DESIGN & ANALYSIS OF A CAR BUMPER BEAM WITH ENERGY ABSORBER

A REPORT

Submitted by

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of

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IN

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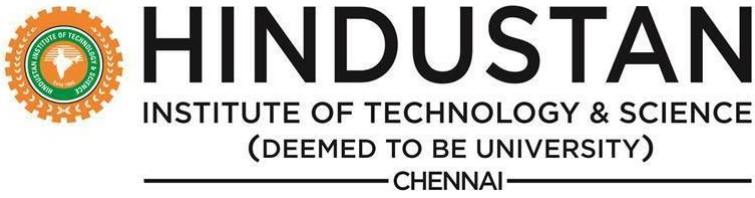

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Certified that this thesis titled **"DESIGN & ANALYSIS OF A CAR BUMPER BEAM WITH ENERGY ABSORBER"** is the bonafied work of **KONETI SRIMANNARAYANA (18104003), EDAGOTTU UMESH NITHIN (18104009), SAMUDRALA RAJKUMAR (18104017), NAGIREDDY HEMANTH KUMAR REDDY (18104115)** who carried out the work under my supervision. Certified further that to the best of my knowledge the work reported herein does not form part of any other thesis or dissertation on the basis of which a degree or award was conferred on anearlier occasion on this or any other candidate.

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ABSTRACT

According to Ministry of Road Transport and Highway Transport Research Wing of India in 2019 1.5 lakh people died and 4.51 lakh people are getting injured in road accidents. Most of the injuries and death are caused due to front collision of vehicle. The bumper beam in automobiles is one of the important components in protecting the passengers from mishap. Up to the day most of the bumper beam are designed to absorb low speed impact, it must be designed in such a way as to minimize impact on the vehicle and reduce mishap to passenger at high-speed collision. This project involves in design of a car bumper beam that could with stand low impact collision with energy absorbing material.

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CHAPTER 1
INTRODUCTION

The car accidents are happening in our day-to-day life. Insights shows that millions of people are dying and massive range are injured every year. It is therefore important to improve the safety of cars in order to reduce the number of deaths and injuries. The bumper beam for automobiles is one of the important components in protecting the lives of passengers and vehicles from injury and damage from major accidents. It must be designed in such a way as to minimize damage to the vehicle and the risk of injury to the occupants by absorbing the energy generated in the vehicle collision.

1.1 Bumper Beam:

Bumper beam designed to absorb the impact energy on the front end in collision condition. They are fixed to the front and rear ends of motor vehicles by means of brackets that act as crash boxes, since they absorb the loads mainly in the axial direction. They guard the engine, trunk, grill, radiator, headlamps and the passengers inside it.

Now a days most of the bumper beams are made of stainless steel and aluminum alloys (high strength) has high density which increases the weight of the vehicle. The bumper beams should be relatively light and have the ability to absorb the impact (i.e.; cancel the effect or reduce the effect of the impact). Composites and Reinforced materials can play an important role in selection of materials for bumper beam.

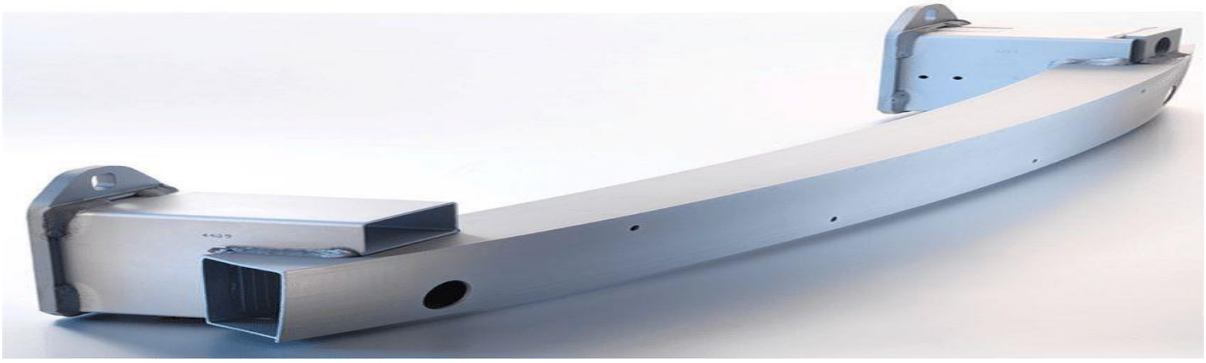


Fig 1.1: Bumper beam (Wikipedia)

1.2 Types of Cross Sections Beams

Cross section of beam also plays a major role in energy absorbing various when collision occurs. Change in shape also increases the energy absorbing capacity of the beam, various cross section of bumper beam is used in modern car like

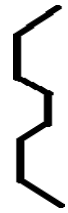
- Open hat section:

  open hat section has a low deformation value and high energyabsorbing property.

- C-section:

  C-section has a high deformation and low energy absorbing property.

- W-Section:



w-section has high impact resistance, low deformation and this type of structure is used at roadside w-beam guardrails help the vehicle to redirect back in the road with low deformation at low speed and adsorbed impact energy at high collision speed.

- Rectangular section:

In general, most of the old model cars have rectangular cross section bumper beam, it has low torsion resistance, high deformation and low energy absorbing capacity. Now a day's hollow section in rectangular beam is filled with foam to absorbed more impact energy.

1.3 Energy absorbing materials and its structures:

1.3.1 Honeycomb structure:

Honeycomb structure is used as energy absorbing material, and it can be placed between bumper beam and fascia which helps in absorbing impact energy when collision occurs. It will absorb 93-98 j /cm^3 of impact energy.

1.3.2 Double cylinder model filled with foam:

In this case, the two-cylinder material are filled with foam to increase the efficiency of impact energy absorbing. Coming to reality it is low efficient than double cylinder model (257J).

1.3.3 Double cylinder model:

Double cylinder various compression stages are used as energy absorber. Due to stages of compression used more impact energy is absorbed (327J).

1.3.4 Double half cylinder model:

This double half cylinder model has high energy absorbing and compression stage (397J).

1.3.5 XPS Polystyrene Foam:

XPS foam board is often used for thermal insulation boards. When used above-grade, it can reduce thermal bridging and improve energy efficiency.

1.4 Alloys:

An alloy is a combination of a metal with at least one other metal or nonmetal. The combination must be part of a solid solution, a compound, or a mixture with another metal or nonmetal in order for it to be considered an alloy. The most common way to combine metals into an alloy is by melting them, mixing them together, and then allowing them to solidify and cool back to room temperature.

1.4.1 Aluminum 6063:

AL 6063 is an aluminum alloy, with magnesium and silicon as the alloying elements. It has generally good mechanical properties and is heat treatable and weldable. Most of the automobile bumpers are made from this material because of its low weight.

1.5 Composites:

A composite is a combination of two or more materials with different physical and chemical properties. Combining the different materials with different physical and chemical properties gives the improvised material property.

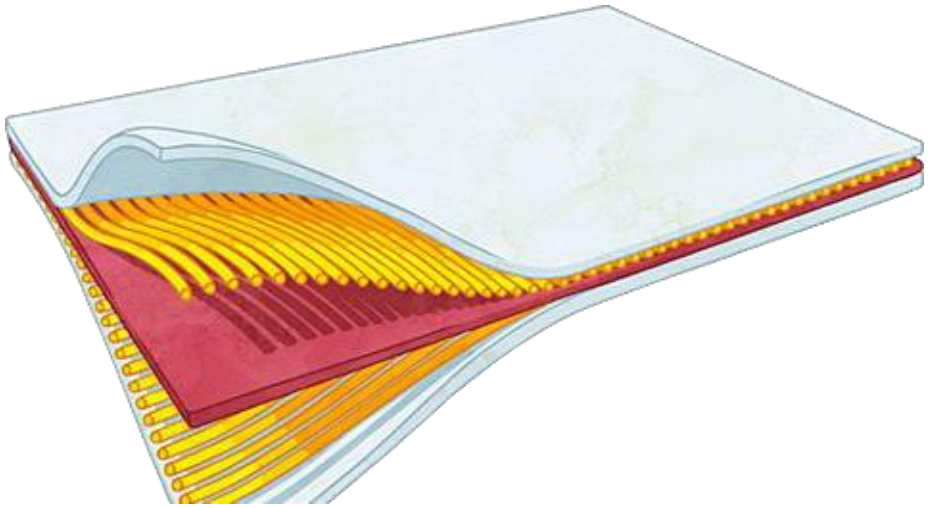


Fig 1.2: Composite (Wikipedia)

Importance of Composites in bumper beam:

Compared to other materials like steel, aluminum etc.., composites have greater strength, low density and light weight. composite materials have high energy absorbing capacity, some of them are carbon fiber and polymer composite.

