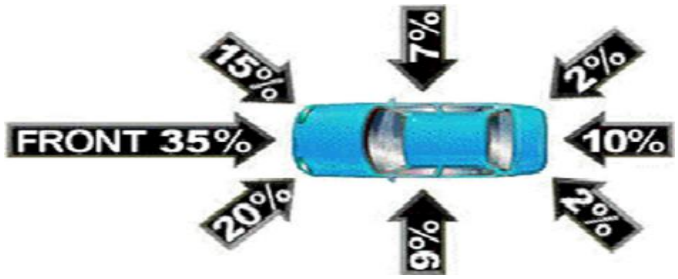


Fig.1 Percentage of Impact for a vehicle

Fig.1 illustrates the percentage impact for a vehicle during crash. It is well known that crashes cause thousands of deaths or severe injuries to people each year all around the world. The car body must absorb the majority of the energy produced by crashes, stop break-ins, and stop the passenger compartment from deforming to protect the occupants of the vehicle. To achieve these conditions, the two longitudinal lines must work together simultaneously to absorb sufficient energy and ensure passenger safety.

1.2 Bumpers in Automobile:

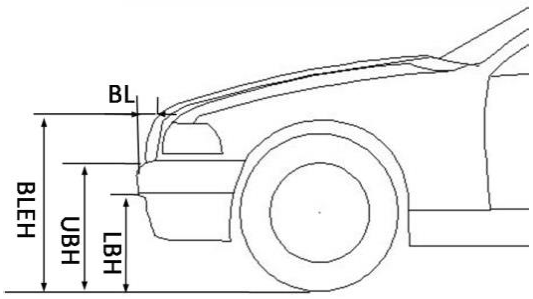


Fig. 2 Terminology of a Conventional Bumper

In Fig 2. above, BL = Bumper Head (cm); BLEH = height of front of cover (cm); UBH = Upper Bumper Height (cm); LBH = Lower Bumper Height (cm). A bumper system mainly consists of 3 components, namely the fairing, the bumper crossbar and the mounting bracket. Fairing and bumper crossbars typically have a gap of 70 mm to 100 mm that can be used to improve safety, by introducing energy-absorbing elements. The design and development of energy-absorbing bumpers to absorb impact energy in the case of a collision is the main goal of this effort.

1.3 Crash Box:

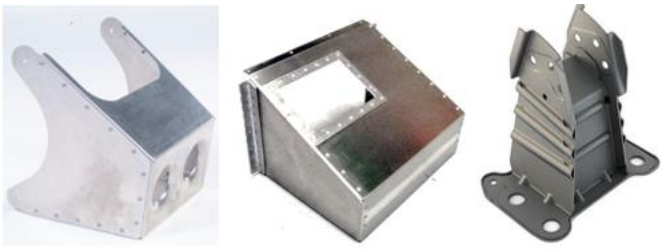


Fig. 3 Typical Crash Boxes

Fig. 3 shows typical crash boxes used in vehicles. The crush box is installed behind the front and rear fenders. One part of a car that absorbs impact energy is called a crash box. The crash box reduces the kinetic energy and absorbs the shock load by bending like a compressible box upon collision. The crash box will be more responsible than other body sections for absorbing impact energy in the case of a frontal collision. In addition to reducing harm to the bumper and main frame, this shields the occupants from grave injuries. A crush box is a structure with thin walls that is fastened to the side rails and bumper body of the vehicle. A crush box must be able to absorb impact energy.

