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ijirset@gmail.com

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Design and Development of Honey Comb Structure based Side Door Impact Beam

Sharvari Prakash Puri, Prof.Amol B Gaikwad

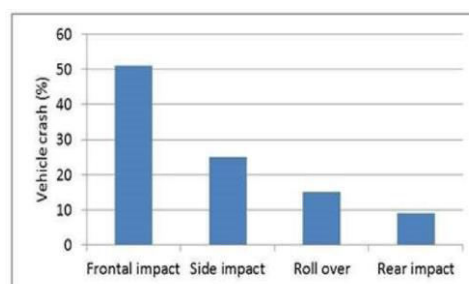
Department of Mechanical Engineering, Ajeenkya DY Patil School of Engineering, Lohegaon, Pune,India

Guide, Department of Mechanical Engineering, Ajeenkya DY Patil School of Engineering, Lohegaon, Pune, India

ABSTRACT: In the automotive industry, vehicle safety is paramount, and side door impact beams play a crucial role in protecting occupants during lateral collisions. This study presents the design and development of a honeycomb structure-based side door impact beam, aimed at enhancing energy absorption properties while minimizing weight. Utilizing a three-point bending analysis, we evaluate the mechanical performance of the proposed beam design in comparison to traditional solid and composite structures. Initially design will crated with the assistance of solid works 2022 then Finite Element Analysis (FEA) was employed to simulate the three-point bending test, allowing for the assessment of deformation, stress distribution, and failure modes. Then experimental 3 point bending test will be performed on universal testing machine. This innovative approach not only meets the regulatory safety standards but also contributes to weight reduction in vehicle design, thereby enhancing fuel efficiency and overall vehicle performance. The findings of this research pave the way for future advancements in vehicle safety technologies, emphasizing the importance of material selection and structural optimization in automotive engineering.

I.INTRODUCTION

Side impact collision accidents happen every day in various countries are mostly dangerous stage condition leads to death. Moreover, the space required of the side impact is less than the frontal impact. Side impact collision is directly impacted by the structure of a vehicle which affects the occupant. The vehicle structure which absorbs the impact energy from the side impact which passes the limited injuries to the occupant from the accident and side impact beam should resist from the crash impact forces, absorb the energy which minimizes the impact to the passenger compartment



A side-impact door beam is a structural component in a vehicle's door designed to enhance the door's ability to withstand impact during a side collision. It is designed to protect passengers from side impacts by absorbing the maximum amount of impact energy and reducing the depth of door intrusion through an elasto-plastic deformation. Anti-intrusion beams are mounted within the internal door cavity of a vehicle at the external plane and fixed to front and rear door supports. These beams are typically made of high-strength steel or other materials that can absorb and distribute the force of a side impact, helping to protect the occupants inside the vehicle. In the event of a side collision, the side-impact door beam helps to prevent the door from collapsing inward towards the occupants, reducing the risk of injury. This added reinforcement also helps to maintain the structural integrity of the vehicle, minimizing damage and improving overall safety.

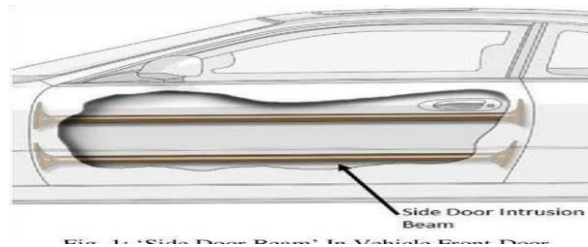


Figure1 – side door impact beam

II. CRASHWORTHINESS

Crashworthiness is a vehicle's capability to shield its occupants during a collision. This concept includes several factors such as the vehicle's structural integrity, material strength, and design principles. By focusing on crashworthiness, automotive engineers work towards creating vehicles that can effectively absorb and disperse crash energy, thereby improving passenger safety. Automotive safety has become a paramount consideration in vehicle design, particularly concerning side impacts. The side door impact beam plays a critical role in preserving passenger safety by absorbing and distributing the energy of an impact. Traditional designs often utilize solid materials that may not offer the best trade-off between strength and weight. Recent advancements in materials and structural design have led to the emergence of honeycomb structures, known for their excellent energy-absorption characteristics, lightweight nature, and structural efficiency protect the occupants in survivable crashes. Similarly, in the automotive industry, crashworthiness connotes a measure of the vehicle's structural ability to plastically deform and yet maintain a sufficient survival space for its occupants in crashes involving reasonable deceleration loads. Restraint systems and occupant packaging can provide additional protection to reduce severe injuries and fatalities. Crashworthiness evaluation is ascertained by a combination of tests and analytical methods. Vehicle crashworthiness and occupant safety remain among the most important and challenging design considerations in the automotive industry. Early in the history of vehicle structural developments, vehicle bodies were manufactured from wood, and the goal of crashworthiness was to avoid vehicle deformations as much as possible. Over the years, the body structures evolved to include progressive crush zones to absorb part of the crash kinetic energy by plastic deformations. At present, vehicle bodies are manufactured primarily of stamped steel panels and assembled using various fastening techniques. Designers create vehicles to provide occupant protection by maintaining integrity of the passenger compartment and by simultaneously controlling the crash deceleration pulse to fall below the upper limit of human tolerance. A crash deceleration pulse with an early peak in time and a gradual decay is more beneficial for protection of a restrained occupant. Therefore, the goal of crashworthiness is an optimized vehicle structure that can absorb the crash energy by controlled vehicle deformations while maintaining adequate space so that the residual crash energy can be managed by the restraint systems to minimize crash loads transfer to the vehicle occupants.