1.5.1 Polymer Matrix Composite:

A polymeric matrix composite (PMC) is a composite material that consists of a various number of short or continuous fibers that are connected to each other by an organic polymer matrix. PMCs are designed to transfer loads between fibers in a matrix. Advantages of PMCs include their light weight, high rigidity, and high strength in the direction of their reinforcements. Other advantages are good abrasion resistance and good corrosion resistance.

1.5.2 Sandwich Structured Composite:

Sandwich structure composite is a mixture of two materials. The core material is usually a low- strength material, but it has high thickness gives the sandwich mix a high flexible stiffness

with low overall density.

Most of them use honey comb and sheet foam as a core for sandwich beam due to its light weight and energy absorbing capacity. Sandwich structured design is also one of the unique and best concepts for energy absorbing for bumper beam since it has two thin plate composite covering thick light weight core the thin composite plates compared to solid composite material it will have almost same energy absorbing capacity.

1.6 Reinforced composite:

Reinforcement material is added to the matrix material to provide the superior levels of strength and stiffness to the composite. When two or more reinforcing material were added to the matrix material, this type of composite is called a hybrid composite. Carbon fiber and steel are most commonly used reinforced materials.

1.6.1 Carbon Fiber Reinforced Composite:

Carbon fiber reinforced composites have exceptional mechanical properties. These strong, stiff and lightweight materials are an ideal choice for applications where lightweight & high strength. Carbon Fiber Reinforced Composite have high strength, specific toughness, light weight, high vibration resistance, low thermal coefficient of resistance and high damping coefficient.

1.6.2 Glass Fiber Reinforced polymer:

Glass fibers are having very good properties like high strength, flexibility, stiffness and resistance to chemical harm. it may be in the type of roving's, sliced strand, yarns, fabrics and mats. every type of glass fibers has distinctive properties and are used for numerous applications in the form of polymer composites.

1.7 Shock Absorber:

A shock absorber or damper is a mechanical or hydraulic device that is used to absorb and dampen shock impulses. This is done by converting the kinetic energy of the impact into

another form of energy (typically heat), which is then dissipated. In a vehicle, shock absorbers reduce the effects of driving over rough terrain, resulting in better ride quality and vehicle handling. There are two types of shock absorbers Twin tube and mono tube

1. Mono Tube

Mono tube shock absorber has oil, high pressure gas, piston in the single chamber.

2. Twin Tube

Twin tube has inner tube for the piston cylinder, and an outer tube that serves as a fluid reservoir.

1.8 Types of Welding:

1.8.1 Arc Welding:

It is a welding process that is used to join metal to metal by using electricity to create enough heat to melt metal, and the melted metals, when cool, result in a binding of the metals. It is a type of welding that uses a welding power supply to create an electric arc between a metal stick ("electrode") and the base material to melt the metals at the point of contact. Arc welders can use either direct (DC) or alternating (AC) current, and consumable or non-consumable electrodes. welding area is usually protected by some type of shielding gas, vapor, or slag.

1.8.2 MIG Welding:

MIG stands for metal inert gas and sometimes may be called gas metal arc welding (GMAW). It is a semi-automatic, quick process where filler wire fed through the gun and shielding gas expelled around to protect from environmental impurities. The filler wire fed on a spool to act as an electrode as well.

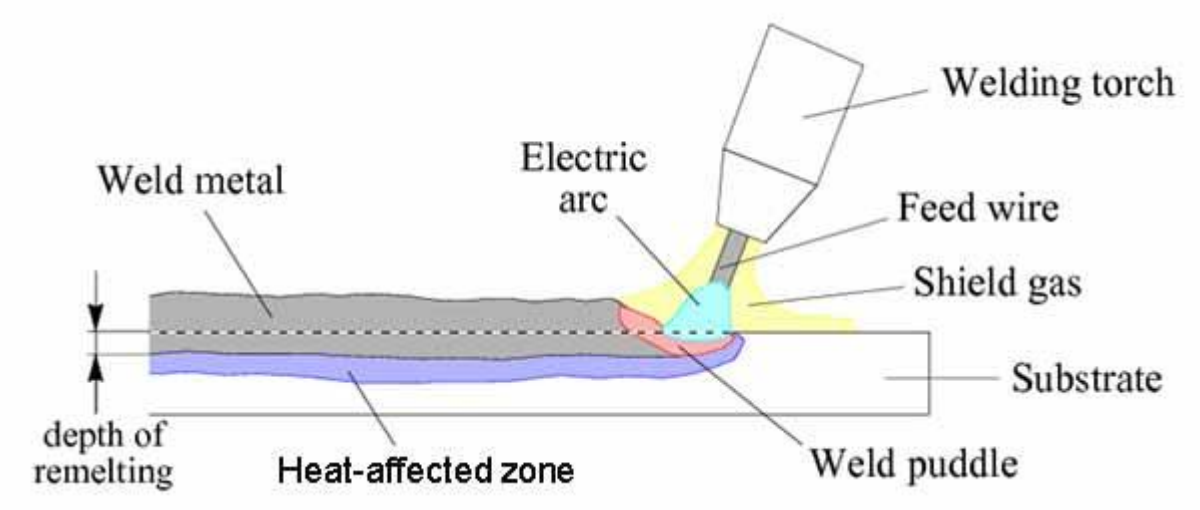


Fig 1.3: MIG Welding (Wikipedia)

1.8.3 TIG Welding:

TIG Welding is possible with no filler material. The non-consumable tungsten electrode is used to create the arc when contacting the base metal. The strong arc melts the two metals and joins them. You may use filler wire if required. We need the constant supply of shielding gas to protect welding from the environmental impurities. It works better indoors and away from elements.

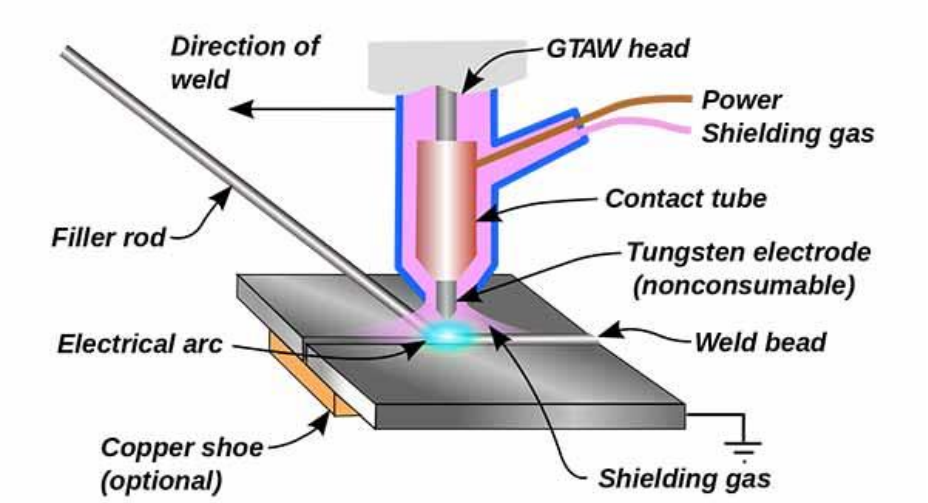


Fig1. 4: TIG welding (Wikipedia)

1.9 Impact Test:

It is a test of the ability of a material to withstand impact, used by engineers to predict its behavior under actual conditions. Many materials fail suddenly under impact, at flaws, cracks, or notches.

1.9.1 Charpy Impact Test:

The Charpy impact test, also known as the Charpy V-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture. Absorbed energy is a measure of the material's notch toughness. It is widely used in industry, since it is easy to prepare and conduct and results can be obtained quickly and cheaply.

1.9.2 Izod Impact Test:

The Izod impact strength test is an ASTM standard method of determining the impact resistance of materials. A pivoting arm is raised to a specific height (constant potential energy) and then released. The arm swings down hitting a notched sample, breaking the specimen. The energy absorbed by the sample is calculated from the height the arm swings to after hitting the sample. A notched sample is generally used to determine impact energy and notch sensitivity.

Fig 1.5: Charpy impact test (Wikipedia)

Fig1.6: Izod impact test (Wikipedia)

1.9.3 Drop Impact Testing:

A drop weight impact test typically determines a material's resistance to a sudden external force. This type of test is also applicable for pipe testing where the impact resistance of thermoplastic pipes is measured. The standards which are applicable for this type of testing include ASTM D2444 and ISO 3127.