Literature Survey :

Energy absorber is a component in the bumper system placed in between bumper fascia and bumper beam. It can be metal, non-metal or a composite. [6] In the past, only metal. Energy absorber is a component in the bumper system placed in between bumper fascia and bumper beam. It can be metal, non-metal or a composite.[2] The front car bumper system is a complex energy-absorbing system in a car design which must meet both the requirements of pedestrian safety and low-speed impact. [4] If one or both longitudinal are not loaded axially, this will decrease the absorbed energy and bending occurs. This gives two discrepancies: The maximum energy has to be absorbed by one or both longitudinal, and that in partial overlap or oblique collisions, the energy absorbed by longitudinal will not reach that of full overlap as in direct impact.[3] It is a proposed New Car Assessment Program for India. Cars sold in the country will be assigned by star ratings based on their safety performance. It will be implemented in phases, according to the plans being drawn up by the National Automotive Testing and R&D Infrastructure Project. It is the 10th NCAP in the world and is being set up by the government of India. [22]

Materials :

3.1 Jute Fiber:

Jute is a naturally occurring fiber that is taken from the jute plant's outer layer and stem. It is a plant fiber that is long, glossy, and soft. It may be spun into strong, coarse threads. Jute is the second most produced natural fiber in the world after cotton, making it one of the least expensive. It is a crucial fiber for the textile sector and goes into making many different items, like hessian, bags, and string.



Fig. 4 Jute Fiber

Fig. 4 shows a typical photo of natural jute. Jute is a natural fiber with a lot of benefits. Because it decomposes naturally, it is eco-friendly. Since jute can grow again after being harvested, it is also a renewable resource. Additionally, jute has inherent flame-retardant qualities and is resistant to decay. Because of its strength and durability, this fiber is appropriate for producing bulky items like ropes and bags. Jute is utilized not just in the textile industry but also in the manufacturing of paper, insulating materials, and biofuels. It is a resource that may be used in many different industries because it is strong and adaptable.

3.2 Bamboo Fiber:

Bamboo is an evergreen perennial flowering plant belonging to the grass family Bambusoideae. The word "bamboo" comes from the Dutch or Portuguese languages, which may have taken it from the Malay language.



Fig. 5 Mechanical Processing of Bamboo Fiber

Fig. 5 indicates the process of making bamboo fiber. Bamboo is a natural cellulose textile material that is renewable, biodegradable, and environmentally beneficial. It is a novel and environmentally beneficial textile material for the twenty-first century because it is not only a green fiber but also possesses natural antibacterial and anti-UV protection qualities.

Because of its great tensile strength, stability, and durability, it is utilized not only in traditional textiles but also makes a highly valuable composite material for high-performance end applications.

We don't extract cellulose during the production process to create our premium bamboo textiles. Rather, the pulverized bamboo fibers are treated with natural enzymes, followed by a washing and spinning process to create yarn. This yarn typically feels silky, and the cloth created with it is commonly referred to as bamboo linen. This is a true natural bamboo fiber cure.

Finite Element Analysis :

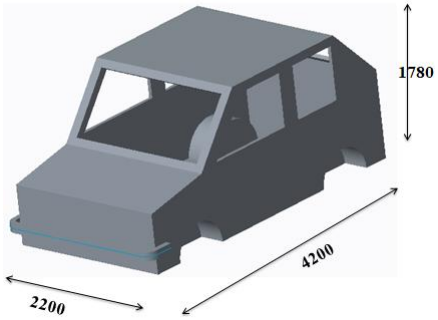


Fig. 6 3D Model of Car Body

Fig. 6 shows a model of a car body was created for preliminary analysis and the effect of change was analyzed accordingly. To complete the initial body analysis, the vehicle body material was identified as aluminum alloy used for structural purposes.

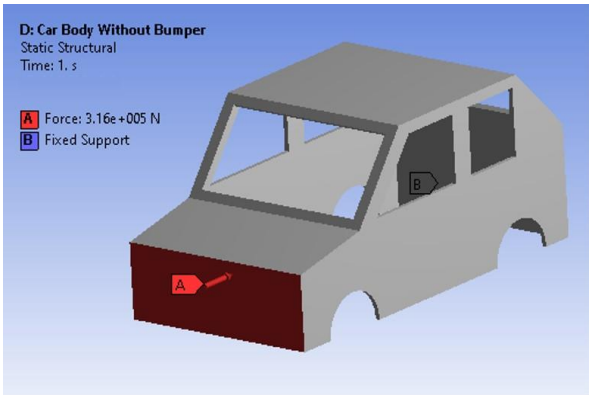


Fig. 7 Analyses Setting for Impact Energy on Simple Car Body without Bumper

Fig. 7 indicates impact energy on simple car body without bumper. The First step of the analysis is to carry out the deformation and energy-absorbing capacity of the car body without using any kind of bumping system. Fig. 6 illustrates the impact analysis shows the impact force which is produced for 25 kmph.