III. FINITE ELEMENT ANALYSIS

The FEA has been extensively used to solve problems involving irregular regions and complicated modals.

Step 1: Details of material namely copper, steel, grey cast iron, composite material, fluid domain material is defined in engineering data. i.e. ANSYS default material is structural steel.

Step 2: Import of geometry created in any CAD software namely CATIA, PRO E, SOLIDWORK, INVENTOR etc. in geometry section. If any correction is to be made it can be created in geometry section in Design modeller or space claim.

Step 3: In model section after import of component

- Material is assigned to component as per existing material
- Connection is checked in contact region i.e. bonded, frictionless, frictional, no separation etc. for multi body components.
- Meshing or discretization is performed i.e. to break components in small pieces (elements) as per size i.e. preferably tetra mesh and hexahedral mesh for 3D geometry and for 2 D quad or tria are generally preferred.

Step 4: Boundary condition are applied as per analysis namely in fixed support, pressure, force, displacement, velocity as per condition.

Step 5: Now problem is well defined and solve option is selected to obtain the solution in the form of equivalent stress, strain, energy, reaction force etc.

Three-Point Bending Test:

In a three-point bending test using a Universal Testing Machine (UTM), the goal is typically to determine the flexural properties of a material, including the flexural strength and modulus of elasticity. The three-point bending test involves applying a load at the center of a specimen supported at two points

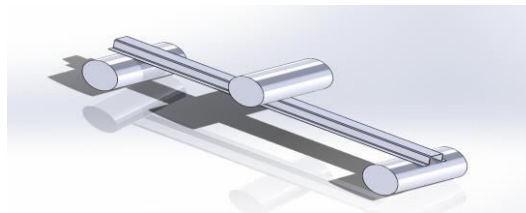


Fig 2-3D Cad Model with Three Point Loading:

P: Maximum load applied (N)

L: Span length between supports (mm)

b: Width of the specimen (mm)

d: Depth or thickness of the specimen (mm)

δ: Maximum deflection at the center of the span (mm)

Flexural Stress (σ):