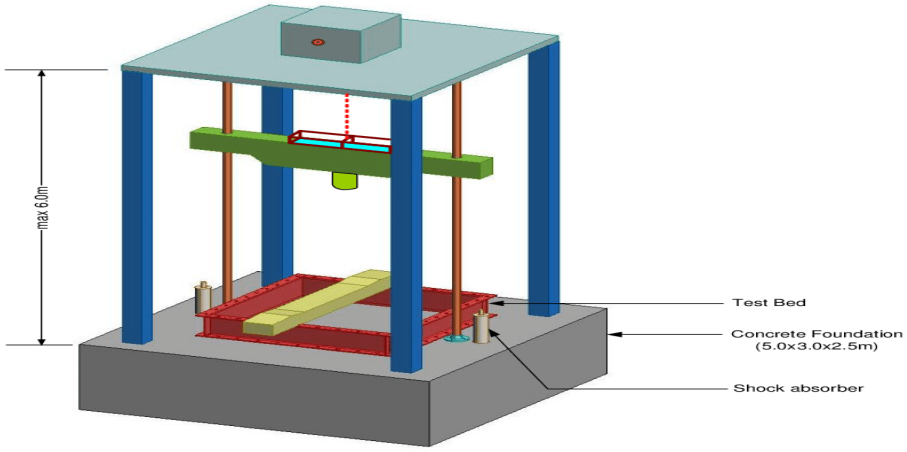


Fig 1.7: Drop impact tester (Wikipedia)

CHAPTER 2

LITERATURE REVIEW

Application Of Sandwich Beam in Automobile Front Bumper for Frontal Crash Analysis; Amarnath Donga. The paper has a new type of sandwich beam structure made up of two thin high strength face sheets bonded to a thick light weight solid material in between two composites. Face sheet thickness used is ranges from 0.15 to 2.2 and core densities ranges from 16kg/m3 to 900kg/m3. Two types of materials are considered for core materials polyurethane foam and vinyl sheet foam. Compared to both materials polyurethane foam is compatible with both polyester and epoxy resin systems and also has better properties compared to vinyl sheet foam. Optimization of sandwich beam showed that high energy absorption and reduces the weight of front bumper by 18 percent.[1]

Design and Analysis of Automobile Bumper Beam with Shock Absorber: S. Joseph, S. Sivaganesan, C. Gnanavel. In this paper absorb maximum amount of shocks shock absorbers are placed inside the crush can assembly. While testing a normal sedan is considered at a low speed of 10kmph.First bumper beam with crush can and bumper beam with shock absorbers are tested individually. After testing shock absorber inside crush can and bumper beam assembly impact and damages are 60% less at compared to crush can and shock absorber individually. [2]

Design and Analysis of Automotive Bumper Beam Using Polymer Matrix Composite: K. Elavarasan, D. Gopinath, T. Rajendiran, T.G. Sakthivel and M. Ganesh. This paper deals with design and analysis of Automotive bumper beam using polymer matrix composites. The stiffness for different cross section bumper beams like I-section, Box section, C-section and T-section are formatted to find the effective cross section for epoxy polymer Glass Fiber. After testing Among all other beams, the I-section bumper beam less deformation and better strength and stiffness. Epoxy polymer glass composite has great strength good fatigue resistance, light in weight and easy to manufacture compared to Structural steel, Aluminum alloys and

copper alloys. Thus, after various static and dynamic analysis of materials and beam sections epoxy polymer glass fiber material with I-section structure bumper beam is suitable.[3]

Design And Analysis of Hydraulic Bumper for Sudden Impact Reduction in Four-Wheeler; N. MuraliRaj, R. Mageshwaran, M. Risheb. In this paper pneumatic cylinder is used to absorb shocks. Any vehicle or object hits bumper it will retract and reduce the shock and after collision it will extract the bumper. Most of the impact energy will dissipate through the compression of damper and remaining force to the vehicle chassis. The hydraulic dampers provide dynamic damping coefficient and reduce crash impact and to reduce the impact to the vehicle body. When coming to materialanalysis carbon fiber composite has less deformation compared to Aluminum alloy, steel instructural and harmonic response analysis. [4]

Design and Sensitivities Analysis on Automotive Bumper Beam Subjected to Low Velocity Impact: Dr. S. Srinivasa Rao, K. Viswatej. This study mainly focused on parameters like thickness, cross section, materials and supports. The bumper beam assumed as a simple support beam with both ends fully constrained with 2mm of thickness of steel and length of 1096mm is used. After analysis bumper beam starts yielding and maximum deformation and stress is observed at overhanging part .Now the thickness of bumper beam is 5mm and 16.5kg of weight .It has better deformation results compared to 2mm thickness still weight of material remains same .So to reduce weight various types of composite materials are tested among all other S2 glass epoxy fiber has high strength properties compared to other composites .Changing the shape of cross section of bumper beam easily changes the strength and stability of bumper beam .Double C-section has high strain energy compared to simple C section .For higher stability ,cost effective and manufacturing of product,S2 glass epoxy fiber is proposed with double C section beam. [5]

Vehicle Bumper Beam of Aluminum Using Honeycomb and Foam: **Rahul Tiwari, Bhupinder Singh**. In this research two types of beams used first is bumper beam filled with polyethylene foam used outer and inner side. Second is A1honeycomb filled with polyethylene foam is used outer side and inner side is only polyethylene foam only. The experiment is done between the existing bumper and bumper beam and bumper beam which is best from simulation. The materials used in bumper beam Were Aluminum, Polyethylene, Structure Steel. After testing both bumper beams bumper beam filled with foam and honey comb has better shock absorbing capacity and less bending compared to first one (polyethylene on both sides). Weight of the new bumper beam is 20% less than the existing bumper beam and also the Impact energy absorbing capacity.[6]

Impact Analysis of Composite Sandwich Structure Bumper Beam for Passenger Vehicles: AMAR N. Chakra, Somasekhar.G. In this paper they have used fiber reinforced composite material to decrease the weight and cost. The composites are used in layers like sandwich structure to increase the ability to absorb the kinetic energy during impact materials like Chopped strand mat, Epoxy resin, core motto make the composite sandwich bumper beam. In this several tests were conducted to know the properties of materials.

In this the HAND-LAY UP method is used to construct the sandwich structure used in this method. It decreases the cost of modeling 40 tm to 0tm machine is used to test the tensile strength of the structure. Charpy test is used to is used to list the tensile strength of the sandwich structure. Charpy test is used to test the impact strength of the specimen. Further the ANSYS software is used to test the static -Nano linear analysis finally, the research goal is reached and weight is reduced up to 38.25% and also cost is reduced up to 58.33%then the impact energy absorption has been increased.[7]

Impact Analysis of Aluminum Honey Comb Sandwich Panel Bumper Beam: Pradip, R. Lande Rajesh, V. Patil. In this paper they tried to create bumper beam with aluminum honey comb sandwich panel to increase the strength and energy absorbing. They have adopted finite element analysis to test the material as conducting experiments is the expensive skin and core are the two primary components and these are the ones that define the properties of sandwich composites. The height of the honey comb sandwich effects the fundamental frequency. if the core

height increases the fundamental natural frequency of the sandwich panel. After performance several tests it is concluded that by increasing the thickness of honey comb core all the strength is increased.[8]

Design Analysis of Automotive Carbon Fiber Composite Bumper Beam Based on Finite Element Analysis: Tie Wang and Yong gang Li. In this paper,to increase the crashworthiness performance of a car bumper beam in low velocity, they studied it by changing the material and thickness. They used finite element analysis is carry out the simulation for impact under low-velocity. They have tested several materials like E-GLASS/EPOXY AND CARBON FIBER. The impact on the bumper is measured using the factor coefficient of restitution (or) it gives the ratio ratio of the speed differences. In the test conducted in this article COR is between 0and 1. For meshing Altair Hyper mesh software is used in this article. The ECER042 standard is followed while conducting simulation. MAT257 material type is used in the simulation of foam and MAT224 is used for the bumper beam simulation. MAT 255 material is used for bumper beam, fascia and brackets. MAT220 is Used for the impactor and the car body. After the analysis it is found by them that carbon fiber with thickness 5.4mm is perfect and it reduced the weight by 20%-40% and increases the fuel economy by 6%-8% it also reduces assembly costs and time. Carbon fiber is also resistant to corrosion and has styling flexibility. By COR values they also concluded that it has high specific energy absorption.[9]

A Review on The Composite Materials Used for Automotive Bumper Beam in Passenger Vehicles: Alen John, Sanu Alex. In this paper they are trying to use only composite materials for selection of bumper beam while selecting the materials they have checked the material criteria like Energy absorption, performed, cost, weight, service conditions, manufacturing process, availability of material. They have selected a few materials like Carbon fiber reinforced epoxy, glass fiber reinforced epoxy, carbon fiber reinforced.

propylene, glass fiber vinyl ester sheet molding compound (smc), Glass fiber reinforced polyester. In these all-composite materials have high strength and they can absorb high impact resistance and rigidity.[10]

An Evaluation of Polymer Composites for Car Bumper Beam: Olumide Osokya. In this literature paper they have used versatile materials with unique properties They have to tried to increase the more safety in a crash management. They have checked with common materials as well as polymer composites. In common materials they have mostly Steel bumper beam, Aluminum bumper beam, plastic bumper beam. IN these three common materials have different properties but they have chosen for selection of car bumper beam in past. Apart from common materials They have chosen polymer composites like carbon fiber epoxy composite, Glass fiber reinforced polypropylene composite, Nylon-6- nano clay composites. In these materials it has good density, young's modulus, yield strength, Tensile strength, Elongation, Shear modulus, Fracture Toughness. IN these materials one material nylon-6- nano composite have best weight reduction and seven times lighter than the high strength steel and three times lighter than aluminum and it has high Specific yield strength than steel. It makes possibilities to alternative to replace many other steel components like bumper, steering...etc. [11]