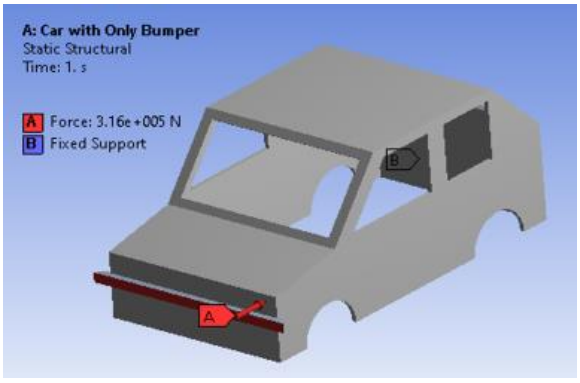


Fig. 8 Analyses Setting for Impact Energy on Simple Car Body with Bumper

Fig. 8 indicates impact energy on simple car body with bumper. The Second step of the analysis is to carry out the deformation and energy absorbing capacity for the car body by using Bumper. The material for bumpers has been used as Carbon Fiber as it is a general material used for traditional automotive bumpers.

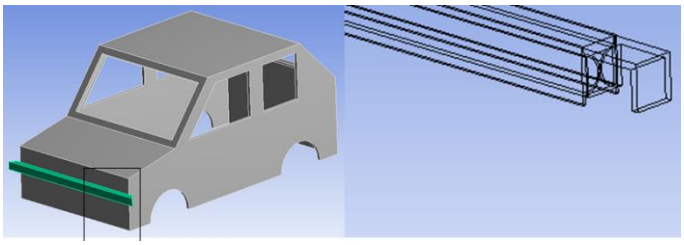


Fig. 9 Analyses Setting for Impact Energy on Simple Car Body with BFEA Bumper

Fig. 9 shows BFEA Bumper mounted on car body. The Third step of the analysis is to carry out the deformation and energy absorbing capacity for the car body by using Bumper with BFEA energy absorbing component. The material for bumper has been used as Carbon Fiber and that of absorber is been used as Bamboo Fiber material.

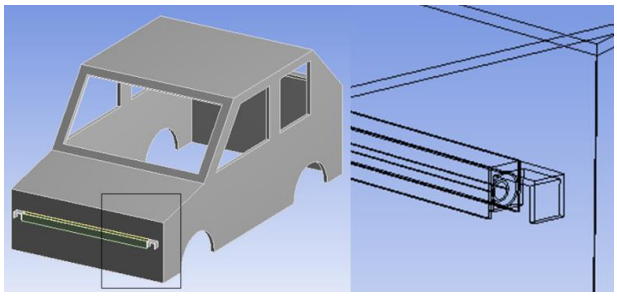


Fig. 10 Analyses Seting for ImpactEnergy on Simple Car Body with JFEA Bumper

Fig. 10 shows JFEA Bumper mounted on car body. The Fourth and Final step of the analysis been carry out the deformation and energy absorbing capacity for the car body by using Bumper with JFEA energy absorbing component by using the impact force. The material for bumper is same as that of BFEA arrangement and absorber is made of Jute Fiber.