$$\sigma = (3PL) / (2bd^2)$$

IV. ENGINEERING DATA – STRUCTURAL STEEL

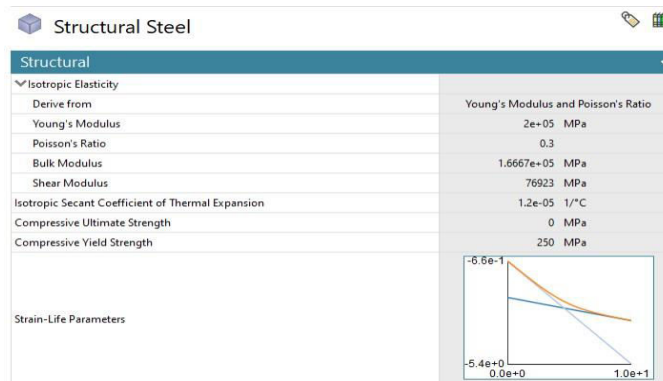


Fig 3 –Material Properties

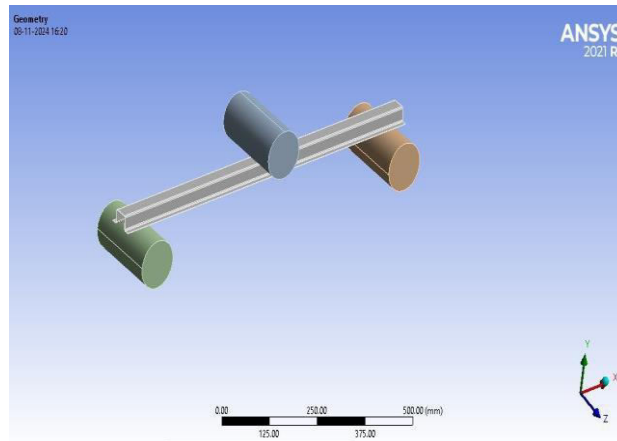
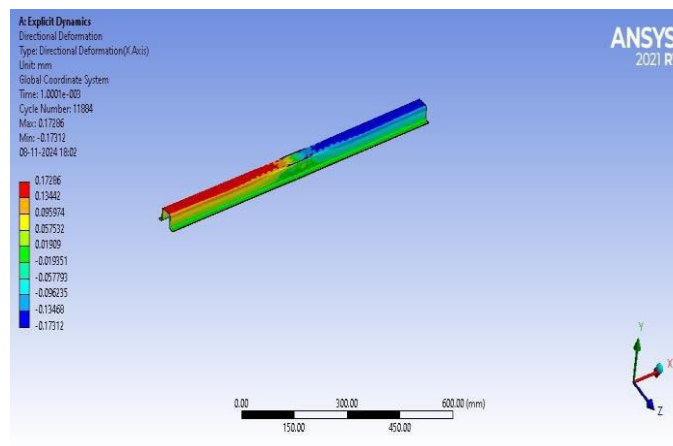


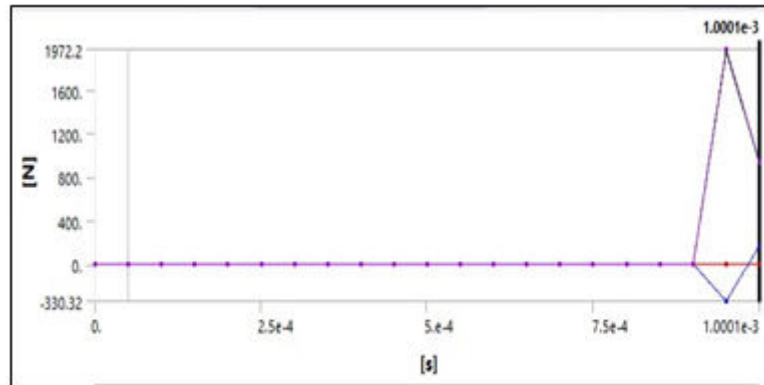
Fig 4- Geometry model of side door impact beam with three point loading

V. RESULT SUMMARY

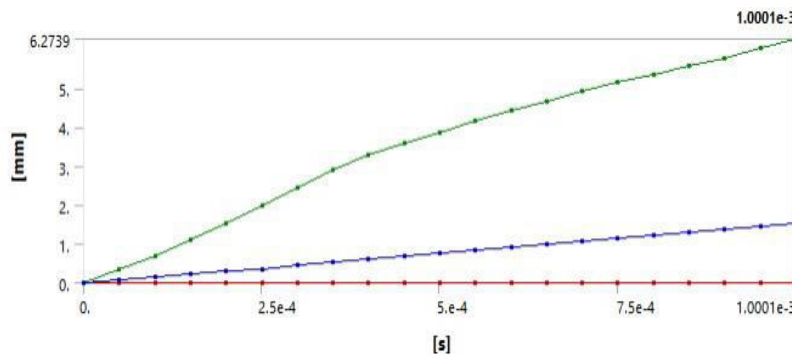


Results	Minimum	Maximum	Units	Time (s)
Total Deformation	0.	6.2739	mm	1.0001e-003
Equivalent Stress	3.5194e-003	501.59	MPa	1.0001e-003
Directional Deformation	-0.17312	0.17286	mm	1.0001e-003

In this research to found out different parameter total deformation, equivalent stress , Directional deformation. The finite element analysis (FEA) is a problem solving approach for the practical (engineering) problems. The problems are first converted to matrix and partial differential equation forms.



Time vs Force



Time vs Displacement

VI. CONCLUSION

The Three-Point Bending Test And Accurately Calculating The Relevant Parameters, You Can Gain Valuable Insights Into The Mechanical Properties Of Materials.

The finite element analysis (FEA) is a problem solving approach for the practical (engineering) problems. The problems are first converted to matrix and partial differential equation forms.

- One of the challenges here is to explore the deformation and energy absorption of these honeycomb based structure using advanced manufacturing techniques, proper mechanical testing and modelling.
- The manufacturing technology should over them the geometry complexity of high order honey comb structure and should be highly precise and low cost.

It can be concluded that when seeking for higher strength and stiffness of the structure, minimal weight and energy absorption.

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