Design and Development of Impact Energy Absorbing Bumper: Amit Chege, Kshitij, Abhishek Kale, Dr. K. C. Vora. In this study various energy absorbing materials and bumper beam are designed and developed (Sandwich panel honey comb structure, Hilton Foam, Double cylinder model, Double half cylinder model and Double cylinder model filled foam etc..,) to increase the impact resistance of bumper beam. The energy absorbing materials are placed between bumper beam and fascia, double half cylinder model has high energy absorbing structured property (397 J) compare to other structures under drop test. A bumper of M1 category vehicle used for testing sample. Simulation of bumper are performed using ANSYS tool as per AIS 100 and ECE R-42 regulation. Simulation as per AIS 100, the length of 926mm and testing mass of 13.5 kg. when the bumper beam is attached with energy absorber then energy absorbed by the bumper beam is only 24.31 J and deformation of 1.2mm, without energy absorber energy absorbed by the beam 73.07J and deformation of 1.52mm to its original position. Simulation as per ECE -42 standard. Trolley is used as a impactor and weight is almost equal to vehicle weight, result shows that impact on beam assembled with energy absorbing material was 147.28 J and deformation 10.4mm comparatively low then without using an energy absorber. The simulation result shows that by implementation of energy absorber materials to bumper beam help to reduce crashworthiness.[12]

Compressive Study of High Velocity Impact Response of Aluminum 3105-H18 & Carbon Fiber-Epoxy Composite Double Hat Bumper Beam: Smith Salifa, Dawood Desai, Olugbenga Outbuying. This study various properties of aluminium 315-h18 and carbon fiber-epoxy composit double hat bumper beam is studied under various testing methods like Impact test, Finite element analysis. In Impact test two form of impact are obtained Elastic and Plastic impact, during in Elastic impact kinetic energy is absorbed and total momentum before and after collision is equal. Double hat cross section bumper beam and impactor was created in FEA software abacus CAE, diameter and height of impactor 0.08m and 0.3m is placed in between hat section of bumper beam , analysis of bumper beam in done in FEA software the beam provided with Impactor has high impact resistance at collision time compare to bumper beam without impact evenly though the Aluminum 3015-H18 has high strength, strain energy and kinetic energy , Carbon fiber energy absorbing composite provides predicative Elastic and high stress value allow manufacture and designer to fabricate carbon fiber energy absorbing composite with the bumper beam .[13]

Analysis of Frontal Bumper Beam of Automobile Vehicle by using Carbon Fiber Composite Materials: S. GODARA, SHIV NARAYAN NAGAR.

In this study different cross-section of bumper beam was designed in CATIA V5 R20software and analysis is done in FEA Hyper mesh R13 software at velocity of 10, 20 and 30km/h. Glass epoxy and carbon epoxy are used as beam materials. Beam is designed with the parameters of Length 1300mm, width 65mm, thickness 1.6mm, rectangular cross-sectional beam is used for simulation process. When the collision occur impact in front of bumper is high equal to impactor stress which a cuss bending at different loads 10,20,30 km/h. Open hat section have high stress, displacement of high and Rolling form is high compared to rectangular section.[14]

Crash Analysis of a Passenger Car Bumper Assembly to Improve Design for Impact Test: Mohammed Abdul basith, N. Chandrashekar reddy.

In this study Aluminum alloy, Thermoplastic and Chromium coated mild steel are the three materials used in analysis. 3d model is built in CAD software and analysis of beam is done in ANSYS software at various speeds 40, 60 and 80km/h. Impact analysis and static analysis is done according to global standard size of 50mm and C3D10M is used for design model. Mild steel has high impact stress, low impact strain and low deformation compared to other materials due to its weight consideration and high cost plays a major role when it's comes to manufacturing, fuel consumption of a vehicle. Glass mat thermoplastic is more suitable material to manufacture due it's high impact absorbing during collision compared to other materials.[15]

Design of a Hydraulic shock absorber for Car Front and Rear Bumpers: B. Kumar Srinivas Rao, B. Shiv Ganesh: In order to prevent damage and injury of the passenger's hydraulic shock absorbers are placed between chassis and bumpers. The spring is made up of a toughest material alloy of Si-Mg which can withstand 10Kmph collision impact and remaining impact force get dissipated by heat energy in hydraulic shock absorbers and crush cans also introduced to reduce collision impact on car.[16]

Design and Fabrication of Shock Absorbers Bumpers to reduce Impact during Road Accident: M. Goudilyan, A. Srinivasan, K. SASIKUMAR. In this study Automatic impact reduces system is developed to reduce Collison impact on road accident, Automatic hydraulic bumper system uses Infrared sensor used to sense the vehicle that is Coming Infront of our vehicle. IR transmitted signal from the vehicle is reflected back and processed in control unit. The control unit activates solenoid value which moves the bumper forward. The hydraulic shock absorbers are built in between the chassis and front bumper and thus reduces the impact on the vehicle and the passengers inside it during collision.[17]

Design and Analysis of a car bumper using springs; Ganasan, Ravi Kumar Reddy, M. Suneetha: This study talks about the development of a new bumper system by springs. Springs are used to minimize the impact of accidents and it will resist or absorbs the shocks. The selection of bumper material plays a major role to withstand the impact load so, the Carbon Fiber Composite, Glass mat thermoplastics, Aluminum B310 are used as a bumper material.[18]

Design and Analysis of Coil Spring Shock Absorbing Bumper to Reduce Impact stress in Automobiles: B. Karthik. This study talks about the absorb the impact energy in the front-end during accidents. Springs will be used to manage the impact and the arms that joins shock absorber and the bumper and the small link which pivots between the two arms at both the sides. These arms and links help in the absorption of the impact energy into springs potential energy and releases to environment and increases the bumper efficiency and reduces the impact on passengers and passengers' safety.[19]

Design of a conceptual Bumper Energy Absorber Coupling Pedestrian Safety and Low-speed Impact Requirements: Fuhau Mo, Siqi Zhao Chuanhui Yu, Zhi Xiao, Shuyong Duan. This study helps in understanding to meet the requirements of both pedestrian safety and low-speed impact of a car front bumper. A modular self-adaptive energy absorber of the front bumper system which can balancing the two performers. An energy absorber is set between the bumper beam and bumper skin to absorb impact energy. The X-shaped energy absorbing structed helps in enhancing the energy. Absorbing capacity during impact by changing its deformation mode based on the amount of external collisional energy.[20]

Automatic Pneumatic bumper shock absorber and braking system: Vishwajeet Godge, Tushar Nagawade, Nikhil Pawar. In this study when any obstacle or vehicle coming in front of the vehicle the ultrasonic sensor in the vehicle senses and sends it to control unit. The control unit operates relay and cut off the electric power supply given to the engine. So, the speed of the vehicle reduces and pneumatic bumper system helps to reduce the impact energy and at the same time automatic brakes are applied to further .[21]

Design and Manufacturing Issues in the Development of Light Weight Solution for a Vehicle Frontal Bumper: A. T. Beyene, B. Martorana.

In this study different composite material are manufactured by using FRP Pultrusion and Die Forming methods, pultrusion method is a fully automated process used for constant cross section composite profile. During this process the many fiber bundles are pulled downstream using hydraulic to increase the strength high tension on fibers applied, due to this aligned allowing good composition. FRP Pultrusion method often high strength then a similar manufacturing by Hand-layup, vacuum bag in fusion and other composite processing methods. Deforming method is a similar like casting method, multiple components (bumper beam and crush box) are casted in to single component this provides a less joints, high strength component. Deforming method has a high strength, high impact strength, less joints and low manufacturing cost compared to Pultrusion method, main drawback is hole component has to change after collision occur or when bumper get deformed.[22]

Modeling & Analysis of A Car Bumper with Different Loads on Different Materials: V. Siva Kumar, S. Timothy. This paper talks about the impact applied on the front part of the car. Even when car bumper cannot protect against the high-speed collisions .so we need to increase the secondary safety measures. The most commonly used material for bumper is aluminum. This author says that the polypropylene foam body or urethane foam body can absorb the more amount of energy at the time of the impact. When we take metals, stainless steel can with stand more amount of energy. It can with stand up to 2000N.[23]

Experimental Investigation for Impact Strength of Front Bumper Beam of Automobile: Mr. Gawale Chetan Somnath; Prof N.K. Kharate.