Result and Discussions :

5.1 Deformation Analysis:

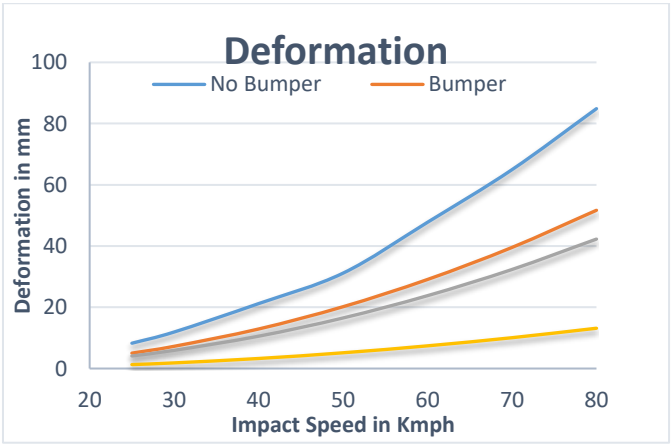


Fig. 11 Deformation Analysis

Fig. 11 shows the response analysis for different impact velocities for different sections. As shown in the Fig., the resulting body deformation with or without the shock absorber system is close to the deformation occurring in BFEA and JFEA shocks. Therefore, regarding the simulation results, it can be said that using an energy absorber can reduce deformation, which has the effect of reducing dislocations.

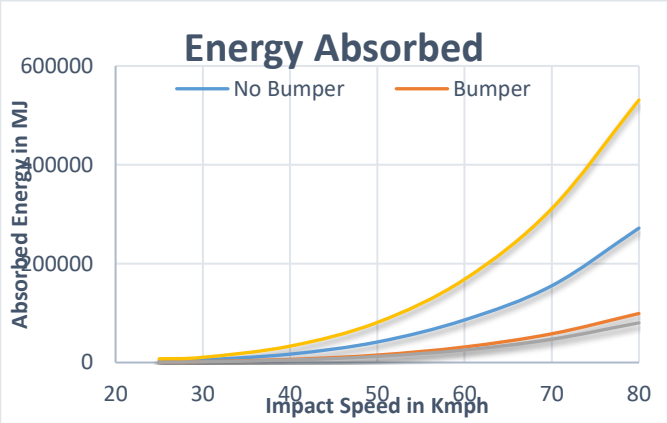


Fig. 12 Energy Absorption Analysis

Fig. 12, shows the response analysis of different impact speeds for various sections. As shown in the graph, the strain energies produced in the JFEA arrangement is maximum which states that implementation of absorber can absorb high impact energy to transmit it to the frontal parts of the vehicle acting as safeguarding member.

CONCLUSIONS

- It deformation analysis, it has been observed that the application of bumper with energy absorber considerably reduces the deformation of the component as that of no bumper arrangement or bumper without any energy absorber.
- The JFEA model and Double BFEA model has been selected as energy absorber component due its ease in manufacturing, its capacity and cost factor availably.
- In order to obtain the impact strength with low weight, polymers are the best material to be made use in, hence the material of Jute, and Bamboo have been discussed with all the properties. The Static analysis is performed for determination of impact strength for considering the material as Bamboo and Jute Fiber Polymer.
- After the FEA we can see that, the deformation produced by the polymer composites energy absorber are less as that of Bamboo bumper and body without bumper. The results of JFEA and BFEA absorber found to be better than that of Bamboo.

REFERENCES

1] Otte, D.; Haasper, C, “Characteristics on fractures of tibia and fibula in car impacts to pedestrians and bicyclists – influences of car bumper height and shape”, Association for the Advancement of Automotive Medicine. Association for the Advancement of Automotive Medicine · , A Research Gate Publication, February 2007

2] Yong Han, Jikuang Yang, Koji Mizuno & Yasuhiro Matsui, “Effects of Vehicle Impact Velocity, Vehicle Front-End Shapes on Pedestrian Injury Risk”, Journal for Traffic Injury Prevention, Published by Taylor & Francis Informa Ltd, 30 Aug 2012.