Most of the car accidents are in in front bumper. Daily occurring of the accidents in angular way is 33.6 %; off set 12.3 %; front 21 %. The author says that the material attached in the front of the vehicle is composed of polypropylene which is also called as PEP which can only help when the impact is low. Th spring system over here contains 26 vertical springs for converting the kinetic energy into springs potential enrgy.in additional 4 horizontal springs are attached to fascia. fascia is used as the bearing for the spring system retainer. Finally, this author says that the among polyamide and poly urethane, poly urethane is the best material to use since the material can with stand more amount of energy.[24]

Shape Optimization of Bumper Beam Under High Velocity Impact Loads: Niyazi Tanlak; Fazil O. Sonmez. The author says that the majority of the accidents are occurred three ways angular collision, pole front collision, full front collision. Here they prefer to use the cross-sectional hollow bumper beam. They used the Al honey comb pattern for beam in which helps in reduction of impact and absorption. In this study got to know about the parameters used in springs and deformation and energy absorption behaviors of the rest of the car behind the brackets.[25]

Improvement Of Front Car Bumper System. Muhamad Firdaus Bin Mahmud: Especially now a days the bumper is damaged even for small impacts. material used polypropylene which is attached to bumper beam which helps in absorption of energy after the impact. Practically proven that the impact beam from glass thermoplastic which is the superior than to the other materials.[26]

Geometrical Design and Crash Simulation of a Shock Absorbers. Ancuta N. Jurco, Liviu: The chosen material is elastic plastic material for making hyper crash can. The Crash result is presented in figures below for three thickness case 4mm,1mm,0. 5mm.The two materials used for making crash can are Al, steel .in these all three cases with two metals the 4mm thickness metal can with stand more amount of internal energy better than the other.[27]

2.1 GAP IDENTIFICATION:

- In many articles they used polyurethane, vinyl sheet foam and honey comb structure commonly considered for energy absorbing material. Styrofoam can be a great alternative for energy absorption.

- Most of the articles described about energy absorbing of bumper beam with shock absorber are capable of absorbing low impact load (i.e., not more than 20kmph). It can be enhanced further.

- In the majority of articles shock absorbers used are springs and twin shock absorbers which has less damping coefficient. Alternative for twin shock absorber is mono tube shock absorber has high damping coefficient.

CHAPTER 3

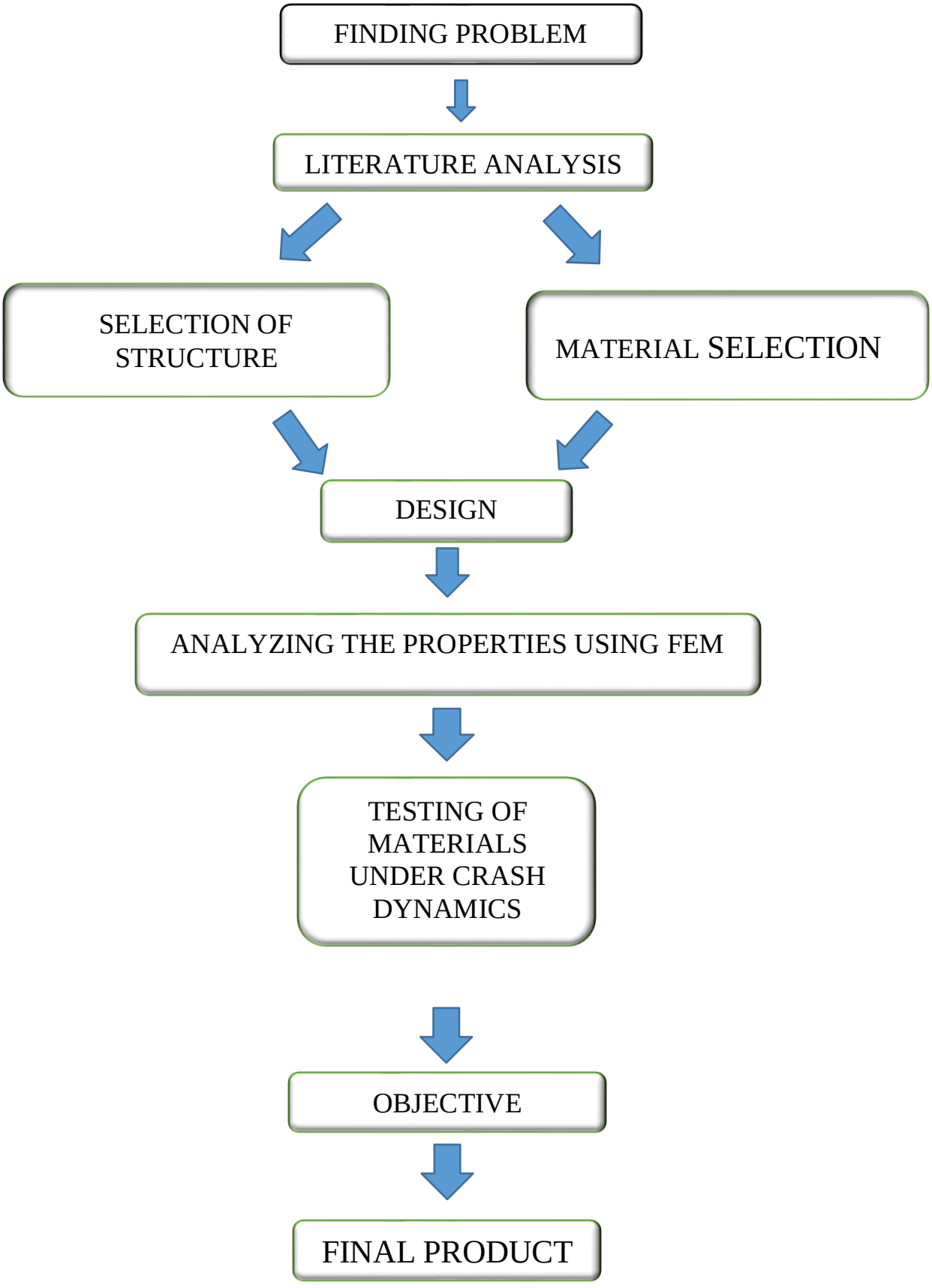
OBJECTIVE

In this study the objective is to design and analysis of a car bumper beam with shock absorber and energy absorbing materials for electric vehicle. To improve the safety of passenger, vehicle and pedestrian when a collision occur, main objective is to design a bumper beam capable of withstand impact load at the time of collision with less displacement of beam and with a better safety easy to manufacture, low cost, lightweight materials. The modelling of bumper beam done in solid works and simulation is carried out in ANSYS software.

- The objective of this work is to study front bumper beam of (Maruti Suzuki Ertiga) .Further, shock absorber has also been studied in the place of crash cans.
- Model and simulate car bumper beam for impact analysis.
- Use diferent materials for better impact attenuation
- Compare the results of Experimental and FEA results.

CHAPTER 4

METHODOLOGY



CHAPTER 5

DESIGN & ANALYSIS

5.1 DESIGN of SHOCK ABSORBER:

Fig 5.1 Shock Absorber

Sl. no.	Specifications	Dimensions
1	Total No of coils (Nt)	8
2	Mean coil Diameter (D)	36.75mm
3	Wire Diameter (d)	6.5mm
4	Spring Index (k)	5.65
5	Pitch coil (P)	10mm
6	Solid length of spring (L)	58.5mm

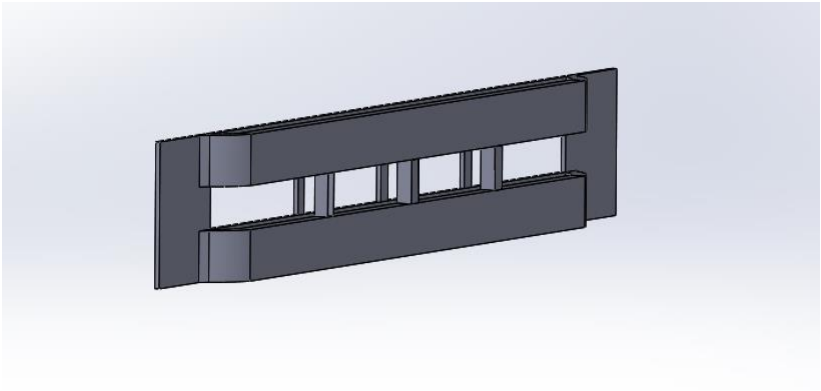
Table :5.1 Spring Specifications

5.1.1 Justification of shock absorber:

The replacement of crash cans with shock absorber in car is not possible because of following reasons:

1. Shock absorber mounting with rail and bumper beam is not rigid.
2. Using a shock absorber does not meet pedestrian safety.

5.2 CAD MODEL of EXISTING BUMPER BEAM OF MARUTI SUZUKI ERTIGA:



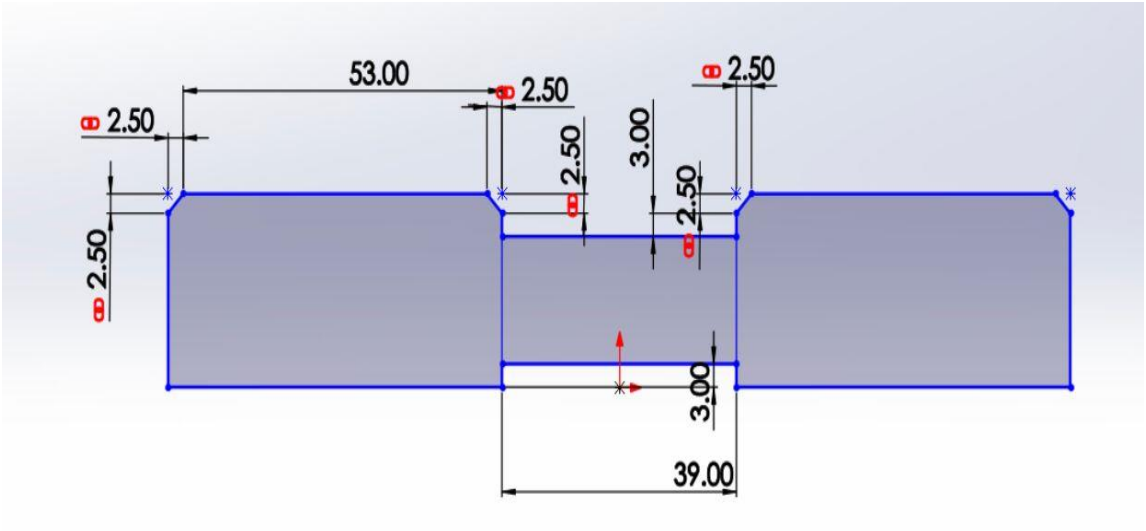
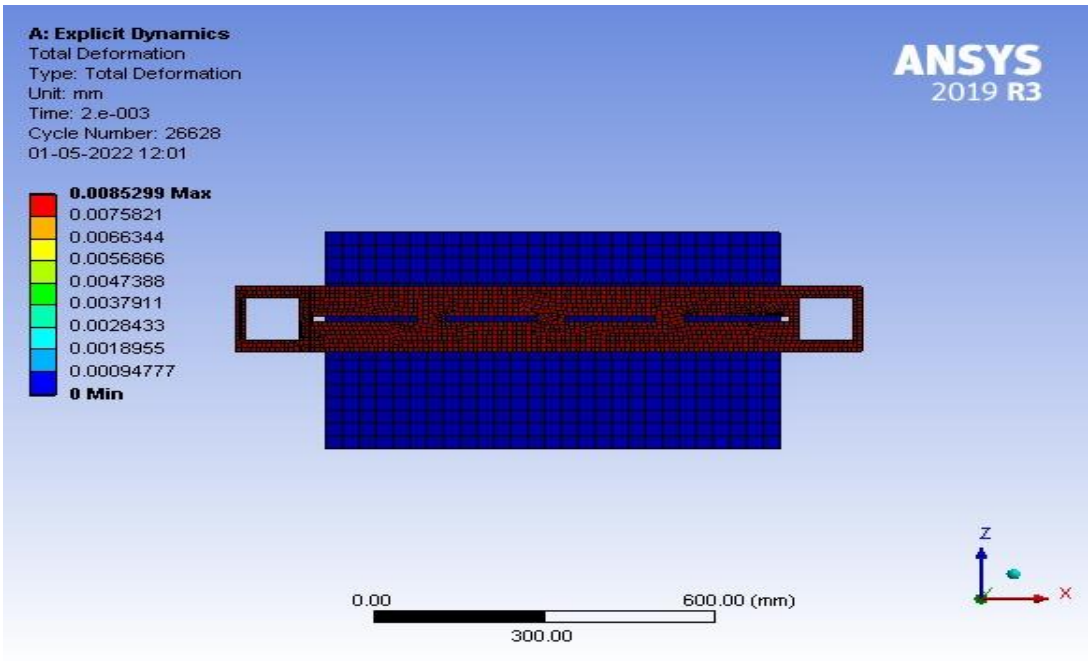


Fig :5.2 Existing beam CAD model and dimensions

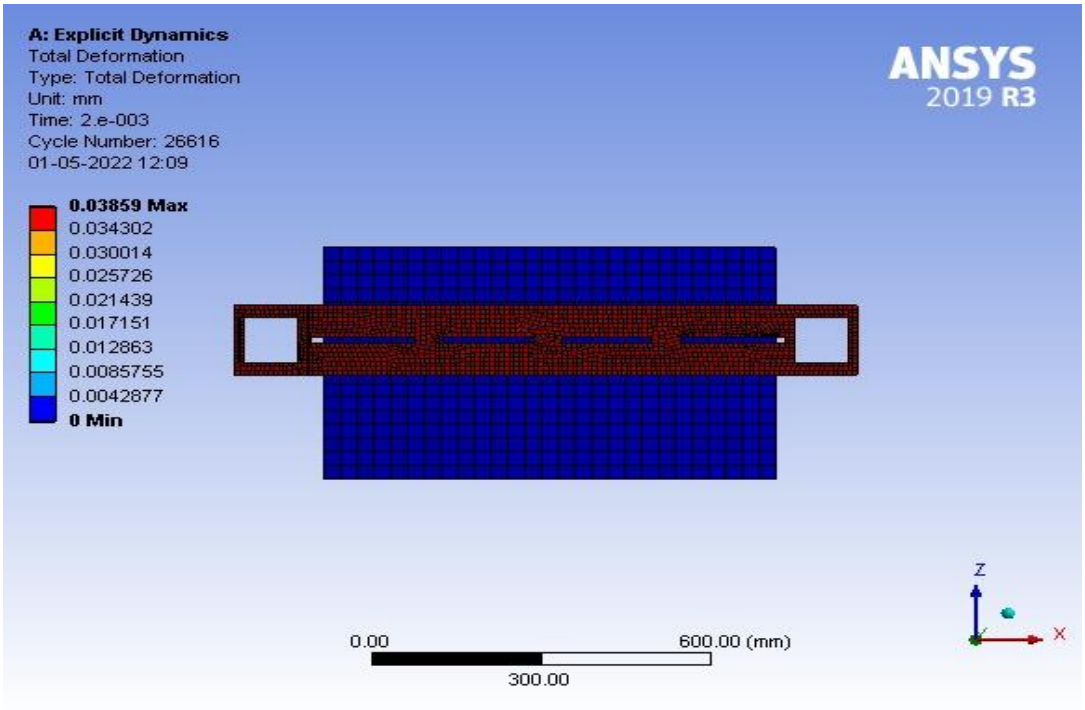
S no.	Beam	Average Von-Misses Stress(Mpa)	Maximum Von Misses Stress (Mpa)	Yield Strength
1	Existing Bumper Beam	64.2	143.61	214
2	Modified W-section Beam	60.3	136.16	214

Table 5.2: Ansys results

5.3 ANALYSIS of EXISTING BUMPER BEAM:



Velocity at 3.91m/s



Velocity at 17.77m/s

Fig 5.3: Analysis of Existing bumper beam

5.4 DESIGN of W-SECTION BUMPER BEAM:

The new design of W- section beam is introduced in this project. This w-section beam has hollow section of 83 mm whereas the existing beam has less hollow cross section. The benefit of having hollow beam is it is easy to absorb energy during impact and energy absorbing materials could be in this hollow section.