3] Guibing Li, Mathew Lyons , Bingyu Wang , Jikuang Yang, Dietmar Otte, Ciaran Simms “The influence of passenger car front shape on pedestrian injury riskobserved from German in-depth accident data”, Journal of Accident Analysis and Prevention, Else Vier Publication, Volume 101, 2017.

4] Bingyu Wang,, Jikuang Yang,, Dietmar Otte, “The effects of Vehicle Front Design Variables and Impact Speed on Lower Extremity Injury in Pedestrian collisions using In-depth Accident Data”, Eighth International Conference on Measuring Technology and Mechatronics Automation, 2016.

5] Rasoul Moradi, “Evaluation of the kinematics and injury potential to different sizes of pedestrians impacted by a utility vehicle with a frontal guard”, International Journal of Crashworthiness, Published by Taylor & Francis Informa Ltd, 2011.

6] A.Siva Kumar, "Experimental Investigations with Crush Box Simulations for Different Segment Cars using LS-DYNA", International Journal of Current Engineering and Technology, International Conference on Advances in Mechanical Sciences, 2014.

7] Y. FUJII, "A method for determining the impact force in crash testing", Journal of Mechanical Systems and Signal Processing, Published by Academic Press, Volume 14, Isssue 6, 2010.

8] H. Naderpour, "A new model for calculating impact force and energy dissipation based on the CR-factor and impact velocity", Sharif University of Technology, A Research Gate Publication, 2014.

9] Xiwu Zhou, "A Study of the Cumulative Impact Forces of Stainless-Steel Reinforced Concrete Pier", International Journal of Steel Structures, Springer Publication, 2019.

10] A.V. Kireev, "Energy-regenerative Shock Absorber Mathematical Model", International Conference on Industrial Engineering, Journal of Procedia Engineering, Else Vier Publication, Volume 206, 2017.

11] Sagar P Dhamone, Dr Arun kumar P, "Advance Robotics Technology on Crash Analysis Automobile Bumper by Varying Suitable Input Parameter in Order to Control Energy Absorption for Improve Passenger Car Safety Aspect", International Research Journal of Engineering and Technology , Volume: 05 Issue: 07, 2018.

12] Gabriel Jiga, "Material and shape crash-box influence on the evaluation of the impact energy absorption capacity during a vehicle collision", Journal of Ciência & Tecnologia dos Materiais, Else Vier Publication, Volume 28, 2016.

13] Samer Fakhri Abdulqadir, "Design a new energy absorber longitudinal member and compare with S-shaped design to enhance the energy absorption capability", Alexandria Engineering Journal, Else Vier Publication, Volume 57, 2018.

14] Rahul Nair, "Design and optimization of automotive energy absorber structure withfunctionally graded material", Journal of Materials Today: Proceedings, Else Vier Publication, Volume 5, 2018.

15] RĤžiþka Milan, "Development of composite energy absorber", Journal of Modelling of Mechanical and Mechatronic Systems, Else Vier Publication, Volume 96, 2018.

16] Fuhao Mo, "Design of a Conceptual Bumper Energy Absorber Coupling Pedestrian Safety and Low-Speed Impact Requirements", Journal of Applied Bionics and Biomechanics, Hindawi Publications, 2018.

17] Nikola Schmidová, "Development of Adaptable CFRP Energy Absorbers for Car Crashes", Journal for Materials Today: Proceedings, Else Vier Publication, Volume 05, 2018.

18] Guangjun Gao, "Experimental investigation of an active–passive integration energy absorber for railway vehicles", Journal of Thin-Walled Structures, Else Vier Publication, Volume 117, 2017.

19] N M Kusaseh et.al. "Flexure and impact properties of glass fiber reinforced nylon 6-polypropylene composites", IOP Conf. Series: Materials Science and Engineering, Volume 319, 2018.

20] Md Nuruddin, "impact behavior of e-glass/carbon hybrid fiber", The Composites and Advanced Materials Expo, CAMX Conference Proceedings, 2015.