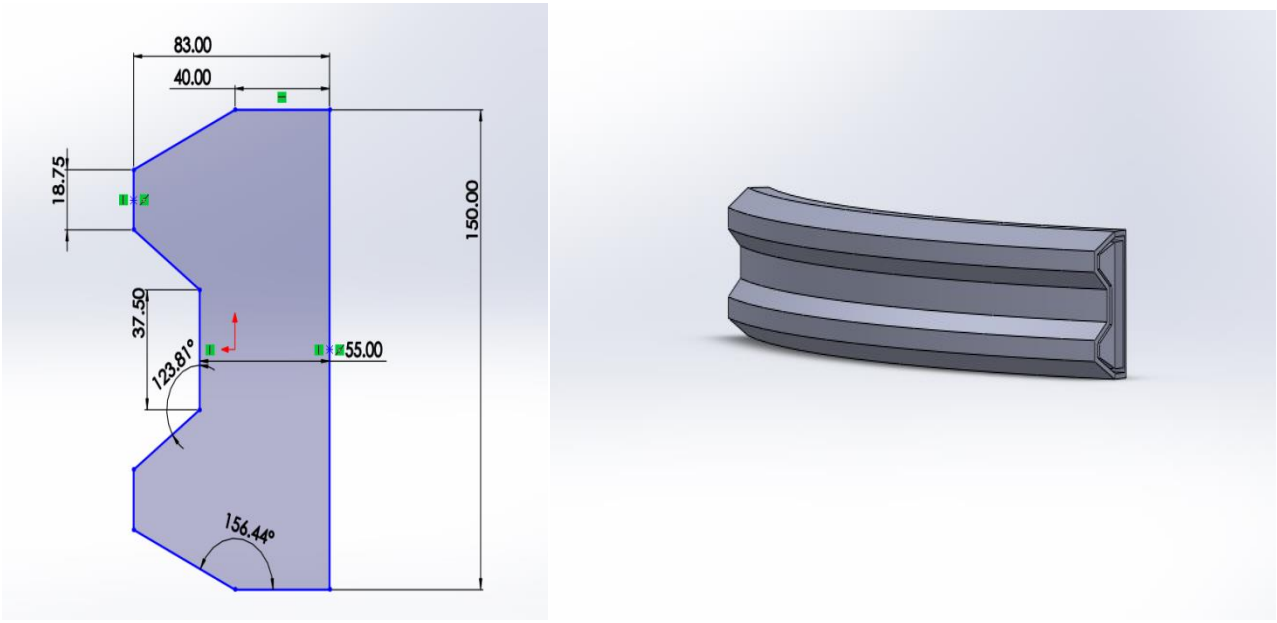
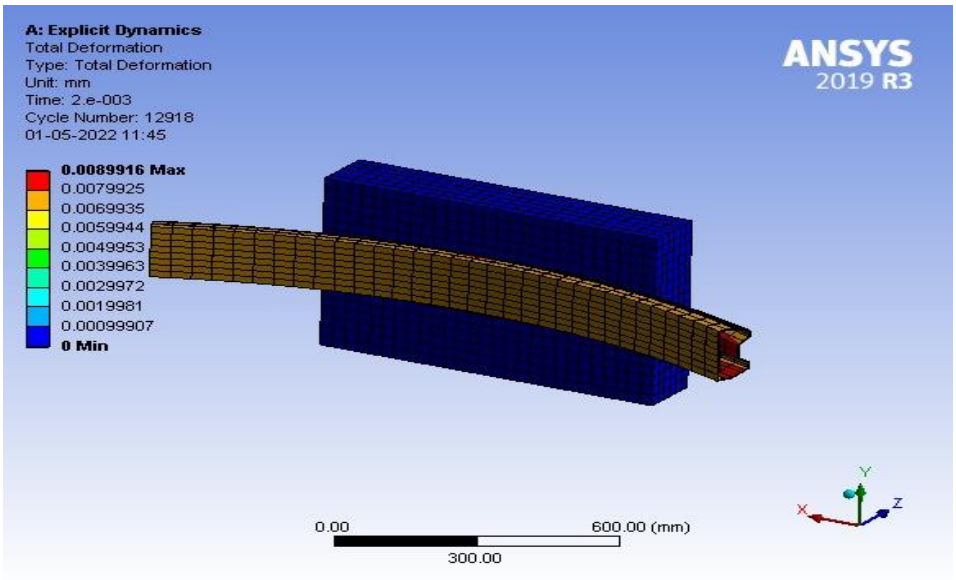


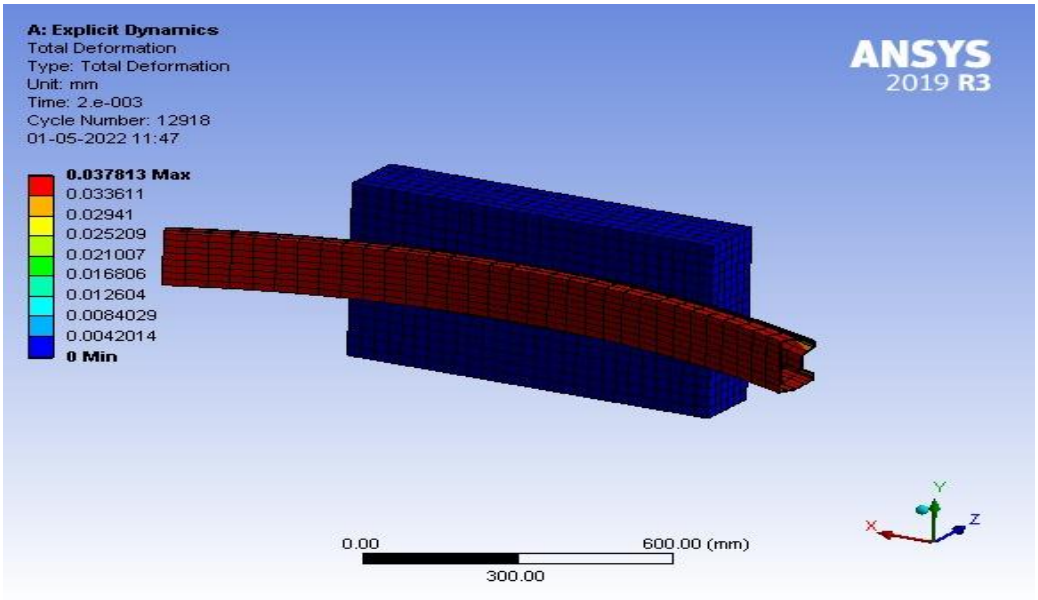
Fig 5.4 Design of W- section bumper beam

5.5 ANALYSIS of MODIFIED BUMPER BEAM:



Velocity at 3.91m/s

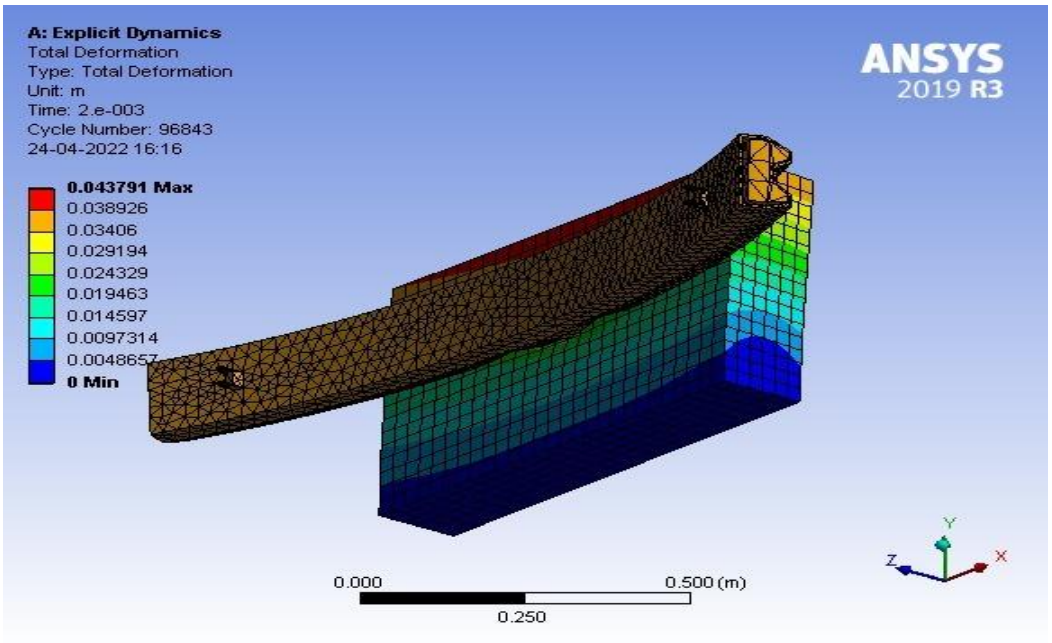
Fig;5.5 Analysis of Modified Bumper Beam at 3.91



Velocity at 17.77m/s

Fig:5.6 Analysis of Modified Bumper Beam at 17.77m/s

5.6 ANALYSIS of MODIFIED BUMPER BEAMWITH FOAM:



Velocity at 17.77m/s

Fig :5.7 Analysis of Modified Bumper Beam with Foam at 17.77m/s

CHAPTER 6
MATERIALS

6.1 ALUMINIUM 6063 ALLOY:

AL 6063 is an aluminum alloy, with magnesium and silicon as the alloying elements. It has generally good mechanical properties and is heat treatable and weldable. Most of the automobile bumpers are made from this material because of its low weight. It is a good energy absorbing material.

Table: 6.1 properties of materials

S.no	Materials	Young's Modulus (Gpa)	Poison's Ratio	Yield Strength (Mpa)	Density (Kg/m^3)
1	ALUMINIUM 6063	68.3	0.3	214	2680

6.3 XPS Polystyrene Foam:

XPS foam board is often used for thermal insulation boards. When used above-grade, it can reduce thermal bridging and improve energy efficiency. Most of the formula cars use this foam as an impact attenuator. In this project this foam is filled in w - section beam.

CHAPTER 7
DROP IMPACT TESTING

7.1 APPARATUS:

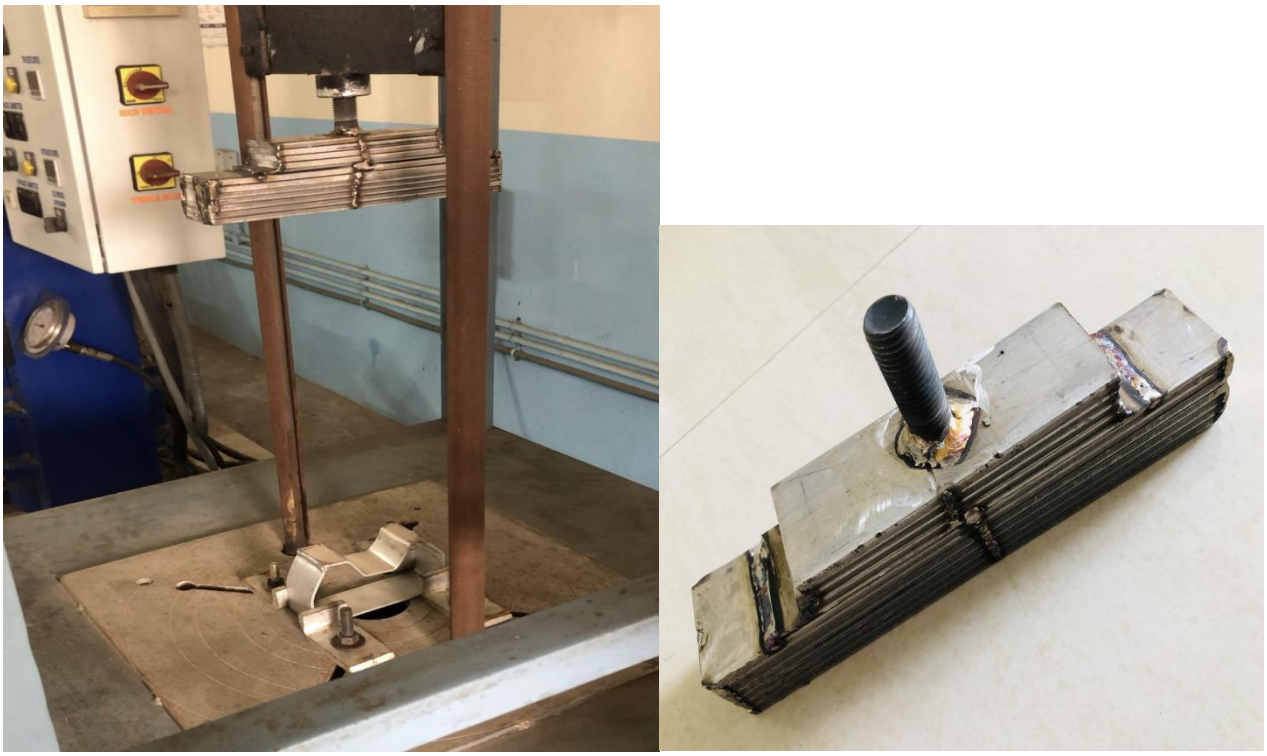


Fig7.1: Apparatus

There are 6 test specimens used in this testing namely.

- Al 6063(t3) without foam - 3
- Al 6063(t3) with foam - 3

7.2 PROCEDURE:

The test specimens of each material are fixed with the help of four chuck keys. The load of 10.15kg is fixed with the help of thread on top of load. Now, this load is dropped from three different heights. The values are taken respectively.

7.3 CALCULATION:

Mass of bumper beam

- Aluminum 6063

Density =2860kg/ m^3

Thickness = 3mm

volume=length *breadth*thickness*4

= 1.4m*0.0925m*0.003m*4

=0.001554 m^3

mass =volume*density

=0.001554m^3*2860kg/ m^3

mass =4.4kg

Table :7.1 Testing Calculations

S.NO.	**HEIGHT(h)**	**VELOCITY($v=\sqrt{2gh}$)**	**POTENTL ENERGY (P. E=mgh)**	**KINETIC ENERGY (K. $E=1/2mv^2$)**
1.	h1=0.26m	v1=2.2m/s	P. E1=28.86J	K. E1=24.68J
2.	h2=0.52m	v2=3.2m/s	P. E2=51.72J	K. E2=51.89J
3.	h3=0.78m	v3=3.91m/s	P. E3=77.58J	K. E3=77.50J

7.4 RESULTS:

The results show that energy absorption rate was higher in Al6063 t3 without foam than Al 6063 t3 with foam.

Fig: 7.2 Aluminum 6063 Results - 3mm

Table :7.2 Deformation values

S.NO.	DEFORMATION (Ansys) mm	DEFORMATION (Impact drop test) mm	DEFORMATION WITH FOAM
1	4.4	6	0
2	6.3	11	2
3	7.8	24	4

7.5 GRAPHS: VELOCITY vs DEFORMATION

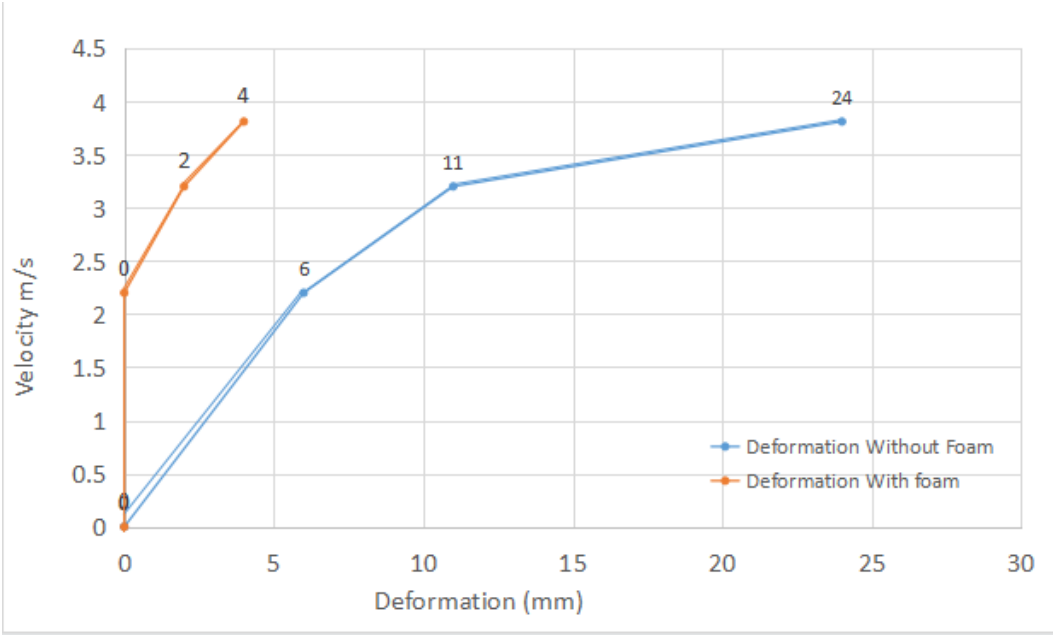


Fig 7.3 Deformation of Al 6063 t3

CHAPTER 8

COST ANALYSIS

Table :8.1 Material costs

S.NO.	MATERIAL	LENGTH(m)	COST (₹)
1	AL6063(t3)	3	1670
2	XPS (EXTRUDED POLYSTYRENE)	2	1000

Table: 8.2 Welding cost

S.NO.	TYPE OF WELDING	MATERIAL	COST (₹)
1	TIG	AL6063(t3)	1200

CHAPTER 9

CONCLUSION

Thus, from the results we can conclude that the new design of bumper beam (Al6063) without foam has less deformation than the existing bumper beam. Even though it has less deformation because of hollow section of W-section beam it can further absorb energy. W-section bumper beam with foam cannot be used for low velocity impact as it does not absorb energy. In addition, using a shock absorber in the place of crash cans does not meet pedestrian safety hence, it cannot be used.

FUTURE SCOPE

- Alternative energy absorbing material can be introduced in the place of XPS foam.
- Various types of bumper beam designs can be introduced

CHAPTER 10

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INDIVIDUAL CONTRIBUTION

- Design & Analysis:

  NagiReddy Hemanth Kumar Reddy & Edagottu Umesh Nithin.

- Materials &Fabrication:

  NagiReddy Hemanth Kumar Reddy, Samudrala Raj Kumar & Srimannarayana.

- Experimental Testing:

  NagiReddy Hemanth Kumar Reddy, Edagottu Umesh Nithin, Samudrala Raj Kumar & Koneti Srimannarayana.

- Paperwork & Ppt:

  Edagottu Umesh Nithin, Samudrala Raj Kumar & Koneti Srimannarayana.

PO NO.	PO Description	Project Mapping
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3
PO 2	**Problem Analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2
PO 3	**Design Development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	3
PO 4	**Conduct Investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.	3
PO 6	**The Engineer & Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	3

PO 7	**Environment & Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	2
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	4
PO 9	**Individual & Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	4
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.	3
PO 11	**Project Management & Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	4
PO 12	**Life-Long Learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	3

PSO – PROJECT MAPPING

PSO NO.	PSO Description	Project Mapping
PSO 1	Design, Analysis, Fabrication and Testing of vehicles, which enable the students to compete globally.	3
PSO 2	Carry out research in materials, Bumper beam, Weight management and Safety for the benefit of the passengers.	4